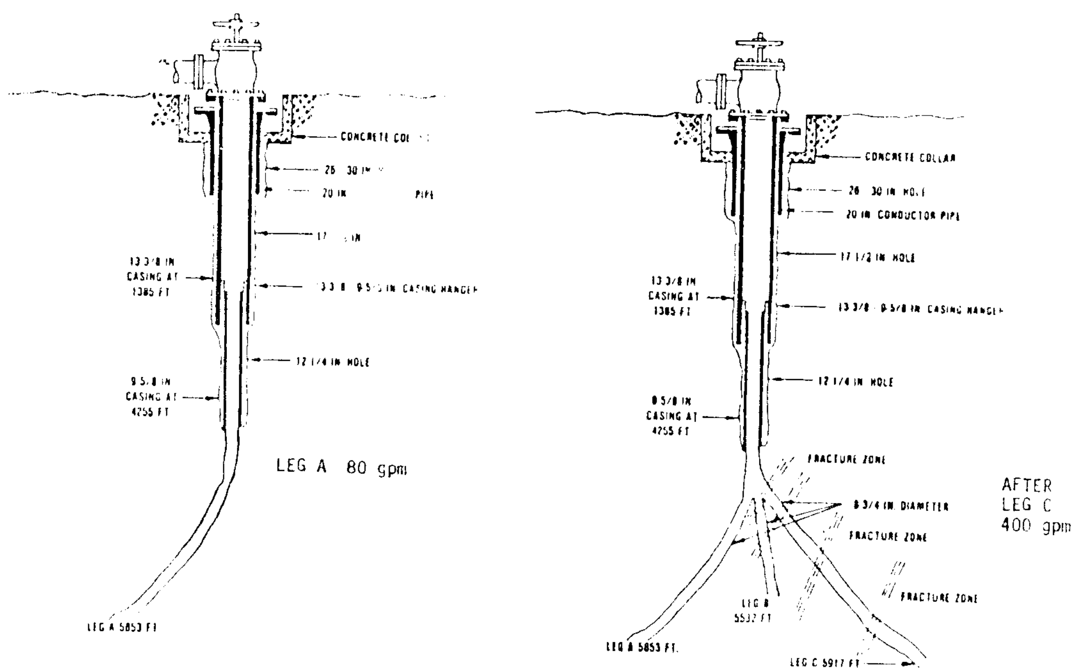
2. Development - Multiple legs in barefoot section of production wells to enhance production at minor increase in cost

Comments - For RRGE-3, production enhanced 3 to 5 times for 20% increase in cost. This is considered an unusually fortunate result, a case in which the first leg encountered few fractures, the other two legs encountered many fractures. For homogeneous permeability, a 50% increase in production for 20% cost increase is the more likely result.

Significance - All future water-dominated production wells should be drilled for multiple legs, if fracture permeability is the predominant source of production.



3. Development - Asbestos-cement pipe used successfully at 300^{O}F, at greatly reduced costs compared to steel pipelines

Comments - During early testing, several breaks occurred. These have been attributed to water hammer and extreme thermal shock. Pipeline since has performed well, especially during routine steady state operation. Pipeline should be buried 2 to 2-1/2 ft, and insulated with 1 in. of urethane foam.

Significance - Cost savings of 55% compared to steel pipe. Next size smaller pipe can be used because of reduced pressure loss in asbestos-cement pipe compared to steel pipe.

2.0 EXPERIMENTS AND TESTING AT RAFT RIVER

J. F. Kunze and L. G. Miller

2.1 Wells

Table I summarizes the uses of the three deep geothermal wells over the six month period.

TABLE I

WELL USE - OCTOBER 1976 TO MARCH 1977

Well	Total Flow	Flow Rate Range	Well Head Temperature	Uses
RRGE-1		50 to 200 gpm (continuous use)	275°F	Supplying corrosion-deposition experiments, cooling tower treatment experiment, fluidized bed and direct contact heat exchanger tests, and building space heating for laboratories and offices.
RRGE-2		20 to 500 gpm	272°F	To supply fish tolerance experiment. Conducted step well performance test to evaluate performance parameters. Well is identical to performance in summer of 1975. Freeze prevention at 20 gpm
RRGE-3		20 to 550 gpm	292°F	Well performance testing and freeze prevention (20 gpm)

The basic characteristics of these are summarized in Table II, while Table III summarizes the flow history to date.

TABLE II

THE CHARACTERISTICS OF THE WELLS

RAFT RIVER

RRGE #1 - Completed in March 1975, 5000 ft deep

Solids in water:	1700 mg/liter
Artesian Pressure:	50 psig cold 175 psig hot
Reservoir Temperature:	297°F (147°C)
Flow Experience:	400 gallons per minute for many days with artesian pressure only, 870 gallons per minute for 4 days with a pump, drawing down 375 ft below ground level
Predicted after 10 years of operation:	1100 gallons per minute with 900 ft drawdown below ground level

RRGE #2 - Completed in June 1975, 6500 ft deep

Solids in water:	1800 mg/liter
Artesian Pressure:	60 psig cold 165 psig hot
Reservoir Temperature:	298°F (148°C)
Flow Experience:	400 gallons per minute for several days with artesian pressure only
Predicted after 10 years of operation:	800 gallons per minute with 900 ft drawdown below ground level

RRGE #3 - Completed in June 1976, 5917 ft deep

Solids in Water:	4600 mg/liter
Artesian Pressure:	40 psig cold 140 psig hot
Reservoir Temperature:	301°F (149°C)
Flow Experience:	350 gallons per minute for a day under artesian pressure (291°F at surface)
Predicted after 10 years of operation:	500 gallons per minute with 1000 ft of drawdown below ground level

BOISE

Test Well #1 (Beard) - Completed August 1976, 1283 ft deep

Artesian Pressure:	11 psig hot
Reservoir Temperature:	172°F
Artesian Flow Experience:	195 gallons per minute for 1/2 day

Test Well #2 (BLM) - Completed September 1976, 1222 ft deep

Artesian Pressure:	9 psig hot
Reservoir Temperature:	>164°F
Artesian Flow Experience:	Minimal to date, briefly at 50 gallons per minute

Both Boise wells have dissolved solids of less than 300 mg/liter

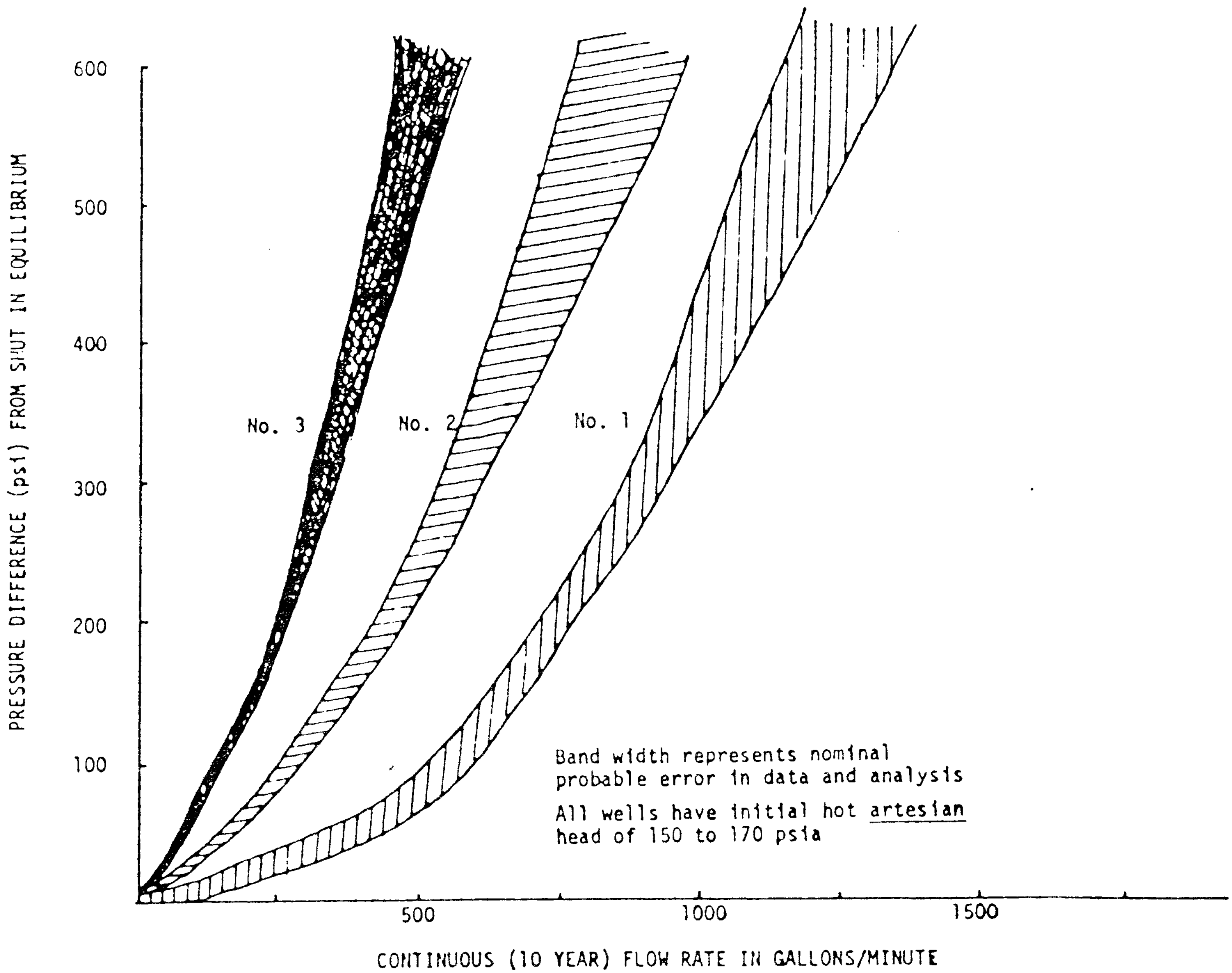


Fig. 1 Raft River Wells Productivity Curves as Extrapolated to 10 years of Continuous Flow

2.1.2 RRGP-2

This well continued to supply the small amount of heat needed for the completion of the first fish tolerance experiment, terminated in early December. The well was then left on small winter flow status, about 20 gpm, to prevent freezing, until February, when a series of step flow production tests were begun. At that time, the nearby farmer could beneficially use the water from these tests, making extensive flow tests possible.

The well site was the second most important test area in the Raft River complex, principally the agriculture, aquaculture, and cooling pond effectiveness test areas. Figure 3 is a sketch of the RRGE-2 Test Facility.

This well had been used for extensive disposal of water during the previous winter. Following that disposal operation, the well demonstrated poor performance. Some concern existed over the chemical blockage potential from reinjection, though preliminary assessment indicated the only effect was from the cooling of the nearby surrounding formation. After reproducing 2.5 times as much water from the well as was previously injected, the formation has still not completely returned to normal. The results of the last of the flow tests in this reporting period compared to a test 1-1/2 years earlier just after the well was drilled is shown in Figure 4. The curves differ for the first 70 minutes because of water column pressure differences as the well heats up. (The one test was measured with the down-hole gauge, the other with a surface gauge.) However, observe the test once it enters the time regime where the logarithmic approximation can be applied to the exponential integral solution of the two-dimensional time-dependent diffusion equation (Thesis Equation). Both pressure drawdown curves are virtually identical. If anything, the well shows a slight improvement with time, but data uncertainty may be the actual reason for this difference.

2.1.3 RRGP-3

The third well has seen little direct use for experiments, since a pipeline connection between it and the test programs at RRGP-1 must first be completed. At the close of this reporting period, this 9000 ft pipeline was completely planned and the asbestos-cement on site ready for installation. One small right-of-way agreement had yet to have negotiations completed before beginning installation. This pipeline will cross the Raft River above the water level, at the location of a new culvert-bridge. (Note: the Raft River at this point is normally only about 15 ft wide, but its spring runoff width can be as much as 100 yards.

RRGP-3 has a dissolved solids content of 4100 ppm, over twice as much as the other wells. Disposal of this fluid to agricultural purposes must await results of small scale tests. It is anticipated that these tests will show that it is difficult to find an acceptable agricultural or other beneficial surface use of the water without undue side effects.

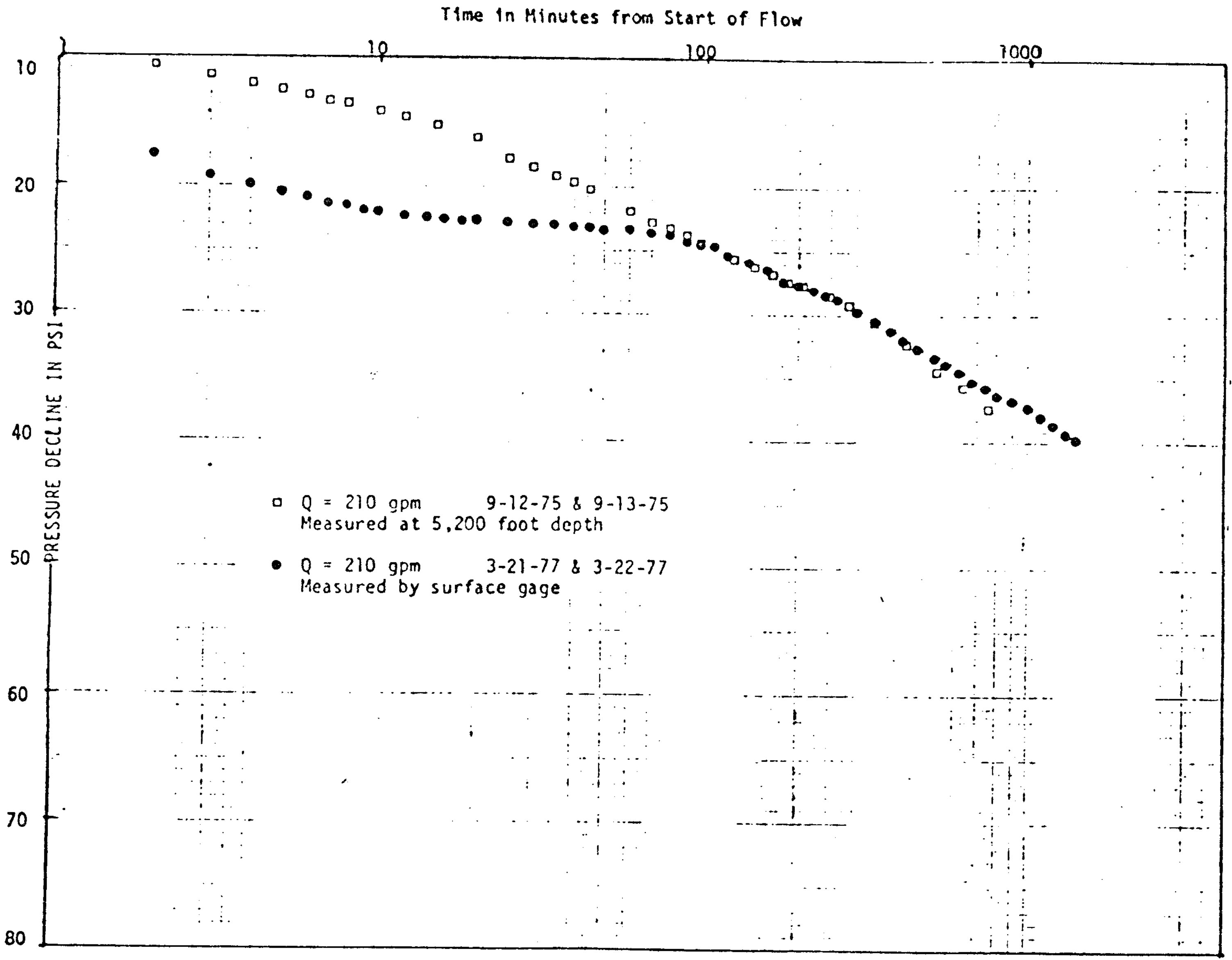


Fig. 4 Flow Tests - RRGP-2

2.3 Reservoir Engineering

R. C. Stoker, D. Goldman, J. F. Kunze

2.3.1 Production Testing of No. 2 and No. 3 Wells

Step testing at constant flow, with recovery periods between each step, were conducted on RRGP-2 and RRGP-3, (January through March period). The results are shown in Figures 6 and 7. These results gave relative consistent values of kH (permeability times producing strata thickness), with a slight trend toward quadratic dependence at the higher flow. In each case, the data were obtained with a quartz pressure transducer installed at the surface. Therefore, the early parts of the curves show water column density differences, which become neglible after about 60 minutes of flow.

Table V summarizes the Raft River well tests results in terms of reservoir parameters. The latest results do not imply, necessarily, a change in well conditions, but merely a difference in analysis. These latter results cover a longer test period than those obtained in 1975, and therefore are more likely to be representative of long term conditions including nearby boundary effects.

Note: in Section 2.3.1 above, direct comparison of measured drawdown curves (Figure 4) showed no change (except for possible slight improvement) of No. 2 well over 1-1/2 years of use, both as a production and a reinjection well.

Table VI(a) and VI(b) summarize the measurements made of porosity and permeability on the cores obtained from these wells.

The performance of the wells was discussed in the previous section 2.1, and the well pressure (drawdown) vs flow characteristics given in Figure 1. There is still some uncertainty in how quadratic the well production function might be, indicating a band of turbulence near the well bore. Therefore, pump testing at high flow rates is being planned, once disposal facilities are available. The band of uncertainty in Figure 1 is expected to include the results of the forthcoming pump tests, at 1000 gpm and above.

2.3.2 Geochemistry (R. E. McAtee, C. A. Allen)

The wells have been routinely sampled since being drilled and first flow tested, and elemental and ion chemistry measurement conducted. From these results, geothermometry calculations were conducted. Figure 8 shows these results as a function of time since the wells developed. The trend toward higher indicated reservoir temperatures with time, for No. 1 and No. 3, may have some significance. However, of greater significance is the considerably different chemistry between No. 2 and No. 3 wells, as

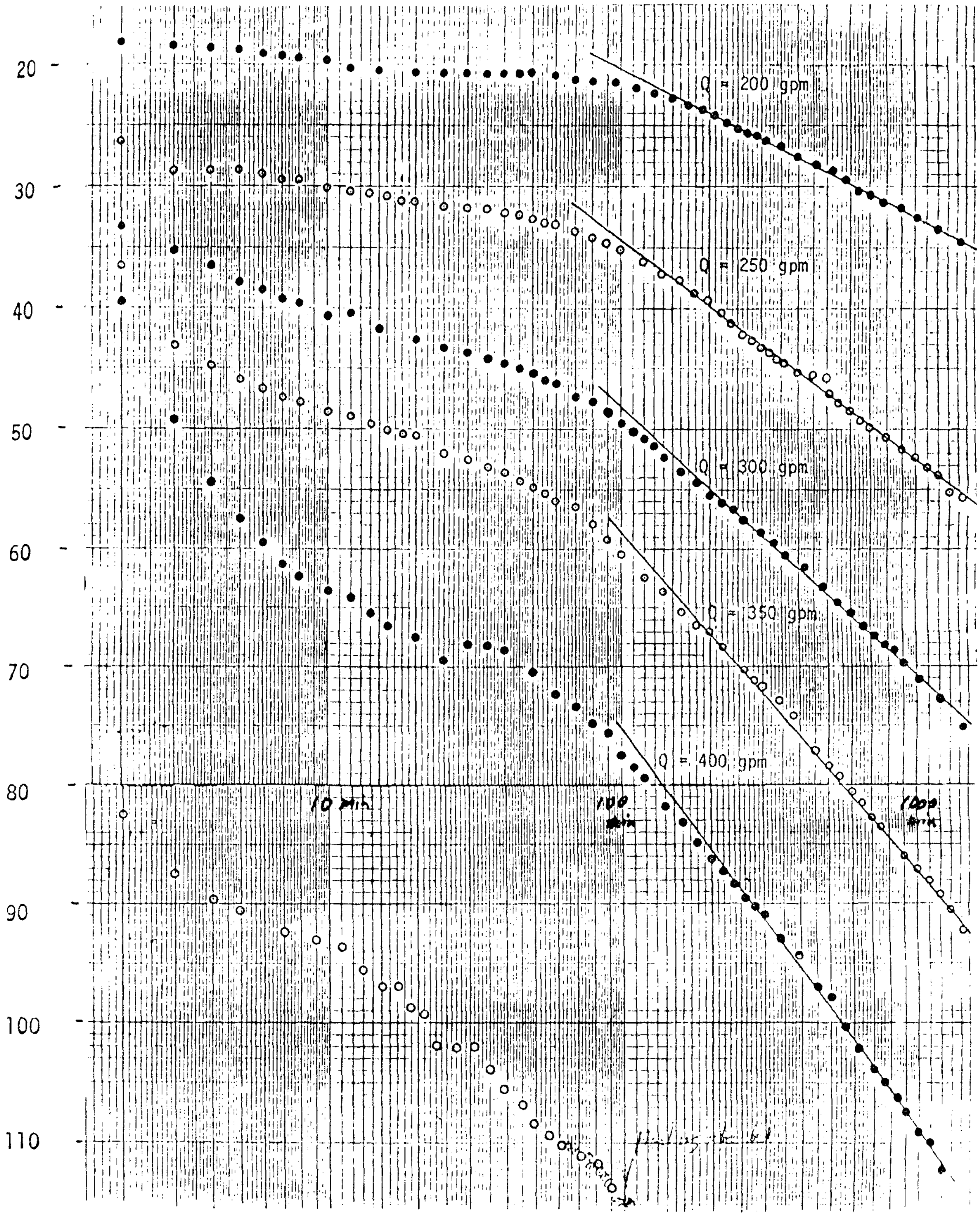


Fig. 6 RRGP-2 Production Test

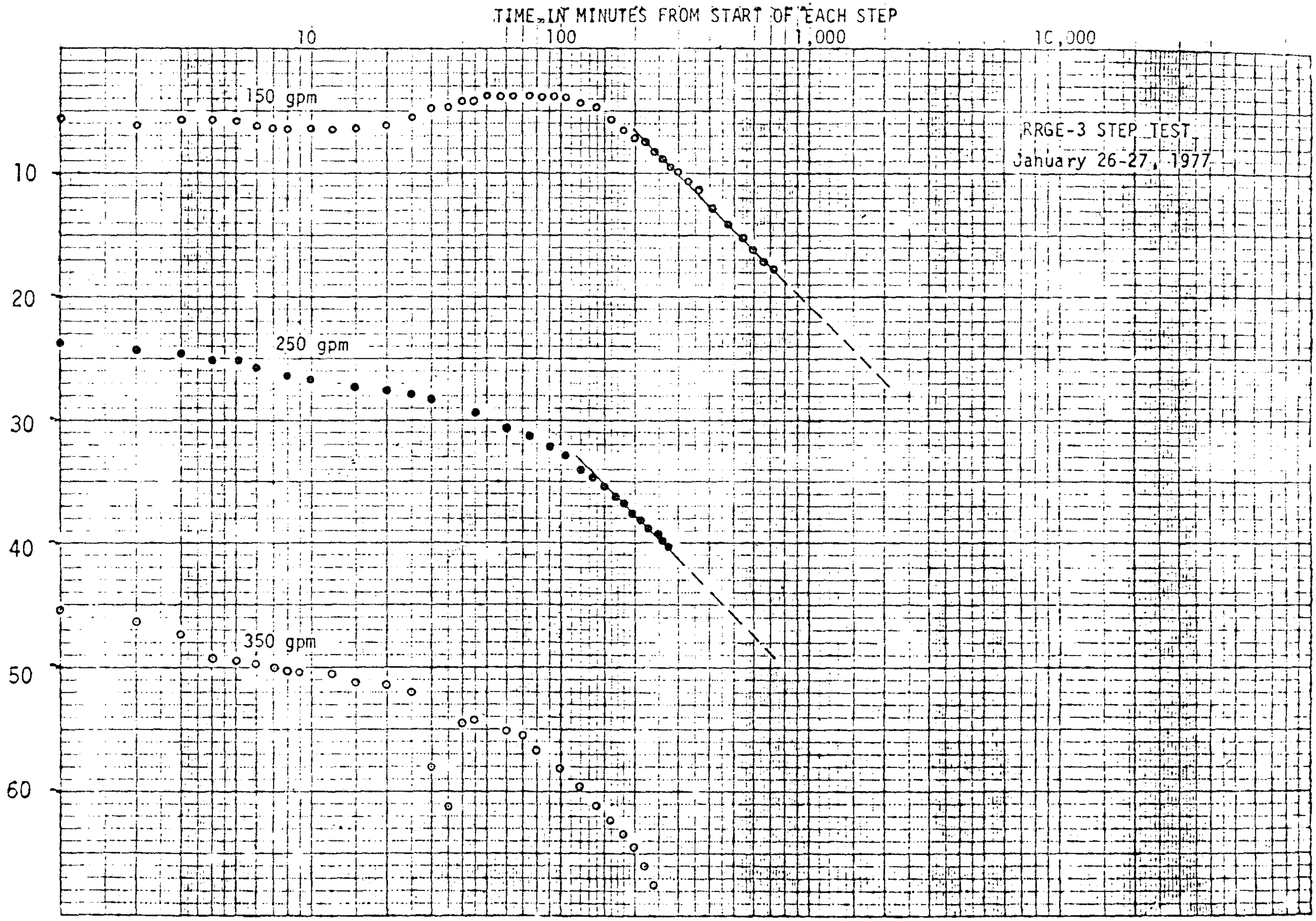


Fig. 7 RRGE-3 Step Test

TABLE V

SUMMARY OF RAFT RIVER WELL TEST RESULTS

Discharging Well & Date	Discharge Rate (gpm)	Duration (hrs)	Data Collected From	Mean kh (md-ft)	Mean T (gpd/ft)	Mean ϕch (ft/psi)	Mean S	Comments
RRGE-2 Sept. 12 - Sept. 13, 1975	210	15	RRGE-2	44,288	4,684	.0276	.0112	
RRGE-2 Sept. 14 - Sept. 17, 1975	800 440	21¼ 73¾	RRGE-1	223,000	23,500	.00056	.00022	
RRGE-2 Sept. 20 - Oct. 16, 1975	400	615¼	RRGE-1	228,000	23,900	.0011	.00043	
RRGE-1 Nov. 5 - Nov. 6, 1975	26	30	RRGE-1	115,000	12,300	.0022	.00081	
RRGE-3 June 8 - June 16, 1976	140	193¾	RRGE-3 *	6,000	633	.001	.0004	r_w ~30 ft
			RRGE-1	220,000	23,300	.00165	.00065	
			No measurable effect in Well RRGE-2					
RRGE-3 Jan. 26 - Jan. 27, 1977 Step Test	150 250 350	12 4¼ 4	RRGE-3	8,500	898	.038	.015	r_w ~30 ft
RRGE-2 Feb. 17 - March 25, 1977 Step Test	200 250 300 350 400 500	24 24 24 24 24 2½	RRGE-2	12,600	1,330	.76	.3	

TABLE VI (a)

RRGE WELL CORE PERMEABILITIES

Well	Depth, KB	Permeability (Millidarcies)	Rock Type
RRGE-1	4,227 ft	.003 - .04 (cap)	Siltstone
RRGE-1	4,506 ft	5.0	Tuffaceous Siltstone
RRGE-2	4,372 ft	0.0022 (cap)	Shale
RRGE-3A	2,807 ft	.25	Sandstone
RRGE-3A	3,365 ft lower	.04	Tuffaceous Siltstone
	3,365 ft upper	>35. (∿100)	Tuffaceous Siltstone
RRGE-3 (A, B, & C)	4,985 ft	.035	Tuffaceous Siltstone
RRGE-3 (A, B, &C)	4,994 ft	.001	Tuffaceous Sandstone
RRGE-3 (A, B, &C)	5,273 ft	.117	Siltstone

NOTE: The best oil producing wells have permeabilities in the order of 1-50 millidarcies.

TABLE VI (b)

SAMPLE	WET BULK DENSITY (gm/cc)	DRY BULK DENSITY (gm/cc)	GRAIN DENSITY (gm/cc)	TOTAL POROSITY (%)	EFF. WATER POROSITY (%)
RRGE-1 4500.5'	--	1.88	2.62	28.8	28.8
4518.0'	--	2.20	2.67	17.6	14.3
4687.0'	--	2.73	2.79	2.2	0.8
RRGE-2 3728.4'	--	2.16	2.66	18.8	13.2
4223.8'	--	2.07	2.66	22.2	15.0
4227.0'	2.29	2.20	2.72	19.3	17.4
4373.0'	--	2.28	2.67	14.5	13.6
6560.0'	--	2.57	2.64	2.7	0.8
RRGE-3A (L) 3365.0'	--	1.74	2.60	33.1	11.3
(U) 3365.0'	--	1.53	2.48	38.3	34.7
RRGE-3C 4994.0'	--	2.31	2.70	14.4	9.1
5273.0'	--	1.97	2.66	25.9	23.0
5550.5'	--	2.64	2.70	2.2	1.2

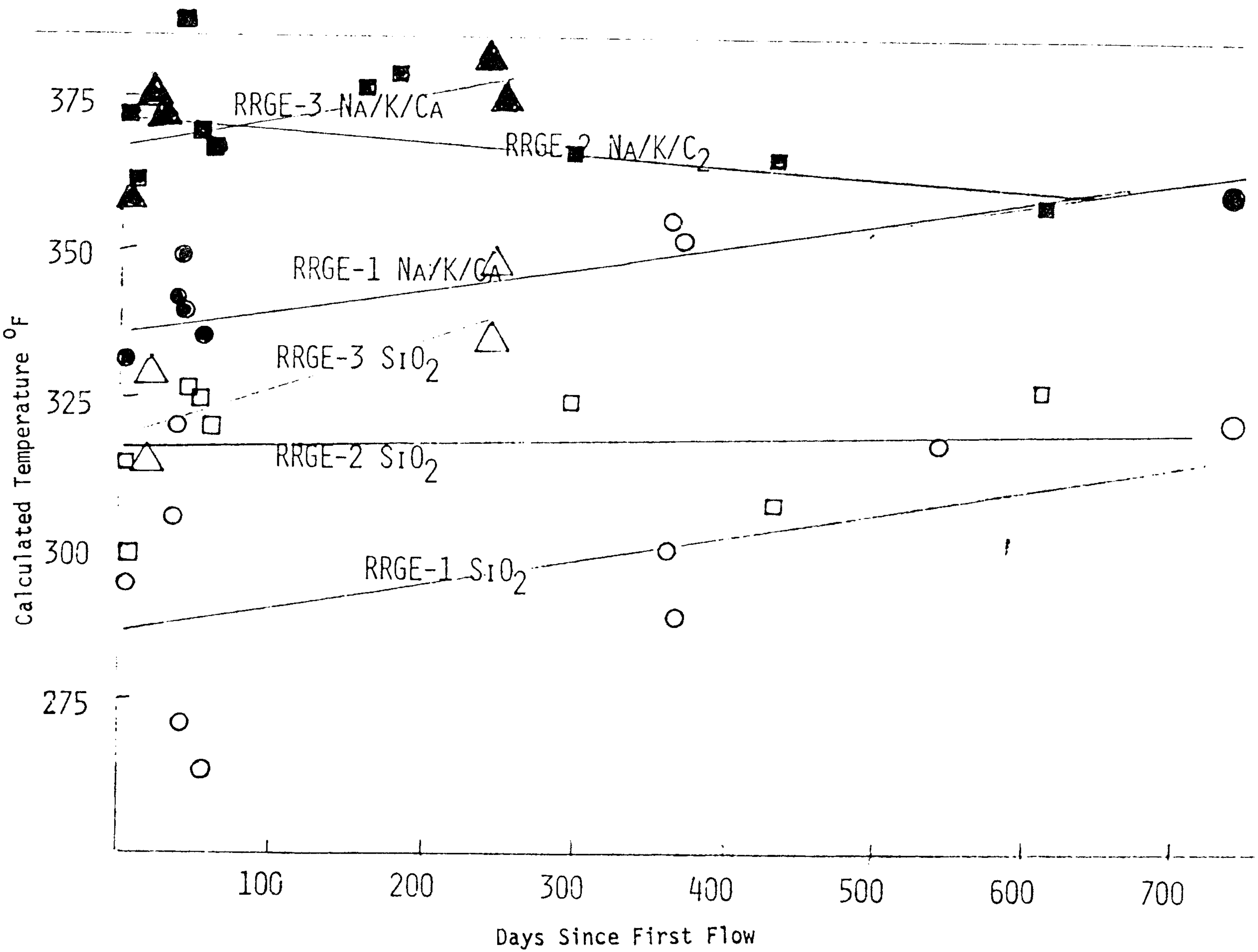


Fig. 8 Raft River Geothermometry

shown briefly in Table VII. At the bottom of the table are best fit values for mixing ratios if one assumes that there are two distinct sources, Resource A characterized by RRGE-2, and B by RRGE-3. The X_m is the fraction of resource A in the particular well water.

The implications, if there are two resources involved, are as follows:

1. If RRGE-1 and the BLM wells are mixtures of resources A and B, then resource A must flow from the north. The fault associated with RRGE-2 runs NE-SW. Since RRGE-1 is SW of RRGE-2, the only way to explain less mixing in RRGE-2 than RRGE-1 is for the water to be moving south along the fault. T This would remove the Narrows as a possible heat source for resource A.

2. The presence of resource B implies a fault which is not obvious at the surface. As seen in Figure 5, the four wells BLM, RRGE-1, Crank, and RRGE-3 are nearly in a straight line. The relationship between RRGE-3 and the Crank well is similar to the relationship between RRGE-1 and the BLM well. This implies a fractured zone connecting the two. Fractured zones are normally associated with faults. The fault associated with resource B could be identified and followed with a surface helium survey.

3. A significant question arises concerning these two resources. Do resources A and B represent two conduits from the same heat source, or are two heat sources involved? If a single heat source is involved, then it must be located to the north. This is because flow between RRGE-2 and RRGE-1 is generally from north to south. If two heat sources are involved, then the heat source for resource B could be to the NE, E, S, or SW. It could not be to the west or north.

It should be cautioned that the above results are deduced primarily from geochemistry. However, at this stage of understanding, geochemistry may be the best definite clue of reservoir source and motion.

2.3.3 Reservoir Modelling

An extensive series of computer runs were made using the reservoir model shown in Figure 9. The area outside of the dotted lines represent lower permeability than inside the dotted lines. Figure 10 shows the results of drawdown within the reservoir with no reinjection after 20 years of 2400 gpm flow, more than necessary for the thermal loop first phase. Figure 11 shows the results with reinjection into an intermediate depth zone, with downward penetration in the area shown.

It is apparent that interferences with the present well spacing is negligible, when one considers that 800 gpm draws down the type RRGE well

TABLE VII
CHEMICAL CONCENTRATIONS AND STANDARD DEVIATIONS IN μg/mL

Chemical Species	RRGE-1 $\overline{X}$	RRGE-1 S_x	RRGE-2 $\overline{X}$	RRGE-2 S_x	RRGE-3 $\overline{X}$	RRGE-3 S_x	RAFT RIVER $\overline{X}$	RAFT RIVER S_x	BLM WELL $\overline{X}$	BLM WELL S_x	CRANK WELL $\overline{X}$	CRANK WELL S_x
CL^-	776	184	708	70	2170	302	153	70	1139			
F^-	6.32	1.47	8.25	1.06	4.55	0.25	0.65	0.21	5.6		4.11	
Br^-	<1.5		<1.5		<1.5		<1.5		<0.15		<0.15	
I^-	0.036	0.003	0.028	0.019			0.066	0.016	<0.040		<0.040	
$*HCO_3^-$	63.9	20.8	41.3	11.2	44.4	11.1	172.5	45.0	83			
$SO_4^=$	60.2	6.7	54.1	5.1	53.3	14.6	55.2	28.0	54		54	
NO_3^-	<0.2		<0.2		<0.2		3.8	<0.2				
Total NH_3	1.56	1.19	0.60	0.41			1.0		0.59			
Total P	0.023	0.014	0.020	0.011			0.038	0.028	0.27			
$S^=$			0.256									
$Si(OH)_4$	182	33	201	40	242	21	40.4	21.0	132		142	
Si	56.6	16.7	61.2	14.5	74.0	8.0	18.7	1.5	46		49	
Na	445	99	416	44	1185	52	77	26	550		1074	
K	31.3	7.0	33.4	5.3	97.2	7.3	7.7	0.7	20		34	
Sr	1.56	0.35	1.03	0.32	6.7	0.7	0.52	0.16	1.35		0.36	
Li	1.48	0.40	1.21	0.57	3.1	0.2	0.04	0.01	1.4			
Ca	53.5	9.5	35.3	8.7	193	15	85.3	29.6	55		130	
Mg	2.35	2.09	0.58	0.80	0.60	0.16	23.9	9.8	0.2		0.5	
pH							7.94	0.15				
Total Dissolved Solids	1560		1267		4130	36			1640		3720	
X_m	.898		.1		0'				.870		.143	
*Conductivity	3373		2742		9530	1546						
*Total Gas	33.4	21.9	35.4	22.1					12.9			
H_2	0.10	0.14	0.67	0.69					0.11			
He	0.03	0.01	0.01	0.01					N.D.			
N_2	30.6	20.8	18.8	7.1					12.4			
O_2	0.13	0.17	0.27	0.56					0.05			
Ar	0.49	0.21	0.35	0.12					0.16			
CO_2	1.91	2.48	1.01	0.63					0.15			

$*HCO_3^-$ Concentrations are recorded in μg/mL as $CaCO_3$

*Conductivity is recorded in μmho/cm

*Gas Volumes are in Standard cc/liter

$\overline{X}$. Average Value

S_x Standard Deviation of a Single [Value]

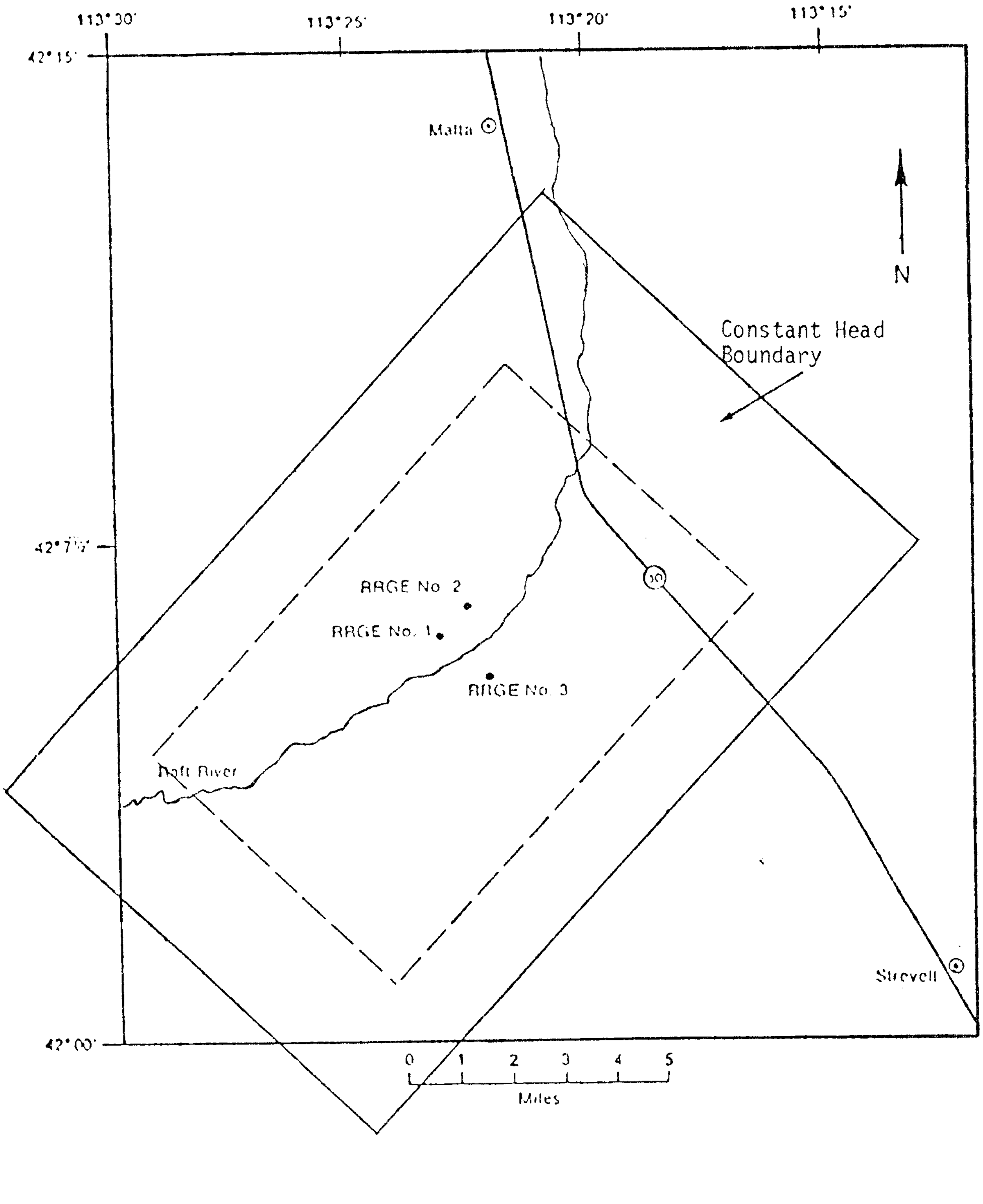


Fig. 9 Computer Modeled Geothermal Reservoir

Computer Projected Pressure Decline

In psi while flowing wells RRGE-1, 2 & 3 at 800 gpm each for 20 years. NW & SE no-flow boundaries and variable permeabilities.

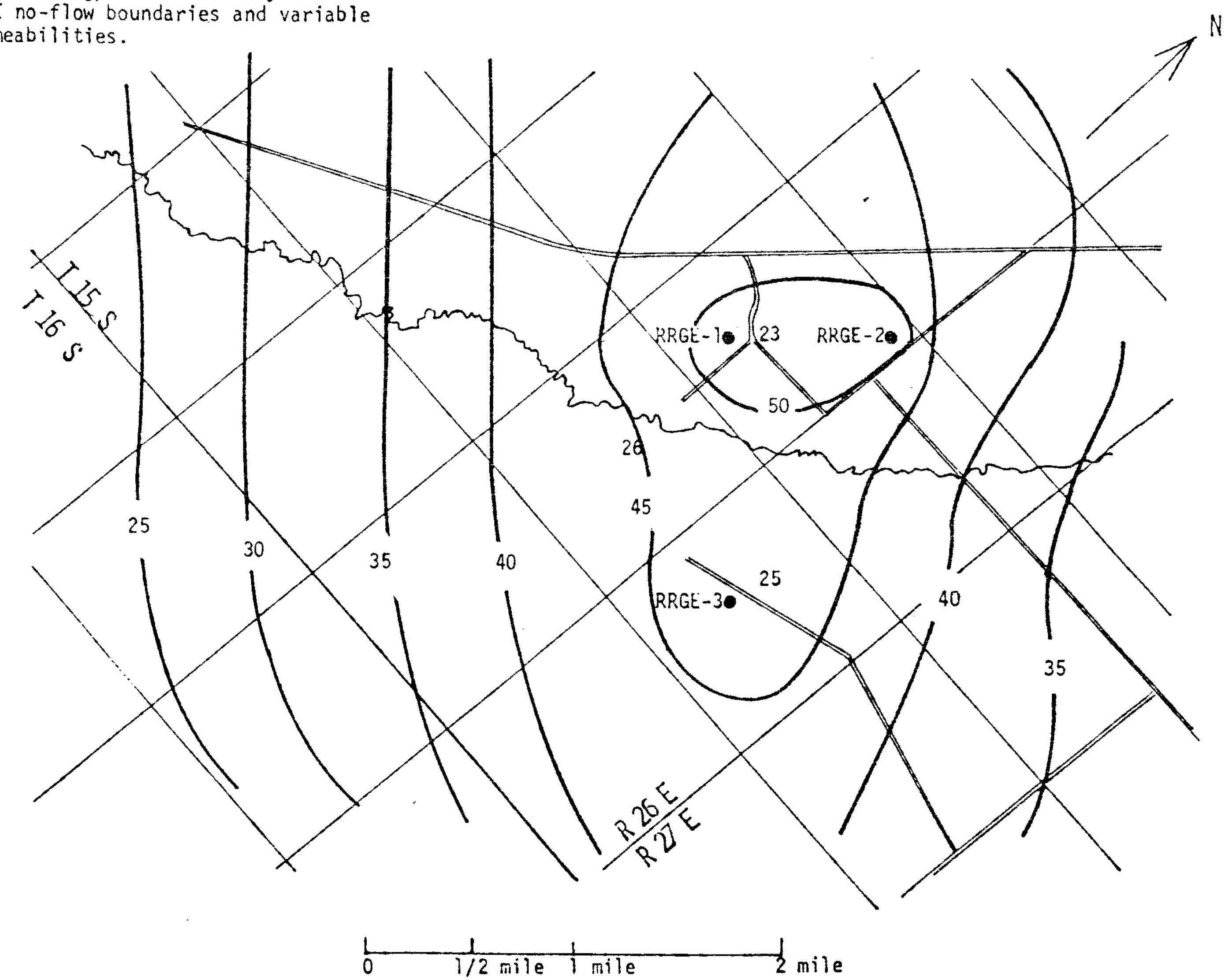


Fig. 10 Computer Projected Pressure Decline - Without Injection

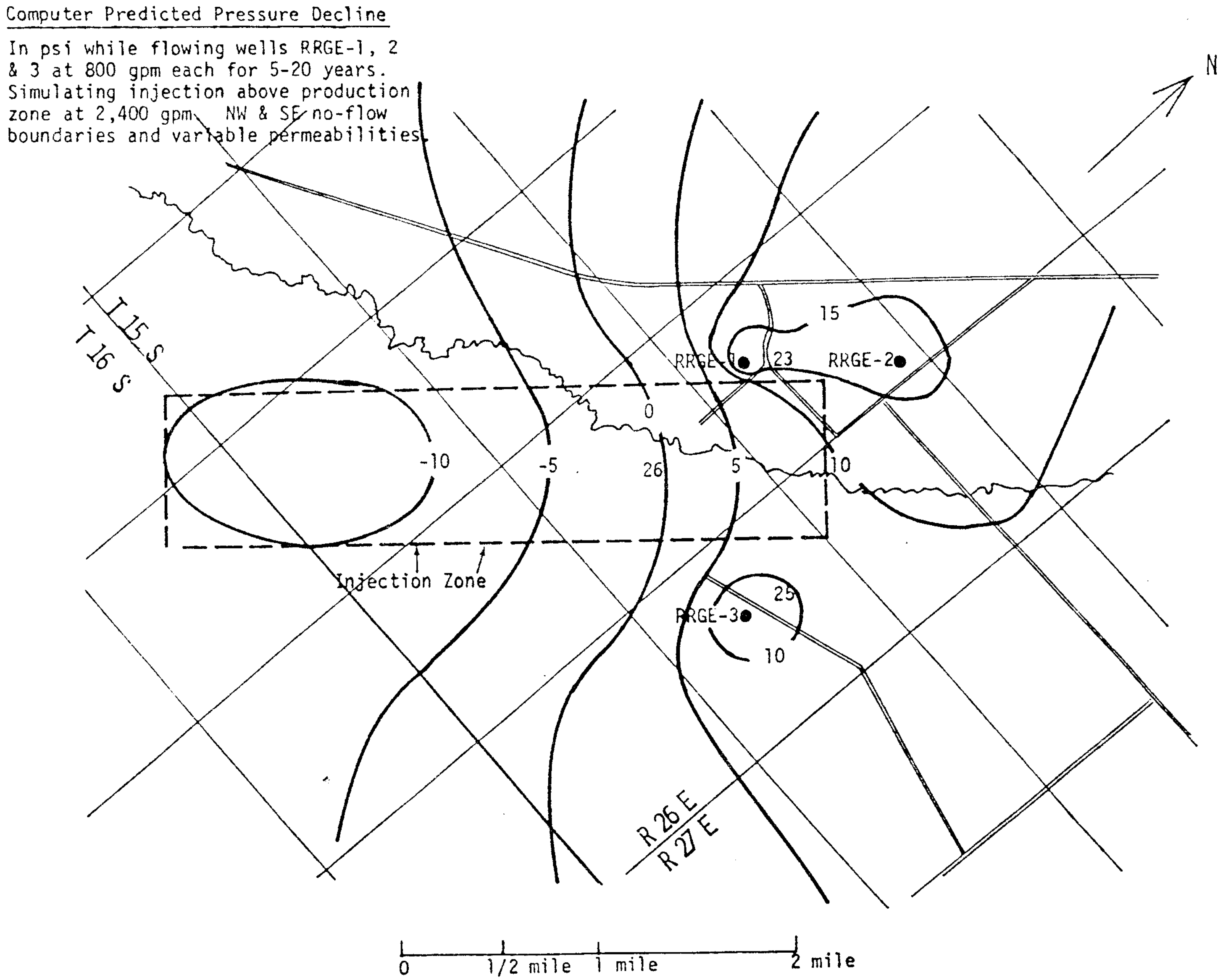


Fig. 11 Computer Predicted Pressure Decline - With Injection

by 500 psi, gross from artesian. Well spacings of 1/2 mile are tolerable, for 20 years operation without reinjection, 1/5 mile with reinjection.

2.3.4 Reservoir Capacity

Of immediate concern to the planned operation of a 40 MW(th) 5 MW(e) "pilot" plant is the adequacy of the present three wells. These must supply 4500 gpm allowing 2000 gpm of 290°F water, preferably 2200 gpm, for contingency. Tables VIII, IX, and X summarize the results as known to date, inferring a reservoir area of only 5 square miles, all within one mile of the present three wells. The reservoir is probably much larger, perhaps an order of magnitude or more. Yet with what is now known over five square miles, the thermal loop could be operated for 100 years or more.

2.3.5 Closed Loop Pump Test

A closed loop reinjection test was run between wells RRGE-1 and RRGE-2. Well RRGE-1 discharged water at an average rate of 340 gpm for 50 minutes. The outlet pump pressure into RRGE-2 was about 260 psi. The quantity of water reinjected was deliberately limited so that for this brief test, no water from the No. 1 well would actually reach the formation within the No. 2 well. The 50 minute test only replaced water in the upper ~2500 ft of the casing.

2.3.6 Interference Measurements

Monitoring of the artesian flow from wells 155 26E 2366C1 (BLM well) and 15S 26E 23ddc1 (Crank Well) have been routinely conducted, during the periods that the deep geothermal wells were producing significant fluids. Historic data on the BLM well show a flow measurement in 1972 by the Idaho State Department of Water Resources at a rate of 58 gpm. Historic data on the Crank well show the first flow measurement in 1952, by the USGS, at a rate of 26.9 gpm. Current measurements on both wells show similar discharge rates, and have shown only minor variations (presumably due to seasonal changes in artesian reservoir head) over the two years that INEL has monitored the flow rates.

2.3.7 Tritium Analysis of Wells

The tritium concentration in the well water has been of interest, despite the difficulty of making the measurement on such small concentrations. The interest is principally because tritium levels occurring naturally in meteoric (rain) water rose by about a factor of 100 with the start of the H-bomb testing in 1952. Samples were drawn in February from the first and second deep wells, and from the Crank well for analysis of tritium. This had been attempted before, but the laboratory analyses at that time were distorted by background. Two sets of analyses were run, one at a commercially available laboratory, and another sampled by the USGS for analyses in their own laboratory.

TABLE VIII

DEDUCTIONS OF CHARACTERISTICS OF AQUIFER IN AND AROUND PRESENT 3 WELLS

TOTAL "RESERVOIR" THICKNESS = 1200 FT AVERAGE

#1 3700' TO 4600' = 900'

#2 4250' TO 6000' = 1750'

#3 4250' TO 5600' = 1350'

EFFECTIVE PERMEABLE PRODUCING THICKNESS = 600 FT

(VARIOUS ESTIMATES FROM TEMPERATURE LOGGING WOULD GIVE RESULTS FROM 300 TO 800 FT.)

POROSITY IN PERMEABLE REGION = 15% FOR WATER

(TOTAL POROSITY = 20%)

APPARENT EXTENT OF RESERVOIR WITH THESE CONDITIONS IS AT LEAST 3 TO 6 SQ MILES (USE 5 SQ MILES)

TOTAL WATER CONTAINED IN THE RESERVOIR AS DESCRIBED ABOVE IS 288,000 ACRE FT.

TABLE IX

WATER INPUT AND ANNUAL FLOW COMPARISONS

SOUTHERN RAFT RIVER VALLEY
(WITHIN 10 MILES OF PRESENT GEOTHERMAL WELLS)

TOTAL ANNUAL PRECIPITATION	400,000 ACRE-FT
ESTIMATED ANNUAL EVAPOTRANSPIRATION	360,000 ACRE-FT
NOMINAL RAFT RIVER ANNUAL RUN-OFF	40,000 ACRE-FT

NEAR-SURFACE (DOMESTIC-IRRIGATION) AQUIFER CAPACITY (Ø = 0.2)

12 MILLION ACRE FT
(200′ TO 500′ DEEP)

ESTIMATED CAPACITY BELOW NEAR SURFACE AQUIFER, BUT ABOUT
GEOTHERMAL AQUIFER = 50 MILLION ACRE-FT (MINIMUM) (Ø = 0.1)

INFERRED CAPACITY OF PRESENTLY KNOWN GEOTHERMAL AQUIFER
= 288,000 ACRE-FT

(BASED ON ASSUMPTION OF NO INFORMATION BEYOND
ONE MILE FROM ANY OF PRESENT WELLS.)

TABLE X

RE-INJECTION ZONE

2000 GPM

INTO PREVIOUSLY ASSUMED RESERVOIR (600 FT, 0.15 POROSITY)

3 YEARS, 70% OPERATION, ZONE OF SPREADING IS TO A RADIUS OF 352 FT

140°F WATER INTO SUCH A WELL DROPS TEMPERATURE 42°F, DOWN TO 250°F, AVERAGE IN THE PERMEABLE ZONES, WHILE THE INBETWEEN ZONES ONLY GRADUALLY COOL OFF, SIMULTANEOUSLY HEATING THE PERMEABLE ZONES.

ALLOWING FOR SUCH 50°F COOLING, THE RESERVOIR OVERALL CONTAINS ENOUGH HEAT CAPACITY FOR <u>PHASE I</u> IN 0.045 SQUARE MILES, 29 ACRES - - AND FOR <u>PHASE II</u> IN 0.13 SQUARE MILES, 83 ACRES. (THE LATTER REPRESENTS A RADIUS OF 633 FT, IF FROM A SINGLE WELL.)

The commercial analyses results were:

	Pico Curies/liter
RRGE-1 (after six months flowing at 200 gal/min)	8.3 ± 1.6
	7.5 ± 1.3
RRGE-2 (after all winter at 20 gal/min)	9.9 ± 1.8
	10.0 ± 1.9
Crank Well	11.0 ± 2.2
Site Domestic Well	6.7 ± 1.8

Since the advent of the H-bomb test in 1952, tritium levels in meteoric water have been in the range of 600 to 10,000 pico Curies/liter. The normal levels prior to 1952 were 16 to 50 pico Curies/liter.

Interpreting the meaning of the above results is difficult. Obviously, the water was all of pre-1952 meteoric origin, since only two half lives have elapsed since that time. That is insufficient time for post H-bomb meteoric water to decay to these levels. Yet if these results represent pre-H-bomb levels, the half life of 12.3 years makes it difficult to explain such high results, unless fortuitously all the water was only 30 to 50 years old, and began as 50 pico Curies/liter activity, not the lower 16 pico Curies/liter. This result would indeed be fortuitous, particularly when the same result was obtained for the shallow (200 ft) domestic well. Such a postulate is therefore discarded as being highly unlikely.

The USGS results have been unofficially reported as nominally equal to background in their lab of 0.5 pico Curies/liter. These data would therefore indicate that the water is very old, with negligible residual tritium from its meteoric origin. It is therefore concluded that the magnitude of the commercial lab results are questionable, but it can be concluded that all the water is of pre-1952 origin.

2.4 ENVIRONMENTAL PROGRAM

W. W. Hickman, S. G. Spencer

A draft report of the baseline environmental analysis was completed in March and will be published as a set of environmental reports, about June 1977. The drafts of this report have been sent out for initial review. The main report includes supplementary analysis and data reports from the several universities participating.* These reports address the immediate environmental effects of a 40 MW(th) thermal loop facility. Included are a characterization of the environment, identification of critical areas, the description of the proposed actions, and recommended development strategies.

A socioeconomic study of the Raft River Valley was initiated under a contract to the Battelle Human Affairs Research Center of Seattle in January. Designed to provide input to the environmental reports, this study is also intended to aid planners and developers in the Valley and to contribute to the growing body of research on energy-related social impacts in rural areas. The three major tasks included in this study are: 1) an examination of information on existing conditions; 2) an estimation of the potential impacts within the area; and 3) an identification of alternative planning strategies for the prevention or amelioration of undesirable effects.

In conjunction with Battelle's study, a questionnaire designed to assess attitudes of Valley residents was presented at the Raft River Coop's Annual Meeting. Nearly 140 responses to the questionnaire were received (representing 50% of the families in the Valley). Of those responding, nearly all were in favor of geothermal development in the Valley and felt that the development should proceed without delay.

A series of chemical analyses have been completed, including an extensive set of measurements on harvested crops and soils, to determine the effect of using geothermal water for irrigation. Those results are summarized in Section 2.5. In addition, corroborating on-site measurements of toxic materials including mercury, hydrogen sulfide, ammonia, fluoride, and arsenic were made by the Battelle Pacific Northwest Laboratory. The results of their analyses are shown in Table XI. The mercury, arsenic, hydrogen sulfide and ammonia were quite low--nearly a factor of 100 lower than that found at Cerro Prieto. Battelle's initial conclusion from these results was that fluoride may be the only potentially harmful effluent on site. A similar conclusion was previously reached from INEL data, reported in ANCR-1247, Quarterly Report, April 1 to June 30, 1975.

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* University of Utah Research Institute - Air quality base-line information and plant environment

Idaho State University - Animal baseline studies
Brigham Young University - Insect populations in the area
Utah State University - Soil baseline data plus cattle baseline conditions

TABLE XI

TOXIC MATERIALS* - RAFT RIVER WELLS

DIRECT CONCENTRATIONS MEASURE FROM FLASHED SAMPLES

	Non-Condensible Gas	Steam Condensate	Brine
H_2S	215 ppm	0.66 ppm	0.1 ppm
Hg	39 ng/l	128 ng/l	8; 35 ng/l
As	--	800 ng/l As^{+3} 11,400 ng/l As^{+5}	2,800 ng/l As^{+3} 24,900 ng/l As^{+5}
F^-	--	0.04 ppm	9.8 ppm
NH_4^+	--	1.9 ppm	0.29 ppm

Steam/brine = 1/14 by weight

Non-condensible gas/steam = 0.02% by volume at STP.

* Data obtained by Battelle Northwest Laboratory

Related to fluoride, Utah State University completed a survey of cattle in the Valley that are exposed to high fluoride waters. Some of the animals examined indicated long-term fluoride ingestion of levels damaging to teeth. Because human tolerance to excessive fluoride ingestion is generally believed to be much lower than that of domestic or wild animals, it was recommended that a survey of the Valley residents and culinary water supplies in the area be undertaken. Recommendations on best water sources, fluoride effects, and fluoride intake alleviation procedures would follow such a survey. This work is considered baseline since the fluoride levels to date in the Valley have no relations to the recent man-made geothermal activity.

The University of Utah Research Institute operated an air quality monitoring trailer downwind of RRGE-1 and RRGE-2 for two weeks in December. The intent was to measure "pollutants" from the steam plumes and reserve pits. The results, shown in Table XII, indicate relatively low concentrations of the constituents monitored--concentrations that would be expected in background measurements. Only the hydrogen sulfide and sulfur dioxide measurements may have been influenced by the proximity of the geothermal wells, but these values are still well below guideline levels. (Note: only occasionally can the smell of H_2S be detected by the site work force, usually right at the edge of a reserve pit, or when fresh geothermal water is released into an enclosed laboratory. The integrating nephelometer observations shown in Table XIII suggest that the prevailing visibility in the area was restrictive to less than 32 km (20 miles). This could be accounted for by locally restrictive steam and fog from the wells. Results from an automatic camera located at RRGE-1 have been analyzed. Initial results from companion nuclepore filters indicate that at times when landmarks were only partly visible or obscured with haze, there were substantially increased concentrations of sulfate particles. This adds credence to the hypothesis that pollutants from the Wasatch Front (100 miles southeast) were moving into the Valley through Kelton Pass, and that this source, not the geothermal wells, is the main source of airborne pollution in winter. (During the summer, wind-blown dust from farming activity becomes the main airborne pollutant source).

The microseismic telemetry system is now operating at the environmental station. Three locations were established for the microseismic systems and the geophones temporarily set at a depth of 3 meters (10 ft). Results from an initial monitoring period will determine where the fourth station will go and how deep the geophones should be permanently set to reduce surface "noise" effects.

The biological baseline surveys conducted by Idaho State University, University of Utah Research Institute, Brigham Young University, Utah State University, and private consultants have been completed. The surveys indicate that, in general, geothermal development will not effect critical habitat areas in the Valley. The U.S. Fish and Wildlife Service has recommended buffer zones around these critical habitats, including that of the Ferruginous Hawk. These recommendations will be taken into account in locating future development in the area. The results of the biological surveys have been summarized in the environmental reports. The detailed biological reports are on file with the Geothermal Programs office and are available on request.

TABLE XII

24-HOUR AVERAGE CONCENTRATION OF VARIOUS ENVIRONMENTAL POLLUTANTS NEAR GEOTHERMAL WELL NO. 2 AT RAFT RIVER, IDAHO

Dates	Sulfur Species ug/m^3	Sulfur Spe (-) SO_2 ug/m^3	H_2S* ug/m^3	SO_2 ug/m^3	Am. Sulfate ug/m^3	Am. Sulf. Converted to SO_2 ug/m^3	NO_2 ug/m^3	NO ug/m^3	NO_x ug/m^3	O_3 ug/m^3	Nephelometer Visibility Miles
12(17-18)76	49.40	36.30	19.25	12.48	1.25	.605	3.23	.25	3.48	58.9	13.4
12(22-23)76	36.40	22.50	11.94	13.52	.74	.358	6.08	0	6.08	61.9	11.2
12(29-30)76	14.30	6.24	3.30	7.80	.54	.261	3.61	.75	4.36	37.9	13.2
11(3 - 4)77	16.90	14.67	7.77	2.08	.32	.155	3.04	.13	3.17	66.4	16.4

* = Sulfur Species (-) SO_2 mathematically converted to H_2S

1. Sulfur Species was monitored by Meloy sulfur dioxide analyzer Model SA 160-2.
2. Ozone was monitored by Meloy ozone analyzer Model OA 350-2R.
3. Visibility was measured by Meleorology Research, Inc. (MRI) Nephelometer, Model 1550.
4. Sulfur dioxide was measured colorometrically by the modified West Gaeke (pararosaniline) method of Scaringelli et al. Analyt. Chem. (1967) 39, 1709-19.
5. Oxides of nitrogen was measured by colorometric method of NASH. Atmos Environ., (1970), 4, 661-6.

Table Prepared by: W. O. Ursenbach, W. H. Edwards, A. Soleimani - University of Utah Research Institute

TABLE XIII

MEASURE AIRBORNE POLLUTANTS NEAR RRGE-2

(24 hours average concentration of various environmental pollutants near geothermal well No. 2 at Raft River, Idaho

Dates	Sulfur Species ug/m3	Sulfur Spe (-) SO_2 ug/m3	H_2S* ug/m3	SO_2 ug/m3	Am. Sulfate ug/m3	Am. Sulf. Converted to SO_2 ug/m3	NO_2 ug/m3	NO ug/m3	NO_x ug/m3	O_3 ug/m3	Nephelomet Visibility Miles
12(17-18)76	49.40	36.30	19.25	12.48	1.25	.605	3.23	.25	3.48	58.9	13.4
12(22-23)76	36.40	22.50	11.94	13.52	.74	.358	6.08	0	6.08	61.9	11.2
12(29-30)76	14.30	6.24	3.30	7.80	.54	.261	3.61	.75	4.36	37.9	13.2
11(3 - 4)77	16.90	14.67	7.77	2.08	.32	.155	3.04	.13	3.17	66.4	16.4

* = Sulfur Species (-) SO_2 mathematically converted to H_2S

1. Sulfur Species was monitored by Meloy sulfur dioxide analyzer Model SA 160-2.
2. Ozone was monitored by Meloy ozone analyzer Model OA 350-2R.
3. Visibility was measured by Meleorology Research, Inc. (MRI) Nephelometer, Model 1550.
4. Sulfur dioxide was measured colorometrically by the modified West Gaeke (pararosaniline) method of Scaringelli et al. Analyt. Chem. (1967) 39, 1709-19.
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