GL08004

DOE/ET/27005-1

GEOTHERMAL RESERVOIR ASSESSMENT CASE STUDY NORTHERN BASIN AND RANGE PROVINCE LEACH HOT SPRINGS AREA PERSHING COUNTY, NEVADA

FINAL REPORT
FOR THE PERIOD
APRIL, 1979 THROUGH DECEMBER, 1981

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PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
DIVISION OF ENERGY TECHNOLOGY
UNDER CONTRACT DE AC 08-79 ET 27005

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ABSTRACT

Aminoil USA, Inc. has conducted a Geothermal Reservoir Assessment Case Study in the Leach Hot Springs Known Geothermal Resource Area of Pershing County, Nevada. The case study included the drilling of twenty-three temperature gradient wells, a magnetotelluric survey, seismic data acquisition and processing, and the drilling of one exploratory well. Existing data from prior investigations, which included water geochemistry, gravity, photogeologic reports and a hydrothermal alteration study, was also provided to the DOE.

The exploratory well was drilled to total depth of 8565′ with no significant mud losses or other drilling problems. A maximum temperature of 260°F was recorded at total depth. The relatively low temperature and the lack of permeability (as shown by absence of mud loss) indicated that a current, economic geothermal resource had not been located, and the well was subsequently plugged and abandoned. However, the type and extent of rock alteration found implied that an extensive hot water system had existed in this area at an earlier time.

This report is a synopsis of the case study activities and the data obtained from these activities. Detailed data is on file at the University of Utah Research Institute Earth Science Laboratory (UURI/ESL), Salt Lake City, Utah.

INTRODUCTION

During 1979, 1980 and 1981, Aminoil USA, Inc., as Contract Operator under Department of Energy (DOE) Contract Number DE-AC08-79ET27005 and working through Field Operator, Sunoco Energy Development Co. (Sunedco), conducted a Geothermal Reservoir Assessment Case Study in the Grass Valley Area of northwestern Nevada (Figure 1). Specific areas of interest were the Leach Hot Springs Known Geothermal Resource Area (KGRA) and the Panther Canyon Area, both in Pershing County, Nevada (Figure 2).

Before beginning the work planned under this contract, existing surface geological data was provided to the DOE which included:

1. Gravity measurements - approximately 500 stations.
2. Gravity interpretation - approximately 900 stations.
3. A water geochemical survey.
4. A hydrothermal alteration study.
5. A surface photogeological study.

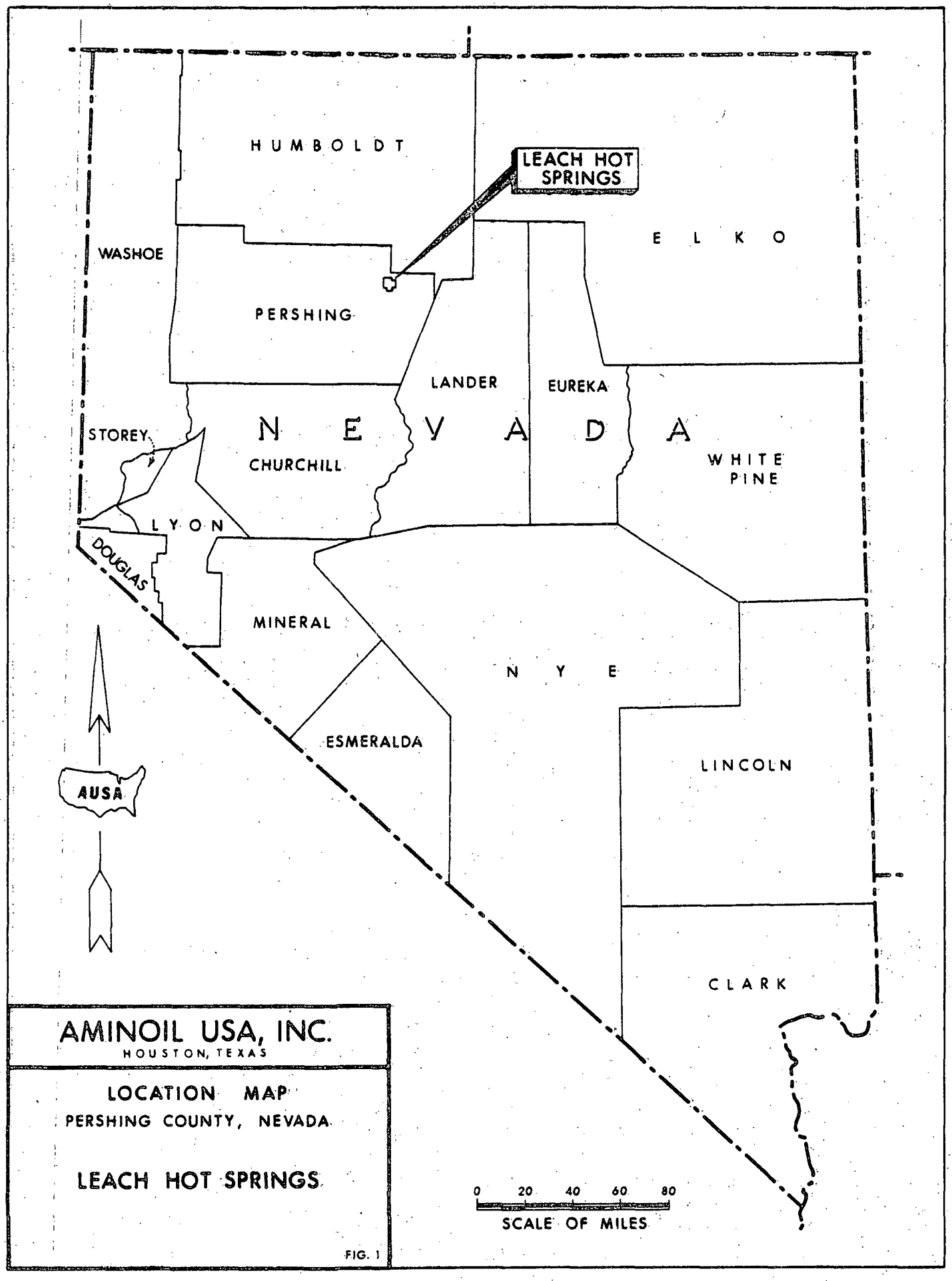
The work performed under this contract was divided into three phases as follows:

Phase I: Drilling and evaluation of sixteen shallow and intermediate depth temperature gradient wells.

Phase II: A magnetotelluric survey covering thirty-nine sites and twenty-seven line miles of seismic data acquisition and evaluation.

Phase III: Drilling and evaluation of the Leach Hot Springs USA 11-36 exploratory geothermal well and seven additional shallow temperature gradient wells.

This report is limited to a discussion of the three contract work phases as outlined above.



AMINOIL USA, INC.
HOUSTON, TEXAS

LOCATION MAP
PERSHING COUNTY, NEVADA

LEACH HOT SPRINGS

FIG. 1

PHASE I

During the period June through September, 1979, thirteen shallow (282′ - 500′) and three intermediate (1,185′ - 1,500′) depth temperature gradient wells were drilled and evaluated in the Grass Valley area of northwestern Nevada.[1] The locations of these wells and of pre-existing temperature gradient wells in the area are shown in Figure 3.

A Gardner - Denver 15 W rig was used to drill the wells with mud used as the circulating medium throughout. Hard drilling and some difficulty with caving were reported for several wells. However, the only problem of any consequence was lost circulation, which resulted in the abandonment of one well at a depth of 80′ (No. S-GV-79-5) and the subsequent drilling of a replacement well 80 yards away (No. S-GV-79-5A). Since lost circulation was a significant problem in only one well and resulted in little additional cost, no recommendations are made for its prevention.

Bottom hole temperatures measured in these wells ranged from 63 to 93°F (17.2 - 33.9°C) for the shallow wells and from 85 to 201°F (29.6 - 94.1°C) for the intermediate depth wells. Calculated heat flow values ranged as follows:

	Range of Heat Flow Values, HFU[2]	
	Maximum Porosity Conditions	Minimum Porosity Conditions
Shallow Wells	.15 - 5.71	.23 - 8.29
Intermediate Wells	1.54 - 9.6	2.09 - 12.9

The heat flow values obtained in this study together with previously published values are also shown in Figure 3. The contours shown confirmed the presence of HFU anamolies (greater than 3 HFU) in both the Leach Hot Springs KGRA and the Panther Canyon Area.

[1]GeothermEx, Inc., 1979, Temperature - Gradient and Heat - Flow Data, Grass Valley, Nevada: Report for Sunoco Energy Development Co., Dallas, Texas.

[2]HFU = heat flow units, 10^{-6} cal/cm^2 - sec. Because all holes penetrated unconsolidated alluvium, water saturated conditions were assumed throughout, and heat flow values were calculated using 20% and 40% as the minimum and maximum porosities expected in this setting.

PHASE II

During April and May, 1979, thirty-nine magnetotelluric (MT) survey sites were occupied by Geotronics Corporation in an attempt to define the potential geothermal source and reservoir in the study area.[3] Survey site locations are shown in Figure 4.

Figures 5 and 6 show the resistivity distribution at $-4{,}000'$ and $-12{,}000'$, respectively, as interpreted from the MT survey. The conductive anamoly shown along the east side of the survey area is interpreted to be a possible heat source, thus enhancing the potential geothermal productivity of the area.

During July, 1979, twenty-seven line miles of seismic data were obtained as shown in Figure 7. This data was utilized to help in selecting the optimum location for the exploratory well, the Leach Hot Springs USA 11-36. The seismic data confirmed that the Eastern Boundary Fault is a major tectonic element in the area and that the area to the east of the Hot Springs fault is seismically anomalous. Data quality of the seismic was insufficient to detail the structural configuration in the Panther Canyon Area.

[3]Geotronics Corporation, 1979, Magnetotelluric Survey of the Leach Hot Springs Area of North Central Nevada: Report for Sunoco Energy Development Co., Dallas, Texas.

PHASE III

Subsequent to the collection and analysis of the data obtained in Phases I and II, the Leach Hot Springs USA 11-36 exploratory geothermal well was spudded on May 15, 1980. Location of the well (Figure 8) was 500 ′ FNL and 500 ′ FWL of Section 36 - Township 32 North -Range 38 East, Pershing County, Nevada.

The USA 11-36 was drilled to a total depth of 8,565 ′ in just over forty-three days. Mud was used as the circulating medium throughout, and no major problems were encountered during drilling. Logging, evaluation, plugging and abandoning required an additional five days, so that operations were completed in forty-eight days on July 2, 1980. Figure 9 shows the drilling time curve and casing program for the well, and Appendix A is the Daily Drilling Log.

The well was drilled through Tertiary alluvium (characterized as variable mixtures of poorly consolidated clay, sand and gravel) from the surface to a depth of 1,340 ′. Some silification was noted in the upper 600 ′. From 1,340 ′ to 2,740 ′, Tertiary mudstone, claystone, sand and gravel were encountered. Tertiary mudstone, claystone, sandstone, siltstone and conglomerate were penetrated from 2,740 ′ to 4,770 ′, with

tuffaceous sandstone, conglomerate and siltstone predominate in the bottom 400'. An abrupt change to tertiary basalt and andesite occurred at 4,770' and continued to 5,010', where a change to silicic tuffs and tuffaceous sediments, claystone, sandstone and conglomerate was noted. An erosional unconformity between Tertiary and Triassic sediments was found at 5,330'. From 5,330' to 7,170', various forms of altered granite were drilled, while from 7,170' to TD, altered and metamorphosed basalt and granite were penetrated.

The maximum recorded temperature in the well was 260°F, reached some 63 hours after circulation had stopped (see Figure 9 for temperature surveys). This low temperature is the primary indication that the well did not locate a current, economic geothermal resource, although the lithological examination (described more fully in Figure 9) indicated that an extensive hot water system had existed in this area at an earlier time. Additionally, there were no significant mud losses during drilling which indicated that the interval penetrated by the well lacked any appreciable permeability. Due to these very discouraging results, the well was plugged and abandoned.

Initial planning for this case study included the drilling of a second exploratory well in the Panther Canyon Area (Figure 2). The disappoin-

ting results of the USA 11-36 well prompted reevaluation of these plans. The decision was made to obtain additional temperature gradient/heat flow data in the Panther Canyon Area in an attempt to determine whether the previously mapped anomaly (Figure 3) justified further exploration efforts.

During the period March through June, 1981, six shallow depth (280′ - 500′) temperature gradient wells were drilled in the Panther Canyon Area.[4] A seventh well (No. S-GV-81-85) planned as a 1,500′ intermediate test was abandoned at 300′ after encountering unresolvable drilling problems while trying to cement off a water zone. The locations of these wells and previously drilled temperature gradient wells are shown in Figure 10.

As during Phase I of this study, a Gardner - Denver 15 W rig was used for drilling. Foam was used as the initial circulating medium in most holes, with a switch to mud as caving/circulation problems dictated. Minor problems were encountered in most wells, but as mentioned above, the only major problem occurred in well No. S-GV-81-85, when drill pipe was cemented in the hole while trying to plug a water flow.

Bottom hole temperatures in these wells ranged from 52 to 80°F (11.2 -26.8°C. Several wells (e.g., Nos. S-GV-81-80, S-GV-81-83 and

S-GV-81-86) had abnormally low bottom hole temperature (52 - 55°F), probably because they did not penetrate below the convective effects of shallow, cool groundwater flowing in the area. The intermediate depth test (No. S-GV-81-85) was designed to eliminate these effects, but unfortunately failed as described above. Calculated heat flow values for these wells ranged from 0.77 to 3.30 heat flow units (10^{-6} cal/cm^2 -sec). These heat flow values, together with previously existing data, are contoured in Figure 10. In summary, an HFU anomaly was confirmed in the Panther Canyon Area, but was judged to be of insufficient size to warrant a deep exploratory test.

These activities concluded the case study under the aforementioned DOE contract.

[4]GeothermEx, Inc., 1981. Temperature-Gradient and Heat-Flow Data, Panther Canyon, Nevada: Report for Sunoco Energy Development Co., Dallas, Texas.

APPENDIX A

DAILY DRILLING LOG

DAILY DRILLING - WORKOVER LOG

LEASE/ WELL USA 11-36 Page 1 SPUDDED May 15, 19 80

ELEVATIONS: GND. _____ BH _____ DF _____ RDB _____

CASING RECORD

PIPE SIZE	HOLE	SEAT	F.C.	CEMENTING DATA: Sacks, Kind, etc.
Conductor:				
Surface:				
Intermed:				
Oil String:				

DATE	DEPTH TODAY	FOOT-AGE	DEGREES OFF DEG.	DEGREES OFF DEPTH	MUD WT	MUD VIS	REMARKS (Activity) (Formation) (D.S.T.) (Coring) (etc.)
5-15	150	150			8.4	58	Rig up, mix mud, rig repairs, drilling to 150'.
5-16	325	175			8.5	45	Survey at 150', drilling, circulate, short trip, wait on Howco and casing crew,
							had three flats on Howco and casing crew truck, rig up to run 20" casing,
							ran three jts. of 20" casing stop, tried to work casing by bridge, POOH
							with casing, stood back and laid down 1 jt., made up 26" bit and TIH
							to 90'.
5-17	325	0			8.5	45	TIH and ream from 80' to 130', circulate and condition mud and wait on stab.,
							POOH, pick up 26" steel stabilizer from 70' to 325', rig up and ran 8 joints of
							20" 94# K55, set 320', circulate and rig up Howco and cement with 800 sacks
							Class G with 3% CaCl, cement in place at 9:45 p.m., waiting on cement.
5-18	325	0	0	150	8.8	57	Waiting on cement, cut off 20" and nipple up 20" hydril, test to 200# on hydril
			0	300			and manifold, pick up bottom hole assembly and TIH to 314', tag cement, drill-
							ing cement and float shoe, circulate and condition mud, POOH to pick up
							stabilizer.
5-19	1585	1260	0	440	9.1	43	Drilling, ream from 1,536' to 1,576', short trip, circulate and survey.
			½	1020			
			½	1267			
			¾	1513			
5-20	2199	614	¾	1764	9.0	37	Drilling, trip for bit, survey.
			¼	2039			
5-21	2634	435	¼	2321	9.0	38	Drilling, survey and short trip.
5-22	2705	71			9.0	40	Drilling to depth of 2,705', circulate, POOH and TIH, clean up run - no fill, rig
							up to run 13 3/8" 61# casing, running 2,700' of 13 3/8" 61# K55 casing, B&W
							shoe on bottom, float collars at 2 jts. above shoe, circulate, prep. to cement job.
5-23	2705	0			9.0	42	Circulate, condition after getting casing to
							bottom, cementing 13 3/8" at 2,701' with 18 bbls. of water ahead followed by 28
							bbls. sepolite flush mixed 1,576 sacks of 1:1 pearlite, 40% SSA-1, .5% CFR-2,
							3% gel, .1% HR7, .25# per sack Flocele, tail cement consisting of 185 sacks
							Class G, 40% SSA-1, .75 CFR2, .1% HR7, 25# per sack of Flocele, displace with
							402 bbls. mud, bumped plug, recover 25% of the 100% excess to surface, cement
							did not fall back, in place at 4:00 a.m., waiting on cement, cut off 13 3/8" cas-

DAILY DRILLING - WORKOVER LOG

LEASE/ WELL USA 11-36 Page 2 SPUDDED May 15, 19 80

ELEVATIONS: GND._____ BH _____ DF _____ RDB_____

CASING RECORD

PIPE SIZE	HOLE	SEAT	F.C.	CEMENTING DATA: Sacks, Kind, etc.
Conductor:				
Surface:				
Intermed:				
Oil String:				

DATE	DEPTH TODAY	FOOT-AGE	DEGREES OFF		MUD		REMARKS (Activity) (Formation) (D.S.T.) (Coring) (etc.)
			DEG.	DEPTH	WT	VIS	
5-23							ing, set out 20" hydril, load out same, break cement sheath, orange peel 20" and 30", dress top of 13 3/8" casing, set on WKM.
5-24	2701	0			8.6	45	Weld on casing head and nipple up, change ram blocks in H&H gate as they
							were upside down, rebuild kill line and manifold line, run in test plug, test blind rams to 1,000 psi for 30 minutes in presence of USGS man at midnight.
5-25	3136	436	½	2961	8.8	42	TIH to 2,603', tag cement, test pipe rams to 1,000# OK by USGS man, drill out
							shoe at 2,701', drilling, POOH after survey to change BHA, Change BHA, TIH to 2,798', ream from 2,798' to 3,085' because of addition of stabilizers.
5-26	3683	546	¼	3222	9.0	41	Drilling, survey.
			½	3467			
5-27	3891	208	¾	3716	9.0	39	Drilling, survey & POOH, TIH to 2,778', reaming from 2,778' to 3,068', circulate and condition hole and mud, ream from 3,068' to 3,192'.
5-28	4185	294	1 ¼	3966	8.9	39	Ream and circulate 3,195' to 3,891', drilling, circulate and survey.
			1 ¼	4025			
			1 ¾	4149			
5-29	4294	109	1 ½	4254	9.0	40	Drilling to 4,254', POOH, tight spot 3,590' to 2,860', TIH with new bit to 2,876', reaming from 2,876' to 4,254', drilling.
5-30	4630	340	1 ¾	4521	9.1	40	Drilling, reaming after short trip, short trip.
5-31	4957	327	2	4647			Drilling, trip, circulate and survey.
6-1	5300	343	4	5300	8.9	45	Drilling, short trips, circulate and survey.
6-2	5526	226	3 ½	5420	8.9	40	Drilling, trip time, POOH and TIH for bit #8, reaming from 5,260' to 5,300', circulate and survey.
6-3	5832	306	3 ¼	5545	9.0	40	Drilling, circulate and survey, short trips.
			3	5669			
6-4	5976	144	3 ¼	5887	8.9	39	Drilling and survey with bit #8, POOH with bit #8, change stabilizers, dress
							reamer with new cutters, check jars and shock sub, pick up bit #9, TIH, drilling twisted off, POOH, left 12 ¼" reamer and bit in hole due to failure of bit sub
							washed out, TIH to screw into fish at midnight.

DAILY DRILLING - WORKOVER LOG

LEASE/ WELL USA 11-36 Page 3 SPUDDED May 15, 19 80

ELEVATIONS: GND. BH DF RDB

CASING RECORD

	PIPE SIZE	HOLE	SEAT	F.C.	CEMENTING DATA: Sacks, Kind, etc.
Conductor:					
Surface:					
Intermed:					
Oil String:					

DATE	DEPTH TODAY	FOOT-AGE	DEGREES OFF		MUD		REMARKS (Activity) (Formation) (D.S.T.) (Coring) (etc.)
			DEG.	DEPTH	WT	VIS	
6-5	6001	25			9.0	40	Fishing, TIH, circulate at fish, screw into fish, established circulation, pumped fish free, chain out, lay down fish, Magna-Flux drill collars and subs, picked up new BHA, TIH, checking tool joints on Hevi-Wall, hit bridge at 5,877', spot reamed to TD, drilling, one of the mud pumps went down around midnight due to electrical short not able to run optimum hydraulics.
6-6	6062	61			8.9	39	Drilling with one mud pump due to electrical failure, POOH on even stands, dressed near bit reamer, changed out worn out drilling jars, partial TIH at mid-night.
6-7	6160	98	1 ½	6098	8.9	45	TIH to 6,002', ream to 6,062', circulate and survey, drilling with bit #10 average 4.9'/Hr.
6-8	6280	120	NG	6280	9.0	45	Drilling, trip, circulate and survey.
6-9	6395	115			9.0	40	Trip for bit, ream after trip 6,240' to 6,280', drilling.
6-10	6528	103	1 ½	6528	8.9	39	Drilling, survey, POOH for bit and reamer cutter change.
6-11	6630	102			9.0	38	TIH to 6,452', reaming after trip, drilling.
6-12	6755	125			9.0	37	Drilling with bit #12.
6-13	6857	102	2 ½	6809	9.0	37	Drilling to 6,809', survey and POOH, TIH with bit #13, stopped at 6,793', break circulation, washed out fill to 6,809', drilling to 6,857' at midnight.
6-14	7056	199			9.0	42	Drilling with bit #13 and one pump.
6-15	7205	149	3 ¼	7121	8.9	42	Drilling with bit #13, POOH to change bit, survey.
6-16	7312	107			9.0	36	Finish POOH, change bit, RIH 11' fill, drilling with bit #14.

DAILY DRILLING - WORKOVER LOG

LEASE/ WELL USA 11-36 Page 4 SPUDDED May 15, 19 80

ELEVATIONS: GND. _____ BH _____ DF _____ RDB _____

CASING RECORD

PIPE SIZE	HOLE	SEAT	F.C.	CEMENTING DATA: Sacks, Kind, etc.
Conductor:				
Surface:				
Intermed:				
Oil String:				

DATE	DEPTH TODAY	FOOT-AGE	DEGREES OFF		MUD		REMARKS (Activity) (Formation) (D.S.T.) (Coring) (etc.)
			DEG.	DEPTH	WT	VIS	
6-17	7438	126	4 ¾	7363	9.0	37	Drilling with bit #14, survey for direction.
6-18	7519	81	5 ¼	7546	8.9	38	Drilling with bit #14, survey, POOH, change bit reamers and stabilizer, RIH - no fill, drilling with bit #15.
6-19	7635	116	5 ¼	7550	9.0	40	Drilling, survey.
6-20	7737	102	4 ¾	7643	9.0	38	Drilling, survey.
			5	7733			
6-21	7809	72			9.0	35	Drilling, trip for bit #16, POOH and TIH - no problems, cut off drilling line.
6-22	7924	115	5 ¼	7859	8.9	38	Drilling with bit #16, survey at 7,859'.
6-23	8022	98	5 ¼	7952	8.9	39	Drilling with bit #16, directional Wireline survey.
			5 ½	8044			
6-24	8144	122	5 ½	8044	9.0	39	Drilling with bit #16, survey.
			5 ½	8137			
6-25	8258	114			9.06	46	Drilling, POOH for bit change, drop junk sub, pick up bit #17, TIH to 8,161', circulate for trip.
6-26	8421	163	5 ½	8258	9.0	38	Drilling, survey.
			5 ¾	8352			
6-27	8565	144	5 ½	8444	8.9	32	Drilling, circulate and condition hole, survey dev.
			5 ½	8565			
6-28	8565	0			9.0	37	POOH, short trip, TIH 35' fill, circulate and condition hole and mud, POOH to
							log, set back drill collars, run temp. surveys, stuck same on second run at 5,700', pulled line in two at key seat, making up four-prong spear to fish wireline and
							instruments at midnight.
6-29	8565	0			9.0	40	TIH with spear, picking up wireline to 8,397' at 6:00, circulate, POOH,
							recovered all of fish, attempt to run electric logs - failed, repairing short in log line of Dresser Atlas, running DI, FL, BHC, AL, Cal at midnight.
6-30	8565	0			9.0	46	Finish electric log Dresser Atlas, CDL GR logs, running Pruitt Wireline Services, temp. surveys, both stops, and travers charts at midnight.

DAILY DRILLING - WORKOVER LOG

LEASE/ WELL USA 11-36 Page 5 SPUDDED May 15, 19 80

ELEVATIONS: GND. _____ BH _____ DF _____ RDB _____

CASING RECORD

	PIPE SIZE	HOLE	SEAT	F.C.	CEMENTING DATA: Sacks, Kind, etc.
Conductor:					
Surface:					
Intermed:					
Oil String:					

DATE	DEPTH TODAY	FOOT-AGE	DEGREES OFF		MUD		REMARKS (Activity) (Formation) (D.S.T.) (Coring) (etc.)
			DEG.	DEPTH	WT	VIS	
7-1	8565	0					Running continuous temp. survey successfully, TIH with DC'S, HW, and 10 stds. of 5" DP, POOH laying down 10 stds. of DP, 12 jts. HW, 12 jts. DC's 12 ¼" tools, stabilizers, reamers, etc., TIH with 5" DP to 7,100', set 50 sacks cement plug consisting of 40% SSA-1, .75% CFR2, 3% HR7, at 7100' 5:40 p.m., POOH setting back 2700' DP, laying down the remainder, picked up EZSV tool TIH with same, set at 2,572', 10:40 p.m., pressure up back side 500 PSI, break down formation at 900 PSI, squeezed 130 sacks cmt. consisting of 40% SSA-1, .75% CFR2, got off of EZSV, pulled 1 std., spotted 20 sxs. cement consisting of 40% SSA-1, .75% CFR-2 on top of EZSV, cleared pipe with 30 bbl. water at midnight.
7-2	8565	0					POOH laying down 81 jts. of DP, TIH with 60 jts. POOH, laying down same, at 60' in, picked up kelley, pumped 9 bbls. water ahead, set 30 sacks cement plug consisting of 40% SSA-1, .75% CFR-2, displaced with 2 bbls. of water to clear lines, washed BOE clean for safety measure, dismantled and set out BOPE stack in 3 components, load drillpipe, cut off casing head 6 ½' below surface, weld on cap with handle, released rig at 12 NOON 7-2-80, P&A at 8,565' depth, final report.

APPENDIX B

FIGURES 2 - 10

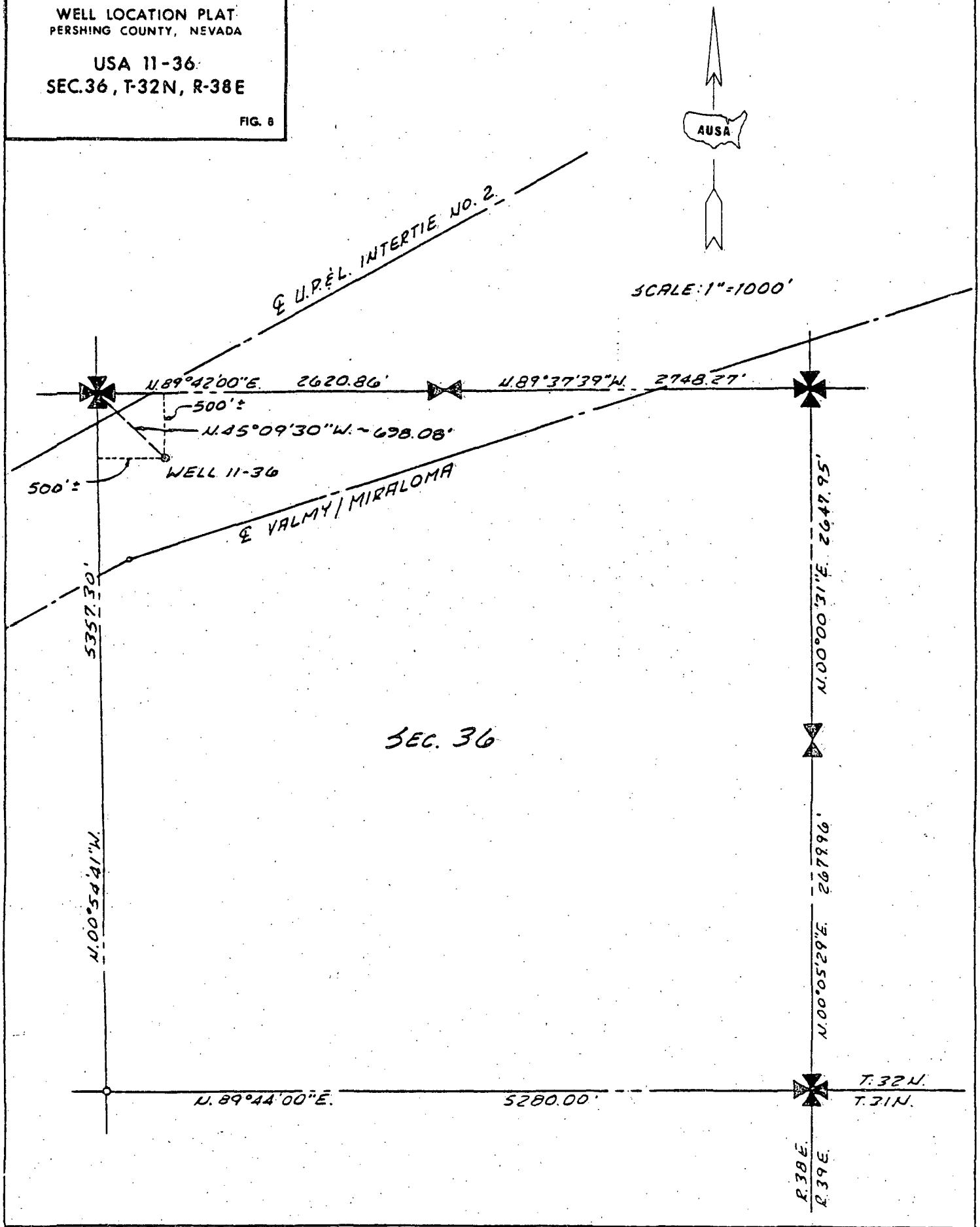
PLOT PLAN

AMINOIL USA, INC.
HOUSTON, TEXAS

WELL LOCATION PLAT
PERSHING COUNTY, NEVADA

USA 11-36
SEC. 36, T-32N, R-38E

FIG. 8



SEI

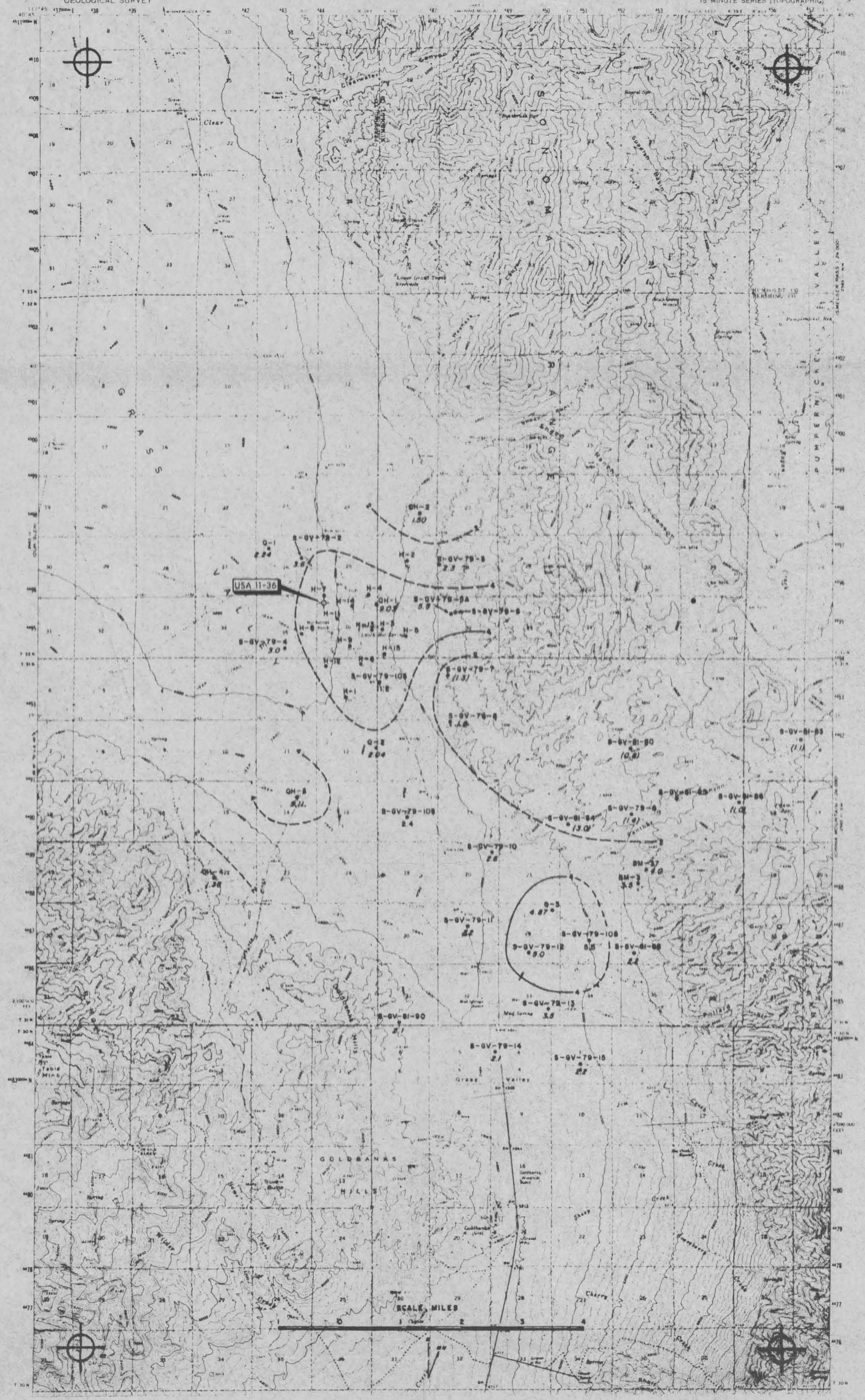
WELL SITE NO. 11-36
SEC. 36, T. 32N., R. 38E., M.D.M.
SPARKS, NEVADA • SEATTLE, WASHINGTON • LAS VEGAS, NEVADA

PROJECT NO. 352-004-791
PLATE 1 of 2

DRAWING 100

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

LEACH HOT SPRINGS QUADRANGLE
NEVADA
15 MINUTE SERIES (TOPOGRAPHIC)



Explanation

S-GV-79-15	Sunedco—Grass Valley project holes.
Q-3, QH-4	Heat-flow and heat-flow-hydrologic test holes.
H-1	Shallow hydrologic test wells.
BM-37	Hole used by Sass et al. (1971) in heat flow determinations.
2.6	Heat flow (in 10^{-6} cal/cm^2-sec, or HFU) from 100-150m depth interval. Parentheses indicate value from slightly shallower depth. Sunedco's holes represented by average of values computed for maximum and minimum porosity conditions. Published values shown as reported.
2.4	Heat-flow (in HFU) from 300-450m depth interval. Average of values computed for minimum and maximum porosity conditions.
———	Contours on heat flow values at 2 and 4 HFU. Based chiefly on values from 100-150m interval, but also reflecting values from deeper interval. Contours dashed where approximate.

PHASE III

AMINOIL USA, INC.
HOUSTON, TEXAS

GRASS VALLEY AREA

TEMPERATURE GRADIENT WELL LOCATIONS & HEAT FLOW CONTOURS

SCALE:	C.I.:	DATE:	FIG. NO. 10
INTERPRETATION:		DRAFTING:	FILE NO:

4-0-23

8067N

117°45

117°40'

117°35'

R 38 E
R 39 E

R 39 E
R 40 E

T 32 N
T 31 N

T 31 N
T 30 N

40°35'

40°30'

LINE 1

LINE 2

LINE 3

LINE 4

USA 11-36

PHASE II

SCALE : 1 = 24,000

1000' 0 1000' 3000' 5000' 7000'

N

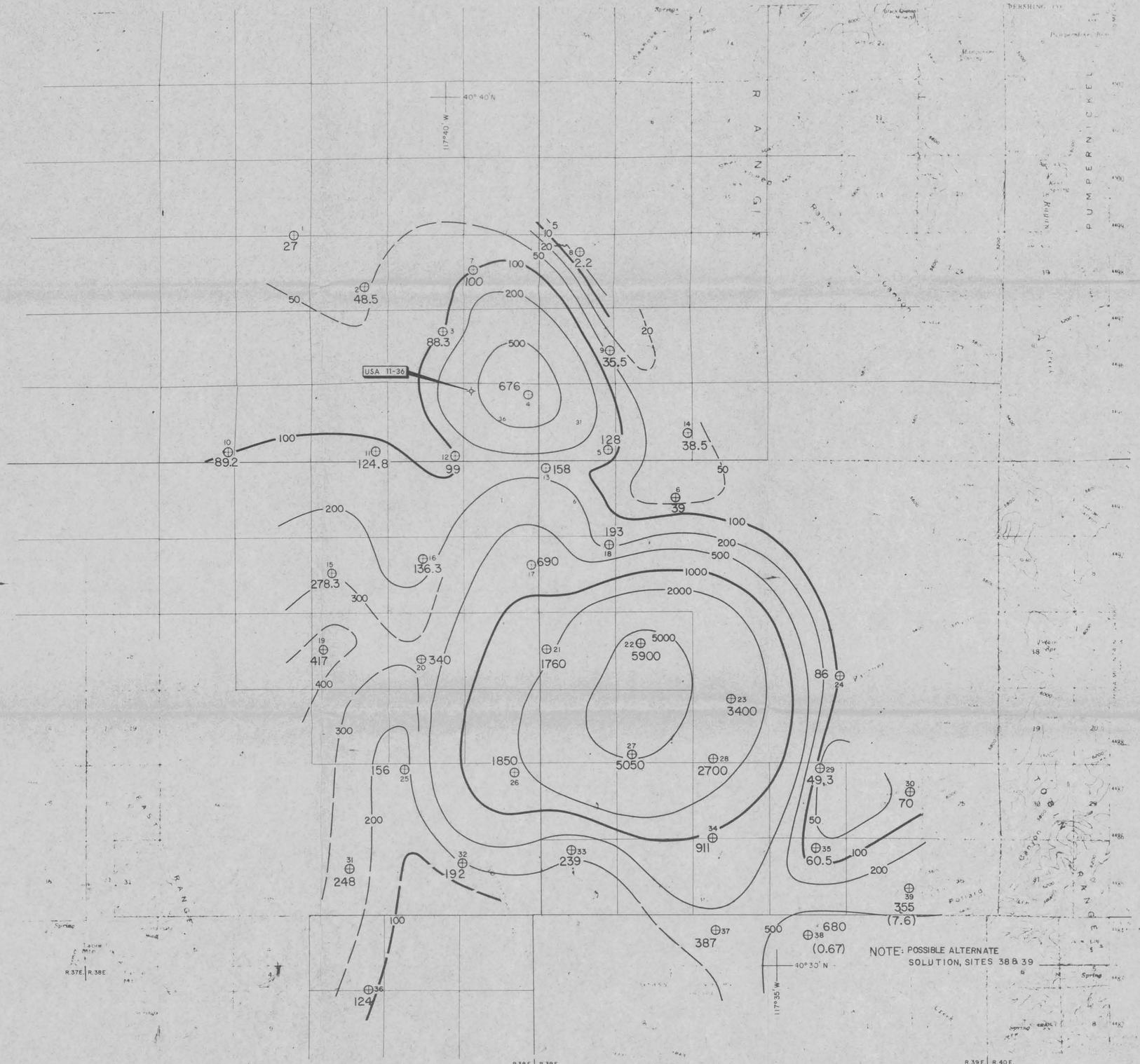
AMINOIL USA, INC.

HOUSTON, TEXAS

SEISMIC SURVEY MAP

PERSHING COUNTY, NEVADA

SCALE: 1" = 2000'	C.I.:	DATE:	FIG. NO. 7



DATA TAKEN FROM RTE COMPONENT

RESISTIVITY VALUES IN OHM-METERS

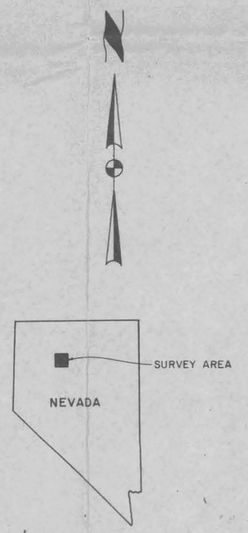
CONTOUR INTERVAL = $1,2,5,\times 10^{N}$ OHM-METERS WITH SUPPLEMENTARY CONTOURS

BASE MAP: USGS TOPO.

⊕ SITE LOCATION

00 SITE NUMBER

3500 1750 0 3500 7000 10,500 14,000 feet



PHASE II

AMINOIL USA, INC.
HOUSTON, TEXAS

GRASS VALLEY AREA
PERSHING COUNTY, NEVADA

RESISTIVITY DISTRIBUTION AT -12,000 FEET

SCALE:	C.I.	DATE:	FIG. NO. 6
INTERPRETATION:		DRAFTING:	FILE NO.

EP5415

DATA TAKEN FROM RTE COMPONENT

RESISTIVITY VALUES IN OHM-METERS

CONTOUR INTERVAL = $1, 2, 5, \times 10^N$ OHM-METERS WITH SUPPLEMENTARY CONTOURS

BASE MAP: USGS TOPO.

⊕ ..... SITE LOCATION

00 ..... SITE NUMBER

3500 1750 0 3500 7000 10,500 14,000 feet

PHASE II

AMINOIL USA, INC.

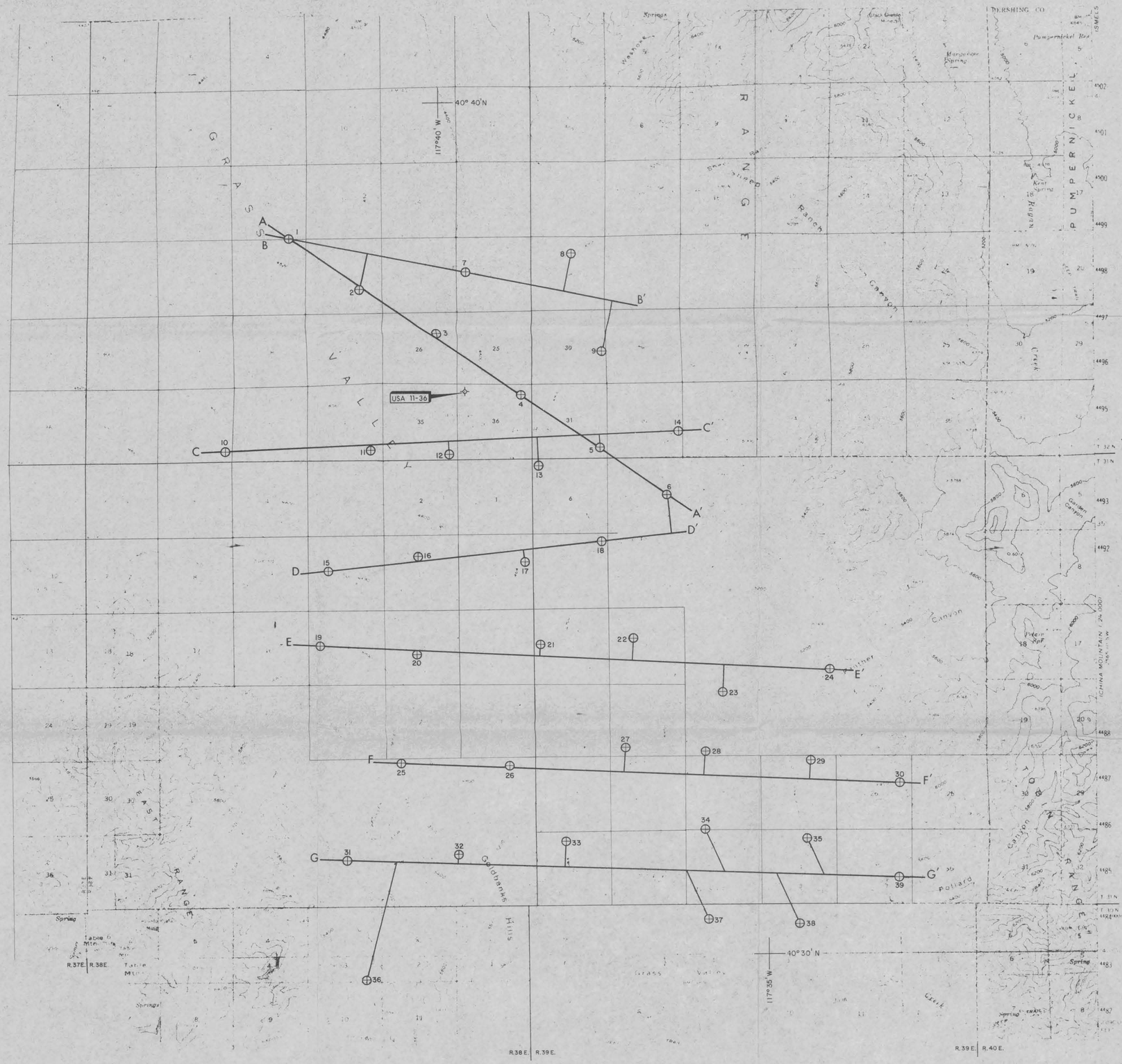
HOUSTON, TEXAS

GRASS VALLEY AREA

PERSHING COUNTY, NEVADA

RESISTIVITY DISTRIBUTION AT -4000 FEET

SCALE	C.I.	DATE	FIG. NO.
			5
INTERPRETATION		DRAFTING	FILE NO.



LEGEND

⊕ SITE LOCATION
A LINE DESIGNATION
00 SITE NUMBER

3500 1750 0 3500 7000 10,500 14,000 feet

PHASE II

AMINOIL USA, INC.
HOUSTON, TEXAS

GRASS VALLEY AREA
PERSHING COUNTY, NEVADA

MAGNETOTELLURIC SURVEY SITES

SCALE:	C.I.:	DATE:	FIG. NO.: 4
INTERPRETATION:		DRAFTING:	FILE NO.:

BG47

117°45'

117°40'

117°35'

R 38 E
R 39 E

R 39 E
R 40 E

40°35'

40°30'

LEACH HOT SPRINGS
KGRA

USA 11-36

PANTHER CANYON AREA

T 32 N
T 31 N

T 31 N
T 30 N

SCALE : 1 = 24,000

1000' 0 1000' 3000' 5000' 7000'

N

AMINOIL USA, INC.
HOUSTON, TEXAS

PERSHING COUNTY, NEVADA

LEACH HOT SPRINGS KGRA & PANTHER CANYON AREA

SCALE: 1" = 2000'	C.I.	DATE:	FIG. NO. 2

CASING

LITHOLOGY

20" — 320'

13-3/8" — 2,701'

12-1/4"

DEPTH (FEET)

0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
7,000
7,500
8,000
8,500

Precipitation of silica and calcite from warm ground water (outflow from Leach Hot Springs?). Almost no other alteration of the original sediments.

Alluvium: variable mixtures of poorly consolidated clay, sand and gravel; partially silicified in upper 600 feet, reaching maximum intensity at about 300 feet; calcareous in upper 100 feet; well developed "tube" structure in silicified sediments.

Mudstone and claystone, predominantly light greenish gray, moderately consolidated, calcareous, locally sandy and gravelly.

Widespread small-scale shearing throughout the Tertiary sediment section, evidenced by slickensided surfaces. No major shear zones recognized.

Predominantly sand and gravel with variable light brown to light gray silty clay matrix and interbeds

Mudstone and claystone, predominantly light green-gray, generally well consolidated, calcareous and commonly sandy, occasional interbeds of clay-cemented sand and gravel; tuffaceous in part.

Tuffaceous sandstone, siltstone, and conglomerate, poorly sorted, locally silicified.

Predominantly mudstone, siltstone, gray green to light green to light brown and gray, calcareous, locally sandy, partly tuffaceous, well consolidated; contains disseminated calcite euhedra and some secondary pyrite.

Tuffaceous sandstone, conglomerate and siltstone, moderately to well consolidated, locally slightly altered and partially silicified

Pervasive mild clay/chlorite alteration of basalt/andesite, probably old; no sign of open fractures.

Basalt and andesite, mostly containing plagioclase and sparse pyroxene (?) phenocrysts. Mildly altered and crumbly rocks.

Silicic tuffs and tuffaceous sediments, red-brown, gray, gray-brown and greenish, non-welded, locally crystal rich.

Mixed claystone, sandstone and conglomerate, clasts predominantly silicic tuffs and cryptocrystalline rhyolite and/or chert.

Erosional Unconformity — TERTIARY / TRIASSIC

Heavily stained by hematite in upper part due to weathering.

Rhyolitic rocks, predominantly white and pastel colors, cryptocrystalline to microcrystalline, variable textures, altered phenocrysts of feldspar and mica; possibly includes lithic tuffs.

Slight sericite(?) alteration at base of unit.

Granite, white, fine-grained, with quartz, feldspar and green and brown mica.

Mafic volcanic rocks, variably recrystallized to biotite-hornblende-epidote rock, locally intensely metasomatized to quartz-feldspar-mica rock.

Traces of drusy quartz-coated fracture surfaces, possibly precipitated by hydrothermal fluids. However, the bulk of the quartz in this rock is intergrown with biotite, chlorite, muscovite and feldspar, evidently crystallized under metasomatic conditions.

Metasomatized rock, white to greenish, fine-grained to extremely fine-grained, consisting of quartz, feldspar, biotite, chlorite and muscovite in varying proportions, with local traces of epidote, hornblende and ubiquitous disseminated pyrite; texture extremely erratic.

50-bbl mud loss, 7,137'

Altered (metasomatized) mafic volcanic rocks and interbedded white tuff.

Increased sericite(?) alteration near diabase contact.

Diabase/gabbro, brownish black, with chilled margins; contains labradorite, pyroxene, magnetite and possible rutile.

Leucogranite, white to light gray, fine- to medium-grained, containg primary quartz, feldspar, biotite and magnetite and secondary chlorite, muscovite, epidote, pyrite, kaolinite and possible zeolite.

Diabase/gabbro, brownish black, coarse-grained with chilled margins; contains labradorite, pyroxene, magnetite and possible rutile.

Continued traces of drusy quartz lining cavities or fracture surfaces.

Leucogranite, white to light gray, fine- to medium-grained, containing primary quartz and feldspar, biotite and magnetite, with widespread deuteric alteration to secondary chlorite, muscovite, epidote, zeolite(?) and pyrite, trace tourmaline intergrown with vein quartz.

Metasomatized contact zone.

Diabase, brownish black, fine- to medium-grained with chilled margins.

Altered and silicified biotite amphibolite.

Diabase as above.

Actinolite-biotite-hornblende amphibolite, green-black, fine-grained.

Diabase, very fine-grained.

Decrease in degree of recrystallization with depth below granite contact.

Hornblende-biotite-actinolite amphibolite, gray-green, fine-grained, with accessory apatite and magnetite; metamorphic grade decreases irregularly with depth.

T.D. 8,565'

TEMPERATURE DATA

TEMPERATURE (°F)

60 80 100 120 140 160 180 200 220 240 260

DEPTH (FEET)

Mud in

Mud out

Mud cooler turned on

Measured bottom-hole temperature on directional surveys (0-220°F MRT)

Post-drilling temperature logs

No. 1 6/28

No. 2 6/30

No. 3 6/30-7/1

7 hours post-circulation

51-1/2 hours post-circulation

89 hours post-circulation

0-220°F MRT

200-500°F MRT

TEMPERATURE (°F)

PENETRATION RECORD

DATE

MAY JUNE JULY

15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3

5 10 15 20 25 30 35 40 45

NUMBER OF DAYS OF DRILLING

Set 20" casing

Set 13-3/8" casing

Bit trip

Twist off

Logging, Plugging Abandoning

DEPTH (FEET)

NUMBER OF DAYS OF DRILLING

DATE

AMINOIL USA, INC. HOUSTON, TEXAS			
USA 11-36			
CASING PROGRAM , LITHOLOGIC LOG TEMPERATURE SURVEYS & DRILLING TIME CURVE			
SCALE	C.I.	DATE	FIG. NO. 9
INTERPRETATION		DRAFTING	FILE NO.