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

by

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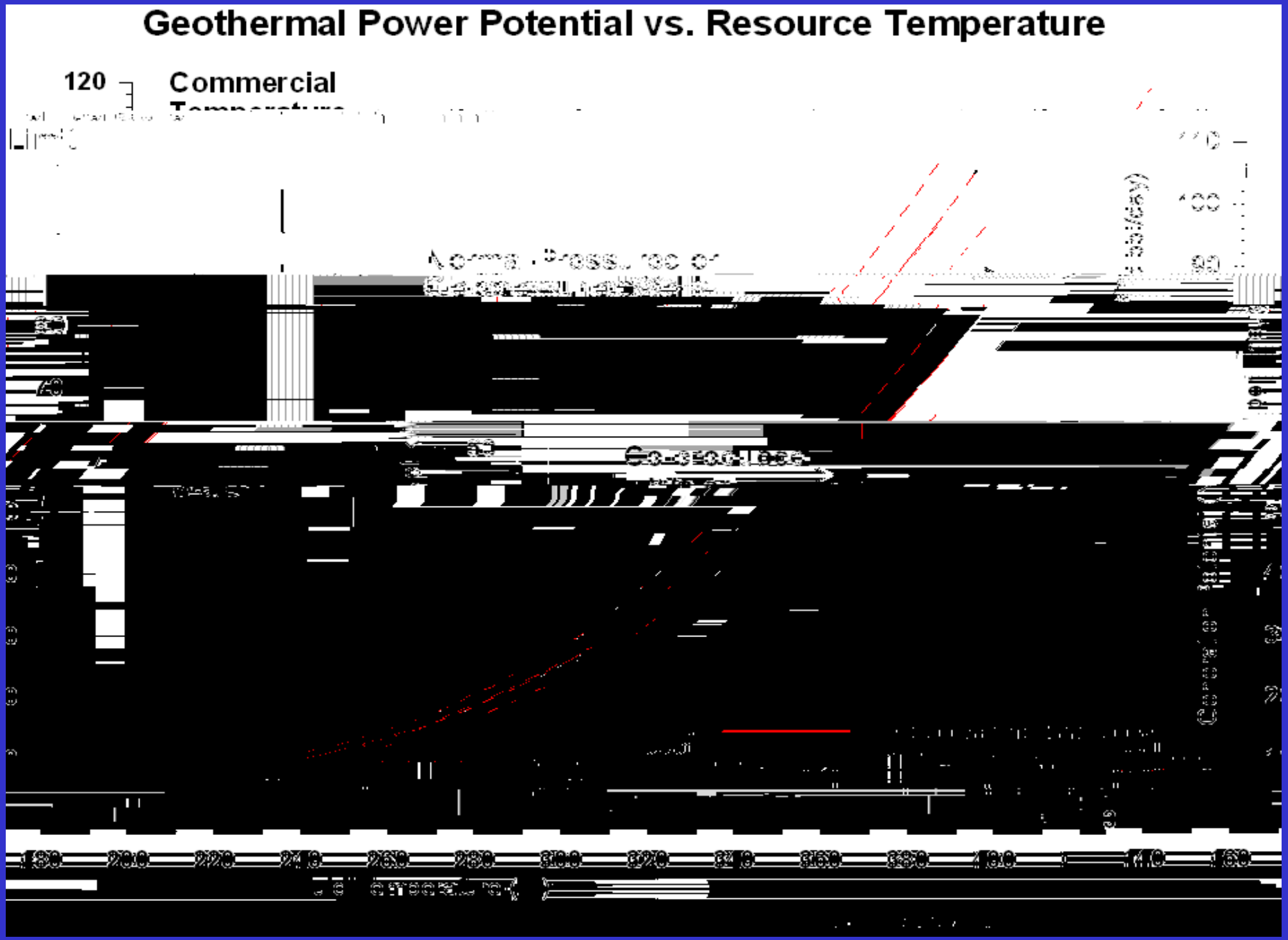
TYPES OF PETROLEUM WELLS POTENTIALLY CAPABLE OF PRODUCING GEOTHERMAL POWER

- 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

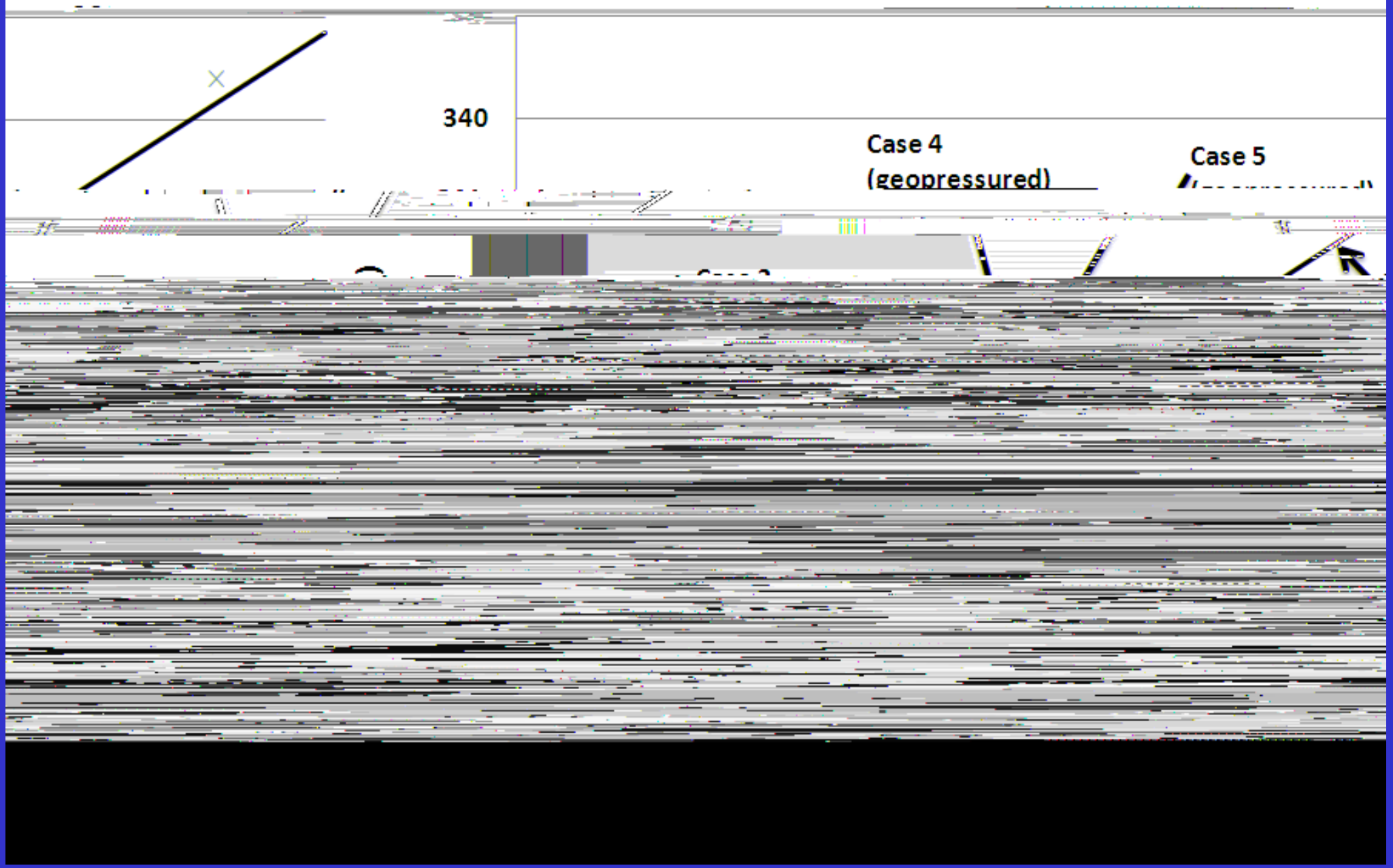
Geothermal Power Potential vs. Resource Temperature



CASE 1: CO-PRODUCED WATER

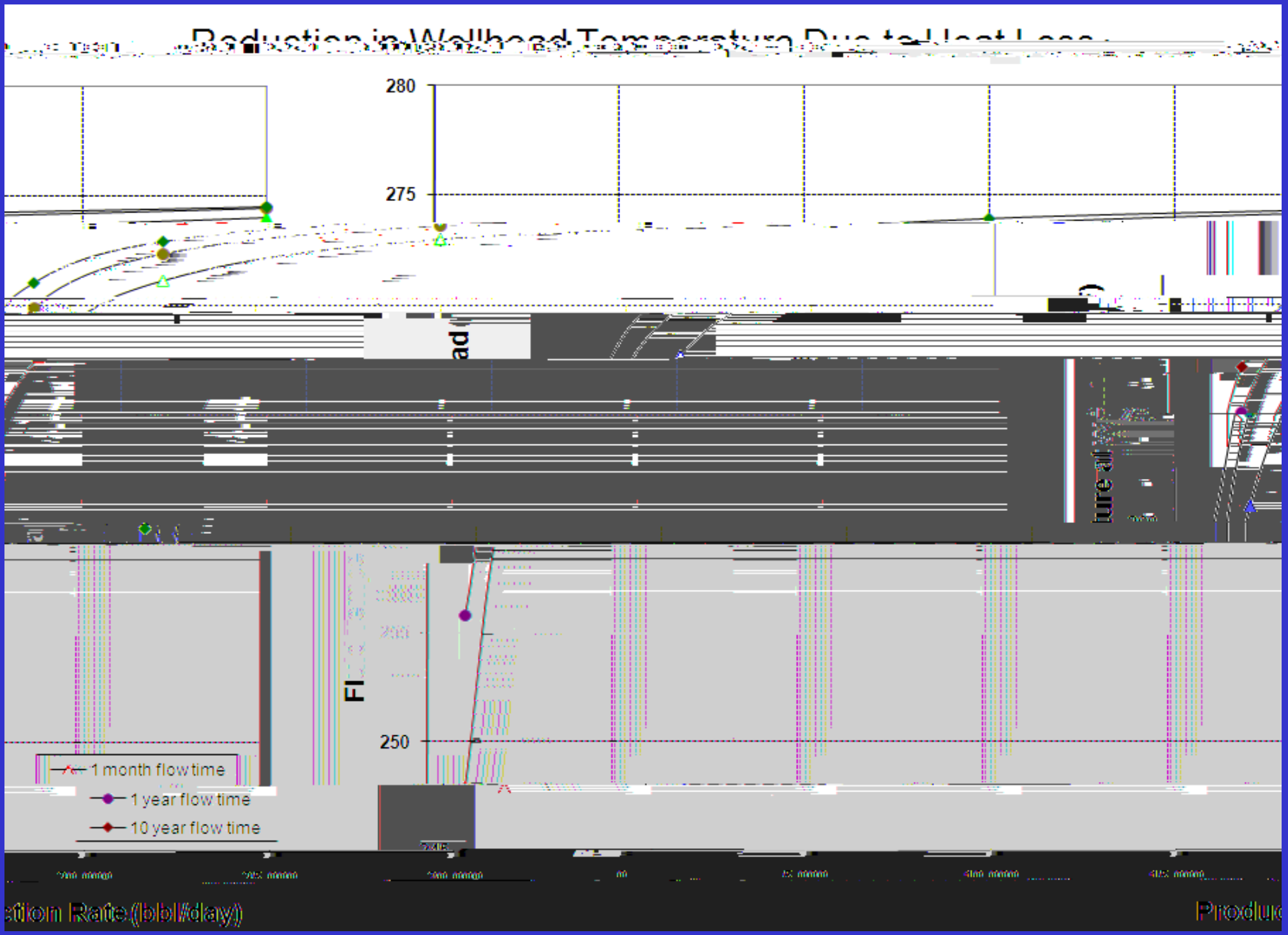
- Surface Temperature of Water: 160° to 212°F
- Power Capacity: 6 to 12 kW per thousand bbl/day
- Unit Capital Cost: $2,800 per kW

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


280
275
250
1 month flow time
1 year flow time
10 year flow time

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 pipeOsUo sdtDw-t
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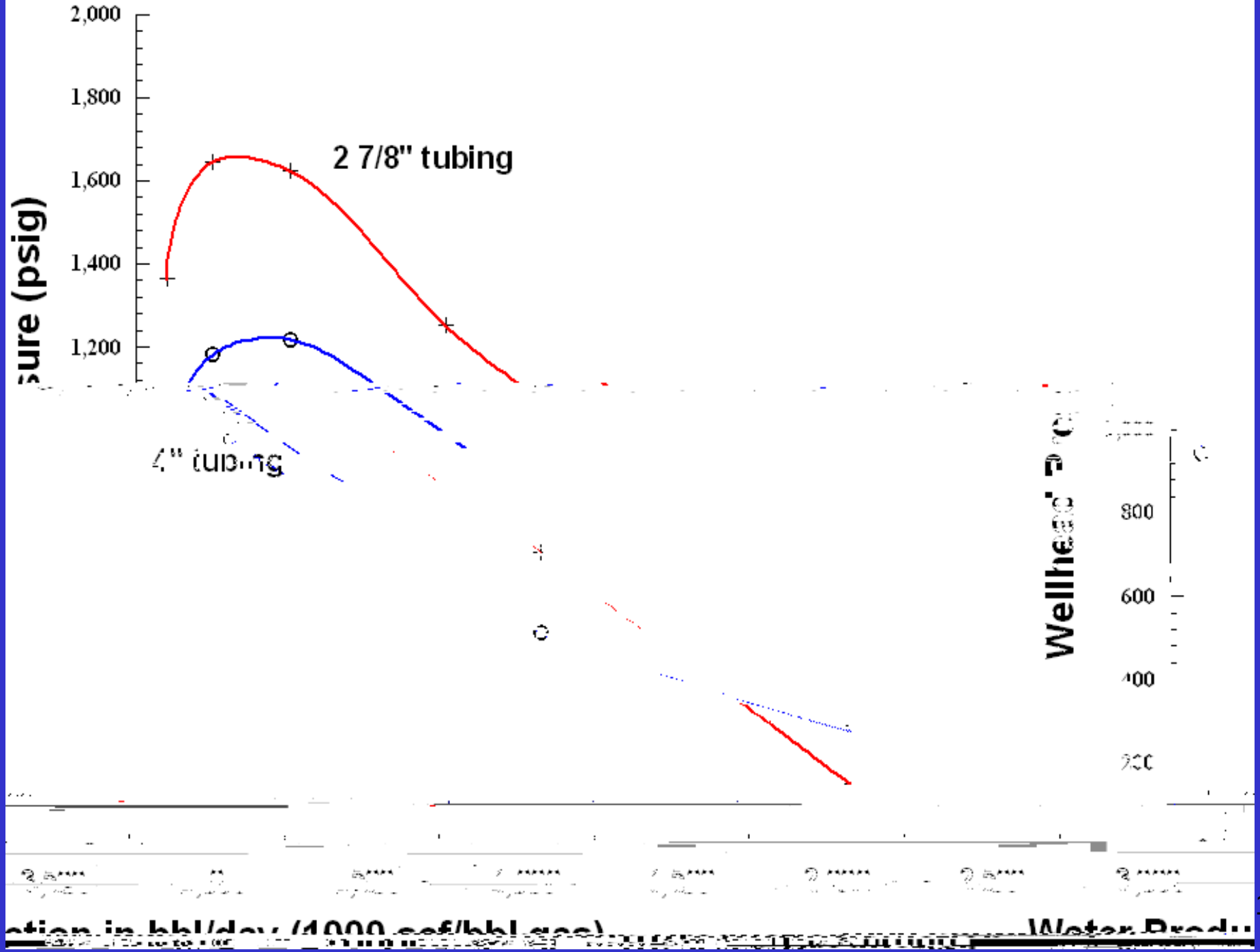
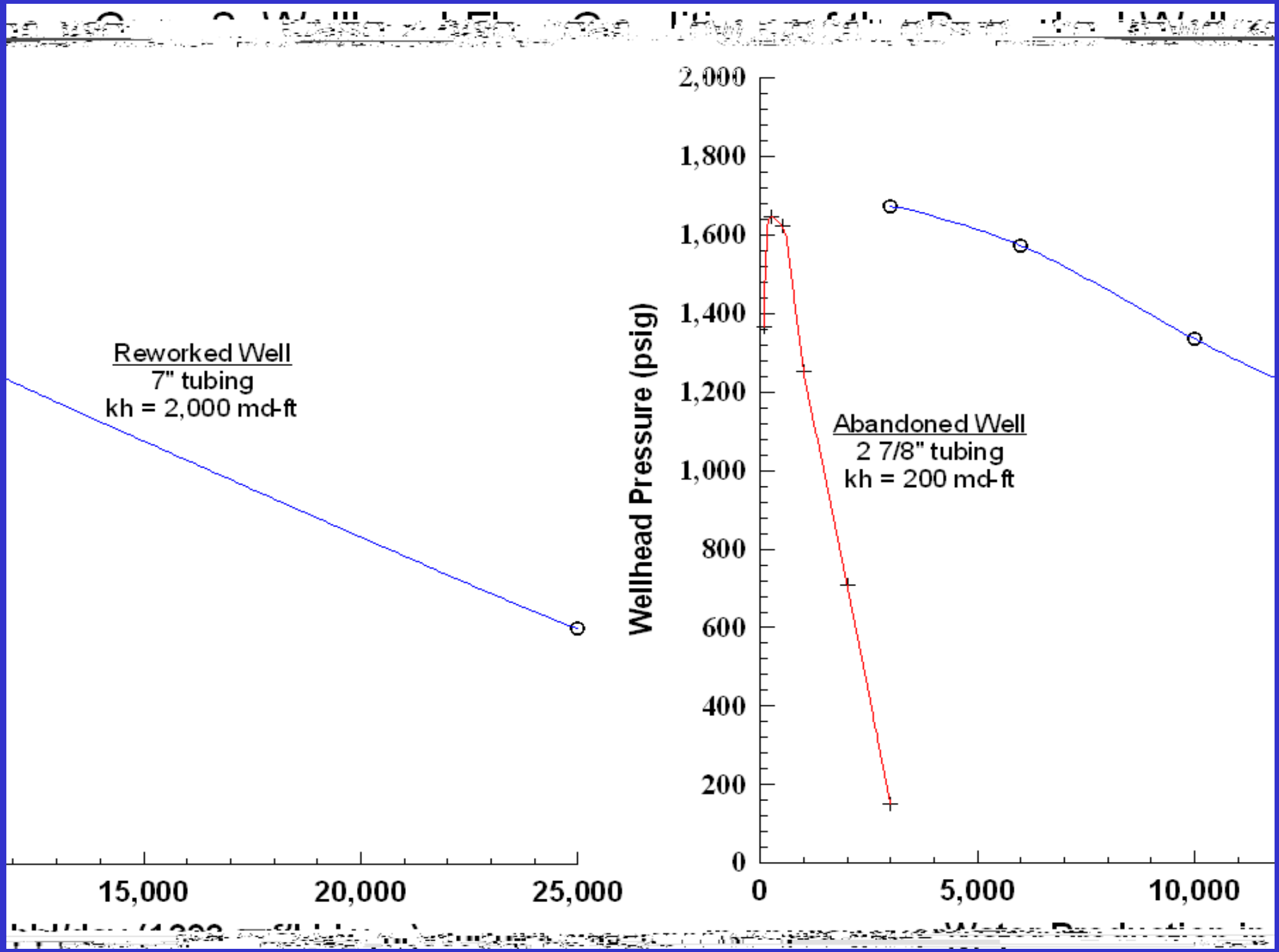
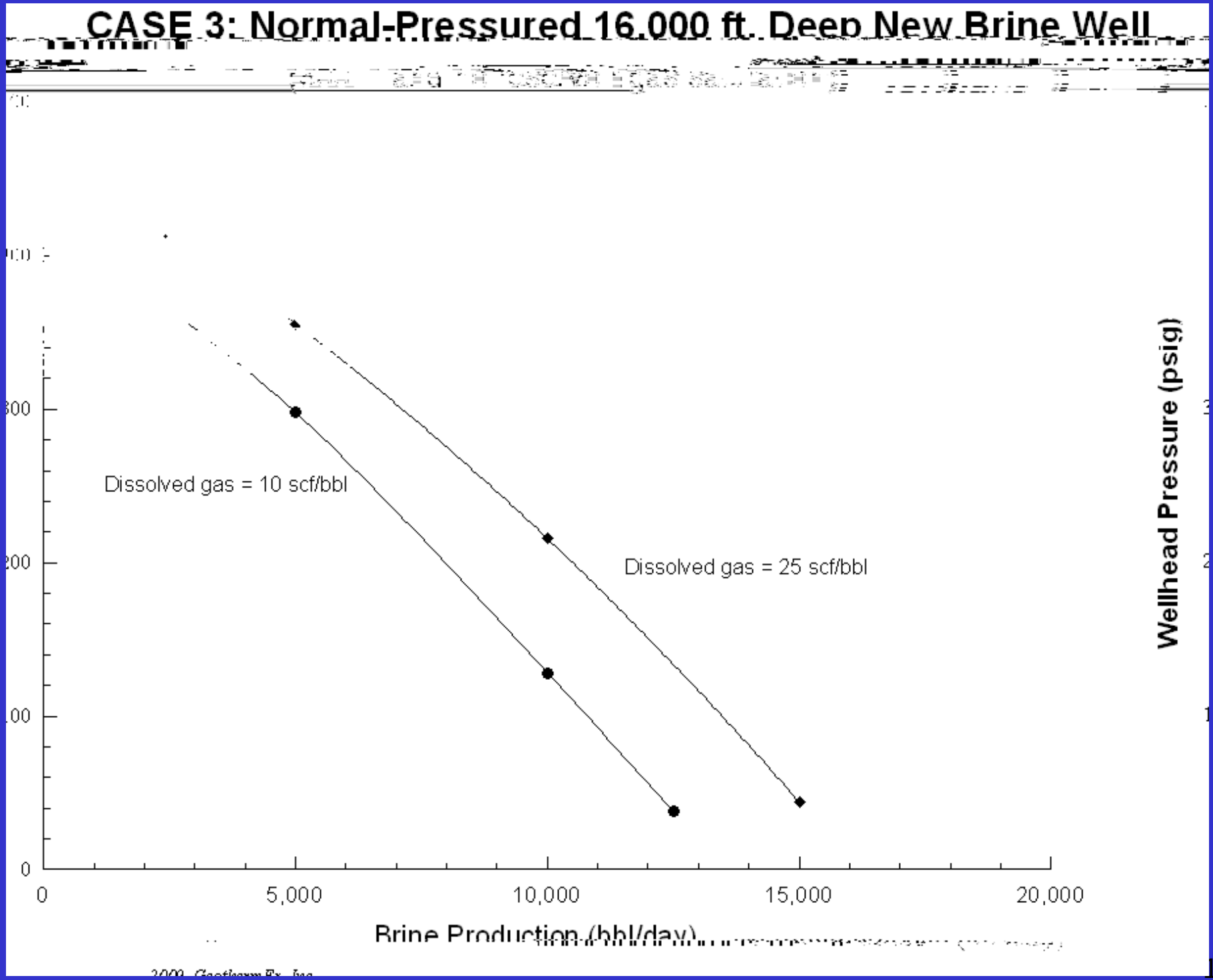
Case 2: Flow Characteristics of a Gas Well at Abandonment Condition



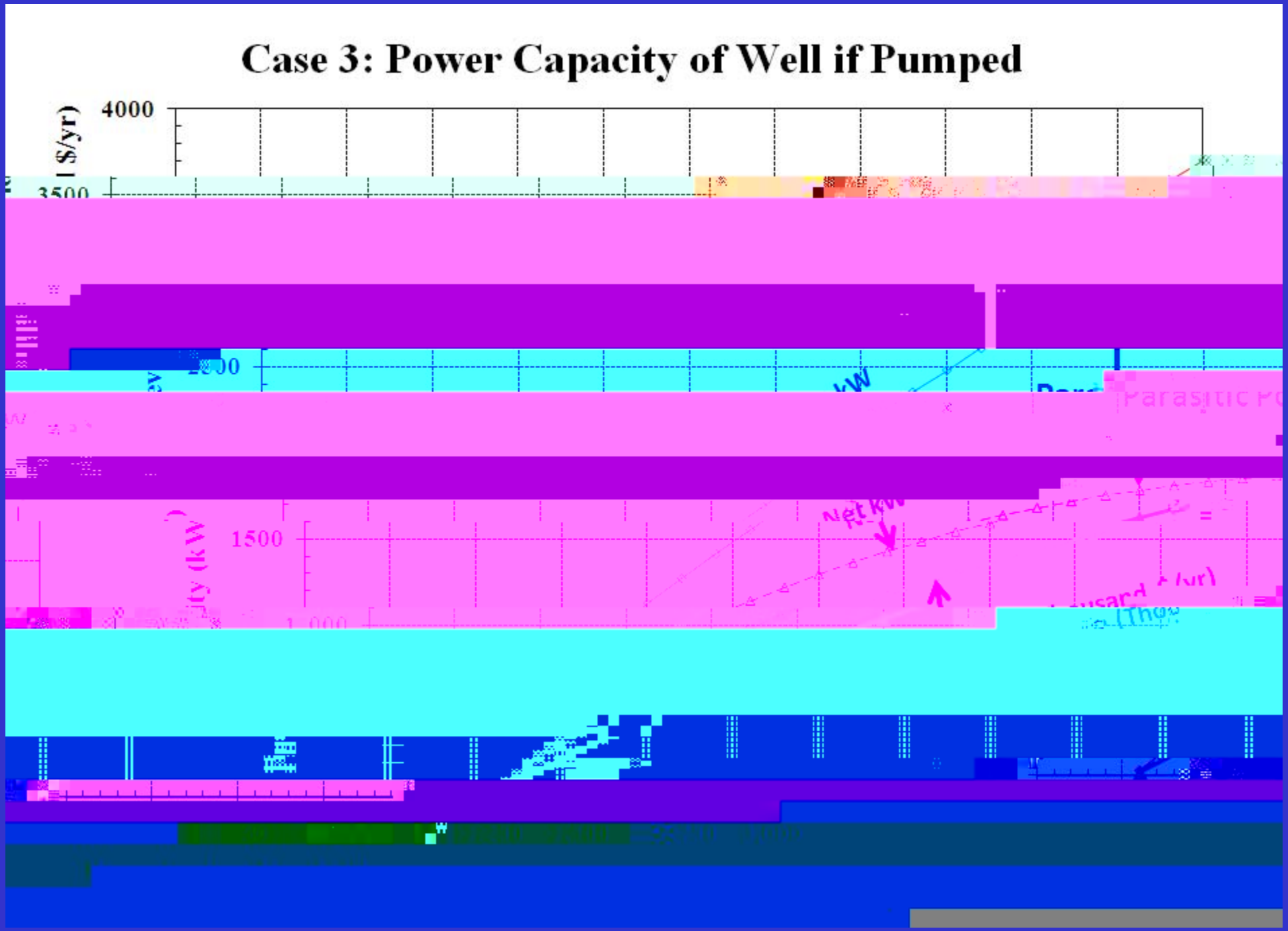

Reworked Well
7" tubing
kh = 2,000 md-ft
Abandoned Well
2 7/8" tubing
kh = 200 md-ft
Wellhead Pressure (psig)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
15,000
20,000
25,000
0
5,000
10,000


1200
2,500
2,750
3,000

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



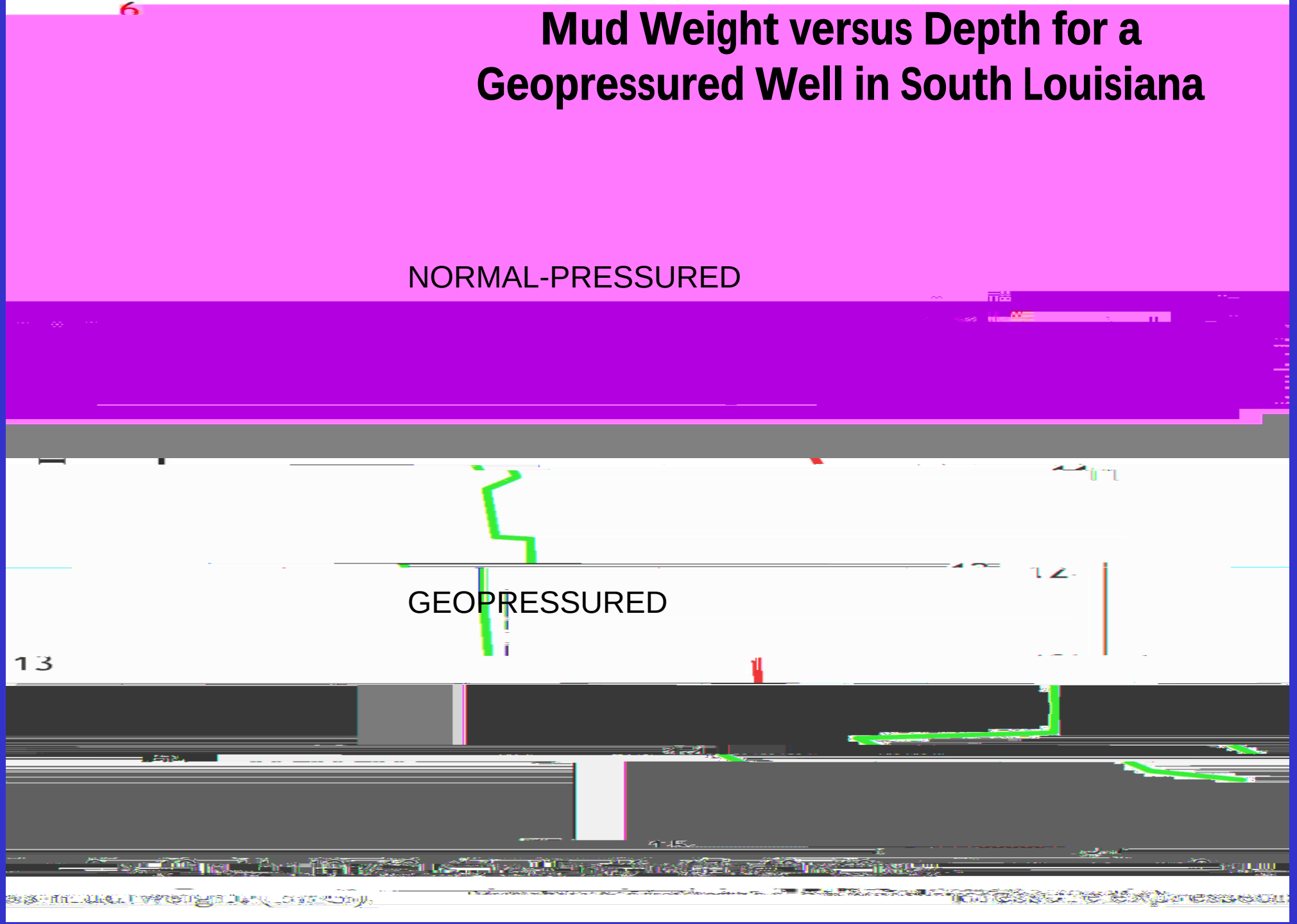
Case 3: Power Capacity of Well if Pumped



ECONOMIC ISSUES FOR CASE 3

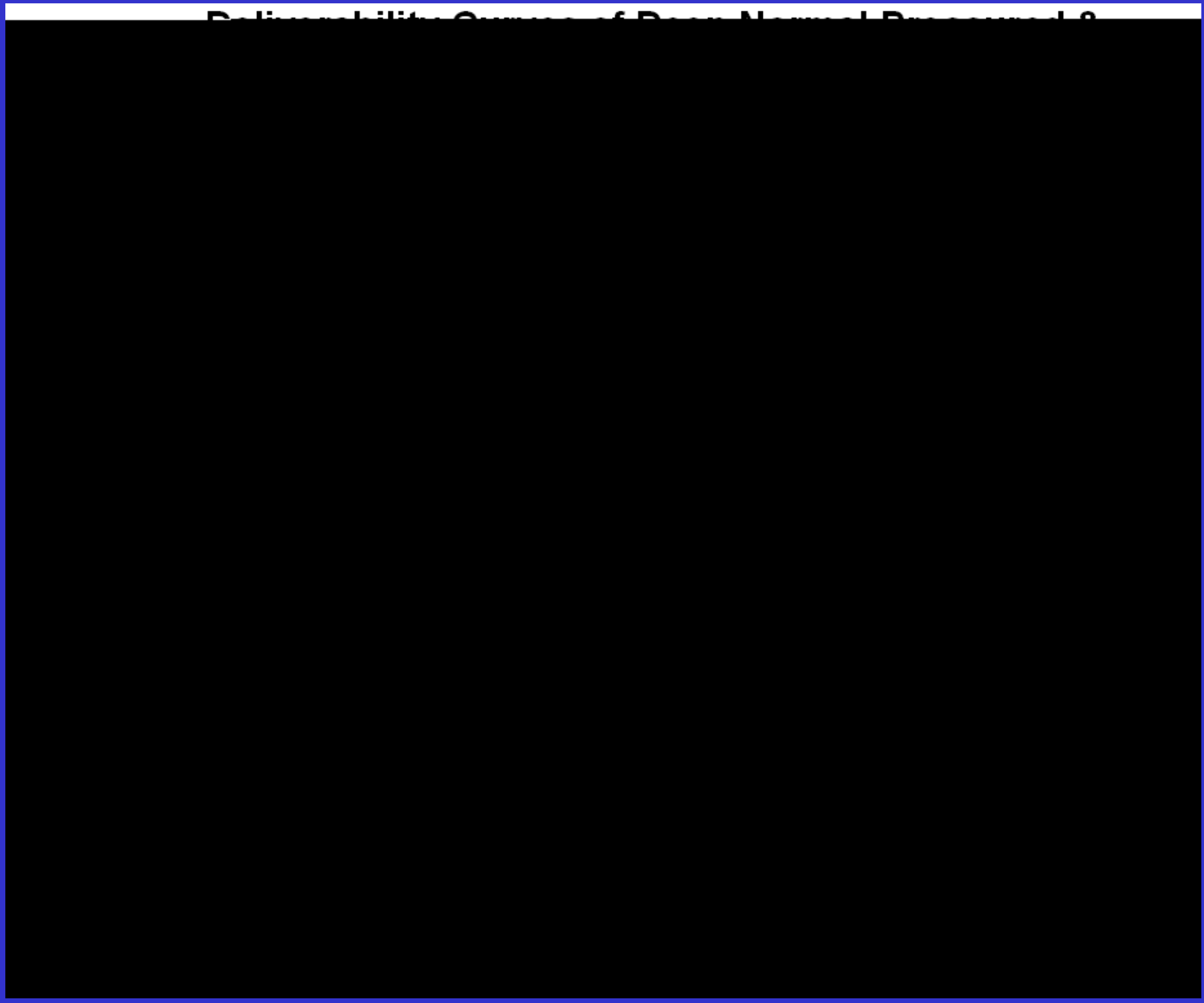
	Self-flowing Well	Pumped Well
Geothermal Power (kW)	120	3,700
Gas-derived Power (kW)	250	1,850
[redacted]		
Total Capital Cost ($)	12,711,000	23,060,000
Unit Capital Cost ($)	34,354	12,464
Net Revenue ($/year)	154,526	1,847,484
Pay-out Time (years)	82.3	12.5

Mud Weight versus Depth for a Geopressured Well in South Louisiana



CASE HISTORIES OF TWO GEOPRESSURED WELLS

CHARACTERISTICS	CASE 4: New well drilled in Louisiana	CASE 5: Existing well in Texas
Depth (feet)	16,000	16,465
Tubing Diameter (in)	5-1/2	5-1/2
Permeability (md)	260	300



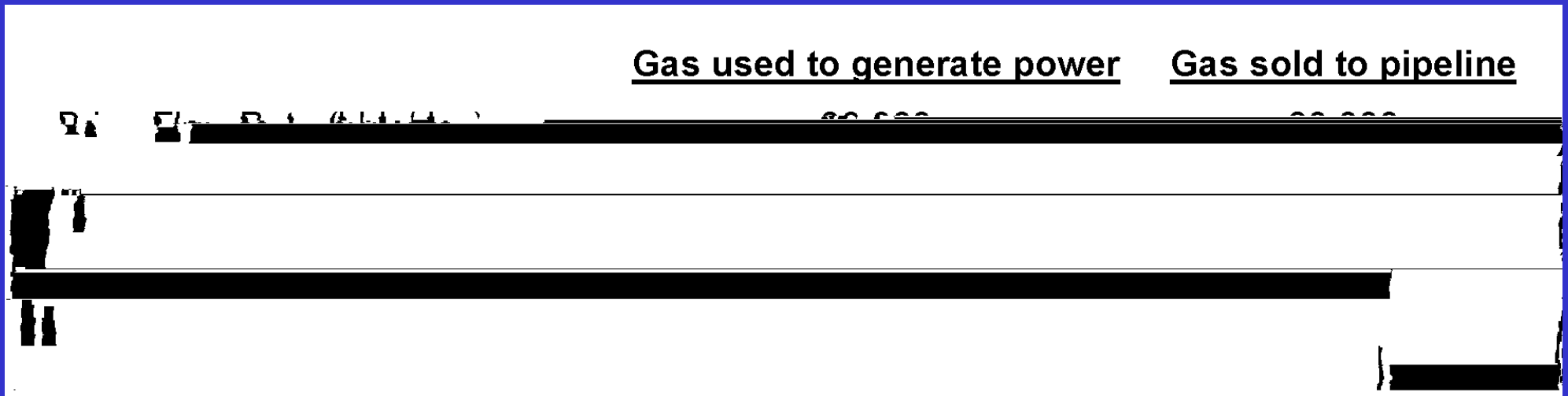
ECONOMIC ISSUES FOR CASE 4 (20 SCF/bbl)

	Gas used to generate power	Gas sold to pipeline
Brine Flow Rate (bbl/day)	50,000	50,000
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
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)

	Gas used to generate power	Gas sold to pipeline
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	
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 ($)	20,120,000	15,720,000

ECONOMIC ISSUES FOR CASE 5



	Gas used to generate power	Gas sold to pipeline
Total Net Power (kW)	2,040	720
Gas Sold (MCF/day)	–	480
Well workover Cost ($)	2,000,000	2,000,000
Total Capital Cost ($)	7,568,000	4,688,000
Unit Capital Cost ($)	2,867	–
Net Annual Revenue ($)	1,031,200	974,400
Pay-out Time (years)	7.3	4.8

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 geopressued 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