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THE GEOTHERMAL POTENTIAL FOR COMMERCIAL AND INDUSTRIAL DIRECT HEAT APPLICATIONS IN SALIDA, COLORADO

Final Report

By
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Jay D. Dick
Michael J. Galloway
James T. Gross
Richard T. Meyer
Rob Raskin
John R. Zocholl

MASTER

October 1982

Work Performed Under Contract No. FC07-81ID12192

Chaffee Geothermal, Ltd.
Denver, Colorado

and

Western Energy Planners, Ltd.
Aurora, Colorado

Technical Information Center
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United States Department of Energy

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Idaho Operations Office

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To conduct this study, a team approach was used, with several sub-contractors contributing their expertise, and their efforts are greatly appreciated by Chaffee Geothermal, Ltd., the prime contractor. Chaffee was responsible for overall administration and coordination, for the geothermal resource assessment and reservoir testing design, and for the final study report. The extensive graphics were the responsibility of Max Piaseck of Chaffee Geothermal, Ltd. Western Energy Planners, Ltd. was responsible for the engineering design, economic analysis, and the environmental and institutional analyses. Michael J. Galloway, Consultant, was responsible for preparation of the detailed reservoir testing plan, and Barbara A. Coe, Consultant, was responsible for compilation of progress and final reports on the project and under WEPL, for conducting environmental and institutional analyses.

In addition, many others willingly provided ideas and information that were essential to accomplish this study. They include both public and private officials. Although they are too numerous to mention individually, their assistance is very much appreciated.

Abstract

The Salida Geothermal Prospect (Poncha Hot Springs) was evaluated for industrial and commercial direct heat applications at Salida, Colorado, which is located approximately five miles east of Poncha Hot Springs. Chaffee Geothermal, Ltd., holds the geothermal leases on the prospect and the right-of-way for the main pipeline to Salida.

The Poncha Hot Springs are located at the intersection of two major structural trends, immediately between the Upper Arkansas graben and the Sangre de Cristo uplift. The hot springs are astride a horst of Precambrian rocks that is thought to divide a once continuous structural trough connecting the San Luis Valley with the Upper Arkansas graben. Both of these depressions are apparently related to the Rio Grande Rift zone and represent the northernmost identifiable extent of the zone. Prominent east-west faulting occurs at the actual location of the hot springs. Preliminary exploration indicates that 1600 gpm of geothermal fluid as hot as 250°F is likely to be found at around 1500 feet in depth. Possible direct heat applications of the geothermal supply system that were considered in the analysis included the following endusers:

<u>Existing</u>

- Fish hatchery
- Egg ranch
- Motels and pools
- Municipal pool
- Senior citizens residence
- Nursing home
- High school
- Commercial greenhouse
- Office buildings
- Townhouses
- City of Salida
- Chemical plant (zinc processing)

<u>Future</u>

- Industrial park
- Motel convention center
- Office buildings
- Townhouses

The prospective existing endusers were estimated to require 5.02×10^{10} BTU per year, but the total annual amount of geothermal energy available for existing and future endusers is 28.14×10^{10} BTU. The engineering design for the study assumed that the 1600 gpm would be fully utilized. Some uses would be cascaded and the spent fluid would be cooled and discharged to nearby rivers.

An examination of the wide range of laws and regulations controlling geothermal energy exploration, production and distribution in Colorado indicated that no significant institutional barriers are anticipated. Similarly, no difficult environmental problems are expected. A possible need to schedule drilling to avoid the deer fawning season can be accommodated. Since geothermal fluids are expected to be similar in quality to the 654 mg/l TDS spring fluid, use, discharge and possible fluid leakage should not be problematic. In any case, all activities must conform to environmental laws and accepted practice.

The economic analysis assumes that two separate businesses, the energy producer and the energy distributor, are participants in the geothermal project. The producer would be an existing limited partnership, with Chaffee Geothermal, Ltd. as one of the partners; the distributor would be a new Colorado corporation without additional income sources.

Economic evaluations were performed in full for four cases: the Base Case and three alternate scenarios. Alternate 1 assumes a three-year delay in realizing full production relative to the Base Case; Alternate 2 assumes that the geothermal reservoir is of a higher quality than is assumed for the Base Case; and Alternate 3 assumes a lower quality reservoir. Mid-1981 natural gas prices in Salida ranging from $4.45 to $4.85 per MMBTU were projected to increase 26 percent annually through 1985. When geothermal production begins in mid-1984, natural gas would then sell at twice the current rate, or $9.25/MMBTU.

For the Base Case, the assumed first-year geothermal price is 70% of natural gas prices, or $6.50/MMBTU, which would escalate at the general inflation rate. The projected annual inflation rate is initially 9% before dropping off to 6%. Because natural gas prices escalate faster than geothermal energy prices, the customer would save increasingly over the life of the project. Under the described assumptions, geothermal would be priced at 60 percent of natural gas levels by 1985 and 50 percent by 1992.

The Base Case return on investment for the distributor is nominally set at 17 percent. The producer's rate of return is calculated. The distributor's equity is assumed to be 50 percent of its capital costs, with long-term financing providing the remaining 50 percent. The equity portion for the producer is assumed to be 100 percent.

As the summary shows, the Base Case yields a 1984 producer-to-distributor price of $4.35/MMBTU and a discounted cash flow rate of return for the producer of 31 percent.

Economic Results Summary

	Base Case	Alternate 1 (Production Delay)	Alternate 2 (Better Resource)	Alternate 3 (Poorer Resource)
Producer DCFROR	31%	20%*	39%	16%
Distributor DCFROR	17%	15%*	20%	13%
1984 Consumer Price (1984 Dollars)	$6.50/ MM BTU	$4.86/ MM BTU	$4.62/ MM BTU	$8.32/ MM BTU
1984 Producer to Distributor Price (1984 Dollars)	$4.35/ MM BTU	$2.62/ MM BTU	$3.86/ MM BTU	$4.22/ MM BTU

*Exogenous variable. All other values are determined by calculation.

The DCFROR varies up and down depending upon the parameters assigned to the alternate cases. Given the expected conditions, the prospect appears to be a very attractive financial venture.

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Section I

SUMMARY AND CONCLUSIONS

Based on this analysis, geothermal energy production for commercial and industrial direct heat applications in Salida, Colorado, would be profitable. The expected discounted cash flow rate of return is of a magnitude normally attracting capital in similar circumstances, given the assumptions of the analysis. The key assumptions, conditions, and findings are described in this section for each of the major areas of concern: resource assessment, engineering, economic analysis, environmental analysis, and institutional analysis. Then the conclusion of the analysis as a whole is indicated, along with a summary of projected subsequent activities.

A. Geothermal Resource Assessment

Geothermal Prospect

The geothermal prospect being considered in this study is the Salida geothermal prospect, located in the Upper Arkansas Valley of south-central Colorado, as shown on Figure 1. It has long been considered to have potential for extensive use. Chaffee Geothermal, Ltd. began exploring the area for geothermal resources in 1974 and subsequently acquired 9500 acres of geothermal leases, with the intention of producing energy for sale to commercial and industrial enterprises in and near the City of Salida, Colorado.

Since the 1930's, geothermal fluid has been piped about five miles from the geothermal springs known as Poncha Hot Springs to the City of Salida for use in their municipal pool. Currently

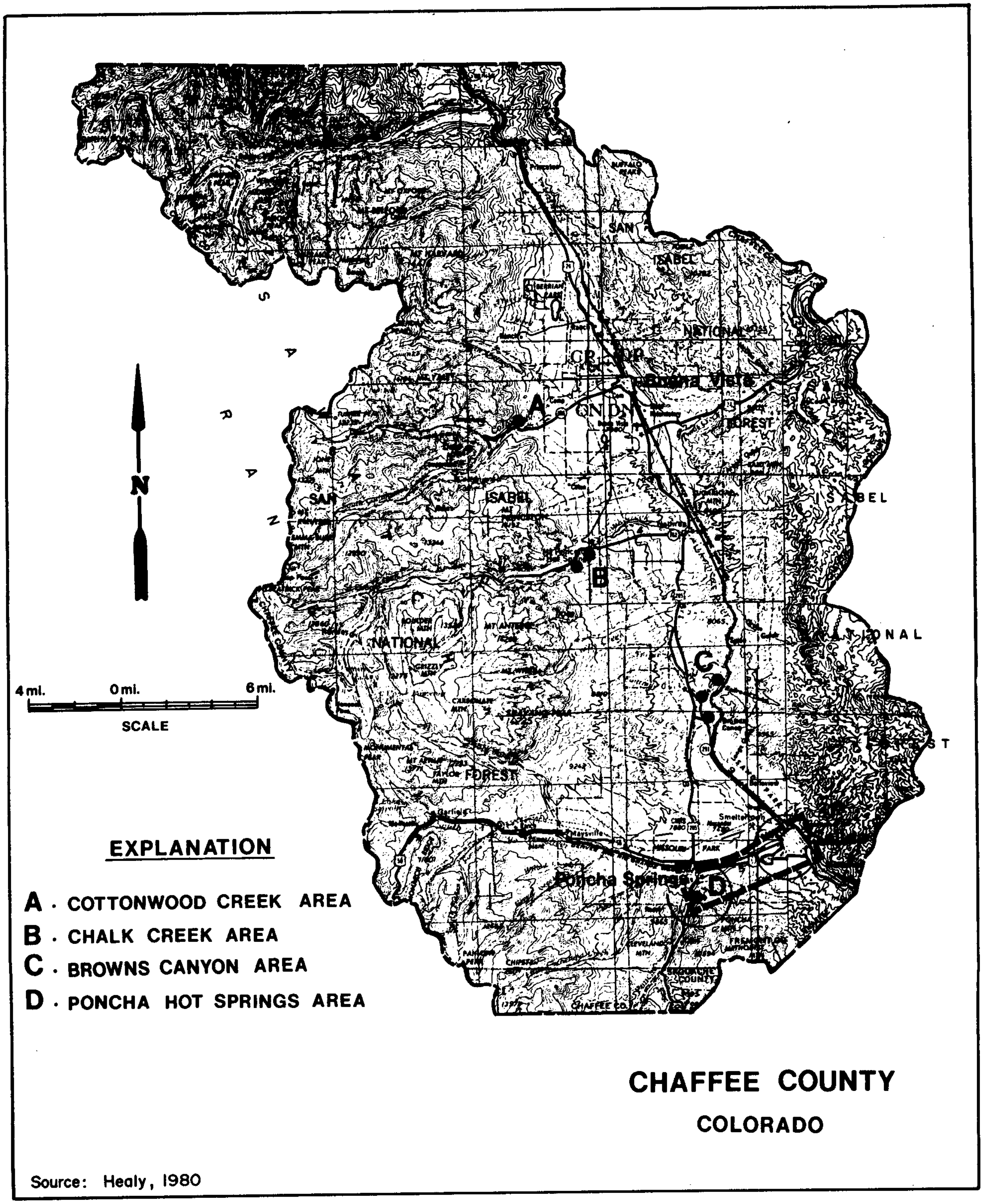


FIGURE 1

Location of Poncha Springs & Salida

there are no wells but rather a gathering system that collects spring waters from a number of springs. The temperature of these spring waters measures up to 160°F at the gathering site. After transmission to the pool in uninsulated pipe, the temperature decreases to approximately 100 to 110°F. The spring water is exceptionally pure (654 mg/l TDS). No significant corrosion or scaling of the pipeline has been experienced.

Based on the tests that have been conducted thus far, the geothermal resource available by drilling wells is expected to yield temperatures up to 250°F and produce as much as 1600 gallons per minute (gpm) of fluid. A resource of this quality and magnitude could satisfy a variety of industrial and commercial heat requirements, at the same time enhancing the economic development of a community very interested in such development.

Resource Investigations

Review and analysis of available published data provided a preliminary understanding of the Poncha Springs geothermal potential. More importantly, an extensive geological evaluation of the geothermal resource was conducted by Jay Dick, now President of Chaffee Geothermal, Ltd., in 1976. Subsequently, Chaffee Geothermal, Ltd. obtained geological and exploration data from a major oil company through a farmout with them. Although additional investigations are necessary in order to target a drill site and confirm the extent and quality of the reservoir, the preliminary findings are most encouraging.

Geology. The Upper Arkansas Valley in which the prospect is located is generally believed to be a part of the Rio Grande Rift system that extends from northern Mexico to Leadville, Colorado, along which numerous geothermal systems are found. This line of reasoning envisions a dynamic environment wherein the tectonic plate west of the Rift is moving west more rapidly than the tectonic plate east of the Rift.

Rocks of Precambrian, Tertiary, and Quaternary age outcrop in the Poncha Springs area. Precambrian igneous and metamorphic rocks form the core of uplifts surrounding the valley graben which is known as the Upper Arkansas Graben. The tertiary rocks, lying directly on the Precambrian, consist of three volcanic units and the sedimentary Dry Union Formation. Quaternary formations are alluvial, fluvial, and moraine deposits.

Prominent folds of Precambrian age trend northeast, interpreted by one investigator to be analogous with the modern San Andreas system. Minor local folds are indicated in the Tertiary sediments within the valley, among them a large regional fold, the Sawatch anticline. Tectonics exhibit north-trending horsts and grabens in an east-west tensional environment. Indications of very deep crustal faulting and fracturing favor geothermal systems, both magmatic bodies and deep circulation of meteoric waters.

Exploration. Water from Poncha Hot Springs was sampled and analyzed. Temperatures predicted from geothermometry models range from 248°F to 392°F. The lower number was obtained from the non-mixing model whereas the higher number was obtained from the silica mixing model. Considerable mixing of cold water with ascending hydrothermal fluid is thought to occur through as much as 1,000 feet of unconsolidated Dry Union sediments.

Temperature gradients ranging from 3.1 to 3.6°F per 100 feet were measured. Estimates of heat flow range from 1.7 heat flow units (HFU) (just slightly over the normal 1.5 HFU), at three of the sites to 6.5 HFU at one site. Although only four heat flow holes (too few for conclusive evaluation) were drilled, analysis of the results suggest that anomalous heat flow is confined to the Precambrian rocks and its contact with the Dry Union Formation.

Gravity surveys support the interpretation of major east-trending faults at Poncha Hot Springs. In resistivity surveys, receiver station density was inadequate to support accurate resistivity contouring near Poncha Springs, so contours reflect outcropping of crystalline versus unconsolidated formations. Higher resistivities are shown overlying the Precambrian rocks; lower resistivities (as low as 5 ohm-meters) are shown in the Dry Union and Quaternary sediments.

Conclusion. Findings of geological, geochemical, and geophysical investigations indicate that a geothermal resource of low salinity water at 250°F may be located within faults and fault intersection conduits beneath Poncha Hot Springs. No compelling evidence is found for shallow magmatism; rather, the heat source is considered to be an anomalous geothermal gradient.

Proposed Exploration Program. Further exploration will be required prior to test drilling the geothermal prospect at Poncha Springs. Structural, tectonic, and subsurface geological modeling are necessary. Simultaneous detailed gravity and soil mercury surveys should be conducted. Additional electrical resistivity surveys would help delineate fault zones and outline the areal extent of the thermal anomaly by indicating electrical conductance. Schlumberger depth soundings would help understand the vertical profile. Finally, six shallow (300 feet) temperature gradient holes should be drilled at locations determined from previous analyses. An existing computer program will then be used to help analyze the data to reveal an accurate geological model of the prospect area.

B. Reservoir Testing

Reservoir testing for the Salida Prospect will consist of three phases: a short-term single-well test; a long-term single-well test; and long-term multi-well tests. The short-term test includes pumping or flowing the well and measuring the extent to which the water level is lowered and the magnitude of the fluid recovered. The long-term single-well test will help determine the extent of the geothermal resource and the amount of fluid and pressure that can be expected over the long run. It involves testing the well for a longer period of time. The long-term multi-well test will consist of pumping one well and monitoring the well drawdown and fluid recovery in all the other wells using methods similar to those used in the other tests.

C. Exploration Drilling and Well Engineering

The specific location for a first exploratory well to be drilled at Poncha Springs would be determined following additional preliminary exploration studies. Based on several assumptions and known data, a site has tentatively been selected, however. The location is shown on Figure 2. Estimated depth is 1500 feet. The well will be cased to depth with minimum 8-5/8 inches outside diameter (OD) production casing to allow for the possible need for a pump. The well will either be completed as open-hole or a slotted liner will be set through the formation from which the fluid is produced.

The drilling procedure will require drilling with mud to 160 feet, setting casing and cementing, then drilling out. Drilling would then continue to depth, using air, foam or produced geothermal fluids. The hole would be reamed out to 11 inches in diameter. About 1450 feet of casing would be set, then the hole completed as open-hole or lined with slotted liner. Projected drilling costs are $176,000 for the first exploration well.

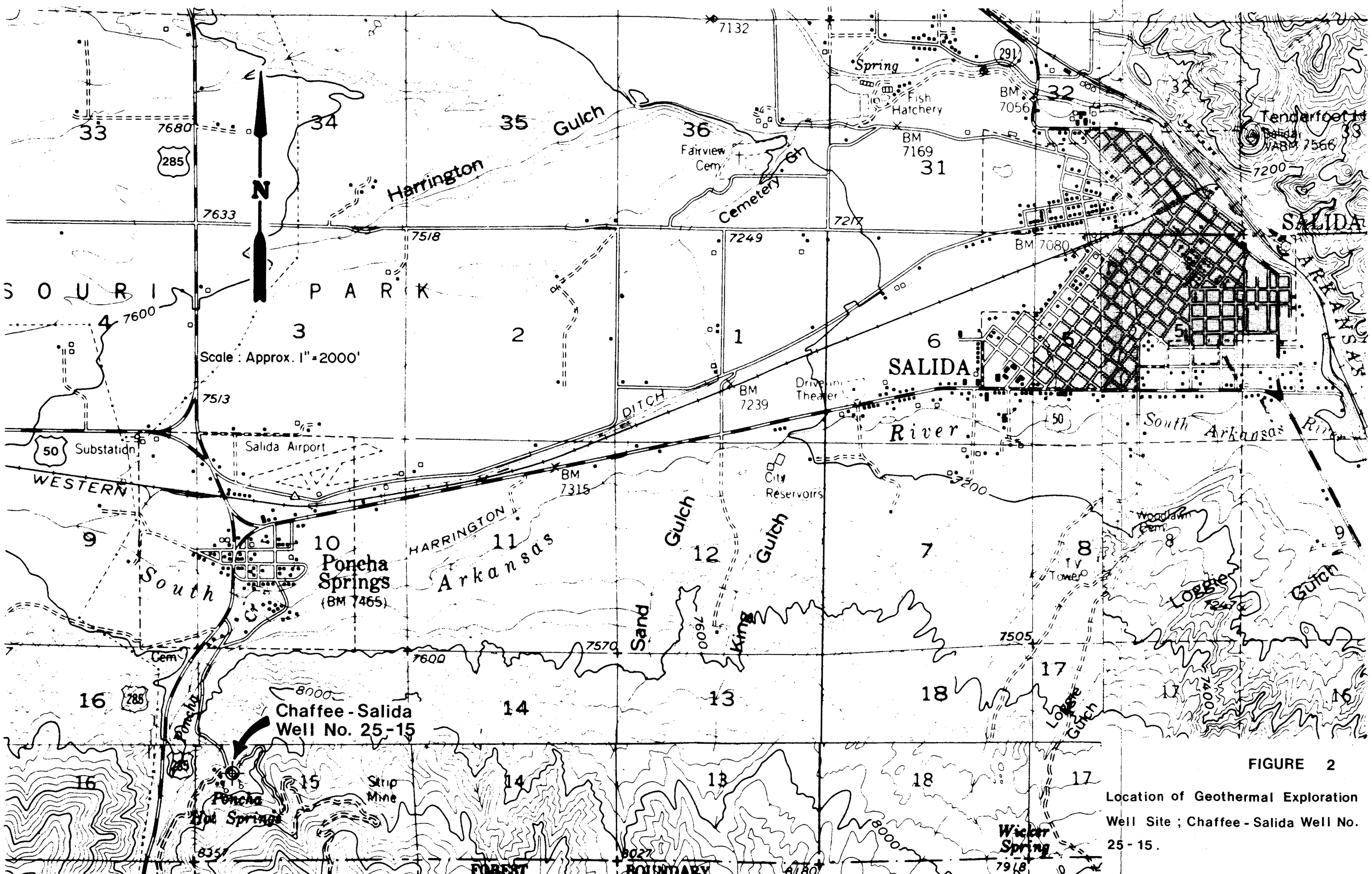


FIGURE 2

Location of Geothermal Exploration Well Site ; Chaffee - Salida Well No. 25 - 15 .

D. System Engineering

Design Objectives

The engineering design for this geothermal prospect provides for use of 100 percent of the expected geothermal energy rather than for use only by specific existing or expected endusers. This system can, therefore, accommodate a sizeable increase in demand, based upon future industrial and commercial development in Salida. Such development is a goal of the community. As a consequence of the year-around energy demands of commercial and industrial energy users, the system is designed for year-round use.

System Description

Overview. In the design for the geothermal system, geothermal fluid is pumped from four wells to be drilled to about 1500 feet in depth near Poncha Hot Springs. A fifth well provides backup. Each well produces about 400 gpm of fluid at 250°F. Pumps are controlled by demand, so that they only operate when needed, thus limiting costs for electricity. Peak capacity is about 8.4×10^{11} Btu/yr. as shown later in the report (Table 4).

A major transmission pipeline carries the geothermal fluid along the existing pipeline right-of-way into Salida. Branch lines are routed to a planned industrial park and routes to other users were selected because they are most direct or are along existing rights-of-way. The industrial park branch crosses the Arkansas River via a buried pipeline.

Spent geothermal fluid is, in the design, discharged into the Arkansas and South Arkansas Rivers at three separate outlet points after being cooled in two cooling towers and an existing cooling pond.

System Design. The fiber glass reinforced plastic (FRP) pipe used for the pipeline is sized to accommodate all the fluid forecast to be available. Branch lines to existing users were sized for their peak demands. Figure 3 is a schematic of the system which shows the sizes of the lines serving each of the users.

The transmission line is, as indicated, sized for 100 percent of the expected available geothermal energy and to meet the peak energy demand for the potential endusers listed in Table 1. As shown in the table, the total estimated peak demand is 445 gpm, leaving an estimated 1155 gpm available for additional users. The fluid is cascaded from some users to others.

As shown on Figure 3, the geothermal fluid is cascaded at Branches No. 2 and 3B in order to accommodate the peak demands of the various facilities.

In the design, four circulating pumps, connected in parallel, pump the geothermal fluid to Salida; a fifth is available for back-up. Each can pump 400 gpm at 250 feet of head. A control valve at the enduser regulates the flow in the main supply line to cycle pumps on or off as needed.

Low demand periods will require bleeding off small amounts of geothermal fluid. A thermostatically-controlled flow control valve will regulate the amount bled off at the end of each branch line. Because the minimum demand for the potential endusers is estimated to be 457 gpm, it would probably be necessary to discharge 65 gpm, from Branch No. 3B but none from the other branches.

A BTU meter measures the delivered and departing temperatures plus the flow rate of the fluid to calculate BTU's consumed for billing purposes.

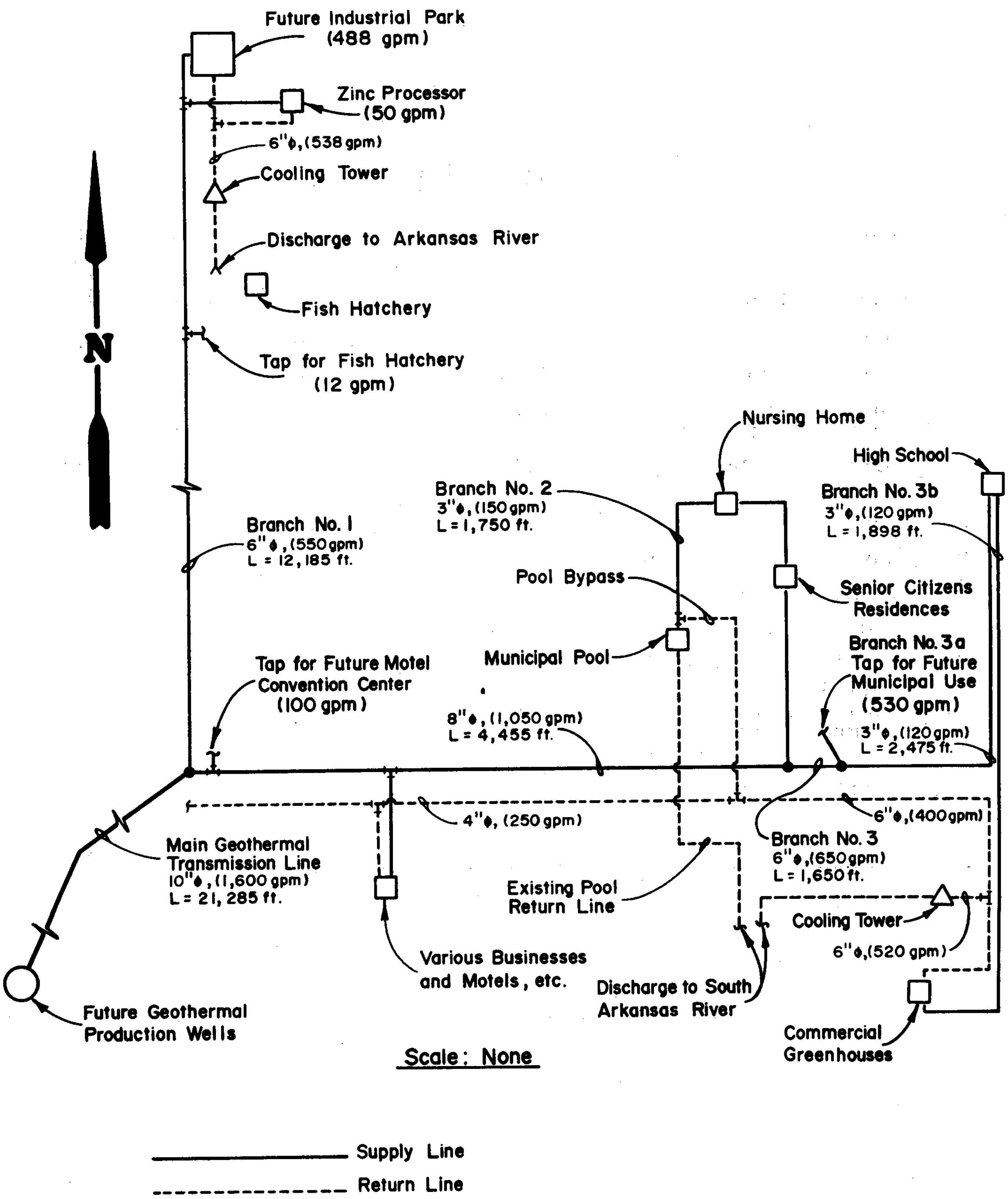


FIGURE 3

Schematic of Geothermal Transmission Pipeline Distribution System

Table 1

Summary of Peak Energy Demands
for Selected End Users in Salida

Institution/Business Name	Energy Consumption (MMBTU/yr)	Peak Load (MMBTU/hr)	T(°F)	Peak Demand (GPM)
Denoyers Greenhouse	7098.4	3260.4	55	120
Salida High School	8136.0	3737.0	65	120
Mt. Shavano Manor Senior Citizens Center	3502.9	1608.9	55	60
Columbine Manor Nursing Home	2450.1	1125.4	40	60
Municipal Pool	-	1925.0	65	60
Mt. Shavano Fish Hatchery	1484.8	682.0	120	15
Western Holiday Motor Hotel	2467.1	1133.2	40	60
Bureau of Reclamation	780.0	358.3	40	20
CoZinCo (includes space heating, low temperature process, and preheat of high temperature process only)	Unknown	3000.0	120	50
Future motel Convention Center				100

System Costs

Capital. The total capital costs for the construction of the geothermal transmission and distribution systems are estimated to be $2,476,456 (a portion of these costs are the financial responsibility of the producer). The component costs are summarized in Table 2, and described in detail in Section IV.

Operating and Maintenance. Operating and maintenance costs to the producer are estimated to vary from $120,500 for 1982 to $158,955 for 1986 as shown in Table 3 which summarizes the operating cost components.

For the distributor, operating and maintenance costs are estimated to be $75,000 per year for each year from 1983 to 1986.

Alternative System Designs

Three alternate system designs were also considered in the analysis. In Alternate No. 1, there are no changes in the resource or engineering parameters; the only change is an assumption of full scale resource production in 1989 instead of 1986. In Alternate No. 2, the resource and engineering parameters are changed as follows: a well pump depth of 250 feet, resource temperature at the surface of 290^{o}F, a total flow of 1500 gpm, three production wells plus one backup/replacement well, a total peak capacity of 10.5 X 10^{11} BTU/year, 45% system utilization, and a preinsulated transmission line. The remaining resource and engineering parameters remained unchanged. For Alternate No. 3, the resource and engineering parameters are changed as follows: a well pump depth of 500 feet, a resource temperature at the surface of 210^{o}F, a total flow of 1000 gpm, a total peak capacity of 3.5 X 10^{11} BTU/year, a system utilization of 30 percent, and the transmission line scaled down in size for the reduced flow. The remaining resource and engineering parameters remained unchanged. See Table 4, Summary of Resource, Engineering, Economic and Production Schedule Parameters for Four Geothermal Systems.

Table 2

Summary of Component Costs for Production and Transmission Systems

Well Pumps (producer)	$278,300
Collection System (producer)	125,000
Circulating Pumps (distributor)	36,034
Electrical Transmission (producer)	10,000
Transmission Line (distributor)	2,027,122
	$2,476,456

Table 3

Summary of Operating Costs

Summary of Operating Costs Including Maintenance, Insurance, Administration, Overhead and Electrical Costs (1981 Dollars).

Energy Producer

Year	Prorated Overhead and Administration Costs	Operating and Maintenance Costs
1982	$120,500	$ 0
1983	95,000	0
1984	67,000	16,119
1985	30,000	96,716
1986	30,000	128,955

Energy Distributor

Year	Prorated Overhead and Administration Costs	Operating and Maintenance Costs
1983	$ 75,000	$ 0
1984	75,000	26,789
1985	75,000	45,782
1986	75,000	53,379

Table 4

Summary of Resource, Engineering, Economic and Production Schedule Parameters for Four Geothermal Systems Assumed Values

Parameters	Base Case	Alternative I	Alternative II	Alternative III
A. Resource				
1. Well Depth	1500'	1500'	1500'	1500'
2. Pump Depth	750'	750'	250'	500'
3. Temperature	250°F	250°F	290°F	210°F
4. Flow (gpm)	1600	1600	1500	1000
5. Number of Wells	4 + 1	4 + 1	3 + 1	4 + 1
6. Well Costs (1981 Dollars Per Well)	$176,000	$176,000	$176,000	$176,000
B. Engineering				
1. Total Peak Capacity (BTU/Yr.)	8.4×10^{11}	8.4×10^{11}	10.5×10^{11}	3.5×10^{11}
2. Annual Utilization	33.5%	33.5%	45%	30%
3. Pipe Characteristics	Insulated in field	Insulated in field	Pre-insulated	Scaled down in size
C. Economic				
1. Escalation Rates (1980 to 2000)		Same as Base Case	Same as Base Case	Same as Base Case
Inflation 9% → 6%				
Electric 13% → 6%				
Natural Gas 26% → 11%				
Geothermal Sales-Inflation Rate				
2. Equity/Debt Ratio				
Producer	100%	100%	100%	100%
Distributor	50/50	50/50	50/50	50/50
3. Interest Rate/Loan Duration	14%/15 yrs.	16%/20 yrs.	12%/10 yrs.	14%/15 yrs.
4a. Sales Price per MMBTU to Consumer (1984 Dollars)	$5.55	TBD	$4.63	$8.32
b. Percent of Natural Gas Price in 1984	60%	TBD	50%	90%
5. Distributor-Rate of Return	17%	15%	20%	14%
6. Producer-Rate of Return	TBD	20%	TBD	TBD
7. Depreciation	5 yr. DDB	14 yr. DDB/SL	5 yr. DDB	5 yr. DDB
8. Tax Credits (Federal & State)	30%	30%	30%	30%
D. Production Schedule				
Full Production in:	1986	1989	1986	1986

Energy Utilization Analysis

The 1600 gpm of geothermal fluid believed to be available from the Poncha Hot Springs prospect was distributed among existing and hypothesized future users. As shown in Table 5, for the peak fluid demand, 1008 gpm for space heating, 179 gpm for the hot water, and 413 gpm for process heat are estimated to be required. Because these are peak requirements, given this distribution, only 33.5 percent of the available heat would be used over the period of a year. Were a larger percentage of the energy to be sold to commercial and process heat users, the total annual fluid utilization would be a higher peaking percentage, thus increasing revenues. Conversely, higher peaking because of increased seasonal needs would result in a lower utilization percentage. Two alternative utilization percentages, 45 percent and 25 percent, were considered in the economic analysis.

Table 5

Estimated Peak Geothermal Fluid Requirement

	Gallons Per Minute			
User	Space Heat	Hot Water	Process Heat	Total
Industrial Park	116	21	413	550
Salida Commercial and Residential Users	892	158	---	1,050
Total	1,008	179	413	1,600

E. Economic Analysis

The geothermal resource would be produced and distributed by two separate entities: Chaffee Geothermal, Ltd., which already owns the geothermal leases for the prospect, as the producer, and some other entity as the distributor. For the purpose of this analysis, the distributor was assumed to be a new Colorado corporation without additional income sources.

The producer, the primary risk-taker in the situation, plans to conduct exploration during 1982. If results are favorable, as this analysis assumes they will be, the distributor could begin operating in 1983. The producer and distributor are considered to be independent of each other. Neither is expected to be a regulated public utility, based on analysis of the Colorado law regarding such utilities (see Institutional Section).

<u>Project Costs</u>

As indicated in Table 6, total capital costs are estimated to be $1,520,300 for the geothermal production system and $2,063,156 for the distribution system. These funds would be fully appropriated by 1984. Expenses include royalties of 10 percent of sales, maintenance, overhead, administration, and electricity costs as shown.

<u>Capital</u>. Financing for the geothermal system is assumed to be from private sources. For the producer, it is assumed to be from venture capital in a partnership arrangement. For the distributor, the assumption is that half the capital will be from equity and half will be financed.

Table 6

Base Case Capital Cost Summary

	Year	Cost Item	1981 Dollars
Producer			
	1982		
		Exploration	$ 291,000
		Equipment (Depreciable)	105,660
		Institutional/Permits	1,000
		Total	$ 397,660
	1983		
		IDC (Drilling)	$ 553,000
		Equipment	286,980
		Institutional/Permits	1,000
		Total	$ 840,980
	1984		
		IDC (Drilling)	$ 186,000
		Equipment (Depreciable)	95,660
		Total	$ 281,660
	Grand Total		$1,520,300
Distributor			
	1983		
		Equipment (Depreciable)	$ 515,789
	1984		
		Equipment (Depreciable)	$1,547,367
	Grand Total		$2,063,156

Taxes. Both producer and distributor are eligible for both alternative tax credits and general investment credits; federal credits totaling 25 percent. The distributor, as a Colorado corporation, is also eligible for State tax credits totaling 12 percent. Net operating losses and investment credits for the distributor are carried forward up to 15 years. The producer is assumed to have other income against which to apply credits and losses. Depreciation on equipment conforms to the new 5-year Accelerated Cost Recovery System (ACRS), defined by the Economic Recovery Act of 1981.

Geothermal Demand and Prices

This evaluation assumes a geothermal energy demand of 2.8×10^{11} BTU year, a demand that fully utilizes the geothermal resource at the peak demand period. To support this demand will require a strong marketing effort - which is planned. The price of geothermal energy must represent a cost savings over other available fuels to attract potential users.

Mid-1981 natural gas prices in Salida ranged from $4.45 to $4.85/MM BTU (Greeley Gas, 1981). Since natural gas prices are expected to increase 26 percent annually through 1985 (SERI, 1980), natural gas could sell for $9.25/MM BTU by the time geothermal production begins in mid-1984. The geothermal prices assumed for this analysis are tied to the natural gas prices.

For the base case, the assumed first-year geothermal price is 70 percent of natural gas prices of $6.50/MM BTU, escalating at the general inflation rate. That rate is assumed to be 9 percent, leveling off to 6 percent in 1995. Since the geothermal escalation rate is lower than the natural gas escalation rate, by 1985 the geothermal energy would be priced at 60 percent and by 1992 it would be 50 percent of natural gas prices.

Analyses Conducted

Discounted Cash Flow Rate of Return (DCFROR). Economic evaluations were conducted for a base case and three alternate cases. Alternate 1 assumes a three-year delay in production. Alternate 2 assumes a higher quality reservoir and Alternate 3 assumes a lower quality reservoir. Sensitivity of the DCFROR to initial geothermal price, geothermal price escalation, percent utilization of peak capacity, and distributor's return on investment was assessed. For the base case, the DCFROR for the distributor was nominally set at 17 percent; the producer's rate of return was calculated.

Findings

The results of the DCFROR analyses for the base case and each of the alternates are as follows:

	Base Case	Alternate I	Alternate II	Alternate III
Producer DCFROR	31%	20%	39%	16%
Sales Price to Consumer	$6.50/ MM BTU	$4.86/ MM BTU	$4.62/ MM BTU	$8.32/ MM BTU

As indicated, the producer of this geothermal resource may obtain a 31 percent discounted cash flow rate of return on his investment. With a better resource, 39 percent DCFROR is possible, whereas with the lesser resource assessed, only a 16 percent DCFROR would be forthcoming.

The ROR would obviously be higher if the price of geothermal energy were higher, but fewer customers might be attracted. Furthermore, variations in utilization of the peak capacity of the resource show greater than proportionate changes in the DCFROR. Adjustments in distributor DCFROR, however, have little impact on the producer's DCFROR.

F. Environmental Analysis

Not only does federal law require that an environmental report be prepared concerning any prospective geothermal development being studied under federal financing, but also a prospective developer is well-advised to prepare such a report in any case. On some occasions, unanticipated environmental conditions have delayed or cancelled projects. If the conditions are known in advance, costly delays or cancellations can be avoided. For this analysis, published data were reviewed and discussions were held with experts in the various specialties to attempt to discover any potential environmental difficulties. No difficulties were found that could not be overcome through relatively simple and customary measures. Each of the major questions investigated and the findings are summarized below.

Physical Environment.

Physiography. The Salida prospect is located in the Upper Arkansas Valley in Chaffee County. The County is predominantly rural, dotted with small communities. The City of Salida, about five miles east of the geothermal prospect site at Poncha Hot Springs, is the principal market area for the resource. The topography of the area varies from valley to high plateaus to high mountains; the prospect area is on the hillside above the valley in which Salida is located. Although slope failure and erosion are potential problems in terrain of this sort, the drill sites selected are flat. Furthermore, if trenching or leveling should be necessary, rip rapping would prevent adverse effects.

Seismicity. Some seismic activity could occur in the Poncha Springs area (up to 4.0 on the Richter scale). Because of its nature, this development would not be expected to either stimulate seismic activity or be damaged by such activity.

Soils. Soils are gravely and sandy with high permeability. Slopes of less than forty percent are stable but steeper slopes are subject to erosion, as indicated above. Prevention of erosion and replacement of any disturbed vegetation should preclude adverse effects.

Hydrology. The Arkansas River and its tributaries are the major drainage-ways in the area. The Arkansas River is over-appropriated, precluding obtaining water rights for waters tributary to that river. The ground water reservoir is extensive and highly developed. The plan to discharge the geothermal fluid to the river system precludes consumptive water use and may in fact add to the river flow.

Water Quality. The quality of the water from Poncha Hot Springs is high, with a TDS of only 654 mg/l, pH values between 7.5 and 8.0, and normal radioactivity levels. The chemistry of this water was compared with stream standards for the Arkansas River system and with basic state standards to learn whether any components were present that would limit or preclude waste water discharge or would require prior treatment. Only one component, fluoride, seemed to offer potential difficulties. Because the fluoride content of the spring water is higher than drinking water standards, it may not be disposed where it will raise fluoride levels of a water supply to unacceptable levels. Mass balance analysis indicated that sufficient dilution would occur well before the discharge fluid reached any water supply intake. The geothermal well water is expected to be very similar to spring waters.

Meteorology. The Upper Arkansas Valley climate is noted for sunshine, low humidity, and light winds. Average precipitation is 11.37 inches per year. Mean average low temperature is 12°F in January; mean high is 85°F in July. There is an average of 6,910 heating degree days per year.

Air Quality. Air quality is excellent in Salida. Although occasional air inversions can occur, only minor effects result. Drilling activities can raise dust and would need to be controlled by sprinkling, graveling, or oiling to preclude unacceptable dust levels. Vehicle emission fumes are minor and short-lived.

Noise. The drilling equipment and, to a certain extent, the pumping equipment for the geothermal project would create increased noise. No significant adverse effects are expected, however, because of the short drilling period and the long distance from the site to populated areas.

Biological Environment

Flora. Vegetation in the area includes grasses, juniper, pinyon pine, and Ponderosa pine, and a variety of shrubs, particularly in the drill site area. Pipeline right-of-way is generally bounded by irrigated cropland and pasture. No endangered species are identified; nor would revegetation represent problems. Since most of the pipeline right-of-way is either now developed for pipeline or follows roads and fences, little land would be newly-disturbed.

Fauna. Many diverse species of wildlife are in the prospect area. These include mule deer, rabbit, squirrel, coyote, badger and skunk. Others are English sparrow, pinyon jay and black-billed magpie. No sensitive, threatened, or endangered species are recorded except for golden eagles seen in the area. Construction and development schedules may need to take into account the deer winter habitat in the area.

Aquatic Organisms. Fishing is active in the Arkansas River system because of both stocking and river hatching. The aquatic environment must be maintained to protect economic, aesthetic and recreation values. Cooling of geothermal fluid to acceptable levels before discharge is required in order to prevent adverse thermal pollution that could threaten this environment.

Human Environment

Salida, the county seat and largest city in Chaffee County, had a 1980 population of 4,870. Its commuting area may have a population of more than 15,000. Growth of 25 percent during the current decade is expected. The economy of the area is based upon tourism, mining, and agriculture. These sectors, plus the manufacturing sector which the community desires to stimulate, could all be significantly stimulated by the availability of clean, lower-priced energy. Adverse stress upon public services, housing, and other needs could result from a major population influx generated by construction activity or major economic development.

This proposed project is expected to produce only a small population influx for construction, if any; and economic development would probably occur slowly over a period of time and could easily be accommodated. If the project can help reduce unemployment levels and add to the revenue base, socio-economic impacts would be positive and in conformity with community values.

Some cultural resources, specifically archaeological sites, are located in the general vicinity of the project but would not seem to interfere. Specific locations of these sites, however, are not pinpointed in order to protect them. The State Archaeological Society could request an investigation be conducted prior to development so that significant artifacts or sites could be protected.

G. Institutional Analysis

Various activities for accomplishing geothermal exploration, production, and distribution are required by law. They include leasing, right-of-way, and permits and approvals of various types stemming from federal, state, and local codes, laws and regulations. They are described in advance so that they may be anticipated and met in a timely fashion in order that development can proceed smoothly.

Leases

Geothermal leases on private, city (Salida) and federal lands are currently held by Chaffee Geothermal, Ltd., on sufficient acreage to allow for the proposed activity.

Right-Of-Way

Much of the necessary pipeline right-of-way for this project has also been obtained. Some additional right-of-way on fee lands and along county roads and streets is needed and would be obtained through negotiations with the owners and officials. Crossing the Arkansas River with a pipeline requires a special type of right-of-way action. Regulated by the U.S. Corps of Engineers under the Clean Air Act, approval is automatic as long as the construction requirements are satisfied. A letter to the Corps serves as notice.

Federal Permits

No activity is planned to occur on the federal leases. Nor are any federal monies expected to be involved in the project. The required National Pollutant Discharge Effluent System permit program is administered by the Water Quality Control Division, as discussed under "State Permits".

State Permits

Drilling. Drilling permits must be obtained from the Colorado Oil and Gas Conservation Commission. A service and filing fee of $75.00 is required, along with a plugging bond of $10,000 per well or $50,000 blanket bond. The application is reviewed by the Colorado Division of Water Resources which must determine that the well will not injure the water rights of others.

Water Rights. If water rights are necessary, they can be either adjudicated by district water court or purchased from another owner. In this case, if the well water were considered by the Colorado Division of Water Resources to be tributary, since the Arkansas River is already overappropriated, no additional rights can be awarded. Therefore, they would have to be purchased. Since removal of heat is not, however, considered by the State to be a consumptive use of water, if the water is returned to the system as planned for this project, water rights may be unnecessary.

Public Utility Regulation. In some cases, a geothermal system could be subject to regulation as a public utility, thus requiring Public Utility Commission determination of necessity and approval of rate of return. What is proposed here is, however, to offer service to certain customers, not to "all members of the public who may require it" as indicated in the Colorado definition of a public utility. Furthermore, since no mention is made of geothermal systems in Colorado public utility law, regulation seems unlikely under existing law.

Waste Water Discharge. Permits for discharge of waste water are issued by the Colorado Water Quality Control Division which was assigned this authority by the U.S. Environmental Protection Agency. A fee of from $10 to $250, depending upon the extent of the proposed development, is submitted with the application. Permits are valid for no more than five years but may be renewed. Discharge may be subject to monitoring.

The quality of the discharge must conform with State standards and be approved by the Division. The discharge of problematic substances is analyzed to determine whether it will be sufficiently diluted within an acceptable period. Temperature of discharge is also restricted.

Air Quality Control. Either a permit or a waiver should be obtained from the Air Pollution Control Division prior to drilling a geothermal well. If it can be demonstrated that any hydrogen sulfide emission would be insignificant, a waiver may be awarded. For a permit, a $40 filing fee is required.

County Permits

Construction Permits. Construction of any buildings (such as a pump house) connected with geothermal systems requires a Special Use Permit obtained from the Chaffee County Administrator. A building permit must also be obtained from the County Building Department. Electrical and plumbing facilities require separate permits.

Waste Disposal. If individual waste disposal systems are planned, the County Sanitarian must verify their conformity to County Regulations.

Pipeline. To use County road right-of-way, an application is submitted to the County Administrator. A fee of $100 is charged for paving replacement for road cuts if any are required.

Salida Permits

Water Quality. A primary concern of the City of Salida is the protection of the geothermal fluid used in their municipal swimming pool. No interference would be tolerated.

Pipeline. Where city streets are used for or crossed by a pipeline, the developer replaces or pays for replacement of the paving. Prior to cutting a street, the City should be contacted.

H. Conclusions

The Poncha Hot Springs geothermal prospect in south-central Colorado continues to be a very attractive prospect. This study indicates that the production and sale of geothermal energy from Poncha Hot Springs to selected industrial and commercial users in and around the City of Salida, located about five miles from the resource site, would be technologically feasible, financially profitable, and would experience no environmental or institutional barriers that would require extraordinary measures or would stymie the development process.

The resource assessment indicates the resource may be capable of producing 1600 gpm of 250°F fluid from a depth of about 1500 feet. Additional preliminary exploration is needed prior to targeting the site location for the first exploration well.

Engineering of the system calls for a main pipeline to follow the existing Salida pipeline right-of-way, a branch tie to the proposed industrial park and branches to commercial greenhouses and to a group of institutional users. The fluid is pumped, but controls assure that only the fluid and pump capacity needed at a given time is being tapped. Waste water would be cooled and discharged to the Arkansas River.

The economic evaluation indicates that a sufficient discounted cash flow rate of return is possible for both a producer and a distributor of geothermal energy from this prospect. For the producer, a DCFROR of 31 percent was calculated and for the distributor, a 17 percent DCFROR was assumed. A better or lesser quality resource would cause the DCFROR to vary.

No environmental barriers were discovered. The well fluid is expected to be similar to the spring fluid and, therefore, quite pure. Although the fluoride content exceeds the standard for drinking water, it would be diluted to below the standard in the surface disposal process. The usual array of leases and permits is required for this project. It is, however, simplified by several conditions:

- Leases have already been acquired.
- No activity will occur on federal lands, thus precluding the need for federal permits.
- The State of Colorado is the designee of the Environmental Protection Agency for issuance of air quality and water discharge permits, thus precluding a duplicative federal and state application process. Also state officials are more familiar with the details of the state than federal officials can be, which seems to promise an accurate and reasonable review.

Because of the characteristics of this geothermal resource and the non-degrading nature of the project, the necessary permits are not expected to be difficult to obtain.

In short, the resource seems exceptional, the existing and future expected market encouraging, the technology readily available, the financial return promising and the environmental and institutional difficulties minimal. There seems little doubt that the geothermal prospect has the necessary ingredients to make it one of the more promising for direct use in individual and commercial applications.

Section II

INTRODUCTION

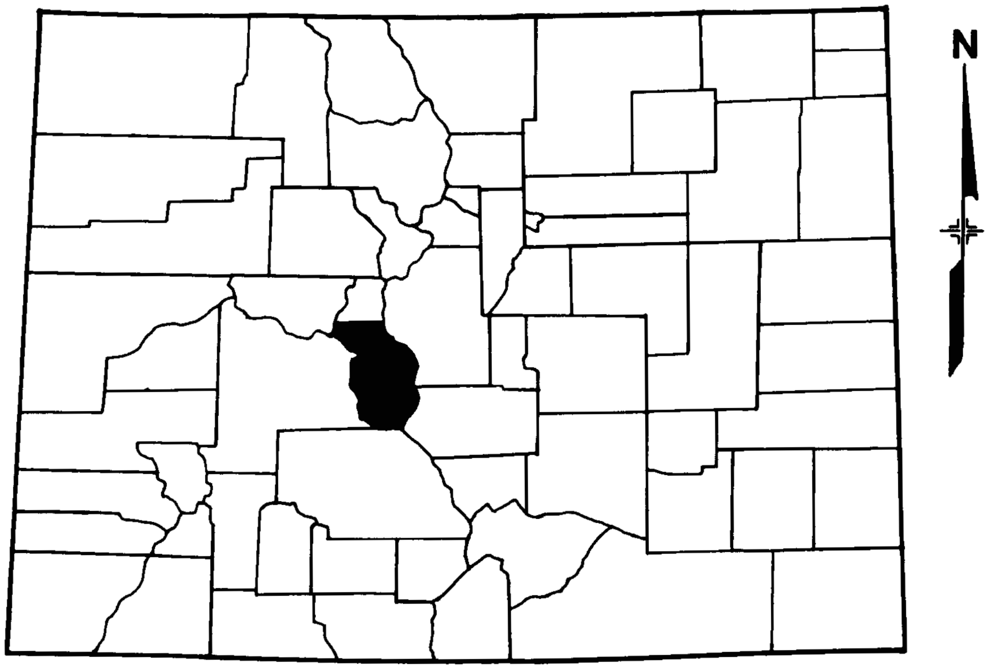
A. Study Purpose

Chaffee Geothermal, Ltd. contracted with the Idaho Operations Office, U.S. Department of Energy, Division of Geothermal Energy, to analyze the economic and engineering feasibility of industrial and commercial direct heat applications of geothermal energy. Chaffee subcontracted with Western Energy Planners, Ltd. to assist with the project.

Chaffee Geothermal, Ltd. has 9500 acres under lease in the Salida geothermal prospect in south-central Colorado. They also have a farmout agreement with a major energy company that allows Chaffee to explore for, produce, and sell geothermal fluids and steam. Existing spring water temperatures of 160°F, the results of preliminary exploration indicating a possible resource of 1600 gpm at 250°F, and an existing energy market at the City of Salida, Colorado, made this a prime geothermal candidate for development. However, answers to two key questions in particular were needed. The questions were: At what price could the geothermal energy be sold and what would be the expected rate of return to a developer? The selling price of the energy is considered to be critical to the attraction of purchasers. The rate of return is the indicator that generally determines whether investment capital to make the development possible can be attracted.

The prospect is located in Chaffee County, Colorado, along the mountainous eastern slope of the Continental Divide, as shown on Figure 4. The area is noted for its scenic beauty,

COLORADO



CHAFFEE COUNTY
GENERAL LOCATION

Source: Upper Arkansas Council of Governments, 1976

FIGURE 4

recreation opportunities, and mineral deposits. In addition to tourism and recreation and mining, agriculture has also been an important economic contributor. Increased light industry is a community goal. The primary market area for the geothermal fluid is the city of Salida, about five miles from the spring site. Since the 1930's, the fluid from the springs has been piped to Salida for use in their municipal swimming pool. Although the population of Salida itself is small (about 5000), the population of the Salida commuting area is about 15,000, the population is growing and the community is seeking additional economic development.

B. Report Format and Methodology

Format

Section I of the report, Summary and Conclusions, is a concise overview of the analyses and findings. This section, the Introduction, provides study background and methodology. The five major tasks of the study are: Resource Assessment, Engineering Design, Economic Evaluation, Environmental Evaluation, and Institutional Evaluation. The background, analyses, and conclusions of each of these is found in a major report section by each of those titles. They are supplemented by more detailed data that are contained in the appendices.

Methodology

Resource Assessment. Published documents and prior analyses by Chaffee Geothermal, Ltd. and others were all reviewed, analyzed, and discussed with other experts. A reservoir confirmation plan was compiled that employs the accepted exploratory tools of geological, geochemical, and geophysical reconnaissance including gradient holes and exploratory drilling. It provides details, based upon information about the prospect area and of similar drilling conditions, of preliminary exploration work, and the exploratory drilling and well completion. Costs for the program are itemized.

Reservoir Engineering and Utilization Design and Evaluation. The engineering and utilization design was based upon the estimated geothermal resource capacity and also upon the prospective endusers' energy demands identified through both historical records and an analysis of peak needs based on weather data.

The engineering plans include preliminary designs for the reservoir-well system, the well head production equipment, the transmission pipelines, the pipeline distribution network and the disposal system. Both the engineering and utilization design plans specify generic equipment, hardware and controls and itemize capital investment costs and operating and maintenance costs in CY 1981 dollars. Design parameters and specifications are based upon current technology and experience for geothermal energy production and delivery systems.

Retrofit engineering design for a zinc processing plant was prepared. The generic design addresses the basic requirement of achieving effective and efficient drying of a material fluid to produce material pellets using a low temperature air-drying process. The design offers industry an opportunity to replace conventional high temperature drying technologies with a low temperature, energy saving technology. To explore options, R.T. Meyer visited the National Fertilizer Development Center in Muscle Shoals, Alabama, to consult with NFDC chemical engineers, pilot plant engineers, demonstration plant engineers, micronutrient specialists, and economists. He examined industrial scale zinc sulfate production processes that might be technically feasible with geothermal energy as a prime energy source.

Economic Analyses. The economic feasibility of the development and application of the Salida Geothermal Prospect to the prospective existing and new endusers of geothermal energy was evaluated for four cases, a Base Case and three alternate scenarios. Key assumptions for the Base Case analysis include:

1. Separate private producer and private distributor, with the producer assuming most of the risk.
2. A future energy demand of 2.8×10^{11} BTU/year accomplished by attracting additional users.
3. Natural gas price escalation of 26 percent/year until 1985.

4. First year Geothermal energy pricing at 70 percent of natural gas prices (Base Case), escalating at inflation rate of 9 percent/year; decreasing over time to a low of 6 percent by 1995.
5. Equity debt ratio of 100 percent for the producer, 50/50 for the distributor.
6. Discounted cash flow rate of return of 17 percent to the distributor; DCFROR to producer was calculated.

For the Base Case capital costs are estimated to be a total of $1,520,300 for the producer and $2,063,156 for the distributor. Royalties are 10 percent of sales, producer maintenance costs are 4 percent of the well and well pump costs and 2 percent of the system collection costs. Overhead and administrative costs are $30,000 and electricity is $89,889.

For the distributor, maintenance costs are estimated to be 2 percent of the cost of the pump, control and disposal system and 1 percent of the cost of the pipeline. Overhead and adminstration are $75,000, electricity is $30,389.

Alternate 1 assumed a delay in obtaining endusers, delaying full production three years. The DCFROR was fixed at 20 percent for the producer and 15 percent for the distributor.

For Alternate 2, a higher quality reservoir was assumed, resulting in increased sales. The price was assumed to be only 50 percent of the natural gas price. A 20 percent DCFROR was assumed for the distributor.

Alternate 3 assumed a poorer quality reservoir and a consumer price that is 90 percent of the natural gas price. Distributor's DCFROR was assumed to be only 13 percent.

Environmental Assessment. A site-specific environmental assessment of the site of the geothermal well production system at Poncha Hot Springs, of modifications to the existing geothermal transmission pipeline, of additions to the transmission pipeline to serve new and existing prospective endusers, and of the environmental impact of additions of the prospective new endusers was conducted. The analyses included a description of the proposed action(s), including a discussion of purpose or need; alternatives, including the no-geothermal action alternative; the affected environment; environmental consequences, both positive and negative; and mitigation measures for potential negative environmental impacts. The analyses were based on published information and discussions with officials of regulatory agencies and other experts.

A System Safety Analysis Report presents consideration of the potential hazards and the steps to be taken to ensure that the hazards are eliminated, reduced to an acceptable level or otherwise controlled.

Institutional Factors Analysis. The institutional analysis is a comprehensive evaluation of the social, financial, legal, regulatory, and socioeconomic consequences of the proposed geothermal project. Much of this analysis was based upon extensive previous experience with the communities and citizens of Poncha Springs and Salida; Jay D. Dick grew up in Chaffee County just north of the Salida Geothermal Prospect. Mr. Dick has been discussing his geothermal development plans with the people and businesses of the area for the past two years. He has made several presentations to the Salida City Council.

Analyses of specific regulatory requirements were based upon reviews of laws and regulations, discussions with regulatory officials, and reviews of previous publications of institutional requirements including publications written by project participants. Quantitative analyses such as the mass balance analysis were conducted to identify the need for environmental mitigation measures.

Section III

GEOTHERMAL RESOURCE ASSESSMENT AND PLANNED EXPLORATION PROGRAM

To preliminarily assess the geothermal resource of the Salida Geothermal Prospect, all available data were examined and analyzed. These included a variety of published reports as indicated in the following section. They also include geological and exploration data that were obtained from another private geothermal company through a farmout agreement. Although these data are helpful, they are not detailed enough to assess definitively the resource or to target a drill site. Additional preliminary investigations will be conducted by Chaffee Geothermal prior to drilling wells. The following analysis is, therefore, based upon the available data and could be modified after more extensive tests are conducted.

A. Geological Evaluation

Geologic Units

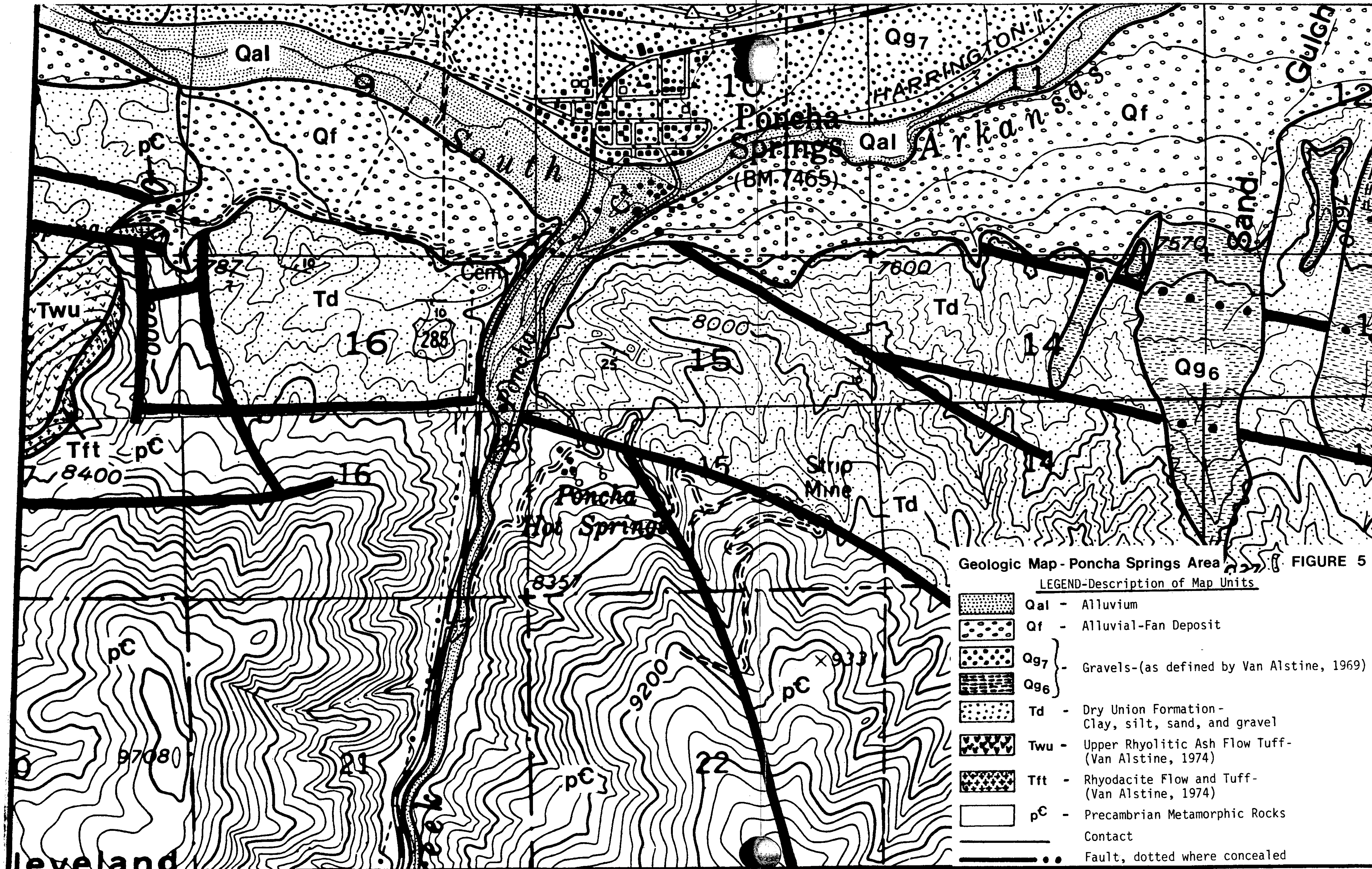
Rocks of Precambrian, Tertiary, and Quaternary age outcrop in the Poncha Springs area. No Paleozoic or Mesozoic rocks remain at the surface, although as much as 10,000 feet of these sedimentary rocks (Tweto, 1968) may have been deposited prior to the Laramide orogeny of late Cretaceous and early Tertiary time. Limbach (1975) has speculated that the Paleozoic and Mesozoic might be found below Tertiary semiconsolidated sediments in the Upper Arkansas Graben. However, a widespread late Eocene erosion surface (Epis and Chapin, 1973) had apparently developed prior to rifting and presumably prior to establishment of the Upper Arkansas Graben. This evidence and the scarcity of Paleozoic and Mesozoic rocks along the flanking ranges suggest that the Tertiary directly overlies the Precambrian in the Upper Arkansas Graben. Figure 5 shows a preliminary geologic map of the area.

Precambrian. Igneous and metamorphic rocks of Precambrian age form the core of uplifts surrounding the Upper Arkansas Graben. These rocks are exposed over most of the eastern flank of the graben (the Mosquito Range), and they are found outcropping west of the graben both north and south of the Mount Princeton Batholith in the Sawatch Range. Near Poncha Springs, these crystalline rocks have been defined by Van Alstine (1974) into three major map units and several smaller ones. However, lithologic types often have gradational contacts or are layered with one another, especially the metamorphic rocks, and areas mapped as one unit may contain two or more different lithologic types.

Van Alstine's descriptions are given below:

Metamorphic rocks:

> Banded Gneiss, fine to medium-grained foliated rock consisting chiefly of quartz, plagioclase, microcline, and biotite. Color ranges from nearly white to almost black depending upon relative amounts of light and dark minerals. Locally, very leucocratic varieties are quartzites.
>
> Quartz ranges from 30 to 90 percent; plagioclase ranges from a few to 40 percent; 5 to 25 percent microcline; 0 to 15 percent biotite; hornblende, muscovite, and garnet comprise 0 to a few percent.
>
> Hornblende Gneiss, dark, foliated, fine- to medium-grained rock containing 35 to 65 percent hornblende; 25 to 35 percent plagioclase; up to 10 percent each of biotite and strained quartz; rare microcline, orthoclase, diopside, and andalusite; magnetite, apatite, and sphene are abundant accessory minerals.


Qal
Qg7
HARRINGTON
Qf
Poncha Springs
(BM 7465)
Arkansas
South
Sand Gulch
pC
Twu
Td
16
285
15
14
Qg6
Tft
8400
8000
7600
7570
Cem
Poncha Hot Springs
Strip Mine
8357
9200
9708
21
22
leveland
Geologic Map - Poncha Springs Area
FIGURE 5
LEGEND-Description of Map Units
Qal - Alluvium
Qf - Alluvial-Fan Deposit
Qg7, Qg6 - Gravels-(as defined by Van Alstine, 1969)
Td - Dry Union Formation - Clay, silt, sand, and gravel
Twu - Upper Rhyolitic Ash Flow Tuff- (Van Alstine, 1974)
Tft - Rhyodacite Flow and Tuff- (Van Alstine, 1974)
p€ - Precambrian Metamorphic Rocks
Contact
Fault, dotted where concealed

A few thin beds of marble are locally present within the metamorphic rocks. This and several geometric features of the metamorphics have led Van Alstine to conclude that they were derived from a predominantly sedimentary and partially volcanic sequence.

Igneous rocks:

> Gneissic Quartz Monzonite, typically-grained, gray to pink, foliated, and porphyroblastic. Quartz comprises 15 to 47 percent; microcline, 10 to 35 percent; orthoclase, 0 to 8 percent; hornblende, 0 to 5 percent; and accessory minerals: magnetite, ilmenite, sphene, apatite, zircon, pyrite, fluorite, 2 to 4 percent each.

Van Alstine notes the presence of several other igneous rock types as dikes cutting the above map units. These dike rocks have not been age dated by radiometric techniques, but all of them are truncated by the unconformity below the Tertiary, and so they are certainly pre-Laramide. Van Alstine (1969) has interpreted these as Precambrian in age.

Tabular intrusive rocks and their host rock relations are given below:

Rock Type	Host Rock Relationships
Granite	Cuts gneissic quartz monzonite in east-northeasterly, steeply dipping dikes. Foliated parallel to contacts.
Aplite	Cuts gneissic quartz monzonite and granite dikes. Steeply dipping and up to 20 feet thick.
Pegmatite	As dikes and sills cutting both the gneissic quartz monzonite and the metamorphic rocks. Up to 50 feet thick. Commonly parallel or at small angles to foliation of host rock.
Lamprophyre	Generally as east or northeast dikes in the gneissic quartz monzonite and roughly parallel to foliation.
Dacite porphyry	Only one such dike found. 15 feet thick, trending easterly in gneissic quartz monzonite.
Diabase	Only one such dike found. 20 feet thick, trending N 20°E in gneissic quartz monzonite.

Tertiary. Tertiary rocks consist of silicic volcanic flows and tuffs and the sedimentary Dry Union Formation. Van Alstine (1974) identified four Tertiary map units: three volcanic and the Dry Union. These are described below.

1.	Dry Union Formation	White, gray, tan, and pink clay, silt, sand, and gravel; locally tuffaceous and bentonitic; includes flood-plain, alluvial fan, pond, mudflow, and volcanic ash deposits. A few slide blocks of Paleozoic rocks.
2.	Upper Rhyolitic Ash-Flow Tuff	Gray to pinkish-brown porphyritic devitrified welded tuff, commonly with sphene and chatoyant sanidine; locally thin black vitrophyric and perlitic welded tuff at base.
3.	Rhyodacite Flow and Tuff	Gray-brown porphyrite flow, interbedded near top with brown lithic and white vitric tuffs; locally vitrophyric layers and perlitic, columnar, or platy structures.
4.	Lower Rhyolitic Ash-Flow Tuff	Pinkish-gray to reddish brown porphyritic devitrified welded tuff; locally thin, black vitrophyric welded tuff at base.

Tertiary rocks lie directly on the Precambrian. Potassium-argon age dates indicate that the Upper Rhyolitic Ash-Flow Tuff is no younger than 32 million years old. Pollen and spores from the lower tuff indicate an Oligocene age. Volcanism in this part of Colorado was coincident with a major pulse of extrusive activity throughout the State.

The Dry Union Formation is somewhat younger and has been interpreted by G. Edward Lewis (Van Alstine, 1974) to be of Miocene and Pliocene age based on various vertebrate fossils.

Quaternary. Quaternary formations consist of alluvial, fluvial, and moraine deposits. These were described as early as 1869 by Hayden in his travels for the U.S. Geological Survey; and further characterization was provided by Powers (1935) and Ray (1940). However, Van Alstine (1969 and 1974) has given the most detailed description of these units and his system was followed by later workers (Knepper, 1974; Limbach, 1975).

Van Alstine (1969) identified nine Pleistocene gravel units in the southern Upper Arkansas Graben (Table 7). He interpreted four of the units to be pre-Wisconsinian pediments and five to be Wisconsinian outwash and terraces. In addition to the Pleistocene gravels, there are limited outcrops of Holocene deposits consisting of landslides, talus, fans, travertine, and sinter.

Structure and Tectonics

Folds. The most prominent folds of Precambrian age are exhibited as large folds trending northeast and parallel to foliation in the metamorphic and igneous rocks. Van Alstine (1969, p. 26) suggests that these rocks lie in isoclinal folds with steep axial planes. Both folding and foliation are generally parallel with the dikes cutting the Precambrian. Van Alstine does not speculate on a regional environment in which the northeasterly trend formed, but these structures are suspiciously aligned with the Colorado lineament.

Warner (1978) has advanced an interpretation of this northeasterly lineament that is analogous with the modern San Andreas system. In a later (1980) summary he says that "initiation of faulting that gave rise to the Colorado lineament probably

Table 7

Pleistocene Gravel Units, Upper Arkansas Graben
(Van Alstine, 1969)

Gravel Unit	Approximate Thickness (feet)	Probable Age
		Wisconsinian:
9	10	Pinedale III
8	30	Pinedale II
7	20	Pinedale I
6	50	Bull Lake II
5	40	Bull Lake I
4	70	Illinoian
3	80	Kansan
2	70	Nebraskan
1	100	Nebraskan

relates to a belt of orogenic activity that extended from the environs of Lake Superior to northern Arizona during the interval 2,000 - 1,700 million years BP. This orogenic belt appears to represent a mid-Precambrian equivalent of Phanerozoic mountain systems that characterize parts of modern continental margins. Associated with most of these mountain chains are longitudinal wrench fault systems of the San Andreas type. Geometrically, the Colorado lineament compares favorably with these systems. Accordingly, it is believed to have developed adjacent to the then southeastern margin of North America in Penokean-Mazatzal time."

Minor local folds are present in Tertiary sediments within the Upper Arkansas Valley. These are probably drag folds, since they tend to steepen towards normal faults. A very large regional fold, the Sawatch anticline, developed in Laramide time. This is a north-trending feature similar to northwest trending regional folds noted by Knepper (1974, page 80). The Sawatch anticline may be related to emplacement of the Mount Princeton Batholith, although Tweto (1973) has indicated that this structure was formed 72 million years ago, and radiometric work (Limbach, 1975, page 87) dates the batholith as 36 million years old.

Tectonics in the Upper Arkansas Valley are similar to the Basin and Range. Both exhibit north-trending horsts and grabens in an east-west tensional environment. Gableman (1952) was one of the earliest workers to recognize a structural link between the San Luis Valley and the Upper Arkansas Valley; and this link was further supported by Van Alstine's (1969) stratigraphic correlation of the two grabens. It is now generally believed that these grabens are structurally and genetically connected with the large Rio Grande Rift system that extends from northern Mexico to Leadville, Colorado. This movement is hinged somewhere in northern Colorado or Wyoming. (See Figure 6).

Generalized map of the Rio Grand Rift
(from Chapin, 1971)

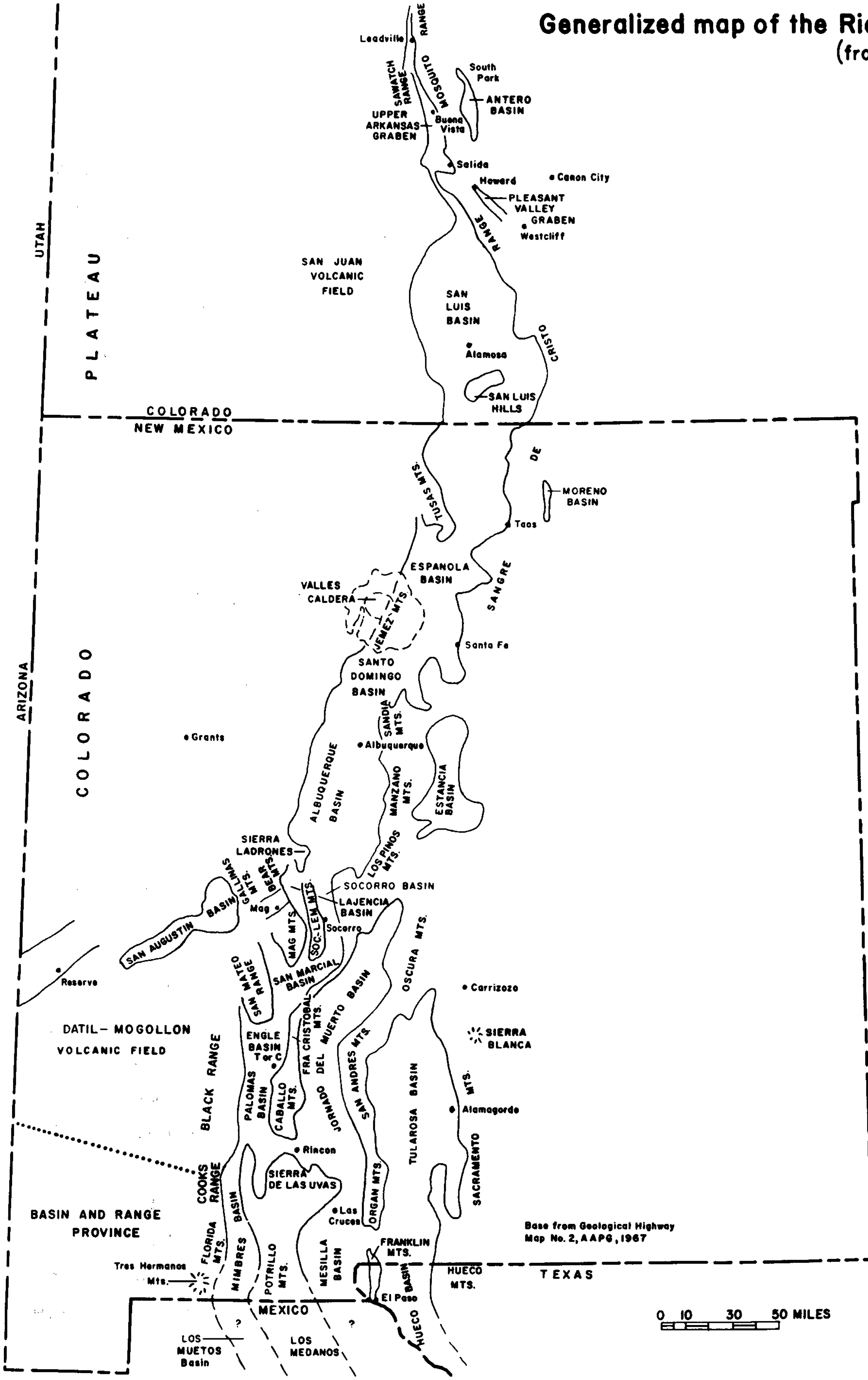
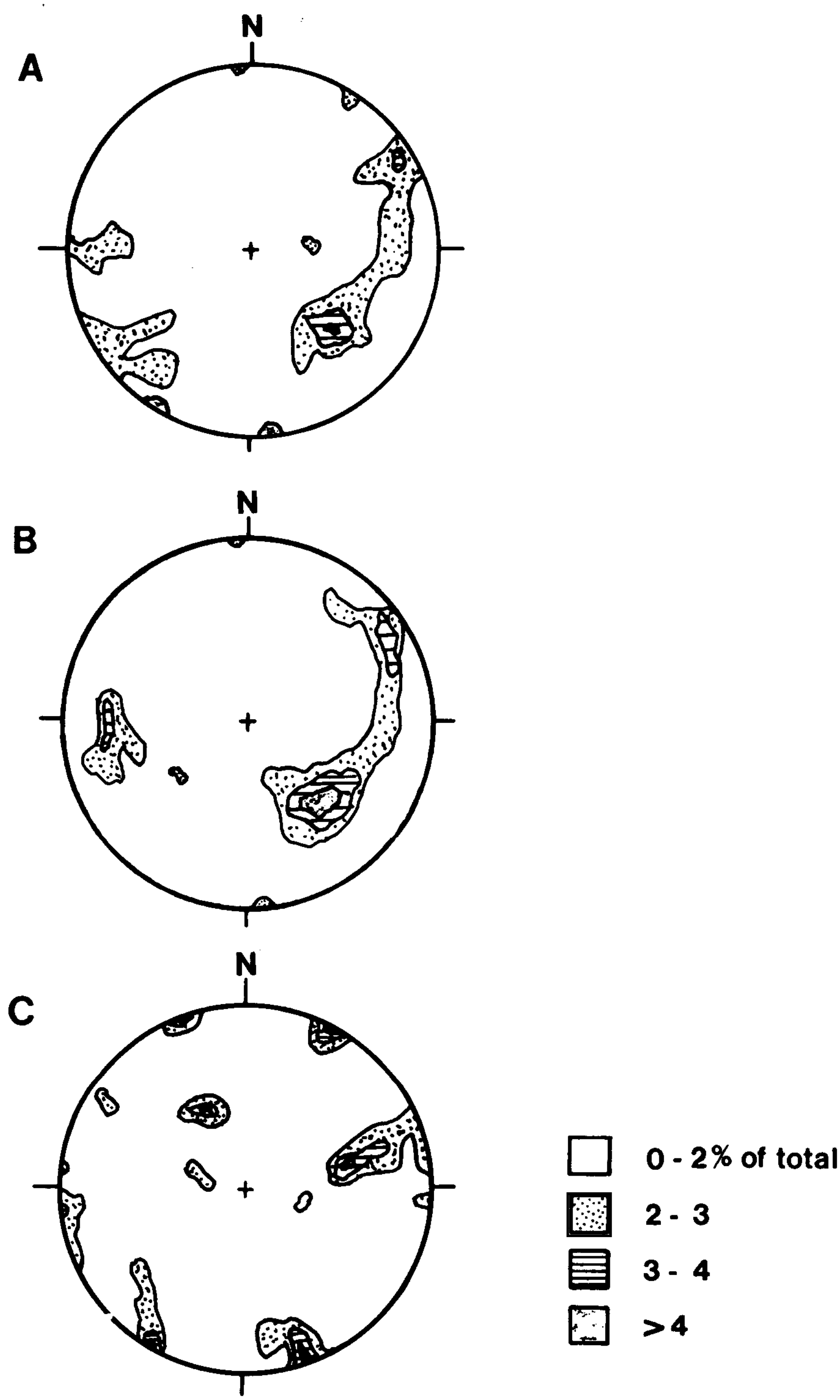


FIGURE 6

Rifting is considerably more youthful than most other deformational features, having begun in mid-Miocene times. Laramide and earlier Pennsylvanian (ancestral Rockies) orogenies may have governed the location of the rift over a pre-existing weakness in the crust. Northwesterly faulting is not uncommon in the Precambrian basement of Colorado and may have developed as a conjugate system with the northeasterly Precambrian trans-current faults. Whatever the genetic relationships really are, the indications of very deep crustal faulting and fracturing have favorable implications for geothermal systems, both for the emplacement of magmatic bodies and for deep circulation of metoric water.

Limbach (1975, page 73) infers that cross faults intersecting the Upper Arkansas Graben have localized hot springs along Cottonwood Creek and Chalk Creek. He cites evidence as "hot spring and alteration pattern location, the nonalignment of the mountain front at Chalk Creek, and the linear nature of the two valleys." Limbach does not specify the strike of the inferred faults, but these valleys run in a northeasterly direction. Measured fracture patterns (Limbach, 1975, p. 68) (Figure 7) in the vicinity have demonstrated the existence of a northeasterly fracture set. Crompton (1976) has plotted epicentral locations of microearthquakes that roughly delineate northeasterly trends in this part of the Upper Arkansas Valley.

Northeasterly faulting is not apparent at Poncha Hot Springs; however, the intersection of two fault trends does appear to control the location of these hot springs. East-west faults truncate and are truncated by northwest trending faults in the Poncha Pass area. Tectonically, Poncha Springs is located at the intersection of the northwest trending Sangre de Cristo Horst and the north-trending Upper Arkansas Graben.



Joint measurements in bedrock on the west side of the Arkansas graben. (A) Contoured poles to joints in and adjacent to the Mount Princeton batholith, 450 readings. (B) Poles to joints measured along Chalk Creek Canyon, 179 readings. (C) Poles to joints measured along Cottonwood Creek, 117 readings. Diagrams are equal area projections on the lower hemisphere.

FIGURE 7

B. Previous Exploration

Several exploration surveys in search of geothermal resources near Poncha Springs have already been completed. These surveys have included geochemical, geophysical, and heat-flow techniques.

Geochemical Analysis

Water sampling and analysis of Poncha Hot Springs have been performed by several investigators. Tables 8 through 14 summarize these data, and Figures 8 and 9 depict graphic solutions for silica mixing models. The background values for temperatures and chemistry that were used in the mixing models were derived from the temperature gradient and geothermal work done by a private geophysical contractor in July of 1979. Figure 10 shows the locations (in the Poncha Springs area) where water samples were taken. The mixing models employ a number of assumptions that may not be correct. Specifically, the silica concentrations are assumed to be controlled by quartz solubility. This second assumption is often correct with high temperature reservoirs, but not necessarily with lower temperature reservoirs.

The fairly close agreement between alkali and silica geothermometers shown in Table 12 is interpreted as evidence that much less mixing is occurring than is suggested by the silica mixing models. The silica mixing models predict 25 percent to 30 percent hot water at 374°F to 392°F whereas the silica and alkali geothermometers (no mixing) predict 284°F. The assumption of no mixing seems unreasonable in the geologic environment that is envisioned. Spring waters are thought to rise through as much as 1,000 feet through unconsolidated Dry Union sediments. The relative values of the silica and alkali geothermometers substantiate the hypothesis of some mixing, since the silica temperature is lower than the alkali temperature. The former

Table 8. Chemical Analysis, Poncha Hot Springs, Discharge Point A. (Barrett & Pearl, 1976)

Location: 38°29'49"N. Latitude; 106°04'37"W. Longitude; T. 49 N., R. 8 E., Sec. 15 cb, N.M.P.M., Chaffee County

	Date Sampled			
	6/75	10/75	1/76	4.76
Arsenic (As), (UG/L):	2.00	3.00	---	---
Boron (B), (UG/L):	80.00	70.00	80.00	80.00
Cadium (Cd), (UG/L):	-0-	-0-	---	---
Calcium (Ca), (MG/L):	20.00	17.00	17.00	17.00
Chloride (Cl), (MG/L):	49.00	50.00	51.00	49.00
Fluoride (F), (MG/L):	11.00	11.00	12.00	14.00
Iron (Fe), (UG/L):	20.00	-0-	20.00	-0-
Lithium (Li), (UG/L):	190.00	180.00	---	---
Magnesium (Mg), (MG/L):	0.70	0.50	0.20	0.20
Manganese (Mn), (UG/L):	40.00	50.00	40.00	30.00
Mercury (Hg), (UG/L):	0.10	-0-	---	---
Nitrogen (N), (MG/L):	0.05	-0-	0.01	0.01
Phosphate (PO_4) Ortho diss. as P, (MG/L):	0.15	0.02	0.03	0.12
Ortho, (MG/L):	0.15	0.06	0.09	0.12
Potassium (K), (MG/L):	8.00	8.10	8.30	8.70
Selenium (Se), (UG/L):	-0-	-0-	---	---
Silica (SiO_2), (MG/L):	81.00	71.00	100.00	77.00
Sodium (Na), (MG/L):	190.00	200.00	200.00	190.00
Sulfate (SO_4), (MG/L):	200.00	220.00	200.00	190.00
Zinc (Zn), (UG/L):	10.00	10.00	---	---
Alkalinity As Calcium Carbonate, (MG/L):	177.00	166.00	180.00	180.00
As Bicarbonate, (MG/L):	216.00	202.00	219.00	219.00
Hardness Noncarbonate, (MG/L):	-0-	-0-	-0-	-0-
Total, (MG/L):	53.00	45.00	43.00	43.00
Specific conductance (Micromohs):	870.00	1040.00	996.00	995.00
Total dissolved solids (TDS), (MG/L):	667.00	678.00	697.00	654.00
pH, Field	---	8.00	7.70	7.50
Discharge (gpm):	---	---	---	200.00
Temperature (°C):	71.00	70.00	70.00	50.00

Remarks: Located 270 feet southeast of house in lowest collection box. Discharge may represent total discharge of all springs.

Table 9. Chemical Analysis, Poncha Hot Springs, Discharge Point B. (Barrett & Pearl, 1976)

Location: 38°29'49"N. Latitude; 106°04'36"W. Longitude; T. 49N., R. 8 E. Sec. 15 cb, N.M.P.M., Chaffee County

	Date Sampled 6/75
Arsenic (As), (UG/L):	2.00
Boron (B), (UG/L):	70.00
Cadium (Cd), (UG/L):	-0-
Calcium (Ca), (MG/L):	18.00
Chloride (Cl), (MG/L):	48.00
Flouride (F), (MG/L):	12.00
Iron (Fe), (UG/L):	50.00
Lithium (Li), (UG/L):	180.00
Magnesium (MG), (MG/L):	0.50
Manganese (Mn), (UG/L):	40.00
Mercury (Hg), (UG/L):	0.10
Nitrogen (N), (MG/L):	0.02
Phosphate (PO_4)	
Ortho diss. as P, (MG/L):	0.04
Ortho, (MG/L):	0.12
Potassium (K), (MG/L):	7.80
Selenium (Se), (UG/L):	-0-
Silica (SiO_2), (MG/L):	83.00
Sodium (Na), (MG/L):	190.00
Sulfate (SO_4), (MG/L):	190.00
Zinc (Zn), (UG/L):	-0-
Alkalinity	
As Calcium Carbonate, (MG/L):	176.00
As Bicarbonate, (MG/L):	214.00
Hardness	
Noncarbonate, (MG/L):	-0-
Total, (MG/L):	47.00
Specific conductance (Micromohs):	940.00
Total dissolved solids (TDS), (MG/L):	655.00
pH, Field	---
Discharge (gpm):	30E
Temperature (°C):	66.00

Remarks: Located approx. 140 feet southeast of Spring A and approx. 50 feet higher up the hill.

Table 10. Chemical Analysis, Poncha Hot Springs, Discharge Point C. (Barrett & Pearl, 1976)

Location: 38°29'50"N. Latitude; 106°04'31"W. Longitude; T. 49 N., R. 8 E. Sec. 15 bc, N.M.P.M., Chaffee County

	Date Sampled			
	6/75	10/75	1/76	4/76
Arsenic (As), (UG/L):	6.00	4.00	---	---
Boron (B), (UG/L):	80.00	70.00	60.00	150.00
Cadium (Cd), (UG/L):	-0-	-0-	---	---
Calcium (Ca), (MG/L):	24.00	17.00	17.00	17.00
Chloride (Cl), (MG/L):	49.00	50.00	52.00	49.00
Flouride (F), (MG/L):	11.00	8.90	12.00	13.00
Iron (Fe), (UG/L):	40.00	10.00	30.00	---
Lithium (Li), (UG/L):	200.00	180.00	---	---
Magnesium (Mg), (MG/L):	0.80	0.40	0.30	0.40
Manganese (Mn), (UG/L):	50.00	40.00	40.00	40.00
Mercury (Hg), (UG/L):	-0-	-0-	---	---
Nitrogen (N), (MG/L):	0.02	0.01	0.02	-0-
Phosphate (PO_4)				
Ortho diss. as P. (MG/L):	0.05	0.02	0.03	0.05
Ortho, (MG/L):	0.15	0.06	0.09	0.15
Potassium (K), (MG/L):	8.30	8.10	8.30	8.60
Selenium (Se), (UG/L):	-0-	-0-	---	---
Silica (SiO_2), MG/L):	81.00	71.00	88.00	79.00
Sodium (Na), (MG/L):	190.00	190.00	200.00	190.00
Sulfate (SO_4), (MG/L):	200.00	210.00	200.00	190.00
Zinc (Zn), (UG/L):	4.00	10.00	---	---
Alkalinity				
As Calcium Carbonate, (MG/L):	176.00	174.00	179.00	180.00
As Bicarbonate, (MG/L):	214.00	212.00	218.00	219.00
Hardness				
Noncarbonate, (MG/L):	-0-	-0-	-0-	-0-
Total, (MG/L):	63.00	44.00	44.00	44.00
Specific conductance (Micromohs):	960.00	860.00	998.00	999.00
Total dissolved solids (TDS), (MG/L):	670.00	660.00	685.00	655.00
pH, Field	---	8.00	7.50	7.50
Discharge (gpm):	2.00	3.00	2.00	4.00
Temperature (°C):	63.00	62.00	63.00	62.00

Remarks: Uppermost spring in draw east of Springs A and B

Table 11. Temperature and Discharge Analysis of Poncha Hot Springs at Points D & E (Barrett & Pearl, 1976)

Location: 38°29'50"N. Latitude; 106°04'32"W. Longitude; T. 49N., R. 8E., Sec. 15 bc, N.M.P.M., Chaffee County

Temperature: 56°C

Discharge: 2 gpm (est.)

Specific conductance: 1,000

Remarks: Located approximately 40 feet northwest of Spring C

Poncha Hot Springs: Spring E

Location: 38°29'50"N. Latitude; 106°04'32"W. Longitude; T. 49N., R. 8E., Sec. 15 bc, N.M.P.M., Chaffee County

Temperature: 60°C

Discharge: 2 gpm (est.)

Specific conductance: 950

Remarks: Located approximately 20 feet southwest of Spring D

Table 12

Na-K-Ca VS. SILICA GEOTHERMOMETERS

Alkali Geothermometer: $T_A = \frac{1647}{\log(Na/K) + [\log(\sqrt{Ca}/Na) + 2.06] + 2.47} - 273.15$ T < 100°C, =4/3; T > 100°C, =1/3

Silica Geothermometer: (no steam loss) $T_S = \frac{1309}{5.19 - \log(SiO_2)}$ Silica Geothermometer: (maximum steam loss) $T_S = \frac{1522}{5.75 - \log(SiO_2)}$

Data Source	Sample Date	Discharge Point(3)	Chemical Analysis (mg/l)				Surface Temp. °C	Alkali Geothermometer °C		Silica Geothermometer	
			Na	K	Ca	SiO_2		= 4/3	=1/3	no st. loss	st. lo
I(1)	7/79	not recorded	170	9.1	19.0	84	44.5	104	150	128	125
B+P (2)	6/75	A	190	8.0	20.0	81	71	99	139	135	123
B+P	10/75	A	200	8.1	17.0	71	70	105	140	119	117
B+P	1/76	A	200	8.3	17.0	100	70	106	141	137	133
B+P	4/76	A	190	8.7	17.0	77	50	106	145	123	121
B+P	6/75	B	190	7.8	18.0	83	66	101	139	127	124
B+P	6/75	C	190	8.3	24.0	81	63	96	140	135	123
B+P	10/75	C	190	8.1	17.0	71	62	103	141	119	117
B+P	1/76	C	200	8.3	17.0	88	63	106	141	130	127
B+P	4/76	C	190	8.6	17.0	79	62	106	145	124	122

(1) Independent Contractor

(2) Barrett and Pearl, 1976

(3) As described in Tables 2-5

Table 13

Temperatures and Discharges
of Hot Springs in the Upper Arkansas Valley
(Barrett and Pearl, 1976)

Hot Spring	Measured Temperature	Estimated Discharge
Hortense Hot Spring	183°F	20-30 gpm
Mt. Princeton Hot Springs	132°F	400 gpm
Cottonwood Hot Spring	138°F	100 gpm
Poncha Hot Springs	158°F	200 gpm

Table 14

Chemistry of Poncha Hot Springs
and Local Cold Springs

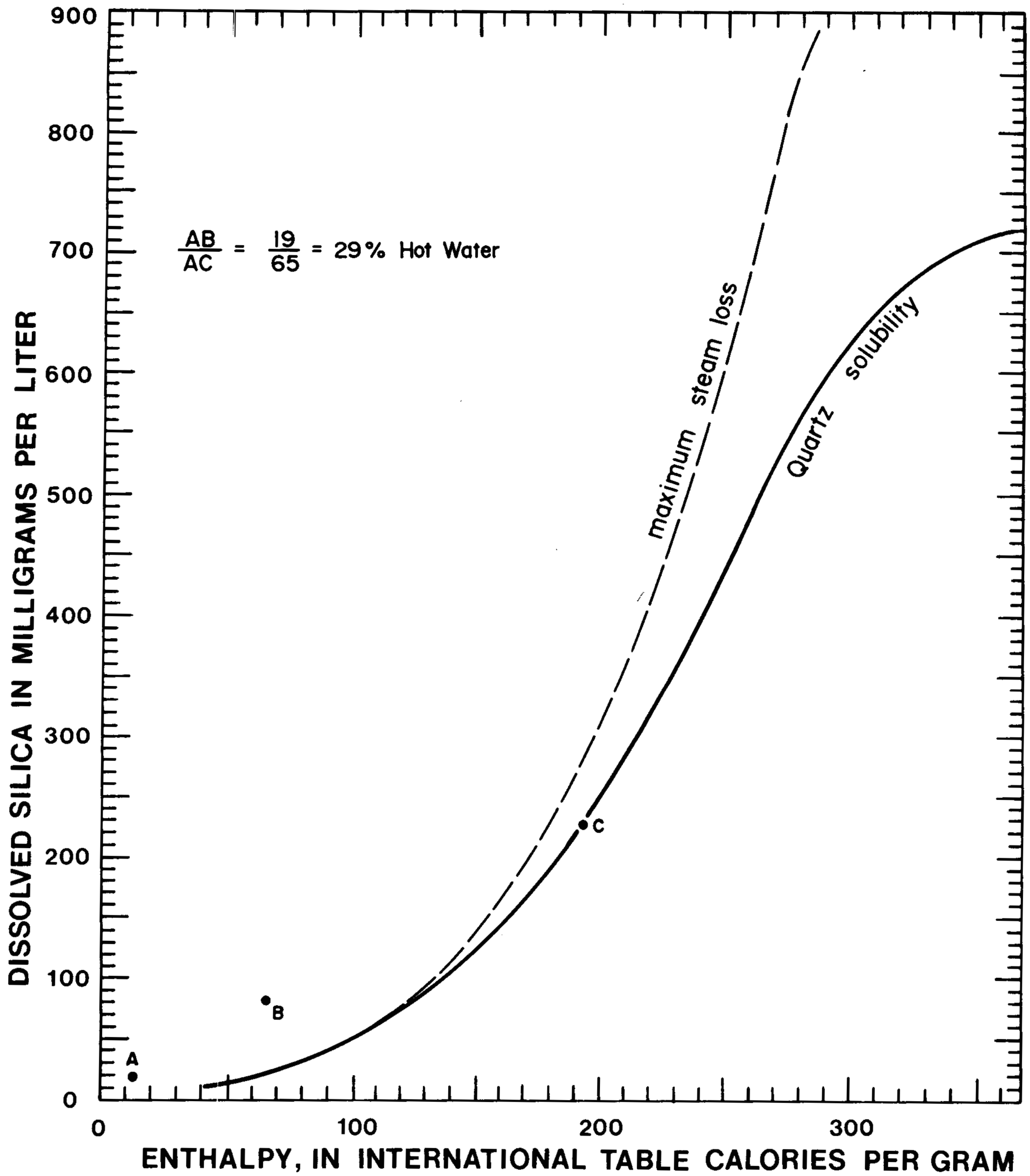
Concentrations in Milligrams/Liter

Samples Taken by an Independent Geophysical Contractor
For a Major Geothermal Company

Analytical Chemistry by Skyline Labs, Inc.
Wheat Ridge, Colorado

Analysis	Spring 1	Spring 2	Spring 3	Spring 4	Poncha Hot Springs
Na	6.20	1.40	7.40	9.40	170.00
K	5.70	4.90	2.70	1.80	9.10
Ca	36.00	12.00	25.00	56.00	19.00
Mg	13.00	2.00	5.50	13.00	1.20
B	< .10	< .10	< .10	< .10	< .10
CO_3	<2.00	<2.00	<2.00	<2.00	<2.00
HCO_3	135.00	36.00	86.00	195.00	180.00
Cl	2.00	2.00	5.00	5.00	46.00
SO_4	14.00	2.00	12.00	14.00	195.00
F	.88	.12	.44	.80	10.00
Al	.50	.30	.20	.20	.70
SiO_2	17.00	6.40	18.00	24.00	84.00
TDS	336.00	2.00	192.00	340.00	728.00
lab pH	7.00	6.90	6.90	6.30	7.90
conductance (Mmhos/cm)	272	74.80	182.00	332.00	750.00

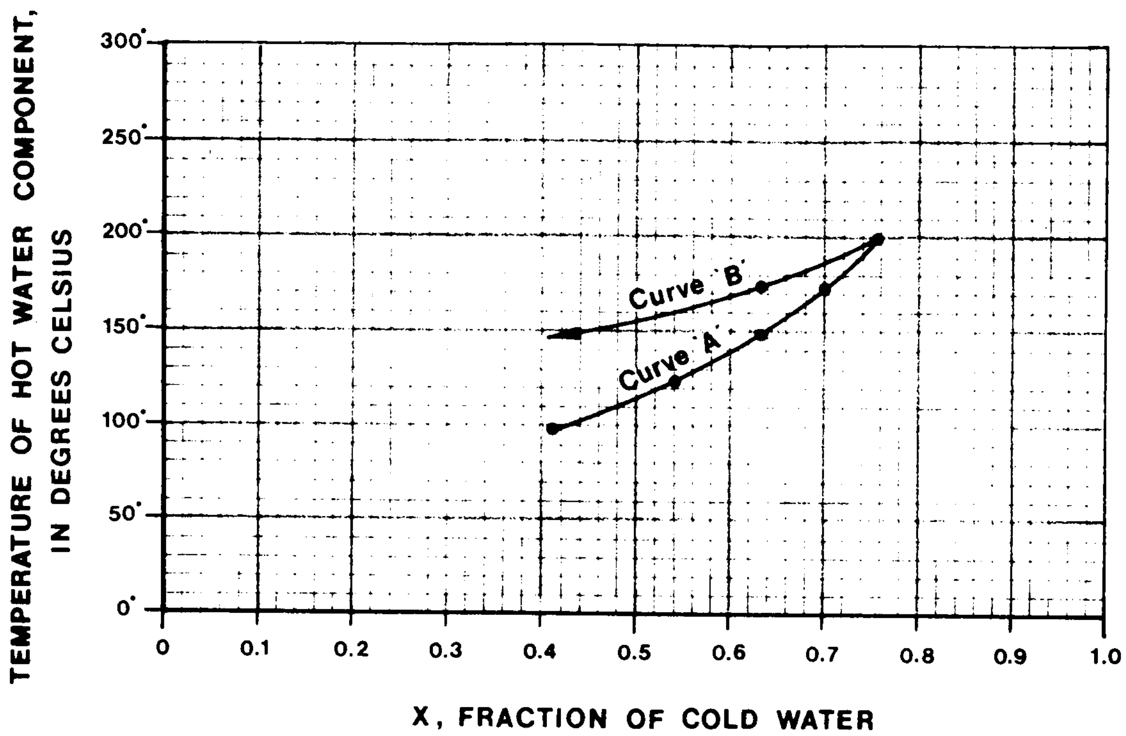
Sample locations are shown on Figure 10.



For determining the enthalpy of a hot-water component C, that mixes with cold water, A, to produce a warm spring, B, where no steam or heat has been lost before mixing. Point A was determined from geochemical data on local groundwater. Point B represents the fraction of hot water in the warm springs discharge, in this case, 29 . The graphical solution indicates a hot water component of approximately 190°C.
(from Truesdell and Fournier, 1977)

FIGURE 8

Dissolved Silica- Enthalpy Graph.



Fraction of cold water relative to temperature of hot water component. The intersection of curves A and B gives the estimated temperature of the hot-water component and the fraction of cold water. This graphical solution indicates that the hot water component has a temperature of 200°C and that the cold water fraction of the spring discharge is 75%.

For Curve A, $X = \dfrac{(\text{Enthalpy of hot water}) - (\text{Temperature of warm spring})}{(\text{Enthalpy of hot water}) - (\text{Temperature of cold spring})}$

For Curve B, $X = \dfrac{(\text{Silica in hot water}) - (\text{Silica in warm spring})}{(\text{Silica in hot water}) - (\text{Silica in cold spring})}$

(from Fournier and Truesdell, 1974)

FIGURE 9

Mixing Model Graph

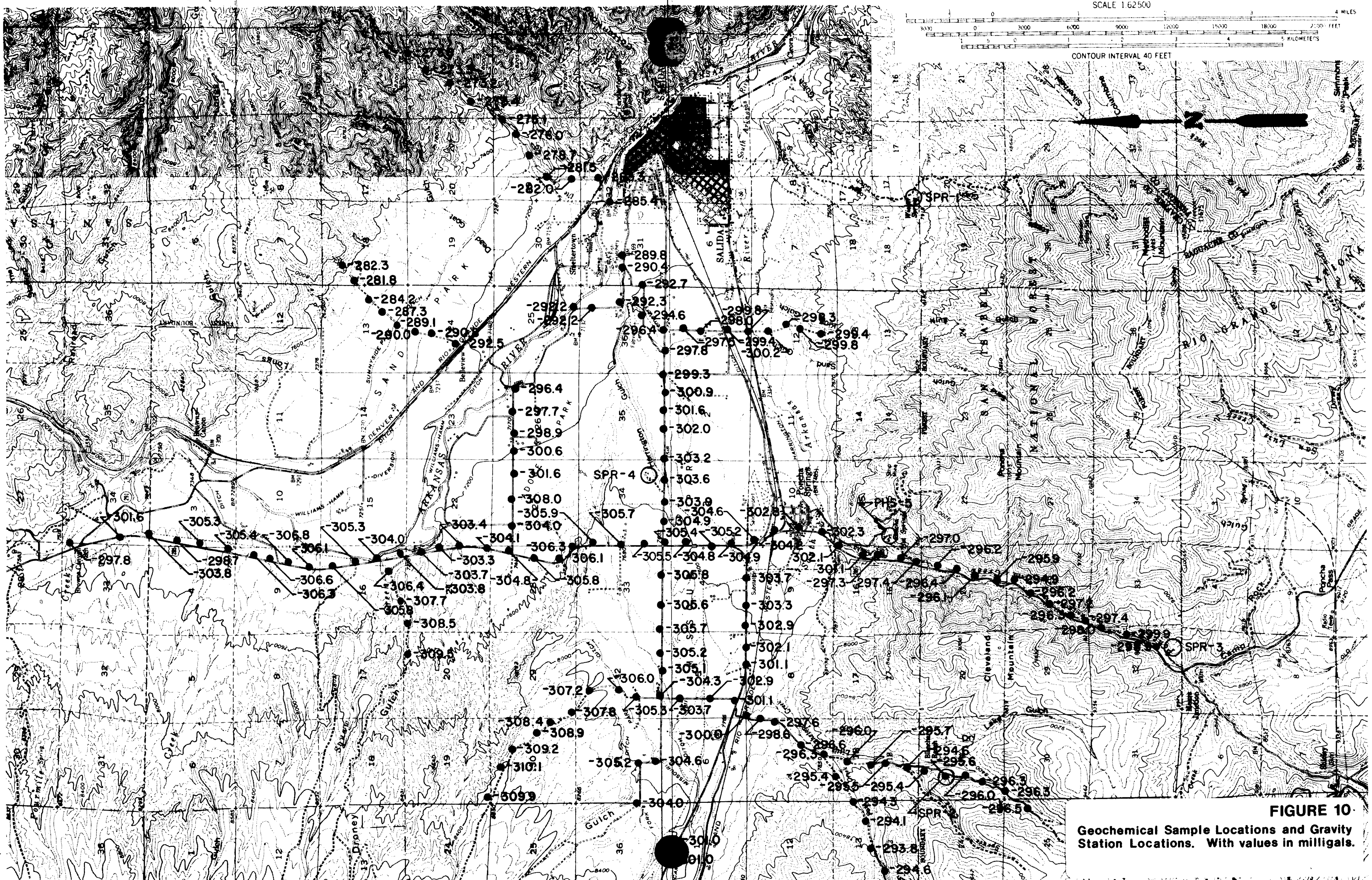


FIGURE 10
Geochemical Sample Locations and Gravity Station Locations. With values in milligals.

is calculated by concentrations, whereas the latter is a ratio of concentrations and is, therefore, somewhat less sensitive to dilution.

Temperature Gradients and Heat Flow

Four temperature gradient holes have been drilled and logged by a private geophysical contractor for a major energy company interested in the Poncha Springs geothermal resource area. Figure 11 shows the locations of these holes. Three of the holes were drilled into Dry Union sediments and exhibit temperature gradients of 3.1 to 3.2^{o}F per hundred feet. The fourth hole penetrates the Precambrian metamorphic rock and is located one-half mile southwest of Poncha Hot Springs. This hole has a gradient of 3.6^{o}F per hundred feet.

Table 15 shows that heat flow at hole number four is more than twice the value computed at the other three sites. Laboratory values for conductivity were unavailable, so they were assigned values typical for their respective lithologies. Although these four holes do not provide enough data to produce a reliable heat flow map, they do suggest that anomalous heat flow is associated with the Precambrian rock and its fault contact with the Dry Union Formation.

Geophysical Surveys

Gravity. A gravity survey was conducted at 168 stations in July, 1979. This work was done with a La Coste-Romberg model "G" gravimeter along existing paved and gravel roads. Station spacing was one quarter mile and line spacing was one to three miles, depending on access.

Figure 12 shows the station locations and the manually contoured isogals. Free air and simple Bouguer corrections were applied to measured values, but no terrain corrections were made. Thus, the gravity map is somewhat inaccurate. However, the isogals do follow surface geology and support the interpretation of major east-trending faults at Poncha Hot Springs. The data

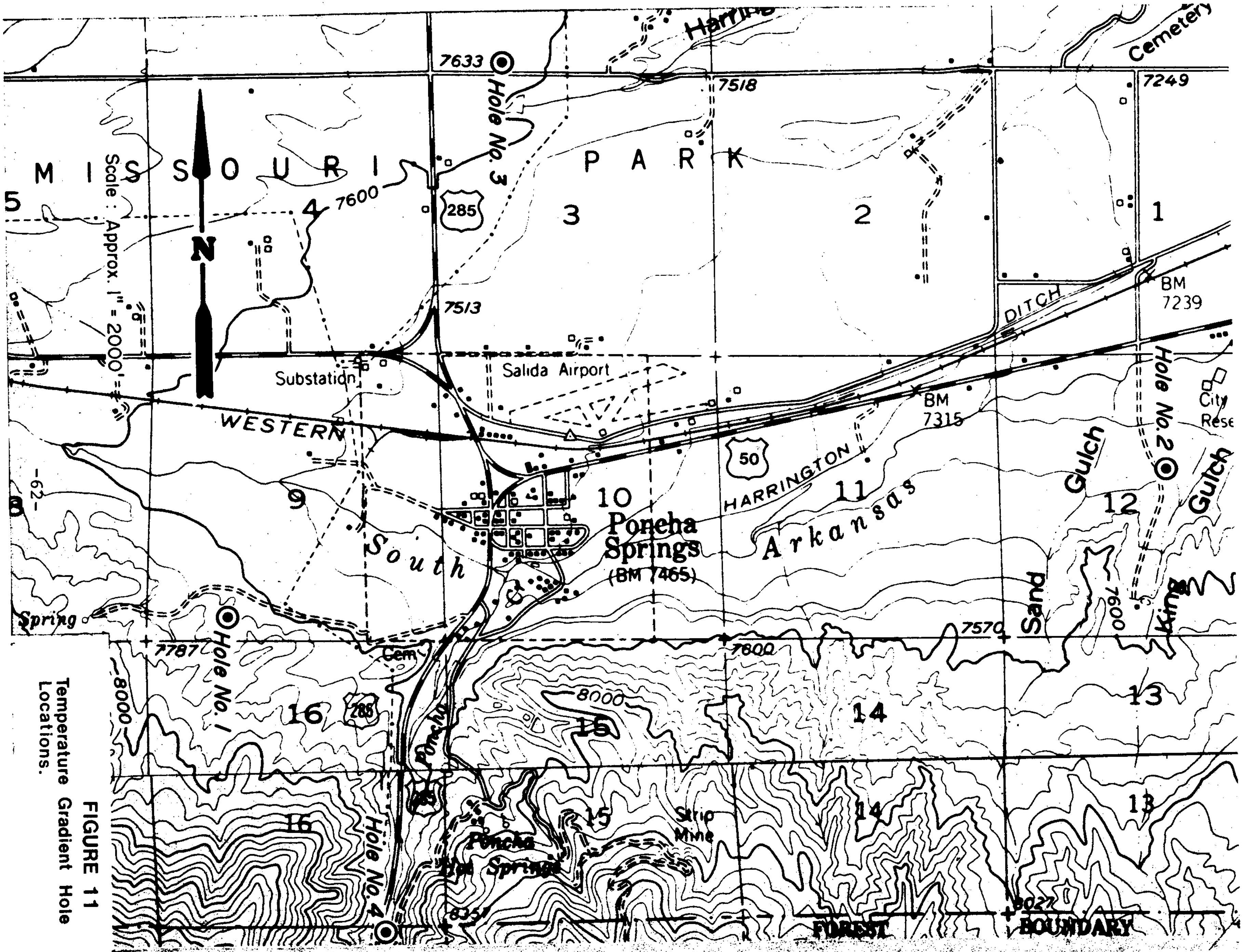


FIGURE 11 Temperature Gradient Hole Locations.

Table 15

Temperature Gradients and Heat Flow
Poncha Springs Area

Hole (1) Number	Temperature Gradient (°F/100)	Temperature Gradient (°C/Km)	Assumed Conductivity (10^{-3}cal/cm·sec·°C)	Calculated Heat Flow (10^{-6}cal/cm^2·sec)
1	3.1	56.5	3.0	1.7
2	3.2	58.3	3.0	1.7
3	3.1	56.5	3.0	1.7
4	3.6	65.6	6.0	3.9

(1) Hole locations shown on Figure 11

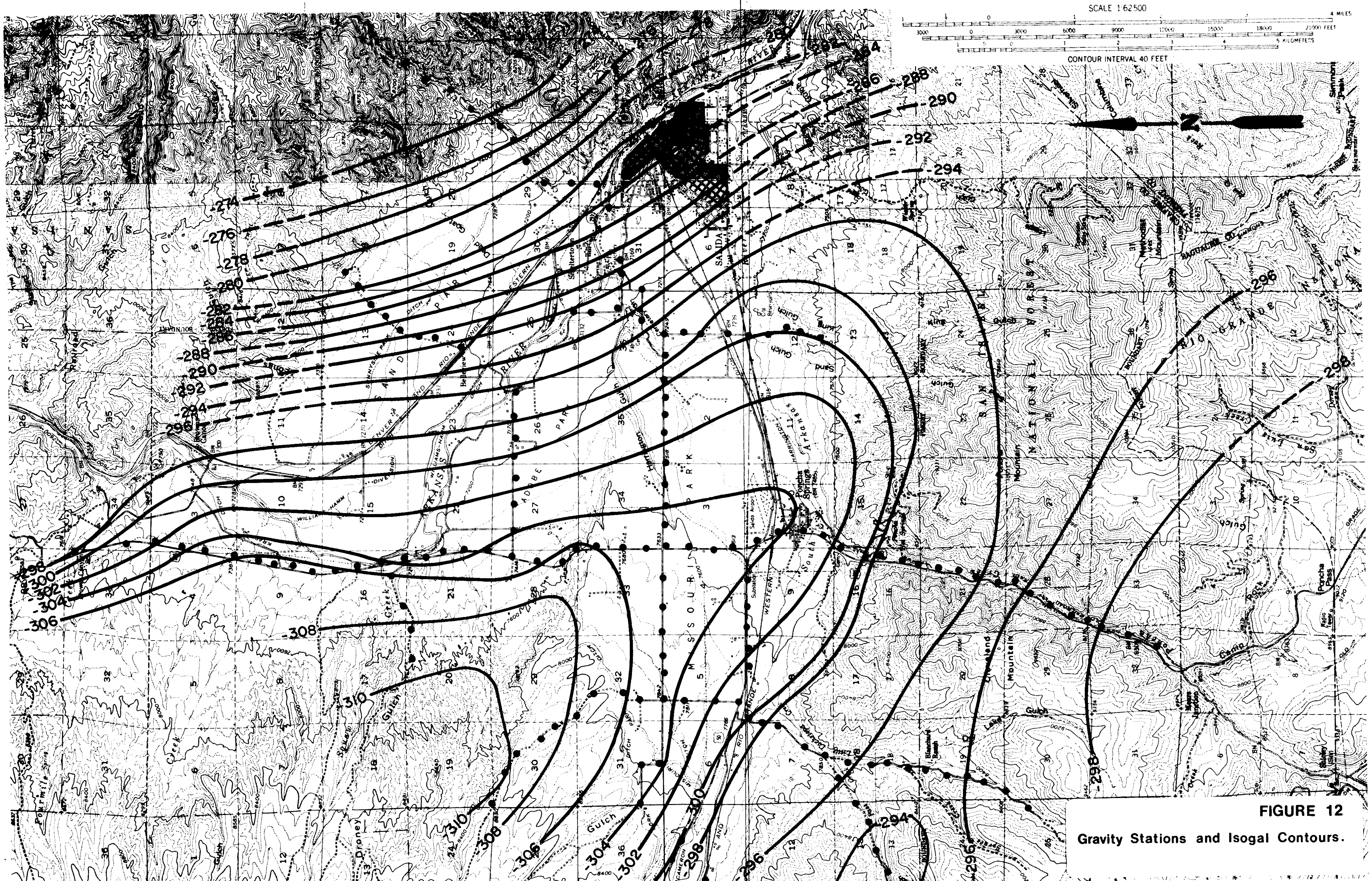


FIGURE 12

Gravity Stations and Isogal Contours.

are of greatest value in assessing throw along these faults and in modeling basement depths beneath the Dry Union Formation north of the Hot Springs.

Figure 13 is a gravity plan map and cross-section of the data line closest to Poncha Hot Springs. The faults that are shown on the plan view are taken from the Geologic Map of the Poncha Springs Quandrangle (Scott, et. al., 1975). Cross-section lines depict the topography while X's mark the calculated basement depths. The cross-section has a vertical exaggeration of approximately 12:1 to emphasize basement relief (and there is apparently 1,000 feet of displacement along the fault just north of the hot springs). Hot water probably migrates upward along one or more of the faults shown in Figure 13.

Resistivity. A regional resistivity survey was conducted in May and June of 1976 by the Department of Geophysics of the Colorado School of Mines, Golden, Colorado. This work was part of a broader effort, and these data were developed into a masters thesis at the School of Mines.

Receiver station density around Poncha Hot Springs was inadequate to justify resistivity contouring near the Springs with much certainty, and so the contours reflect outcrop patterns of crystalline versus unconsolidated formations. Higher resistivities up to 200 ohm-meters are found overlying the Precambrian rocks, whereas the Dry Union and Quaternary sediments exhibit resistivities as low as 5 ohm-meters. The Hot Springs seem to have no expression on apparent resistivity (see Figures 14 and 15).

The higher apparent resistivity of the Precambrian crystalline rocks suggests that although the geothermal resource may be confined to these rocks, (as indicated by temperature gradient data), it is not pervasively distributed in them but is confined to selective conduits and planar (fault, fracture) features.

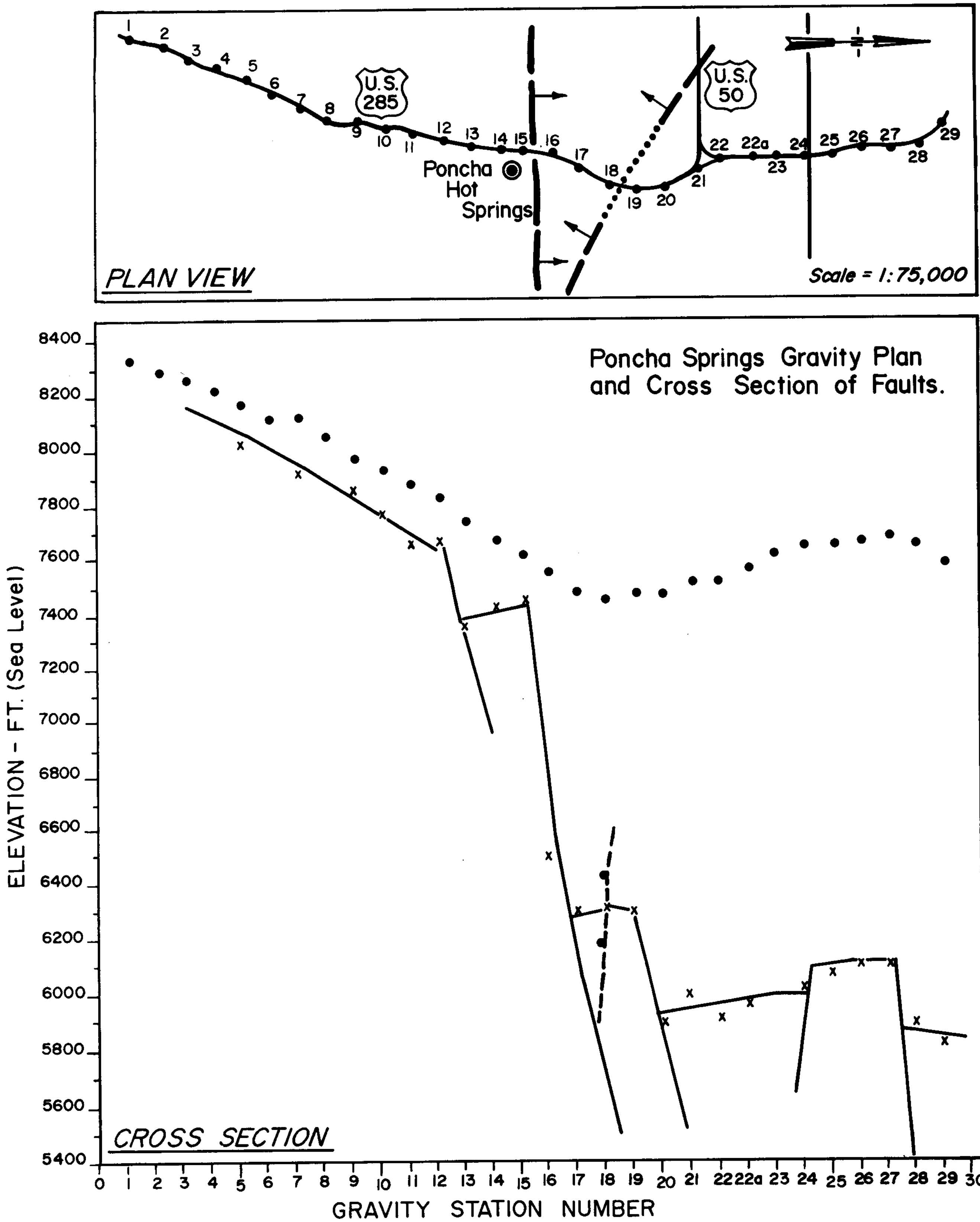
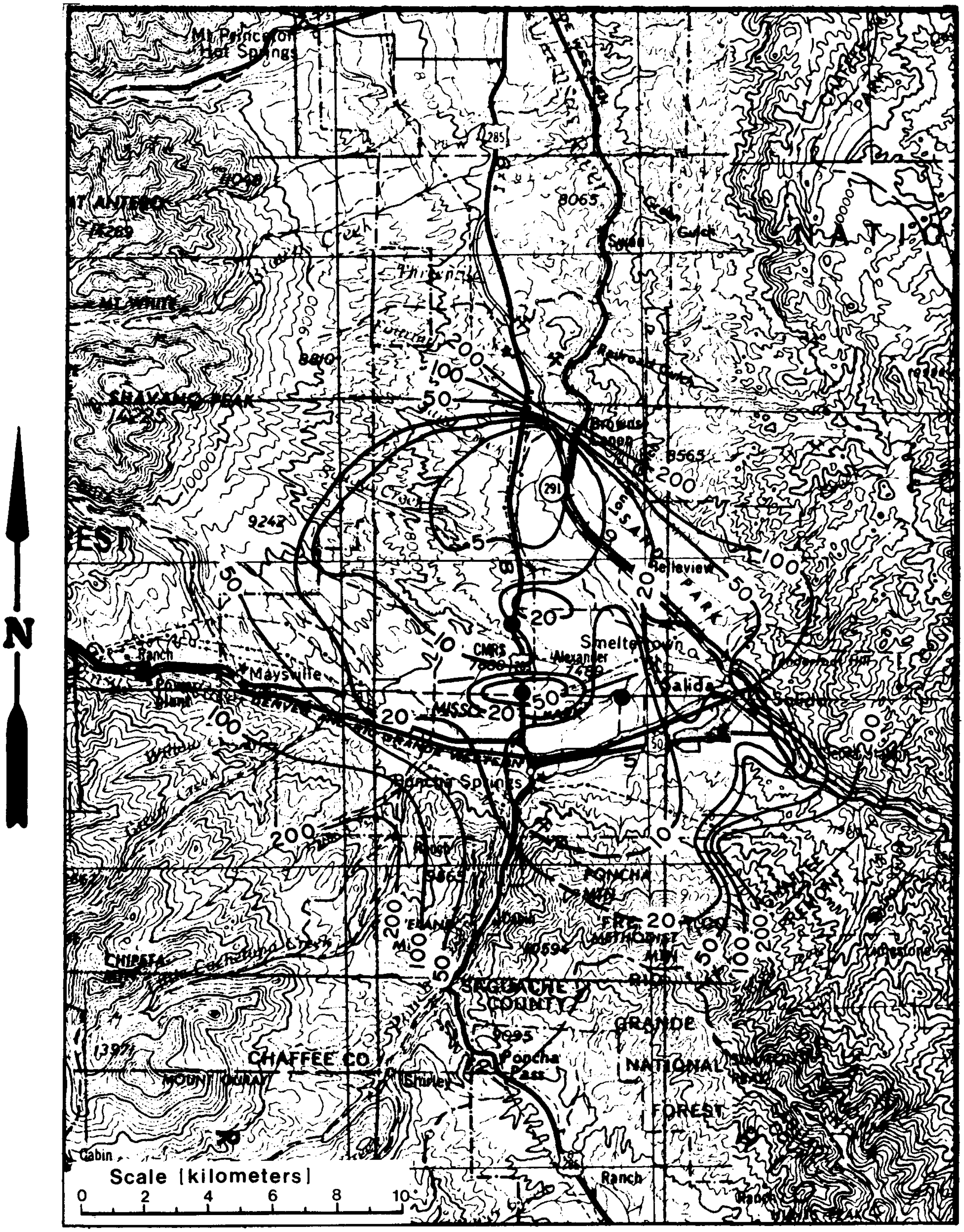


FIGURE 13

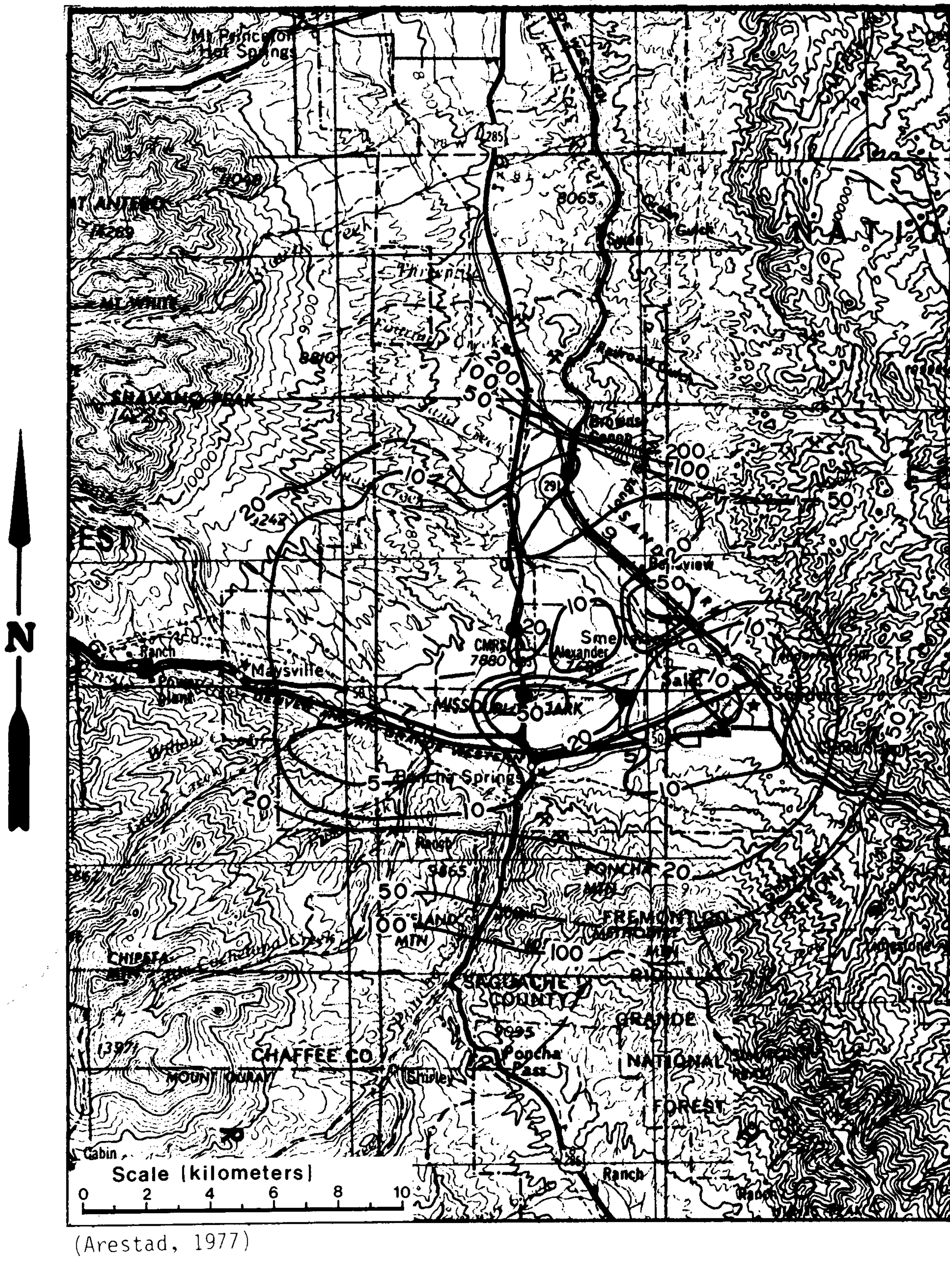
Gravity Plan and Cross Section of Faults.



(Arestad, 1977)

FIGURE 14

Apparent Resistivity, North - South Bipole



(Arestad, 1977)

FIGURE 15

Apparent Resistivity, East - West Bipole

C. Summary of Existing Data

The evidence from geochemical, geophysical, and geological work indicates that a geothermal resource of low salinity water at 250°F may exist within fractures and fault intersections in the Poncha Hot Springs area. The heat source that is envisioned is a slightly higher regional temperature gradient associated with late Tertiary rifting. There is no compelling evidence for shallow magmatism beneath Poncha Hot Springs. Structural trends reflect regional stress fields as they have evolved in the area and do not exhibit any identifiable volcano-tectonic features. Neither radial nor concentric fracturing and faulting has been identified, and Quaternary volcanics are absent. Fumarolic activity, although not a prerequisite, is also absent.

Limbach's analysis (1975, pp. 80 through 81) of hydrothermal systems within the Upper Arkansas Graben further supports a non-magmatic heat source: "The zeolitic alteration assemblage present at Chalk Cliffs is normally formed at depths of 150-2000m (500-6600 feet) (Sharp, 1970). This would indicate that the alteration high on the side of Mount Princeton, 1000m (3300 feet) above Mount Princeton Hot Springs, has been uplifted and exposed for a considerable length of time.

The above discussion would suggest that hydrothermal activity along the Upper Arkansas Graben has been nearly continuous from the Miocene to the present. Such a long-lived geothermal system must rely on an abnormal geothermal gradient or continuous magma generation at shallow depths for such a long-lived source."

D. Proposed Exploration Program

As indicated previously, further exploration will be required prior to test drilling the Salida Geothermal Prospect. The present exploration data which have been derived by others, as well as for Chaffee Geothermal, are adequate to show the existence of a known geothermal resource. However, data compiled and interpreted herein are of too broad a nature to target a specific drilling site; therefore, further exploration is needed.

To date, adequate stratigraphic studies and overall geological reconnaissance have been performed. There is no need to study further the compositions of the stratigraphic units near Poncha Hot Springs. More detailed structural and tectonic interpretation, as well as field mapping confirmation and overall subsurface geological modeling are mandatory. The ground water geochemical models of the Poncha Springs area are adequate and need no further interpretation or analysis. The hot water sampling and computer modeling programs of the Colorado Geological Survey are very precise and yield sufficiently valid information.

The first phase of the proposed exploration program would include extensive structural, tectonic, and subsurface geological modeling of previously existing data. Then a cheap, quick, and highly cost effective gravity survey would be conducted at the prospect site. Previous gravity surveys were conducted but because of their lack of appropriate computer reduction and wide spacing of station locations, more detailed gravity measurements are required. Proposed gravity lines should run across anticipated fault traces as indicated by the dash lines (---) on Figure 16. In order to target more accurately true fault locations, gravity stations should be located

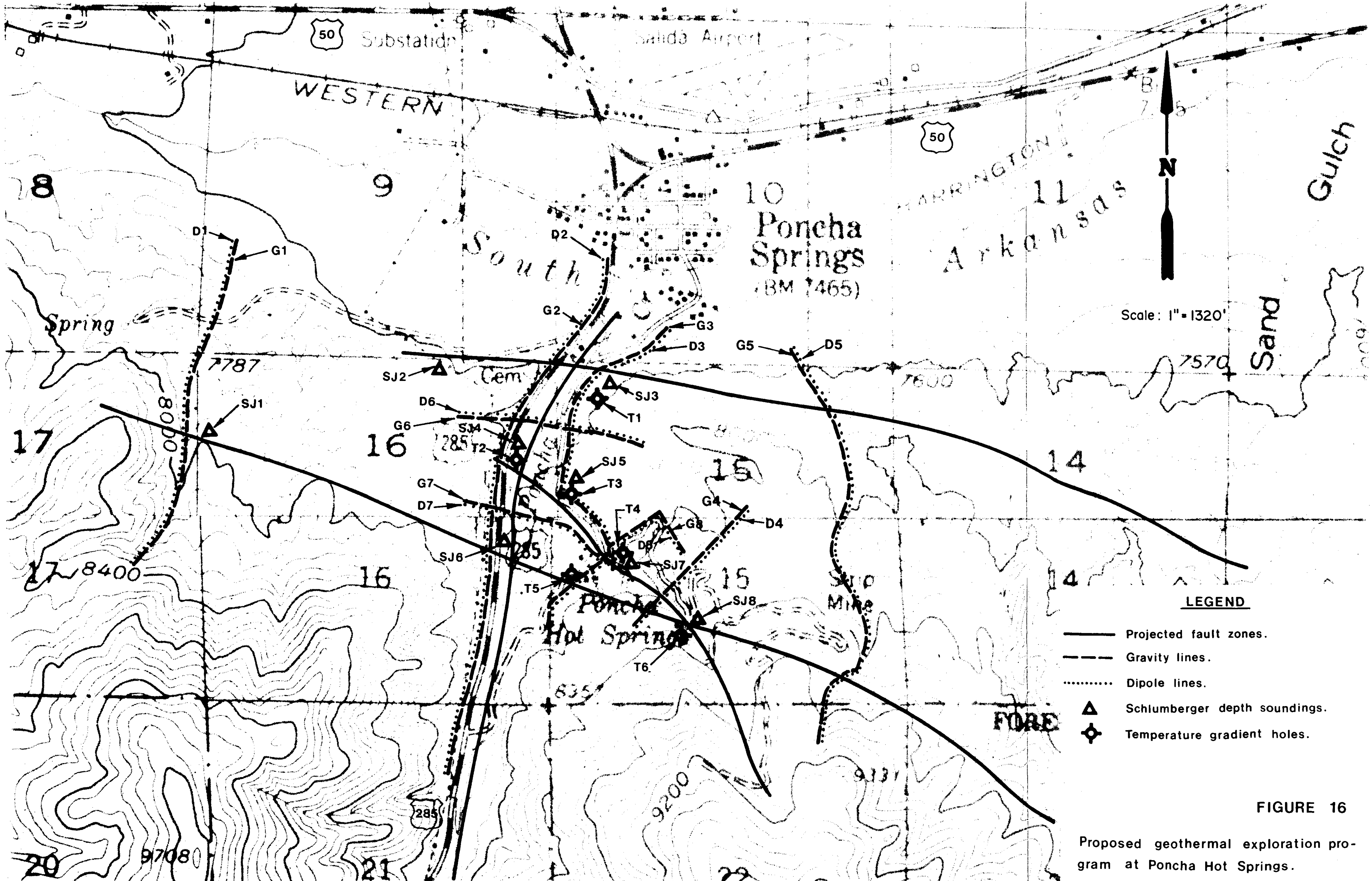


FIGURE 16

Proposed geothermal exploration program at Poncha Hot Springs.

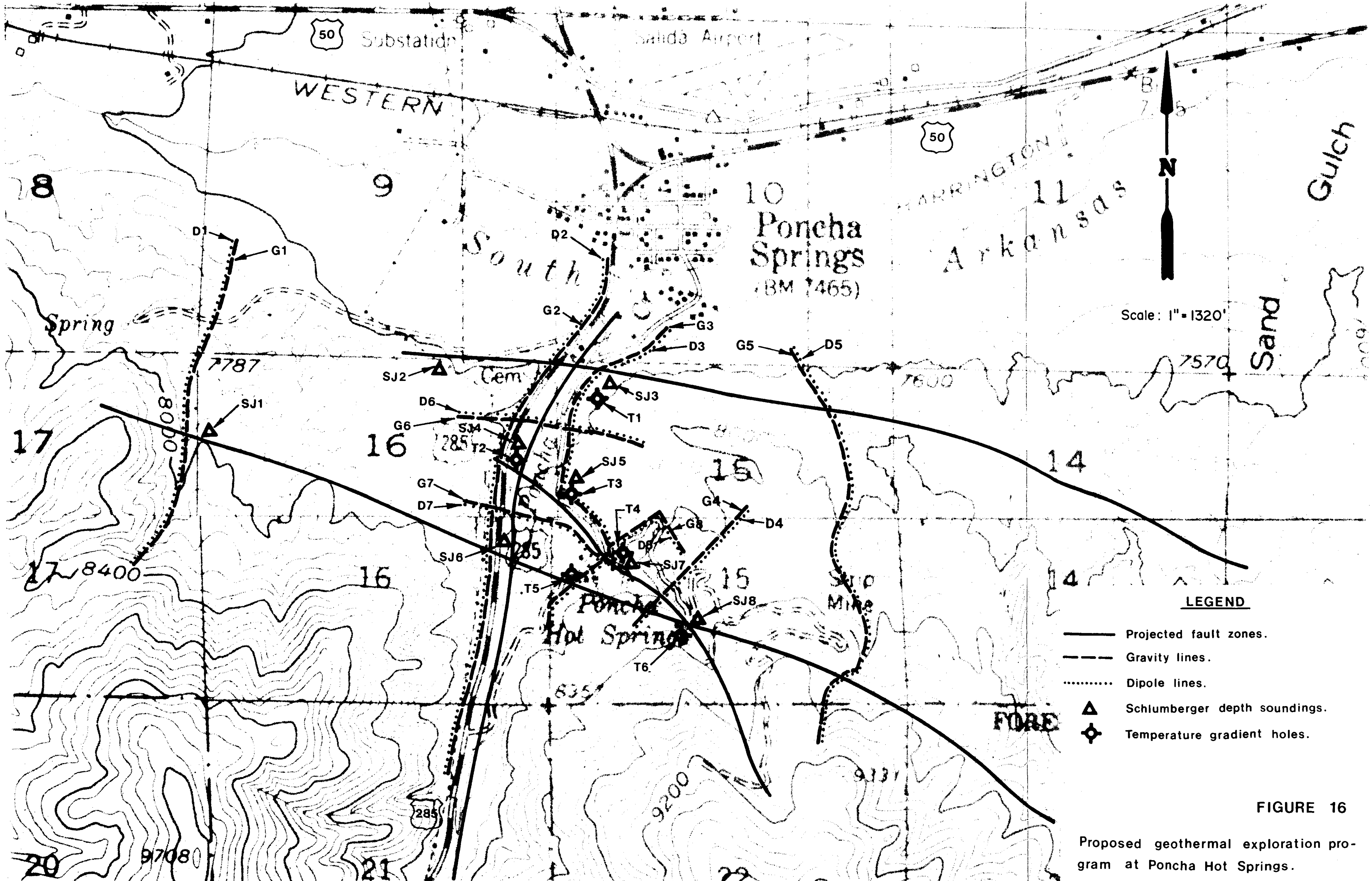


FIGURE 16

Proposed geothermal exploration program at Poncha Hot Springs.

every 200 to 300 feet. Simultaneously with conducting the gravity survey, numerous soil mercury samples should be taken throughout the entire prospect area.

After the gravity and soil mercury surveys have been interpreted, an accurate projection of fault locations may be traced. At this time, it would be prudent to conduct further electrical resistivity surveys to enhance those previously conducted by researchers. One suggested electrical survey might be running several dipole-dipole lines trending north-south and east-west through the prospect area as shown by (......) on Figure 16. These surveys should further delineate fault zones and outline the areal extent of the thermal anomaly by indicating shallow zones of high electrical conductance.

At this time, an accurate picture can be projected of fault traces and the outer margins of the geothermal resource area. Further information pertaining to vertical profile modeling may be derived by conducting Schlumberger depth soundings. Schlumberger depth soundings yield accurate data on the vertical changes in electrical resistivity at depth. Actual station locations will be determined as a function of the interpretation of previously conducted exploration surveys. However, anticipated target sites are projected on Figure 16 and represented by Δ .

The last exploration survey to be conducted should be the drilling of six shallow temperature gradient holes (300 feet). As indicated herein, four temperature gradient holes have been drilled at the prospect site. As with the location of the Schlumberger stations, temperature gradient drilling sites will be a function of the interpretation of previously conducted surveys, but possible sites are represented as (–⌖–) as shown on Figure 16. After gradient holes have been drilled and temperature logged, all data will be fed into an existing computer program which has been made available by another major geothermal exploration company. This computer program will calculate temperature gradients and heat flow. It will also construct contour maps of these calculations as well as projecting depths to the 200°F isotherm and temperatures at 1000-1500 feet of depth.

This exploration program combined with previous surveys and interpretations of the Poncha Hot Springs area should reveal an accurate geological model of the geothermal resources of the area. From these surveys, a specific location can be sited to drill the initial 1500 foot exploration/production well. Table 16 shows the approximate costs of those exploration surveys outlined herein.

Table 16

1982 Exploration Program and Costs

Geological review and interpretation (February)	$ 5,000
Detailed, close-grid gravity survey (March)	10,000
Detailed, close-grid soil mercury survey (March)	5,000
Dipole-dipole or roving-bipole surveys (April)	25,000
Schlumberger soundings (May-June) 8 - 10 / 1500' soundings	20,000
Gradient hole drilling (July-August) 6 / 300' holes	30,000
Temperature logging gradient holes (September)	-0-
Drafting, maps, computer, etc.	5,000
	$ 100,000

E. Reservoir Testing

After wells are drilled (see following section), the testing of the geothermal reservoir in the Salida area will consist of three successive phases: 1) short-term single-well test, 2) long-term single-well test, and 3) long-term multi-well tests. Information developed during each phase will be used to design the subsequent test(s). This stepped approach to determining reservoir characteristics stems partly from the proposed drilling and production schedule and the need to provide reservoir information for short- and long-term projections of production requirements.

During the drilling of each hole, vital data will be collected from the borehole and nearby springs. Well discharge, temperature, conductivity, pH, spring discharge and/or pressure, and various geologic data will be monitored. This information will not only be used to design the specific well construction, but also will be used to develop a conceptual model of the reservoir.

Short-Term Single-Well Test

Once the production casing is in place and the first hole fully developed, a short-term test will be performed using the rig and its equipment. The purpose of this test is to determine approximate reservoir characteristics which can then be used for efficient design of the longer tests. This test will consist of air-lift pumping through the drill stem for 2 to 3 hours, while measuring residual drawdown. Drawdown and subsequent recovery will be measured via airline which has a resolution of about .5 feet. A water level probe will be used to calibrate the airline. Discharge will be measured with a cut-throat flume of an appropriate width for the expected flow.

These procedures assume the well will have to be pumped. If flowing conditions exist, then the well can be tested without the rig and drawdown and recovery will be measured with a pressure gauge or manometer tube.

From the short-term test, an estimate of transmissivity and specific capacity can be calculated. A semi-log plot of time in minutes on the log scale versus drawdown divided by discharge on the arithmetic scale will allow a straightline calculation of transmissivity in gallons per day per foot. As a check, recovery data can also be plotted on semi-log paper, plotting residual drawdown on the arithmetic scale and t/t' (time pump turned off divided by elapsed time since off) on the log scale. This will also result in a straightline calculation of transmissivity. In addition, the discharge divided by total drawdown is the specific capacity in gpm/ft. of drawdown.

These calculated numbers will help determine pump size, depth of pump placement, and test duration for the long-term test.

Long-Term Single-well Test

The purpose of this test is to determine accurate reservoir characteristics so that production projections can be made with some confidence. These projections include long-range discharge, head-loss, and radius of influence.

The long-term test will involve setting a submersible or turbine pump, depending on the flow rate, at a predetermined depth. Drawdown and recovery will be measured with a downhole transducer and an airline as a backup. Discharge will be measured with an appropriate orifice plate and a flume as a backup. Prior to pumping, barometric pressure and water level will be measured and recorded continuously for at least two weeks in order to develop background water level fluctuations and response to barometric changes. The pumping phase of this test will last for at least 24 to 72 hours, depending on the specific conditions. The recovery portion will continue until fully recovered or for 72 hours. Water temperature will be measured hourly during the pumping phase.

Numerous interpretation methods are available for this type of test, including Theis, Jacob, and Hantush. Several will be tried to confirm the accuracy of the results. With relatively accurate calculated reservoir characteristics, long-range projections of discharge, head-loss, and radius of influence can be determined. However, since storativity cannot be calculated from a single-well test, it will have to be estimated for these projections. The radius of influence will be important for the placement of future production wells in order to avoid excessive interference and therefore headloss.

Long-Test Multi-Well Test

As other wells are drilled to meet production requirements, they will undergo short-term tests to check well efficiencies and then become part of a larger multi-well test. A long-term multi-well test is the most desirable method for determining reservoir characteristics, particularly if the system is anisotropic and geologically complex.

This test will consist of pumping one well and monitoring drawdown and recovery in all wells, using methods described in preceding sections. If anisotropic conditions are thought to be dominant, each well can be alternately pumped, while measuring drawdown and recovery in the nonpumping wells. A 10-channel recorder could be used with the transducers to insure accurate and complete records of water levels in each of the wells.

Again, numerous interpretation methods are available and several will be tried. Storativity can be calculated from the results of a multi-well test, which will lend more confidence to the projections described above.

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Section IV

WELL ENGINEERING AND SYSTEM DESIGN

A. Well Engineering

As previously discussed in Section III, a site-specific target location for the first exploration well cannot be determined. Making several assumptions based upon the interpretation of the resource assessment, the first exploration well is targeted for that location shown on Figure 17. This site has been selected based upon known geological data, proximity to the hot springs and controlling faults, and the current acreage leasing position held by Chaffee Geothermal, Ltd. If the geothermal resource is confined to the basement contact between the crystalline banded-gneiss and the overlying Dry Union sediments, then well depth should be approximately 1500 feet.

It is not known if these wells will produce under flowing artesian conditions or if they will be pumped. Therefore, production casing run back to the surface will be no smaller than 8-5/8 inches (OD) as shown on the well profile in Figure 18. This will allow pumping (if necessary) via downhole impellers or a submersible pump.

The first exploration well for the Salida Geothermal Prospect will be numbered via the "Modified Kettleman Well Numbering System" as required by the BLM and USGS. Combining this numbering system with Chaffee Geothermal's standard limited partnership well numbering system, a well located, as shown on Figure 17, will be named "Chaffee-Salida 25-15."

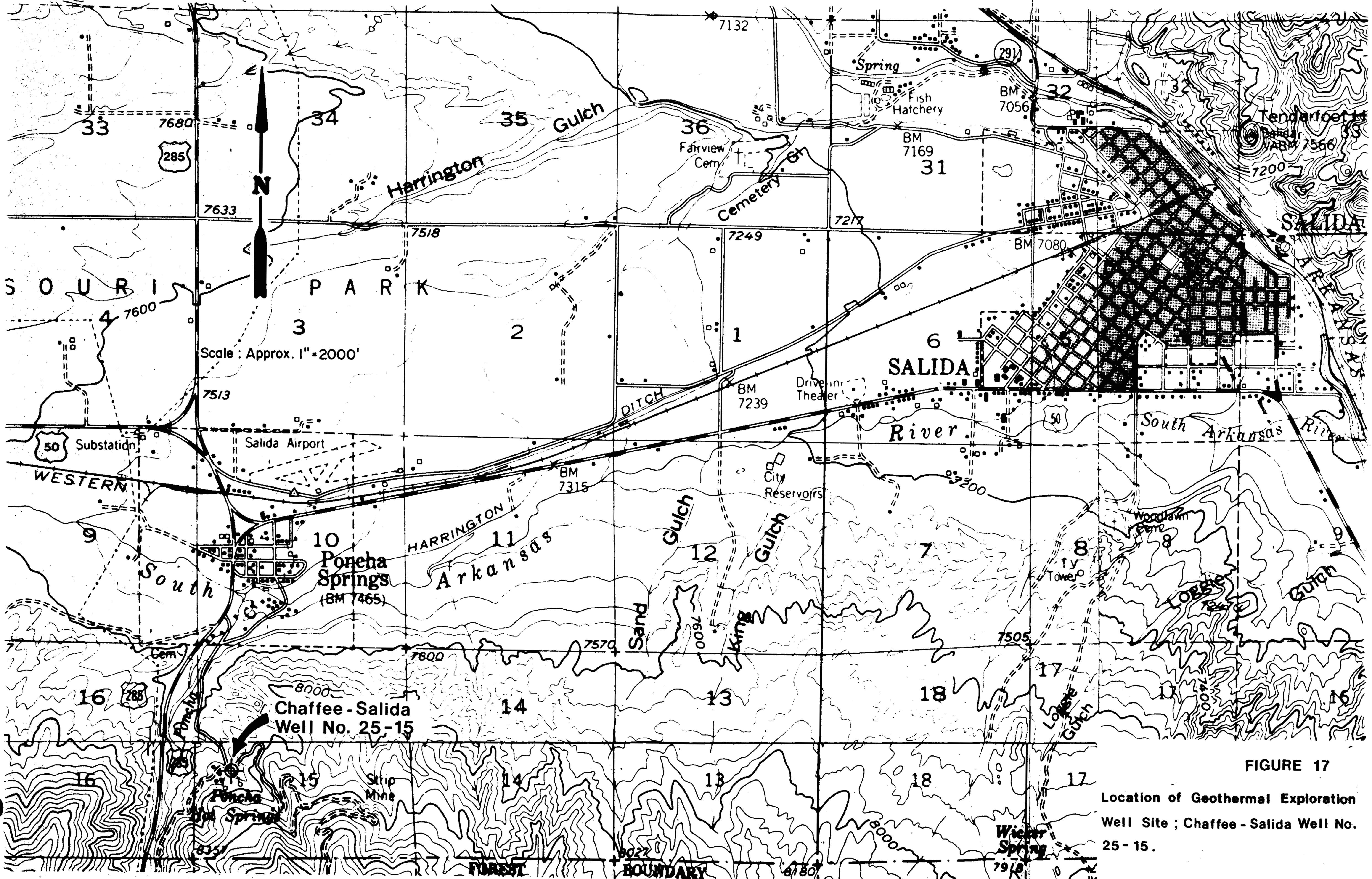
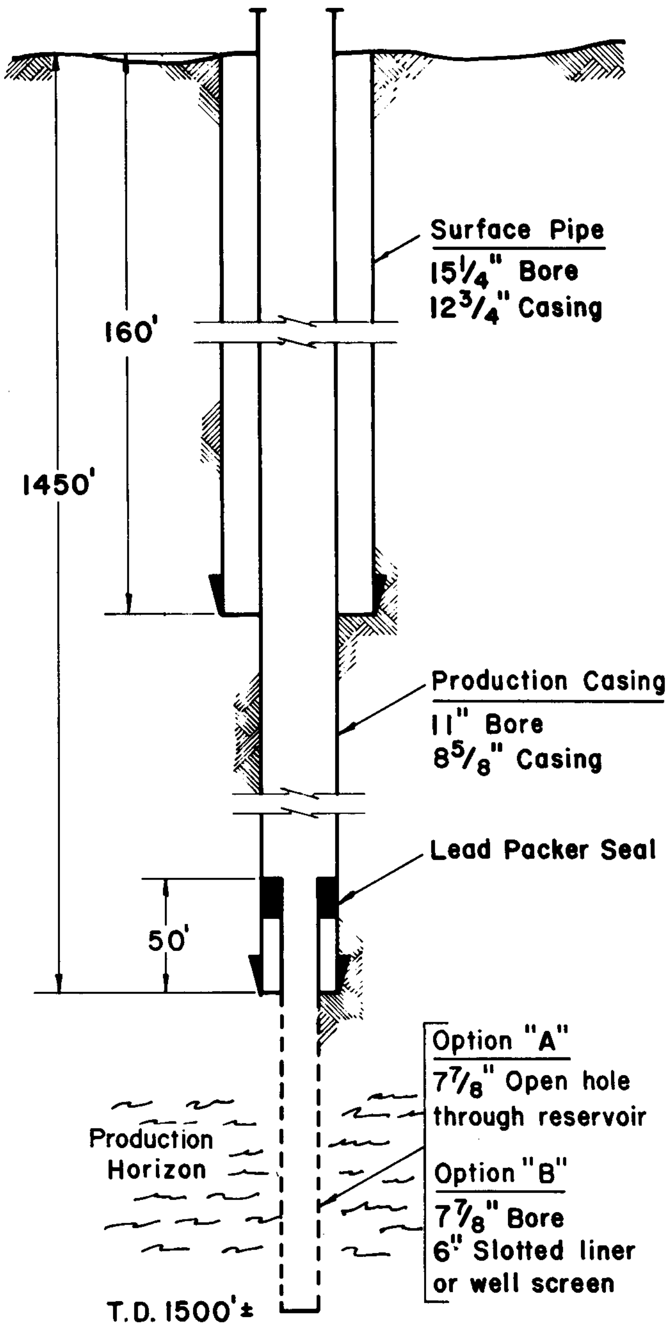


FIGURE 17

Location of Geothermal Exploration Well Site ; Chaffee - Salida Well No. 25 - 15.



Borehole and Casing schematic for geothermal exploration well; Chaffee-Salida 25-15.

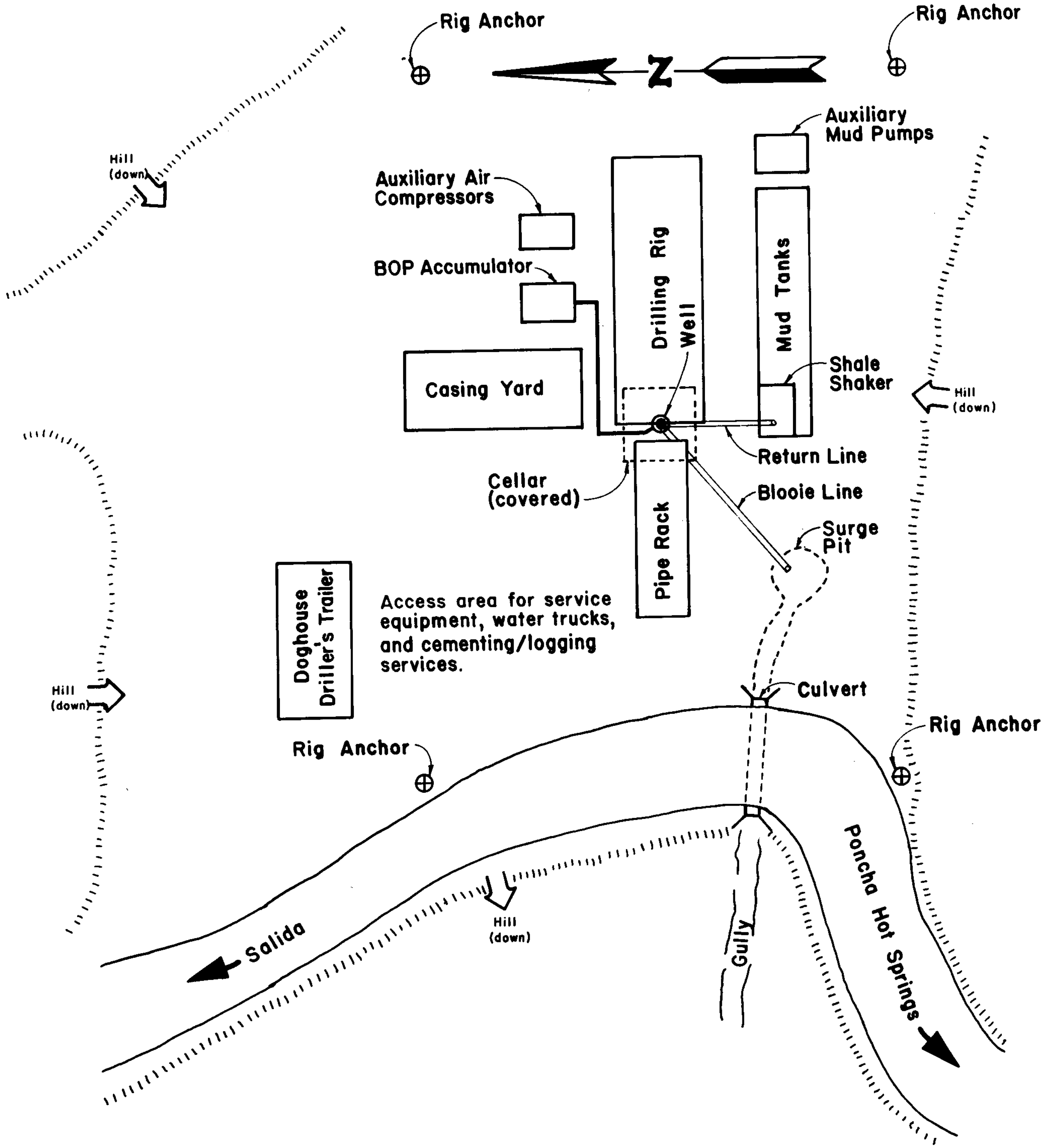
FIGURE 18

As shown on Figure 18, no conducter pipe is necessary and therefore will not be used in order to reduce costs. The first string of casing will be 12-3/4 inch surface pipe (casing specifications are cataloged later herein) and will be set into the Dry Union Formation to a depth of approximately 160 feet. It is very important that the surface casing be set prior to encountering any large volume of fluids because blowout prevention equipment will be nippled-up to this casing string. Previously drilled temperature gradient holes in the immediate proximity to Chaffee-Salida 25-15 will indicate if fluids are anticipated shallower than 160 feet.

Production casing (8-5/8 inch OD) will be run from the top of the reservoir (projected at 1400 to 1500 feet) back to the surface. Pending the competency of the Dry Union Formation or the basement rock at the production horizon, either the well will be completed as an open-hole (7-7/8 inch) or a 6 inch slotted liner can be set through the production horizon.

The general procedure for the drilling of Chaffee-Salida 25-15 will be as follows:

1. Level a drilling pad of approximately 100' X 125' and excavate a drilling cellar of 5' X 5' X 3'. Mud pits should be excavated on the downhill side of the cellar and a flowline constructed away from the site. At this time, a reserve pit should not be built as any flow can be turned to an adjacent gulch. When production rates increase sufficiently, this gulch can be diked to form a reserve pit. The planned layout of the drilling site is shown on Figure 19.
2. Line cellar with cement or railroad ties; install drains.
3. Move in rotary drilling tools and rig-up.



Operations site plan for geothermal exploration well;Chaffee-Salida 25-15. (Approx. Scale: 1/16"=1'-0")

FIGURE 19

4. Begin drilling with 7-7/8 inch rock bit and drill a pilot hole to 160 feet (Dry Union Formation). Drilling fluids should be mud until the setting of the surface pipe. If large volumes of fluids are encountered, flow will be controlled with heavy gel or barite (if necessary) until surface pipe can be set.

5. Let well stabilize and run temperature logs.

6. Re-enter hole with 7-7/8 inch pilot and 15-1/4 inch reamer to 160 feet. Circulate and condition hole.

7. Run 160 feet of 12-3/4 inch surface pipe and cement with 125 sx, or until returns are to the surface, of class "G" cement. If returns are not shown at the surface, then top grout the annulus with cement. Wait on cement for twelve hours.

8. Re-enter the hole with an 11-inch bit and drill out the cement plus 5 feet of new formation. Test the casing seat with 100 psi for one hour. Observe the pressure gauge for leakage and if pressure bleeds off, then rig-up to squeeze.

    - Pick up an RTTS packer and set it at 150 feet. Pump 20 sx of class "G" cement, plus 2 percent CaCl, and do not exceed 250 psi. Keep the bore pressurized and wait on cement for twelve hours.

9. Drill out cement and retest the casing seat and cement job.

10. Nipple-up 12-inch wellhead drilling assembly. It is not anticipated that large-capacity blowout prevention equipment will be needed, but when return temperatures exceed 125°F, appropriate personnel will be contacted. If large-capacity blowout

prevention equipment is required, then a wellhead drilling assembly similar to Figure 20 will be used.

11. Re-enter hole with 7-7/8 inch pilot bit and begin making new hole in the Dry Union Formation. Drilling fluids from this point on should consist of air, foam, or produced geothermal fluids. Drilling should continue through the producing geothermal reservoir, or to approximately 1500 feet, and into the crystalline basement rock (Precambrian banded gneiss). It is anticipated that the producing reservoir will be situated either in the fault contact between the Dry Union Formation and the basement or within the Dry Union Formation at the unconformity with the basement.

12. Trip out of the hole and shut in the well to let it stabilize. Run temperature logs on the entire bore.

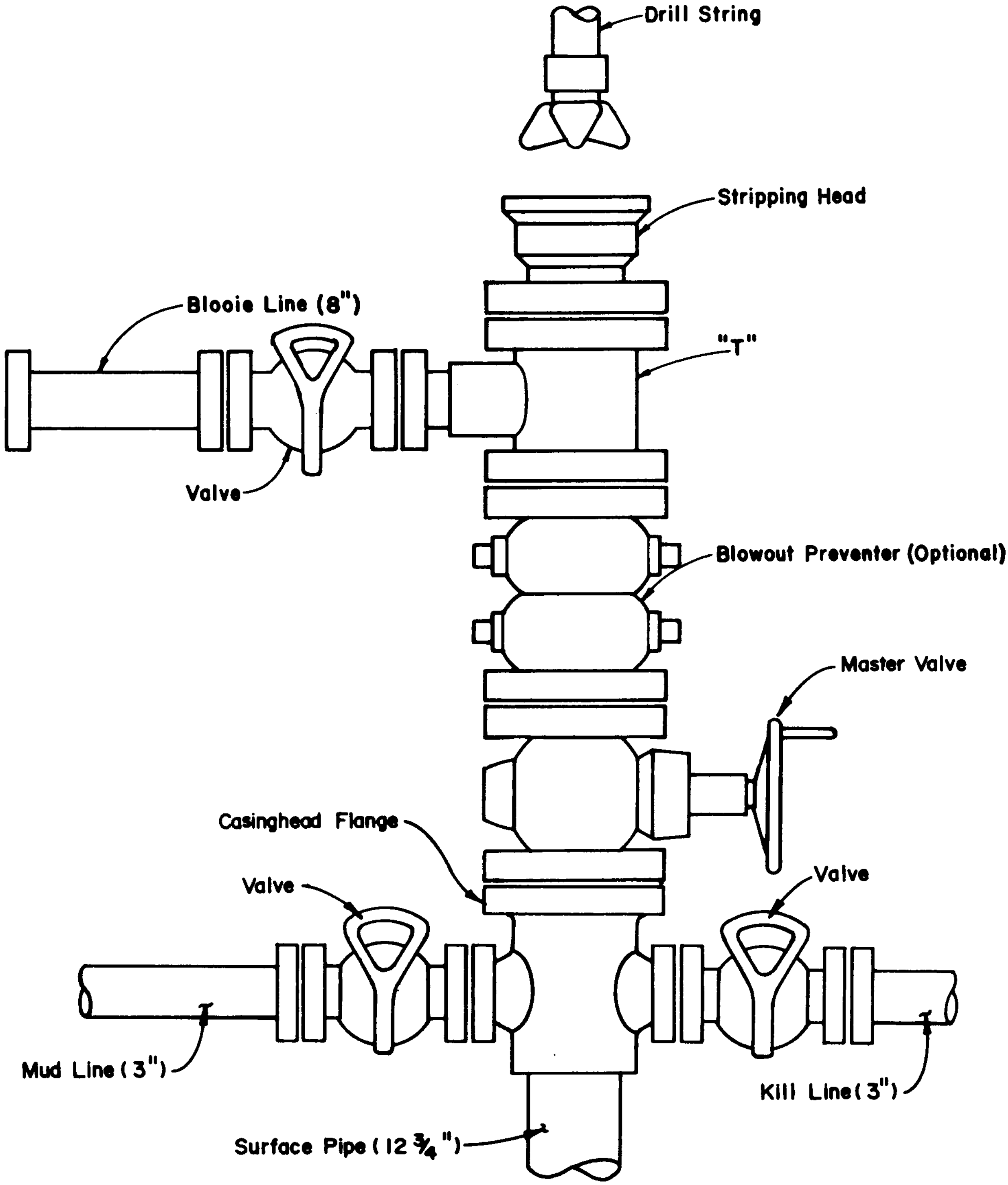
13. Re-enter the hole with a 7-7/8 inch pilot and 11 inch reamer and drill to just above the producing horizon (herein projected at 1450 feet). Produce or air lift the well to stabilize and develop the borehole.

14. Weld a DV Tool, grout basket, or cementing basket at the bottom of the 8-5/8 inch production casing and set approximately 1450 feet of casing. Cement the casing with 800 sx of class "G" cement plus perlite or silica flour. (These cement additives are only needed if reservoir temperatures are approaching 250°F). Wait on cement for twelve hours.

15. Re-enter well with 7-7/8 inch bit and drill out DV Tool or casing plug.

Option A

16. If formation is sufficiently competent, then the well will be completed as open-hole.



Wellhead drilling assembly and BOP equipment for geothermal exploration well; Chaffee - Salida 25-15.

FIGURE 20

17. Produce or air lift well for twelve to twenty-four hours to completely clean and develop the entire bore.

18. Air lift or pump the well for several short-term production/deliverability tests as described in the Reservoir Testing Section herein.

19. Shut in well and nipple down. Bolt on wellhead assembly as shown in Figure 21.

20. Release rig.

Option B.

16. If the formation is unstable to the point of requiring casing or liner, then the following procedure will be used.

17. Run 100 feet (or as required to TD) of 6 inch slotted liner or well screen through the production horizon to TD (a gravel pack is a third option for completion).

18. The 6 inch liner will be set on bottomhole and will not be hung from the 8-5/8 inch production casing nor cemented. The upper 50 feet of 6 inch liner will be overlapped within the 8-5/8 inch production casing.

19. Install a lead seal packer between the 6 inch production liner and the 8-5/8 inch production casing.

20. Produce or air lift well for twelve to twenty-four hours to completely clean and develop the entire bore.

Chaffee-Salida 25-15 will be drilled immediately adjacent to a previously completed 300 foot temperature gradient hole. Therefore, drilling conditions will be known in the upper 300 feet of the hole prior to setting surface pipe. If fluids are encountered prior to setting surface pipe, they will be controlled with heavy gel and/or barite. No large-capacity BOP equipment will be set in place until return temperatures exceed 125°F. At that time, the well will be shut in and the appro-

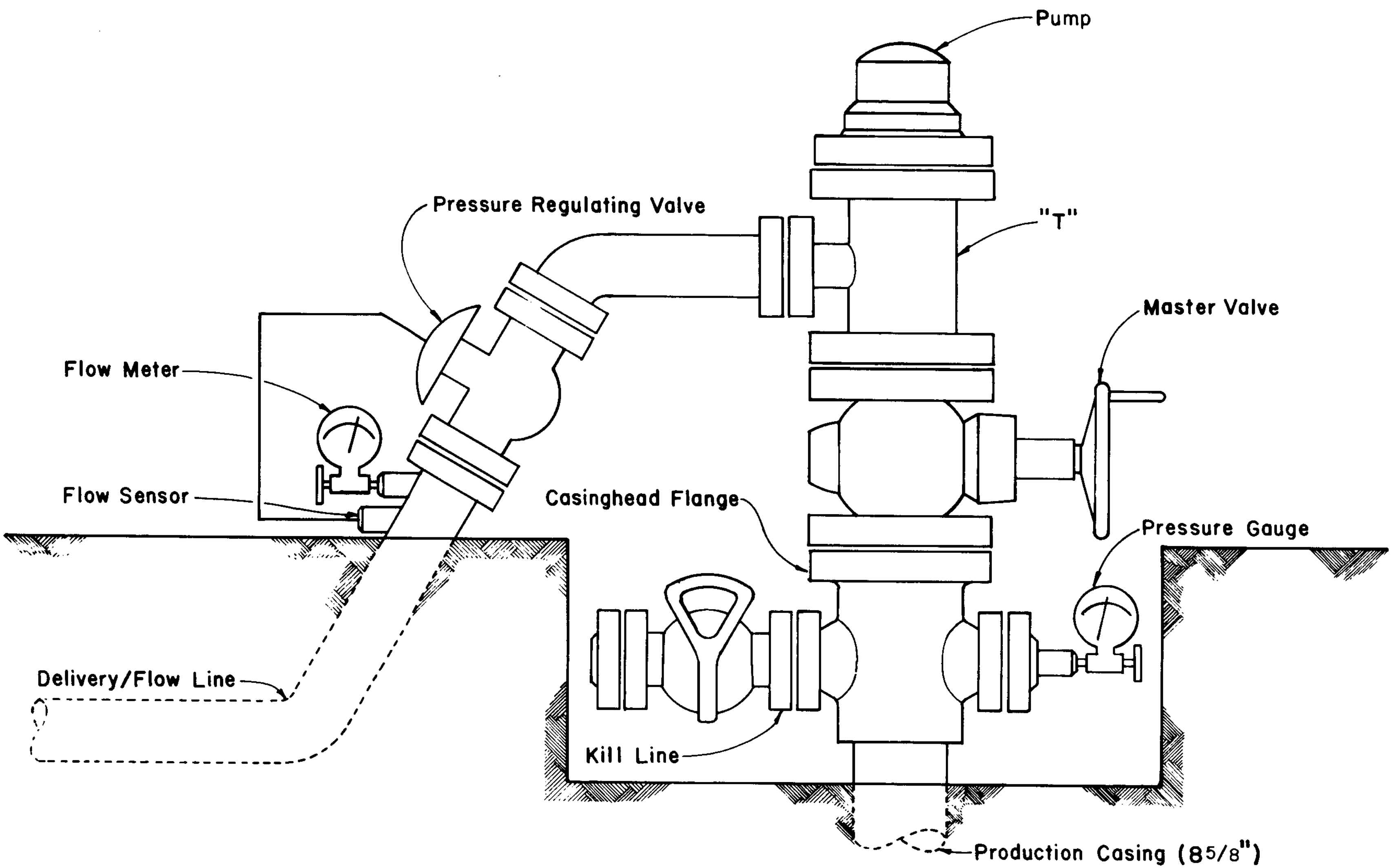


FIGURE 21

Production wellhead assembly (with pump) for geothermal exploration well; Chaffee-Salida 25-15.

priate authorities will be notified. BOP equipment will be nippled up to the 12-3/4 inch surface pipe and BOP tests run. With the pipe rams shut in, the well will be pressured up to 500 psi and held. If there is less than 10 percent pressure decay after thirty minutes, the BOP equipment will be deemed functional. A standard three-valve accumulator will be used to control the BOP equipment.

Casing and liner specifications, sizes, and landing depths have been previously shown on Figure 18 and are detailed as follows:

Surface Pipe

- OD: 12-3/4"
- ID: 12.375"
- grade: A-53, water well
- weight: 49.56 lbs./ft.
- collapse: 800 psi (est.)
- burst: 2200 psi (est.)
- allowable working pressure: 650 psi at 300°F*

Production Casing

- OD: 8-5/8"
- ID: 8.38"
- grade: A-106, water well
- weight: 34.24 lbs./ft.
- allowable working pressure: 750 psi at 300°F*

Production Liner (optional)

- OD: 6"
- ID: 5.72"
- grade: A-53, water well
- weight: 18.98 lbs./ft.
- collapse: 800 psi (est.)
- burst: 1800 psi (est.)
- allowable working pressure: 880 psi at 300°F*
- slot size: 1/4" x 2-3/4", or well screen. Actual slot size will be determined on site as a function of the formation.

* Calculated from the pressure piping code ASA B31.3.

Table 17 represents the projected itemized well costs (1981 dollars) to drill Chaffee-Salida 25-15 if drilling were to take place during the Fall of 1982. The costs are based on the well engineering and drilling procedures as outlined herein.

Table 17

Projected Drilling Costs For Chaffee-Salida 25-15

(1981 $)

Site Preparation:	
Pad preparation, fill and leveling	$ 1,000
Cellar construction	500
Miscellaneous preparation and excavation	1,000
	$ 2,500
Mobilization:	
Rig, water truck, pipe truck, backhoe, pickups X 1,000 miles R/T	$ 6,000
Drilling Time:	
11 Days, 24 hours/day, $175/hour	$46,200
Drilling Supervision:	
Drilling engineer, 11 days, $450/day	$ 4,950
Geologist (in-house salary)	-0-
Well design and engineering	4,500
	$ 9,450
Casing:	
12-3/4" surface pipe	$ 2,627
8-5/8" production casing	14,863
6" slotted liner	1,200
	$18,690
Cement:	
Cement and additives	$ 7,000
Trip charges, pumping, miscellaneous	4,000
	$11,000
Drilling Mud:	
Gel, barite, LCM, mica flakes	$ 4,000
Bits and BOP Rental:	
Bits	$ 5,400
BOP Rental	11,550
	$16,950
Wellhead Equipment:	
Master valve	$ 7,500
Safety valve	3,000
Casinghead flange	1,300
Wellhead "T"	2,000
Miscellaneous fittings	1,500
	$15,300
Wireline Surveys:	
SP, resistivity, sonic, neutron, gamma, spinner, temperature	$10,000

Site preparation:	$ 3,000*
Mobilization:	6,000*
Drilling time:	46,000*
Drilling supervision:	10,000*
Casing:	19,000***
Cement:	11,000*
Drilling mud:	4,000*
Bits and equipment rental:	17,000*
Wellhead assembly:	15,000**
Wireline services:	10,000*
TOTAL DRILLING COSTS:	$141,000
25% Contingencies:	35,000
Maximum anticipated costs:	$176,000

Tax Clarification

* Intangible drilling costs - 100% deductible during year incurred.

** Capitalized costs - depreciable over 10 to 12 years.

*** Casing is generally a capitalized expense in oil and gas wells, however, in geothermal wells, it is impractical and/or more expensive to pull casing than merely to abandon it. Therefore, Chaffee feels it has a convincing argument with the IRS to consider casing as an IDC.

B. Engineering Evaluation and Design

Utilization Design Principles and Objectives

Several significant engineering considerations are involved in the Salida Geothermal Project: First, the distribution system is designed for 100 percent of the resource capacity: that is, for 100 percent utilization of the 1600 gpm of fluid at 250°F estimated to be available at the geothermal well site. This approach contrasts with the more typical case of designing a system for the identified endusers only. The distribution system is actually designed to include a large future demand, based on future industrial and commercial development in Salida. Second, the distribution system is designed to operate for twelve months a year, as opposed to operating only in the winter months. This design feature is a consequence of the commercial and industrial energy requirements. However, this requires a design that can maintain a hot-water supply-temperature of 240°F in certain segments of the distribution system throughout the low-demand summer months. Third, the system is designed for discharge of geothermal fluid into adjacent rivers rather than reinjection into the resource aquifer. This is a consequence of disposal regulatory requirements in Colorado, of long distances (five to seven miles) between the well site and the various points of the enduse and of the expected fluid quality. Therefore, the design includes cooling the geothermal water through cooling towers, then discharging it into the Arkansas and South Arkansas Rivers. A fourth engineering consideration includes the environmental requirements for a geothermal transmission line across the Arkansas River; the design provides for burying the pipeline in the river bed.

Production Wells and Pumps

Available exploration data on the Poncha Springs area indicate that future production wells will most likely be drilled in the general vicinity of the Poncha Hot Springs. A total of four production wells are anticipated; a fifth well will also be drilled for back-up. Each well could possibly produce a flow of 400 gallons per minute at a maximum temperature of 250°F. Each well may be drilled to a depth of approximately 1500 feet.

With an anticipated flow of 400 gpm from each well, well depth of 1500 feet, and a possible temperature of 250°F maximum the well pump selection was made. It is assumed that the well pumps will be set at a maximum depth of 750 feet in the wells and will be required to pump 3000 feet horizontally to the circulating pumps. The well pumps will also be required to pressurize the system in order to prevent the 250°F geothermal fluids from flashing to steam. As a result, the well pump specifications are 400 gpm at 875 feet of head for each well pump. Centrilift pumps and motors were selected through Dave Tetreault, Centrilift Motor & Pump Co., Casper, Wyoming (pers. comm.). The actual selection is a Model No. R-330, 18 stage pump, 150 horsepower motor.

The control of the well pumps will be tied directly to the control of the circulating pumps. One circulating pump and one well pump will be operating at all times. When the demand exceeds 400 gpm, a second well pump and a second circulating pump will cycle on. When demand exceeds 1200 gpm, the fourth well pump and a fourth circulating pump will cycle on. Then, when the demand decreases, the pumps will cycle off in sequence.* The pump controls will be discussed further in the section on circulating pumps.

Since adequate electrical power for the well pumps and the circulating pumps is not currently available at the Poncha Hot Springs, an additional electrical power line from the Town of Poncha Springs will be necessary.

* The pumps maintain pressure. Flow control valves and operation are included in costs.

Pipeline Distribution System

The proposed routing of the new transmission line will start in the general area of the Poncha Hot Springs and follow the existing transmission line into Salida, as shown on Figure 22. The most direct path possible was selected for the routing of the main transmission line and its branches to take advantage of existing rights-of-way and to keep capital costs to a minimum. Figure 23 presents a schematic of the transmission line system, including the diameters of the supply and return lines, their respective flows, the line lengths, and the potential endusers. A 10" diameter line (1600 gpm) originates at the production wells at Poncha Hot Springs and continues to the west side of Salida. At that point, Branch No. 1 (6" diameter, 550 gpm) proceeds north to an existing fish hatchery and to a planned industrial park. The main transmission line continues east into Salida (8" diameter, 1050 gpm) to Branch No. 2. Branch No. 2 (3" diameter, 150 gpm) runs north to a large senior citizens complex, a nursing home, and the Salida municipal pool; the geothermal water is cascaded in Branch No. 2 to the three endusers. Branch No. 3A (6" diameter, 650 gpm) originates at the juncture of the main line and Branch No. 2 and proceeds to a tap for future use by the City of Salida. Thereafter, Branch 3B (3" diameter, 120 gpm) continues on to the high school and a commercial greenhouse.

The return water from Branch No. 1 is cooled in a cooling tower to 90^{o}F and discharged into the Arkansas River. The water from the municipal pool is cooled in the existing cooling pond that has been used for that purpose since the installation in the 1930's. Branch No. 3B return water is cooled in a cooling tower to 90^{o}F and discharged into the South Arkansas River near the greenhouse.

Pipeline Material Selection. Various materials were considered for the transmission line, but FRP (fiberglass reinforced plastic) pipe was ultimately chosen. This materal was selected for several

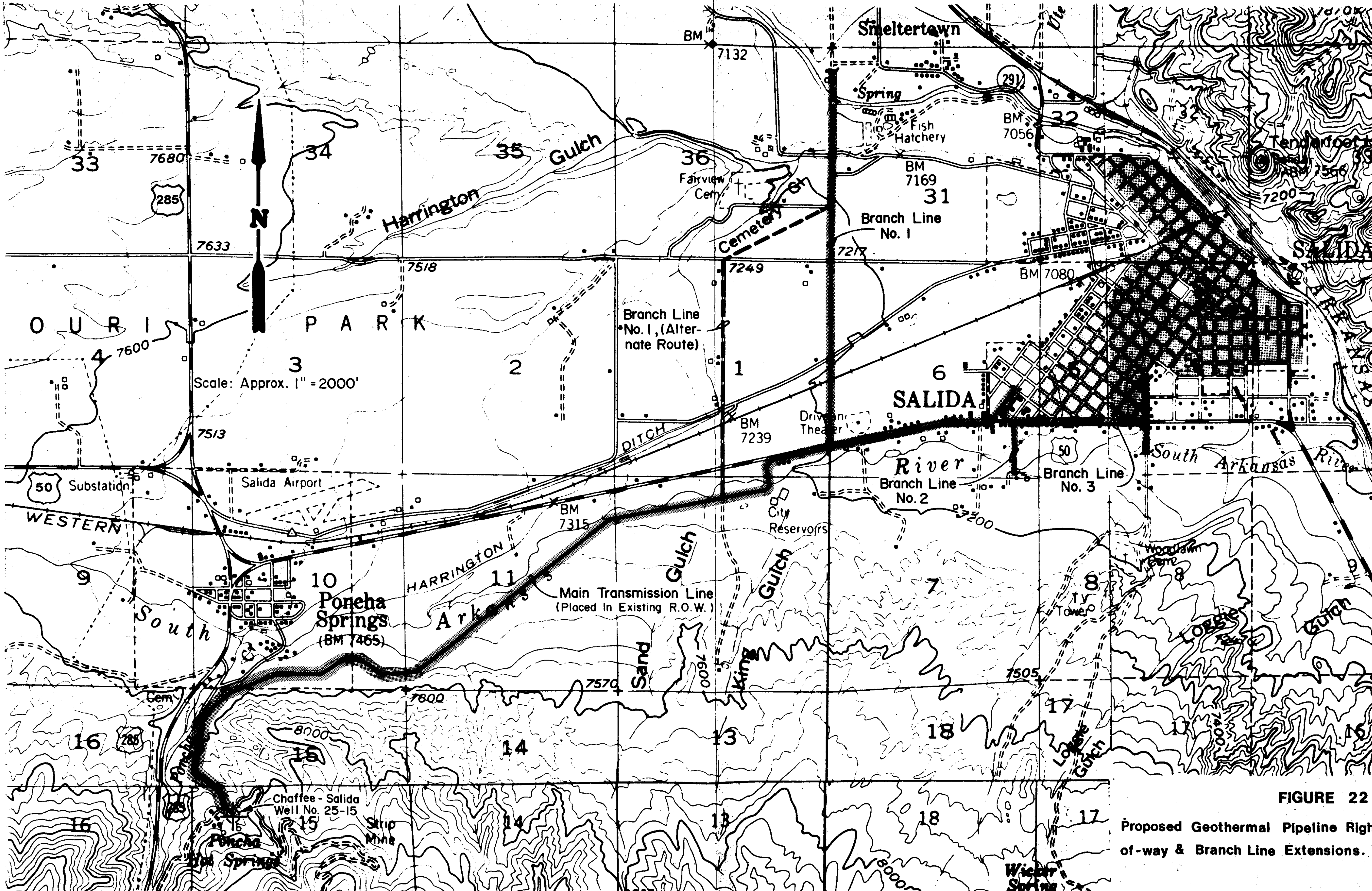


FIGURE 22

Proposed Geothermal Pipeline Right-of-way & Branch Line Extensions.

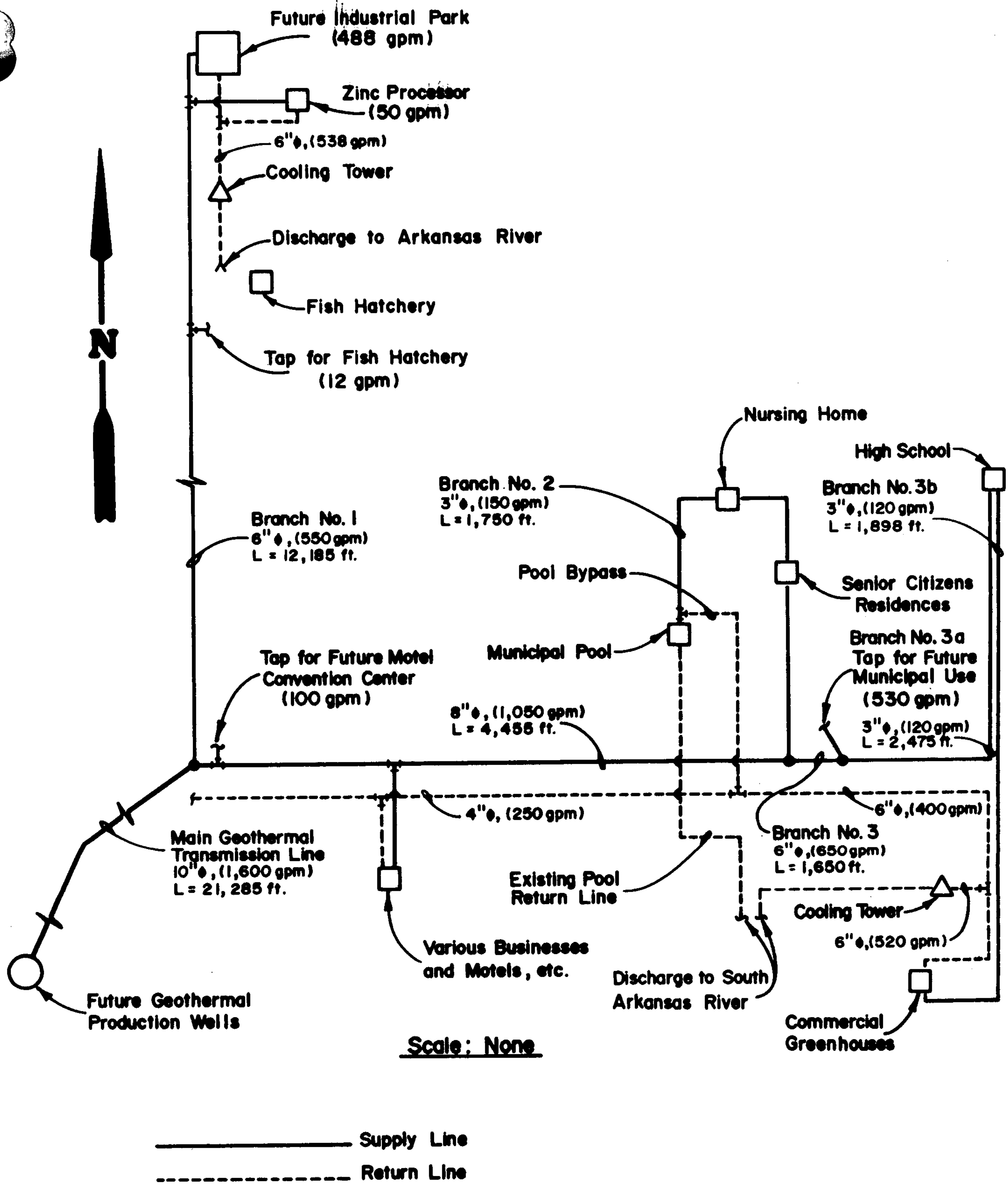


FIGURE 23

Schematic of Geothermal Transmission Pipeline Distribution System

reasons: (i) ease of installation, due to its comparative light weight and its simple assembly requirements; it is bonded together with adhesive rather than welded; (ii) reduced piping friction loss relative to other pipe types for the same gpm; (iii) as a result of (ii), a greater gpm can be pumped through the same diameter as compared to other types of pipe; (iv) also as a result of (ii), the pump requirements are less, thus resulting in a smaller pump and motor and lower electrical pump operating costs (Ameron, 1981); and (v) no expansion joints are required (Ameron, 1977). For these reasons, the cost of using FRP pipe for the transmission line is lower than other pipe types; consequently, the capital costs for the transmission line are minimized.

Construction costs are further reduced by insulating the FRP pipe in the field rather than installing preinsulated FRP pipe. Two inches of urethane sprayed in the field was used in developing the capital costs for the transmission line. The application of the insulation in the field produces no significant reductions in quality of the installed pipeline (Gould, 1981).

Pipeline Sizing for Supply and Demand. The main transmission line and its branches are designed to utilize 100 percent of the available geothermal resources and to meet peak demand requirements for prospective users. Primary data were gathered from on-site inspections of potential endusers in Salida. Peak space heating demands for existing facilities were calculated using the ASHRAE modified degree day method (ASHRAE, 1980) and each enduser's annual space heating energy requirements; See Table 18 Summary of Peak Energy Demands for Selected Endusers in Salida, for detailed information.

The ASHRAE formula for these calculations is given by Equation (1):

$$H_L = \frac{E(\Delta T)(n)(V_H)}{24(D.D.)(C_D)}, \quad \text{(Eq. 1)}$$

where

H_L = Design peak thermal load (BTUH)

E = Fuel consumption per year (CCF/yr)

D.D. = Number of base $65^{O}F$ degree days per year; in Salida D.D. = 6910/yr.

24 = Unit is hours per day, converts out degree days

ΔT = Design temperature difference; in Salida T = $72^{O}F - (-3^{O}F) = 75^{O}F$

n = Heating system efficiency; for natural gas in Salida, n = 0.65

V_H = Heating value of fuel; for natural gas in Salida, V_H = 80,000 BTU/CCF

C_D = Correction factor for heating effect vs. degree days; in Salida, C_D = 0.64.

Table 18

Summary of Peak Energy Demands for Selected End Users in Salida

Institution/ Business Name	Energy Consumption (MMBTU/yr)	Peak Load (MMBTU/hr)	T(°F)	Peak Demand (GPM)
Denoyers Greenhouse	7098.4	3260.4	55	120
Salida High School	8136.0	3737.0	65	120
Mt. Shavano Manor Senior Citizens Center	3502.9	1608.9	55	60
Columbine Manor Nursing Home	2450.1	1125.4	40	60
Municipal Pool	---	1925.0	65	60
Mt. Shavano Fish Hatchery	1484.8	682.0	120	15
Western Holiday Motor Hotel	2467.1	1133.2	40	60
Bureau of Reclamation	780.0	358.3	40	20
CoZinCo (includes space heating, low temperature process, and preheat of high temperature process only	Unknown	3000.0	120	50
Future Motel Convention Center	---	---	---	100

Energy requirements were analyzed separately for the commercial and industrial applications. Then total peak demands were estimated for each of the three main branches of the transmission line. The branch lines and the main pipeline from the production wells were sized accordingly.

Cascaded Uses in Branch Line. The concept of cascading the geothermal fluids is utilized at Branch No. 2 and Branch No. 3B. At Branch No. 2, 240°F water at 60 gpm enters Mt. Shavano Manor, where the fluid temperature is dropped 55°F to 185°F. The water then continues to Columbine Manor Nursing Home, where the temperature is lowered 40°F to 145°F. The water is then piped to the Municipal Pool, where it is mixed with circulating pool water in order to cool the fluid to 110°F prior to entry into the pool. This particular cascading scheme is designed to handle the peak energy demand loads of the three facilities. When less than the peak demand is required, hotter water will be available to the nursing home and the pool. When this occurs, any excess geothermal water not needed by the pool will bypass the pool and be cooled at the cooling tower for Branch No. 3B. The pool demand is year-round.

The same cascading design was used at the end of Branch No. 3B for the Salida High School and Denoyers greenhouses. The cascading concept will accommodate the situation when peak energy demands for the small commercial endusers are so low that, in dropping the temperature of the geothermal fluid from 240°F to 120°F, a very small quantity of fluid (less than one gpm) might be required. Such a small flow would not allow for efficient transfer of heat from the geothermal fluid to the heat transfer equipment.*

Circulating Pumps and Flow Rate Controls. Four circulating pumps, connected in parallel, were selected to pump the geothermal fluid to Salida. A fifth circulating pump will be available for back-up purposes. The branch with the greatest head requirement is

* Heat exchangers are not considered to be necessary.

Branch No. 1. The total head was calculated as shown in Table 19.

Assuming four circulating pumps connected in parallel, each sized to pump 400 gpm at 250 feet of head, the following pumps were selected: B&G Series 1510-2-1/2B base mounted pumps, 50 horsepower. 230-60 volt, 3 phase (Holley, 1981).

The advantages of using four circulating pumps in parallel as opposed to one circulating pump are the following: if the demand is low, only one pump would be on, thus saving on electricity costs, pump wear and the geothermal resource. The concept of four pumps also allows for immediate back-up capability should one pump fail; with only one circulating pump, there is no immediate back-up capability. If the demand is 400 gpm, a second pump will cycle on. As the demand exceeds 800 gpm, a third pump will cycle on. As the demand is reduced, the pumps will cycle off in sequence. One circulating pump will be operating at all times.

A flow recording device, located between the circulating pumps and the first enduser, will control the number of circulating pumps that is operating. As an enduser requires and uses the geothermal energy, the flow (via a control valve at the enduser) increases in the main supply line. As this demand approaches 400 gpm, the flow recording device would sense this and cycle on a second circulating pump. This control method would be similar as demand increases or decreases.

Low Demand Temperature Maintenance Requirements. In order to maintain a minimum geothermal water supply temperature of 240°F during periods of very low demand, it will be necessary to bleed out small amounts of geothermal water. A flow control valve, thermostatically controlled, will regulate the amount of fluid bled out at the end of each branch.

Table 19

Circulating Pump Feet of Head Requirements

Description	Pipe Size (GPM)	Length	Equivalent Length, Add 5% /Valves & Fittings	FT hd/** 100 L.F.	Total Head (Feet)
From Central Collection to Branch No.1	10"/1600GPM	21,285LF	22,349LF	.9'/100LF	201
Branch No.1-total supply return and discharge	6"/550GPM	15,485LF	16,259LF	1.3'/100LF	211
Process and Space Heating Requirements at Future Commercial Park (Estimate)					
a) Piping					30
b) Heat Exchangers					30
Pressure required to keep steam from flashing at 250°F = 30.7 psi X $\frac{2.3 \text{ Ft Hd}}{\text{Psi}}$ =					71
				Subtotal	543
Less 300 feet vertical drop from production wells to end user					-300
				TOTAL	243
				Use	250*

* Head overestimated to be conservative

** Ameron, Corrosion Resistant Piping Division, Bondstrand Geothermal Catalog, March 1981.

Based on energy consumption data obtained through personal interviews with potential endusers in Salida and on estimates of energy consumption for future developments, the minimum (summer) demand was estimated as follows:

Branch No. 1	250 gpm
Branch No. 2	39 gpm
Between Branch No. 1 and No. 2	50 gpm
Branch No. 3A	106 gpm
Branch No. 3B	12 gpm
Total	457 gpm

Then the amount of fluid to be bled out at the end of each branch was calculated from Equation 2:

$$TD = \frac{(LF)\ (BTU/LF/HR)}{(GPM)\ (60\ \frac{min}{hr})\ (8.33\ \frac{lbs}{gal})} \quad \text{(Moore, 1981)} \quad \text{(Eq. 2)}$$

where

TD = Temperature drop in degrees Fahrenheit per linear foot

BTU/LF/HR = Heat transfer in BTU/LF/HR (Rovanco Corporation, 1979)

GPM = Flow in gallons per minute.

With a minimum summer demand of 457 gpm, it is necessary to discharge 65 gpm from Branch No. 3B in order to maintain a geothermal water supply temperature of 240°F. It is not necessary to discharge any supply water at the other branches, since their estimated minimum demand is sufficiently high to maintain a minimum geothermal supply water temperature of 240°F.

Meters. In order to bill the endusers for actual energy consumed, a Btu meter is incorporated in each user's supply line. The Btu meter measures the temperature of the geothermal fluids delivered to the enduser, the temperature of the fluid leaving the enduser, and the flow rate (gpm). As a result of these measurements, the Btus consumed can be accurately calculated.

Towers. Cooling towers have been selected rather than ponds for cooling the used geothermal fluids. Past studies for geothermal plants indicate that it is more economically advantageous to install and maintain cooling towers than cooling ponds (Idaho National Engineering Aerojet Nuclear Company, 1976).* For direct heat applications, the choice is optional depending upon the total size of the system.

Cooling towers will be used to cool the spent geothermal water prior to disposing the water into the Arkansas River or South Arkansas River. At Branch No. 1, the winter duty, which is more demanding than the summer duty, was used to size the cooling tower. The winter peak cooling demand is 538 gpm, to be cooled from 120° to 90°, the maximum temperature at which the geothermal water can be discharged into the river (Bob Shukle, pers. comm.).

Assuming a 50°F wet bulb temperature in the winter for Salida, a Marley Cooling Tower No. 47125 with a 7.5 horsepower fan motor was selected (King, 1981).

At Branch No. 3B, the winter duty, again more demanding than the summer duty, was used to size the cooling tower. The winter peak cooling demand is 520 gpm to be cooled from 120°F to 90°F. The selection is again a Marley Cooling Tower No. 47125 with a 7.5 horsepower fan motor (King, 1981).

The circulating pump for the cooling tower at Branch No. 1 is sized to pump 538 gpm at 13 feet of head. The circulating pump for

* The final design should re-evaluate cooling ponds as well as towers.

the cooling tower at Branch No. 3B is sized to pump 520 gpm at 13 feet head. The pump selection is the same for both cooling towers: B&G Series 1510-5BC base mounted pump, 1150 rpm and 3 horsepower (Rutz, 1981).

The summer conditions at Branch No. 3B that produce the greatest cooling requirements are 936 gpm at 183°F to be cooled to 90°F because 65 gpm of fluid are being bled out at this branch to maintain a geothermal supply water temperature of 240°F. The 183°F entering water temperature is above the exposure limits for a galvanized steel tower; therefore, it is necessary to circulate 216 gpm of cooled 90°F discharge water to mix with the 183°F entering water in order to dilute the entering water temperature to 130°F. This mixing requires the use of a recirculating pump sized for 216 gpm at 13 feet of head; see Figure 24. The resultant selection is a B&G Series 1510-3BB base mounted pump, 1150 rpm, 1.5 horsepower (Rutz, 1981).

The cooling towers and the circulating pumps for the cooling towers will run continuously. When less than the peak cooling demand is required, the cooling towers will cool the water to a temperature less than the design discharge temperature of 90°F. The recirculating pump will be controlled automatically with a temperature sensor sensing the entering water temperature.

Disposal by Discharge into Rivers

Once the used geothermal fluid has been cooled, the water will gravity-flow to one of two rivers. At Branch No. 1, the cooled water will be discharged into the Arkansas River and at Branch No. 3B, the cooled water will be discharged into the South Arkansas River.

Cooling Tower Recirculating Schematic

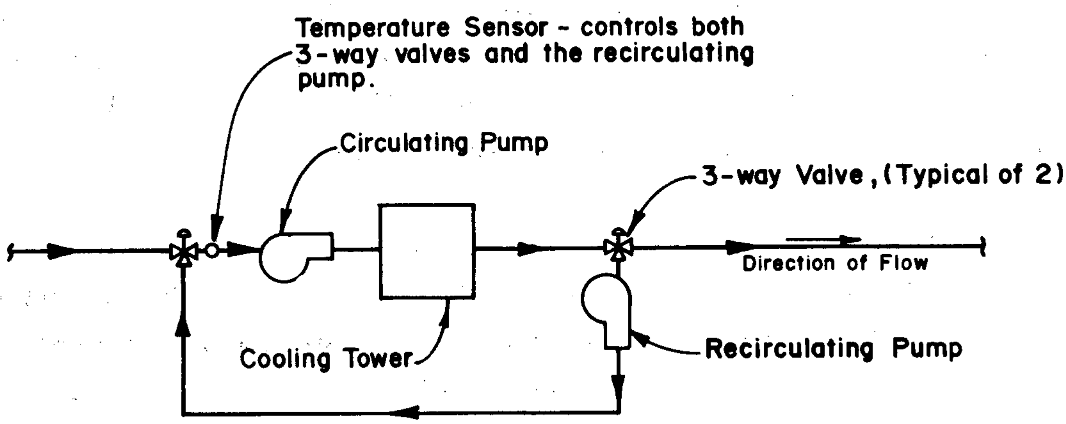


FIGURE 24

Discharge of the geothermal fluid into the rivers has been selected as the first method of disposal instead of reinjection, for several reasons. First, the expected quality of the geothermal water is acceptable for direct discharge into the rivers. Second, reinjection of the used water into the same aquifer from which it was pumped would be prohibitively expensive because of the distance; if the fluid were reinjected in Salida, it would be difficult to reinject into the same aquifer from which it was extracted at Poncha Hot Springs. Finally, the overall economics favor cooling towers and discharge into the rivers in contrast to reinjection, because of the high capital costs associated with drilling reinjection wells.

Capital Costs

The following subsections itemize the estimated capital costs in 1981 dollars for the major engineering and equipment components of the geothermal transmission and distribution systems.

Well Pumps. The capital costs for the well pumps are as follows:

Pump, motor, connector cost, starter, transformer wellhead, controls and cable		$ 44,000 each
Freight		1,500 each
Labor		500 each
	Subtotal	$ 46,000 each
		x 5 units
	Subtotal	$230,000
	Contingency (10%)	$ 23,000
	Subtotal	$253,000
	Engineering Design (10%)	$ 25,300
	TOTAL	$278,300

The fifth pump is for the fifth well, which will be used for back up.

Circulating Pumps. The capital costs for the circulating pumps are as follows:

Pump, motor and accessories		$ 4,356 each
Starter		1,000 each
	Subtotal	$ 5,356 each
		x 5 units
	Subtotal	$ 26,780
Mounting base and building		$ 1,000
Electrical hookup and installation		$ 2,000
	Subtotal	$ 29,780
	Contingency (10%)	$ 2,978
	Subtotal	$ 32,758
	Engineering Design (10%)	$ 3,276
	TOTAL	$ 36,034

The fifth circulating pump is for back up purposes.

Cooling Towers. The capital costs for the cooling towers are as follows:

ITEM	BRANCH NO. 1	BRANCH NO. 3B
Cooling Tower	$ 6,700	$ 6,700
Circulating Pump	$ 2,960	$ 2,960
Recirculating Pump	---	$ 2,250
Concrete Slab 6' x 8' piping and electrical hookup, miscellaneous labor	$ 2,000	$ 2,500
Return Piping to river	$ 1,000	$ 1,000
Automatic temperature controls for re-circulating pump	---	$ 1,000
Subtotals	$12,660	$16,410

These subtotals will be incorporated with the transmission line costs. Contingency and engineering design costs for the cooling towers will be added to the totals for the transmission line capital costs.

Transmission Pipelines. The capital costs for the transmission lines are as follows:

From Production Wells to Branch No. 1	Insulated in Field	Pre-insulated
10" supply line	$ 766,473	$1,135,555
Controls, valves & fittings (10% of above)	76,647	113,556
Contingency (10% of above)	84,312	124,911
Engineering design (10% of above)	92,743	137,402
TOTALS	$1,020,175	$1,511,424

Branch No. 1	Insulated in Field	Pre-insulated
6" supply to north side of Arkansas River	$ 174,324	$ 291,161
6" supply and 6" return from Arkansas River to Commercial Park and return to Cooling Tower	112,992	167,937
Controls, valves and fittings (10% of above)	28,732	45,910
Incremental cost to cross Arkansas River	18,675	18,675
Cooling Tower assembly	12,660	12,660
Contingency (10% of above)	34,738	53,634
Engineering design (10% of above)	38,212	58,998
TOTALS	$ 420,333	$ 648,975

From Branch No. 1 East on Highway 50 to Branch No. 2	Insulated in Field	Pre-insulated
8" supply line, 4" return line	$ 193,124	$ 288,283
Controls, valves and fittings (10% of above)	19,312	28,828
Contingency (10% of above)	21,244	31,711
Engineering design (10% of above)	23,368	34,882
TOTALS	$ 257,048	$ 383,704

Branch No. 2	Insulated in Field	Pre-insulated
3" supply	$ 19,779	$ 35,466
3" supply and 3" return	12,929	19,191
Controls, valves and fittings (10% of above)	3,271	5,466
Contingency (10% of above)	3,598	6,012
Engineering design (10% of above)	3,958	6,614
TOTALS	$ 43,535	$ 72,749

Branch No. 3A & 3B	Insulated in Field	Pre-insulated
From Branch No. 2 East on Highway 50 to F Street 6" supply and 6" return	$ 66,710	$ 92,582
From F Street East on Highway 50, then North to High School and South to Denoyers 3" supply and 6" return	82,046	120,285
3" supply	36,128	57,446
3" supply and 3" return	15,097	22,120
Controls, valves and fittings (10% of above)	19,998	29,243
Cooling tower assembly	16,410	16,410
Contingency (10% of above)	23,639	33,809
Engineering design (10% of above)	26,003	37,190
TOTALS	$ 286,031	$ 409,085

Capital Cost Summary. The total capital costs are summarized as follows:

PRODUCER

Description	Cost
Well pumps (5 total, includes controls, etc.) =	$ 278,300
Collection System (for 5 wells)	125,000
Electrical transmission line to well site from Poncha Springs	10,000
Wells (5 @ $ 161,000)	805,000
Wellhead assemblies (5 @ 15,000)	75,000

Well testing		$ 125,000
Permits		2,000
Exploration		100,000
	TOTAL	$ 1,520,300

DISTRIBUTOR

Transmission line (includes controls, valves and fittings, 10% of capital costs)	Cost
a) From production wells to Branch No. 1	$ 1,020,175
b) Branch No. 1 (including cooling tower)	420,333
c) From Branch No. 1 to Branch No. 2	257,048
d) Branch No. 2	43,535
e) Branch No. 3A and No. 3B (including cooling tower)	286,031
f) Circulating pumps (5 total, includes controls, etc.)	36,034
TOTAL	$ 2,063,156

Operating and Maintenance Costs

The following subsections delineate the estimated operating and maintenance costs for the equipment components of the geothermal distribution system.

Well Pumps. The operating costs for the well pumps are calculated as follows:

Peak demand = 150 horsepower X 0.7457 KW/HP X 4 pumps = 447.7 KW

Avg. monthly use = 447.7 KW (peak) X 730 hrs/mo X 50% utilization = 163,301 KWH/month.

Demand charge:	First 25 KW =	$ 220.00/mo
	Next (447.4-25KW) x $6.99/KW =	$2,952.58/mo
	TOTAL DEMAND CHARGE =	$3,172.58/mo
Energy charge:	163,301 KWH x $0.01543/KWH =	$2,519.73/mo
	Subtotal	$5,692.31/mo
	*Estimated unallocated increase (15%)	853.85/mo
	Subtotal	$6,546.16/mo
	Electrical cost adjustment (4-81); 163,301 KWH x $0.00402/KWH =	656.47/mo
	Subtotal	$7,202.63/mo
	Sales Tax (4%)	$ 288.11/mo
	TOTAL ELECTRICAL COST	$7,490.74/mo

*Per Bill Heldman, Public Service Company, Leadville, Colorado

Circulating Pumps. The operating costs for the circulating pumps are calculated as follows:

Peak demand = 50 HP each X 0.7457 KW/HP X 4 pumps = 149.1 KW

Avg. monthly use = 149.1 KW (Peak) X 730 hrs/mo X 50 % utilization
54,422 KWH/month.

From Public Service Company of Colorado, Sheet No. 125:

Demand charge:	First 25 KW =	$ 220.00/mo
	Next (149.1-25KW) x $6.99/KW =	$ 867.46/mo
	TOTAL DEMAND CHARGE =	$1,087.46/mo
Energy charge:	54,422 KWH/mo x $0.01543/KWH =	$ 839.73/mo
	Subtotal	$1,927.19/mo
	Estimated unallocated increase (15%)	$ 289.08/mo

Subtotal	$2,216.27/mo
Electrical cost adjustment (4-81);	
54,422 KWH x $0.00402/KWH =	218.78/mo
Subtotal	$2,435.05/mo
Sales Tax (4%)	$ 97.40/mo
TOTAL ELECTRICAL COST	$2,532.45/mo

Cooling Tower Pumps. The operating costs for the cooling tower pumps are calculated as follows:

Branch No. 1 — Fan Motor 7.5 HP
Circulating Pump 3.0 HP

Peak demand = 10.5 HP X 0.7457 KW/HP = 7.8 KW

Average monthly use = 7.8KW X 730 hrs/mo X 100% utilization = 5,694 KWH/month.

From Public Service Company of Colorado, Sheet No. 123:

Demand charge and Energy charge combined:	First 50 KWH = $0.07514/KWH =	$ 3.76/mo
	Next 50 KWH = $0.05740/KWH =	$ 2.87/mo
	Next 50 KWH = $0.04203/KWH =	$ 2.10/mo
	Next 100 KWH = $0.03023/KWH =	$ 4.53/mo
	Next 150 KWH = $0.02906/KWH =	$ 4.36/mo
	Excess = 5694KWH - 450KWH = 5244KWH X $0.02451/KWH =	$128.53/m
	Subtotal	$146.15/mo
	Estimated unallocated increase (15%)	$ 21.92/mo
	1981 Dollars	$168.07/mo
	Electrical cost adjustment (4-81); $0.00402/KWH X 5694 KWH =	22.89/mo
	Subtotal	$190.96/mo
	Sales Tax (4%)	$ 7.64/mo
	TOTAL ELECTRICAL COST	$198.60/mo

Branch No. 3B

Fan Motor	7.5	HP
Circulating Pump	3.0	HP
Recirculating Pump	1.5	HP

Peak Demand = 12.0 HP X 0.7457 KW/HP = 8.9 KW

Average monthly use = 8.9 KW X 730 hrs/mo X 100% utilization = 6,497 KWH/month.

From Public Service Company of Colorado, Sheet No. 123:

Demand Charge and charge combined	First 50 KWH = $0.07514/KWH =	$ 3.76/mo
	Next 50 KWH = $0.05740/KWH =	$ 2.87/mo
	Next 50 KWH = $0.04203/KWH =	$ 2.10/mo
	Next 150 KWH = $0.03023/KWH =	$ 4.53/mo
	Next 150 KWH = $0.02906/KWH =	$ 4.36/mo
	Excess = 6497KWH - 450 KWH = 6047KWH X $0.02451/KWH	$ 148.21/mo
	Subtotal	$ 165.83/mo
	Estimated unallocated increase (15%)	$ 24.87/mo
	1981 Dollars	$ 190.70/mo
	Electrical cost adjustment (4-81); $0.00402/KWH X 6497 KWH =	$ 26.12/mo
	Subtotal	$ 216.82/mo
	Sales Tax (4%)	8.67/mo
	TOTAL ELECTRICAL COST	$ 225.49/mo

Total Operating Costs Including Maintenance, Insurance, Administration, Overhead and Electrical Costs (1981 Dollars).

1. Energy Producer - For the energy producer company, the above costs for the respective years are as follows:

Year	Prorated Overhead and Administration Costs		Operating and Maintenance Costs	
1982	Liability/Ins.	$ 5,000	Maintenance	$ 0
	Marketing	10,000	Electrical	0
	Computer, Drafting, Miscellaneous	5,000		
	Travel	10,000		
	Overhead/Admin.	90,500		
	Total	$120,500	Total	$ 0
1983	Liability/Ins.	$ 10,000	Maintenance	$
	Marketing	20,000	Electrical	0
	Travel	3,000		
	Overhead/Admin.	62,000		
	Total	$ 95,000	Total	$ 0
1984	Insurance	$ 5,000	*Maintenance (6 mo., 1 pump) 0.5 [0.04 (176,000) + 55,660) + 0.02 (0.2 X 125,000)]	$ 4,883
	Overhead/Admin.	62,000	Electrical (6 mo., 1 pump)	11,236
	Total	$ 67,000	Total	$ 16,119
1985	Ins., Overhead and Administration	$ 30,000	Maintenance (3 pumps) 0.04 [3 (176,000) + 3 (55,660) + 0.02 (0.6 X 125,000)]	$ 29,299
			Electrical (3 pumps)	67,417
	Total	$ 30,000	Total	$ 96,716
1986	Ins., Overhead and Administration	$ 30,000	Maintenance (4 pumps) 0.04 [4 (176,000) + 4 (55,660) + 0.02 (0.8 X 125,000)]	$ 39,066
			Electrical (4 pumps)	89,889
	Total	$ 30,000	Total	$128,955

*Maintenance costs are estimated to be 4% of the well costs plus 4% of the well pump costs plus 2% of the collection system costs.

2. <u>Energy Distributor</u> - For the energy distribution company, the total operating costs including maintenance, insurance, administration, overhead and electrical costs for the respective years are as follows (1981 dollars):

Year	Prorated Overhead and Administration Costs		Operating and Maintenance Costs	
1983	Insurance, Overhead and Admin.	$75,000	-	$ 0
	Total	$75,000	Total	$ 0
1984	Insurance, Overhead and Admin.	$75,000	*Maintenance	$22,990
			Electricity (1 pump, 6 mo.)	3,799
	Total	$75,000	Total	$26,789
1985	Insurance, Overhead and Admin.	$75,000	Maintenance	$22,990
			Electricity (3 pumps)	22,792
	Total	$75,000	Total	$45,782
1986	Insurance, Overhead and Admin.	$75,000	Maintenance	$22,990
			Electricity (4 pumps)	30,389
	Total	$75,000	Total	$53,379

* Maintenance costs are estimated to be 1% of the pipeline costs plus 2% of the circulating pump, controls, valves, and fitting cost plus 2% of the disposal system costs.

Maintenance costs = 0.01 ($1,812,916) + 0.02 ($207,860) + 0.02 ($35,175) = $22,990.

Energy Utilization Analysis

Table 20 provides a summary of the allocation of the total available geothermal resource among the major applications and uses within each application.

The estimated total system peak demand equals 1600 gpm. Of this amount, 550 gpm is for the future industrial/commercial park, and 1050 gpm is for existing and future commercial and residential endusers in Salida. Twenty-five percent of the 550 gpm, or 137 gpm, is assumed to be for domestic hot water and space heating; the balance, 413 gpm, is for process heat. Of the 137 gpm for domestic hot water and space heating, 15 percent (21 gpm) is estimated to be for domestic hot water and the balance, 116 gpm, is for space heating (Okagaki and Benson, 1979). Of the 1050 gpm demand for existing and future commercial and residential endusers, 158 gpm is estimated to be for domestic hot water and 892 gpm is estimated to be for space heating. In summary, the total peak requirements can be divided into the following uses:

Space heating	1008 gpm
Domestic hot water	179 gpm
Process heat	413 gpm
TOTAL	1600 gpm

Conversion of these peak demands to average yearly energy utilization is obtained by applying equations (3) and (1).

Using equation (3)first:

$$BTUH = GPM \times \Delta T \times 500 \text{ (ASHRAE, 1980)}, \qquad \text{(Eq. 3)}$$

and $\Delta T = 120°F$, the peak space heating demand is converted to BTUH.

Table 20

Estimated Geothermal Fluid Requirement

Gallons per Minute

User	Space Heat	Hot Water	Process Heat	Total
Industrial Park	116	21	413	550
Salida Commercial and residential users	892	158	-0-	1050
Total	1008	179	413	1600

Inserting this value into the modified degree day Equation No. 1, the fuel consumption for space heating in hundred cubic feet of gas for the year is calculated. This value is then converted to BTU/year. The domestic hot water requirement and the process requirement are converted to BTU's/year using Equation 3, 8760 hours per year, 35 percent utilization for the domestic hot water, and 75 percent utilization for the process requirements. The results of these calculations are as follows:

Space heating requirements:	8.6×10^{10} BTU/year
Domestic hot water requirements:	3.3×10^{10}
Process heat requirements:	16.3×10^{10}
Total average yearly geothermal energy requirements	28.2×10^{10} BTU/year

The system utilization is determined by dividing the average yearly geothermal energy requirements by the total yearly geothermal energy available (84.1×10^{10} BTU/year). The resultant system utilization is 33.5 percent.

System utilization increases in direct relation to an increasing proportion of industrial endusers and decreases accordingly with a decreasing proportion of industrial endusers because year-round energy demands of industrial endusers are less variable than are the seasonal energy demands of commercial and residential endusers. For example, if an additional 550 gpm were allocated for future industrial development, if the amount allocated for existing and future commercial and if residential endusers were reduced by 500 gpm to 550 gpm, and if all other parameters remained unchanged, then the system utilization would increase from 33.5 percent to approximately 45 percent. If the allocation for the future industrial development were significantly reduced, and the allocation for the existing and future commercial and residential development increased accordingly, then the system utilization would be reduced from 33.5 percent to 25 percent.

As these examples indicate, the system utilization can vary considerably depending upon the type of enduser. Therefore, the economic analyses were performed assuming a base case of 33.5 percent system utilization and two variations from the base case - namely, system utilizations of 45 percent and 25 percent.

Design Alternatives. Economic analyses were also performed for three different system design alternatives. For the Base Case the resource parameters include a well depth of 1500 feet, a well pump depth of 750 feet, a resource temperature at the surface of 250°F, a total flow of 1600 gpm, and four production wells plus one back-up/replacement well. The engineering parameters include a total peak capacity of 8.4 X 10^{11} BTU/year, annual utilization of 33.5 percent and the transmission line insulated in the field.

In Alternate No. 1, there are no changes in the resource or engineering parameters; the only change is an assumption of full scale resource production in 1989 instead of 1986. In Alternate No. 2, the resource and engineering parameters are changed as follows: a well pump depth of 250 feet, resource temperature at the surface of 290°F, a total flow of 1500 gpm, three production wells plus one back-up/replacement well, a total peak capacity of 10.5 X 10^{11} BTU/year, 45 percent system utilization, and a pre-insulated transmission line. The remaining resource and engineering parameters remained unchanged.

For Alternate No. 3, the resource and engineering parameters are changed as follows: a well pump depth of 500 feet, a resource temperature at the surface of 210°F, a total flow of 1000 gpm, a total peak capacity of 3.5 X 10^{11} BTU/year, a system utilization of 30 percent, and the transmission line scaled down in size for the reduced flow; the remaining resource and engineering parameters remained unchanged. See Table 4, (Section I), Summary of Resource, Engineering, Economic and Production Schedule Parameters for Four Geothermal Systems for further information.

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Technical Evaluation of a Low Temperature Zinc Sulfate Granulation Process

A key component of the DOE funded geothermal resource engineering, economic and environmental feasibility study for the Salida Geothermal Prospect by Chaffee Geothermal, Ltd. and Western Energy Planners, Ltd. has been the technical evaluation of a low temperature process for the preparation of zinc sulfate granules from waste zinc metal scraps. Zinc sulfate granules are used commercially as micronutrients for fertilizers and for animal feed supplements.

Current chemical processes for producing zinc sulfate granules utilize high temperature air drying and granulation techniques. High temperature techniques have been practiced generally by the fertilizer industry because of the past easy access to low cost natural gas as an energy source. As a consequence, application of temperatures higher than needed and waste of unused energy have not been important factors in chemical process design.

The potential development of the Salida Geothermal Prospect by Chaffee Geothermal and the rising costs of natural gas in the Salida, Colorado area, however, have provided the incentive to investigate conceptually whether a low temperature (250^{o}F) process exists for the commercial production of zinc sulfate granules. This report provides evidence that a low temperature zinc sulfate granulation process is technically feasible. A chemical process flow diagram is presented which indicates qualitatively the sequential steps and process parameters which might apply to a successful low temperature process (Figure 25).

This technical study is limited, however, to the chemical flow diagram and is not expanded to include a materials balance, an energy balance, or the sizing and selection of process

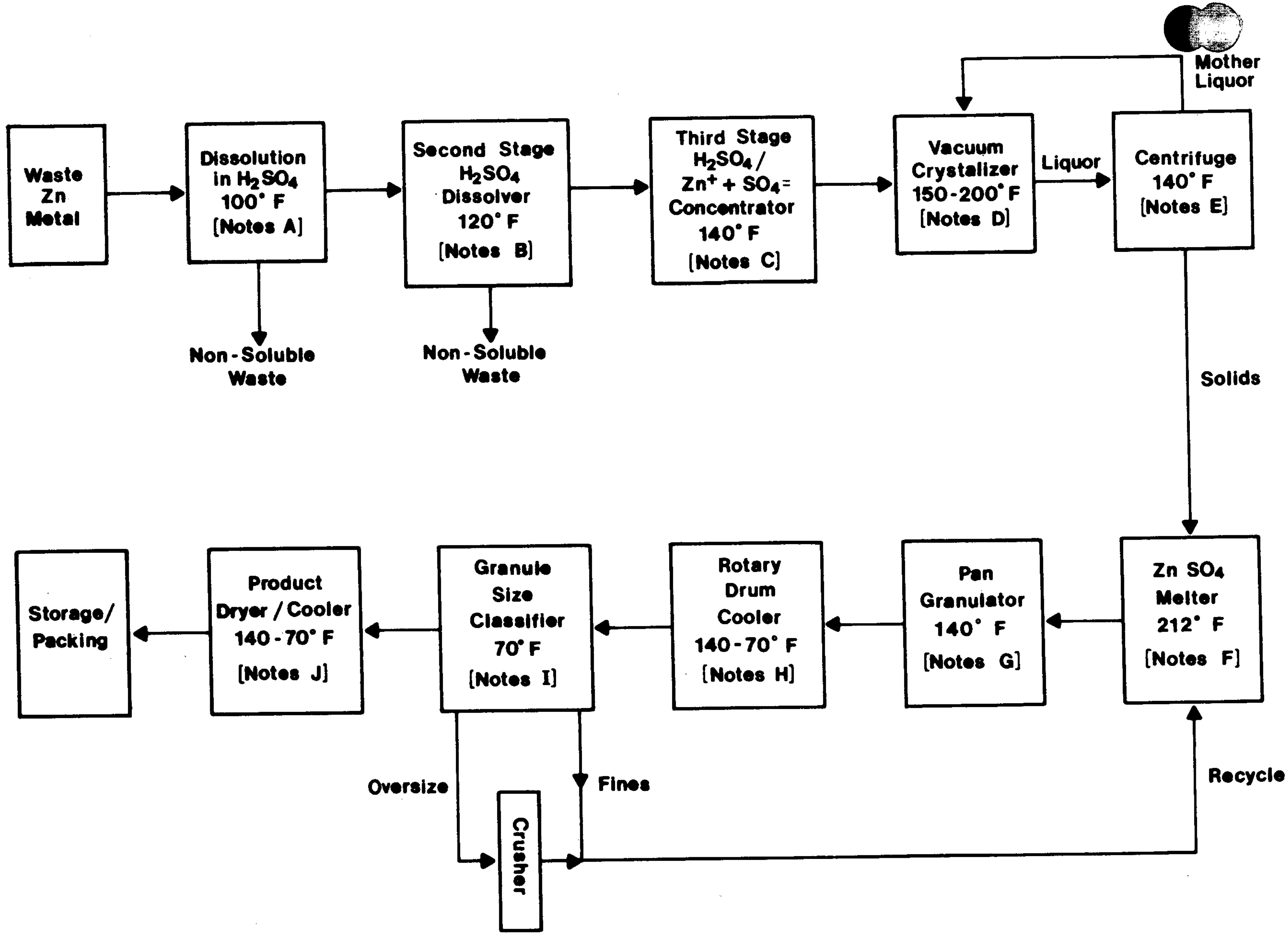

Figure 25

Low Temperature [Geothermal] Zinc Sulfate Granulation Process

(Explanatory notes are found on the following pages)

Notes A: First Stage Dissolver

1. Use lower temperature (32-100^{o}F), higher solubility of $ZnSO_4 \cdot 7\ H_2O$ to maximize dissolution of waste zinc.
2. Heat of solution of $ZnSO_4 \cdot 7\ H_2O$ is exothermic (-4.29 kcal/mole).
3. Solubility of $ZnSO_4 \cdot 7\ H_2O$ in H_2SO_4 is 41 wt% $ZnSO_4$ at 100^{o}F (38^{o}C).

Notes B: Second Stage Dissolver

1. Increase H_2SO_4 temperature and adjust concentration to shift hydrate equilibrium to $ZnSO_4 \cdot 6\ H_2O$.
2. $ZnSO_4 \cdot 6\ H_2O$ is stable hydrate form at 100-120^{o}F.
3. Heat of dehydration of 1 H_2O from $ZnSO_4 \cdot 7\ H_2O$ is +2.79 kcal/mole endothermic.
4. Solubility of $ZnSO_4 \cdot 6\ H_2O$ in H_2SO_4 is 43 wt% $ZnSO_4$ at 120^{o}F (49^{o}C).

Notes C: Concentrator

1. Increase H_2SO_4 temperature and adjust concentration further to shift hydrate equilibrium to $ZnSO_4 \cdot H_2O$.
2. $ZnSO_4 \cdot H_2O$ is stable hydrate form above 120^{o}F.
3. Heat of dehydration of 1 H_2O from $ZnSO_4 \cdot 6\ H_2)$ is 2.49 kcal/mole endothermic.
4. Solubility of $ZnSO_4 \cdot H_2O$ in H_2SO_4 is 42 wt% $ZnSO_4$ at 140^{o}F (60^{o}C).
5. Hold H_2SO_4 temperature to not exceed 150^{o}F to minimize stainless steel corrosion.

Notes D: Vacuum Crystalizer

1. Vacuum crystalizer reduces water concentration further to stabilize $ZnSO_4 \cdot H_2O/ZnSO_4$ and to initiate crystal formation.
2. Temperature of 150-200^{o}F used to facilitate vaporization of water.

Notes E: Centrifuge

1. Centrifuge operated at 140°F to maintain stability of $ZnSO_4 \cdot H_2O/ZnSO_4$ solids.
2. Powder solids could be recovered and cooled at this stage if desired.

Notes F: Melter

1. Melter used to put $ZnSO_4 \cdot H_2O/ZnSO_4$ in a fluid form for granulation process.
2. Melting point of $ZnSO_4$ is 212°F.

Notes G: Granulator

1. Granules of $ZnSO_4 \cdot H_2O/ZnSO_4$ are formed from the melt.
2. Temperature of 140°F maintained to stabilize $ZnSO_4 \cdot H_2O/ZnSO_4$.

Notes H: Rotary Drum Cooler

1. Rotary drum cooler provides a gradually-decreasing temperature environment for granules prior to size classification.

Notes I: Size Classifier

1. Two screen classifiers provide selection of granule size range for final product
2. Oversize granules are crushed, added to fines, and recycled.

Notes J: Product Dryer

1. Rotary drum dryer/cooler provides final drying of product after granule sizing.

equipment. The state of the science of low temperature zinc sulfate chemistry is minimal. Significant research on a laboratory scale of the proposed process needs to be conducted before the basic chemistry can be reasonably converted to a chemical engineering process even on a bench-top scale.

The proposed low temperature zinc sulfate granulation process is believed to be patentable by the originator, Richard T. Meyer, Ph.D., President of Western Energy Planners, Ltd. Patentability is still being determined. The reader should be aware that the process use may be protected under patent law.

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Section V

ECONOMIC ANALYSIS

The Salida Geothermal Prospect is an actual, not hypothetical, prospect. Geothermal leases have already been obtained by a geothermal production company, Chaffee Geothermal, Ltd., which plans to conduct exploration activities in 1982. The production company prefers not to be the distributor for the resource. Rather, the producer would produce the geothermal fluid and sell it to a distributor for resale to industrial, commercial and public consumers in Salida, as is generally the case in marketing similar resources. The economic analysis is based on this structure, with Chaffee Geothermal being the producer. The distributor is assumed to be a new Colorado corporation without additional income sources.

The producer is the primary risktaker of the business venture. The producer conducts various exploration activities throughout 1982. If results are favorable, as is assumed here, the distributor would initiate operations in 1983. No ties are assumed between the producer and the distributor and each is considered to be unregulated.

Economic evaluations will be presented in full for four cases: the Base Case and three alternate scenarios. Alternate 1 hypothesizes a three-year delay in realizing full production relative to the Base Case. For Alternate 2, it is planned that the geothermal reservoir is of a higher quality than is assumed for the Base Case. For Alternate 3, a lower quality reservoir is assumed.

Finally, sensitivity analyses will be performed varying each of four factors: initial geothermal price, geothermal price escalation, percent utilization of peak capacity, and distributor's return on investment.

A. Economic Assumptions

Supply, Demand and Prices

Implicit in the economic evaluation is a future demand of 2.8 X 10^{11} BTU per year. To satisfy this requirement, additional energy users would need to be attracted. To attract additional industrial users to the Salida industrial park, a strong marketing effort is planned. In general, the geothermal delivery price must represent a clear economic savings over conventional fuels if these potential users are to be attracted.

Mid-1981 natural gas prices in Salida ranged from $4.45 - $4.85/MMBTU (Greeley Gas, 1981). According to projections of the Office of Policy and Evaluation, Department of Energy (Table 21), natural gas prices are expected to increase 26 percent annually through 1985 (SERI, 1980). When geothermal production begins in mid-1984, natural gas would then sell at twice the current price levels, or at $9.25/MMBTU.

For the Base Case, the assumed first-year geothermal price is 70 percent of natural gas prices, or $6.50/MMBTU. It is further assumed that this price will be escalated by the producer at the general inflation rate. In Table 21, the projected annual inflation rate is initially 9 percent before dropping and leveling off at 6 percent. Because natural gas is escalating faster than the projected rate for geothermal, greater savings would accrue to the customer over the life of the project. Under the described assumptions, the geothermal energy would be priced at 60 percent of natural gas levels by 1985 and 50 percent by 1992.

Table 21

Assumed Annual Escalation Rates

Item	Annual Percentage Increase 1980-85	1985-90	1990-95	1995-2000
Natural Gas[1]	26	11	11	10
General Inflation[1]	9	8	7	6
Geothermal Sales	General Inflation Rate Assumed			
Electricity[1]	13	10	11	6

[1]Based on projections from the Office of Policy and Evaluation, Department of Energy, 1980. Escalation rates for years 1995-2000 have been carried forward until project end.

Table 22 shows various Base Case economic assumptions for producer and distributor. The return on investment for the distributor is nominally set at 17 percent. The producer's rate of return is determined by calculation. The distributor's equity is assumed to be 50 percent of its capital costs, with long-term financing providing the remaining 50 percent. The equity portion for the producer is assumed to be 100 percent. Both producer and distributor are assumed to be eligible for alternative energy tax credits as well as for general investment credits. The Federal credits are a combined 25 percent. The distributor, as a Colorado corporation, is also eligible for state tax credits totaling 12 percent.

Net operating losses and investment credits are carried forward up to 15 years for the distributor. The producer is assumed to have other income against which the credits and losses may be applied. Depreciation on all equipment follows the new 5-year Accelerated Cost Recovery System (ACRS), defined by the Economic Recovery Act of 1981.

B. Capital Costs and Expenditure Schedule

An expenditure and production schedule is displayed in Table 23. As shown, capital expenses are to be fully appreciated by 1984, with full production slated for 1986.

Base Case

Table 24 summarizes the yearly capital costs in 1981 dollars. Exploration costs are those incurred to determine the location, magnitude and quality of the geothermal resource as shown, including expenditures for exploration work to determine whether a commercially developable resource exists. The total capital cost for the Base Case is $1,520,300 for the producer and $2,063,156 for the distributor. Although exploration costs are deductible, they must be recaptured when the project reaches the production stage.

Table 22

Base Case Economic Assumptions

(1981 Dollars Except Where Otherwise Indicated)

Economic/Financial Variable	Producer	Distributor
Discounted Cash Flow Rate of Return (DCFROR)	To be Determined	17%
1984 Geothermal Sale Price	To be Determined	\$6.50/MMBTU (1984 Dollars)
Quantity of Energy Sold		2.8×10^{11} BTU/yr
Loan Assumptions		
Equity/Debt Ratio	100% equity	50/50
Loan Duration	-	15 years
Interest Rate	-	14%
Taxation		
Business Status	Limited partnership; partners assumed to have other income.	Colorado corporation; new corporate entity.
Federal & State Taxes	50% Total	46% Federal 5% State
Tax Credits:		
Federal - Energy	15%	15%
Federal - General	10%	10%
State - Energy		10%
State - General		2%
Total	25%	37%
Depreciation	5-year (ACRS)	5-year (ACRS)
Property Tax	1.8% of purchase price	1.8% of purchase price
Depletion Allowance	15% of sales minus royalties; maximum 50% of taxable income	N/A

Note: The tax calculations in the cash flow analyses add the tax rate to the federal tax rate and apply this effective rate to taxable income. Because this approach does not recognize that state taxes are deductible on the federal return, it overstates the actual tax liability. This is a relatively minor point which should not affect the conclusions about the project's viability.

Table 23

Base Case Expenditure and Production Schedule

Year	Producer	Distributor	Consumers On-Line
1982	Expend exploration costs		
1983	Expend costs for 3 production wells.	Expend 25% of capital costs.	
1984	Expend cost for 1 production well.	Obtain loan: expend 75% of capital costs.	25% during last six months only
1985			75%
1986			100%

Table 24

Base Case Capital Cost Summary

	Year	Cost Item	1981 Dollars
Producer			
	1982		
		Exploration	$ 291,000
		Equipment (Depreciable)	105,660
		Institutional/Permits	1,000
		Total	$ 397,660
	1983		
		Intangible Drilling Costs (IDC)	$ 553,000
		Equipment	286,980
		Institutional/Permits	1,000
		Total	$ 840,980
	1984		
		IDC	$ 186,000
		Equipment (Depreciable)	95,660
		Total	$ 281,660
	Grand Total		$1,520,300
Distributor			
	1983		
		Equipment (Depreciable)	$ 515,789
	1984		
		Equipment (Depreciable)	$1,547,367
	Grand Total		$2,063,156

Table 24 (Cont'd)

Economic/Financial Variable		Producer	Distributor
Capital Costs			
Exploration			
Well	$161,000	-	-
Reservoir Test	30,000	-	-
Exploration	100,000	-	-
		$ 291,000	-
Intangible Drilling Costs		739,000	-
Equipment		488,300	$2,063,156
Institutional/Permits		2,000	-
	Total	$1,520,300	$2,063,156
Expenses			
Royalties		10% of Sales	-
Annual Operating & Administrative:			
Maintenance		4% of well and well pump costs; 2% of collection system costs.	2% of circulating pump, controls, valves, fittings, disposal system costs; 1% of pipeline costs.
Overhead & Administration (after full production)		$ 30,000	$ 75,000
Electricity (at full production)		$ 89,889	$ 30,389

Once a decision has been made to develop a resource commercially, any drilling costs not creating tangible assets are considered Intangible Drilling Costs (IDC's). Included are direct and indirect costs, including labor and materials, to develop a well to the production stage. IDC's are deductible and need not be recaptured.

Yearly operating costs are tabulated in Table 25. All costs except electricity are escalated at the general inflation rate and range from $120,500 in 1982 to $69,066 in 1986 and thereafter for the producer and from $75,000 in 1983 to $97,990 in 1986 for the distributor. Electricity costs are escalated according to Table 21 and range from $11,236 in 1984 to $89,889 in 1986 and thereafter for the producer and from $3,799 in 1984 to $30,389 in 1986 and thereafter for the distributor.

Alternate 1

Alternate 1 (Table 26) assumes a delay in obtaining endusers such that full production is set back three years to 1989. For further variations, the DCFROR for the producer is fixed at 20 percent and the distributor's DCFROR is fixed at 15 percent. The 1984 sales prices are then determined by calculations. Capital costs are as shown in Tables 27 and 28. Operating costs are deferred for three years, as shown in Table 28.

Alternate 2

For Alternate 2, a higher quality geothermal reservoir is assumed. As a result, a larger quantity of energy can be sold (Table 29). The enduser price is assumed to be lower; in 1984 it is assumed to be 50 percent of the natural gas price. In addition, a shorter loan period and greater rate of return are assumed for the distributor. Capital costs are $1,140,840 for the producer and $3,054,765 for the distributor as shown in Table 30. Operating costs are the same for the producer in

Table 25

Base Case Operating Costs

	Year	Cost Item	1981 Dollars
Producer			
	1982	O&A	$120,500
	1983	O&A	$ 95,000
	1984		
		O&A	$ 71,883
		Electricity	$ 11,236
	1985		
		O&A	$ 59,299
		Electricity	$ 67,417
	1986 and thereafter		
		O&A	$ 69,066
		Electricity	$ 89,889
Distributor			
	1983	O&A	$ 75,000
	1984		
		O&A	$ 97,990
		Electricity	$ 3,799
	1985		
		O&A	$ 97,990
		Electricity	$ 22,792
	1986 and thereafter		
		O&A	$ 97,990
		Electricity	$ 30,389

Table 26

Changed Assumptions for Alternate 1

Item	Producer Percent	Distributor Percent
DCFROR	20	15
1984 Geothermal Sale Price	To Be Determined	To Be Determined

Production Schedule

Year	Consumer Percent On-Line
1984	20
1985	35
1986	50
1987	70
1988	90
1989	100

Table 27

Alternate 1 Capital Cost Summary

	Year	Cost Item	1981 Dollars
Producer			
	1982		
		Exploration	$ 291,000
		Equipment (Depreciable)	105,660
		Institutional/Permits	1,000
		Total	$ 397,660
	1983		
		IDC	$ 186,000
		Equipment (Depreciable)	95,660
		Institutional/Permits	1,000
		Total	$ 282,660
	1984		
		IDC	$ 186,000
		Equipment (Depreciable)	95,660
		Total	$ 281,660
	1985		
		IDC	$ 372,000
		Equipment (Depreciable)	191,320
		Total	$ 563,320
	Grand Total		$1,525,300
Distributor			
	1983	Equipment (Depreciable)	$ 515,789
	1984	Equipment (Depreciable)	$1,547,367
	Grand Total		$2,063,156

Table 28

Alternate 1 Operating Costs

	Year	Cost Item	1981 Dollars
Producer			
	1982	O&A	$120,500
	1983	O&A	$ 95,000
	1984		
		O&A	$ 71,883
		Electricity	$ 11,236
	1985		
		O&A	$ 49,533
		Electricity	$ 44,945
	1986		
		O&A	$ 49,533
		Electricity	$ 44,945
	1987		
		O&A	$ 59,299
		Electricity	$ 67,417
	1988 and thereafter		
		O&A	$ 69,066
		Electricity	$ 89,889
Distributor			
	1983	O&A	$ 75,000
	1984		
		O&A	$ 97,990
		Electricity	$ 3,799

Table 28 (Cont'd)

Year	Cost Item	1981 Dollars
1985		
	O&A	$ 97,990
	Electricity	$ 11,396
1986		
	O&A	$ 97,990
	Electricity	$ 11,396
1987		
	O&A	$ 97,990
	Electricity	$ 22,792
1988 and thereafter		
	O&A	$ 97,990
	Electricity	$ 30,389

Table 29

Changed Assumptions for Alternate 2

Economic/Financial Variable	Producer	Distributor
DCFROR	To Be Determined	20%
1984 Geothermal Sale Price	To Be Determined	\$4.62/MMBTU (1984 Dollars)
Quantity of Energy Sold		4.7×10^{11} BTU/yr
Capital Costs		
Exploration	\$291,000	
IDC	558,000	
Equipment	289,540	\$3,054,765
Institutional/Permits	2,000	
Total	\$1,140,540	\$3,054,765
Loan Assumptions		
Loan Duration	-	10 years
Interest Rate	-	12%
Expenses		
Electricity (at full production)	\$ 44,944	\$ 30,389

Table 30

Alternate 2 Capital Cost Summary

	Year	Cost Item	1981 Dollars
Producer			
	1982		
		Exploration	$ 291,000
		Equipment (Depreciable)	79,660
		Institutional/Permits	1,000
		Total	$ 371,960
	1983		
		IDC	$ 372,000
		Equipment (Depreciable)	139,920
		Institutional/Permits	1,000
		Total	$ 512,920
	1984		
		IDC	$ 186,000
		Equipment (Depreciable)	69,960
		Total	$ 255,960
	Grand Total		$1,140,840
Distributor			
	1983		
		Equipment (Depreciable)	$ 763,691
	1984		
		Equipment (Depreciable)	$2,291,074
	Grand Total		$3,054,765

1982 and 1983, but decline after that compared to the Base Case (see Table 31). For the distributor, operating costs are higher from 1984 than for the Base Case. Electricity costs are the same for the distributor but lower for the producer than in the Base Case.

Alternate 3

For Alternate 3, a poorer quality reservoir is assumed, with less energy to be sold (Table 32). The 1984 consumer price is 90 percent of that of natural gas, while a reduced rate of return is assumed for the distributor. Because of the reduced resources, both producer and distributor capital costs are lower than for the Base Case, as shown in Table 33. Operating costs are lower for most years, as shown in Table 34.

C. Results of DCFROR Analyses

The basis for analysis of this investment opportunity is the Disounted Cash Flow Rate of Return (DCFROR) method. The DCFROR is the particular discount rate that makes the present worth of the net cash flow equal to the present worth of the investment. For the Base Case, Alternate 2, and Alternate 3, the producer DCFROR is the output (endogenous) value. For Alternate 1, a price is determined instead. In all cases, the distributor DCFROR is specified rather than calculated. The results are summarized in Table 35 and described below. Appendix A shows details of the analyses. (It must be recognized that the dollar figures in the cash flow analysis in Appendix A are nominal dollars for each stated year, whereas the dollars in Table 24 are 1981 dollars; as a result, the present value of the capital investment in the cash flow tables do not numerically agree with the figures in Table 24.)

Table 31

Alternate 2 Operating Costs

	Year	Cost Item	1981 Dollars
Producer			
	1982	O&A	$ 120,500
	1983	O&A	$ 95,000
	1984		
		O&A	$ 71,369
		Electricity	$ 5,618
	1985		
		O&A	$ 47,477
		Electricity	$ 33,708
	1986 and thereafter		
		O&A	$ 56,215
		Electricity	$ 44,944
Distributor			
	1983	O&A	$ 75,000
	1984		
		O&A	$ 107,690
		Electricity	$ 3,799
	1985		
		O&A	$ 107,690
		Electricity	$ 22,792
	1986 and thereafter		
		O&A	$ 107,690
		Electricity	$ 30,389

Table 32

Changed Assumptions for Alternate 3

Economic/Financial Variable	Producer	Distributor
DCFROR	To Be Determined	13%
1984 Geothermal Sale Price	To Be Determined	$8.32/MMBTU
Capital Costs		
Exploration	$291,000	
IDC	739,000	
Equipment	338,400	$1,790,282
Institutional/Permits	2,000	
Total	$1,370,400	$1,790,282
Expenses		
Electricity (at full production)	$ 44,944	$ 15,194

Table 33

Alternate 3 Capital Cost Summary

Year	Cost Item	1981 Dollars
Producer		
1982		
	Exploration	$ 291,000
	Equipment (Depreciable)	75,680
	Institutional/Permits	1,000
	Total	$ 367,680
1983		
	IDC	$ 553,000
	Equipment (Depreciable)	197,040
	Institutional/Permits	1,000
	Total	$ 751,040

Alternate 3 Capital Cost Summary (cont'd.)

Year	Cost Item	1981 Dollars
1984		
	IDC	$ 186,000
	Equipment (Depreciable)	65,680
	Total	$ 251,680
Grand Total		$1,370,400
Distributor		
1983		
	Equipment (Depreciable)	$ 447,570
1984		
	Equipment (Depreciable)	$1,342,712
Grand Total		$1,790,282

Table 34

Alternate 3 Operating Costs

Year	Cost Item	1981 Dollars
Producer		
1982	O&A	$ 120,500
1983	O&A	$ 95,000
1984		
	O&A	$ 71,284
	Electricity	$ 5,618
1985		
	O&A	$ 55,702
	Electricity	$ 33,708
1986 and thereafter		
	O&A	$ 64,269
	Electricity	$ 44,944

Alternate 3 Operating Costs (cont'd.)

Year	Cost Item	1981 Dollars
Distributor		
1983	O&A	$ 75,000
1984		
	O&A	$ 95,354
	Electricity	$ 1,899
1985		
	O&A	$ 95,354
	Electricity	$ 11,396
1986 and thereafter		
	O&A	$ 95,354
	Electricity	$ 15,194

Table 35

Results of Economic Analysis

	Base Case	Alternate 1 (Production Delay)	Alternate 2 (Better Resource)	Alternate 3 (Poorer Resource)
Producer DCFROR	31%	20%*	39%*	16%
Distributor DCFROR	17%*	15%*	20%*	13%*
1984 Consumer Price (1984 Dollars)	$6.50/MMBTU*	$4.86/MMBTU	$4.62/MMBTU*	$8.32/MMBTU*
1984 Producer to Distributor Price (1984 Dollars)	$4.35/MMBTU	$2.62/MMBTU	$3.86/MMBTU	$4.22/MMBTU

*Exogenous variable. All other values are determined by calculation.

Base Case. A fixed DCFROR (17 percent) has been assumed for the distributor along with a fixed 1984 price to the consumer ($6.50/MMBTU). From this information, the 1984 producer-to-distributor price is determined to be $4.35/MMBTU. The producer selling at this price would realize a highly favorable 31 percent DCFROR. The complete 30-year cash flow analyses are presented in Appendix A.

Alternate 1. Under this alternative, partial production is extended through 1988. The producer's and distributor's DCFROR have been specified at 20 percent and 15 percent, respectively. The 1984 sales prices are determined by calculation to be $4.86/MMBTU from distributor to consumer and $2.62/MMBTU from producer to distributor. The 30-year cash flow is given in Appendix A.

Alternate 2. With a better resource and increased output, the 1984 consumer price is presumed to be $4.62/MMBTU (50 percent of projected natural gas prices). The resulting producer DCFROR is 39 percent (Table 35).

Alternate 3. With reduced BTU output, the 1984 consumer price is set at $8.32/MMBTU (90 percent of natural gas levels). The resulting producer DCFROR is only 16 percent (Table 35).

D. Sensitivity Analyses

Sensitivity analyses were performed on the Base Case to determine the effects of varying one parameter at a time. The results are graphically displayed in Figures 26 through 29 and summarized in Table 36. When the initial consumer price is dropped from 70 percent of projected natural gas levels to 50 percent, the producer DCFROR drops from 31 percent to 23 percent(Figure 26). If the price is increased to 90 percent of natural gas, a 38 percent DCFROR results.

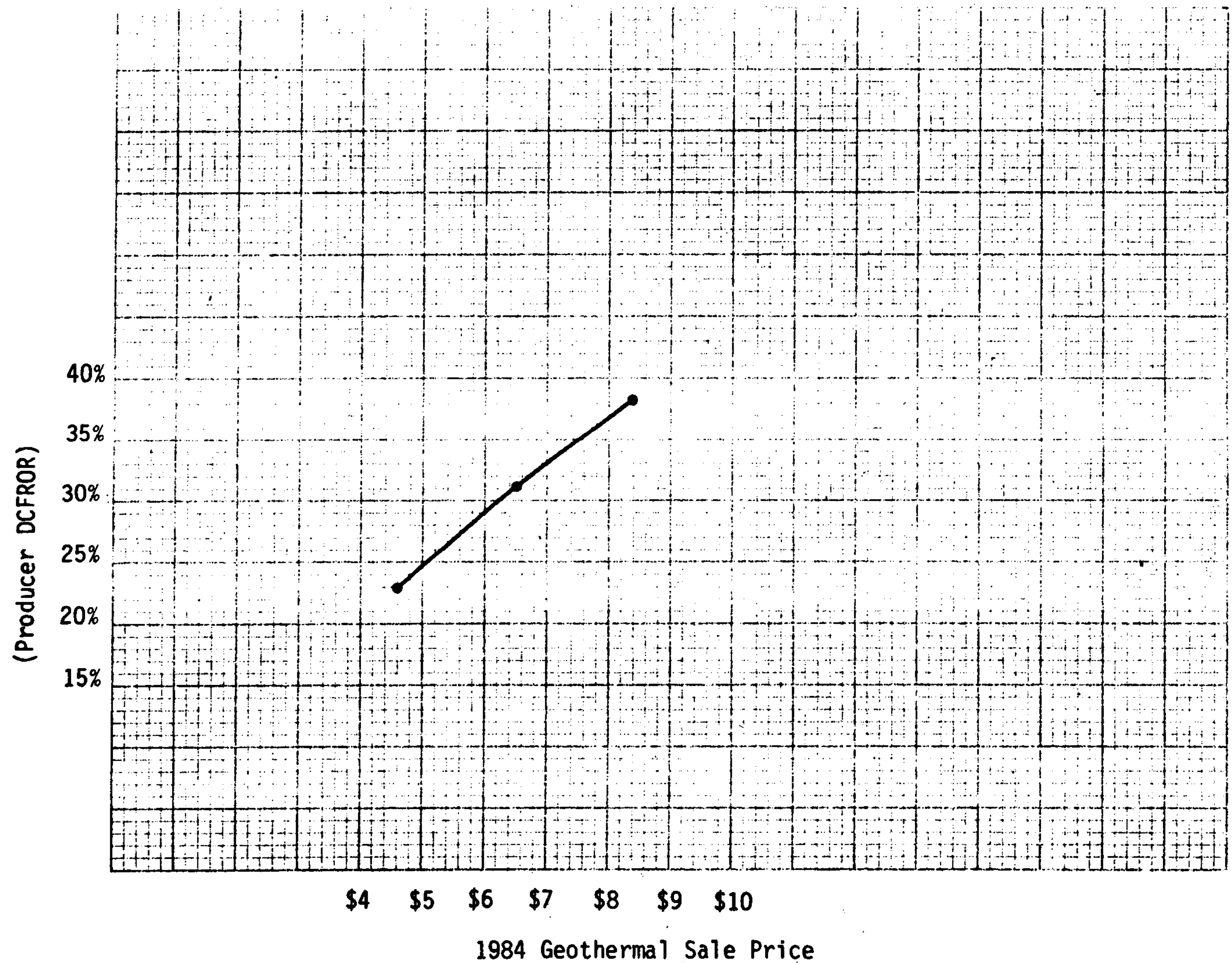

FIGURE 26

Sensitivity Analysis – 1984 Geothermal Sale Price

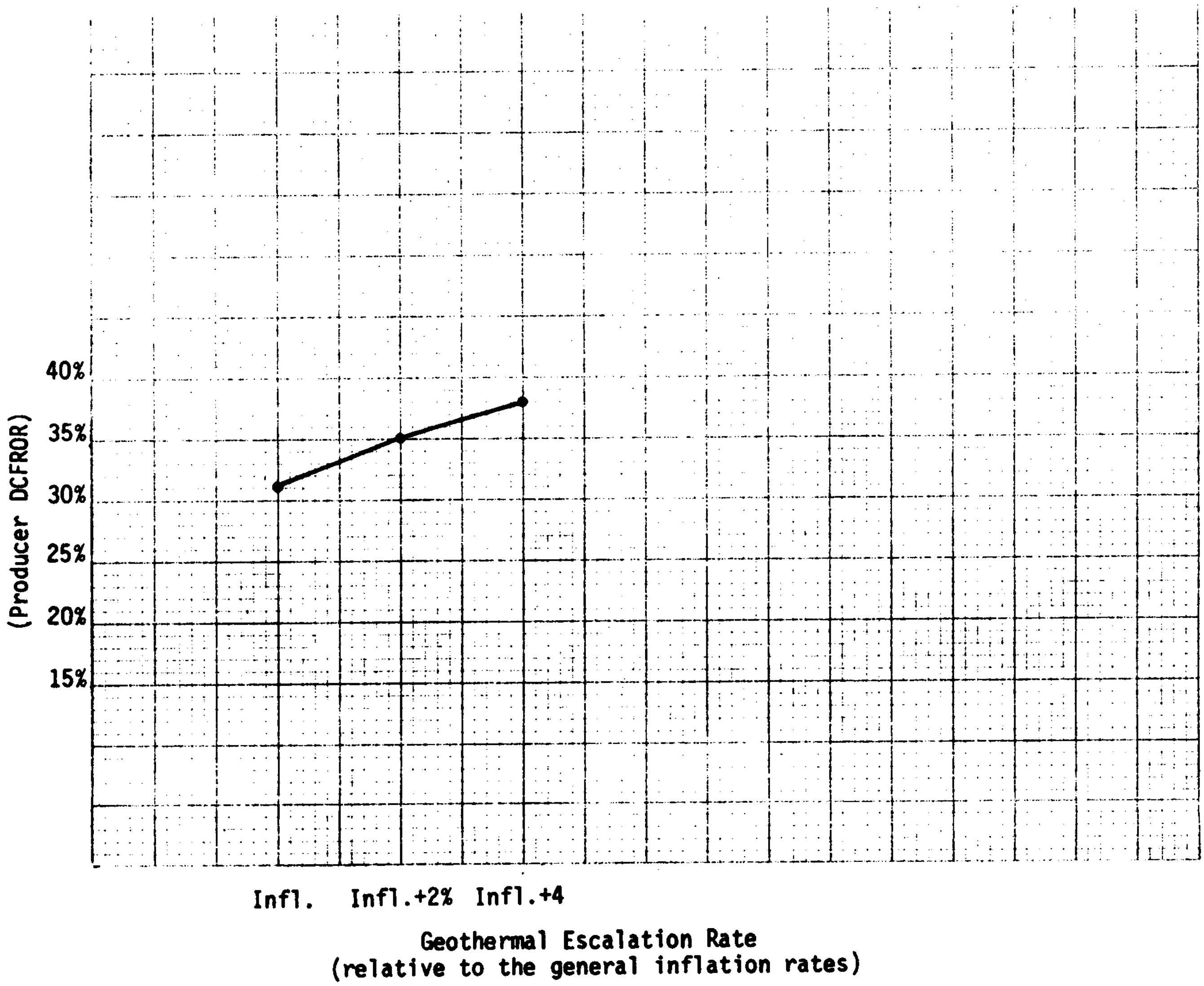

FIGURE 27

Sensitivity Analysis - Geothermal Escalation Rate

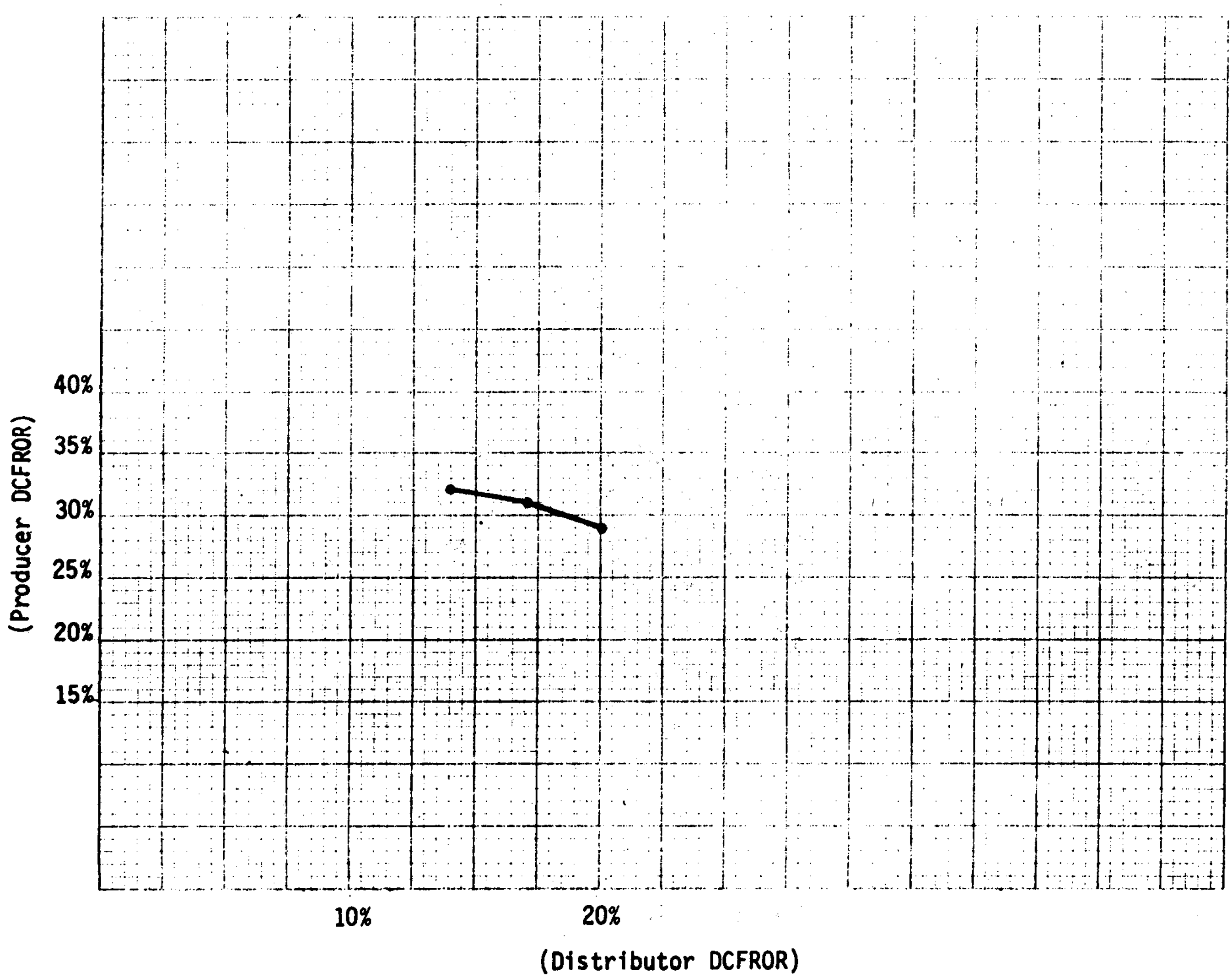

FIGURE 28

Sensitivity Analysis – Distributor DCFROR

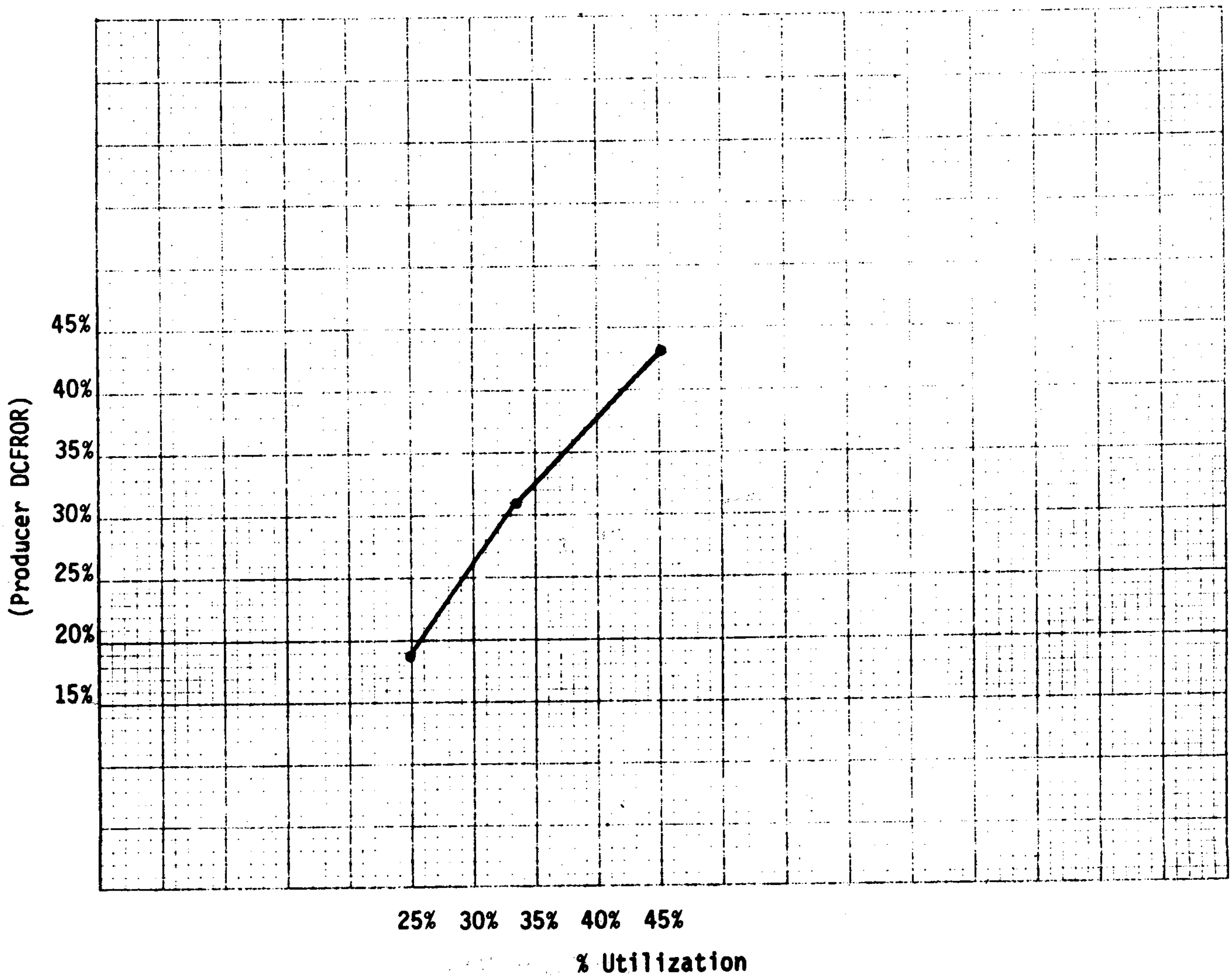

FIGURE 29

Sensitivity Analysis - Percent Utilization

Table 36

Sensitivity Analysis Summary

Variable	Producer DCFROR
45% Utilization	43%
33.5% Utilization	31%
25% Utilization	19%
Distributor DCFROR = 14%	32%
Distributor DCFROR = 17%	31%
Distributor DCFROR = 20%	29%
Geothermal Sales Escalation Rate = Inflation Rate	31%
Geothermal Sales Escalation Rate = Inflation Rate + 2%	35%
Geothermal Sales Escalation Rate = Inflation Rate + 4%	39%
Initial Geothermal Sale Price = 50% of Natural Gas Price ($4.62/MMBTU)	23%
= 70% of Natural Gas Price ($6.50/MMBTU)	31%
= 90% of Natural Gas Price ($8.32/MMBTU)	38%

Figure 27 illustrates the effect of escalating the geothermal price at faster than inflation rates. The producer DCFROR jumps to 35 percent and 39 percent when an additional 2 percent and 4 percent, respectively, are added to the escalation rate. In Figure 28, the distributor DCFROR is adjusted. The resulting producer DCFROR shows only minor, less than proportionate, changes.

Finally, the utilization of the peak capacity is varied. Greater than proportionate changes are evident (Figure 29), ranging from 19 percent DCFROR at 25 percent utilization to 43 percent DCFROR at 45 percent utilization.

The summary of the sensitivity analyses shows producer DCFROR's ranging from 19 percent to 43 percent for the variation in parameters (Table 36).

Section VI

ENVIRONMENTAL ANALYSIS

The National Environmental Policy Act requires an environmental report be prepared to evaluate the environmental effects of exploration and resource definition work performed as part of a study funded by the U.S. Government. Additionally, it requires the evaluation of potential environmental impacts associated with the prospective geothermal development and use such as that being evaluated in this report. This section describes that analysis.

A. Physical Environment

Physiography

The Salida Geothermal Prospect is located in Chaffee County just southwest of central Colorado. The County is predominantly rural, dotted with the small communities of Salida, Buena Vista, and Poncha Springs. It is a part of the Upper Arkansas Valley along the Arkansas River flowing from the Continental Divide to the eastern plains. The County is bordered by the Sangre de Cristo Range on the southeast, the Sawatch Range on the west and the Arkansas Hills on the east (Healy, 1980).

The City of Salida, the site of the prospective users of the geothermal energy from the Poncha Springs resource area, is located in the Arkansas Valley near the confluence of the South Arkansas River with the Arkansas River. As shown on Figure 30, the Poncha Springs area lies southwest of Salida. The study area is outlined with the dashed line.

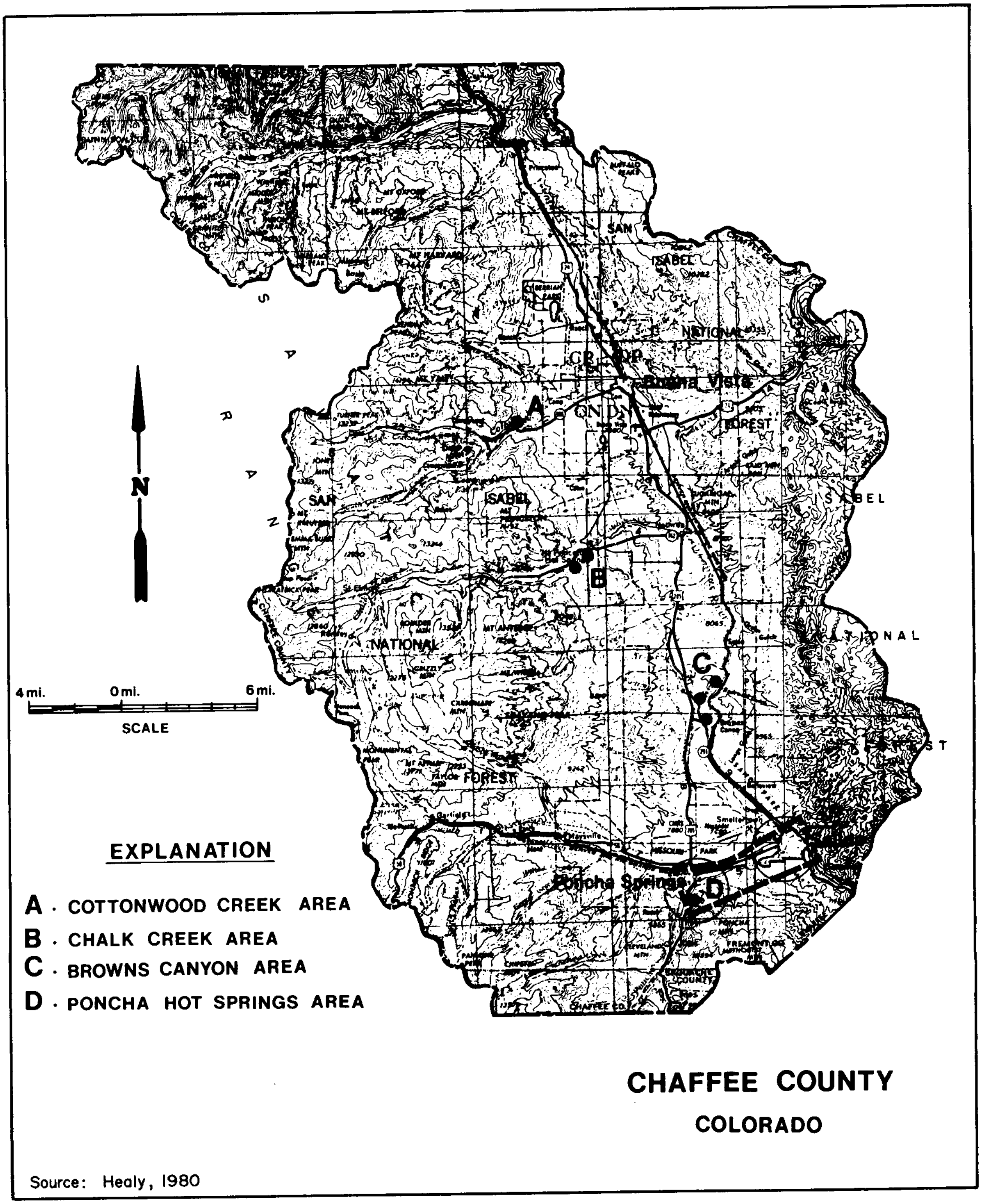

FIGURE 30

Location of Poncha Springs & Salida

The topography of the area varies from the north-south trending valley to bordering high plateaus to high mountains along the western edge, with elevations ranging from a low of 6,900 feet to peaks over 14,000 feet (Upper Arkansas Council of Governments, 1976).

Geology

As discussed previously, the Upper Arkansas Basin "is part of the northern extension of the Rio Grande Rift zone extending from southern New Mexico northward to central Colorado. Faulting associated with the Rio Grande Rift zone has generally resulted in local surface manifestations of hydrothermal springs in Chaffee County" (Healy, 1980).

"... The Sawatch Range, which reaches as much as 7,000 feet above the valley floor, consists of predominantly Precambrian Age metamorphic and igneous rocks and Tertiary intrusives. The Arkansas Hills, the southern limit of the Mosquito Range (Romero and Fawcett, 1978), consist of Precambrian metamorphic and igneous rocks capped in places by complexly-folded and faulted Paleozoic sedimentary rocks and Tertiary Age volcanics. The Arkansas Hills are a small mountain area in comparison to the towering peaks of the Sawatch Range to the west. Sedimentary deposits found along the interior portions of the County include both consolidated and unconsolidated sediments of Tertiary and Quaternary Ages" (Healy, 1980).

Seismicity. Geothermal resources are commonly found adjacent to areas of seismic activity. The Salida region lies just east of an active seismic belt. While large destructive events are not anticipated in the near future, earthquakes up to 4.0 on the Richter scale can be expected each year. Those of a greater magnitude are rare. (McEldery, 1975).

Soils

According to the Soil Survey of Chaffee - Lake Area, Colorado: the soils of the most probable drill site are of the St. Elmo Series (SeF) (Figure 31), (Soil Conservation Service, 1968, Issued 1975). The surface layer is typically dark-brown gravely sandy loam about 10 inches thick. The underlying layer is brown gravely and cobbly loamy sand that is strongly calcareous and is about 10 inches thick. Lime-coated gravel and cobbles are located below a depth of 20 inches. The series is calcareous and moderately alkaline throughout. Permeability of the soil allows rapid water absorption; and available water capacity is low. Effective rooting depth is 60 inches or more. Soils appear to be generally stable at slopes of less than forty percent. Cut and fill sections of old mountain roads have retained their original slopes. At the steep slopes seen in the site area, surface runoff is medium to rapid, and the hazard of erosion is moderate to high. A grass cover is used for limited grazing (Schessler, 1980).

The rough broken land (Ru) near the proposed drill sites is made up of highly stratified, gray, brown, and pinkish-yellow silt, clay that has lenses of sand, and gravel and cobbles. The layers of deposition are not uniform, differing within short distances. The land is calcareous with pockets of high lime accumulation. Surface runoff is rapid and erosion-hazard is high (U.S. Department of Agriculture, Soil Conservation Service, 1975).

Hydrology

As indicated in the Chaffee County Comprehensive Plan, "The major drainage-ways in the area are the Arkansas River, the South Arkansas River, Cottonwood Creek, Chalk Creek, Clear Creek, and Trout Creek. The Arkansas flows from north to south and is by far the most important, traveling about 360 miles in Colorado and draining a total of about 25,000 square miles" (UAACOG, 1976).

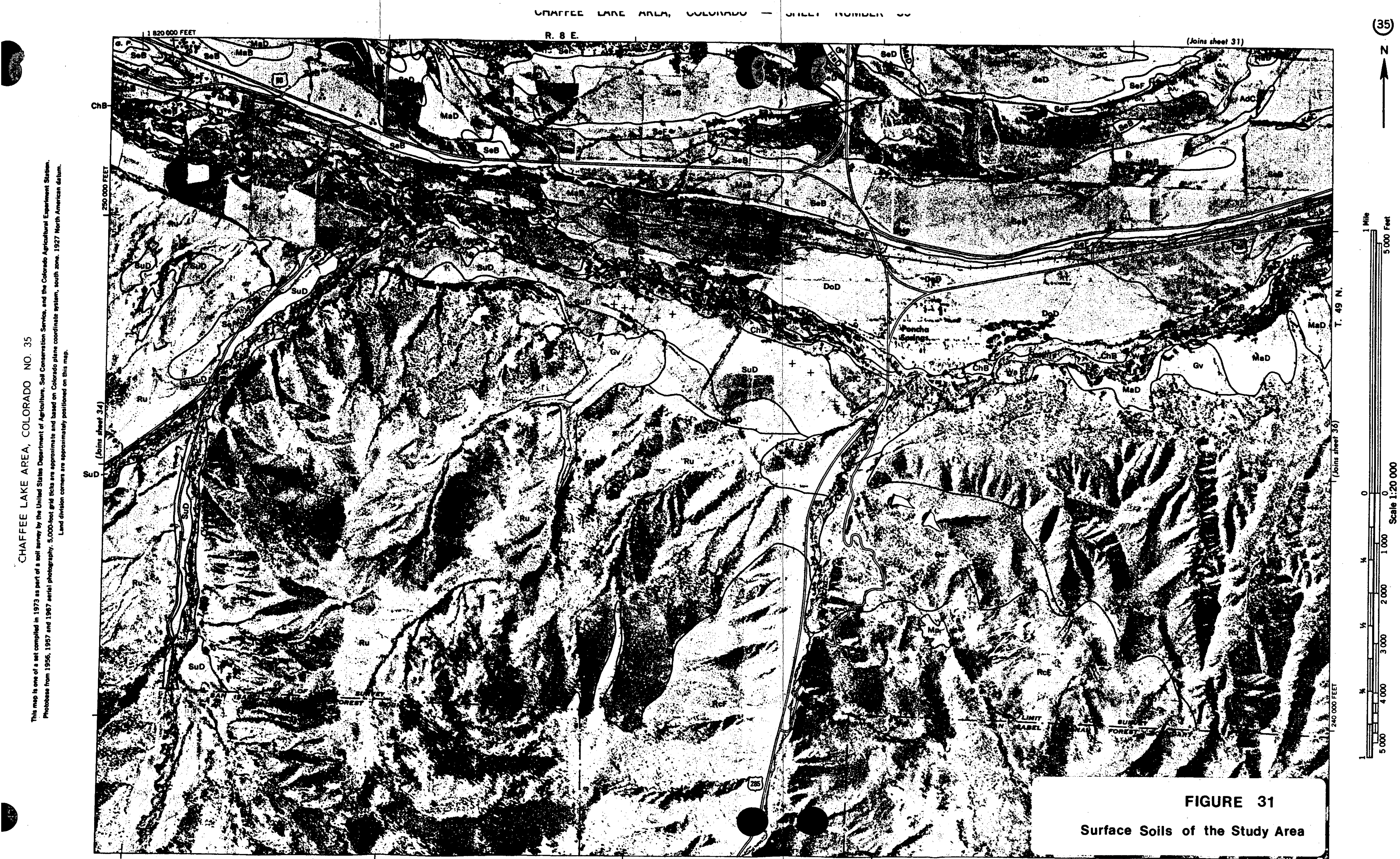

FIGURE 31

Surface Soils of the Study Area

The South Arkansas, which flows into the Arkansas, drains about 210 square miles at the junction (URS, 1975). Low Flows have been measured and analyzed. The Arkansas River at Salida has a Statistical Critical Low Flow of roughly 111,000 gallons per minute. The South Arkansas has a Statistical Critical Low Flow of about 2,000 gpm (URS, 1975).

There is a significant amount of groundwater in this part of the Arkansas River Basin, which underlies most of Chaffee County. This is one of the most highly developed groundwater reservoirs in the State according to a report from the Colorado Division of Planning (1979).

Water Quality

Although the actual water quality of fluid from wells cannot be known with certainty until wells are drilled and tested, a geologic and hydrologic evaluation provides the best possible hypothesis regarding probable water quality. In this situation, the well water quality is expected to be very similar to the spring water quality which is extremely high (TDS = 654 mg/l). The only element identified that exceeds drinking water quality is fluoride. Obviously, the normal stream water quality standards could then easily be met.

The best waters for support of diversified aquatic life are those with pH values between 7 and 8, having a total alkalinity of 100 to 120 mg/l or more (Schessler, 1980). Tests of waters from Poncha Hot Springs shows pH values ranging from 7.5 to 8.0 and alkalinity between 166 and 219 mg/l (Barrett and Pearl, 1976). Radioactivity tests reveal that only normal background levels are present (Barrett and Pearl, 1976).

Meteorology

Climate in the Upper Arkansas Valley as in most Colorado valleys is characterized by abundant sunshine, low humidity, light winds and a wide daily temperature range. Precipitation averages 11.37 inches annually in Salida, mostly in the form of summer thundershowers, although snowfall and annual precipitation increase rapidly at the higher elevations (UAACOG, 1976).

Mean average high and low temperatures are 43°F and 12°F, respectively, in January and 85°F and 47°F, respectively, in July (UAACOG, 1976). Heating degree days (HDD) number 6,910 (U.S. Department of Commerce, 1978). Soil temperatures at 20-inch depth are below 32°F for 50 days per year; the growing season is 107 days long. Winter climate may suddenly turn mild due to westerly chinook winds (UAACOG, 1976).

Air Quality

The air is considered to be quite clean in Salida, and no complaints in this regard are known (Upper Arkansas Area Council of Governments, 1976). Although there are no existing monitoring stations for air quality, a series of tests were performed prior to the widening of the Salida-Coaldale Highway (Colorado Department of Highways, 1975). Several simulations were carried out to forcast air quality near and along the expanded highway. All present and forecast future concentrations of hydrocarbon (HC), nitrogen dioxide (NO_2), and carbon monoxide (CO) were found to be well below applicable State and Federal standards (Colorado Department of Highways, 1975). Air inversions can occur occasionally in the immediate Salida area but will have only minor effects (Upper Arkansas Area Council of Governments, 1976).

B. Biological Environment

Flora

In the study area, terrestrial vegetation is characteristic of the lower montane ecological zone - grasses, scattered pinyon pine, and ponderosa pine. As reported in the Salida Facilities Plan, "... the majority of the non-urban terrestrial vegetation includes irrigated hayland and pastureland, with some intermittent areas of rangeland. In many instances, the irrigated cropland and the native rangeland border the Upper Arkansas riparian community. Much of the existing native rangeland is in poor condition because of drought and/or overgrazing practices. The Soil Conservation Service has indicated that the grass species such as Indian rice and needle-and-thread grass, which are usually associated with a healthy range, are decreasing, or are being replaced by blue grama, buckwheat, broom snakeweed, rabbitbush, and annual weeds."

As noted in the Facilities Plan, "In the eco-system along the Arkansas River there are willows and cottonwoods present which provide a major aesthetic contribution to the natural environment. Pinyon and juniper trees are common along the Arkansas River canyon areas where steep, rocky walls and less soiled slopes predominate. Within the Arkansas River environment, there are also numerous shrubs, including sagebrush, scrub oak, chokecherry, alder, snowberry, rose currant, rabbitbrush, mountain mahogany, and clematis. In conclusion, the natural grass vegetation in the planning area is not well developed, although a slight number of grasses and forbes help contribute to the provision of low ground cover" (Wright-McLaughlin Engineers, 1978).

Fauna

It is reported that many diverse species of wildlife are found within the Salida area. Wildlife most commonly found are mule deer, cottontail rabbit, jackrabbit, ground squirrel, coyote, badger, and spotted skunk. Other wildlife species are believed to exist within the study area as well; however, their numbers are significantly less. The most commonly found birds are the English sparrow, pinyon jay, and blackbilled magpie (Wright-McLaughlin Engineers, 1978). See Appendix B.

A key winter deer range borders the likely drill site. The District Manager of the Colorado Division of Wildlife reports that about 300 head of deer also graze on alfalfa and grass along sections of the pipeline right-of-way. Construction or development should be done in the summer, after April or May, to avoid displacing these deer (Willie Travniceck, pers. comm., 1981). (See Appendix B for comments from District Manager.) A key winter elk range is 1.5 miles to the southwest of the probable drill site and should not be affected.

Aquatic Organisms

As cited in the Facilities Plan, "the Arkansas River receives heavy fishing pressure between Salida and Canon City. The Division of Wildlife stocks the river with tons of trout yearly. Additionally, many thousands of brown trout are hatched in the River and adjacent tributaries. The Division of Wildlife feels that these "wild" trout, the brown trout, are the key to the excellent fishing in the Arkansas River, which is why strong emphasis must be placed on maintaining a proper aquatic environment ...."

An aquatic biological inventory was compiled for the Salida planning area in 1975 by the Ken R. White Company as part of the preparation of the Arkansas River Basin 303 Plan. This report showed that the Arkansas River has a diverse assortment of bacteria, fish, and aquatic insects in the Salida planning area. As indicated in the report,

> "The major bacteria analysis dealt with total and fecal coliform levels in the Arkansas River. The total coliform bacteria tests showed a geometric mean of 101 organisms/100 ml. The fecal coliform bacterial geometric mean was 15 organisms/100 ml near Salida. Both coliform bacteria counts were well below the State standards which for total coliform are 10,000 organisms/100 ml and for fecal coliform, 1,000 organisms/100ml. A fecal coliform analysis is of importance since this bacteria originates in the intestinal system of man and other warm-blooded animals and their presence indicates the possible contamination of water by human or animal wastes ...."

Analyzing aquatic insects is of importance since particular species are sensitive to changes in water quality, affected by sudden exposure to a polluting source. As part of the Basin Plan study, aquatic insect samples were taken from the Arkansas River in the vicinity of Poncha Springs. Thirteen (13) samples were taken and a total of 930 insects were analyzed. Test results showed the Arkansas River and South Arkansas Salida planning area to have generally a very good water quality. The equitability and species diversity tests did <u>not</u> indicate a moderate level of organic pollution in the planning area (Wright-McLaughlin Engineers, 1978). Tables in Appendix B list the aquatic species found in the river. The Water Quality Control Division confirms that the water quality is very good with only <u>occasional</u> problems from metals from upstream sources, which are not severe because of the dilution (Jon Scherschligt, pers. comm., 1981).

<u>Sensitive, Threatened and Endangered Species</u>

No sensitive, threatened and endangered species are known to be in the area, as reported by Wright-McLaughlin in 1978. The

District Manager of the Colorado Division of Wildlife indicated, however, that golden eagles are seen in the area but would be unaffected by the activity indicated (Willie Travniceck, pers. comm., 1981).

C. Human Environment

Demography

Salida is the county seat and the largest city in Chaffee County. Its 1980 population numbered 4,870 (U.S. Bureau of the Census, 1981). The commuting area of Salida is estimated to contain over 15,000 persons (Colorado Division of Commerce and Development, 1979). A breakdown of the population by ethnic group shows 95.4 percent of the residents to be white, 14.4 percent of which are of Spanish origin (U.S. Bureau of the Census, 1981). The city expects a 25 percent growth rate during the present decade, with a higher growth rate anticipated for the unincorporated areas (Colorado Division of Commerce and Development, 1979). Growth opportunities may be limited by employment opportunities and water availability (UAACOG, 1976).

Socioeconomics

The economy of Chaffee County is based upon tourism, mining, and agriculture. Salida is the service center for these and other economic activities (UAACOG, 1976).

Year-around recreation is popular; the region is known for its natural beauty. Downhill skiing, snowmobiling, ski touring, sledding, and snowshoeing attract winter tourists; and summer trout fishing on the Arkansas River is considered among the best in the United States (UAACOG, 1976).

As shown in Table 37, mining also provides a significant source of revenue for area residents. The mines are primarily located outside Chaffee County, but within commuting range of Salida (Healy, 1980)

Table 37

Employment by Major Category

Employment Category	1970 #	1970 %	Current Year Estimate #	Current Year Estimate %
Agriculture	448	10.1	356	5.5
Mining	512	11.6	640	9.9
Contract Construction	298	6.7	301	4.7
Manufacturing	190	4.3	158	2.5
Transportation & Public Utilities	482	10.9	266	4.1
Wholesale Trade	45	1.0	120	1.9
Retail Trade	898	20.3	959	14.9
Finance, Insurance and Real Estate	66	1.5	168	2.6
Service and Miscellaneous	409	9.3	1,264	19.6
Government (Federal, State and Local)	563	12.7	1,237	19.2
TOTAL EMPLOYMENT	4,166	94.2	6,032	93.7
UNEMPLOYMENT	258	5.8	408	6.3
TOTAL LABOR FORCE	4,424	100.0	6,440	100.0

Source: Colorado Division of Commerce and Development, 1979.

Hay production and cattle raising are the predominant rural occupations (Colorado Division of Commerce and Development, 1979). Agricultural land use is declining as the area becomes more urbanized.

The Salida Hospital and the U.S. Bureau of Reclamation are the largest employers within Salida. They employ 100 and 75 persons, respectively (Colorado Division of Commerce and Development, 1979). Income data are available only for the county as a whole: median spendable income in Chaffee County is $11,074 (Table 38)(Colorado Division of Commerce and Development, 1979).

Table 39 summarizes community characteristics. As indicated, the City has a full-time fire department, a hospital, and a variety of recreation facilities.

Since the natural environment is considered the most important resource available in the area, it is in the economic interest of the region to maintain the high quality of that environment (UAACOG, 1976). Light, non-polluting industry is, at the same time, considered to be desirable to increase economic activity and to diversify the economy.

Heritage Resources

Several historical sites have been designated in the area. The Overland Mail Express Route of the 1850's followed what is now U.S. Highway 50 between Salida and Poncha Springs. During the same period, Indians were known to have settled in the Poncha Springs area. Appendix C shows the primary historic sites.

Table 38

Spendable Income in County - Percent of Households

$0 - $7,999	35.9%	$15,000 - $24,999	25.0%
$8,000 - $9,999	8.9%	$25,000 plus	3.8%
$10,000 - $14,999	26.4%	Median household income	$11,074

Source: Sales & Marketing Management, July 1978.

Table 39

Colorado Planning and Management Region No. 13

Community Social and Environmental Profile - 1980

SALIDA

SUBJECT	COMMUNITY CHARACTERSTIC
County	Chaffee County
Commuting Area	All of Chaffee County, northern Saquache County, western Fremont County, southern Park County.
Climate and Topography	
Mean Temperature in January	30 degrees F
Mean Temperature in July	66 degrees F
Annual Precipitation	11 inches
Elevation	7,036 feet
Topography	High western mountains with valley and plateau in east.
Population	
Community	4,895
Community Area	15,604
Type of Government	Mayor/Council
Type of Fire Department	Full Time
Insurance Rating	7
Education Services	
Elementary Schools	1
Enrollment/Teachers	772
Junior High Schools	1
Enrollment/Teachers	420
High Schools	1
Enrollment/Teachers	415
Vocational Schools and Colleges	1
Name	Colorado Mountain College (Leadville)
Enrollment	730
Type of Program	Vocational and Technical Training
Hospital or Clinic	Salida Hospital Inc.
Beds	60

Table 39 (Cont'd.)

SUBJECT	COMMUNITY CHARACTERISTIC
Hotels and Motels	
Number of Establishments	19
Number of Rooms	555
Meeting and Banquet Accomodations	
Name (capacity)	Monarch Ramada Inn (300); Salida Inn (50); The Spa (45); Elks Lodge (300); St. Joseph Gym (500).
Recreation Areas, Facilities and Sports	San Isabel National Forest (Fishing, hunting, hiking, camping); Municipal swimming pool; 9-hole municipal golf course; Arkansas River (fishing, kayaking); Antero Reservoir (fishing, boating); Monarch (skiing, winter sports).

Source: Upper Arkansas Area Council of Governments, 1980.

Several archaeological sites have been identified by the National Historical Society in the following sections:

T 49N R8E Sec. 16
T 50N R8E Sec. 9

The exact location of these sites is not revealed in order to preserve the artifacts.

Land Ownership and Use

Land ownership as well as terrain dictate the land uses. Communities, farming and ranching are along the river plains and adjoining terraces. Livestock, grazing, recreation and lumbering are conducted on the high terraces and forest lands. Mineral deposits and thus mining are in the mountainous areas.

In the study area, urban development and agriculture co-exist. From Salida to Poncha Springs along Highway 50, much of the land is preserved as a green belt. Within the Salida city limits, commercial development occurs along Highway 50 as well as within the Central Business District.

Of the 657,150 acres of land in Chaffee County, 529,414 acres or 80.5 percent, are publicly-owned; 77 percent is under federal management. Most of the private land, except for scattered parcels (many of which were formerly mining claims), is along the Arkansas River and its tributaries (UAACOG, 1976).

Several locations have been identified as suitable for industrial use and zoned accordingly. One of these is the area surrounding the CoZinCo facility; another is south of the airport.

Community Values

An economic development plan for the four county region that includes Chaffee County indicates the goals, resources, significant problems, needs and policies regarding the four economic sectors important to the region: agriculture, manufacturing, tourism and mining. Of these sectors, the irrigated agriculture sector has limited potential, but the opportunities for continuing livestock grazing are better. The stated policy is to protect the existing agricultural area. Tourism, mining and manufacturing are all considered to have excellent potential for growth and economic development. Policies explicitly stipulate the desire to encourage greater development in these sectors. At the same time, the plan emphasizes that the environment must be protected so that the beauty and the healthfulness of the region will be maintained. Therefore, industry of a non-polluting sort and environmentally sound mining techniques are to be encouraged in the region (UAACOG, 1980).

D. Potential Impacts Of Proposed Action

Geology

Seismicity. The location of this project is just east of an active seismic belt, with earthquakes of up to 4.0 on the Richter scale anticipated each year. Microearthquakes that have been recorded in the Upper Arkansas Valley and the geology near faults that moved during the Quaternary were discussed by Kirkham and Rogers (1981). Because the area is part of the Rio Grande Rift zone, there is some potential for damaging earthquakes. There has been no induced seismic activity from fluid withdrawal reported for Colorado. There is a small risk that facilities could be damaged by an earthquake. Well casing and pipelines could rupture during seismic activity, liquefaction of the soils and landslides could occur. As a result, geothermal fluids could be released to the environment. If pollutants are contained in the geothermal fluid, surface water and groundwater could be contaminated. The well fluid is expected to be similar to the spring water, however. Since the spring fluid is high quality, with only 654 mg/l of dissolved solids, no significant impact is expected if fluid should be released. In any event, if ruptures should occur, cut-off valves will be closed and repairs made immediately. Given the nature of the proposed development, the risk is not considered to be significant (Junge, pers. comm., 1981).

Subsidence. When wells are drilled and large quantities of water removed, subsidence sometimes occurs from pressure declines in the aquifer that lead to consolidation of the sediments. Usually, effects are more apparent from shallow wells than from deeper ones. If significant subsidence occured, it could cause rupturing of pipelines and sinking of structure foundations. No evidence is available to suggest that subsidence would occur in this area. In any event, since there is no development where the wells will be located, no structural damage would occur if the area should subside. Subsidence will, however, be monitored.

Soils

The principal impact of geothermal development in this area on soils could be erosion, especially on steep slopes. However, flat areas have been selected as tentative drill sites to minimize disturbance to steep slopes. If it should be necessary to level or trench land in areas that might be susceptible to erosion, preventative measures such as rip rapping could be used to prevent such erosion. Following completion of the drilling and wellhead installation, the land will be restored to its original contour and revegetated. A small building will be erected around each wellhead.

Water Resources

The availability of water is a major concern in the Upper Arkansas River Basin. An additional consumptive use of water in large volumes could be harmful. Since the Arkansas River is overappropriated, no additional water rights are available except through purchase. The use of geothermal fluid is not considered to be a consumptive use. Furthermore, the geothermal system is likely to be considered tributary to the Arkansas River. Thus, returning it to the system after removing the heat should preclude loss of water (Schroeder, pers. comm., 1981).

Water Quality

Geothermal fluid of poor quality can contaminate ground water and surface water through casing leaks, holding pond seepage, or improper disposal of fluids. Prevention of such contamination is required by law. Proper design of the drilling program, wells, wellheads, pipelines and discharge systems is the principal means of avoiding such contamination. Where necessary, casing will be installed and cemented, a blowout preventer will be used, and materials will be chosen based upon their resistance to heat and corrosive elements in the fluid.

Where it is used for water supply, water must be maintained at drinking water quality. A mass balance analysis was conducted of the fluoride content of the spring water (see Section VII) to determine whether mixing would be sufficient to maintain the quality. The analysis showed that the fluoride content would fall under the maximum limits indicated in the Safe Drinking Water Standards. In any event, discharge of waste water is controlled by the State Division of Water Quality Control as the designee of the U.S. Environmental Protection Agency. They would assure that any discharge, either surface or interjection, met the legal requirements.

Air Quality

During geothermal well drilling and system construction, air can be polluted by dust from clearing and digging, from vehicle emissions and from dissolved gases in the geothermal fluid. Dust can be readily controlled by graveling, watering or oiling. In any event, any dust and vehicle emission problems would be short-lived. No noticeable odor from hydrogen sulfide, a gas that is often found in geothermal fluid, is now emitted from spring fluid.

Noise

During well drilling, noise levels connected with geothermal development will be highest. Generally, the drill rig will operate on a twenty-four hour/day schedule. The drill site is five miles from Salida and about one mile from Poncha Springs, the nearest municipality. However, the noise should have no more than minimal impact. Following the drilling phase, noise from the pumps for the gathering system should be minimal. If an enclosure is used for the wellhead, the noise will probably be inaudible at close range.

Flora and Fauna

Vegetation can be harmed by clearing of land for drill sites, roads, pipelines and process facilities. It can also be harmed by contamination by minerals or excessive heat from fluids. To assure that erosion does not occur following the removal of foliage, revegetation is effective. To preclude the contamination by minerals and/or heat requires the control of fluids and use of materials that are properly selected and installed to prevent leakage.

Regarding fauna, there is a possibility of a negative impact on about 300 deer that feed in the area, as shown on the map, Figure 32. If well drilling and pipeline construction were done carelessly, deer feeding could be interrupted, possibly increasing the mortality rate of the deer. For this reason, according to the District Wildlife Manager for the Colorado Division of Wildlife, the drilling and construction should be done after April or May to preclude disturbance (see Appendix B). By this time, deer will have moved to higher ground for fawning.

No areas will be fenced when the project is completed; rather, buildings of about 10 feet X 10 feet would contain wellhead pumps. Therefore, only very minimal, if any, habitat would be removed from use, with no impact on the deer population now or in the future.

In any event, since deer population is managed in this area, allowing hunting at a level to thin the herds appropriately, any reduction could be compensated by restricting the hunting.

Aquatic species can be harmed by thermal pollution, erosion into streams or discharge of poor quality fluids into streams. As indicated above, cooling towers will be used to cool the geothermal fluid to a maximum temperature of 90°F before discharge. And, a mass balance analysis shows that drinking water standards will not be exceeded in the stream due to the fluid discharge assuming the water quality approaches the existing hot spring fluid quality. Also, a discharge permit requires conformity with the water quality standards. As indicated, measures will be taken to prevent erosion.

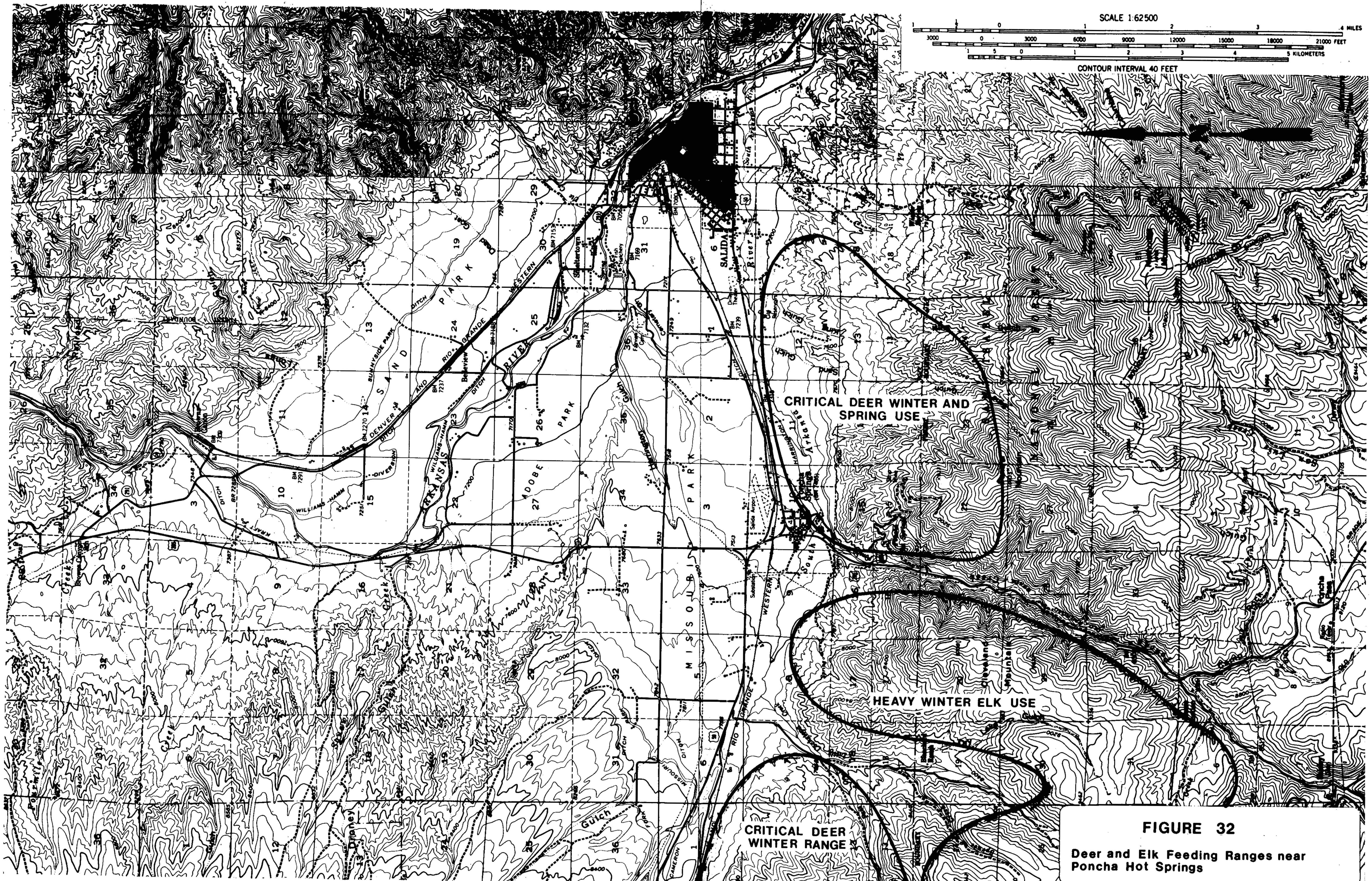

FIGURE 32

Deer and Elk Feeding Ranges near Poncha Hot Springs

Human Environment

Land Use. Minimal land will be disturbed by this project. At the well site, the land is undeveloped and unused. The major part of the pipeline would use the right-of-way that is followed by the existing pipeline. Additional right-of-way will follow fence lines and/or roads for the most part.

There may be archaeological sites in the areas. Some such sites have been identified nearby but a complete survey has not been conducted for the area. If the federal or state government is involved in a project where there are such cultural resources, those cultural resources must be protected, by authority of the National Historic Preservation Act of 1966, as amended. Prior to beginning activity in the area, therefore, the developer should submit a map of the area of activity to the Director of Cultural Resource Preservation for the State of Colorado. The Director will indicate whether a survey should or should not be conducted by a cultural resource management firm. That firm will then indicate the need for further investigation or archaeological clearance (Patterson, pers. comm., 1981).

Socioeconomics. Drilling activities for this project would have no negative effect on the socioeconomic conditions in Chaffee County because the drilling crew would consist of only about 6 persons, given 24-hour drilling. The construction of a pipeline and retrofitting structures could be a larger problem if large work crews were imported from outside the region. Housing and infrastructure in Salida are already stretched. Furthermore, since the construction activities would constitute a temporary activity it would not warrant permanent housing and infrastructure. In some energy development areas in Colorado, campers and recreation vehicles have served as homes for numerous workers and job seekers and their families, sometimes exceeding the capacity of authorized sites. Vehicles are then parked in unauthorized areas, resulting in contamination from improper sewage and solid waste disposal; in general, the quality of life is threatened.

In Chaffee County, however, the March, 1981, unemployment rate was nearly twice that of the State as a whole (7.2 percent versus 3.8 percent) (Colorado Department of Labor and Employment, 1981). Presumably, some of the local labor force could be used for the system construction. Others could probably commute from the San Luis Valley, where unemployment rates are also historically very high. Others, such as skilled plumbing and heating workers, may migrate from cities such as Denver and locate temporarily in Salida or surrounding areas.

Accommodations for housing workers and possibly their families would be needed. In Pagosa Springs, Colorado, however, an actual geothermal development similar to the Salida prospect, the construction of both the pipeline and retrofitting required a work crew of a maximum of 25. The work was phased so that only about 15 workers were on the project at any one time (Garing, pers. comm., 1981). The work on the Poncha Springs prospect would be similar, so any negative impact is not likely to be severe. Furthermore, additional revenue would be brought to Salida - a distinctly positive impact.

Over the long-term, there should be no significant adverse socioeconomic impact at all from the system itself. If the availability of geothermal energy can help attract some additional light industrial or commercial users, the economic base of the area should be enhanced in line with the goals of the community. A better economic climate would probably encourage fewer young people to out-migrate and some new residents to in-migrate, resulting in higher net population growth rate. This could result in increased housing shortages, inadequacy of sewer and water systems, schools, traffic congestion, and so on. It could mean higher incomes but also higher prices. Secondary impacts such as this are remote and indeterminable. In any event, moderate economic growth that is favored by the community would likely be stimulated by this project. It is not the sort of project likely to have a large socioeconomic impact either alone or accompanied by any foreseeable development.

Potential Accidents. Because the construction of a geothermal system requires the use of heavy construction equipment such as backhoes, trucks and tractors, there is a potential for accidents during construction. The implementation of the U.S. Office of Safety and Health Administration and the Colorado Office of Safety and Health Administration requirements and standard safety practices will help minimize the accidents. Heat from the fluid of about 250°F is also a source of potential injury. Pipes and heat exchangers will be insulated to prevent both heat loss and accidents.

If leaks in the well casing should occur, some contamination of water could result. Tried, tested and accepted casing and cementing procedures are the principal means of avoiding such accidents.

E. Prevention of Environmental Degradation

Effluent and Environmental Monitoring Programs

Baseline information was collected for this study from a wide variety of secondary sources, including state agencies such as the Colorado Division of Wildlife, Division of Water Quality, Division of Water Resources, State Historical Society, and others. Several monitoring programs will be conducted including:

(1) H_2S levels at the rig during drilling;

(2) Chemical analyses of the geothermal effluent during flow testing. These will include analyses of all those parameters required by the State Health Department, the EPA designated regulatory agency for water quality, to be tested. (See Industrial Wastewater Discharge Application).

(3) Chemical analyses of the effluent from the cooling towers prior to disposal.

(4) Radon and other noncondensible gases.

Information from geochemical analyses does not indicate that radon would be present in measurable quantities. Wellheads and pipelines will be checked periodically to assure their condition and discover any problems or potential problems. Vegetation along the system will be observed as well to identify any impacts from gases or other substances.

Alternatives

Alternatives that were investigated during this period included alternative pipeline routes, well sites, heating systems, and fluid disposal methods. Also investigated was the possibility that the well might be a failure, necessitating abandonment.

Selection of the route for the pipeline was based primarily upon economic considerations, i.e. the shortest distance being the most economical. Careful consideration was given to whether impacts would vary from one possibility to another. The conclusion was that the impacts would be similar, the right-of-way would be more easily obtained for one of the other alternatives, and that the cost for purchase of private right-of-way would not reach that of the additional pipeline required to skirt the private and so far unleased land.

Well sites will be finally selected based upon a more extensive geophysical and geological evaluation. Preliminarily, however, drill sites were selected to avoid more than minimal leveling and trenching and the additional costs and possibility of erosion associated thereto.

The only realistic alternative heating systems considered were the existing ones, natural gas and propane. The primary overriding attractions of the geothermal system are reduction of heating costs and assurance of availability of fuel.

Waste fluid disposal methods considered were surface disposal and reinjection. Because the spring fluid is very high quality and can meet the requirements for surface disposal, surface disposal seems to be the preferable method. Reinjection, given the permit requirements, monitoring wells, and other costs would be much more expensive. The well fluid is expected to be very similar to the spring fluid. If, however, the well fluid significantly differs from the spring fluid, reinjection may be required.

If the well should be a failure, abandonment would be necessary. The well would be plugged and disturbed areas would be restored to their original surface contours and revegated.

Restoration

After well drilling and testing, all equipment and structures will be removed from the drill site and, if necessary, disposed of at an approved disposal site. The wellheads will be either fenced with chain link fencing or covered with a small metal building that will blend with the vegetation. The land will be graded and contoured to approximate the natural slope. Cleared land will be reseeded with native plant species to preclude soil erosion. If the well should be abandoned, abandonment will occur in accordance with state requirements.

Irreversible and Irretrievable Commitment of Resources

The only irreversible and irretrievable commitment of resources in this project is the heat itself and possibly a very small amount of water through evaporation from the cooling towers. The fluid would be removed at a rate designed to assure the longevity of the resource.

Federal

Since there will be no operations on Federal lands, or federal funding assistance for this project, regulations of the "Geothermal Steam Act of 1970" are not applicable. This environmental report is required because the study is funded by DOE/DGE.

Water management will conform to the Federal Water Pollution Control Act and Amendments of 1972 and the Clean Water Act of 1977. Operations and activities will also conform to the provisions of the Clean Air Act and the amendments of 1977.

<u>State</u>

As indicated in the Institutional Analysis, in conformance with the Geothermal Resources Act of 1974, a permit will be obtained from the Colorado Oil and Gas Conservation Commission prior to drilling the wells. Additionally, permits will be obtained from the Water Quality Control Division and the Air Pollution Control Division (if needed) of the Colorado Department of Health.

<u>Local</u>

Permits or permission as applicable will be obtained from Chaffee County and from Salida.

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Section VII

INSTITUTIONAL ANALYSIS

To explore for, develop, produce, and sell geothermal energy requires a variety of institutional activities. Many of these activities are required by law. Others result from economic necessity. Ownership or right to the use of geothermal energy requires obtaining geothermal leases. Use of land for pipelines or other facilities requires either outright land ownership, land leases, or rights-of-way. Exploration, production, construction, and other activities needed to use geothermal energy require permits including drilling permits, building permits and waste disposal permits. Water rights may be required. This section documents and assesses legal and financial actions required, then also indicates on a time line chart the totality of events that are required in order for a geothermal system to be constructed.

A. Ownership or Right to Use of Geothermal Energy

Leases

To explore for, develop, and produce geothermal energy, geothermal leases are required. Leases are now held by Chaffee Geothermal, Ltd., on a sufficient number of acres to allow for the proposed activity; these include leases on private, State, City (Salida), and Federal lands. Although additional fee leases are being sought, they are not considered to be essential to development of the proposed geothermal project.

Rights-of-way

To construct a geothermal pipeline that crosses land owned by persons other than the developer requires obtaining right-of-way. For this proposed project, much of that right-of-way has already been obtained as part of the geothermal lease provisions. The right-of-way for an existing geothermal pipeline from the springs to the Salida Municipal Pool is available as well. Since the well site that is preferred, based upon existing information, is near the springs, the right-of-way from the well to Salida is assured. For the branch from the existing right-of-way to the CoZinCo plant and the industrial park, some right-of-way is available as part of existing geothermal leases; some additional right-of-way on fee lands and along County roads and City streets is needed. Right-of-way must be negotiated with the land owners, the State, the City, and the County. Permission for use of County and City right-of-way is obtained through the Chaffee County Administrator's office and the City Clerk's office as indicated in the section on Local Requirements.

Crossing a river with a pipeline (as required for the industrial park) has unique right-of-way requirements. By authority of the Clean Water Act, the U.S. Army Corps of Engineers is mandated to regulate the discharge of dredge or fill material into waters of the U.S. Utility line crossing is covered by a type of permit known as the Nationwide Permit, an umbrella permit that covers those activities which are believed will have a minimal impact on the environment, as specified in the regulations shown in Appendix D. Although no application is required, a letter to the U.S. Corps of Engineers describing the activities to be conducted is recommended. The Corps must assure that the construction requirements spelled out in the regulations are met. When violations or suspected violations are reported, the Corps takes action to remedy the problem. As long as the conditions are met, no additional permit should be necessary.

B. Permits

Exploration, development and production of geothermal development require a number of permits. Some of these are required by the State; some of them are required by the two local governments, the Town of Salida and Chaffee County. Federal permits are required where activity will be conducted on federal leases. Although some of the leases in this project are federal, no activity is planned on these federal properties. The State permit requirements are indicated below, followed by those for Chaffee County and then by those of Salida.

State Permits

Well Permits. The Geothermal Resources Act (C.R.S. 1973, 34-70-101-110) establishes the authority of the Colorado Oil and Gas Conservation Commission to regulate geothermal well drilling. The Act requires a permit from the Commission to drill observation, exploration and development wells. Additionally, no well may be constructed without a finding by the State Engineer that such a well will not injure the water rights of others. Permits for wells in a designated groundwater basin must be approved by the Groundwater Commission (C.R.S. 1973, 37-90-104).

To obtain a permit, an application for a permit to drill is filed with the Director of the Commission, along with a filing and service fee of $75.00. An accurate plat or map showing the location of the well must also be submitted. The developer is required to post a plugging bond to insure that the well, upon abandonment, will be plugged in accordance with the Commission's rules and regulations. Bond is set at $10,000 per well or a $50,000 blanket bond to cover all wells, but this bond would be waived where a bond has been filed in accordance with Federal or Indian lease requirements. An observation well permit may be processed in two weeks, although the law allows 60 days (Coe and Forman, 1980).

Additional drilling requires additional permits. A written statement based upon data obtained from the observation well or from "similarly situated geothermal resource areas" must be submitted. It must include the following information:

(1) Names and addresses of the owner, operator, and designated agents of both;

(2) Location of the wells and proposed depth thereof;

(3) Description of the lease;

(4) Amount and extent of surface development anticipated.

(5) Measures taken to protect against land subsidence, contamination of surface and ground waters and the air, and excessive noise levels;

(6) Proposed methods of geothermal by-product disposal and geothermal by-product recovery;

(7) Mineral and chemical compositon of any brine and associated gases of the geothermal resource;

(8) Proposed casing program;

(9) Any other information requested by the Commission.

Additionally, the developer must secure public liability insurance commensurate with the scope of the application (Coe and Forman, 1980).

The application and geological data are submitted by the Commission to the Colorado Division of Water Resources for review and comment. If the proposed exploration well is located in a designated groundwater basin or has hydrological connections to a surface spring, the Division must determine that the construction of the well will not interfere with the water rights of others.

A permit must also be obtained from the Oil and Gas Conservation Commission to excavate a retaining pit to store any substances produced from a well and to plug a completed well or abandon a well.

Within 30 days after recompletion, plugging back, abandonment, formation fracturing or other similar operations, the developer must submit a report to the Commission describing the activities.

All retaining pits must be filled and the location cleared and restored (to the satisfaction of the Director) before the plugging report will be approved. Upon completion of the well, a Completion Report must be filed within 60 days. This form may be obtained from the Commission (Coe and Forman, 1980).

Water Rights or Permits. For hydrothermal energy production, it may be necessary to obtain water rights. Consequently, prior to the issuance of a permit, the State Engineer must determine that the construction of a geothermal exploration or development well would not interfere with the water rights of others. As previously described, after the well application and the geological data are reviewed by the Oil and Gas Conservation Commission, the application is sent to the State Engineer for comment. The proposed geothermal well may be hydrologically connected to a ground water basin or to a surface water source. Tributary ground water or that connected with surface streams is subject to appropriation (C.R.S. 1973, 37-92-0). In this case, applications for water rights to tributary water must be filed in the district water court (Coe and Forman, 1980).

If no water rights are available, however, because the relevant stream has been fully- or over-appropriated (as in this case), there are still two ways to obtain control of the necessary water that carries the geothermal energy. One option is to obtain water rights from an existing owner and submit a plan of augmentation to allow the diversion of water from one part of the stream system to another (Richard Pearl, pers. Comm., 1977).

If the proposed well is in a designated ground water basin, the permit must be approved by the Ground Water Commission and is subject to a different set of conditions. In accordance with the law, a maximum of 1/100th of the water supply in the formation can be removed each year (C.R.S. 1973, 37-90-137).

A second option may be to avoid consumptive use of the water by removing the heat from the water and returning the water to the stream system from which it originated. Or, a "closed loop" may be used whereby the water is reinjected back into the aquifer after heat removal. No final decision is possible regarding the use of water until following submittal of an application.

In this project, the plan is to return the geothermal water to the Arkansas River, to which it is considered to be tributary, and thus avoid consumptive use.

Public Utility Regulation. Although currently no reference is made to them in Colorado public utility law, geothermal systems could become subject to regulation as public utilities in Colorado. Whether a geothermal system in Salida would be subject to regulation as a public utility is significant for two reasons:

(1) Approval of such a system would be dependent upon a decision of the Public Utility Commission;

(2) The rate of return on investment (RORI) for the developer would be subject to approval by the Commission. A RORI considered by the Commission to be suitable might or might not be sufficient incentive for a private developer to install and operate a system.

The Colorado public utilities law defines a public utility as: "every common carrier, pipeline corporation, gas corporation, electrical corporation, telephone corporation, telegraph corporation, water corporation, person or municipality operating for the purpose of supplying the public for domestic, mechanical, or public uses and every corporation, or person declared by law to be affected with a public interest" [underlining added] - - - 1973, C.R.S., 40-1-103. Although the definition does not specifically discuss geothermal systems, a broad interpretation would suggest that such coverage could be indicated. In the case of geothermal systems in Colorado, however, the State Attorney for the Public Utilities Commission has indicated preliminarily that geothermal systems do not seem to be included under existing legislation, but such a determination would need to be made at the time that a system was proposed (Coe and Forman, 1980).

In the case of the Salida geothermal system being evaluated herein, in any event, provision in the public utilities law seems to remove the possibility of regulation. The law states that "To fall into the class of a public utility, a business or enterprise must be impressed with a public interest and those engaged in the conduct thereof must hold themselves out as serving or ready to serve all members of the public, who may require it" - - - [underlining added] (1973, C.R.S. 40-1-103, II). The system being evaluated for Salida, as proposed, would supply geothermal energy to specific customers on a contract basis, but not to "all members of the public."

Waste Water Discharge. A discharge permit is required to discharge the spent geothermal fluid, whether the fluid will be discharged to the surface or injected into a subsurface aquifer. The Water Quality Control Commission is mandated to adopt regulations for the state discharge permit system, designed to be in conformity with the Federal Water Pollution Control Act Amendments of 1972 and the Clean Water Act of 1977 (C.R.S. 1973, 25-8-501 through 508). Accordingly, the Commission has classified the water quality of streams and rivers within the State and has adopted regulations for the control of water quality. Permits for discharge are under the jurisdiction of the Water Quality Control Division.

To obtain a permit, an application must be submitted to the Water Quality Control Division, along with a filing fee that may vary from $10 to $250, depending upon the extent of the proposed development (Coe and Forman, 1980). An annual fee, as set forth in C.R.S. 1973, 25-8-501, must be paid to the Department of Health. The application must be submitted not later than 180 days in advance of the proposed discharge commencement. The short form application for a discharge permit may be used for discharge volumes that are 50,000 gallons or less on any one day at one or more discharge points. Existing industrial operations and new industrial operations are required to submit a different set of forms. Form 1, required for all applicants, is essentially a description of the site and effluent (Environmental Protection Agency, Form 3510-1).

If the Division requires further information or a site visit, the Division must specify a date not later than 60 days from the notification date for the applicant to provide information or arrange a site visit date. Unsatisfactory response can result in permit application denial.

Discharge will not be permitted if it will violate land use plans, control regulations, water quality standards, or 201, 208, 209 or 303 water quality management plans (unless a schedule of compliance is approved), if it will impair anchorage and navigation, if it will include radiological, chemical or biological warfare agents or high level radioactive waste, or if the Regional Administrator of the U.S. Environmental Protection Agency pursuant to Section 402(d) of the Federal Act objects to the discharge.

The permit must include as a minimum the following items:

(1) Identification and address of the owner and operator or responsible individual.

(2) Location, quantity and quality characteristics of the permitted discharge.

(3) Effluent limitations and any other requirements for treatment prior to discharge;

(4) Guidelines for equipment and procedures required for mandatory monitoring, record keeping and reporting requirements;

(5) Schedule of compliance to achieve applicable effluent limitations if not presently complying;

(6) The permittee must allow the Division or its authorized representatives, plus representatives of the Environmental Protection Agency to review and copy records, to inspect monitoring equipment, or to sample pollutant discharge.

A permit will be valid for no more than five years. If the permittee desires to continue the discharge beyond the expiration date, he or she must apply for permit renewal at least 180 days prior to its expiration and it will be treated as an original permit. Any discharge may be subject to monitoring as required by the Division.

Records of the required monitoring activities must be maintained by the permittee.

If the Division decides to issue a permit, it is prepared by the Division and then made available to the public for inspection and copying. Public notice is give to the applicant and circulated to inform interested persons. An opportunity is provided for the applicant, any affected State, agency, county the Regional Administrator (EPA), or interested person, agency or group to request or petition for a public non-adjudicatory hearing regarding the tentative permit.

Any such request of petition must be filed within a thirty (30) day period, along with an explanation of the party's interest and justification for hearing. Following the thirty (30) day notice period and/or public hearing, the Division shall issue or deny the permit with such modifications as may be appropriate (Water Quality Control Commission, 1978).

The evaluation of a discharge permit application is based upon the State's system water quality classification. Criteria for classification and classifications are shown in Appendix E. Water quality standards are used to describe the current characteristics of particular state streams and the extent of identified pollutants within them. The standards refer to measurable characteristics of water, including:

(a) Toxic substances;

(b) Suspended solids, colloids, and combinations of solids with other logical constituents and characteristics;

(c) Bacteria, fecal coliform, fungi, viruses, and other biological constituents and characteristics;

(d) Dissolved oxygen and the extent of oxygen demanding substances;

(e) Phosphates, nitrates, and other dissolved nutrients;

(f) pH and hydrogen compounds;

(g) Chlorine, heavy metals, and other chemical constituents;

(h) Salinity, acidity, and alkalinity;

(i) Trash, refuse, oil and grease, and other foreign material;

(j) Taste, odor, color, and turbidity;

(k) Temperature.

All waters of the state are also subject to basic standards (shown in Appendix E). These limit discharge of human waste and radioactive materials. Although not yet finally approved at the time of preparation of this report, a classification system and standards have been proposed for the entire Arkansas Basin, which includes the study area for the Salida project. The basic and organic standards are shown in Appendix E. They indicate standards for temperature, restricting temperatures that will be deleterious to resident aquatic life. According to Division officials, temperatures over 90°F are considered to be deleterious as a rule of thumb. The standards also regulate a variety of organics. Not all organics or other substances are specifically mentioned; some are covered by the basic state standards. Where domestic water is among the classifications for a stream request, safe drinking water standards are applicable. Violations of the standards are punishable by law (Colorado Department of Local Affairs and the Upper Arkansas Area Council of Governments, 1979).

The rate of flow of the stream to be used for discharge plays a large role in determining the volume of pollutants that can be safely discharged. Assessment is based upon the minimum annual average seven-consecutive day flow expected in ten years. A mixing zone for the dilution of the discharge substance is determined by a "mass balance analysis" in order to assess the extent to which any undesirable substances will be present in the stream. Some key flow considerations for review are detailed in Appendix E. The ability of effluent to comply with the restrictions is calculated by a mass balance analysis, as follows:

$$C\,(\text{mixed}) = \frac{Q(\text{stream})\;C(\text{stream}) + Q(\text{discharge})\;C(\text{discharge})}{Q(\text{stream}) + Q(\text{discharge})}$$

Where:

Q = quantity (flow)

C = concentration
(Robert Shukle, pers. comm., 1981)

To be certain that discharge of the geothermal fluid would be allowed without treatment would require either preparation of a complete application to the Division of Water Quality Control for processing or the conduct of a mass balance analysis by another party. Both of these approaches are outside the scope of this study. The approach is, therefore, to identify the proposed discharge points, flow and parameters, and then to compare them with the proposed stream standards and the basic standards.

Table 40 shows the comparison of physical properties of the Arkansas River system with those of the Poncha Hot Springs. As the table shows, even without mixing, only fluoride exceeds the standards indicated. It seems more than likely that with mixing, both the fluoride level and the temperature would be well within the allowable range (Robert Shukel, pers. comm., 1981).

Table 40

Comparison of Upper Arkansas River and Poncha Springs Chemistry

		Unit	Geothermal Springs	River Water Quality	Drinking Water Standard
Arsenic	(As)	(ug/l)	2-6	50	
Boron	(B)	(ug/l)	60-150	750	
Cadmium	(Cd)	(ug/l)	0	0.1	
Calcium	(Ca)	(mg/l)	17-24	-	
Chloride	(Cl)	(mg/l)	48-52	250	
Copper	(Cu)	(ug/l)	<1	9	
Fluoride	(F)	(mg/l)	8.9-14		1.4-2.4
Iron	(Fe)	(ug/l)	0-50	300	
Lead	(Pb)	(ug/l)	<4	8	
Lithium	(Li)	(ug/l)	180-200		
Magnesium	(Mg)	(mg/l)	0.2-0.8		
Manganese	(Mn)	(ug/l)	30-50	50	
Mercury	(Hg)	(ug/l)	0-0.1	0.05	
Nitrogen	(N)	(mg/l)	0-0.5		
Phosphate	(P)	(mg/l)	0.02-0.15		
Selenium	(Se)	(ug/l)	0		
Silica	(SiO_2)	(mg/l)	71-100		
Potassium	(K)	(mg/l)	7.8-8.7		
Silver	(Ag)	(ug/l)	0	0.1	
Sodium	(Na)	(mg/l)	190-200		
Sulfate	(SO_4)	(mg/l)	190-220	250	
Zinc	(Zn)	(ug/l)	0-10	135	
pH			7.5-8.0	6.5-9.0	
TDS		(mg/l)	654-697		
222 Rn		(pCi/l)	1400		
226 Ra		(pCi/l)	0.16	5	
234 U		(pCi/l)	0.041		
235 U		(pCi/l)	<0.0084		
238 U		(pCi/l)	0.034	15	
230 Th		(pCi/l)	0.022	60	
232 Th		(pCi/l)	0.02	60	

Because the South Arkansas tributary has much smaller flows than the Arkansas River, higher concentrations of pollutants from fluid discharge are expected to go into this tributary than into the Arkansas River. It is, however, a very short distance from the proposed point of discharge to the South Arkansas and the joining of the tributary with the Arkansas River.

Because of the purity of the water from the Poncha Springs, which is expected to be much like the geothermal well water, ($\approx$ 700 mg/l TDS) surface discharge of the fluid was assessed for this project. The various dissolved solids, pH, and radioactivity from available data were compared with the stream standards for the Arkansas River and its tributary, the South Arkansas. None exceeded the standards. However, because the Arkansas River is classified as a water supply source, the drinking water standards must also be taken into account. Before mixing, the fluoride content in the geothermal fluid from the Springs does exceed the drinking water standards. A mass balance analysis was conducted, therefore, to determine what would be the effect after mixing:

$$\frac{(111,000)\ (0.46)\ +\ (1600)\ (14)}{112,600} = 0.6 \text{ mg/l fluoride}$$

Source of flow data: Wright McLaughlin Engineers, 1978

The above assumes the <u>entire</u> discharge would occur into the Arkansas River at one point. This is exaggerated because it represents peak loading, less would actually be discharged at any one point yet it is still well below the allowable limit. A similar mass balance analysis for discharge to the South Arkansas tributary was more critical because of the low flow of that body of water:

$$\frac{(2,000)(0.46)\ +\ (520)(14)}{2,520} = 3.25 \text{ mg/L}$$

Source of data: Wright McLaughlin Engineers, 1978

That stream section is not, however, used for water supply before it enters the Arkansas River, a short distance from the outlet from the geothermal system. Once it mixes with the Arkansas River flow, as indicated above, the fluoride content is well below the maximum allowed.

Based on this analysis and conversations with responsible officials at the Division of Water Quality Control, surface discharge seems to be quite acceptable. The cost considerations add to the desirability of surface discharge where the waste fluid is of high quality.

Two additional considerations should be noted. First, the geothermal well fluid may not be identical to the spring fluid. The geologist concludes, however, that it is very likely to be similar because the formation from which the fluid will be obtained does not appear to contain soluble unconsolidated sediments (Dick, pers. comm., 1981). Secondly, some of the physical characteristics that are required by the Division of Water Quality Control are currently unknown, even for the springs. These parameters would have to be identified for a more certain conclusion.

Air Pollution Permit. Authorized to achieve and maintain the air quality in the state (C.R.S. 1973, 25-7-108), the Air Pollution Control Commission has established mandatory air quality standards. Either an emissions permit or a waiver should be obtained prior to drilling a geothermal well. If it can be demonstrated that any hydrogen sulfide emission would be insignificant, the Commission may award a waiver. In addition to a $40 filing fee for the permit, the applicant must pay for an expert opinion on the estimated emission level. This information must be reviewed by the engineering staff before the permit can be issued by the Division. The process requires approximately 20-90 days, depending upon the scope of the geothermal development. Emission measurements must be taken periodically (Coe and Forman, 1980).

Local Permits

Chaffee County Permits. To construct any buildings (such as a pump house) associated with geothermal systems in Chaffee County, a Special Use Permit should be obtained from the County Administrator. Where a new utility corridor is proposed, the proposal must be brought before the County Planning Commission for review. They then make a recommendation for approval or denial to the Board of County Commissioners, which makes a final decision. The time required for the process varies depending upon the submittal date. The Planning Commission meets monthly on the last Tuesday of the month. An application must be submitted at least 10 days prior to the meeting. The County Commissioners meet each Monday. Therefore, the minimum time to obtain a permit would be from 16 days to 45 days, barring any extreme difficulties.

A building permit must also be obtained prior to beginning construction by filing an application with the County Building Department. The plans and specifications will be reviewed by the Building Inspector to assure that they conform to the Uniform Building Code, a process generally requiring about two to four days. Electrical and plumbing facilities require separate permits. Although plumbing fees are set at $10.00 plus $1.00 per fixture, the fees for buildings vary with the valuation.

The proposed geothermal pipeline route is along County road rights-of way for varying distances as shown in Figure 21. A pipeline developer would have to file an application with the County Administrator to use the right-of-way and sign an agreement to indemnify the County for any rehabilitation work that might be required. If a road cut is made in a paved road, a fee of $100 is charged for replacement of the paving. Although a bond is not always required, it may be and probably would be required for a large project.

To install an individual waste disposal system, the developer is required to consult with the County Sanitarian to assure that the system conforms to County as well as State regulations. Similarly, if culverts will be installed, the County may require they meet County specifications.

City of Salida Permits. The City's legal, regulatory and procedural requirements for the construction of a geothermal system were investigated. In Salida, the primary considerations relative to geothermal development are protection of the geothermal fluid that is used in the municipal swimming pool and the repair of any damage that might occur. For example, no interference with the flow of water supplying the pool would be tolerated. And, if the city streets are to be used or crossed by a pipeline, the geothermal developer would have to pay for the replacement of paving. The actual paving work could be performed by the City (at $1.00 per square foot at the current rate) or by a private contractor.

No special city permits are required at this time for retrofitting a heating system or for constructing a geothermal pipeline. Prior to cutting a street, however, the developer should clear it with the City (Anthony E. Gentile, pers. comm., 1981).

Financing

Financing a major geothermal system is not a small matter. The exploration, drilling and construction costs are significant. Even though the returns from a given project may cover the capital plus operating and maintenance costs at a lower cost for energy over a period of years, obtaining the front-end financing is often very difficult if not impossible. There are many competing uses for capital; geothermal is often considered highly risky; and the institutional structure for financing these projects is not yet well established.

In the case of this prospective Salida project, Chaffee Geothermal, Ltd., the developer, has established its preferred method of financing exploration and production. Because of the tax incentives, it prefers and expects to be able to attract risk capital from private investors on a limited partnership basis. They have, in fact, been successful in obtaining such participation for other prospects. In such a situation, the payback period must be relatively short, probably four years or less, and the rate of return on investment relatively high, perhaps 30 percent or more.

The distribution system would probably need to be developed by a different party or, at least, as a separate entity. The payback for a distribution system, not considered to be as risky a venture, could be longer and the rate of return less than that for an exploration program. Two options for the distribution system financing are possible: public development or private development. Several government financing programs have been available off and on for assisting with financing of a geothermal system. Some of these are briefly described below:

DOE User-Coupled Reservoir Confirmation Drilling Program. This DOE program shared the cost of geothermal exploration for direct heat applications. The Program absorbed most of the risk of an unsuccessful well by paying from 20 percent of a completely successful project to 90 percent of the cost of a completely unsuccessful project.

Program Research and Development Announcement (PRDA). This cost-sharing program was also made available by DOE from time to time to conduct economic and engineering feasibility studies. The awards were based on competitive proposals but generally were directed toward geothermal uses that had not previously been studied.

DOE Geothermal Loan Guaranty Program. Still another DOE program was the Geothermal Loan Guaranty Program. The program guaranteed 100 percent of a loan for up to 75 percent of the project cost for a period of time up to 30 years.

DOE Appropriate Technology Small Grants Program. Another DOE funding program was the Appropriate Technology Small Grants Program. This Program provided grants of up to $50,000 for studies, models, testing, and hardware development.

These federal financing programs have, however, all been suspended. Because the current federal administration has announced its desire to let the market assume the responsibility for energy development, a resumption of these programs or initiation of similar ones is unlikely in the near future. No known funding programs are available at the state or local levels. Given the magnitude of cutbacks in federal assistance, these jurisdictions will be hard-pressed to meet existing responsibilities and in no position to assume new ones.

Furthermore, the scope of this study is limited to several key users that would contract with the distributor to buy energy. It does not include generally-available energy as would be provided by a public utility. Were the City or some other public entity to contract for a portion of the energy, their system could be financed in any way they chose and could arrange. But that is not relevant to this study. For the aspects of the system being analyzed in this study, therefore, private financing is much more realistic and appropriate than public financing. This sort of venture could be financed by a private firm that itself possesses sufficient surplus capital or equity. Alternatively, capital must be raised in some manner such as through the acquisition of venture capital in a partnership arrangement. It is presumed that, once the reservoir is proven, the investment would be perceived as sufficiently risk-free to first, attract participants and second, avoid the necessity of as high a rate of return and short a payback period as for the reservoir confirmation work.

Tax advantages available to the private geothermal developer in the form of investment tax credits could stimulate sufficient capital to finance the transmission and distribution lines. If the developer sells heat and is not a publicly-regulated utility, he is eligible for the full tax credit. The participants in such a venture must, however, have an actual operating role in the business (Grattan and Hansen, 1981).

The conclusion regarding financing for this project is, therefore, that the entire geothermal system addressed in this study would be privately financed. For the resource development, the payback period and rate of return would vary from those of the transmission and distribution system. These assumptions were used in the economic analysis.

Geothermal Development Time Schedule

The purpose of this section is to present the probable schedule and coordination requirements between the engineering and non-engineering components of the Salida Geothermal Project. Figures 33 and 34 are time-line flow charts of engineering, institutional/environmental, and business factors to be considered by the geothermal producer and geothermal distributor. The details of each step are discussed in the preceding sections of this report; here, it is sufficient to show only how each step affects others.

Several events precede the 1982 starting date in the diagram. It is assumed that geothermal leases have been obtained and that discussions have taken place with potential users. In addition, the research contained in this report serves as a preliminary resource assessment, engineering design, institutional report, environmental analysis, and economic evaluation.

The well producer would form a limited partnership at the start of 1982. It would then immediately obtain liability insurance and exploration well permits. During the remainder of 1982, surveys and drilling would determine whether a commercially-developable resource exists. Assuming a favorable outcome, the producer could proceed with a final design of the well and collection system. The producer could also obtain well permits for three production wells and could perform an environmental analysis. The extent of the environmental report would depend on the ownership status of the drilling sites. On federal or state lands, a comprehensive impact analysis would be required. It is assumed here that no well sites will be on federal public lands.

The energy distribution corporation would be formed after the energy producer has made the decision to develop the geothermal resource. Once its business operation is in place, several steps

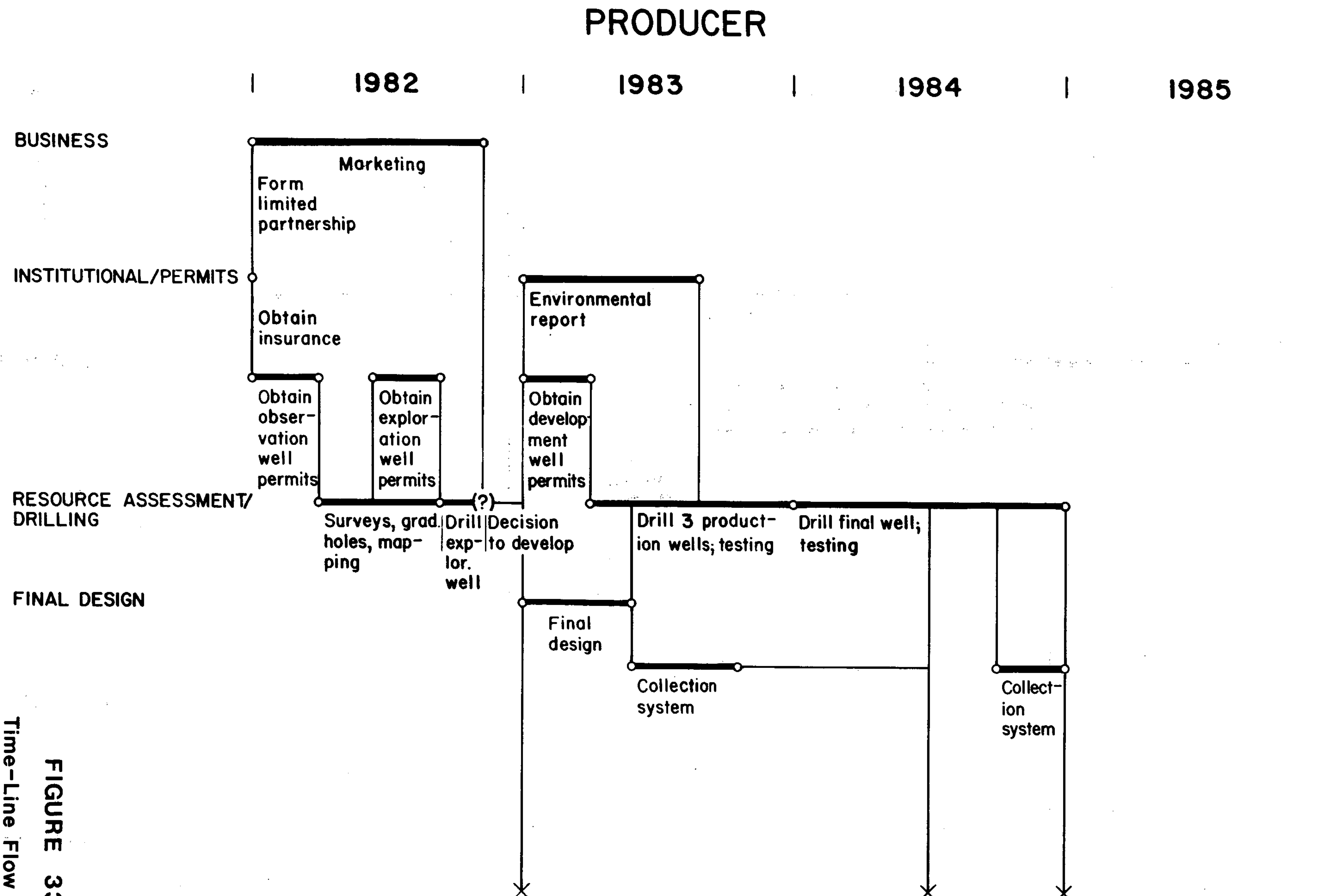

FIGURE 33
Time-Line Flow Cha

DISTRIBUTOR

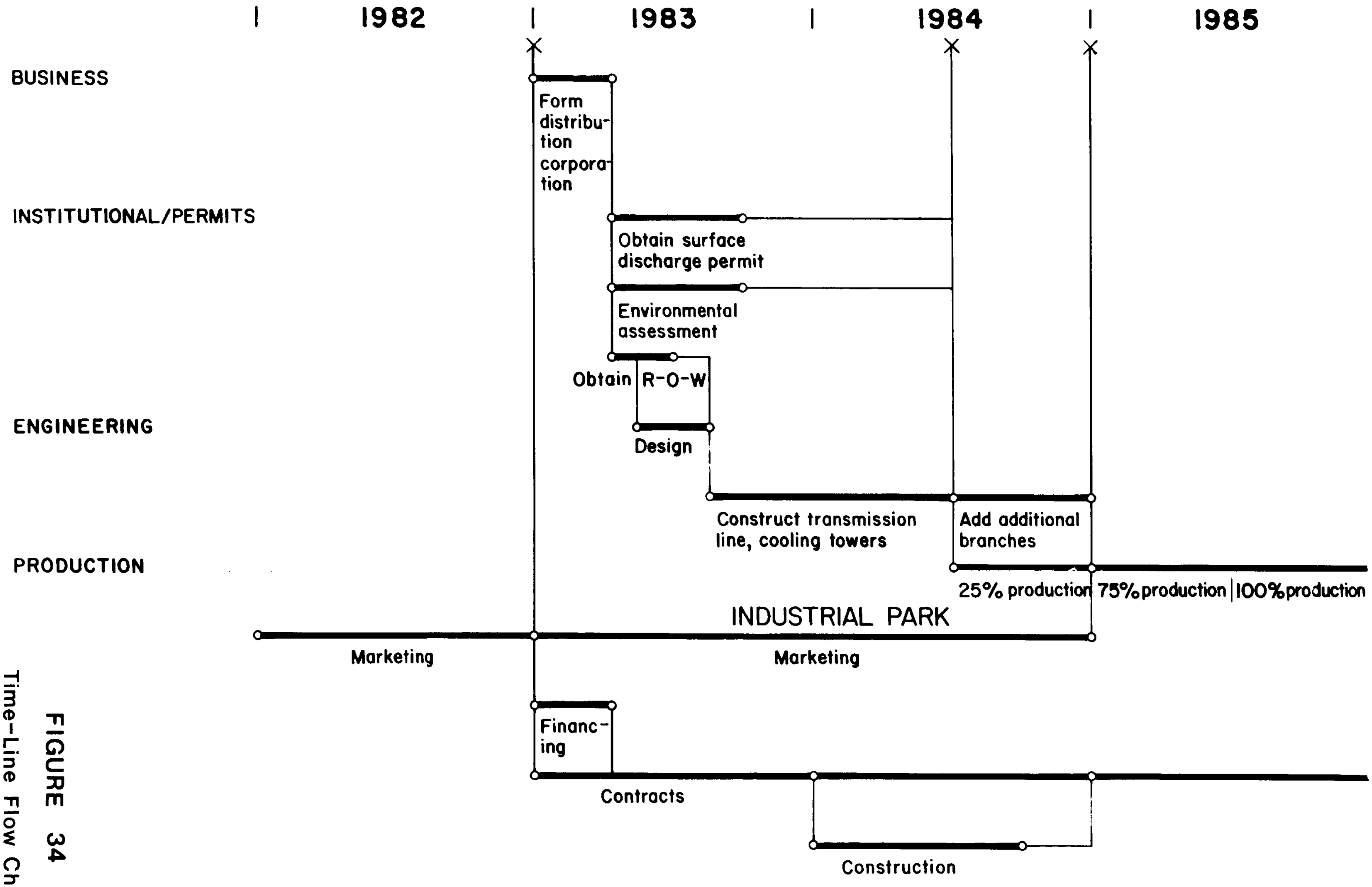

FIGURE 34
Time-Line Flow Chart

could take place simultaneously. The permits for surface discharge would be obtained while the associated environmental analysis is being performed. Meanwhile, the rights-of-way (ROW) could be obtained and engineering design would begin as soon as the pipeline path is known. Construction of the transmission line and cooling towers would begin by mid-to-late 1983 to allow partial production in mid-1984. Additional branches of the transmission line, such as to serve the industrial park, could be put in place in late 1984.

Serious planning for the industrial park could also begin right after the well producer's final decision to develop. If financing is obtained and major contracts are in place, construction would occur during 1984. Marketing would be considered an on-going process through 1985 to realize the well producer's goal of 100 percent production in 1986.

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Appendix A
Cash Flow Analyses

Base Case Net Cash Flow Analysis - Producer

YEAR	YR #	G/T SALES	ROYALTIES	EXPLORATION	IDC	DEPREC	ELECTRIC	O&M	PROPERTY TAX	TAXABLE INCOME	DEPLETION ALLOWANCE	EXPLORATION RECAPTURE	NET TAXABLE INCOME	FED & STATE TAX	NET PROFIT	ADD BACK	INVESTMENT TAX CREDIT	NET CASH FLOW	PRESENT VALUE @ 31% DISC
1982	1	0	0	317190		17275	0	131345	2091	-467901			-467901	-233951	-233951	334465		100515	76828
1983	2	0	0		657019	76481	0	112870	8284	-854654			-854654	-427327	-427327	733500		306173	178873
1984	3	153202	15320		240875	117779	16213	93091	10534	-340611			-340611	-170305	-170305	358654	145003	333352	148858
1985	4	1001940	100194			123041	109921	83705	10534	574544	135262	135262	574544	287272	287272	123041		410314	140047
1986	5	1442793	144279			121803	161218	105292	10534	899667	194777	181928	886818	443409	443409	134651		578061	150807
1987	6	1558217	155822			97617	177340	113715	10534	1003189	210359		792830	396415	396415	307976		704391	140459
1988	7	1682874	168287			26015	195074	122813	10534	1160151	227188		932963	466482	466482	253203		719685	109690
1989	8	1817504	181750				214581	132638	10534	1278001	245363		1032638	516319	516319	245363		761682	88734
1990	9	1962904	196290				236039	143249	10534	1376792	264992		1111800	555900	555900	264992		820892	73095
1991	10	2100308	210031				262004	153276	10534	1464463	283542		1180922	590461	590461	283542		874002	59485
1992	11	2247329	224733				290824	164005	10534	1557233	303389		1253843	626922	626922	303389		930311	48396
1993	12	2404642	240464				322815	175486	10534	1655344	324627		1330717	665358	665358	324627		989985	39364
1994	13	2572967	257297				358324	187770	10534	1759042	347351		1411692	705846	705846	347351		1053196	32009
1995	14	2753075	275307				397740	200914	10534	1868580	371665		1496915	748457	748457	371665		1120122	26021
1996	15	2918259	291826				421604	212968	10534	1981327	393965		1587362	793681	793681	393965		1187646	21088
1997	16	3093355	309335				446901	225746	10534	2100838	417603		1683235	841618	841618	417603		1259221	17090
1998	17	3278956	327896				473715	239291	10534	2227521	442659		1784862	892431	892431	442659		1335090	13849
1999	18	3475693	347569				502137	253649	10534	2361804	469219		1892585	946293	946293	469219		1415511	11223
2000	19	3684235	368424				532266	268868	10534	2504144	497372		2006772	1003386	1003386	497372		1500758	9095
2001	20	3905289	390529				564202	285000	10534	2655025	527214		2127811	1063905	1063905	527214		1591119	7370
2002	21	4139606	413961				598054	302100	10534	2814958	558847		2256111	1128056	1128056	558847		1686903	5973
2003	22	4387983	438798				633937	320226	10534	2984488	592378		2392110	1196055	1196055	592378		1788433	4840
2004	23	4651262	465126				671973	339439	10534	3154189	627920		2536269	1268134	1268134	627920		1896055	3922
2005	24	4930338	493034				712292	359806	10534	3354673	665596		2689077	1344539	1344539	665596		2010134	3178
2006	25	5226158	522616				755029	381394	10534	3556585	705531		2851054	1425527	1425527	705531		2131058	2575
2007	26	5539727	553973				800331	404278	10584	3770612	747863		3022749	1511374	1511374	747863		2259238	2087
2008	27	5872111	587211				848351	428534	10534	3997481	792735		3204746	1602373	1602373	792735		2395108	1691
2009	28	6224438	622444				899252	454246	10534	4237962	840299		3397663	1698831	1698831	840299		2539130	1370
2010	29	6597904	659790				953207	481501	10534	4492872	890717		3602155	1801077	1801077	890717		2691794	1110
2011	30	6993778	699378				1010399	510391	10534	4763076	944160		3818916	1909458	1909458	944160		2853618	900

TOTAL 30-YEAR CASH FLOW 40243497 1420026

INVESTMENT (PRES VAL) 1420258

Table

Base Case Net Cash Flow Analysis - Distributor

YEAR	YEAR #	G/T SALES	G/T PURCH	DEPREC	ELECTRIC	O&A	INTEREST	PROP TAX	LOSS FWD	TAXABLE INCOME	FED & STATE TAXES	NET PROFIT	PRINC PYMT	ADD BACK	INVESTMENT TAX CREDIT	NET CASH FLOW	PRESENT VALUE I=17%
1983	1	0	0	91633		89108		10901		-191642	0	-191642	0	91633		-100009	-85478
1984	2	228899	153202	434033	5481	126900	179406	47375		-717498	0	-717498	85431	434033		-368896	-269484
1985	3	1496998	1001940	567755	37161	138321	167446	47375		-463000	0	-463000	85431	567755		19325	12066
1986	4	2155677	1442793	547780	54503	149387	155485	47375		-241645	0	-241645	85431	547780		220703	117778
1987	5	2328132	1558217	547780	59953	161338	143525	47375		-190055	0	-190055	85431	547780		272293	124196
1988	6	2514382	1682874	419494	65949	174245	131564	47375		-7119	0	-7119	85431	419494		326944	127456
1989	7	2715533	1817504		72543	188184	119604	47375	470322	0	0	0	85431	470322		384891	128244
1990	8	2932775	1962904		79798	203239	107644	47375	531816	0	0	0	85431	531816		446385	127122
1991	9	3138069	2100308		88576	217466	95683	47375	588662	0	0	0	85431	588662		503231	122488
1992	10	3357734	2247329		98319	232688	83723	47375	220158	428142	218352	209790	85431	220158	218352	562869	117098
1993	11	3592776	2404642		109134	248976	71762	47375		710886	362552	348334	85431	0	362552	625455	111212
1994	12	3844270	2572967		121139	266405	59802	47375		776582	396057	380525	85431		384231	679326	103240
1995	13	4113369	2753075		134464	285053	47842	47375		845561	431236	414325	85431			328894	42721
1996	14	4360171	2918259		142532	302156	35881	47375		913968	466123	447844	85431			362413	40235
1997	15	4621781	3093355		151084	320286	23921	47375		985761	502738	483023	85431			397592	37727
1998	16	4899088	3278956		160149	339503	11960	47375		1061145	541184	519961	85431			434530	35241
1999	17	5193034	3475693		169758	359873		47375		1140334	581571	558764				558764	38732
2000	18	5504616	3684235		179943	381465		47375		1211597	617914	593683				593683	35173
2001	19	5834892	3905289		190740	404353		47375		1287135	656439	630696				630696	31937
2002	20	6184986	4139606		202184	428614		47375		1367206	697275	669931				669931	28994
2003	21	6556085	4387963		214315	454331		47375		1452081	740561	711520				711520	26320
2004	22	6949450	4651262		227174	481591		47375		1542048	786445	755604				755604	23889
2005	23	7366417	4930338		240805	510487		47375		1637414	835081	802333				802333	21681
2006	24	7808402	5226158		255253	541116		47375		1738501	886635	851865				851865	19675
2007	25	8276907	5539727		270568	573583		47375		1845653	941283	904370				904370	17853
2008	26	8773521	5872111		286802	607998		47375		1959235	999210	960025				960025	16198
2009	27	9299932	6224438		304010	644478		47375		2079632	1060612	1019020				1019020	14695
2010	28	9857928	6597904		322251	683146		47375		2207252	1125699	1081554				1081554	13330
2011	29	10449404	6993778		341586	724135		47375		2342530	1194690	1147840				1147840	12092
2012	30	11076368	7413405		362081	767583		47375		2485924	1267821	1218103				1218103	10968

TOTAL 30-YEAR CASH FLOW 17001252 1203398

INVESTMENT (PRES VAL) 1203493

Table

Alternate 1 Net Cash Flow Analysis - Producer

YEAR	YR #	G/T SALES	ROYALTIES	EXPLORATION	IDC	DEPREC	ELECTRIC	O&A	PROPERTY TAX	TAXABLE INCOME	DEPLETION ALLOWANCE	EXPLORATION RECAPTURE	NET TAXABLE INCOME	FED & STATE TAX	NET PROFIT	ADD BACK	INVESTMENT TAX CREDIT	NET CASH FLOW	PRESENT VALUE @ 20% DISC
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1982	1	0	0	317190		17275	0	131345	2091	-467901			-467901	-233951	-233951	334465		100515	83762
1983	2	0	0		220987	42385	0	112870	4156	-380398			-380398	-190199	-190199	263372		73173	50815
1984	3	73817	7382		240875	67772	16213	93091	6406	-357922			-357922	-178961	-178961	308647	88176	217862	126078
1985	4	281611	28161		525108	123918	73281	69920	10534	-549312		0	-549312	-274656	-274656	649026	67516	441887	213101
1986	5	434485	43449			163189	80609	75513	10534	61192	30596	30596	61192	30596	30596	163189		193785	77878
1987	6	656942	65694			117399	133005	97634	10534	232676	88687	88687	232676	116338	116338	117399		233737	78278
1988	7	912211	91221			69225	195074	122813	10534	423343	123148	123148	423343	211672	211672	69225		280897	78393
1989	8	1094653	109465			21605	214581	132638	10534	605829	147778	74759	532809	266405	266405	94625		361029	83964
1990	9	1182225	118223				236040	143249	10534	674180	159600		514580	257290	257290	159600		416890	80796
1991	10	1264981	126498				262004	153277	10534	712668	170772		541896	270948	270948	170772		441720	71340
1992	11	1353529	135353				290824	164006	10534	752812	182726		570086	285043	285043	182726		467769	62956
1993	12	1448277	144828				322815	175486	10534	794614	195517		599096	299548	299548	195517		495065	55525
1994	13	1549656	154966				358325	187770	10534	838061	209204		628858	314429	314429	209204		523632	48941
1995	14	1658132	165813				397740	200914	10534	883130	223848		659282	329641	329641	223848		553489	43109
1996	15	1757620	175762				421605	212969	10534	936750	237279		699471	349736	349736	237279		587014	38100
1997	16	1863077	186308				446901	225747	10534	993587	251515		742071	371036	371036	251515		622551	33672
1998	17	1974861	197486				473715	239292	10534	1053834	266606		787228	393614	393614	266606		660220	29758
1999	18	2093353	209335				502138	253650	10534	1117696	282603		835094	417547	417547	282603		700149	26298
2000	19	2218954	221895				532266	268869	10534	1185390	299559		885831	442916	442916	299559		742474	23240
2001	20	2352092	235209				564202	[illegible]	10534	1257145	317532		939613	469807	469807	317532		787339	20537
2002	21	2493217	249322				598054	302101	10534	1333206	334584		996622	498311	498311	336564		834895	18148
2003	22	2642810	264281				633938	320227	10534	1413831	356779		1057051	528526	528526	356779		885305	16036
2004	23	2801379	280138				671974	339440	10534	1499293	378186		1121106	560553	560553	378186		938739	14170
2005	24	2969461	296946				712292	359807	10534	1589882	400677		1189005	594502	594502	400877		995380	12521
2006	25	3147629	314763				755030	381395	10534	1685907	424930		1260977	630489	630489	424930		1055419	11064
2007	26	3336487	333649				800332	404279	10534	1787694	450426		1337268	668634	668634	450426		1119060	9776
2008	27	3536676	353668				848352	428536	10534	1895587	477451		1418136	709068	709068	477451		1186519	8637
2009	28	3748877	374888				899253	454248	10534	2009954	506098		1503856	751928	751928	506098		1258026	7632
2010	29	3973809	397381				953208	481503	10534	2131184	536464		1594720	797360	797360	536464		1333824	6743
2011	30	4212238	421224				1010400	510393	10534	2259687	568652		1691035	845517	845517	568652		1414169	5958

TOTAL 30-YEAR SAVINGS 19922536 1437226

INVESTMENT (PRES VAL) 1436779

Table

Alternate 1 Net Cash Flow Analysis - Distributor

YEAR	YEAR #	G/T SALES	G/T PURCH	DEPREC	ELECTRIC	O&A	INTEREST	PROP TAX	LOSS FWD	TAXABLE INCOME	FED & STATE TAXES	NET PROFIT	PRINC PYMT	ADD BACK	INVESTMENT TAX CREDIT	NET CASH FLOW	PRESENT VALUE @ 15% DISC
1983	1	0	0	91633		89108		10901		-191642	0	-191642	0	91633		-100009	-86964
1984	2	137024	73817	434033	5481	126900	179406	47375		-729988	0	-729988	85431	434033		-381386	-288383
1985	3	522746	281611	567755	37161	138321	167446	47375		-716923	0	-716923	85431	567755		-234599	-154253
1986	4	806522	434485	547780	54503	149387	155485	47375		-582493	0	-582493	85431	547780		-120144	-68693
1987	5	1219461	656942	547780	59953	161338	143525	47375		-397451	0	-397451	85431	547780		64897	32265
1988	6	1693309	912211	419494	65949	174245	131564	47375		-57529	0	-57529	85431	419494		276534	119553
1989		2031970	1094653		72543	188184	119604	47375	509611	0	0	0	85431	509611		424180	159465
1990	8	2194528	1182225		79798	203239	107644	47375	574248	0	0	0	85431	574248	0	488817	159795
1991	9	2348145	1264981		88576	217466	95683	47375	634065	0	0	0	85431	634065	0	548634	155956
1992	10	2512515	1353529		98319	232688	83723	47375	696881	0	0	0	85431	696881	0	611450	151141
1993	11	2688391	1448277		109134	248976	71762	47375	260141	502726	256390	246336	85431	260141	256390	677436	145610
1994	12	2876579	1549656		121139	266405	59802	47375		832202	424423	407779	85431	0	424423	746771	139577
1995	13	3077939	1658132		134464	285053	47842	47375		905074	461588	443486	85431	0	284322	642377	104404
1996	14	3262615	1757620		142532	302156	35881	47375		977051	498296	478755	85431	0		393324	55588
1997	15	3458372	1863077		151084	320286	23921	47375		1052630	536841	515789	85431	0		430358	52889
1998	16	3665875	1974861		160149	339503	11960	47375		1132026	577333	554693	85431	0		469262	50148
1999	17	3885827	2093353		169758	359873		47375		1215468	619889	595579				595579	55345
2000	18	4118977	2218954		179943	381465		47375		1291239	658532	632707				632707	51126
2001	19	4366115	2352092		190740	404353		47375		1371556	699493	672062				672062	47223
2002	20	4628082	2493217		202184	428614		47375		1456692	742913	713779				713779	43612
2003	21	4905767	2642810		214315	454331		47375		1546936	788937	757998				757998	40273
2004	22	5200113	2801379		227174	481591		47375		1642594	837723	804871				804871	37186
2005	23	5512120	2969461		240805	510487		47375		1743992	889436	854556				854556	34331
2006	24	5842847	3147629		255253	541116		47375		1851474	944252	907222				907222	31693
2007	25	6193418	3336487		270568	573583		47375		1965405	1002357	963049				963049	29255
2008	26	6565023	3536676		286802	607998		47375		2086172	1063948	1022224				1022224	27002
2009	27	6958925	3748877		304010	644478		47375		2214185	1129234	1084951				1084951	24921
2010	28	7376460	3973809		322251	683146		47375		2349879	1198438	1151441				1151441	22999
2011	29	7819048	4212238		341586	724135		47375		2493714	1271794	1221920				1221920	21223
2012	30	8288191	4464972		362081	767583		47375		2646179	1349551	1296628				1296628	19583

TOTAL 30-YEAR CASH FLOW 17616889 1213871

INVESTMENT (PRES VAL) 1213800

Table

Alternate 2 Net Cash Flow Analysis - Producer

YEAR	YEAR #	G/T SALES	ROYALTIES	EXPLORATION	IDC	DEPREC	ELECTRICITY	O&A	PROPERTY TAX	TAXABLE INCOME	DEPLETION ALLOWANCE	EXPLORATION RECAPTURE	NET TAXABLE INCOME	FED & STATE TAX	NET PROFIT	ADD BACK	INVESTMENT TAX CREDIT	NET CASH FLOW	PRESENT VALUE I=39%
1982	1	0	0	317190	0	13073	0	131345	781	-462389	0	0	-462389	-231195	-231195	330263		99069	71119
1983	2	0	0		441973	44110	0	112870	4686	-603639	0	0	-603639	-301820	-301820	486083		184264	94959
1984	3	172149	17215		240875	68465	8107	91011	6248	-259772	0	0	-259772	-129886	-129886	309340	85999	265453	98205
1985	4	1125857	112586			73145	54961	70101	6248	808817	151991	151991	808817	404408	404408	73145		477553	126829
1986	5	1621235	162123			72239	80609	85700	6248	1214315	218867	165199	1160648	580324	580324	125906		706230	134645
1987	6	1750933	175093			53936	88670	92556	6248	1334430	236376		1098054	549027	549027	290312		839339	114876
1988	7	1891008	189101			19026	97537	99960	6248	1479136	255286		1223850	611925	611925	274312		886237	87075
1989	8	2042289	204229				107291	107957	6248	1616564	275709		1340855	670427	670427	275709		946136	66734
1990	9	2205672	220567				118020	116594	6248	1744243	297766		1446477	723239	723239	297766		1021004	51697
1991	10	2360069	236007				131002	124755	6248	1862057	318609		1543447	771724	771724	318609		1090333	39632
1992	11	2525273	252527				145412	133488	6248	1987598	340912		1646686	823343	823343	340912		1164255	30380
1993	12	2702043	270204				161407	142833	6248	2121350	364776		1756575	878287	878287	364776		1243063	23285
1994	13	2891186	289119				179162	152831	6248	2263826	390310		1873516	936758	936758	390310		1327068	17845
1995	14	3093569	309357				198870	163529	6248	2415565	417632		1997933	998967	998967	417632		1416598	13675
1996	15	3279183	327918				210802	173341	6248	2560874	442690		2118184	1059092	1059092	442690		1501782	10407
1997	16	3475934	347593				223450	183741	6248	2714901	469251		2245650	1122825	1122825	469251		1592076	7920
1998	17	3684490	368449				236857	194766	6248	2878170	497406		2380764	1190382	1190382	497406		1687788	6028
1999	18	3905559	390556				251069	206452	6248	3051235	527250		2523984	1261992	1261992	527250		1789243	4587
2000	19	4139893	413989				266133	218839	6248	3234684	558886		2675798	1337899	1337899	558886		1896785	3491
2001	20	4388286	438829				282101	231969	6248	3429140	592419		2836721	1418361	1418361	592419		2010779	2657
2002	21	4651583	465158				299027	245887	6248	3635263	627964		3007299	1503650	1503650	627964		2131613	2022
2003	22	4930678	493068				316968	260640	6248	3853754	665642		3188112	1594056	1594056	665642		2259698	1539
2004	23	5226519	522652				335987	276279	6248	4085354	705580		3379774	1689887	1689887	705580		2395467	1171
2005	24	5540110	554011				356146	292856	6248	4330850	747915		3582935	1791467	1791467	747915		2539382	891
2006	25	5872517	587252				377515	310427	6248	4591076	792790		3798286	1899143	1899143	792790		2691933	678
2007	26	6224868	622487				400165	329052	6248	4866915	840357		4026558	2013279	2013279	840357		2853636	516
2008	27	6598360	659836				424175	348796	6248	5159305	890779		4268526	2134263	2134263	890779		3025042	393
2009	28	6994261	699426				449626	369723	6248	5469238	944225		4525013	2262506	2262506	944225		3206732	299
2010	29	7413917	741392				476603	391907	6248	5797767	1000879		4796888	2398444	2398444	1000879		3399323	227
2011	30	7858752	785875				505200	415421	6248	6146008	1060932		5085077	2542538	2542538	1060932		3603470	173

TOTAL 30-YEAR CASH FLOW 50251350 1013956

INVESTMENT (PRES VAL) 1013733

Table

Alternate 2 Net Cash Flow Analysis - Distributor

YEAR	YEAR #	G/T SALES	G/T PURCH	DEPREC	ELECTRICITY	O&M	INTEREST ON DEBT	PROPERTY TAX	LOSS FWD	TAXABLE INCOME	FED & STATE TAXES	NET PROFIT	PRINC PYMT	ADD BACK	INVESTMENT TAX CREDIT	NET CASH FLOW	PRESENT VALUE I=20%
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
1983	1	0	0	136101		89108		16479		-241688	0	-241688	0	136101		-105587	-87989
1984	2	273459	172149	644666	5482	139462	232461	70366		-991127	0	-991127	193717	644666		-540178	-375124
1985	3	1788424	1125857	843283	37165	152014	209215	70366		-649475	0	-649475	193717	843283		91	52
1986	4	2575331	1621235	813613	54503	164175	185969	70366		-334529	0	-334529	193717	813613		285367	137619
1987	5	2781357	1750933	813613	59953	177309	162723	70366		-253539	0	-253539	193717	813613		366357	147230
1988	6	3003866	1891008	623071	65949	191493	139477	70366	22503	0	0	0	193717	645574		451857	151326
1989	7	3244175	2042289		72543	206813	116231	70366	735934	0	0	0	193717	735934		542217	151323
1990	8	3503709	2205672		79798	223358	92984	70366	831532	0	0	0	193717	831532		637815	148335
1991	9	3748969	2360069		88576	238993	69738	70366	878921	42307	21576	20730	193717	878921	21576	727511	140996
1992	10	4011397	2525273		98319	255722	46492	70366		1015224	517764	497460	193717	0	517764	821507	132678
1993	11	4292195	2702043		109134	273623	23246	70366		1113783	568029	545754	193717	0	568029	920066	123830
1994	12	4592648	2891186		121139	292777		70366		1217181	620763	596419		0	326139	922558	103471
1995	13	4914134	3093569		134464	313271		70366		1302464	664257	638207				638207	59649
1996	14	5208982	3279183		142532	332067		70366		1384834	706265	678569				678569	52851
1997	15	5521521	3475934		151084	351991		70366		1472146	750794	721352				721352	46820
1998	16	5852812	3684490		160149	373111		70366		1564697	797995	766701				766701	41469
1999	17	6203981	3905559		169758	395497		70366		1662801	848028	814772				814772	36724
2000	18	6576219	4139893		179943	419227		70366		1766790	901063	865727				865727	32518
2001	19	6970793	4388286		190740	444381		70366		1877020	957280	919740				919740	28789
2002	20	7389040	4651583		202184	471044		70366		1993863	1016870	976993				976993	25484
2003	21	7832383	4930678		214315	499306		70366		2117717	1080036	1037681				1037681	22556
2004	22	8302325	5226519		22717	529265		70366		2249002	1146991	1102011				1102011	19962
2005	23	8800465	5540110		240805	561020		70366		2388164	1217964	1170200				1170200	17664
2006	24	9328493	5872517		255253	594682		70366		2535676	1293195	1242481				1242481	15629
2007	25	9888202	6224868		270568	630363		70366		2692038	1372939	1319099				1319099	13828
2008	26	10481495	6598360		286802	668184		70366		2857782	1457469	1400313				1400313	12232
2009	27	11110384	6994261		304010	708275		70366		3033471	1547070	1486401				1486401	10820
2010	28	11777007	7413917		322251	750772		70366		3219701	1642048	1577654				1577654	9571
2011	29	12483628	7858752		341586	795818		70366		3417106	1742724	1674382				1674382	8464
2012	30	13232645	8330277		362081	843567		70366		3626354	1849440	1776913				1776913	7486

TOTAL 30-YEAR CASH FLOW 25198775 1236265

INVESTMENT (PRES VAL) 1236253

Table

Alternate 3 Net Cash Flow Analysis - Producer

YEAR	YR #	G/T SALES	ROYALTIES	EXPLORATION	IDC	DEPREC	ELECTRIC	O&A	PROP TAXES	TAXABLE INCOME	DEPLETION ALLOWANCE	EXPLORATION RECAPTURE	NET TAXABLE INCOME	FED & STATE TAXES	NET PROFIT	ADD BACK	INVESTMENT TAX CREDIT	NET CASH FLOW	PRESENT VALUE I=16%
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
1982	1	0	0	317190	0	12374	0	131345	1499	-462408	0	0	-462408	-231204	-231204	329564		98360	84574
1983	2	0	0		657019	53263	0	112870	5750	-828902	0	0	-828902	-414451	-414451	710282		295831	218718
1984	3	55392	5539		240875	81584	8106	92315	7295	-380322	0	0	-380322	-190161	-190161	322459	100413	232711	147937
1985	4	362265	36227			85197	54960	78628	7295	99959	48906	48906	99959	49979	49979	85197		135176	73889
1986	5	521662	52166			84347	80609	97979	7295	199266	70424	70424	199266	99633	99633	84347		183980	86471
1987	6	563395	56339			67024	88670	105817	7295	238249	76058	76058	238249	119125	119125	67024		186149	75228
1988	7	608467	60847			17862	97537	114283	7295	310643	82143	82143	310643	155322	155322	17862		173184	60180
1989	8	657144	65714				107291	123425	7295	353419	88714	39659	304363	152181	152181	49056		201237	60127
1990	9	709715	70972				118020	133299	7295	380130	9[illegible]12		284318	142159	142159	95812		237971	61137
1991	10	759395	75940				131002	142630	7295	402529	102518		300010	150005	150005	102518		252524	55783
1992	11	812553	81255				145412	152614	7295	425976	109695		316282	158141	158141	109695		267836	50873
1993	12	869432	86943				161407	163297	7295	450489	117373		333116	166558	166558	117373		283931	46372
1994	13	930292	93029				179162	174728	7295	476077	125589		350488	175244	175244	125589		300833	42246
1995	14	995412	99541				198870	186959	7295	502747	134381		368366	184183	184183	134381		318564	38465
1996	15	1055137	105514				210802	198177	7295	533250	142444		390906	195453	195453	142444		337897	35082
1997	16	1118445	111845				223450	210067	7295	565788	150990		414798	207399	207399	150990		358389	31995
1998	17	1185552	118555				236857	222671	7295	600173	160050		440124	220062	220062	160050		380111	29178
1999	18	1256685	125669				251069	236032	7295	636621	169653		466969	233484	233484	169653		403137	26608
2000	19	1332086	133209				266133	250194	7295	675256	179832		495425	247712	247712	179832		427544	24264
2001	20	1412012	141201				282101	265205	7295	716209	190622		525588	262794	262794	190622		453415	22126
2002	21	1496732	149673				299027	281118	7295	759620	202059		557561	278780	278780	202059		480839	20176
2003	22	1586536	158654				316968	297985	7295	805635	214182		591452	295726	295726	214182		509908	18397
2004	23	1681728	168173				335987	315864	7295	854410	227033		627377	313688	313688	227033		540722	16774
2005	24	1782632	178263				356146	334816	7295	906113	240655		665457	332729	332729	240655		573384	15294
2006	25	1889590	188959				377515	354904	7295	960917	255095		705822	352911	352911	255095		608006	13945
2007	26	2002965	200297				400165	376199	7295	1019010	270400		748609	374305	374305	270400		644705	12714
2008	27	2123143	212314				424175	398771	7295	1080568	286624		793964	396982	396982	286624		683606	11592
2009	28	2250532	225053				449626	422697	7295	1145861	303822		842039	421020	421020	303822		724841	10568
2010	29	2385564	238556				476603	448059	7295	1215050	322051		892999	446500	446500	322051		768551	[illegible]
2011	30	2528698	252870				505200	474942	7295	1288391	341374		947017	473508	473508	341374		814883	8784
																	TOTAL 30-YEAR CASH FLOW	11878225	1409137
																	INVESTMENT	(PRES VAL)	1408993

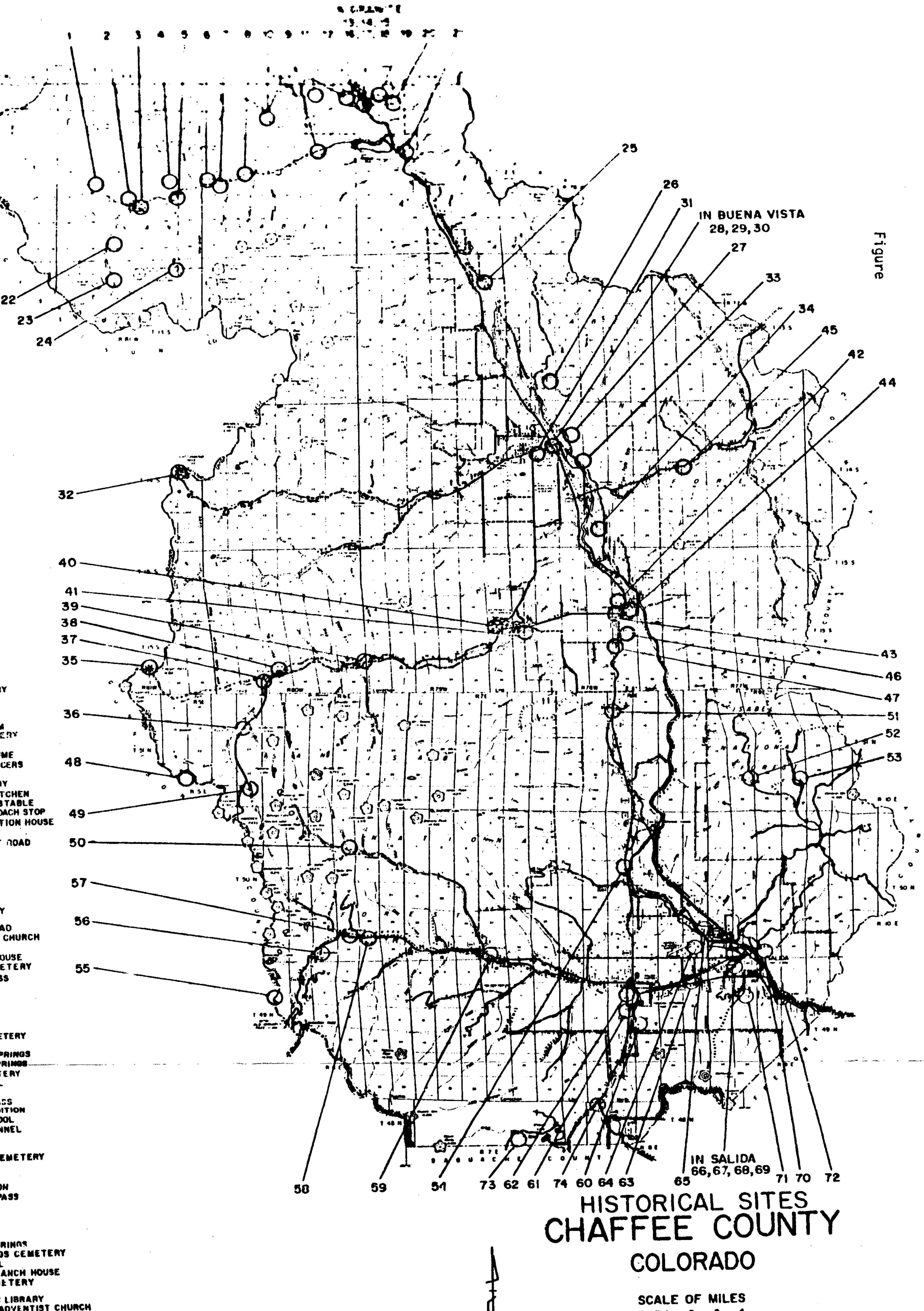
Table

Alternate 3 Net Cash Flow Analysis - Distributor

YEAR	YEAR #	G/T SALES	G/T PURCH	DEPREC	ELECTRIC	O&A	INTEREST	PROP TAX	LOSS FWD	TAXABLE INCOME	FED & STATE TAXES	NET PROFIT	PRINC PYMT	ADD BACK	INVESTMENT TAX CREDIT	NET CASH FLOW	PRESENT VALUE I=13%
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1983	1	0	0	79764		89108		9678		-178559	0	-178550	0	79764		-98786	-87421
1984	2	109266	55392	377814	2740	123486	158943	41239		-650348	0	-650348	75687	377814		-348221	-272708
1985	3	714597	362265	494216	18580	134600	148346	41239		-484649	0	-484649	75687	494216		-66120	-45825
1986	4	1029020	521662	476828	27252	145368	137750	41239		-321078	0	-321078	75687	476828		80063	49104
1987	5	1111342	563395	476828	29977	156997	127154	41239		-284248	0	-284248	75687	476828		116893	63445
1988	6	1200249	608467	365158	32974	169557	116558	41239		-133704	0	-133704	75687	365158		155767	74818
1989	7	1296269	657144		36272	183121	105962	41239	272531	0	0	0	75687	272531		196844	83671
1990	8	1399970	709715		39899	197771	95366	41239	315980	0	0	0	75687	315980		240293	90389
1991	9	1497968	759395		44288	211615	84769	41239	356661	0	0	0	75687	356661		280974	93532
1992	10	1602826	812553		49159	226428	74173	41239	399273	0	0	0	75687	399273		323586	95325
1993	11	1715024	869432		54567	242278	63577	41239	443931	0	0	0	75687	443931	0	368244	96000
1994	12	1835075	930292		60569	259238	52981	41239	264201	226555	115543	111012	75687	264201	115543	415070	95759
1995	13	1963531	995412		67232	277384	42385	41239		539878	275338	264540	75687	0	275338	464191	94771
1996	14	2081343	1055137		71266	294027	31789	41239		587885	299821	288063	75687	0	299821	512198	92542
1997	15	2206223	1118445		75542	311669	21192	41239		638135	325449	312686	75687	0	149423	386422	61785
1998	16	2338597	1185552		80074	330369	10596	41239		690766	352290	338475	75687	0		262788	37184
1999	17	2478912	1256685		84879	350191		41239		745918	380418	365500				365500	45767
2000	18	2627647	1332066		89972	371203		41239		793147	404505	388642				388642	43066
2001	19	2785306	1412012		95370	393475		41239		843210	430037	413173				413173	40517
2002	20	2952424	1496732		101092	417083		41239		896277	457101	439176				439176	38113
2003	21	3129570	1584536		107158	442108		41239		952528	485789	466739				466739	35845
2004	22	3317344	1681728		113587	468635		41239		1012154	516199	495956				495956	33707
2005	23	3516385	1782632		120402	496753		41239		1075358	548433	526925				526925	31692
2006	24	3727368	1889590		127626	526558		41239		1142354	582600	559753				559753	29793
2007	25	3951010	2002965		135284	558152		41239		1213369	618818	594551				594551	28005
2008	2[illegible]	4188070	2123143		143401	591641		41239		1288646	657209	631437				631437	26320
2009	27	4439354	2250532		152005	627139		41239		1368439	697904	670535				670535	24735
2010	28	4705716	2385564		161125	664768		41239		1453020	741040	711980				711980	23242
20[illegible]	29	4988059	2528698		170793	704654		41239		1542675	786764	755911				755911	21837
2012	30	5287342	2680420		181041	746933		41239		1637710	835232	802478				802478	20515

TOTAL 30-YEAR CASH FLOW 11112961 1065524

INVESTMENT (PRES VAL) 1065870



1. TASMANIA MINE
2. WINFIELD CEMETERY
3. WINFIELD
4. SWISS BOY MINE
5. ROCKDALE
6. VICKSBURG MUSEUM
7. VICKSBURG CEMETERY
8. BEAVER CITY
9. CLEAR CREEK FLUME
10. LOST CANYON PLACERS
11. CACHE CREEK
12. GRANITE CEMETERY
13. GRANITE CANDY KITCHEN
14. GRANITE LIVERY STABLE
15. GRANITE STAGE COACH STOP
16. GRANITE R.R STATION HOUSE
17. GRANITE SCHOOL
18. LEADVILLE STAGE ROAD
19. HAWKINSVILLE
20. LOW PASS
21. GEORGIA BAR
22. BANKER MINE
23. HAMILTON
24. CLOYSES LAKE
25. MAYOLL CEMETERY
26. ARRASTRA
27. MIDLAND RAILROAD
28. GRACE EPISCOPAL CHURCH
29. PARK CHAPEL
30. OLD B.V. COURT HOUSE
31. MT OLIVET CEMETERY
32. COTTONWOOD PASS
33. FREEGOLD HILL
34. WESTON HOUSE
35. TINCUP PASS
36. ROMLEY
37. ST ELMO
38. IRON CITY & CEMETERY
39. ALPINE
40. HORTENSE HOT SPRINGS
41. HEYWOOD HOT SPRINGS
42. NATHROP CEMETERY
43. NACHTRIEB MILL
44. NATHROP
45. TROUT CREEK PASS
46. FREMONT EXPEDITION
47. GAS CREEK SCHOOL
48. OLD ALPINE TUNNEL
49. HANCOCK
50. SHAVANO TOWN
51. CENTERVILLE CEMETERY
52. TURRET
53. CALUMET
54. PIKE EXPEDITION
55. OLD MONARCH PASS
56. MONARCH
57. GARFIELD
58. ARBORVILLE
59. MAYSVILLE
60. PONCHA HOT SPRINGS
61. PONCHA SPRINGS CEMETERY
62. JACKSON HOTEL
63. HUTCHINSON RANCH HOUSE
64. FAIRVIEW CEMETERY
65. SMOKESTACK
66. SALIDA PUBLIC LIBRARY
67. SEVENTH DAY ADVENTIST CHURCH
68. CHURCH OF THE ASCENSION
69. FIRST BAPTIST CHURCH
70. RIO GRANDE RAILROAD
71. WOODLAWN CEMETERY
72. CLEORA CEMETERY
73. MARSHALL PASS
74. OTTO MEARS TOLL ROAD

Figure

Map II-28

Source: Chaffee County Comprehensive Plan.

Wildlife Believed to be Found Within Salida Planning Area[1]

Species	Resident Status	Frequency
Mammals:		
Masked Shrew	R	A
Wandering Shrew	R	C
Dwarf Shrew	R	R
Water Shrew	R	R
Merriam's Shrew	R	R
Long-eared Myotis	R	U
Fringed Myotis	R	U
Long-legged Myotis	R	C
Silver-haired Bat	R	C
Big Brown Bat	R	A
Hoary Bat	R	C
Townsend's Big-eared Bat	R	C
Big Free-tailed Bat	R	R
Nuttail's Cottontail	R	A
White-tailed Jackrabbit	R	C
Least Chipmunk	R	C
Colorado Chipmunk	R	C
Richardson's Ground Squirrel	R	U
Golden mouthed Ground Squirrel	R	A
Gunnison's Prairie Dog	R	U
Chickaree	R	C
Valley Pocket Gopher	R	C

R - Resident
M - Migratory

A - Abundant
C - Common
U - Uncommon
R - Rare
E - Endangered

[1]Based upon review by local Wildlife Conservation Officer, Colorado Division of Wildlife, of list initially prepared for Salida-Coaldale Environmental Impact Statement, Colorado Division of Highways.

Source: Wright-McLaughlin, 1978.

Species	Resident Status	Frequency
Northern Pocket Gopher	R	
Nive-backed Pocket Mouse	R	
Silk Pocket Mouse	R	
Ord's Kangaroo Rat	R	
Beaver	R	
Deer Mouse	R	
White-footed Mouse	R	
Brush Mouse	R	
Pinon Mouse	R	
Rock Mouse	R	
Northern Grasshopper Mouse	R	
Mexican Woodrat	R	
Muskrat	R	
Porcupine	R	
Coyote	R	
Red Fox	R	
Grey Fox	R	
Ringtail	R	
Raccoon	R	
Black Bear	R	
Short-tailed Weasel	R	
Long-tailed Weasel	R	
Mink	R	
Badger	R	
Spotted Skunk	R	
Striped Skunk	R	
Hog-nosed Skunk	R	
Mountain Lion	R	
Bobcat	R	
Elk	R	
Mule Deer	R	
Whitetail Deer	R	

Source: Wright-McLaughlin, 1978.

Species	Seasonal Occurrence	Resident Status	Frequency
Passerines and Upland Game Birds:			
Kingbird		R	C
Oriole	SP,S	R,M	C
Munco		R	C
Common Flicker	SP,S	R,M	C
Keller's Jay		R	C
Canada Jay		R	C
Sapsucker	SP,S	M	C
Starling	SP,S	M	C
House Finch		R	C
English Sparrow		R	C
Shrike	SP,S	R,M	C
Barn Swallow		R	C
Cliff Swallow		R	C
Ruby-Throated Humingbird	SP,S	M	C
Belted Kingfisher		R	C
Red-winged Blackbird	SP,S	R,M	C
Yellow-headed Blackbird	SP,S	M	C
Meadow Lark		R	C
American Robin	SP,S	R,M	C
Lewis Woodpecker		R	U
Pinon Jay		R	C
Black-billed Magpie		R	C
Common Raven		R	C
Mountain Bluebird		R	C
Water Ouzel		R	C
Mourning Dove	SP,S,F	M	C
Band-tailed Pigeon	SP,S,F	M	C
Chukar		R	U
Wild Turkey*		R	U

SP - Spring
S - Summer
F - Fall
W - Winter

*Considered big game by Division of Wildlife regulation.

Source: Wright-McLaughlin, 1978.

Species	Seasonal Occurrence	Resident Status	Frequency
Captors:			
Bald Eagle	W	M	U
Golden Eagle		R	C
Marsh Hawk		R	C
Red-tailed Hawk		R	C
Sharp-skinned Hawk		R	C
Cooper's Hawk		R	R
Sweinson's Hawk	S,F	M	C
Sparrow Hawk	S,F	M	C
Osprey	S,F	M	R
Turkey Vulture	S,F	M	C
Great Horned Owl		R	C
Goshawk	S,F	M	
Prairie Falcon		R	
Waterfowl and Shorebird Species:			
Mallard	SP,F	R,M	C
Pintail	SP,F	M	C
Gadwall	SP,F	M	C
Widgeon	SP,F	M	C
Canvasback	SP,F	M	C
Redhead	SP,F	M	C
Lesser Scaup	SP,F	M	C
Buffle Head	SP,F	M	C
Common Goldeneye	SP,F	M	C
Barrows Goldeneye	SP,F	M	C
Blue-winged teal	SP,F	M	C
Green-winged teal	SP,F	M	C
Canada Goose	SP,F	M	C
American Merganser	SP,F	M	C
Wilson Snipe	SP,F	R,M	C
Least Bittern	SP,F	M	U
Great Blue Heron	SP,F	M	C
Snowy Egret	SP,F	M	U
Black-crowned Night Heron	SP,F	M	U

Source: Wright-McLaughlin, 1978.

Fish of the Arkansas River Basin in Colorado

Species	Resident Status	Frequency
Fish:		
Rainbow trout	R	C
Brown trout	R	A
Brook trout	R	U
Cutthroat trout	R	U
Western white sucker	R	C
western longnose sucker	R	C
Creek chub	R	C
Arkansas River Speckled chub	R	U
Red shiner	R	C
Fathead minnow	R	C

Source: Wright-McLaughlin, 1978.

STATE OF COLORADO
Richard D. Lamm, Governor
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE
Jack R. Grieb, Director
6060 Broadway
Denver, Colorado 80216 (825-1192)

May 18, 1981

Barbara A. Coe
Western Energy Planners LTD
11111 E. Mississippi Ave Suite #208
Aurora, Colo. 80012

Dear Ms. Coe:

I have had the opportunity to review the map of the prospective geothermal development in the Poncha Springs area. With the present layout as it is, I feel there will be a minimum of negative impact on wildlife. One problem that does concern me, is the possible displacement of deer, about 300 in number, that utilize the alfalfa and grass during a critical time of the year. (Use areas are marked with an X on the map.) I would request that any construction or development would be done after April or May when the deer will be leaving this area.

I have several questions about the proposed well and pipeline. (1) Is there any noise associated with the well? (2) Will there be any warm or hot water released into the adjacent streams that may harm the fisheries?

I appreciate your giving me the opportunity to comment on the proposed development. Feel free to contact me if you have further questions. Thank you. I am enclosing your map with marked deer use areas.

Yours truly,

Willie Travnicek
District Wildlife Manager
Colorado Division of Wildlife

WT/bjt
Enclosure

Aquatic Insects of the Arkansas River Basin in Colorado

September 27, 1974

Salida, above discharge

Family	Genus	No. Individuals
Brachycentridae	Brachycentrus	99
Glossosomatidae	Glossosoma	1
Hydropsychidae	Hydropsyche	18
Hydropsychidae	Arctopsyche	4
Perlidae	Acroneuria	5
Heptageniidae	Rhithrogena	1
Tendipedidae	--	1

Salida, below discharge

Family	Genus	No. Individuals
Brachycentridae	Brachycentrus	30
Rhagionidae	Atherix	8
Glossosomatidae	Glossosoma	1
Hydropsychidae	Hydropsyche	5
Hydropsychidae	Arctopsyche	5
Perlidae	Acroneuria	8
Heptageniidae	Rhithrogena	1
Baetidae	Baetis	4
Tendipedidae	--	4
Elmidae	Optioservus	2

In Poncha Springs

Family	Genus	No. Individuals
Rhagionidae	Atherix	5
Tendipedidae	--	14
Physidae	Physa	3
Lymnaeidae	Lymnaea	3
Gammaridae	Gammarus	2
Lepidostomatidae	Lepidostoma	45
Ephemerellidae	Fphemerella	4
Ephemerellidae	Ephemerella	1
Leptophlebiidae	Pataleplophlebia	1
Pteronarcidae	Pteronarcella	1
Perlodidae	Isoperla	1
Chloroperlidae	Alloperia	1
Elmidae	Optioservus	

Source: Wright-McLaughlin, 1978.

Appendix C
Historical Sites
in
Study Area

Appendix D
Requirements for Utility Line Crossing Under the Section 404 Permit Program

REQUIREMENTS FOR UTILITY LINE CROSSING UNDER THE SECTION 404 PERMIT PROGRAM

The nationwide permit for utility line crossings under the Section 404 Permit Program stipulates the following: "The nationwide permit authorizes the placement of dredged or fill material as backfill or bedding for utility line crossings, providing there is no change in the preconstruction bottom contours of the waterbody and all excess material is removed to an upland disposal area. A temporary cofferdam may be constructed adjacent to the trench; however, only those materials taken from the trench may be used, since no additional fills are authorized except for backfill or bedding. A "utility line" is defined as any pipe or pipeline for the transportation of any gaseous, liquid, liquifiable or slurry substance, for any purpose, and any cable, line or wire for the transmission, for any purpose, of electrical energy, telephone and telegraph messages, and radio and television communication. Utility lines crossing navigable waters of the United States will require a permit under the Section 10 Permit Program.

For an activity to be authorized under this nationwide permit, the following conditions contained in Part 323.4-2(b) of the regulations must be satisfied:

"(1) That the discharge will not be located in the proximity of a public water supply intake.

"(2) That the discharge will not occur in areas of concentrated shellfish production.

"(3) That the discharge will not destroy a threatened or endangered species as identified under the Endangered Species Act, or endanger the critical habitat of such species.

"(4) That the discharge will not disrupt the movement of those species of aquatic life indigenous to the waterbody.

"(5) That the discharge will consist of suitable material free from toxic pollutants in other than trace quantities.

"(6) That the fill created by the discharge will be properly maintained to prevent erosion and other non-point sources of pollution.

"(7) That the discharge will not occur in a component of the National Wild and Scenic River System or in a component of a State Wild and Scenic River System."

If a proposed crossing satisfies <u>all</u> of the such conditions and is not located in a navigable water of the United States, it is automatically permitted and no further permit action from the Corps of Engineers is required."

Source: U.S. Army Corps of Engineers

Appendix E
Bases for Analyses of Water Quality

CLASSIFICATION CRITERIA AND CLASSIFICATIONS

Following are the criteria used for classification of the streams in the State:

(1) <u>Criteria for Classification</u>

(a) The existing extent of pollution or the maximum extent of pollution to be tolerated as a goal;

(b) Whether or not pollution arises from natural sources;

(c) Present uses of the water, the uses for which the water is suitable in its present condition, or the uses for which it is to become suitable as a goal;

(d) The character and uses of the land area bordering the water;

(e) The need to protect the quality of the water for human purposes and also for the protection and propagation of wildlife and aquatic life; and

(f) The type and character of the water, such as surface and sub-surface lake, stream or ditch, volume flow, depth, stream gradient, temperature, surface area involved, and daily or seasonal variability of any such characteristics.

As stated in the regulations, "waters are classified according to the uses for which they are presently suitable or intended to become suitable. When the term "waters" is used without the modifiers "surface" or "ground," it includes both surface and groundwater. In addition to the classifications, one or more of the qualifying designations described in paragraph 3.1.13 (2), may be appended.

(2) Classifications

(a) Recreation

(i) Class 1- Primary Contact

These surface waters are suitable or intended to become suitable for prolonged and intimate contact with body or for recreational actities when the ingestion of small quantities of water is likely to occur. Such waters include but are not limited to those used for swimming.

(ii) Class 2 - Secondary Contact

These surface waters are suitable or intended to become suitable for recreational uses on or about the water which is not included in the primary contact subcategory.

(b) Agriculture

These waters are suitable or intended to become suitable for irrigation of crops usually grown in Colorado and which are not hazardous as drinking water for livestock.

(c) Aquatic Life

These surface waters are suitable or intended to become suitable for the protection and maintenance of aquatic life forms as described below:

(i) Class 1- Cold Water Aquatic Life

These waters provide, or could provide, a habitat consisting of water quality levels and other considerations such as flow and stream bed characteristics which do or could protect and maintain a wide variety of cold water biota, including sensitive species. Cold water biota are considered to be life forms, including trout, in water where temperatures do not normally exceed 20°C. If there are limitations to the potential variety of life forms, they are due primarily to uncorrectable water quality conditions. This information will be considered in assigning specific standards.

(ii) Class 1 - Warm Water Aquatic Life

These waters provide, or could provide, a habitat consisting of water quality levels and other considerations such as flow and stream bed characteristics which do or could protect and maintain a wide variety of warm water biota, including sensitive species. Warm water biota are considered to be the life forms in waters with temperatures frequently exceeding 20°C. If there are limitations to the potential variety of life forms, they are due primarily to uncorrectable water quality conditions. This information will be considered in assigning specific standards.

(iii) Class 2 - Cold and Warm Water Aquatic Life

These are waters where the potential variety of life forms is presently limited primarily to flow and stream bed characteristics. Standards will be assigned to protect existing species and encourage the establishment of more sensitive species which are compatable with the flow and stream bed characteristics.

(d) Domestic Water Supply

These waters are suitable or intended to become suitable for potable water supplies. There may be waters which do not fit into either the Class 1 or Class 2 classification but which may be suitable for domestic water supplies after special treatment.

(i) Class 1- Uncontaminated Groundwaters

These are groundwaters which receive a high degree of natural protection and meet, without treatment, all Colorado drinking water regulations and any revision, amendments, or supplements thereto. Colorado drinking water regulations require disinfection of all domestic water supplies regardless of source unless a waiver has been obtained.

(ii) Class 2 - Waters Requiring Disinfection and/or Standard Treatment

These are waters which, after receiving approved disinfection such as simple chlorination or its equivalent or which after receiving standard treatment (defined as coagulation, flocculation, sedimentation, filtration, and disinfection with chlorine or its equivalent) will meet Colorado drinking water regulations and any revisions, amendments, or supplements thereto. This class may include groundwaters which, due to natural or human causes, do not meet the requirement for Class 1 waters.

(e) Existing High Quality Waters

Waters currently of a quality higher than necessary to support primary contact recreation and propagation of fish, shellfish, and wildlife and which are generally suitable for agriculture and domestic water supply may be classified as high quality waters. This classification precludes the necessity to classify for other beneficial uses.

(i) Class 1 - These are high quality waters which constitute an outstanding state or national resource such as waters in national and state parks and forests, wildlife refuges, and waters of exceptional recreational and ecological significance. For example, waters which provide a unique habitat for an endangered or threatened species or rivers designated under the Wild and Scenic Rivers Act may be designated as outstanding state or national resource waters. No degradation of these waters will be allowed; thus, these waters will be protected and maintained at their existing quality.

(ii) Class 2 - These are other high quality waters which are not classified as outstanding state or national resources. These waters shall be maintained and protected at their existing quality unless the Commission chooses, after full intergovernmental coordination and public participation, to allow lower water quality as a result of necessary and justifiable economic or social development. In no event, however, may degradation of water quality interfere with or become injurious to existing instream water uses" (Colorado Department of Health, 1979).

The classifications and standards are designed to assure the following:

"(1) Existing uses shall be maintained as required by state and federal law. No further water quality degradation is allowable which would interfere with or become injurious to existing uses.

"(2) High Quality Waters - Class 1 - no degradation shall be allowed in High Quality Waters - Class 1. (See Section 3.1.13(e) (i). These waters shall be maintained and protected at their existing quality.

"(3) <u>High Quality Waters</u> - Class 2 - these waters shall be maintained and protected at their existing quality unless the Commission chooses, after full intergovernmental coordination and public participation, to allow lower water quality as a result of necessary and justifiable economic or social development. See Section 3.1.13(e) (ii). In no event, however, may degradation of water quality interfere with or become injurious to existing uses.

"(4) <u>Waters Other Than High Quality Waters</u> - the numeric values of waters other than high quality waters may change; however, a quality must be maintained which will protect the existing and classified uses" (Colorado Department of Health, 1979).

CONSIDERATIONS FOR DETERMINATION OF WATER MIXING

To determine the extent to which discharged substances will have an effect upon the water quality of a given stream segment, the following must be considered:

"(1) Low Flow Exceptions
Water quality standards shall apply at all times except where surface waters are below minimum annual average seven-consecutive-day flow expected to occur once in ten (10) years. For certain substances, such as ammonia, the low flow exceptions may be based on the seasonal average seven-consecutive-day low flow expected to occur once in ten (10) years. Each season will normally consist of a minimum of three months.

"(2) Waters Not Yet Classified
Discharges to waters not presently classified must meet established effluent limitation regulations, the basic and antidegradation standards and control regulations. Effluent flows which reach a classified body of water, even though the discharge point is to a water not yet classified, must be of a quality which will not cause the standards of the classified body of water to be violated.

"(3) Mixing Zone
(a) The mixing zone is that area of a water body designated on a case-by-case basis by the Division which is contiguous to a point source

and in which the standards may not apply. The mixing zone is intended to serve as a zone of initial dilution in the immediate area of a discharge; however, the ecological and human health effects of some pollutants may be so adverse that a mixing zone for such pollutants will not be allowed.

(b) The size and shape of the mixing zone will be determined by the Division considering the following factors:

(i) Where necessary to protect aquatic life, there shall be a zone of passage around the mixing zone which allows sufficient passage of aquatic life so as not to have a detrimental effect on their population.

(ii) Biological communities or populations of imported species shall not be interfered with to a degree which is damaging to the ecosystem in adjacent waters; nor shall there be detrimental effects to other beneficial uses.

(iii) There shall be no mixing zones for certain harmful substances such as those identified pursuant to 307 (a) of the Federal Act.

(iv) Mixing zones shall not overlap so as to cause harmful effects in adjacent waters or to interfere with zones of passage.

(v) Concentrations of harmful substances in the mixing zone shall not exceed the 96-hour LC-50 concentrations for biota significant to the aquatic community.

(vi) The conditions of the mixing zone shall be controlled so as to comply with items 1(a) (b) and (f) of the Basic Standards, Section 3.1.11.

(vii) In establishing a mixing zone, potential groundwater aquifer contamination shall be considered.

(viii) The Division will also be guided by other concerns such as the mixing zone discussion in EPA, Guidelines for State and Areawide Water Quality Management Program Development, published November 1976, or similar documents" (Colorado Department of Health, 1979).

WATER QUALITY STANDARDS
FOR THE
STATE OF COLORADO

As described below, some basic standards apply to all waters of the State.

"BASIC STANDARDS APPLICABLE TO WATERS OF THE STATE

"All waters of the State are subject to the following basic standards; however, discharge of substances regulated by permits which are within those permit limitations shall not be a basis for enforcement proceedings under these basic standards:

"(1) Substances attributable to human-induced discharges, as indicated below, not otherwise controlled by permits, BMP's or plans of operation approved by the Division, shall not be introduced into the waters of the State:

(a) which can settle to form bottom deposits detrimental to the beneficial uses. Deposits are stream bottom buildup of materials which include but are not limited to anaerobic sludges, mine slurry or tailings, silt, or mud; or

(b) which form floating debris, scum, or other surface materials sufficient to harm existing beneficial uses; or

(c) which produce color, odor, or other conditions in such a degree as to create a nuisance or harm existing beneficial uses or impart any undesirable taste to significant edible aquatic species or to the water; or

(d) in amounts, concentrations, or combinations which are harmful to the beneficial uses or toxic to humans, animals, plants, or aquatic life; or

(e) in amounts, concentrations or combinations which produce a predominance of undesirable aquatic life; or

(f) in concentrations which cause a film on the surface or produce a deposit on shorelines.

"(2) The radioactive materials in surface and groundwaters shall be maintained at the lowest practical level. In no case shall radioactive materials in surface waters be increased by any cause attributable to municipal, industrial, or agricultural practices or discharges so as to exceed the following levels:

Parameter	Picocuries per Liter
Cesium 134	80
Plutonium 238, 239, and 240	15
Radium 226 and 228	5
Strontium 90	8
Thorium 230 and 232	60
Tritium	20,000

> "No increase in radioactive materials in groundwaters of the State over naturally-occurring concentrations shall be permitted, except under specific circumstances that must be approved by the Commission or the Division pursuant to applicable regulations."

The report indicates that excessive salinity and suspended solids levels can be detrimental; however, no general standards have been established as yet (Colorado Department of Health, 1979).

WATER QUALITY STANDARDS
FOR
THE ARKANSAS RIVER BASIN

The basic and organic standards for water quality in the State of Colorado are indicated in

"(1) <u>Basic</u>

All waters of the Arkansas River Basin are subject to the following standard for temperature. (Discharges regulated by permits, which are within the permit limitations, shall not be subject to enforcement proceedings under this standard). Temperature shall maintain a normal pattern of diurnal and seasonal fluctuations with no abrupt changes and shall have no increase in temperature of a magnitude, rate, and duration deemed deleterious to the resident aquatic life. Generally, a maximum 3°C increase over a minimum of a four-hour period, lasting 13 hours maximum, is deemed acceptable for discharges fluctuating in volume or temperature. Where temperature increases cannot be maintained within this range using Best Management Practices (BMP), Best Available Technology Economically Achievable (BATEA), and Best Practical Waste Treatment Technology (BPWTT) control measures, the Commission may determine, by a rule-making hearing in accordance with the requirements of the applicable statutes and the basic regulations, whether or not a change in classification is warranted.

"(2) Organics

All waters of the Arkansas River Basin are subject to the following standards for organics. (Discharges regulated by permits, which are within the permit limitations, shall not be subject to enforcement proceedings under these standards.)

(a) The organic substances listed below along with concentrations listed are assigned as basic standards intended to protect all waters in the Arkansas River Basin:

Parameter	Aquatic Life mg/l	Water Supply mg/l
Aldrin	0.000003	
Dieldrin	0.000003	
DDT (DDD & DDE)	0.000001	
Endrin	0.000004	
Heptachlor	0.000001	0.0002
Lindane	0.0001	0.004
Methoxychlor	0.00003	0.1
Mirex	0.000001	
Toxaphene	0.000005	0.005
Demeton	0.0001	
Endosulfan	0.000003	
Guthion	0.00001	
Malathion	0.0001	
2,4-D		
PCB (Poly-chlorinated Biphenyls)	0.000001	
Chlorphenol	0.001	0.001
Monohydric phenol	0.5	0.001
Benzidine	0.0001	0.00001

(b) Due to their toxicity persistence, bioaccumulation potential, and carcinogenicity, these organic substances shall be maintained at the lowest practical level in both surface or groundwater. In no case shall their presence in surface or groundwater be increased by any cause attributable to minicipal, industrial, or agricultural practices or discharges, so as to exceed the levels specified in paragraph (a) above.

(c) Aldrin and dieldrin in combination should not exceed 0.000003 mg/l.

(d) All organics not covered by paragraph (a) above are covered by Section 3.1.11 of the "basic regulations" (Colorado Department of Health, 1980)."

The influent parameters for which information must be presented to the Water Quality Control Division are listed below:

("All samples must be taken as grab samples and analyzed for the following parameters and the results submitted to the Permits Section, Water Quality Control Division, as soon as available.")

___Temperature, °C
___Dissolved Oxygen, (mg/l)
___Total Alkalinity (mg/l)
___pH
___Total Suspended
___ Solids (mg/l)
___Fecal Coliform (#/100 ml)
___Total Residual
Chlorine (mg/l)
___Ammonia (mg/l)
___Fluoride (mg/l)
___Nitrate (mg/l)
___Nitrite (mg/l)
___Sulfide as H_2S (mg/l)
___Boron (mg/l)
___Chloride (mg/l)
___Sulfate (mg/l)
___Aluminum, Dissolved (mg/l)
___Antimony, Total (mg/l)
___Gross Alpha (pCi/l)
___Gross Beta
___Radium 226 & 228
___Chromium, Trivalent (mg/l)
___Other

___Copper, Total (mg/l)
___Cyanide, Free (mg/l)
___Cyanide, Total (mg/l)
___Iron, Dissolved (mg/l)
___Iron, Total (mg/l)

___Lead, Total (mg/l)
___Molybdenum, Total (mg/l)

___Manganese, Dissolved (mg/l)
___Mercury, Total (mg/l)
___Nickel, Total (mg/l)
___Phenols, Total (mg/l)
___Selenium, Total (mg/l)
___Silver, Total (mg/l)
___Thallium, Total (mg/l)
___Uranium, Total (mg/l)
___Zinc, Total (mg/l)
___Arsenic, Total (mg/l)
___Barium, Total (mg/l)
___Beryllium, Total (mg/l)
___Cadmium, Total (mg/l)
___Chromium, Hexavalent (mg/l)

United States Department of Agriculture

Soil Conservation Service

P.O. Box 863
Salida, CO 81201

May 28, 1981

Ms. Barbara A. Coe
Western Energy Planners, Ltd.
11111 East Mississippi, Suite 208
Aurora, CO 80012

Dear Ms. Coe,

Thanks for the opportunity to comment on the prospective geothermal development you are studying in the area. At this stage of planning I think the vegetative information you have obtained from the Chaffee-Lake Area Soil Survey should be adequate. I don't have any more site specfic information. I might add that revegetation of disturbed areas as a result of development of the project should not be an insurmountable problem. Obviously, the short growing season and low annual precipitation will be the mast limiting factors.

I have no knowledge on whether subsidence around drilling sites will be a problem or not. I would suggest that you contact the U.S. Geological Survey, P.O. Box 1542, Pueblo, CO 81002 (PH: 544-5277 Ext. 345) in regards to the possible problem. This agency also has offices in Denver, if that would be more convienent.

My biggest concern about the proposed project is in the area of water quality. I would hope that any geothermal waters developed would not degrade the excellent quality waters in the area when disposed of. I would encourage you to contact the Colorado Water Quality Control Division of the Department of Health on this matter. Correspondence should be directed to Mr. Gary Broetzman, Director, Colorado Water Quality Control Division, Department of Health, 4210 E. 11th Avenue, Denver, CO 80220. Of course, little can be determined until test wells are drilled and water quality tested.

Please contact me if you have further questions.

Sincerely,

Bob Schroeder

Bob Schroeder
SCS, Salida
539-7331

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