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REC.

INDUCED POLARIZATION SENDER NOTES

project: FLAGSTAFF Line: SCHULTZ #2-W Date: 9/20/66

Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2	CAL 4-5	CAL 3-4
Receive	0-60	50-100	→	100-150	→	→	150-200	→	→	→	40.5 40.4	4.05 4.04
Time	960 960	3.0 1530 1530	.3 166 168	3.0 1480 1480	1.0 285 285	.3 63 64	3.0 950 950	1.0 23.5 23.3	.3 9697 9898	.1 3168 3168	40.5 40.4	4.05 4.04
Range	960 960	1530 1530	166 170 168 169	1480 1480	285 285	63 64	950 950	23.4 23.6	9697 9898	3165 3167	.1	.1
Current	960 960	1528 1530	168 167 168 168	1480 1480	285 285	63 64	950 950	23.4 23.6	9698 9898	3165 3167		
Send	4-5	3-4	2-3	1-2	4-5	3-4	2-3	1-2				
Receive	300-350	→	→	→	250-300	→	→	→				
Time	.18 127 128	.13 63 63	.1 38.4 38.4	.08 15.6 15.2	.1 45.7 46.0	.1 33.0 33.7	.1 23.5 23.6	.03 10.4 10.5				
Range	127 128	63 64	38.0 38.8	15.4 15.4	45.8 45.8	33.2 33.5	23.5 23.6	10.4 10.5				
Current	128 128	63 64	38.4 38.2	15.8 15.0	45.8 45.8	38.3 33.5	23.5 23.6	10.4 10.4				
			38.6 38.6	15.6 15.2				10.4 10.4				

INDUCED POLARIZATION SENDER NOTES

project: FLAC Line: SCH B2-E Date: 9/30/86

Send	4-5	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5	CA3	CA2
Receive	1460 1530	3.0 1240 1240	1.0 205 206	3.0 1110 1120	1.0 20.8 20.7	.3 64 64	3.0 780 780	1.0 201 201	.3 76 76	11 33.6 34.5	4.10 402	30.1 30.1
Time	1460 1530	1240 1240	205 206	1110 1120	205 210	64 64	780 780	201 202	76 76	33.6 18 34.2	40.2 40.0	30.1 30.1
Range	1460 1530 2998	1240 1240	204 206	1100 1120	205 210	64 64	780 790	200 202	76 76	33.8 34.0 18	40.1 40.1	
Current	1495	1240	205	1115	207.5	64	780	201	76	33.2 17 34.5	40.1	30.1

Send	1-2	2-3	3-4	4-5	1-2	2-3	3-4	4-5		33.9		
Receive	200-250				250-300							
Time	.3 112 113	.1 56.5 58.5	.1 30.3 29.6	.03 13.5 14.5 .1	.1 53.0 .7 54.5	.1 34.0 34.0	20.5 19.2	11.1 10.9				
Range	115 111	57.0 58.0	30.2 29.5	16.0 14.8 .4	52.2 51.2 .7	33.8 34.2	20.5 19.5	11.1 10.9				
Current	114 117 111 110	57.0 58.5	30.2 29.7	16.0 .3 14.6	51.0 .1 51.2	33.7 34.2	20.5 19.5	11.4 10.7				

113.5 114 114 57.5 30.0 15.6 .1 50.8 34.0 20.0 11.0
114 114 57.1 58.5 29.8 14.9 15.7 51.0 51.3

INDUCED POLARIZATION SENDER NOTES

project: _____ Line: I B E½ Date: 9-20-66

Send	4-5	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5	1-2	23
Receive	0-.5 E	.5-1 E	→	1-1.5 E	→	→	1.5-2 E	→	→	→	2-2.5 E	—
Time												
Range												
Current	400	400	400	400	400	400	300	400	400	400	300	400
Send	3-4	4-5	1-2	2-3	3-4	4-5		2-3	1-2			
Receive	→	→	2.5-3 E	→	→	→		CAL	CAL			
Time												
Range												
Current	400	400	300	400	400	400		400	300			

INDUCED POLARIZATION SENDER NOTES

project: _____ Line: I-B W½ Date: 9-20-66

Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2	4-5	3-4
Receive	0.5W	5-1W	→	1-1.5W	→	→	1.5-2W	→	→	→	2-2.5W	—
Time												
Range												
Current	300	400	300	400	400	300	400	400	400	300	400	400
Send	2-3	1-2	4-5	3-4	2-3	1-2		4-5	3-4			
Receive	→	→	2.5-3W	→	→	→		CAL				
Time												
Range												
Current	400	300	400	400	400	300		400	400			

INDUCED POLARIZATION - RECEIVER NOTES PAGE

Project: FLAGSTAFF Line: SCHULTZ #1-E Int.Cal Date:

Send	4-5	2-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-3	CAL	CAL
Rec.	0-50'	50-100	→	100-150	→	→	150-200	→	→	→	2-3	1-2
Time	3.0	3.0	1.0	3.0	.5	.3	3.0	.3	.3	.3	.1	.1
DC-1	999 1000	1680 1690	260 260	710 710	167 166	92 92	1040 1040	122 125	84 84	69 69	40.0 40.2	50.0 50.2
DC-2	999 999	1690 1690	260 262	710 710	166 166	91 93	1040 1040	124 123	84 84	70 69	40.0 40.2	50.0 50.2
Σ		1690 1690			166 166						40.0 40.2	50.0 50.2
DC-3	999 1000	1680 1700	262 263	710 710	167 166	91 92	1040 1040	124 123	85 84	70 69		
Dc-4	1-2	2-3	3-4	4-5	1-2	2-3	3-4	4-5				
Σ	210-250	→	→	→	350-300	→	→	→				
DC-AV	.3	.1	.1	.1	.1	.1	.1					
AC-1	171/172	53.0 53.6	49.5 54.0	47.0 47.2	58.4 58.4	26.5 24.8	27.2 27.0	27.6 27.8				
AC-2	171/172	53.2 53.0	50.5 54.0	46.8 47.2	58.4 58.5	25.3 25.0	27.4 27.0	27.7 27.7				
Σ	170/173	52.8 53.5	50.0 54.0	47.0 47.4	58.5 58.6	25.3 24.9	27.5 27.0	27.6 27.8				
S. P.		52.2 53.1	50.5 50.5	46.8 47.4	58.2 58.2	25.5 24.9	27.3 27.2	27.6 27.9				
AC-N			50.5 50.5		58.6 58.2							

INDUCED POLARIZATION SENDER NOTES

project: _____ Line: I W1/2 Date: 9-20-66

Send	~~1-4~~	2-3	~~1~~-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2	4-5	3-4
Receive	0-5W	5-10	→	1-1.5W	→	→	1.5-2W	→	→	→	2-2.5W	→
Time	~~5~~											
Range												
Current	500	400	500	600	400	500	1000	600	400	500	1000	600
Send	2-3	1-2	4-5	3-4	2-3	1-2		4-5	3-4			
Receive	→	→	2.5-3W	→	→	→		CAL	CAL			
Time												
Range												
Current	400	500	1000	600	400	500		1000	600			

REC.

INDUCED POLARIZATION SENDER NOTES

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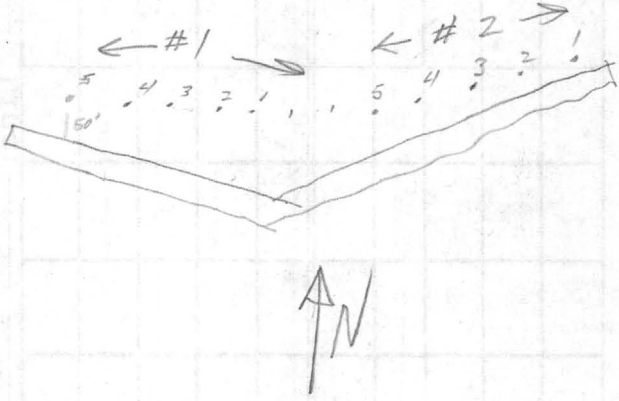
project: FLAGSTAFF Line: SCHULTZ #1-W Date: 9/20/66

Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2	CAL 4-5	CAL 3-4
Receive	0-50	60-100	→	100-150	→	→	150-200	→	→	→	1.0 1.0	5.8 5.8
Time	~~3.0~~ 11 58	~~1.0~~ 40 400	~~.3~~ 1.3 12.4	1.0 6.10 6.10	.3 1.10 1.12	.1 60.0 58.2	3.0 6.60 6.68	.3 1.67 1.68	.1 58.0 58.2	.1 33.0 31.5	1.00 1.00	5.8 5.8
Range	1150 1150	400 400	122 123	608 612	110 110 110 111	58.4 58.8	660 660	166 169	50.2 48.0	33.0 31.5		
Current	1150 1150	400 400	126 125 124	610 615 610 605	110 109 112 112	58.4 58.8	660 660	167 168	50.0 48.2	33.0 31.5		
Send	4-5	3-4	2-3	1-2	4-5	3-4	2-3	1-2				
Receive	200-250	→	→	→	250-300	→	→	→				
Time	~~.3~~ ~~202~~ 198	~~.3~~ 58 61	~~.1~~ 24.7 24.3	~~.03~~ 19.0 18.2	~~.3~~ 135 136	.1 58.5 58.3	.1 22.5 22.8	18.9 19.0				
Range	202 198	59 60	24.5 24.3	18.4 18.4 19.2 19.1	135 136	58.5 58.3	23.0 22.7	19.0 19.0				
Current	202 198	59 60	24.7 24.3	18.8 18.8 18.7 18.8	135 136	58.5 60.0	22.8 22.7	18.9 19.1				
						58.8 58.0	22.6 22.7	18.7 19.0	18.8 19.1			


#1
#2
5
4
3
2
1
1
5
4
3
2
1
50'
N

INDUCED POLARIZATION SENDER NOTES

project: _____ Line: I E½ Date: 9-20-66

Send	4-5	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5	1-2	23
Receive	0-.5 E	.5-1.0	→	1.0-1.5 E	→	→	1.5-2 E	→	→	→	2-2.5 E	—
Time												
Range												
Current	1000	600	1000	400	600	1000	500	400	600	1000	500	400
Send	3-4	4-5	1-2	2-3	3-4	4-5		23	1-2			
Receive	→	→	2.5-3 E	→	→	→		CAL	CAL			
Time												
Range												
Current	600	1000	500	400	600	1000		400	500			

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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page_____

Project FLAGSTAFF Line SCHULTZ 2nd Field date 9/20/66 Data page 1 & 2 Comp. date 9/30/66. Comp by JMc

(A) Send	1-2	2-3	1-2	2-4	2-3	1-2	4-5	3-4	2-3	1-2		
(B) Receive	0-50	50-100	→	100-150	→	→	150-200	→	→	→		
(C) n separation	1	1	2	1	2	3	1	2	3	4		
(D) I	300	400	300	400	400	300	400	400	400	300		
(E) Vdc (avg)	960	1530	167.5	1475	285	63.5	950	23.5	97.3	31.6		
(F) DCcal	.997	.997	.997	.990	.997	.997	.990	.990	.997	.997		
(G) Kn x 10^{-3}	.15	.15	.6	.15	.6	1.5	.15	.6	1.5	3.0		
(H) ρdc=ExFxGx10^3/D	480	573	334	548	426	317	353	349	364	315		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project_____ Line_____ Field date_____ Data page_____ Comp. date_____ Comp by_____

(A) Send	4-5	3-4	2-3	1-2	4-5	3-4	2-3	1-2		CAL	CAL	
(B) Receive	200-250	→	→	→	250-300	→	→	→		4-5	3-4	
(C) n separation	2	3	4	5	3	4	5	6				
(D) I	400	400	400	300	400	400	400	300		400	400	
(E) Vdc (avg)	127.5	63.5	38.4	15.4	45.8	33.35	23.55	10.43		40.45	40.45	
(F) DCcal	.990	.990	.997	.997	.990	.990	.997	.997		.990	.990	
(G) Kn x 10^{-3}	.6	1.5	3.0	5.25	1.5	3.0	5.25	8.4				
(H) ρ dc=ExFxGx10^3/D	189	236	294	269	170	248	309	292				
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

HEINRICHS GEOEXPLORATION COMPANY
INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page_____

Project FLAGSTAFF Line SCHOLTZ #2E Field date 9/20/86 Data page_____ Comp. date_____. Comp by JMC

(A) Send	4-5	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5		
(B) Receive	0-50	50-100	→	100-150	→	→	150-200	→	→	→		
(C) n separation	1	1	2	1	2	3	1	2	3	4		
(D) I	400	400	400	400	400	400	300	400	400	400		
(E) Vdc (avg)	1495	1240	205	1115	207.5	64	780	201	76	33.9		
(F) DCcal	.990	.990	.990	.997	.990	.990	.997	.997	.990	.990		
(G) Kn x 10^{-3}	.15	.15	.6	.15	.6	1.5	.15	.6	1.5	3.0		
(H) ρdc=ExFxGx10^3/D	555	461	304	417	308	238	389	301	282	251		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project_____ Line_____ Field date_____ Data page_____ Comp. date_____ Comp by_____

(A) Send	1-2	2-3	3-4	4-5	1-2	2-3	3-4	4-5		CAL	CAL	
(B) Receive	200-250	→	→	→	250-300	→	→	→		1-2	2-3	
(C) n separation	2	3	4	5	3	4	5	6			4	
(D) I	300	400	400	400	300	400	400	400		300	400	
(E) Vdc (avg)	113.5	57.7	29.9	15.2	51.3	34.0	20.0	11.0		30.1	40.1	
(F) DCcal	.997	.997	.990	.990	.997	.997	.990	.990		.997	.997	
(G) Kn x 10^{-3}	.6	1.5	3.0	5.25	1.5	3.0	5.25	8.4				
(H) ρ dc=ExFxGx10^3/D	226	215	222	197	256	254	260	229				
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

V/I K

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INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page_____

Project FLAGSTAFF Line SCHUETZ #1-E Field date 9/20/66 Data page 142 Comp. date 9/20/66. Comp by JMc

(A) Send	4-5	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5		
(B) Receive	0-50'	50-100	→	100-150'	→	→	150-200	→	→	→		
(C) n separation	1	1	2	1	2	3	1	2	3	4		
(D) I	1000	600	1000	400	600	1000	500	400	600	1000		
(E) Vdc (avg)	999.7	1685	261	710	166.5	92	1040	1235	84	69.5		
(F) DCcal	1.000	1.035	1.000	.997	1.035	1.000	.998	.997	1.035	1.000		
(G) Kn x 10^{-3}	.15	.15	.6	.15	.6	1.5	.15	.6	1.5	3.0		
(H) ρdc=ExFxGx10^3/D	150	426	156	265	172	138	312	185	218	208		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project_____ Line_____ Field date_____ Data page_____ Comp. date_____ Comp by_____

(A) Send	1-2	2-3	3-4	4-5	5-6	2-3	3-4	4-5		2-3	1-2	
(B) Receive	200-250	→	→	→	250-300	→	→	→		CAL	CAL	
(C) n separation	2	3	4	5	3	4	5	6				
(D) I	500	400	600	1000	900	400	600	1000		400	500	
(E) Vdc (avg)	171.5	53.0	50.4	47.1	58.4	25.2	27.2	27.7		40.1	50.1	
(F) DCcal	.998	.997	1.035	1.000	.998	.997	1.035	.998		.997	.998	
(G) Kn x 10^{-3}	.6	1.5	3.0	5.25	1.5	3.0	5.25	8.4				
(H) ρ dc=ExFxGx10^3/D	206	198	261	247	175	188	246	232				
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

HEINRICHS GEOEXPLORATION COMPANY

INDUCED POLARIZATION SURVEY COMPUTATION SHEET

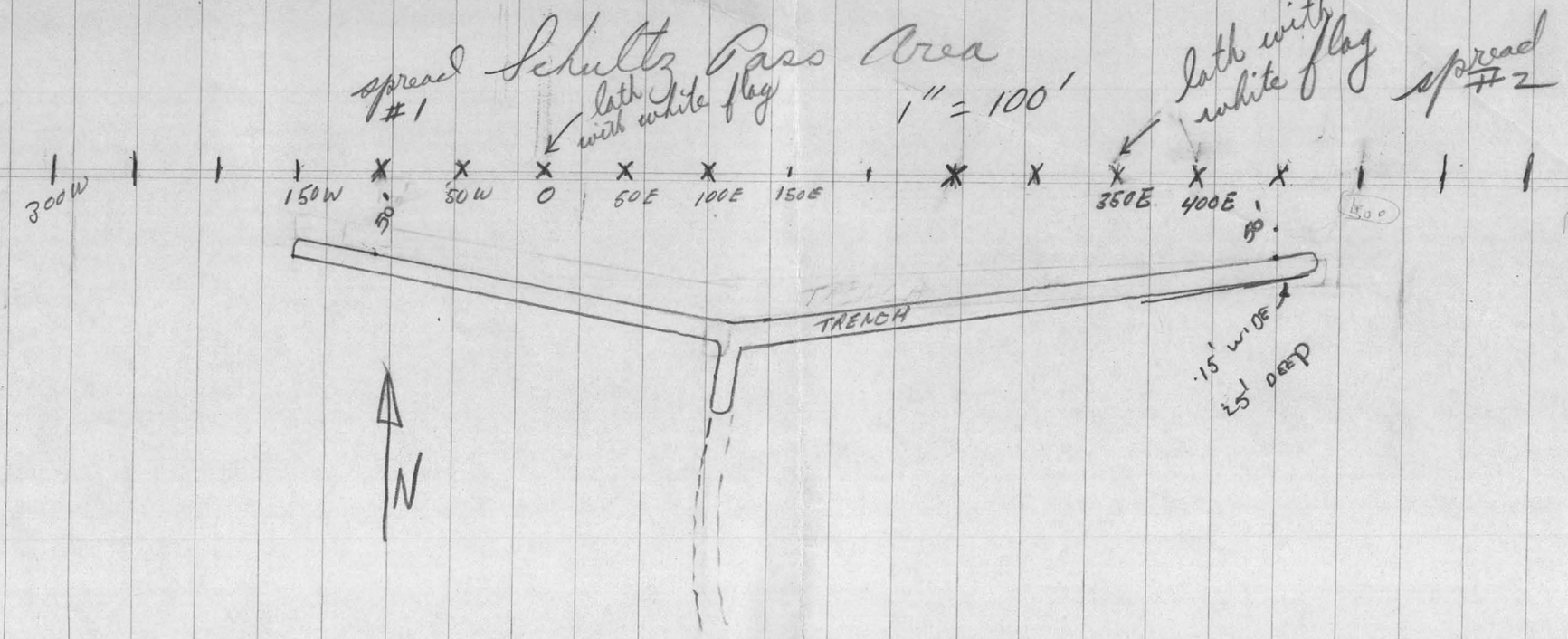
Page_____

Project FLAGSTAFF Line SCHULTZ W½ Field date 9/20/66 Data page 1 of 2 Comp. date 9/20/66. Comp by JMC

(A) Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2		
(B) Receive	0-50'	50-100	~~100-150~~	100-150	→	→	150-200	→	→	→		
(C) n separation	1	1	2	1	2	3	1	2	3	4		
(D) I	500	400	500	600	400	500	1000	600	400	500		
(E) Vdc (avg)	1150	400	125	610	111	58.6	660	167.5	48.6	32.25		
(F) DCcal	.998	.997	.998	1.035	.997	.998	1.000	1.035	.997	.998		
(G) Kn x 10^{-3}	.15	.15	.6	.15	.6	1.5	.15	.6	1.5	3.0		
(H) ρdc=ExFxGx10^3/D	344	150	150	158	166	176	99	174	182	194		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project_____ Line_____ Field date_____ Data page_____ Comp. date_____ Comp by_____

(A) Send	4-5	3-4	2-3	1-2	4-5	3-4	2-3	1-2		CAL	CAL	
(B) Receive	200-250	→	→	→	250-300	→	→	→		4-5	3-4	
(C) n separation	2	3	4	5	3	4	5	6				
(D) I	1000	600	400	500	1000	600	400	500		1000	600	
(E) Vdc (avg)	200	59.5	24.5	18.7	135.5	58.5	22.7	19.0		10.0	5.80	
(F) DCcal	1.000	1.035	.997	.998	1.000	1.035	.997	.998		1.000	1.035	
(G) Kn x 10^{-3}	.6	1.5	3.0	5.25	1.5	3.0	5.25	8.4				
(H) ρ dc=ExFxGx10^3/D	120	154	183	196	235	325	297	319				
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

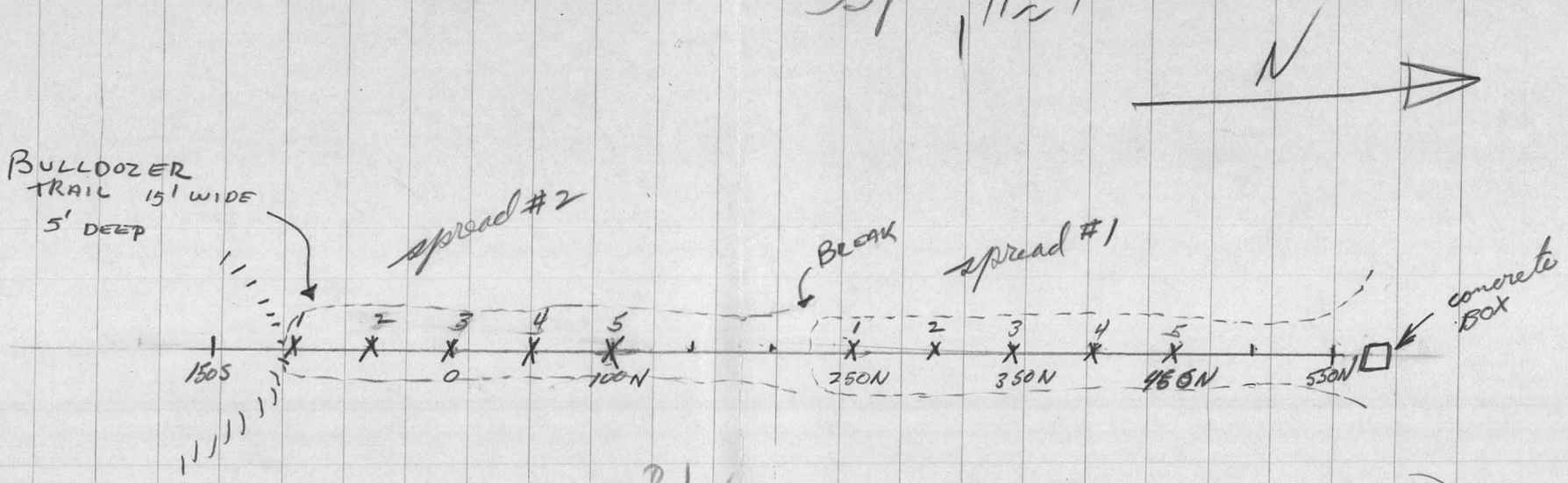

spread #1
Schultz Pass Area
1" = 100'
lath with white flag
lath with white flag
spread #2
300W
150W
50W
0
50E
100E
150E
350E
400E
650E
700E
50'
50'
TRENCH
15' WIDE
25' DEEP
N

950'
700

Resistivity Cross-section

Bearpaw Springs area

1" = 100'



Resistivity Survey

Title Block
— N-Arrow
Border

City of Flagstaff
For
Coconino County

Sept 4th, Pass, Area 17

9

INDUCED POLARIZATION - RECEIVER NOTES PAGE _____

Project: FLAGSTAFF Line: B.P. #2-S Int.Cal _____ Date: _____

Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2		
Rec.	0-50	50-100	→	100-150	→	→	150-200	→	→	→		
Time	3	3	1	3	1	.3						
DC-1	1800 1800	1380 1380	286 296 305	1110 1110	208 208	77 77						
DC-2	1810 1800	1380 1380	292 296 300	1110 1110	208 208	77 77						
Σ												
DC-3	1810 1800	1380 1380	292 302 297	1110 1110	208 208	76 78						
Dc-4	1810 1790		292 297 302									
Σ												
DC-AV								CAL	CAL			
AC-1								1-2	2-3			
AC-2								.3	.3			
Σ								58.0	58.0			
S. P.								58.0	58.0			
AC-N								58.0	58.0			
Pot.Res												

INDUCED POLARIZATION SENDER NOTES

project: BEAR PAW Line: I B 5½ Date: 9-21-66

Send	4-5	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5		
Receive	0-5^S	5-1S	→	1-1.5S	→	→	1S-2^S	→	→	→		
Time												
Range												
Current	600	600	600	600	600	606						
Send									1-2	2-3		
Receive									CAL	CAL		
Time												
Range												
Current									600	600		

INDUCED POLARIZATION - RECEIVER NOTES PAGE _____

Project: FLAGSTAFF Line: BEARPAW #2-N Int.Cal _____ Date: _____

Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2		
Rec.	0-50	50-100	→	100-150	—	→	150-200	—	—	→		
Time	3	3	1	3	1	.3	3	1	.3	.1		
DC-1	1330 1330	1710 1720	304 306	1430 1430	324.23 322	91 92	1610 1610	260 255	96 75	26.2 24.2		
DC-2	1330 1330	1720 1720	304 307	1430 1430	318 19 320	90 93	1610 1610	260 256	76 75	26.2 24.2		
Σ					322 323.22							
DC-3	1330 1330	1720 1720	303 306	1430 1430	327.27 327	90 93	1600 1620	258 256	76 75	26.4 24.0		
Dc-4			302 308		325.25 325	91 92		258 257				
Σ	4-5	3-4	2-3	1-2	4-5	3-4	2-3	1-2	CAL	CAL		
DC-AV	200-250	—	—	→	250-300	—	—	→	4-5	3-4		
AC-1	232 232 (1)	.3	.1	.03	.3	.1	.03	.03	.3	.3		
AC-2	232 232	65 65	25.8 26.0	11.4 11.4	75 76	30.0 .7 31.5	16.1 13.9	25 9.85 8.2	580 58.0	580 580		
Σ	232 232	65 65	25.8 26.0	11.4 11.4	75 76	31.2 .7 29.0	14.5 16.4	7.2 7.85 8.5	58.0 58.0	580 580		
S. P.		65 64	25.8 25.8	11.5 11.5	74 77	29.8 30.0	15.1 14.6	8.4 7.85 7.5				
AC-N			26.0 26.0		74 77	30.2 29.5	15.7 13.6	7.8 7.9 8.0				
Pot. Res												

INDUCED POLARIZATION SENDER NOTES

project: BEAR PAW Line: I B 1½ Date: 9-21-66

Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2	4-5	3-4
Receive	0-.5 N	.5-1 N	→	1-1.5 N	→	→	1.5-2 N	→	→	→	2-2.5 N	→
Time												
Range												
Current	600	600	600	600	600	600	600	600	600	600	600	606
Send	2-3	1-2	4-5	3-4	2-3	1-2				4-5	3-4	
Receive	→	→	2.5-3 N	→	→	→				CAL	→	
Time												
Range												
Current	600	600	600	600	600	600				600	600	

INDUCED POLARIZATION - RECEIVER NOTES PAGE ____

Project: FLIN Line: B.P #1-5 Int.Cal Date:

Send	4-5	3-4	4-8	2-3	3-4	4-5	1-2	2-3	3-4	4-5		
Rec.	0-50	50-100	→	100-150	→	→	150-200	→	→	→		
Time	3	3	1	10	1	.3	3	1	.3	.1		
DC-1	1540 1510	1830 1830	317 310 305	2000 1980	410 08 405	106 105	1640 35 1630	437 39 440	128 5 123	40.5 41.5	42.5	
DC-2	1540 1520	1830 1830	312 314 313	2000 1980	412 08 405	106 105	1650 40 1630	440 41 442	127 124 6	43.0 41.0	42.5	
Σ	1525 1530		313 310 312					438 41 441		43.2 41.6	42.4	
DC-3	1520 1510 1600	1820 1840	312 310 311	1980 1980	407 08 408	106 105	1650 40 1630	442 43 445	124 127 5	42.8 41.5	42.2	
Dc-4	1540 1510 1525		315 308 311	1980 1980	415 09 403		1640 35 1640	445 42 438		41.0 43.5	42.8	
Σ	1-2	2-3	3-4	4-5	1-2	2-3	3-4	4-5		CAL	CAL	
DC-AV	200-250	→	→	→	250-300	→	→	→		1-2	2-3	
AC-1	.3	.3	.1	.03	.3	.1	.03	.03		.3	.3	
AC-2	164 163	57 58	19.5 19.5	8.1 7.9 8.0	81 83	45.5 45.4	18.6 .9 19.1	9.1 9.5		63 64	63 64	
Σ	164 163	56 57	19.5 19.5	8.2 7.8 8.0	82 84	45.3 45.7	18.6 .9 19.2	9.1 9.5		63 64	63 64	
S. P.	164 163	56 59	19.5 19.5	8.4 7.6 8.0	80 84	44.0 46.2	18.3 19.4 .9	9.3 9.4		63 64	63 64	
AC-N		56 59		8.5 7.6 8.0	80 84	44.4 46.3	19.3 1.2 19.1	9.0 8.5				
Pot.Res				8.6 7.5 8.0		43.7 46.0	19.0 1.6 19.6 19.4 18.6	8.9 9.6				

INDUCED POLARIZATION SENDER NOTES

project: BEAR PAW Line: I S 1/2 Date: 9-21-66

Send	4-5	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5	1-2	2-3
Receive	0-5	5-15	1-5 →	1-1.5	2- →		1.5-2	— →			2-2.5	—
Time												
Range												
Current	350	450	350	650	450	350	650	650	450	350	650	650
Send	3-4	4-5	1-2	2-3	3-4	4-5		1-2	2-3			
Receive	→	→	2.5-3		→			CAL	CAL			
Time												
Range												
Current	450	350	650	650	450	350		650	650			

INDUCED POLARIZATION - RECEIVER NOTES LINE N-S PAGE 1

Project: FLAGSTAFF Line: BEARPAW #1-N Int.Cal Date: 9/21/66

Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2		
Rec.	0-50'	50-100	→	100-150	→	→	150-200	→	→	→		
Time	10	10	1.0	3.0	1.0	.3	3	1	.3	.1		
DC-1	2440 2440	2630 2640	560 54 548	1700 1710	500 11 522	175 171 168	750 770	198 198	121 122	58.0 .2 58.6		
DC-2	2440 2440	2660 2630	555 51 547	1700 1710	498 10 522	173 171 170	770 760	197 198	120 123	57.8 .2 58.5		
Σ			560 55 552									
DC-3	2440 2440	2640 2640	550 55 560	1700 1710	505 10 515	175 171 168	760 760	198 198	121 122	58.0 58.5 .2		
Dc-4	2440	2640 2640	558 56 563		507 515 11	175 171 168	770 760			57.6 58.7 .2		
Σ	4-5	3-4	2-3	1-2	4-5	3-4	2-3	1-2		4-5	3-4	
DC-AV	200-250	→	→	→	250-300	→	→	→		CAL	CAL	
AC-1										.1	.1	
AC-2									355	360	45.3 45.5	
Σ										3.60	45.5 45.5	
S. P.									359	3.60	45.3 45.5	
AC-N									354	3.55	45.4 45.4	
Pot. Res									354	3.54		

INDUCED POLARIZATION SENDER NOTES

project: BEAR PAW Line: I N 1/2 Date: 9-21-66

Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2	4-5	3-4
Receive	0-5 N	5-1 N	→	1-1.5 N	→	→	1.5-2 N	→	→	→	2-2.5 N	—
Time												
Range												
Current	650	650	650	450	650	650	350	450	650	650		
Send	2-3	1-2	4-5	3-4	2-3	1-2	4-5	3-4				
Receive	→	→	2.5-3 N	→	→	→	CAC	CAC				
Time												
Range												
Current							350	450				

HEINRICHS GEOEXPLORATION COMPANY

INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page_____

Project FLAGSTAFF Line B.P. #2-5 Field date 9/21/66 Data page_____ Comp. date 9/23/66. Comp by JMC

(A) Send	1-2	2-3	1-2	3-4	2-3	1-2						
(B) Receive	0-50	50-100	→	100-150	→	→						
(C) n separation	1	1	2	1	2	3						
(D) I	600	→	→	→	→	→						
(E) Vdc (avg)	1805	1380	296	1110	208	77						
(F) DCcal	1.034	→	→	→	→	→						
(G) Kn x 10^{-3}	.15	.15	.6	.15	.6	1.5						
(H) ρdc=ExFxGx10^3/D	468	357	306	287	215	200						
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project_____ Line_____ Field date_____ Data page_____ Comp. date_____ Comp by_____

(A) Send										CAL	CAL	
(B) Receive										1-2	2-3	
(C) n separation										600	600	
(D) I										580	580	
(E) Vdc (avg)												
(F) DCcal										1.034	1.034	
(G) Kn x 10^{-3}												
(H) ρ dc=ExFxGx10^3/D												
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

HEINRICHS GEOEXPLORATION COMPANY
INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 9/23/66

Project FLAGSTAFF Line B.P. #2-N Field date 9/21/66 Data page _____ Comp. date _____. Comp by JMc

(A) Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2		
(B) Receive	0-50	50-100	→	100-150	→	→	150-200	→	→	→		
(C) n separation	1	1	2	1	2	3	1	2	3	4		
(D) I	600	→	→	→	→	→	→	→	→	→		
(E) Vdc (avg)	1330	1720	305	1430	323	91.5	1610	257.5	75.5	25.2		
(F) DCcal	1.034	→	→	→	→	→	→	→	→	→		
(G) Kn x 10^{-3}	.15	.15	.6	.15	.6	1.5	.15	.6	1.5	3.0		
(H) ρdc=ExFxGx10^3/D	344	444	316	370	334	237	417	266	196	131		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) =$\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project _____ Line _____ Field date _____ Data page _____ Comp. date _____ Comp by _____

(A) Send	4-5	3-4	2-3	1-2	4-5	3-4	2-3	1-2		CAL	CAL	
(B) Receive	200-250	→	→	→	250-300	→	→	→		4-5	3-4	
(C) n separation	2	3	4	5	3	4	5	6				
(D) I	600	→	→	→	→	→	→	→		600	→	
(E) Vdc (avg)	232	65	25.9	11.4	75.5	30.1	15.0	7.9		580	580	
(F) DCcal	1.034	→	→	→	→	→	→	→		1.034	1.034	
(G) Kn x 10^{-3}	.6	1.5	3.0	5.25	1.5	3.0	5.25	8.4				
(H) ρdc=ExFxGx10^3/D	240	168	134	100	196	156	136	114				
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) =$\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

827-3457

HEINRICHS GEOEXPLORATION COMPANY

INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page_____

Project FLAGSTAFF Line B.P.# 1-S Field date 9/21/66 Data page_____ Comp. date 9/23/66. Comp by JMc

(A) Send	4-5	3-4	4-5	2-3	3-4	4-5	1-2	2-3	3-4	4-5		
(B) Receive	0-50	50-100	→	100-150	→	→	150-200	→	→	→		
(C) n separation	1	1	2	1	2	3	1	2	3	4		
(D) I	350	450	350	650	450	350	650	650	450	350		
(E) Vdc (avg)	1522	1830	311	1985	408	105.5	1638	441	125.5	42.3		
(F) DCcal	.986	.990	.986	1.023	.990	.986	1.023	1.023	.990	.986		
(G) Kn x 10^{-3}	.15	.15	.6	.15	.6	1.5	.15	.6	1.5	3.0		
(H) ρdc=ExFxGx10^3/D	644	604	526	468	538	446	388	416	414	358		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project_____ Line_____ Field date_____ Data page_____ Comp. date_____ Comp by_____

(A) Send	1-2	2-3	3-4	4-5	1-2	2-3	3-4	4-5		CAL	CAL	
(B) Receive	200-250	→	→	→	250-300	→	→	→		1-2	2-3	
(C) n separation	1	2	3	4	1	2	3	4				
(D) I	650	650	450	350	650	650	450	350		650	650	
(E) Vdc (avg)	163.5	57.5	19.5	8.0	82	45.4	18.9	9.3		635	635	
(F) DCcal	1.023	1.023	.990	.986	1.023	1.023	.990	.986		1.023	1.023	
(G) Kn x 10^{-3}	.6	1.5	3.0	5.25	1.5	3.0	5.25	8.4				
(H) ρ dc=ExFxGx10^3/D	155	136	129	118	194	214	218	220				
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

HEINRICHS GEOEXPLORATION COMPANY

INDUCED POLARIZATION SURVEY COMPUTATION SHEET

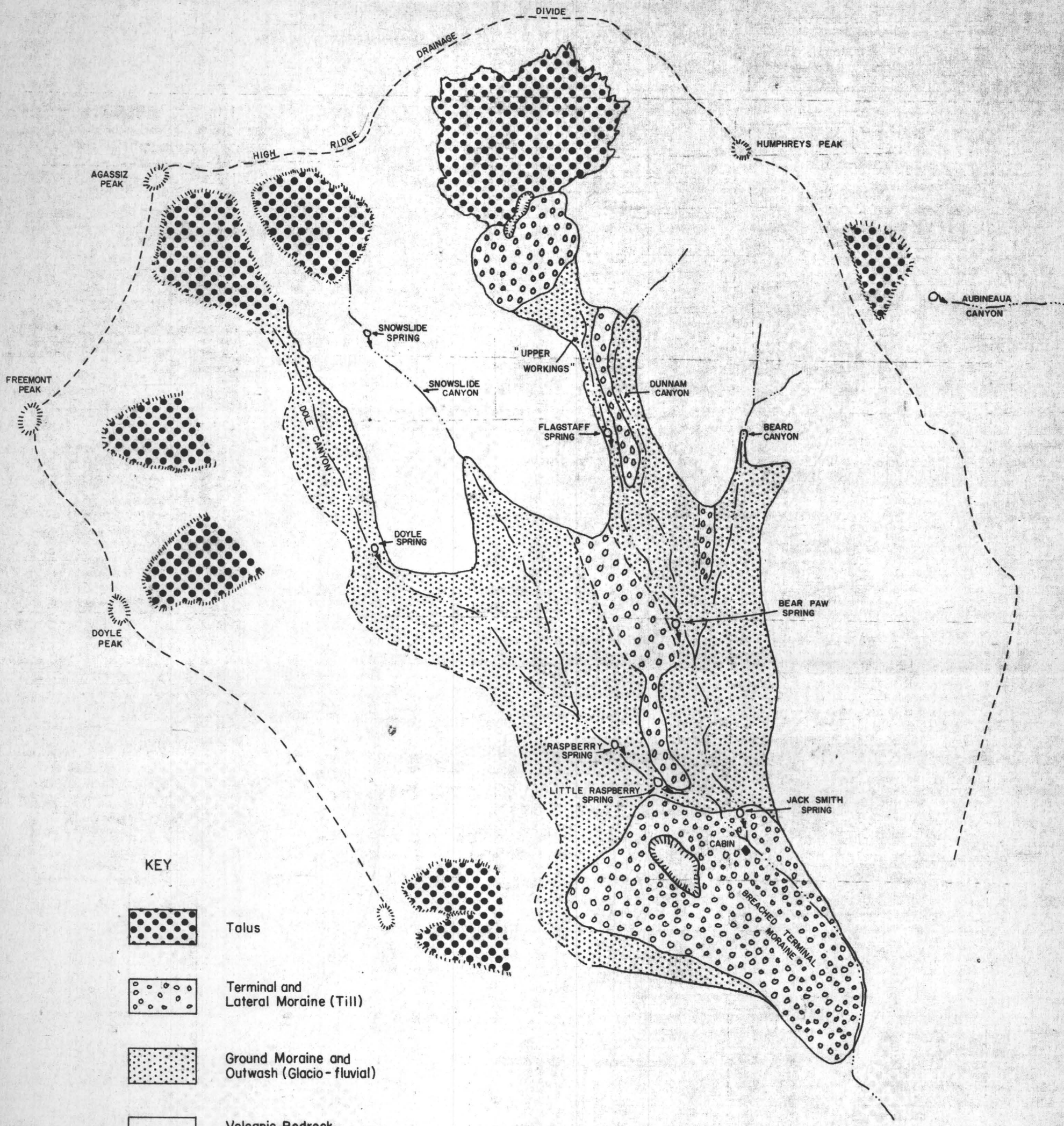
Page_____

Project FLAGSTAFF Line SEARPAW #1-N Field date 9/21/66 Data page 1 Comp. date 9/23/66. Comp by JMC

(A) Send	1-2	2-3	1-2	3-4	2-3	1-2	4-5	3-4	2-3	1-2	CAL	CAL
(B) Receive	0-50'	50-100	→	100-160'	→	→	150-200	→	→	→	4-5	3-4
(C) n separation	1	1	2	1	2	3	1	2	3	4		
(D) I	650	650	650	460	650	650	350	450	650	650	350	450
(E) Vdc (avg)	2440	2642	554	1705	511	172	762	198	121.5	58.2	355	454.5
(F) DCcal	1.023	1.023	1.023	.990	1.023	1.023	.986	.990	1.023	1.023	.986	.990
(G) Kn x 10^{-3}	.115	.115	.6	.115	.6	1.5	.115	.6	1.5	3.0		
(H) ρdc=ExFxGx10^3/D	576	624	524	562	484	406	322	261	287	275		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project_____ Line_____ Field date_____ Data page_____ Comp. date_____ Comp by_____

(A) Send												
(B) Receive												
(C) n separation												
(D) I												
(E) Vdc (avg)												
(F) DCcal												
(G) Kn x 10^{-3}												
(H) ρ dc=ExFxGx10^3/D												
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												



MAP SHOWING GEOLOGIC and HYDROLOGIC FEATURES

In The "Inner Basin" of San Francisco Mountain

W-205

Traced Ron Werhan

BEFORE FIELD COMPLETION

This is a copy of a U. S. Geological Survey manuscript compiled by photogrammetric methods. It does not include information to be obtained during field completion surveys.

FLAGSTAFF #1 SW, ARIZ.
N 35 15 00 W 111 37 30
SCALE 1:24 000 / 7.5 C.I. 40'
FLAGSTAFF NO. PROJ. 030502
PHOTO VBAF FH 18000' DATE 8/64

Base & Woodland Edge by Stine, 2.21.66
Contours Edge drawn by Stine, 2.21.66
Base & Woodland Edge by Tosking 2/66
Contour Edge by Tosking 2/66
Base & Woodland Edge by Seifert 1/66
Contour Edge Joined By Seifert 1/66
Base & Woodland Edge Joined By Seifert 2/66
Contour Edge Joined By Seifert 2/66

1-550,000 FT
ARIZ CENT ZONE

550,000 FT

580,000 FT

35 15 00

111 37 30

Base & Woodland Edge Joined by H. Woodcock 3-66

Contour Edge Joined by H. Woodcock 3-66

Base & Woods joined by Alvillar 1/66

Contours joined by Alvillar 1/66

12/65 DWC

12/65 JKW 12/65 DWC 12/65 KJM

12/65

N EDGE OF FLAGSTAFF WEST 7.5 1962

20 FT

RECEIVED
SEP 6 1966
ENGINEERING

FLAGSTAFF #1 SW, ARIZ.
N 35 15 00 W 111 37 30
SCALE 1:24 000 / 7.5 C.I. 40'
FLAGSTAFF NO. PROJ. 030502

mapped in some detail. Fortunately the broader aspects of the glaciation have already been worked out and a general map of the area is available. Building upon these we hope to determine the character and location of the individual bodies of glacial material and their relation to present springs that represent places of overflow of the ground-water bodies. This information likely will be of great assistance in determining locations and methods of ground-water development.

During this fiscal year we will prepare a report a report on the ground water in the Flagstaff area that will be more comprehensive than the administrative report previously prepared on the Woody Mountain well field. It will include a map and cross sections showing the distribution of the geologic formations and the main structural features in an area of about 400 square miles surrounding the city of Flagstaff. It will include a map showing water-level contours and the direction of ground-water movement. In brief, the report will summarize the geology and hydrology of the Flagstaff area and will indicate the most favorable areas for future ground-water development.

We plan to begin the mapping in the inner basin in the next few weeks and will get in touch with you to make final plans.

I hope this letter contains the information you asked for and that it will be of assistance to you in making your plans for water development.

With kindest personal regards,

Sincerely yours,

P. Eldon Dennis

P. Eldon Dennis
District Geologist

603 Water

ADDRESS REPLY TO
DISTRICT GEOLOGIST,
U. S. GEOLOGICAL SURVEY,
P. O. BOX 4126
TUCSON, ARIZONA

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ARIZONA DISTRICT

WATER RESOURCES DIVISION
GROUND WATER BRANCH
232 GEOLOGY BUILDING
UNIVERSITY OF ARIZONA
TUCSON, ARIZONA

July 8, 1960

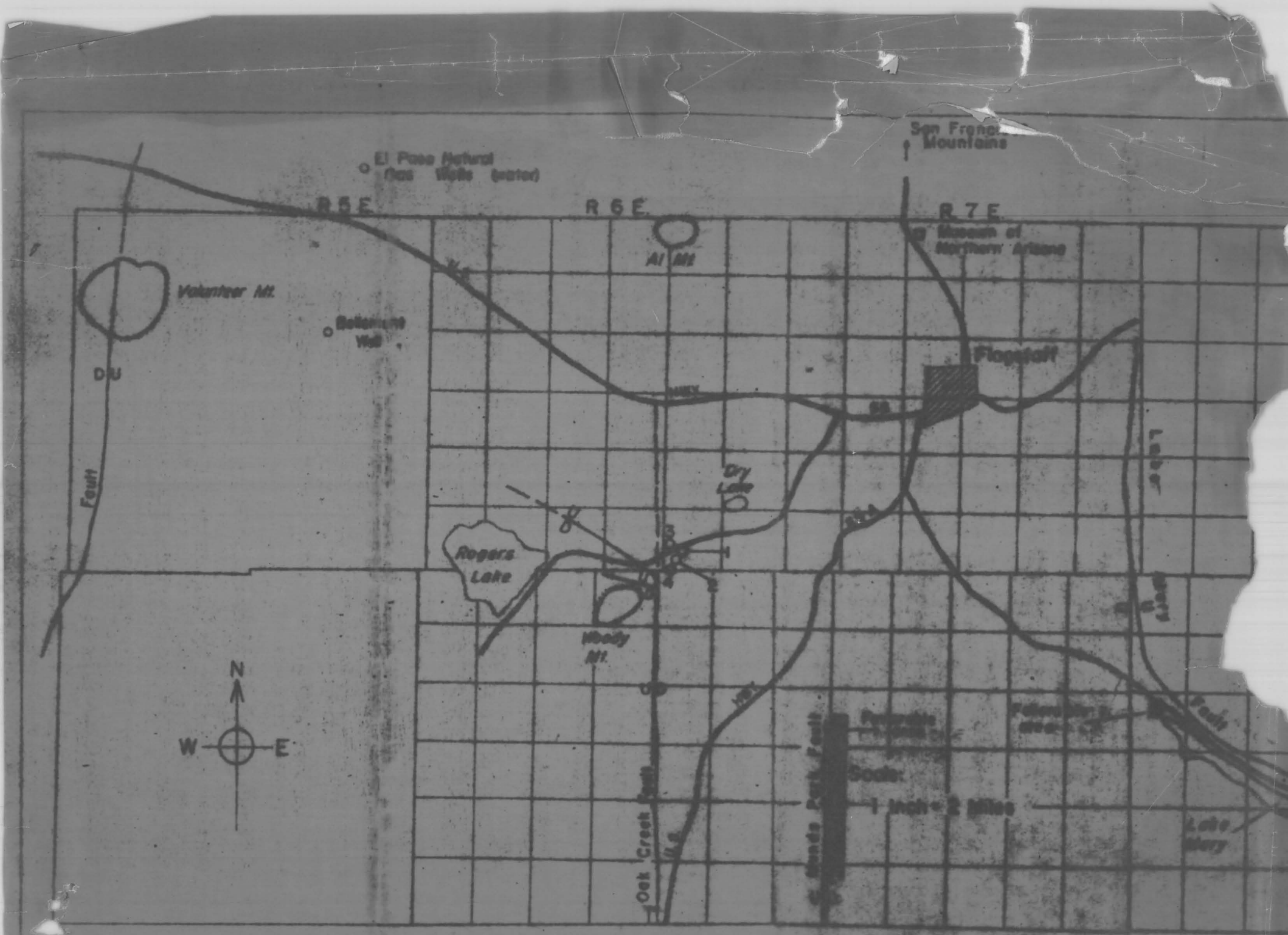
Mr. C. T. Pulliam
City Manager
City of Flagstaff
Flagstaff, Arizona

Dear Mr. Pulliam:

Following the suggestion made by you during our conversation at Flagstaff on June 6, I have prepared this letter outlining the work we have done in the Flagstaff area during the past year and the work we plan to do during this fiscal year (July 1, 1960 to June 30, 1961).

Mr. Akers and his assistants, working out of our Holbrook office, have obtained on-the-spot information about the new wells drilled in the Flagstaff area. This information and additional geologic work has suggested two areas similar to the Woody Mountain area that might be favorable for deep well development. You will recall that Mr. Harshbarger explained to you the relation of the Oak Creek fault on the east side of Woody Mountain to the ground water found in the Coconino sandstone in your Woody Mountain well field. The fracturing in the broad fault zone makes the sandstone much more permeable than it is in undisturbed areas, therefore wells in the fractured zone produce more water than wells in other parts of the formation. Also fracturing at the present land surface facilitates recharge to the aquifer especially on the downthrown side of the fault. On the enclosed sketch map the two cross-hatched areas on the downthrown sides of the Lake Mary fault and the Munds Park fault appear to be similarly favorable areas for deep well development. Thick layers of lava are not present in these two areas as they are in the Woody Mountain field and drilling costs would be much less. The area near the Lake Mary fault has the added advantage to the city in being located near the water main from Lake Mary to the city. I am sure you'll be glad to know about these areas as possible future sources of water supply even though it may not be possible to prospect them with test wells at the present time.

Mr. Akers has made preliminary studies in the inner basin of the San Francisco Mountains and I accompanied him on the last trip. We agree with Mr. Baird that there is much ground water in storage in the glacial materials of the basin. How best to develop the ground water will not be apparent until the glacial materials and the springs have been



Sketch map showing location of Flagstaff, major faults, and areas favorable for gas drilling

FLAGSTAFF WATER DEPARTMENT
RECORD OF WATER PRODUCED AND CONSUMED

	Inflow Springs	Pumped Lakes	Pumped Wells	Total Pro Produced	Total Consumed	Cost per Thousand
1958 (21.24"P	388,321,178	200,825,000	31,903,000	621,049,178	577,935,743	35¢
1959 (21.46"P	98,320,237	518,743,000	16,034,100	638,614,860	657,725,102	75¢
1960	178,444,497	568,728,000	89,931,000	837,103,600	784,309,750	44¢
1961	115,055,080	527,433,000	126,483,700	768,971,780	780,282,400	49¢
1962	290,283,000	496,114,000	68,383,900	854,761,649	875,169,659	50¢
1963	38,552,724	542,014,000	373,286,100	953,852,824	926,290,449	49¢
1964	111,511,889	424,807,000	385,870,800	922,189,689	942,895,879	52¢
1965	379,415,134	558,353,000	95,005,800	1,032,773,934	1,018,623,141	59¢

The above cost figures are based on the gallonage produced and using the total expenditures, including debt service and capital expenditures. If you considered capital improvements as a business does calculating the cost, but they depreciate and write off a portion each year based on the estimated life of the improvement. So this reflects a higher figure per gallon than if the municipalities used business accounting principles.

The cost of the electricity at the Woody Mountain Wells for pumping per 1,000 gallons is 26.9¢. It is estimated that including salaries and repairs there would be an additional $18,000 charged to the operation of the wells each year. This would make a total cost of 33.8¢ per thousand.

1966-67.
Rec'd by City Council
April 11

February 3, 1966

MEMO TO: Water Use and Utilization Commission

RE: Proposed Water Projects

A meeting was held at 9:00 A.M., February 3, with Mr. Dunnam, Rawlinson, Woltersdorf, McGavock, Barney, and City Manager Field, to discuss and make recommendations to the Water Use and Utilization Commission regarding the City's water program.

1. Inner Basin

Don Woltersdorf reported that the Bureau of Reclamation would drill at least three test holes in the Inner Basin in the vicinity of Jack Spring, Snow Slide, and Doyle Canyon, where seismograph studies have been made previously. This work will be done in August of 1966.

From these studies the Astrogeological Center will also make additional seismograph tests which may necessitate the drilling of additional test holes. Upon the completion of these studies recommendations will be made to the Water Use and Utilization Commission. The cost of this work will be borne by the Bureau of Reclamation and the U.S.G.S.

2. Completion of Tunnel

It was the opinion of those present at this meeting that the completion of the tunnel started by the City in 1963 be held in abeyance pending the results of the information gained by the seismograph test and test holes. It may be that a test well should be drilled at the tunnel site in order to determine if the project should be completed.

At present the tunnel is 75 feet in depth.

3. Replacement of Flow Lines

The replacement of flow lines from the Inner Basin to the City's reservoirs was discussed and it was felt that due to the absence of specific cost and benefits to be derived that studies of this project should be continued for a future consideration. This requirement will also be considered in the Bureau of Reclamation studies scheduled for completion in October, 1967. Rough estimate would be approximately $1,000,000.

4. Shultz Pass - Reservoir

Don Woltersdorf would take the need and development of possibilities into consideration during studies to be completed after October, 1967. Soil and topographic conditions might cause the cost of the project to exceed its worth. However, it was felt that consideration should be given to the possibility of this project in the future.

5. Water Shed Roof

The roofing or guniting of specific areas in the Inner Basin was discussed.

In view of the limited amount of pipe line capacity and reservoir storage it does not seem feasible at this time to pursue studies on this matter.

As the Commission knows, large quantities of water must be dumped by the City due to lack of storage capacity in the present City reservoirs. Water is also dumped due to lack of pipe line capacity and murky conditions.

6. Extension of Additional Flow Lines in the Inner Basin - Shultz Pass

It was felt that the greatest benefit to the City in collection of water would be through the repair and replacement of catch basins at the upper end of Shultz Pass. This would take approximately 4,000 feet of pipe and would cost approximately $12,000 to $16,000.

Mr. Beard was not able to attend the meeting, therefore, it was estimated that approximately 7,000 feet of pipe should be laid in the Inner Basin area. Estimated cost $21,000 to $28,000.

Total recommended work for 1966-67 would be $33,000 to $44,000 which should be budgeted for the fiscal year.

7. Walnut Canyon Dam

Damming of Walnut Canyon will be given consideration during studies to be completed by the Bureau of Reclamation after October, 1967.

A letter to the Phoenix, Cement Company, written after the last Water Use and Utilization Commission meeting, concerning the use of Gunite has not been answered to date. It was felt that a flexible lining instead of a rigid type cement or Gunite type lining would be better under the conditions. It was also brought out that the present crevices would have to be filled to provide adequate support for any type of lining material.

It was the consensus that the cost probably would out-weigh any additional water supply received. However, this should be a project which bears study by the City in the future.

8. Woody Mountain Well Fields

Upon completion of the present contract the Woody Mountain Well Field there will be six producing wells. To increase the number would give greater production but over a shorter period of time. It was felt that the six wells would produce 3,000,000+ gallons a day for an unlimited period of time, whereas eight or ten wells might cause the field to be useable only for specified periods.

9. Lake Mary Well Field

It was stated that Lake Mary Well Field, which ultimately should have eight wells would produce approximately 3,000,000 gallons of water per day on a sustained basis. This takes into consideration that Well No. 1 and Well No. 3 may be of little value to the water system, however, could be used during peak needs.

Therefore, in the field of well drilling the City should be considering the drilling of Well No. 4 just south of the new pumping station located in Lower Lake Mary. It is estimated that the cost would be approximately $175,000 which would include tying into the 36" water line.

It is assumed that the wells in the Lake Mary area would only be used when lake storage would not furnish the necessary water supply.

10. Anderson Mesa

Don Woltersdorf advised that he would schedule the Anderson Mesa for study but that no definite date had been set.

11. Lake Mary Water Shed

The Commission recommended and the Council approved the participation of the City with the U.S.F.S. in the use of Neighborhood Youth Corps personnel in a program to clear the water shed to start on or about June 1, 1966. The cost of this project would be about $10,000.

12. Evaporation and Seepage Study

Woltersdorf felt and McGavock concurred that an Evaporation and Seepage Study of Upper Lake Mary might prove beneficial to the City.

This would require the measuring of the in-flow at each inlet (canyon) into the Lake. The equipment and manpower on this program might be available under the present agreement that the City has with the U.S.G.S. The results of studies might disclose that the City should take action on the lining of a portion of the Lake Mary due to loss of water.

It is suggested that a letter be written requesting that this study be scheduled in the future by the U.S.G.S. under terms of the present agreement. A similar study is being made in Williams by the U.S.G.S.

13. Wilkens Dam and Reservoir

Don Woltersdorf advised that the Bureau of Reclamation was presently studying the diversion of water from Wilkens Dam and reservoir on Clear Creek in the southern part of Coconino County to the City of Flagstaff and the City of Williams. This system would develop unappropriated water supplies of the Little Colorado River.

In view of the benefits to be derived from fish and wildlife, funds from these sources might be available to assist in this program. This study will be completed with recommendations in October, 1967. It would yield a total of about 19,500 acre feet per year, of which Flagstaff would receive 14,000 acre feet per year in town based on its population in the year of 2020.

This project would entail the approval of Congress, therefore, could take some time for approval if the study proves it is feasible.

The meeting with the U.S.G.S. and Bureau of Reclamation ended and the review of the Yost and Gardner 1961 Report was made.

14. Repair, Replacement, and Extensions to Existing Water Mains.

A. Installation of an 8" main a distance of 700 feet to complete the circuit between Hereford Drive and Talkington Drive on Meade Lane. Estimated cost $6,600.

B. Replacement of 2,000 feet of 4" pipe to increase water pressure north of Cedar Avenue between Mesa Drive and Beaver Street. Estimated cost $8,800.

C. Replacement of 2,525 feet of 4" mains connecting Maple Avenue with Sixth Avenue, East Street and Center Street, to provide increased water pressure.
Estimated cost $11,000.

D. Replacement and tie in of 6" line between Izabel and Fourth Street on Dortha to increase water pressure and eliminate dead ends. Estimated cost $13,300.

E. Removing and replacing the 4" water line on U.S. 89 South with 8" main between Frisco Hills and the Southwest Forest Industries Railroad. Estimated cost $10,000. This work should be accomplished on or about May, 1966. In connection with Interstate 40 construction. A portion of the cost will be borne by the Highway Department. (This portion has been excluded from the cost estimate.)

F. Extension of a 10" main on Butler Avenue from Babbitt's Wholesale Warehouse to Elden Street in order to increase water pressure and circuit in the Elden Street area. 3,650 feet of 10" pipe including fire hydrants $24,000. This extension goes through a portion of property which is outside the City limits. Reduce price to 1/3 through developer's participation.
Estimated cost $8,000.

G. 3,000 feet of 8" pipe, including fire protection on Industrial Road from the 16" main (across from the Museum Club, to the east side of Harenberg's office building).
Estimated cost $15,000. The City Council permitted Harenberg a temporary 2" tap on the north side of U.S. 66 in the vicinity of U.S. 89 - 66. However Harenberg agreed that he would participate, in the event water service was not extended by the City, in an Improvement District or lay at his expense a water main to serve his area within a period of five years from November 8, 1961. No City participation is planned.

15. Total requirements for work under Paras. 6, 11, and 14:

a.	Mountain Work	$ 44,000
b.	Lake Mary Water Shed	10,000
c.	Hereford Drive	6,600
d.	Mesa Drive	8,800
e.	Maple	11,000
f.	Izabel	13,300
g.	U.S. 89 South	10,000
h.	Butler Avenue	8,000
		$111,700

16. A. Work deleted from the 1961 Program due to lack of funds.

(1) 5,100 feet, 12" CI main on Izabel between Felice to Arrowhead.
Cost $40,800.

(2) 8,000 feet, 12" CI main, on Arrowhead west along south line McMillan Mesa, south to Quarry Canyon across U.S. 66 and Railroad to tie in with 27". Bore under U.S. 66 and Railroad. Cost $80,000. If we participate with the developer reduce to 1/3,
Cost $26,500.

(3) 3,100 feet, 12" CI main, on U.S. 66 from Blackbird Roost, on Milton Road on Phoenix Avenue to South Humphrey to tie in with existing 12".
Cost $24,800.

(4) 3,700feet, 12", CI main, on Seventh Avenue between Fourth Street and Steves Boulevard to 16" main south of U.S. 66 and Railroad. Bore under Railroad and Highway. Cost $45,600. If we participate with the developer 1/3. Cost $25,800. (City pay boring).

(5) 4,000 feet , 12" main on Birch and Bertrand into 16" in Switzer Canyon. Cost $32,000. 1,000 feet is on Switzer Canyon development, therefore, if we participate with developer 1/3 could reduce $32,000 by $5,300 for a cost of $26,700.

(6) 1,700 feet, 8", CI main on Columbus from North San Francisco to Turquoise. (Ties in with 6" main on Columbus and 16" main in Switzer Canyon). May be installed be developers. Cost $9,775.

(7) 9,000 feet, 8" CI mains, Elden Street, Agassiz, Verde etc. area, to increase pressure. Cost $51,750.

(8) 5,000 feet, 8" CI main on Thorpe Road (Park) from Santa Fe to Marshall School. Increase pressure. Cost $28,750.

(9) 3,000 feet, 6" CI main (for Fire purposes) and fire hydrants. Circle Pine Park Manor to Greenlaw 1-2, off 12" main on east side. Cost $15,000. (Area is presently in high rated fire district).

(10) 36 fire hydrants, various areas. Cost $10,800.

B. Total work deleted 1961 program $339,275. Population 20,000.

17. A. Work deleted from 1965 Program due to lack of funds.

(1) Water Plant expansion requires $300,000 to complete. (Must be available before May, 1966. Is a part of present contract with Del Webb).

(2) 106 fire hydrants various locations. Cost $31,800.

(3) Woody Mountain Well #6 - completion of electrical, pipe line, pump house, and pump. Cost $87,500. (Must be available by January, 1967.)

(4) a. 30,200 feet, 12" CI main and in different pressure zone to serve McMillan Mesa, areas north, and north east thereof, and Switzer Canyon. Cost $241,600.

b. 19,300 feet, 8" CI mains tie in with 12" in different pressure zone. Cost $110,975.

c. 10,000 feet, 8" CI main tie in with 12", and 8" to serve upper Greenlaw 6 and 7. Cost $57,500.

d. 5,200 feet, 8" CI main toe in with pressure zone on McMillan Heights.

e. 9,200 feet, 8" CI main vicinity of Museum of Northern Arizona. Lower zone. Cost $53,000. (Outside City limits.)

B. Total work deleted from 1965 Program (7.35 MGD), $695,675. Population 27,500.

18. Program for 1970 - (10.2 MGD) $1,266,000. Population 34,000.

19. Program for 1975 - (12.5 MGD) $1,117,000. Population 41,500.

20. Program for 1980 - (14.7 MGD) $907,000. Population 48,000.

21 Program for 1985 - (17.0 MGD) $537,000 Population 56,500.

22. On or about March 15, 1966, the City will sell $300,000 in bonds to complete the Water Plant expansion project. This will leave bonding ability at zero until old bonds are paid off, or there is an increase in profits.

23. Suggest the following as priority:

U.S. 89 South (Para. 14E.)	$ 10,000	
Mountain Work (Para. 6)	44,000	
Lake Mary Water Shed (Para. 11)	10,000	
Mesa Drive (Para. 14B)	8,800	
Maple (Para 14C.)	11,000	
Birch-Bertrand	26,700	(Developer participate)
Pine Park Manor (Para 16A. (9))	15,000	
Water Plant (Para. 17A (1))	300,000	
Woody Mountain Well #6 (Para. 17A (3)	87,500	
TOTAL REQUIREMENTS	513,000	

Source of Funding:

Bond Issue	$300,000
*Water Revenues	113,000
Sales Tax	100,000
	$513,000

*If not available hold completion of Woody Mountain Well No. 6.

All Price estimates are from Yost and Gardner 1961 Report.

H. L. Field, Jr.
City Manager

March 2, 1966

TO: Mr. Harry Field
City Manager

RE: Proposed Water Projects

The meeting on February 3, 1966, regarding proposed water projects, came to my attention too late to attend and was sorry to have missed it. However, I did get a copy of your letter to the Water Use and Utilization Commission from Mr. Rawlinson and I would like to make a few comments on some of the subjects.

First on Item #1, Inner Basin. I was pleased to know that the U.S.G.S. was going to help in investigation and help on the drilling. I think they will come up with the answer to more water. The seismograph survey work done in the Inner Basin did not cover all of the areas that I thought it should, but with their present grids they will probably be able to determine other areas needed.

Item #2, Completion of Tunnel. With the large snow packs in the Aubineau Canyon this year, it may be we can determine where this underground stream flows. I hope to investigate the tunnel area this summer, as I will have ample time to be in the area during the peak flow period. The existing tunnel excavation should be a big help.

Item #3, Replacement of Flow Lines. Here again I agree that the project is too costly, when we don't have developed water to utilize a larger line. However, there are some restrictive bottlenecks in the flow line that can be removed or re-aligned at a very nominal cost. I would like to discuss this with the City Engineer at an early date and get his opinion.

Items #4 and #5, I will agree, need more study.

Item #6, Extension of Additional Flow Lines in the Inner Basin - Shultz Pass. One flow line needing reconstruction in the Inner Basin, is the Dunnam Canyon line. This canyon produced a good amount of water during the time it was in operation, but last year during a flash run off we lost about 1,000 feet of upper line. At the time of construction we had no steel pipe on hand and the line was laid with reject vitrified clay pipe. We need 1,000 feet of 10" steel pipe and about $1,500 for labor and equipment to put this canyon back in production.

Item #6 cont.

Another project needed in the Inner Basin is to install a new larger flow line from Weir #1 to a junction box sump. This would require a 16" line of 600 feet. At present there are two old 8" lines handling the entire flow, both are rusting out and one by passes though a tunnel, where it may be losing considerable water.

In Shultz Canyon area we need a flow line extension of 4,000 feet to connect Weatherford Canyon with the main flow line and about 1,000 feet to take in Powers Draw.

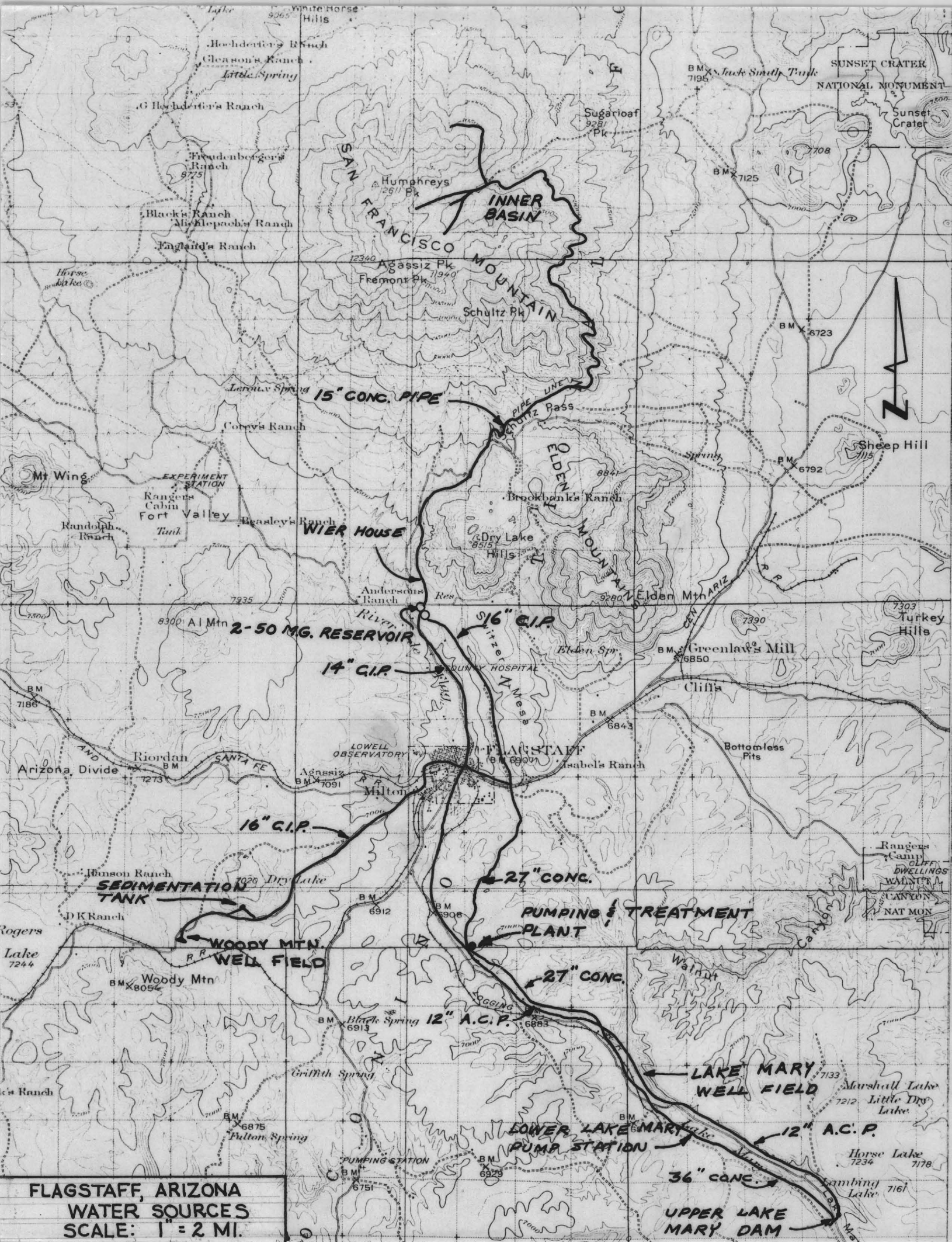
The six water development projects completed in Shultz Pass in the past few years are in need of some improvements and this work should be done this year, if possible. The work needed here consists of adding more rock to the filters. At the times of construction, the City had no rock truck and all of these projects were shorted. This work should not cost much and will improve the water pick-ups considerably.

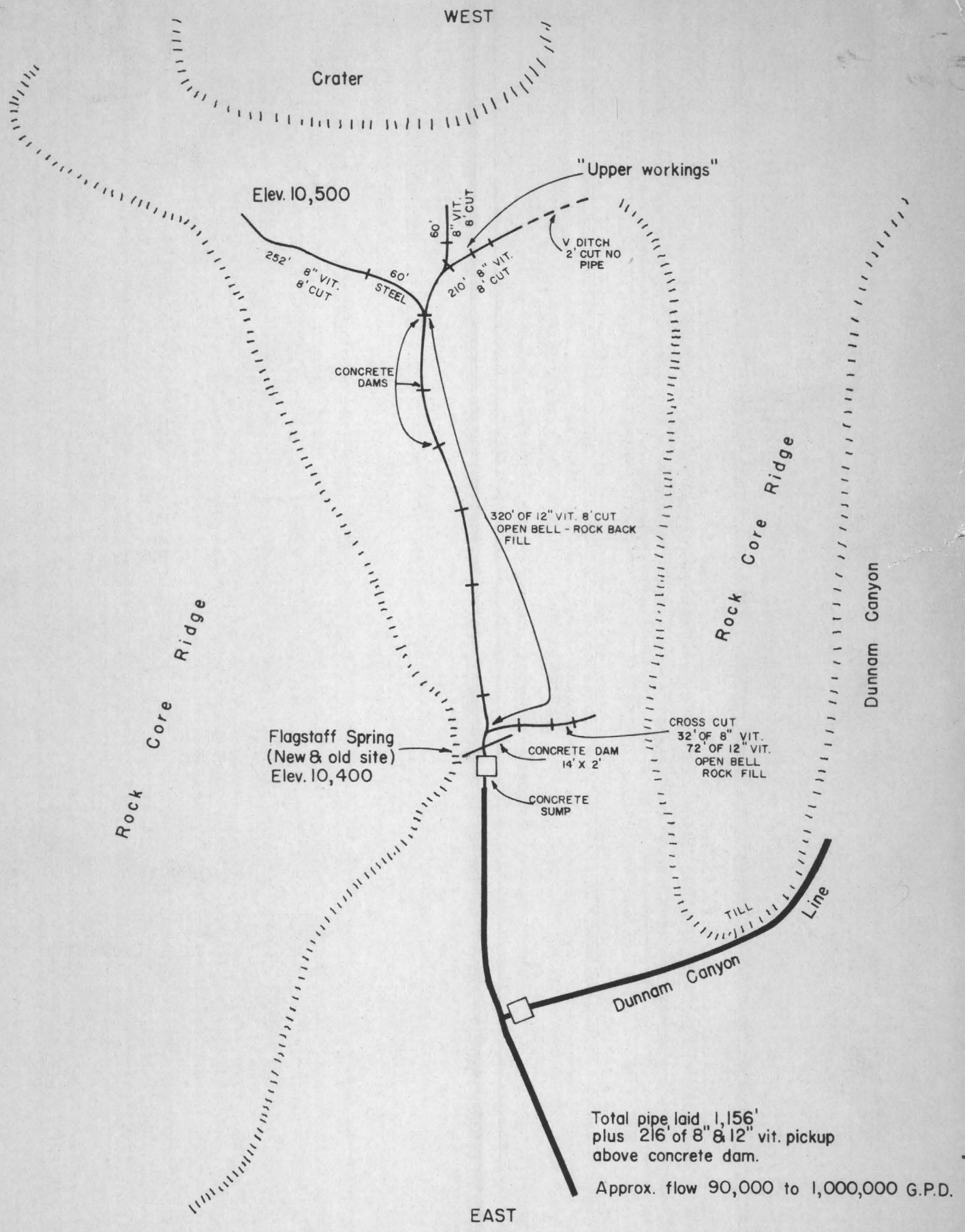
Your budget request estimates seem very good to me and if the request is approved I will be glad to work up the individual jobs for permits.

Very truly yours,

James D. Beard

James D. Beard


SAN FRANCISCO MOUNTAIN
INNER BASIN
Humphreys Pk
Agassiz Pk
Fremont Pk
Schultz Pk
Sugarloaf Pk
SUNSET CRATER NATIONAL MONUMENT
Sunset Crater
Jack Smith Tank
White Horse Hills
Hochderffer's Ranch
Gleason's Ranch
Little Spring
G Hochderffer's Ranch
Freudenberger's Ranch
Black's Ranch
Michelpach's Ranch
England's Ranch
Horse Lake
Leroux Spring
15" CONC. PIPE
PIPE LINE
Schultz Pass
Corry's Ranch
Mt Wing
EXPERIMENT STATION
Rangers Cabin
Fort Valley
Beasley's Ranch
Randolph Ranch
Tank
WIER HOUSE
Brookbank's Ranch
Dry Lake Hills
ELDEN MOUNTAIN
Elden Mtn
Sheep Hill
Spring
Andersons Ranch
Res
Riordan
Arizona Divide
SANTA FE
AND
R R
Agassiz
Milton
LOWELL OBSERVATORY
FLAGSTAFF
Isabel's Ranch
Bottomless Pits
Cliffs
Greenlaw's Mill
Turkey Hills
Elden Spr
COUNTY HOSPITAL
Fletcher Mesa
Al Mtn
2-50 M.G. RESERVOIR
16" C.I.P.
14" C.I.P.
16" C.I.P.
27" CONC.
PUMPING & TREATMENT PLANT
SEDIMENTATION TANK
Hunson Ranch
Dry Lake
D K Ranch
Rogers Lake
WOODY MTN. WELL FIELD
Woody Mtn
Black Spring
12" A.C.P.
27" CONC.
LAKE MARY WELL FIELD
Griffith Spring
Fulton Spring
PUMPING STATION
LOWER LAKE MARY PUMP STATION
12" A.C.P.
36" CONC.
UPPER LAKE MARY DAM
Marshall Lake
Little Dry Lake
Horse Lake
Lumbing Lake
Walnut Canyon
Rangers Camp
CLIFF DWELLINGS
WALNUT CANYON NAT MON
FLAGSTAFF, ARIZONA
WATER SOURCES
SCALE: 1" = 2 MI.

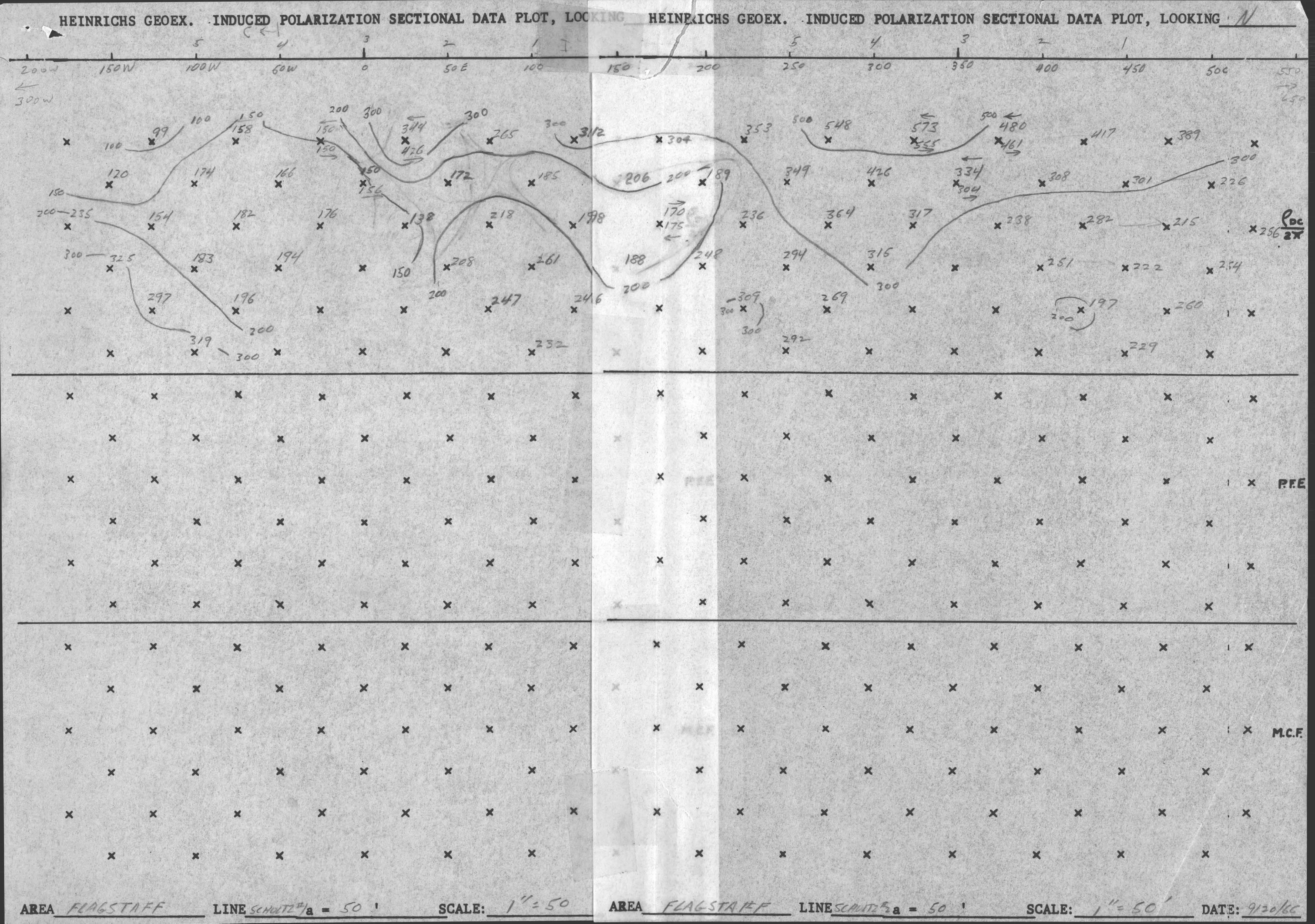


FLAGSTAFF SPRING RE-DEVELOPMENT, COMPLETED SEPT. 1960

Drawn James D. Beard
Traced Ron Werhan

HEINRICHS GEOEX. INDUCED POLARIZATION SECTIONAL DATA PLOT, LOOKING

HEINRICHS GEOEX. INDUCED POLARIZATION SECTIONAL DATA PLOT, LOOKING N



AREA FLAGSTAFF LINE SCHULTZ II a = 50 ' SCALE: 1" = 50'

AREA FLAGSTAFF LINE SCHULTZ II a = 50 ' SCALE: 1" = 50' DATE: 9/20/66

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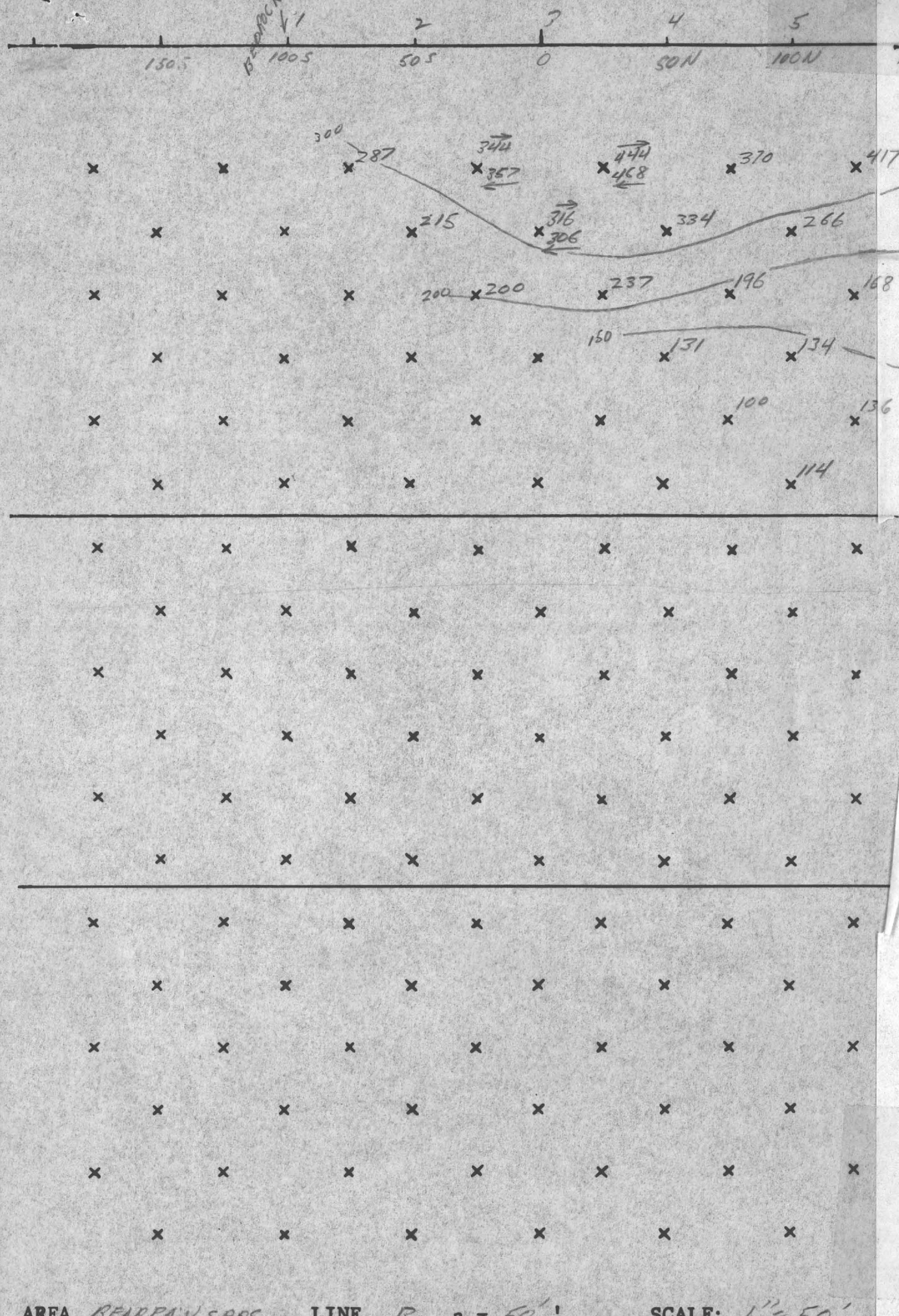

AREA BEARPAW SPRS LINE B a = 50' SCALE: 1"=50'

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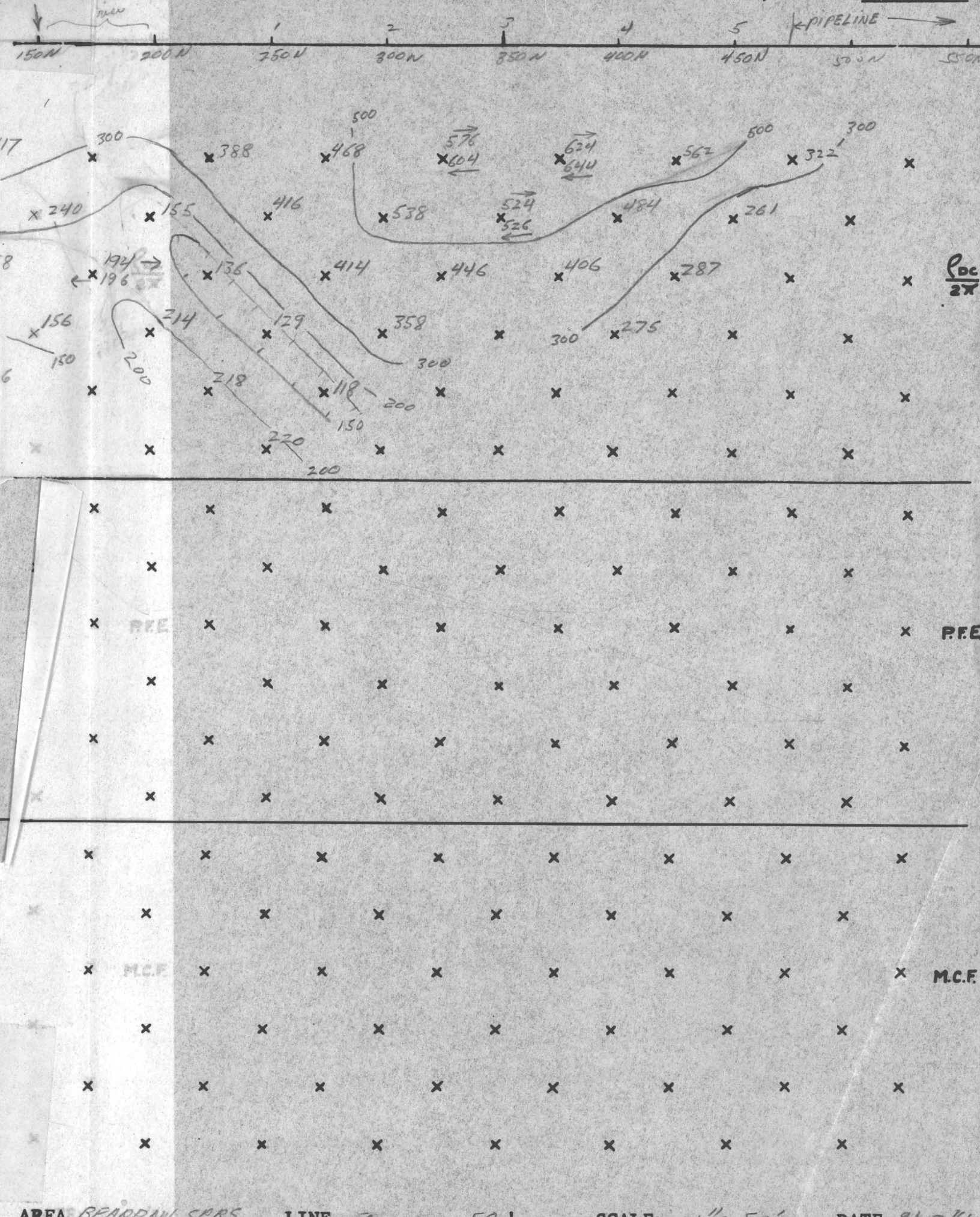


AREA BEARPAW SPRS. LINE A a = 50' SCALE: 1"=50' DATE: 9/23/66

HEINRICHS GEOEXPLORATION COMPANY

806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

August 12, 1966

City of Flagstaff
P. O. Box 1208
Flagstaff, Arizona 86002

Attn: Mr. R. G. Barney, City Engineer & Dr. of Public Works
Mr. Frank M. Findlay, Water/Sewer Engineer

Re: Weatherford Canyon Project
Shultz Pass Water Development

Gentlemen:

We are in receipt of Mr. Findlay's letter of 4 August 1966 and attachment of memo dated 22 July 1966 from Mr. James D. Beard.

Certainly we could run a 600 ft. resistivity profile along the ditch, or rather in the ditch, as proposed in three days including travel time Tucson to Tucson. However, at the risk of possibly second guessing, we are somewhat perplexed at the applicability or possibly, we probably do not fully understand exactly what has been accomplished so far. In other words, what is presently known, what is unknown, and exactly what objectives are intended. For example, it would be most helpful to us if we could be explained the nature of the geophone evidence of numerous small streams of water coursing through the gravel under your deepest cuts.

As an alternate possibility, would a few exploratory slim hole well points testing for the possible water under-flow be at all feasible? Whatever is decided, we would certainly like to feel that there was a reasonable chance that a worthwhile contribution could be made to your problem. Toward this end, we are wondering if it is not too involved to do so, that we be furnished with further details, including such information as maps, sketches, sections, photos, etc.

Meanwhile, we are enclosing a little bit of our literature including some pertinent cost information as requested.

Faithfully,
HEINRICHS GEOEXPLORATION COMPANY

Walter E. Heinrichs, Jr.
President & General Manager

WEH:jh
Enclosures

RESISTIVITY SURVEY OF SCHULTZ PASS TRENCH

AND

BEARPAW SPRINGS AREA

For

City of Flagstaff

September 1966

By

Heinrichs Geoexploration Company
P. O. Box 5671 Tucson, Arizona
85703

TABLE OF CONTENTS

INTRODUCTION

At the request of Mr. Frank Findlay, Flagstaff City Water Engineer, and for the City of Flagstaff, Heinrichs Geoexploration Company of Tucson, Arizona, conducted and completed resistivity surveys in the Schultz Pass and Bearpaw Springs areas of the San Francisco Peaks, Coconino County, Arizona during the period of September 20 through September 22, 1966.

The field work consisted of two lines of two dipole-dipole spreads each for a total of 1650 feet of surface coverage and 1250 feet of subsurface plotted data. Included are sketch maps showing the relation of the resistivity lines to the trenches in the Bearpaw and Schultz Pass Areas.

The data are presented on sectional data sheets showing resistivity as rho/2 pi. The field work was carried out by a Geoex crew comprised of John McLean, Hydrologist, and Rex Montierth, sender operator. Interpretation and compilation was conducted by the Tucson Geoex staff.

CONCLUSIONS AND RECOMMENDATIONS

Schultz Pass

The area lying west of the center of spread 1 (0 E-W) has the highest probability of producing water with the area from 50'E to 200'E of secondary importance. It is recommended that the existing trench be deepened and drain tile installed from bedrock on the west to at least 250'E of the center of spread 1 (0 E-W). Some slight water production may be possible from the area east of 250'E from permeable zones too small to accurately define with this method.

Bearpaw Springs

If the pipeline is extended south of its present terminus, there is a possibility of cutting some perched water-bearing zones in the outwash. South of 150N, however, it is unlikely that any major sources of water will be intercepted.

INTERPRETATION

Schultz Pass Line

In general, this line shows a gradation from a low resistivity zone on the west to a shallow high resistivity zone on the east.

On the west, a shallow zone believed to represent surface soils with a high moisture content overlies a deeper zone of intermediate resistivity immediately to the east. Lying between 250'W and the center of spread 1 (0 E-W) is a low resistivity zone believed to represent a zone of higher water content, the shallowest portion of which lies in the region of 50'W. To the east of this zone is a deeper zone of intermediate resistivity extending from 50'E to 200'E. The eastern end of the line shows a shallow high resistivity zone from 250'E to 350'E, probably due to dry surface soil. The easternmost end of the line shows a shallow, approximately 25 feet, alluvial zone overlying a higher resistivity zone of coluvium and bedrock.

Bearpaw Springs Line

This line shows in general a low resistivity bedrock overlain by higher resistivity alluvium, interrupted near 150'N by a steeply dipping low resistivity zone.

The southern portion of the line shows a shallow zone of intermediate resistivity between 100'S (the side of the ridge) and 150'N. The steeply dipping discontinuity lying at 150'N may define a buried ridge. The shallow, high resistivity zone lying between 300'N and 450'N represents the coarse outwash sand overlying the silt layers noted in the trench. This formation appears to continue to dip southward until broken by the low resistivity zone between 150'N and 200'N.

Since there was no water production data available with which to correlate our survey, it makes the interpretation somewhat uncertain in that water bearing horizons can be high or low in resistivity. After more production data is available, the interpretation can be revised, also refining any future interpretations.

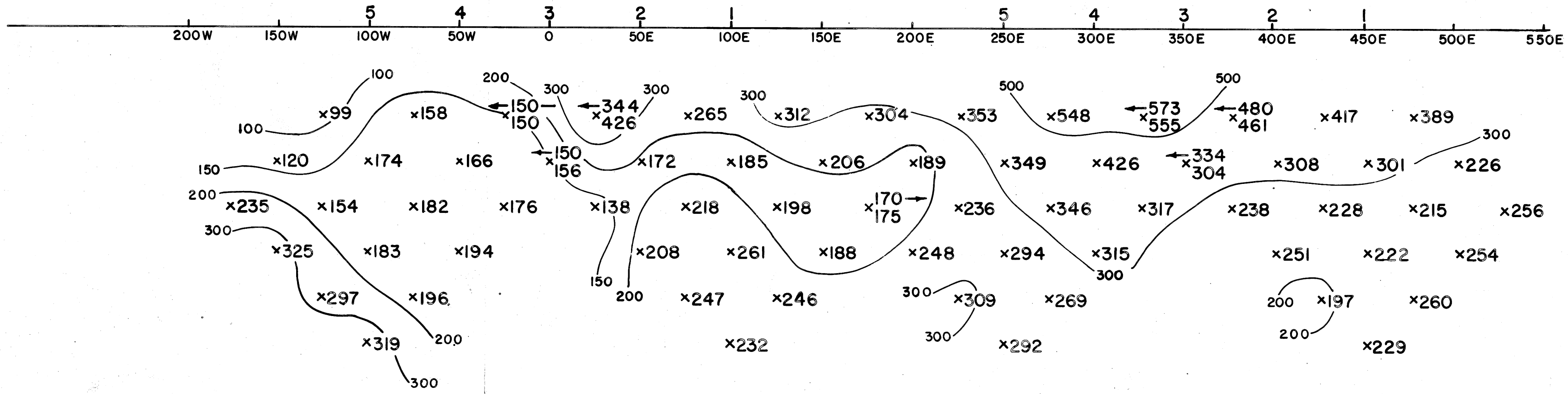
Respectfully submitted,

HEINRICHS GEOEXPLORATION COMPANY

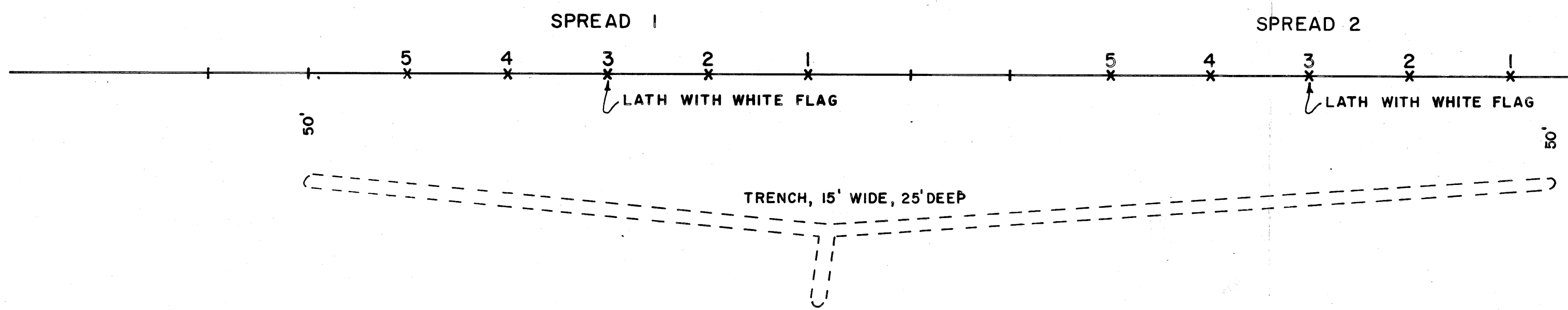
John S. McLean
Hydrologist

APPROVED: _____
E. Grover Heinrichs
Vice President

RESISTIVITY CROSS SECTION



PLAN

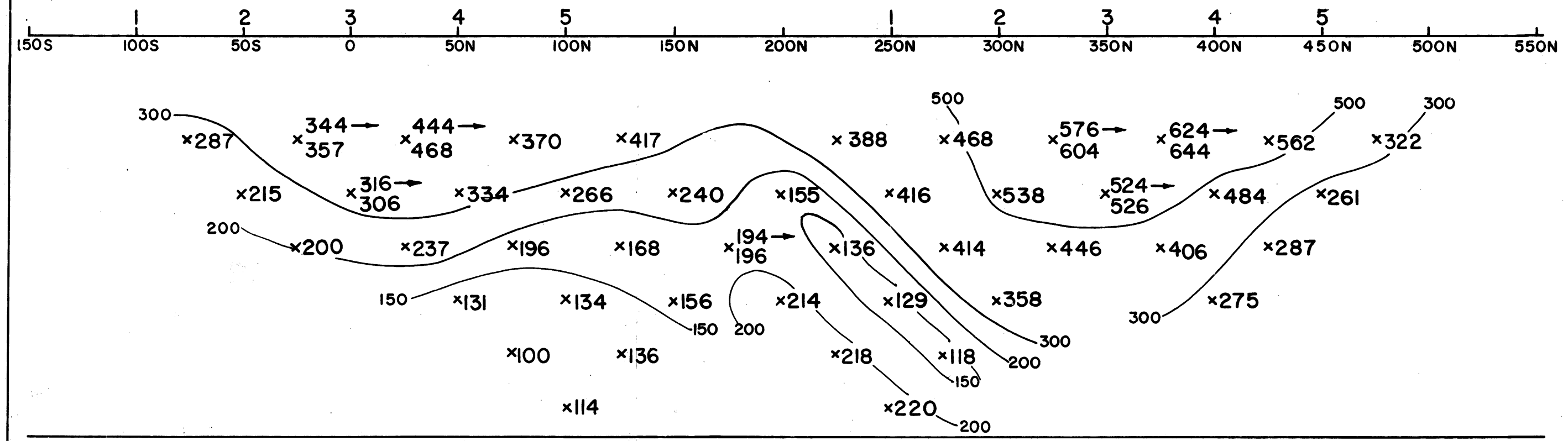


HEINRICHS GEOEXPLORATION CO.
GEOPHYSICAL ENGINEERS
POST OFFICE BOX 5671. TUCSON, ARIZONA. 85703

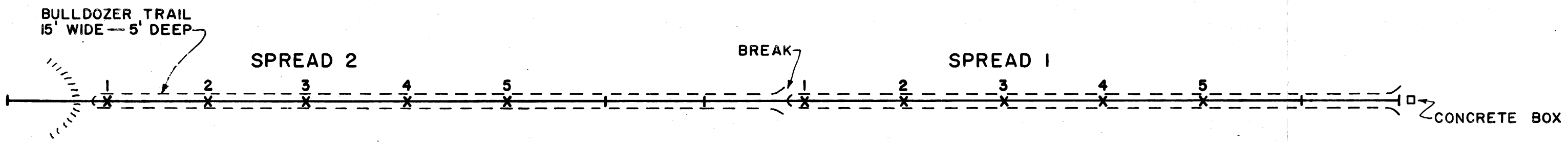
RESISTIVITY SURVEY
SCHULTZ PASS AREA
FOR
CITY OF FLAGSTAFF
COCONINO COUNTY

Scale 1" = 50' | Date : SEPT. 1966

RESISTIVITY CROSS SECTION



PLAN



HEINRICHS GEOEXPLORATION CO.
GEOPHYSICAL ENGINEERS
POST OFFICE BOX 5671. TUCSON, ARIZONA. 85703

RESISTIVITY SURVEY
BEARPAW SPRINGS AREA

FOR

CITY OF FLAGSTAFF
COCONINO COUNTY

Scale 1" = 50' | Date SEPT. 1966

CITY OF FLAGSTAFF

P. O. BOX 1208 • FLAGSTAFF, ARIZONA 86002

August 4, 1966

Mr. Walter Heinrichs
Geoexploration Co.
808 W. Grant Road
Tucson, Arizona

Dear Mr. Heinrichs:

Mr. Ed McGavock of the Geological Survey, Water Resources Division, here in Flagstaff, recommended your firm to do some resistivity work for us in our Weatherford Canyon Project as described in the enclosed letter by Mr. Beard.

Jim feels that with the preliminary work he has done with the geophone, you could locate these streams more accurately for us and save the City considerable money on our construction costs.

Ed told me he estimated you could do the job in three (3) days counting travel time from Tucson. The site is about eight (8) miles from Flagstaff over unimproved roads.

We will be able to supply temporary shoring to the protect the probes and your personnel while in the ditch as there is loose material on some of the banks of the ditch.

Will you let us know if you could do the work for us and the cost per day including tavel time?

Please reply at your earliest convenience.

Very truly yours,

R.G. Barney, City Engr. &
Director of Public Works

Frank M. Findlay

By: Frank M. Findlay
Water/Sewer Engineer

FMF:lm

cc: Jim Beard
Ralph Barney
City Manager
Jim Rawlinson

P.A.H.

John Mackey

P.M.

Frank

July 22, 1966

MEMO TO: Harry Field, Jr.

SUBJECT: Shultz Pass Water Development

FROM: James D. Beard

The Shultz Pass Water Development Project, started in Weatherford Canyon, at present consists of a cross canyon ditch approximately 700 feet long by 6 feet wide and between 12 and 14 feet in depth. This exploratory work shows hard material on both ends of the ditch with sand and gravel in the central area.

On July 21, 1966 I made a field survey of the excavation, using a geophone in the ditch bottom, which indicated that there are numerous small streams of water coursing through the gravel under our deepest cuts.

In my experience with similar conditions, it was found necessary to excavate deeper and find the water bearing formations; however, in this area we are up against the cost factor of excavating such a large area and I am sure there is some way we can determine the more or less exact locations of these under ground streams, thereby cutting the amount of exploratory excavations.

My suggestion would be for you to contact Mr. Waltersdorff and also Mr. McGavock of the U.S.G.S. and have them make a site check to see if it is possible with some of their (U.S.G.S.) instruments to pinpoint these underground streams. I am most sure with the probe, wire and battery type machine this could be done.

The present open ditch and the length of prospect area being shortened to less than 600 feet, should make the survey much simpler; then, too, the area is easy accessible and close to town.

This project, in my opinion, can be a big water producer, if properly worked and I think it should be well investigated, and if necessary more funds should be appropriated to do the job right. By this I mean if the geologists agree with my findings, the City should be prepared to get the work done properly almost regardless of cost. This area has a very good and big watershed and should produce more water than one of our deep wells.

Yours truly,

J. D. B. kw

James D. Beard
Water Consultant

JDB/kw
cc. Ralph G. Barney, Frank Findlay
Jim Rawlinson