

30-045-26420

## MEMORANDUM

**TO:** Kate Rao, U.S. Environmental Protection Agency, Region IX  
**FROM:** James Walker, James Walker Environmental Consulting/Horsley Witten Group  
**DATE:** May 27, 2014  
**SUBJECT:** Technical Memorandum, Evaluation of Step-rate Test of the Hogback 18-43 Water Disposal Well Conducted on April 29, 2014

### Introduction

Vision Energy performed a step-rate test (SRT) on the Hogback 18-43 Class II disposal well on April 30, 2014 following a workover to reperforate and acidize the Entrada Formation injection zone. The purpose of the SRT was to determine the fracture gradient of the Entrada injection zone and allow the Navajo Nation EPA to increase the maximum allowable surface injection pressure (MASIP) above the current MASIP of 425 pounds per square inch gauge (psig). That would allow the operator to increase the maximum injection rate anticipated in future operations on the lease. The injection zone is located in the perforated interval from 2,140 to 2,180 feet electric log depth.

### Discussion of Step-Rate Test Procedures.

The initial bottom hole shut-in pressure of the well was 1,155.9 psig, increasing from 1,155.7 psig over a one-minute interval, which equates to a pressure gradient of 0.467 psi/foot, just prior to starting the SRT. That pressure gradient exceeds the hydrostatic pressure gradient (0.430 psi/foot.) of the fresh water used in the SRT, which indicates that the injection zone is somewhat overpressured if the shut-in pressure of 1,155.9 psig represents a static reservoir pressure. The well was acidized before the SRT was performed, which would have elevated the reservoir pressure temporarily. Therefore, we cannot be certain that the initial shut-in pressure stabilized to a static level before the SRT. Not reaching a static reservoir pressure before starting the SRT could affect the validity of the SRT.

The SRT was performed in 12 steps, increasing the rate approximately 0.5 barrels per minute (bpm) in each step and the step time duration was 15 minutes in each step. The operator encountered difficulty establishing the starting rate and limiting it to 0.5 bpm. Consequently, the initial rate was 0.8 bpm at a final pressure of 1,297.7 psig. It would have been preferable to start at a lower rate and pressure, but the interpretation of the fracture gradient may be unaffected by the higher than optimum starting rate. The SRT was otherwise performed consistent with EPA and industry standards except for the possible failure to reach static pressure conditions before starting the SRT. The Summary of Test Data for the SRT and a plot of the injection pressure versus rate are enclosed.

### SRT Results and Interpretation

The results of the SRT are inconclusive because the bottom hole pressure versus rate plot fails to show a definitive break point and decrease in slope that would indicate the formation parting pressure had been reached. There are two points at which the slope decreases somewhat, but the changes are insufficient to definitively indicate a formation parting pressure had been reached. The pressures at those possible break points are approximately 1,353 and 1,420 psig. If that is a valid interpretation, it could indicate that an initial fracture occurred or opened at 1,353 psig followed by a secondary fracture at 1,420 psig in a more

fracture resistant interval. If available, it would be useful to review the pressure versus injection rate of the acid stimulation treatment to compare with the SRT results.

It is possible that the fracture pressure was not reached during the SRT. The maximum pressure imposed during the SRT was 1,462 psig, which equates to a pressure gradient of 0.68 psi/foot. The pressure gradients at the two possible break points are 0.63 and 0.66 psi/foot. Typical fracture gradients in consolidated sandstones such as those within the Entrada Formation are on the order of 0.70 psi/foot or greater. The current maximum allowable surface injection pressure is 425 psig, which equates to 1,354 psig at 2,160 feet and a gradient of 0.63 psi/foot without consideration of friction losses in the tubulars.

Based on the 2013 Annual Monitoring Report for this well and the SRT injection rates and pressures, it appears that the reperforation and acid stimulation treatment of the well increased the injectivity by more than four times the average injection rate of 445 barrels per day (bpd) in October, 2013. The injectivity increase may be less than four times due to the short 15 minute duration of the SRT steps, which may not represent injectivity over an extended period of sustained injection. Nevertheless, the data indicate a significant increase was attained. Consequently, an increase in the MASIP may not be necessary to attain the desired maximum injection rate. The operator did not provide a proposed injection rate for future operations.

### **Recommendations**

Limit the maximum allowable surface injection pressure to 400 psig, based on the lower possible break point of 1,353 psig on the SRT plot at 2.5 bpm and 404 psig wellhead pressure at that rate. That would allow a maximum injection rate of approximately 2.5 bpm or 3,600 bpd based on the SRT results. The maximum recent injection rate was only 445 bpd in October, 2013. That should allow ample excess capacity for injection rate increases in the future. The alternative is to rerun the SRT with a higher final injection pressure in order to determine whether the actual fracture gradient exceeds the highest pressure imposed in the recent SRT.

Since the shut-in bottom hole pressure apparently exceeds the normal hydrostatic pressure gradient by a significant amount, we would recommend that a periodic fall-off test (FOT) be performed to evaluate the adequacy of the one-half mile radius area of review (AOR) for this well. It has been active for 20 years and the permit may be overdue for a review of permit conditions and limitations. The FOT would provide a more accurate measure of static reservoir pressure and permeability, which would allow a re-evaluation of the Zone of Endangering Influence (ZEI) in the Entrada injection zone and possibly require an increase to the AOR size if less than the ZEI. Any improperly constructed and/or abandoned wellbores that penetrate the Entrada injection zone within the AOR could require corrective action. Based on the ZEI determined for the Dugan West Bisti Unit SWD #1 disposal well, which is completed in the Entrada Sandstone and located approximately 20 miles south of the subject well, the ZEI may be much larger than the initial 0.5 mile radius AOR attributed to the subject well.

Enclosures

BOTTAM  
3 X 5 TO 17 INCHES  
KALPPELL & ERSER CO. HOUSTON TEX.

46 0862

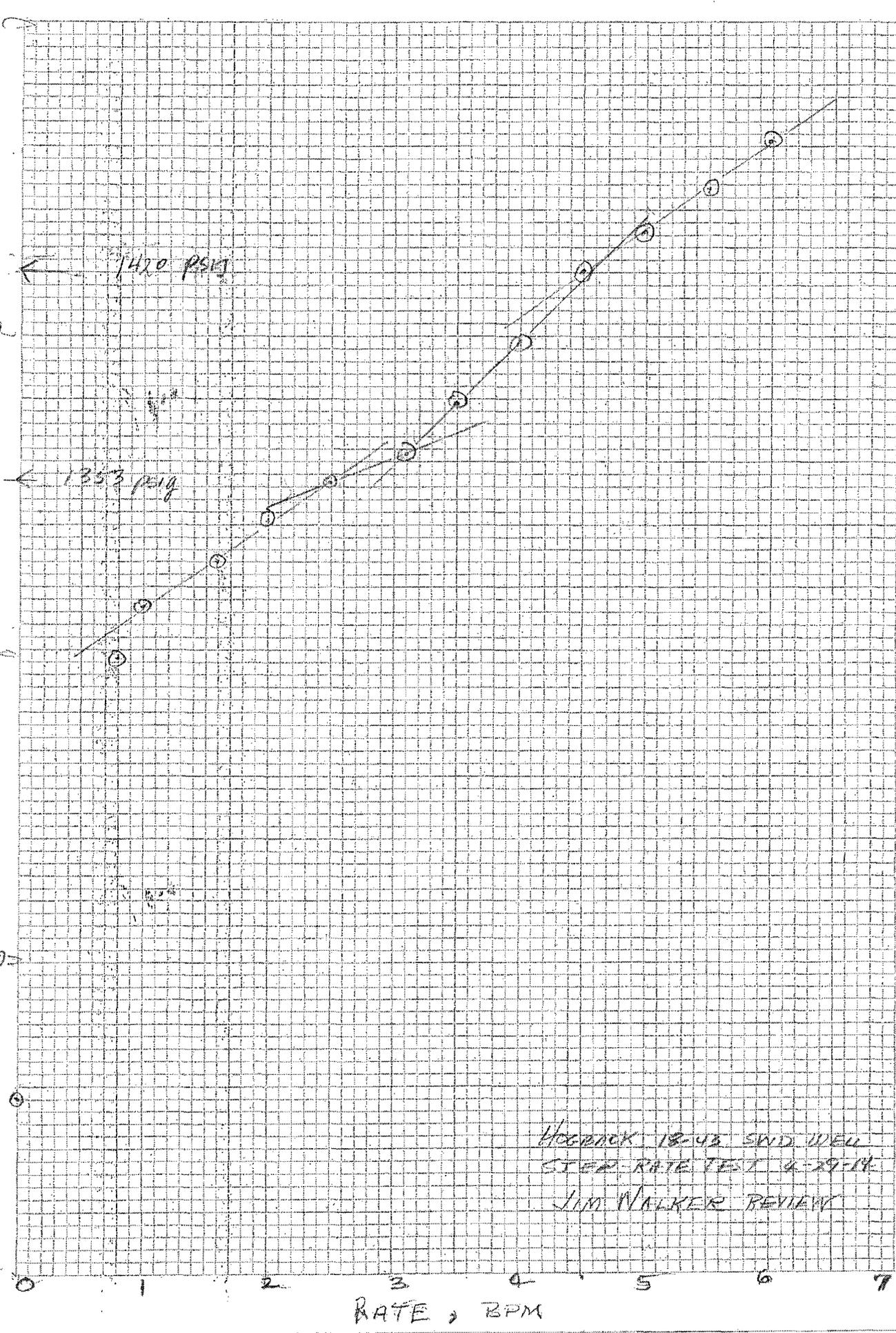
1500

1400

1300

2000

1100



HOEDACK 18-43 SWD WELL  
STEP RATE TEST 4-29-14  
JIM WALKER REVIEW

RATE, BPM

SUMMARY OF TEST DATA  
HOGBACK 18-43 CLASS II DISPOSAL WELL  
APRIL 29, 2014

Period	Start	Step	Rate	Time	WHP	BHP	Step	Cum	Step	Cum	Comments
Time	Step	bpm	min	psig	psig	bbl	Vol	Vol	Vol	Vol	
							bbl	bbl	gal	gal	
7:58		0.0		179	1156.5						
8:00	1	0.8	15	314	1297.7	11.3	11.3	475	475	475	Rump crew struggled to get low rate, choked thru valve, 1st downstream of pressure measurement, then upstream. Switched valves sometime during this step. Surface pressure may be affected.
8:15	2	1.0	15	314	1314.4	15.0	26.3	630	1,105	1,105	Still some choking thru valve but this time upsteam of pumps
8:30	3	1.6	15	330	1328.4	23.8	50.2	1,001	2,106	2,106	Discrepancy between micro motion rate & turbine volume count. Chose to go by micro motion rate.
8:45	4	2.0	15	381	1341.9	30.0	80.1	1,259	3,366	3,366	
8:50	5	2.5	15	404	1353.4	37.9	118.0	1,591	4,957	4,957	
9:15	6	3.1	15	426	1362.5	45.8	163.8	1,923	6,880	6,880	
9:30	7	3.5	15	471	1378.8	52.7	216.5	2,212	9,092	9,092	
9:45	8	4.0	15	493	1398.5	60.1	276.6	2,526	11,618	11,618	
10:00	9	4.5	15	538	1420.3	67.9	344.5	2,850	14,468	14,468	Plot of BHP vs rate still looked inconclusive, decided to add two more steps. Approved by Leroy.
10:15	10	5.0	15	583	1433.6	75.2	419.7	3,159	17,628	17,628	
10:30	11	5.5	15	628	1446.8	82.3	502.0	3,456	21,083	21,083	
10:45	12	6.0	15	695	1461.5	90.5	592.4	3,799	24,883	24,883	
ISIP				426	1455.0						BHP ISIP implies 7 psi perf friction, Wellhead ISIP implies additional 262 psi of tubing and surface pipe friction at final 6 bpm rate.
10:50			5	381	1403.2						5 minute shut in value
10:55			5	359	1369.6						10 minute shut in value
11:00			5	336	1344.9						15 minute shut in value