



051-06073



**Step Rate and Injection/Falloff Test Results for
Hotchkiss Federal 1289 #18-22D
CBM Test Well**

**Final Report for
Gunnison Energy Corporation an Oxbow Company**

Project No.: Gunn-1681

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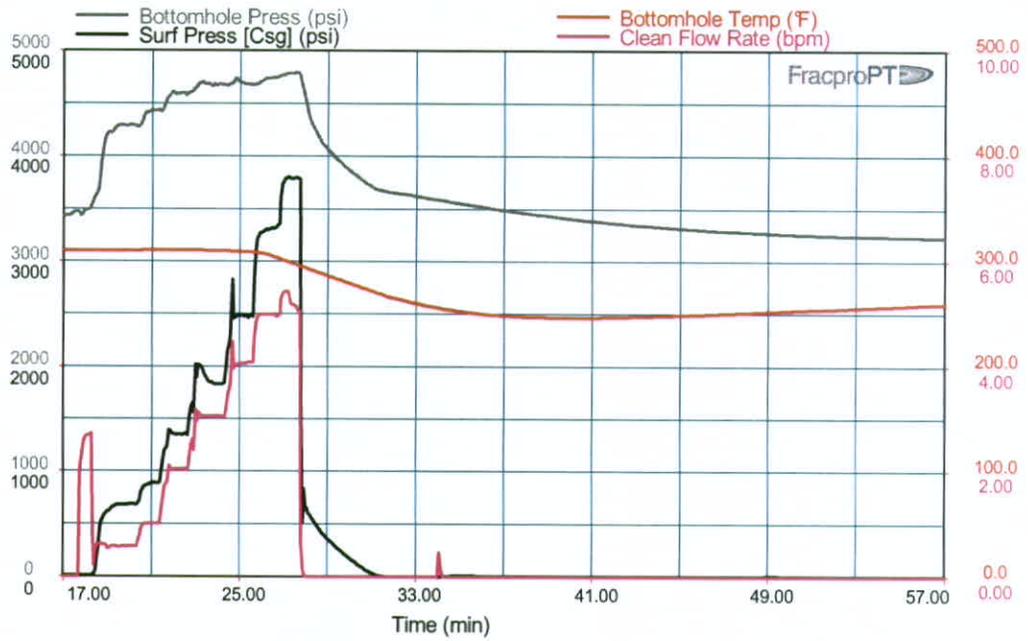
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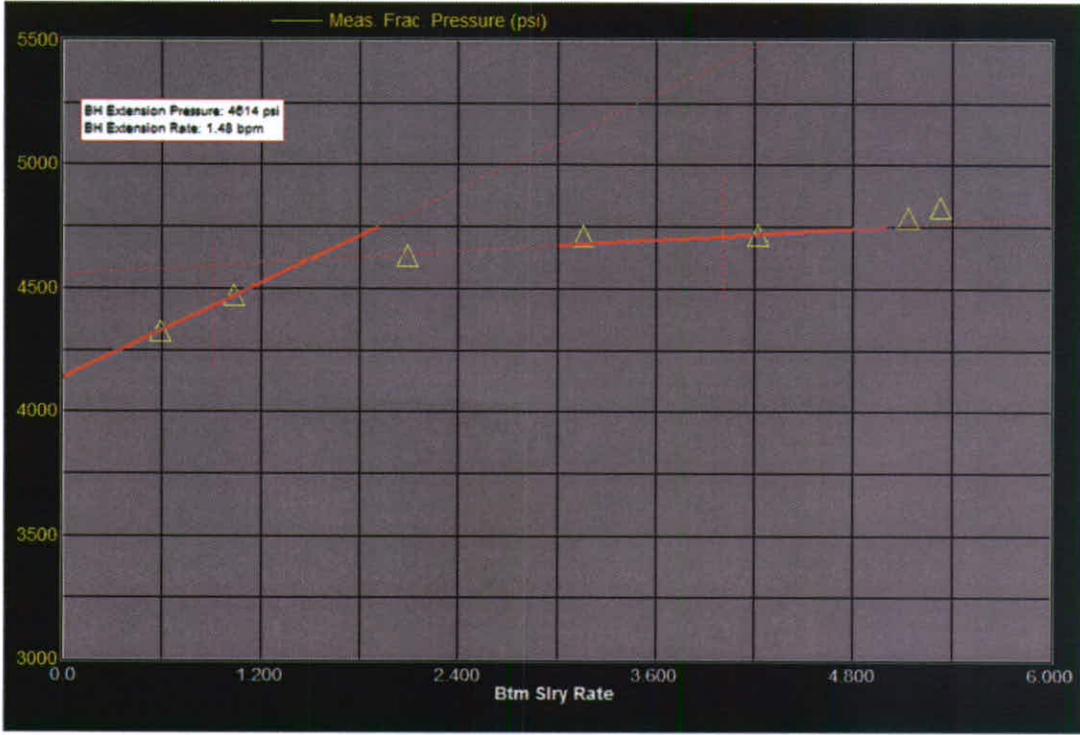
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1. Executive Summary

Pinnacle Technologies, Inc. conducted a step rate and injection/falloff test in a wellbore located in Gunnison County, Colorado for Gunnison Energy Corporation an Oxbow Company. This report discusses the work performed in the Hotchkiss Federal 1289 #18-22D wellbore. The purpose of the work was to determine both hydraulic fracture extension pressure and *in situ* permeability to water in a large perforated water disposal interval.

Pinnacle used its Denver, CO-based injection/falloff expert to conduct the test. Tefteller bottom hole pressure and temperature measurement equipment was used for the test, with Halliburton measuring surface injection rates and pressures. Both tests were conducted in a perforated interval from 8,654 to 8,725 ft, having a gross pay of 71 ft.

Fracture extension pressure and rate was determined from a step rate test, pumped prior to the injection test, and was used to determine maximum injection pressure to remain within a matrix flow regime. The step rate test was designed with 9 steps from 0.5 to 8 bpm. However, with relatively high surface pressures experienced at the higher rates, horsepower limitations of the Halliburton equipment only allowed a maximum flow rate of 5 bpm. Bottom hole fracture extension pressure was found to be 4,610 psi (0.52 psi/ft) at a rate of 1.5 bpm.

For the permeability test, fresh water was injected for 3 hours at an average rate of 1.1 bpm with a surface injection pressure of about 650 psi. The well was shut-in downhole and allowed to fall off for 111 hours following the injection period. Gunnison Energy provided the porosities for three distinct layers within the gross pay interval of 10.5%, 6.0% and 7.5% with corresponding layer thicknesses of 22, 20 and 29 ft. Using a multilayer analysis, with the porosities and layer thicknesses provided, analysis of the pressure falloff data with a single-phase pressure transient analysis program resulted in permeability to water of 12.7, 0.5 and 1.0 mD in the three distinct layers. The calculated skin is -4.0, indicating that the reservoir was stimulated.

Results of the injection/falloff testing are shown in **Table 1** below.

Table 1. Job Summary

Company:	Gunnison Energy Corporation an Oxbow Company		Project No.:	Gunn-1681	
Treatment Well:	Hotchkiss Federal 1289 #18-22D		API No.:	05-051-06073	
Field:	Wildcat				
County:	Gunnison				
State:	Colorado				
Surface Location:	N39.017551 W107.379605				
Casing	4 ½ inch 11.6 lb P-110	Casing ID (in)	4.0	Casing Capacity (gal/ft)	0.652
Tubing	2 3/8 inch 4.7 lb J-55	Tubing ID (in)	1.995	Tubing Capacity (gal/ft)	0.162

Treatment Date:		January 24, 2007
Perforated Interval (MD):	ft	8,654 to 8,725
Formation Type		Granite Wash
Net Pay		71
Packer Depth	ft	8,570
Pressure Gauge Depth	ft	8,590

Treatment Volumes:

Fresh Water	bbl	197
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Rates & Pressures:

Hydrostatic	psi	3,763
Bottomhole Fracture Extension Pressure	psi	4,610
Fracture Extension rate	bpm	1.5
Average Injection Rate	bpm	1.09
Average WHTP	psi	647
ISIP	psi	250

Results & Analysis:

Shut in time	h	111
Reservoir Temperature	°F	308
Water Formation Volume Factor	bbl/STB	1.078
Calculated Water Viscosity	cp	0.1783
Formation Porosity	%	10.5 6 7.5
Formation Thickness	ft	22 20 29
Water Compressibility	psi ⁻¹	4.12e-06
Model used	Type	Multilayer Rectangular

Calculated:

Calculated Permeability	mD	12.7	0.5	1
Calculated Transmissivity	mD·ft/cp	1559	56	157
Calculated Skin Factor		-4.0	-4.0	-4.0
Calculated Average Reservoir Pressure	psi	3,183		
Calculated Average Reservoir Pressure Gradient	psi/ft	0.37		

Pinnacle Personnel:

On site supervisor		B. Laging
Project Manager		B. Laging
Documentation		B. Laging
Report Review		L. Weijers

2. Field Operations Summary

- Arrive on location and setup Tefteller slickline and Halliburton equipment. Conduct safety meeting and review job procedures and expectations with all personnel on location.
- Nipple up wellhead connections, pressure test surface injection lines to 5,000 psi and annulus to 3,000. Fill tubing and conduct a step rate test. Cease pumping and record ISIP, 5, 10 and 15 minute pressure readings. Pressure went to zero, on surface, after only 3 minutes.
- 2 hours after step rate shutdown, inject into the target perforated interval for at least three hours and record surface injection rates and injection pressures.
- Shut-in well downhole for minimum of 72 hours by pumping down Tefteller slickline plug.
- Nipple down wellhead assembly and demobilize equipment. Clean up and secure location for future completion work.

3. Step Rate Test

Pinnacle conducted a step rate test prior to the injection fall/off test. The purpose of the step rate test was to determine the hydraulic fracture extension pressure and rate. The step rate test was designed to have 9 steps from 0.5 to 8 bpm. Halliburton’s acid pump truck was only able to reach 5 bpm. A total of 27.1 bbl were injected during this test. Rates and pressures are illustrated in **Figure 1**.

In **Figure 2**, stabilized rates and bottomhole pressure for the step rate test are plotted against each other to obtain a fracture extension pressure and a fracture extension rate. It is possible to fit two tangent lines to the data –at the low rates, where pressure response is associated with a matrix flow regime, and at higher rates, where pressure response is associated with injection into a hydraulic fracture system. The intersection of the tangent lines associated with these flow regimes represent the fracture extension pressure, at 4,610 psi, and the fracture extension rate, at 1.5 bpm.

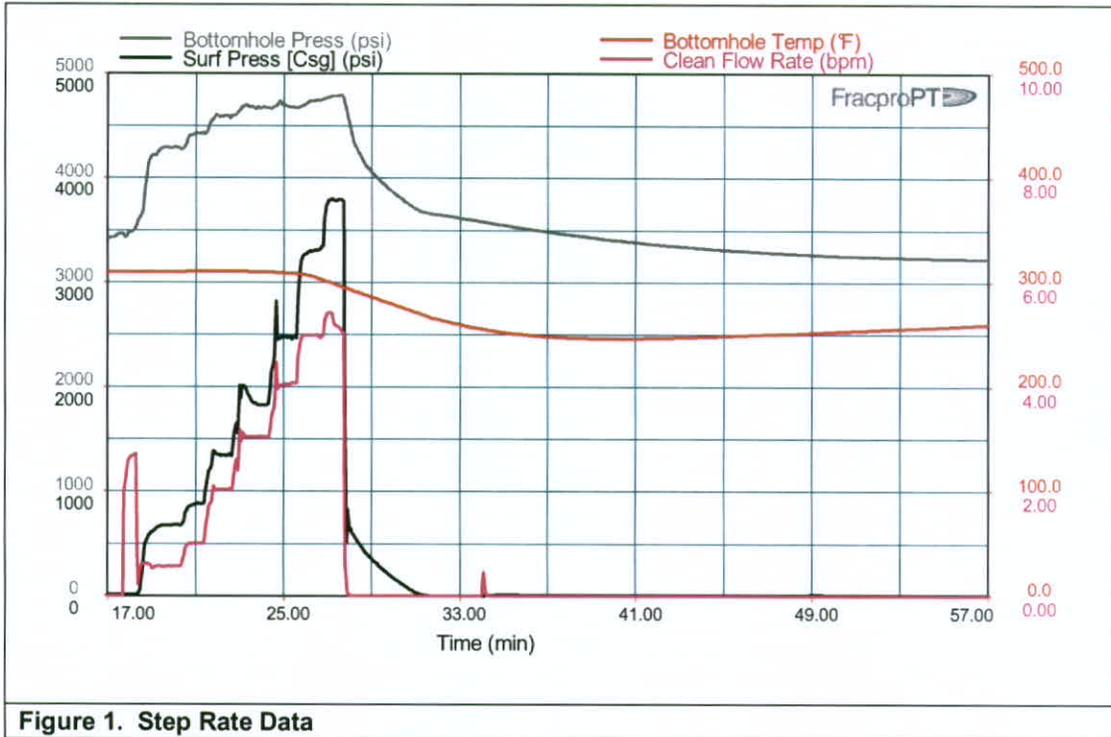


Figure 1. Step Rate Data

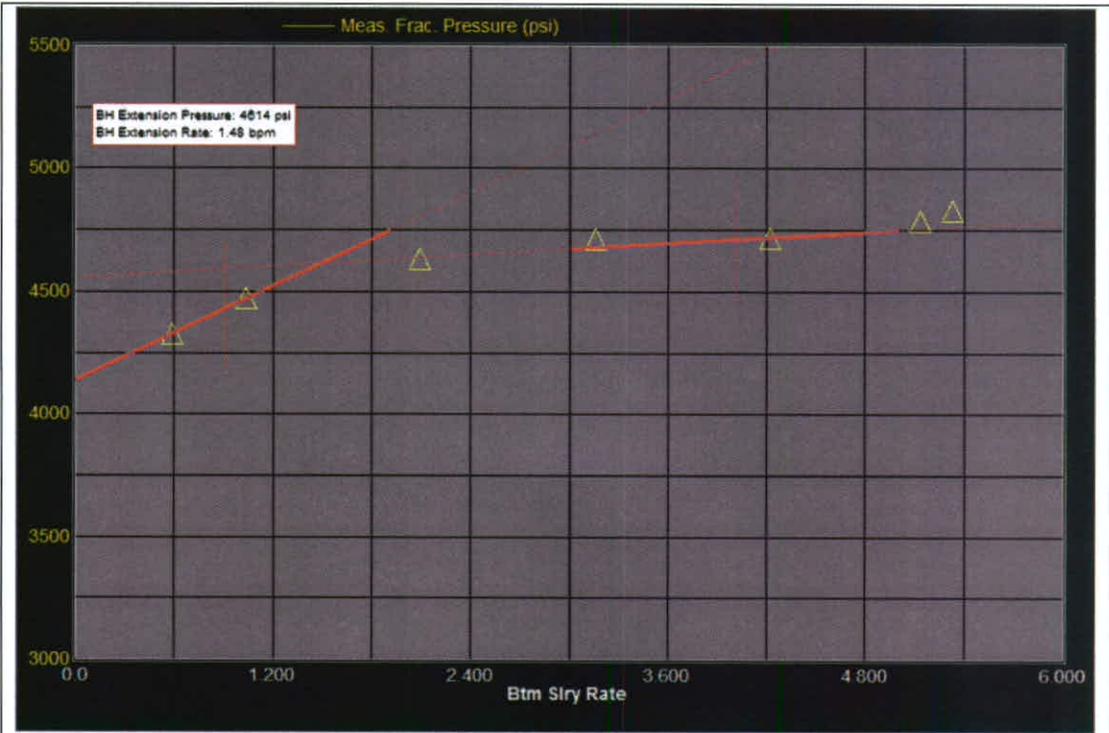
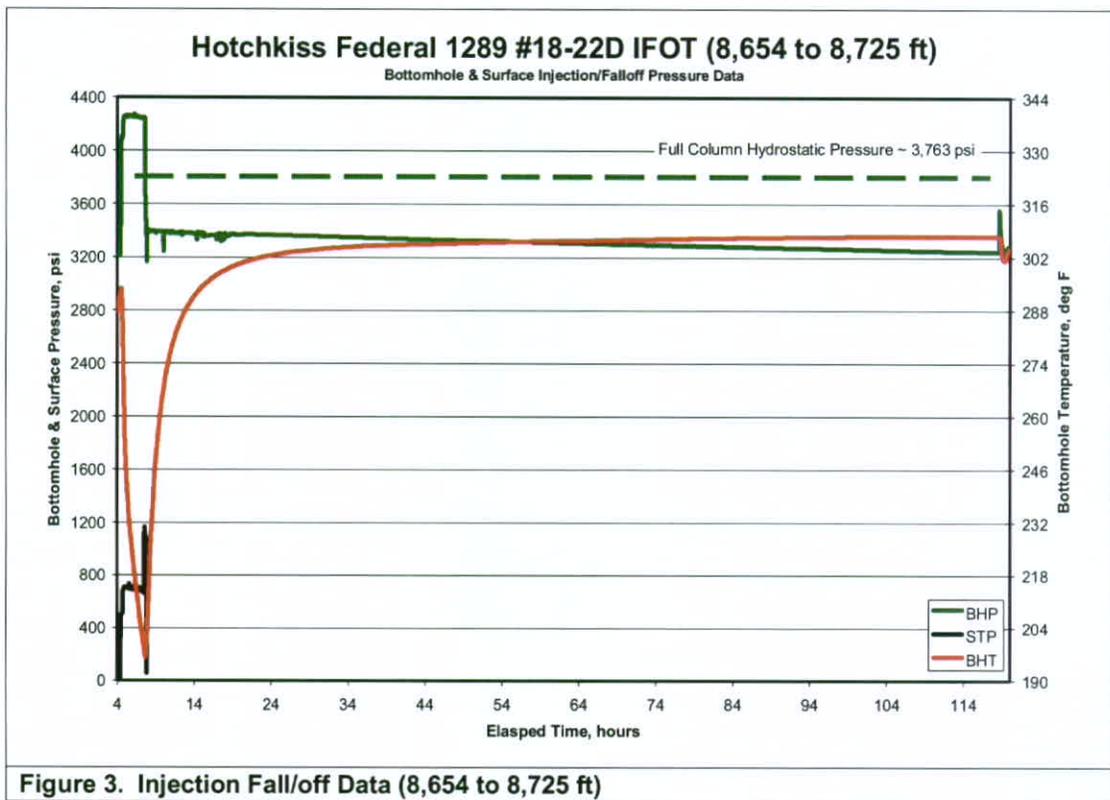


Figure 2. Bottomhole Pressure Versus Rate Plot for the Step Rate Test

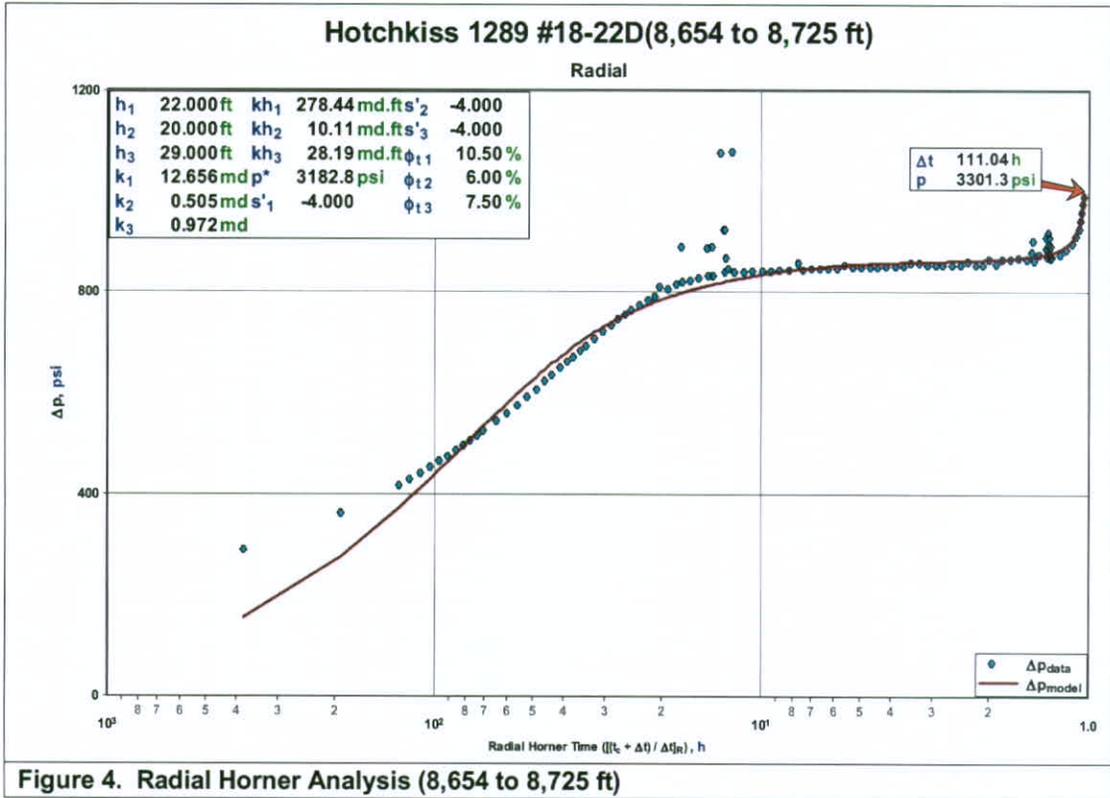
4. Injection Fall/off test

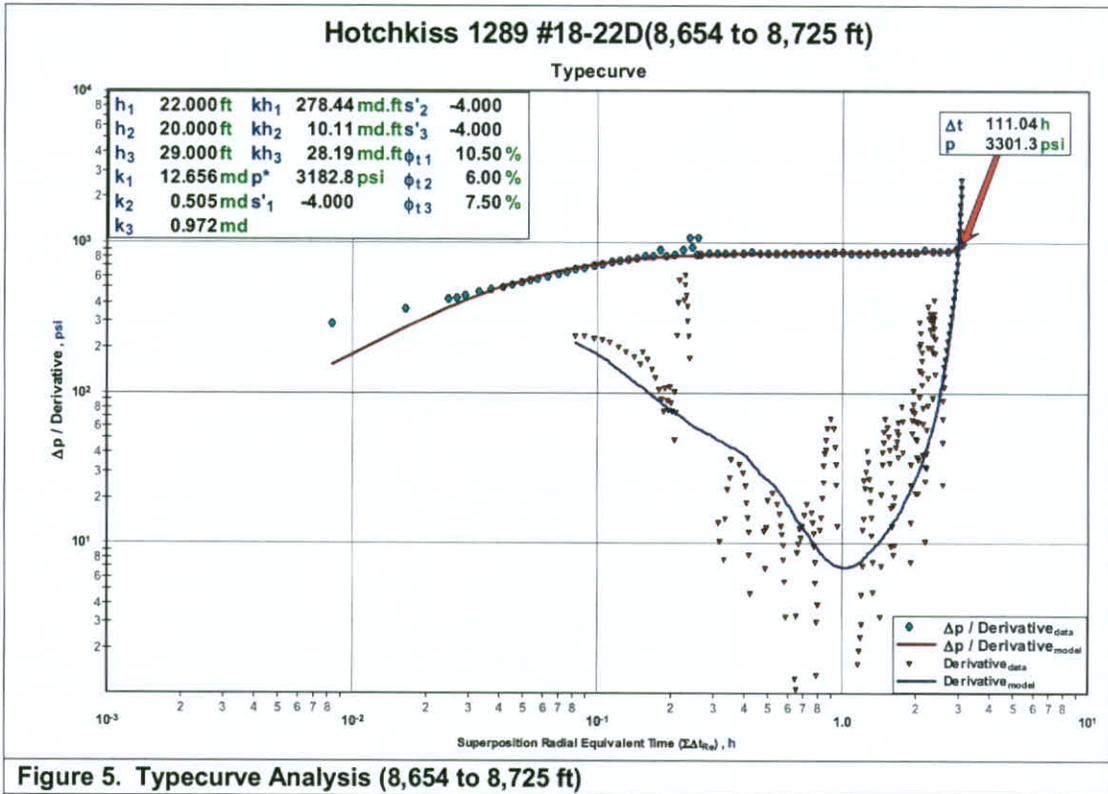
Following the step rate test Pinnacle conducted a single injection fall/off test, in the Granite Wash formation, perforated from 8,654 to 8,725 ft. **Figure 3** illustrates the data collected. Note that the bottomhole pressure measurement contains pressure spikes in the first few hours following shut-in. The cause of these pressure spikes is unknown.

Gunnison Energy provided the log analysis breaking down the 71 ft of gross interval into 3 sections of differing porosity. The top 22 ft was given a porosity of 10.5%, the middle 20 ft 6% and the remaining 29 ft 7.5%. Using the provided information a three layer rectangular single-phase pressure transient analysis model was created for data analysis. **Figure 4** and **Figure 5** show the Radial Horner plot and the Typecurve analysis plots respectively. At approximately 409 ft from the wellbore the Horner plot indicates a possible boundary, most likely a fluid differential pressure boundary caused by the different salinity of the injected water vs. reservoir water.



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5. Conclusions and Recommendations

5.1 Conclusions

1. All injections were conducted without complications. The data collected is of fair quality. The downhole pressure data shows spikes of unknown cause. These spikes were eliminated from the analysis and have no impact on the final analysis results.
2. The step rate test, conducted before the main injection, resulted in a bottomhole hydraulic fracture extension pressure of 4,610 psi at a rate of 1.5 bpm.
3. Permeability to water was found to be 12.7, 0.5 and 1.0 mD in the three distinct layers for which Gunnison provided porosities. Analysis of the pressure falloff data was conducted using a multi-layer setting with porosities provided by Gunnison in a single-phase pressure transient analysis program.
4. The calculated skin is -4.0 , indicating that the reservoir was stimulated and that there was no substantial near-wellbore damage. It is possible that the negative skin was created by the step rate test.
5. The analysis of the injection test falloff shows an average reservoir pressure gradient of 0.37 psi/ft.

5.2 Field development Recommendations

1. Continued testing throughout the development of this field will aid in optimizing completions and help focus on the commercial coal intervals.
2. Conduct permeability testing on select seams throughout the development phase of the field to optimize completion practices. Additionally, permeability testing can help define optimum well spacing in the field.
3. Following completion of the wells and sufficient production testing, pressure transient testing should again be conducted to ascertain effective reservoir permeability for dewatering.

6. PermPT Surface Injection Data Sheet

Table 2. Test #1 (8,654 to 8,725 ft)

Pinnacle Technologies PermPT Surface Data Sheet								
Test Date: January 24, 2007								
Well Name:	Hotchkiss Federal 1289 #18-22D							
Operator:	Gunnison Energy							
Perforations:	8654	ft to	8725	ft	LDHPG:	8590	ft	
Fluid Type:	Fresh water		Breakdown:		psi	UDHPG:	8566	ft
Fluid Gradient:	0.433	psi/ft	Frac Gradient:	0.70	psi/ft	PKR:	8570	ft
Hydrostatic:	3763	psi	Max STP:	2204	psi	RBP		ft

Injection Test Data				
Time of Day (24hr) (hh:mm)	Δt (min)	Injection Rate (bpm)	Injection Pressure (psi)	Comments
14:56	0	0.8	414	Began injection portion of test
15:11	15	0.8	515	
15:26	30	1	701	
15:41	45	1	706	
15:56	60	1.1	705	
16:26	90	1	694	
16:56	120	1	695	
17:26	150	1	692	
17:56	180	1	700	Concluded injection portion of test
Test Totals		197.0		
Average		1.09	646.9	

Additional Comments:
07:00 Lead from field entrance to location
07:30 Rig up Teffteller.
12:30 Pressure test lines
14:56 Began injection test.
17:45 RIH with slickline plug.
18:04 Seat slickline plug to conclude injection portion of test.
Pressured up on TBG to 1,000 psi. Max pressure on downhole plug is 1200 psi. on surface
Pinnacle on-site supervisor: Brian Laging