

GEOHERMAL POWER FROM OIL, GAS AND GEOPRESSURED WELLS IN TEXAS AND LOUISIANA

by

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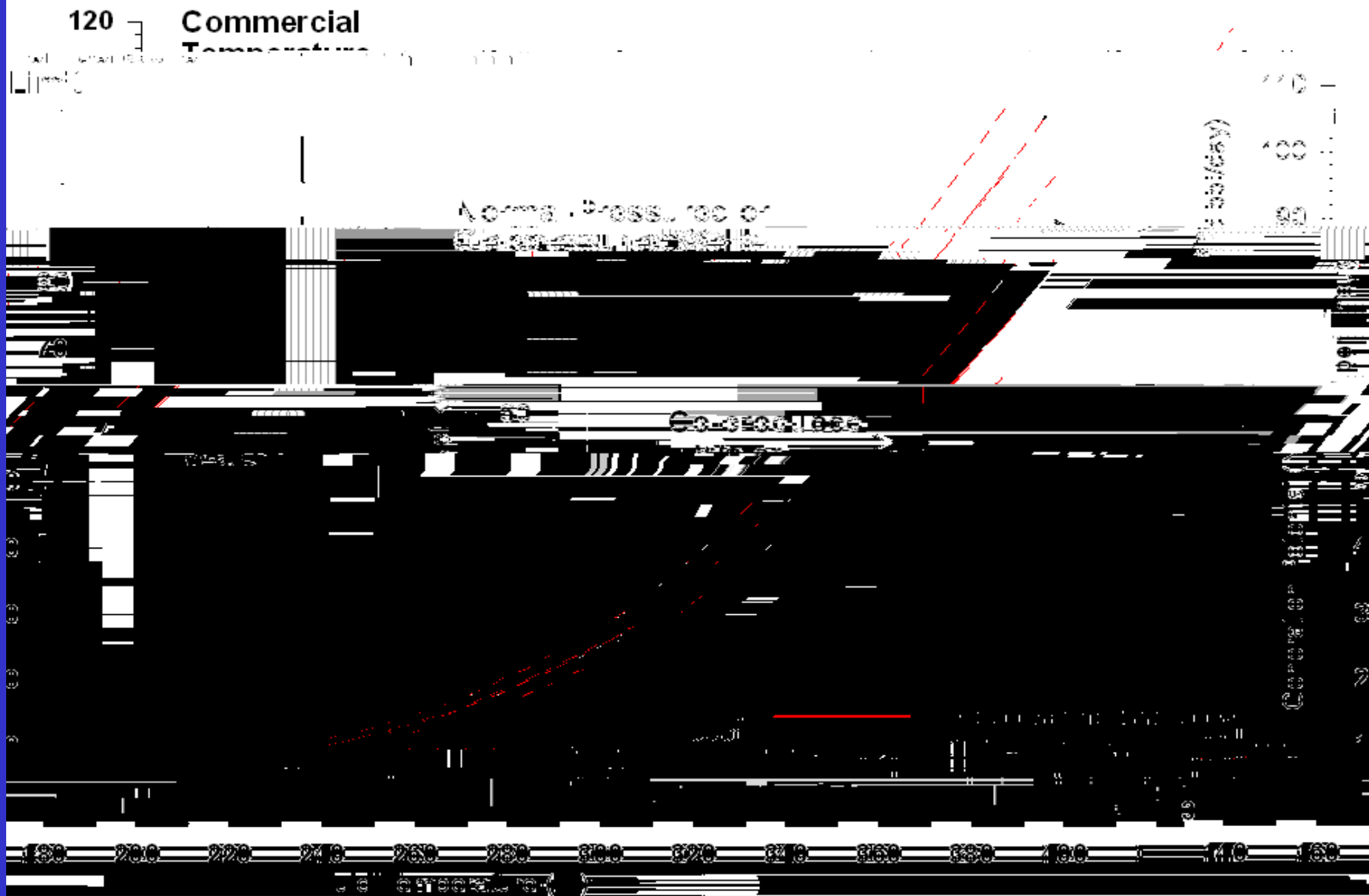
TYPES OF PETROLEUM WELLS POTENTIALLY CAPABLE OF PRODUCING GEOTHERMAL POWER

- CO-PRODUCED WATER FROM OIL OR GAS FIELD
- OIL OR GAS WELL SHUT IN OR ABANDONED BECAUSE OF A HIGH WATER CUT
- GAS WELL TEMPORARILY SHUT IN BECAUSE OF LOW GAS PRICE
- GEOPRESSURED BRINE WELL
- NORMAL-PRESSURED BRINE WELL

FACTORS DETERMINING THE GEOTHERMAL POWER CAPACITY OF A WATER-CUT PETROLEUM WELL

- Water Production Rate
- Temperature of Produced Water
- Ambient Temperature
- Conversion Efficiency of Power Plant

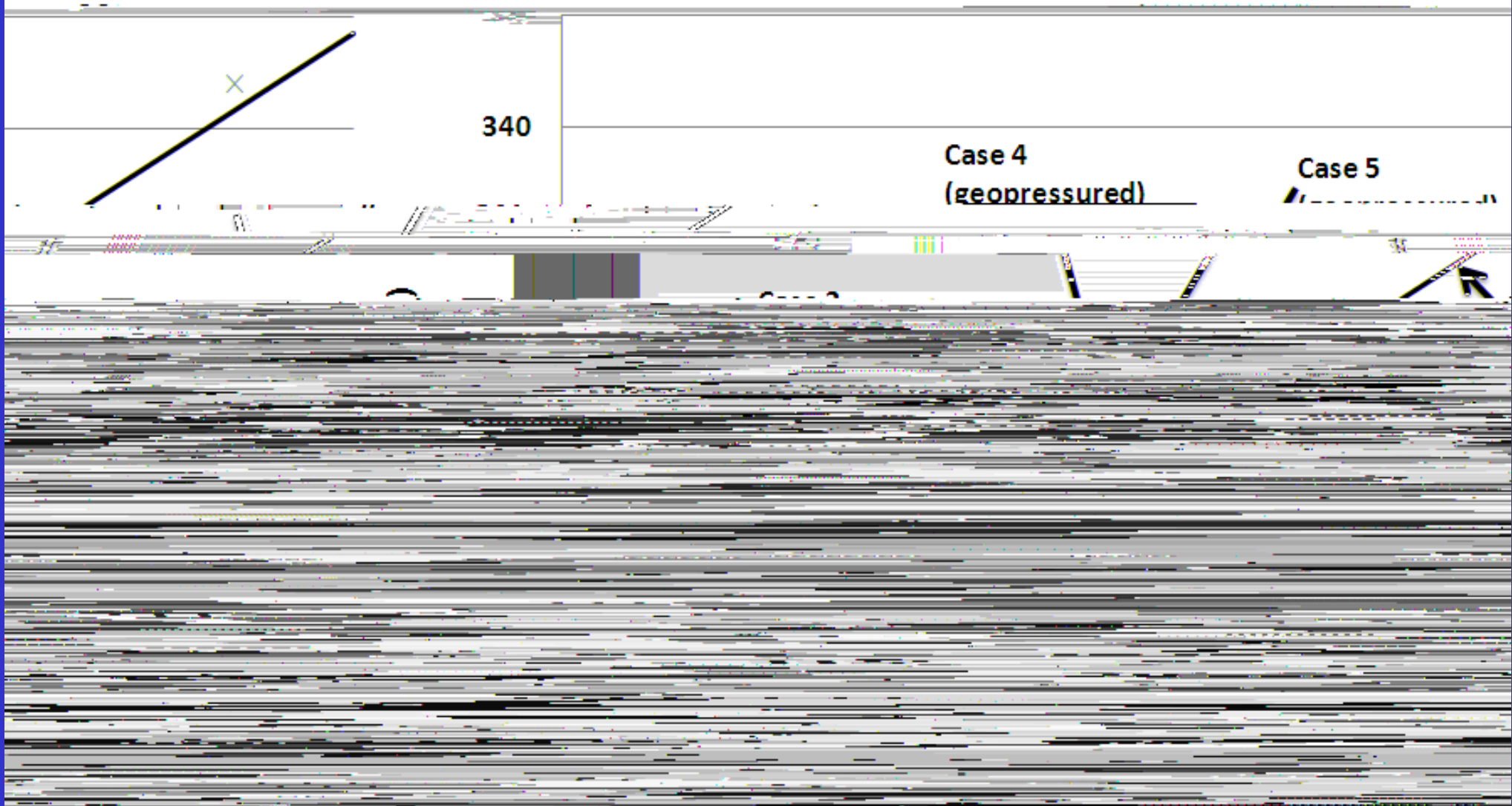
Geothermal Power Potential vs. Resource Temperature



CASE 1: CO-PRODUCED WATER

- Surface Temperature of Water: 160° to 212°F
- Power Capacity: 6 to 12 kW per thousand bbl/day
- Unit Capital Cost: \$2,800 per kW

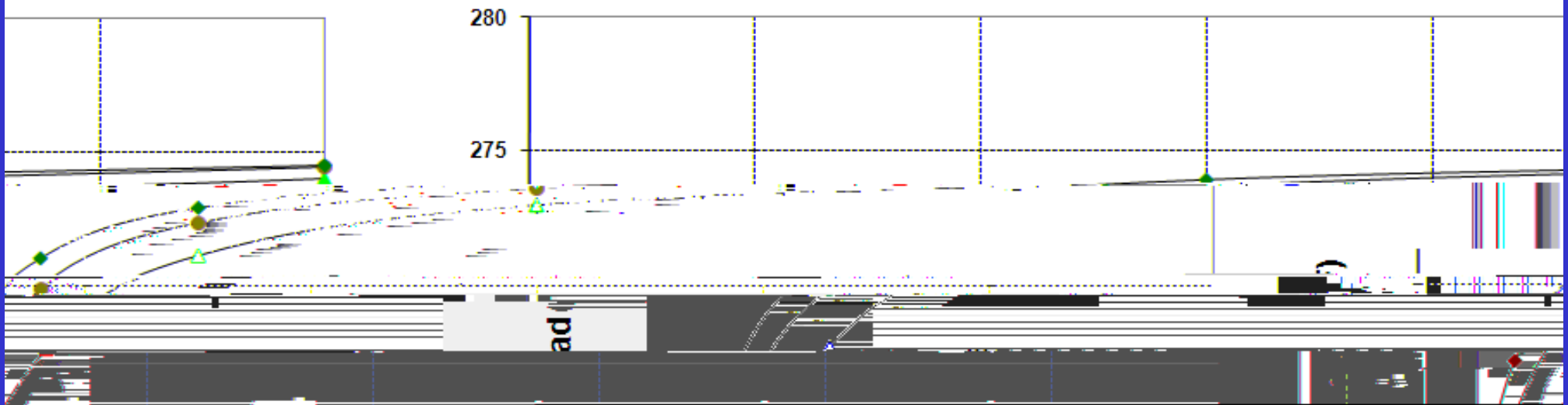
Temperature vs. Depth of abandoned wells in an area of the U.S. Gulf Coast



FACTORS THAT DETERMINE WELLHEAD TEMPERATURE OF THE PRODUCED FLUID

- WELL DEPTH
- BOTTOMHOLE TEMPERATURE
- PRODUCTION RATE
- WELL DIAMETER

Reduction in Wallhead Temperature Due to Heat Loss



CASE 2: AN ABANDONED WATER-CUT GAS WELL IN TEXAS

- 10-3/4-inch casing to 13,400 feet
- 7-5/8-inch liner to 19,200 feet
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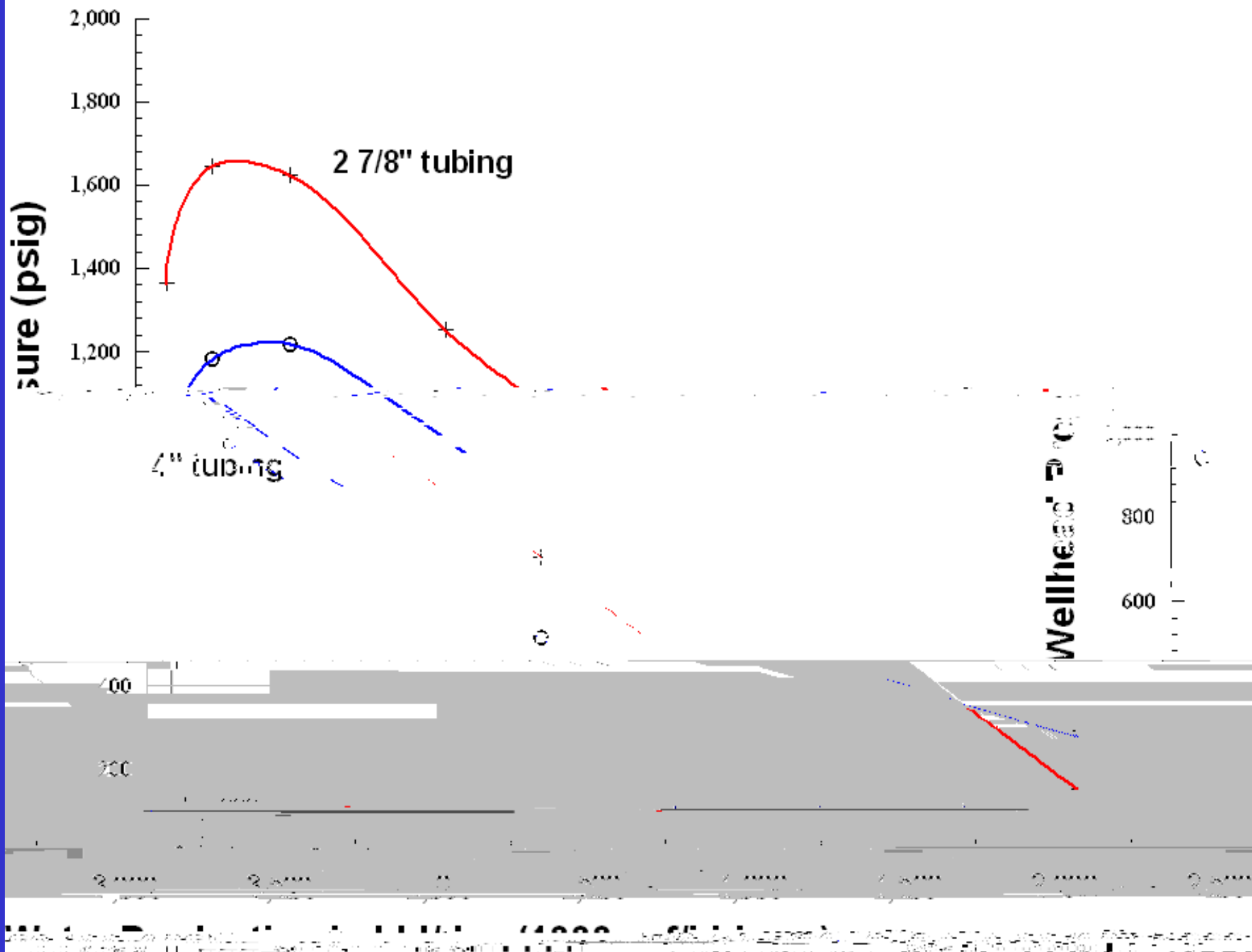
ASSUMPTIONS FOR ECONOMIC ASSESSMENT FOR CASES 2 THROUGH 5

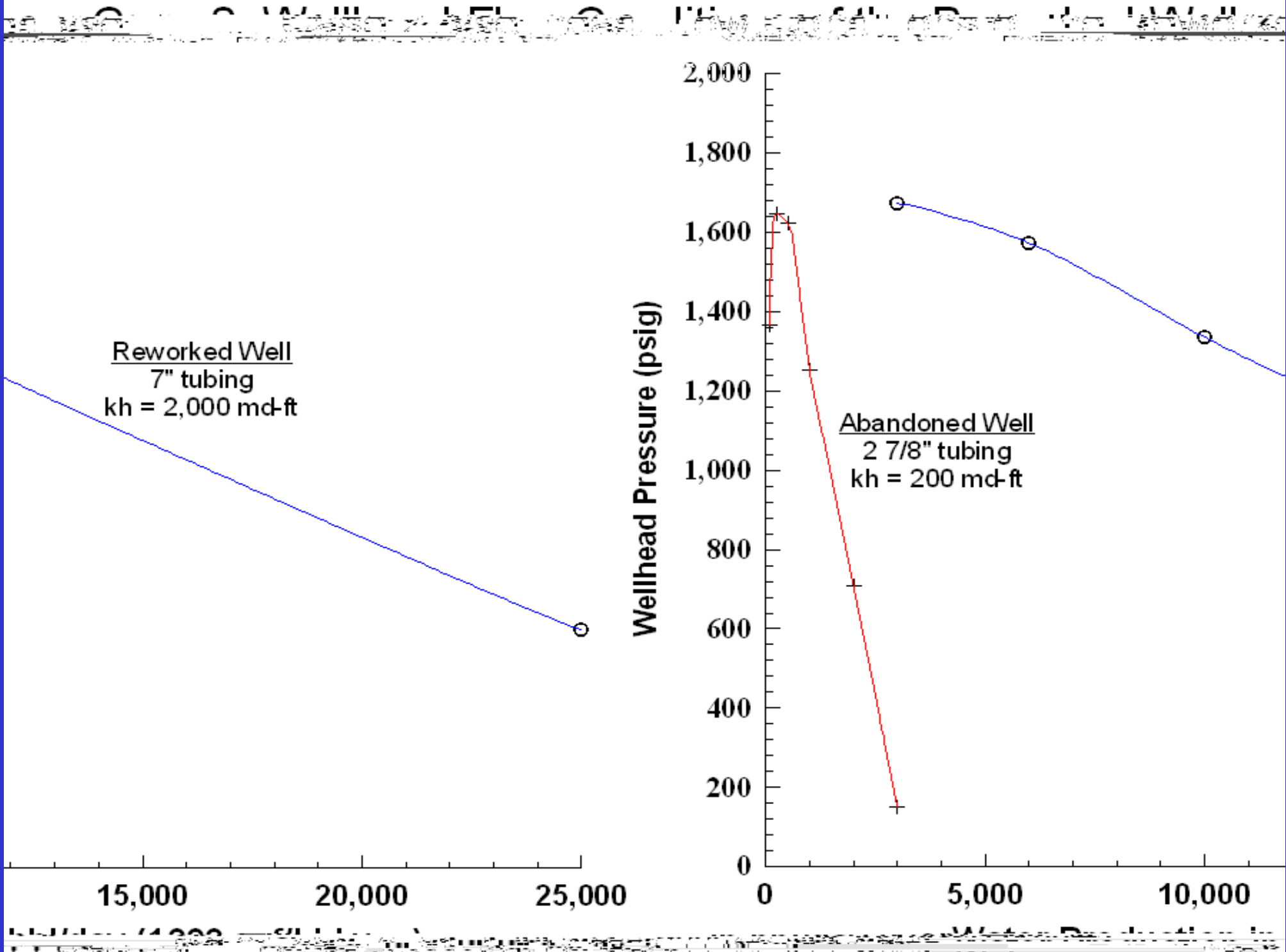
- Unit capital Cost for Geothermal Plant: \$2,800/kW
- Unit capital Cost for Gas-fired Plant: \$1,500/kW

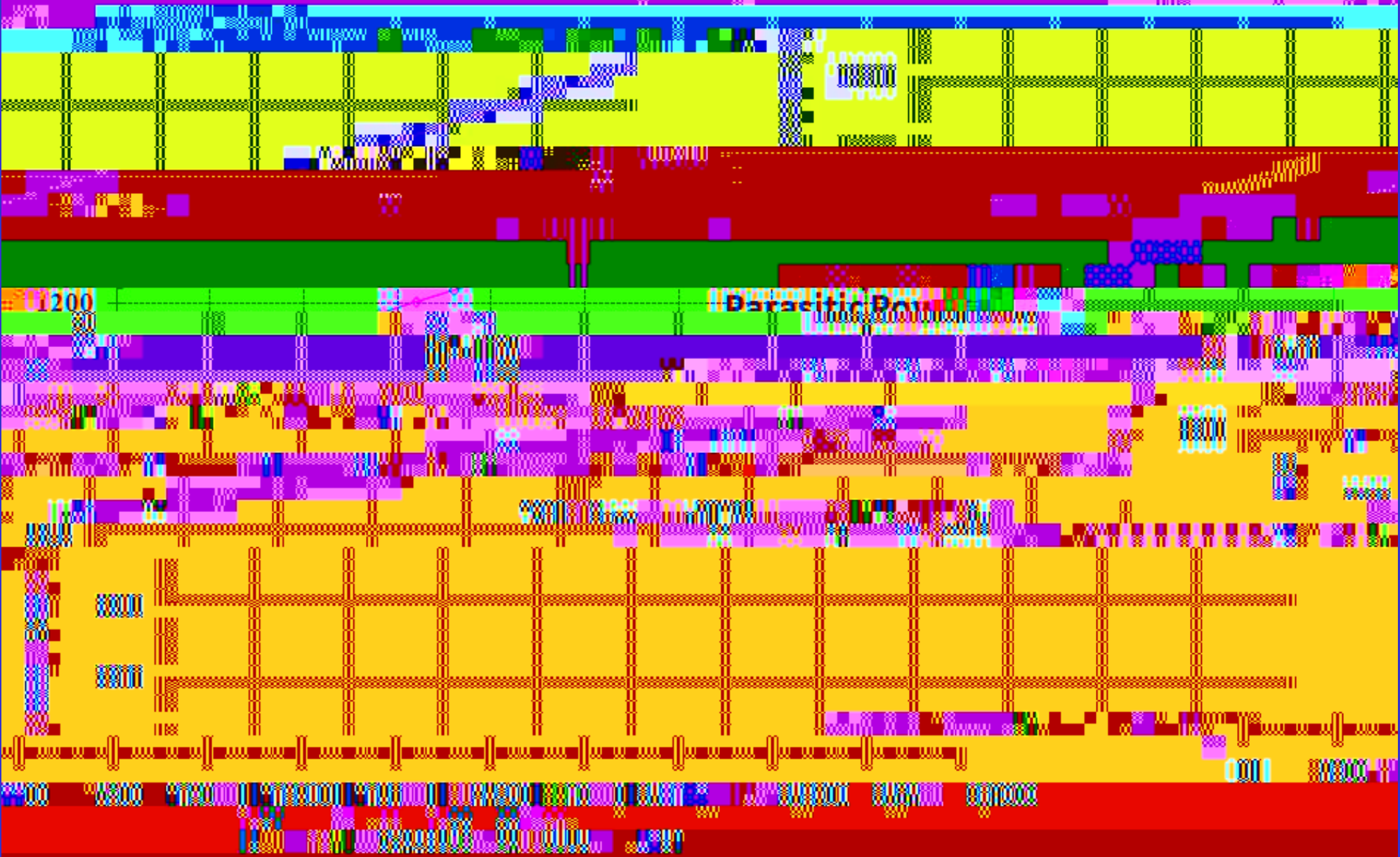
ASSUMPTIONS FOR ECONOMIC ASSESSMENT FOR CASES 2 THROUGH 5 (continued)

- For geopressured systems injection parasitic is 25% of geothermal power generation
- Operations cost: 2¢/kWh net for normal-pressured/2.5¢/kWh for geopressured wells
- Capacity factor for geothermal plant: 95%
- Capacity factor for combined geothermal and gas power plant (or gas sales system): 90%
- Costs of well acquisition and gas pipe
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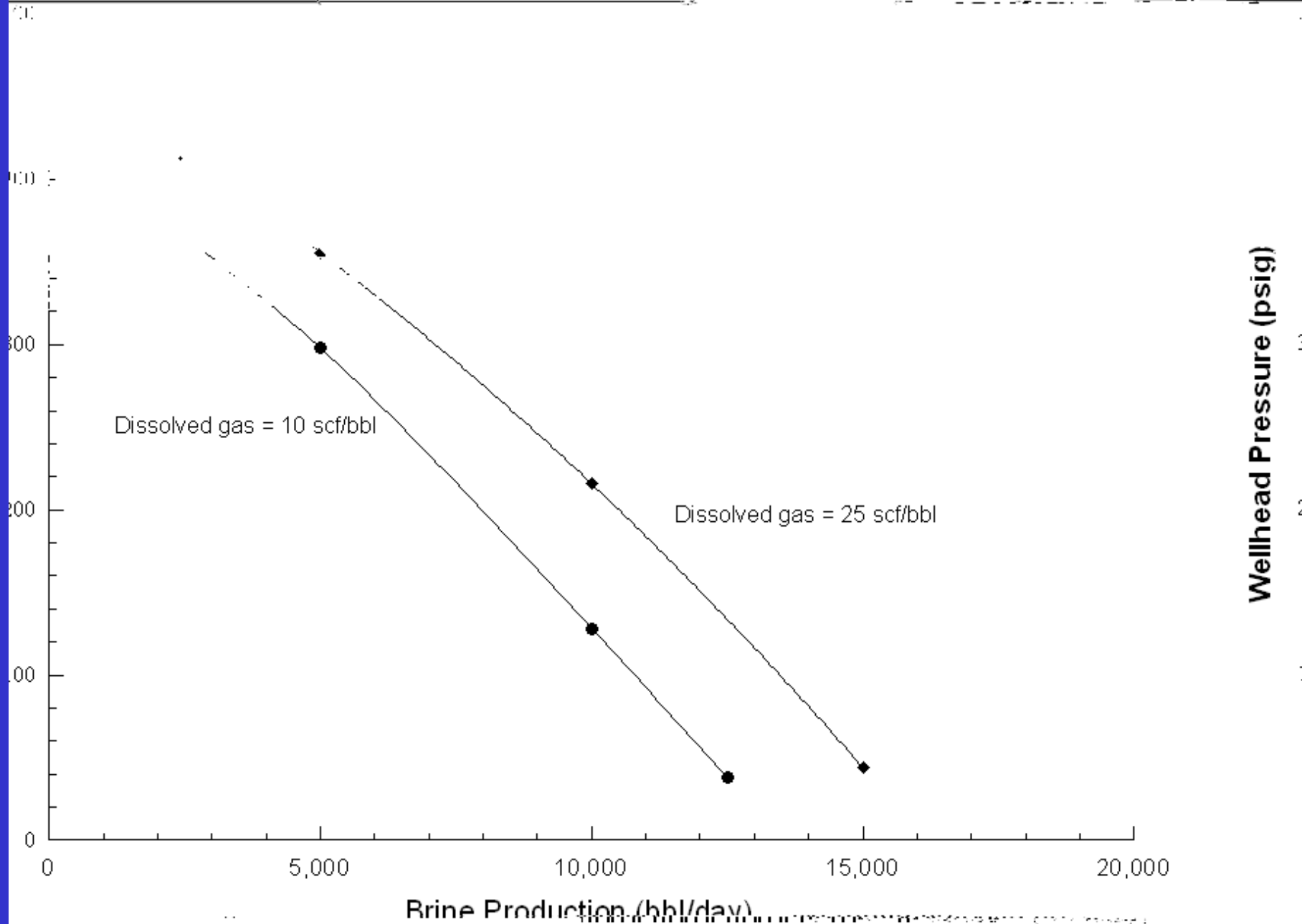
Case 2: Flow Characteristics of a Gas Well at Abandonment Condition



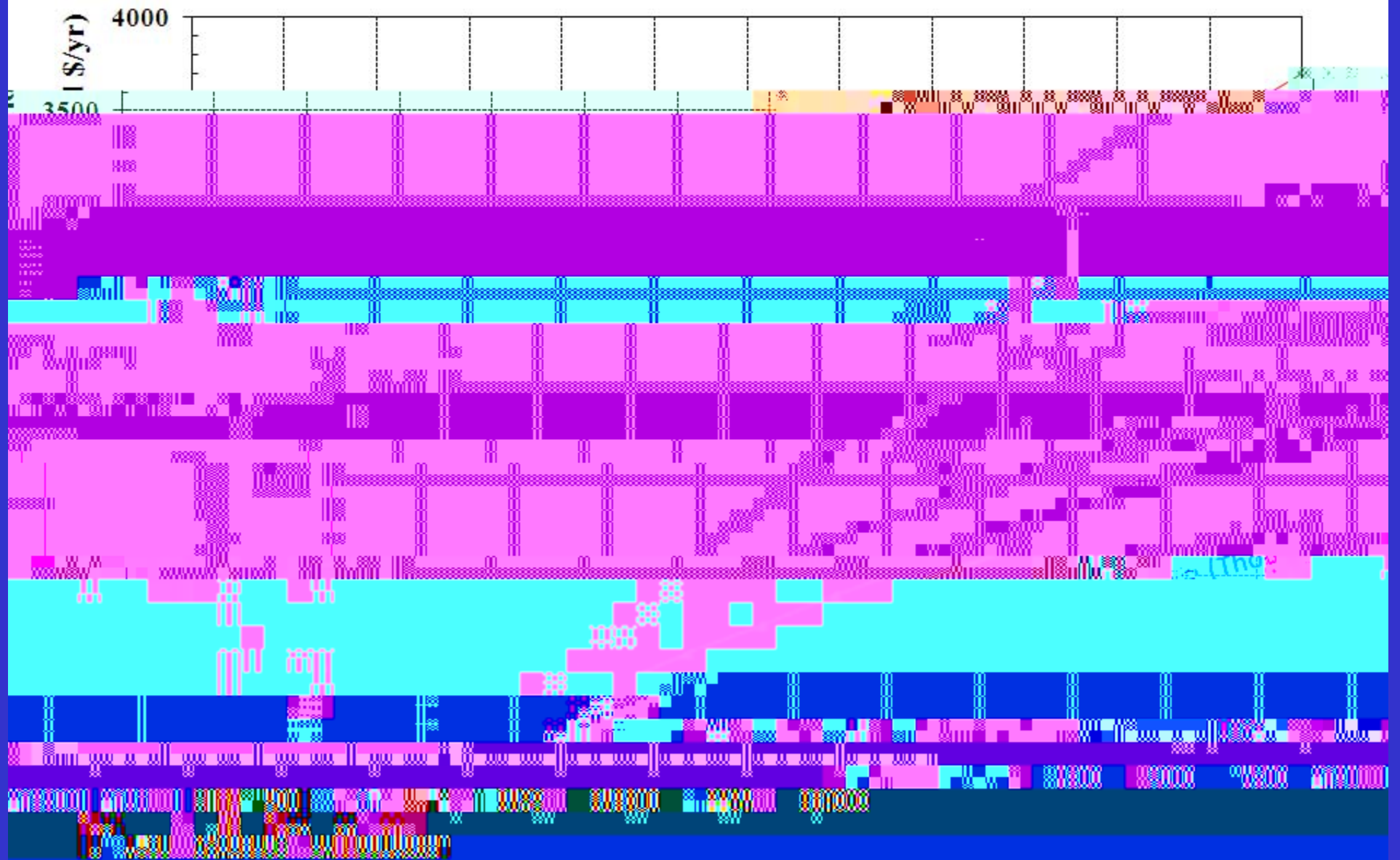




CASE 3: Normal-Pressured 16,000 ft. Deep New Brine Well



Case 3: Power Capacity of Well if Pumped



ECONOMIC ISSUES FOR CASE 3

	<u>Self-flowing Well</u>	<u>Pumped Well</u>
Geothermal Power (kW)	120	3,700
Gas-derived Power (kW)	250	1,850
Permitted Power for Dispatch (kW)	4,000	4,050
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Total Capital Cost (\$)	12,711,000	23,060,000
Unit Capital Cost (\$)	34,354	12,464
Net Revenue (\$/year)	154,526	1,847,484
Pay-out Time (years)	82.3	12.5

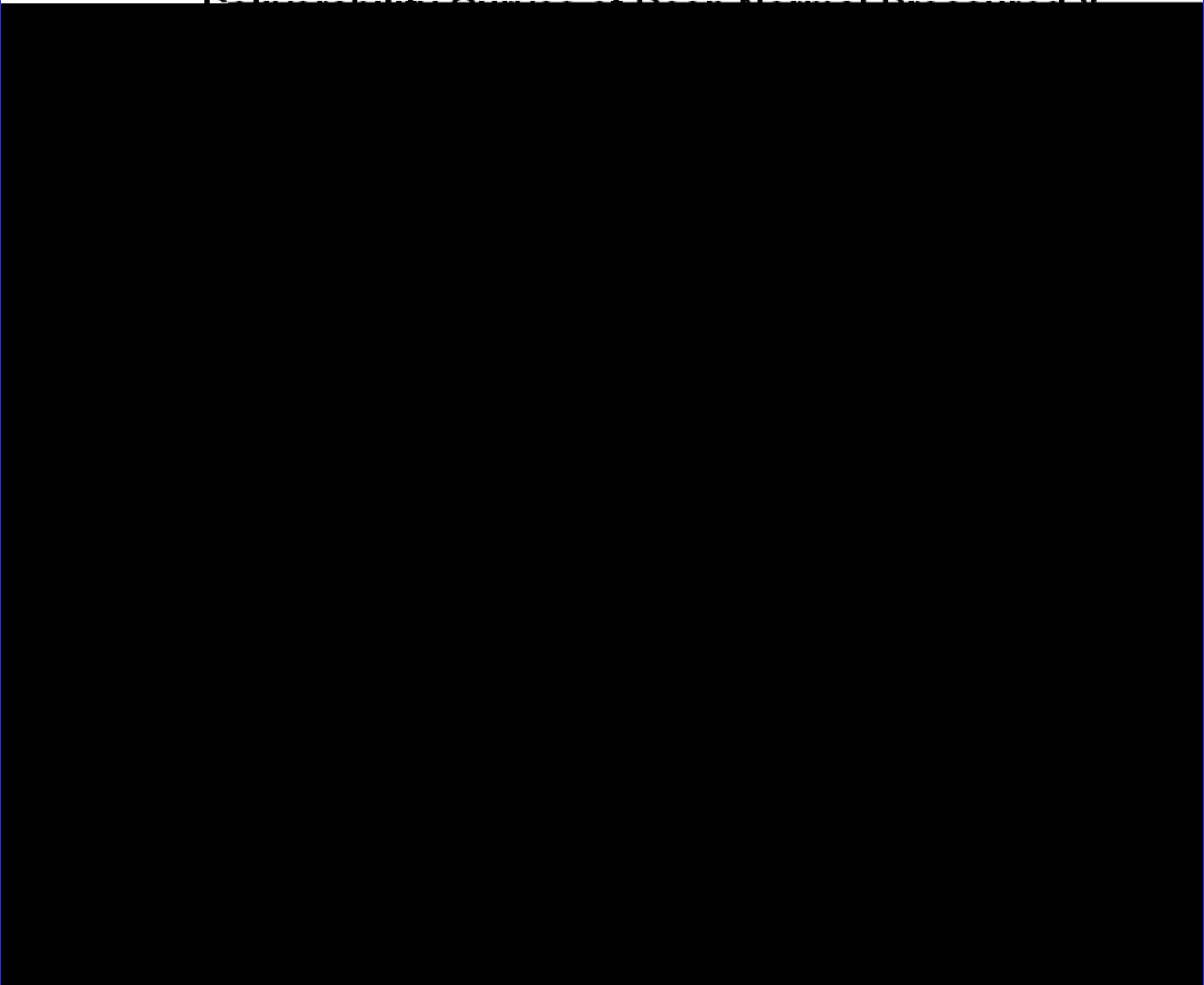
Mud Weight versus Depth for a Geopressured Well in South Louisiana

NORMAL-PRESSURED

GEOPRESSURED

CASE HISTORIES OF TWO GEOPRESSURED WELLS

<u>CHARACTERISTICS</u>	<u>CASE 4: New well drilled in Louisiana</u>	<u>CASE 5: Existing well in Texas</u>
Depth (feet)	16,000	16,465
Wellbore Diameter (in)	5.410	5.410
Permeability (md)	260	200



ECONOMIC ISSUES FOR CASE 4 (20 SCF/bbl)

	<u>Gas used to generate power</u>	<u>Gas sold to pipeline</u>
Brine Flow Rate (bbl/day)	50,000	50,000
Gas Flow Rate (MCF/day)	1,000	1,000
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Parasitic Power (kW)	600	—
Total Net Power (kW)	5,800	1,800
Gas Sold (MCF/day)	0	1,000
Production Well Drilling Cost (\$)	8,000,000	8,000,000
Injection Well Drilling Cost (\$)	1,000,000	1,000,000
Total Capital Cost (\$)	21,720,000	15,720,000
Unit Capital Cost (\$)	3,745	—
Net Revenue (\$)	2,357,000	2,120,800
Pay-out Time (years)	9.2	7.1

ECONOMIC ISSUES FOR CASE 4 (40 SCF/bbl)

	<u>Gas used to generate power</u>	<u>Gas sold to pipeline</u>
Brine Flow Rate (bbl/day)	50,000	50,000
Gas Flow Rate (MCF/day)	2,000	2,000
Geothermal Power (kW)	2,400	2,400
Gas derived Power (kW)	8,000	8,000
Parasitic Power (kW)	600	—
Total Net Power (kW)	9,800	1,800
Gas Sold (MCF/day)	0	2,000
Production Well Drilling Cost (\$)	8,000,000	8,000,000
Injection Well Drilling Cost (\$)	1,000,000	1,000,000
Total Capital Cost (\$)	20,400,000	15,700,000

ECONOMIC ISSUES FOR CASE 5

	<u>Gas used to generate power</u>	<u>Gas sold to pipeline</u>
Pay-out Time (years)	7.3	4.8
Net Annual Revenue (\$)	1,031,200	974,400
Unit Capital Cost (\$)	2,867	—
Total Capital Cost (\$)	7,568,000	4,688,000
Well workover Cost (\$)	2,000,000	2,000,000
Gas Sold (MCF/day)	—	480
Total Net Power (kW)	2,070	120

CONCLUSIONS

- Co-produced water hotter than 160°F can yield 6 kW (at 160°F) to 12 kW (at 212°F) per thousand bbl/day
- Whether an existing normal-pressured gas well, if reworked, can be an economic source of geothermal power and gas is a highly site-specific issue
- Drilling new wells to produce geothermal power from a normal-pressured aquifer without any gas saturation is unlikely to be economic for self-flowing wells but may be economic for pumped wells

CONCLUSIONS (continued)

- Gas-derived component of total power from a geopressured well is larger than the geothermal component; the kinetic energy component is minor
- Economic value of a geopressured well is sensitive to temperature and overpressure, and highly sensitive to gas content
- Geopressured systems are economic sources of geothermal power plus gas, if re-worked existing wells are used

CONCLUSIONS (continued)

- Geopressured systems can be economic sources of geothermal power and gas even if new wells are drilled
- Selling produced gas from a geopressured well becomes more attractive than making gas-derived power as gas price increases
- Economics of geothermal and gas-derived power from abandoned or new wells is sensitive to resource degradation rate, which cannot be generalized