

**DAVID VOORHIS & ASSOCIATES**

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March 30, 1998

Mr. Larry D. Wright, P.E.  
Water Quality Protection Division - Source Water Protection  
Environmental Protection Agency  
1445 Ross Avenue  
Dallas, Texas 75202-2733

Re: TRRC Lack of Regulatory Control  
over EPA Class II Injection Wells

Dear Mr. Wright:

This letter is to bring to your attention some other problems with the Texas Railroad Commission (TRRC) program for EPA Class II injection wells. The problems will relate to the ..... Well No. 6 water injection well cited in my previous letter/report to you, dated February 20, 1998. The following three problems areas are briefly discussed by this letter:

- 1) Problems in Setting of Initial Injection Pressures,
- 2) Problems of When Injection Begins, and
- 3) Problems of Accurate Reporting of Injection Volumes and Pressures.

**1.0 Problems in Setting of Initial Injection Pressures:**

The initial, maximum allowable injection pressure for many of the TRRC approved injection projects may create downhole pressures that are higher than the formation parting pressure. Before describing a real world example, general equations for approximating the downhole fracture pressure and the downhole injection pressure will be presented. The equations are as follows.

$$p_{frac} = \text{Fracture Gradient} \times \text{Depth} \tag{1}$$

$$p_{wf} = p_{wh} + \Delta p_{el} - \Delta p_f \tag{2}$$

where

- $p_{frac}$  = wellbore pressure at the completion interval depth required to hold the fracture open
- $p_{wf}$  = wellbore pressure at completion interval depth
- $\Delta p_{el}$  = pressure due to the weight of the injected fluid from the wellhead to the completion interval depth
- $\Delta p_f$  = pressure drop due to the friction from the wellhead to the completion interval

An example of this problem can be seen in the TRRC approved application for the ..... Well No. 6 water injection well (TRRC District 9, Project No. F.....). Fracture gradient data from companies that perform fracture stimulations in the area indicate the Strawn and Ellenburger

formations have fracture gradients that range from 0.4 to 0.65 psi/ft. The top of the injection interval for the Strawn in the ..... Well No. 6 is at 1654 feet. The fracture gradient data represents the downhole wellbore pressure that will hold a fracture open. Calculations using equation (1) indicate the downhole pressure,  $p_{frac}$ , that will hold a formation fracture open in the ..... Well No. 6 ranges from 662 to 1075 psi. This downhole fracture pressure range is estimated as the fracture gradient times the depth of the top of the injection interval ( lower limit:  $661.6 = 0.4 \times 1654$ ).

The approved TRRC permit allows the ..... Well No. 6 to inject fluids at a maximum pressure of 650 psig and a maximum rate of 200 stbwpd. Form H-1A of the injection application indicates 1650 feet of 2 <sup>3</sup>/<sub>8</sub> inch tubing (ID  $\approx$  1.995 inch) is used. The oilfield brine injected is estimated to have a fluid gradient of 0.465 psi/ft. Calculations reveal that  $\Delta p_{el} \approx 767$  psi and  $\Delta p_f \approx 0.9$  psi. When these values are substituted into equation (2) the TRRC approved, maximum downhole injection pressure,  $p_{wf}$ , is 1416 psi ( $1416 \approx 650 + 767 - 0.9$ ). Since  $p_{wf} \geq p_{frac}$ , the TRRC maximum approved wellhead injection pressure allows the creation of downhole injection pressures that are above formation fracture pressures. Injection operations at or above formation parting pressures are dangerous because uncontrolled fluid movement can result. This analysis is valid if the formation fracture gradient for the ..... Well No. 6 falls into the 0.4 to 0.65 psi/ft fracture gradient range.

The annual injection well reports (Form H-10's) indicate the ..... Well No. 6 is injecting at pressures that exceed the Strawn formation parting pressure. The analysis above revealed that the Strawn in Well No. 6 is estimated to have a downhole formation fracture pressure that ranges from 662 to 1075 psi. The 1996-1997 Form H-10 reports (enclosed as Additional Documents) indicate the average wellhead injection pressure is near 400 psig. The lease water production analysis of Problem 3.0 indicates actual water injection may be as high as 125 stbwpd. Calculations with these parameters reveal that  $\Delta p_{el} \approx 767$  psi and  $\Delta p_f \approx 0.4$  psi. When substituted into equation (2), the downhole injection pressure,  $p_{wf}$ , is 1167 psi ( $1167 \approx 400 + 767 - 0.4$ ). Since  $p_{wf}$  is greater than the estimated range of pressures for formation fracturing, there is a good likelihood that the ..... Well No. 6 is being operated at pressures that exceed the Strawn formation parting pressure.

One possible solution to this problem is to require initial permitted downhole injection pressures of newly approved injection projects **to be less than** the estimated formation fracture pressure. This means the permitted wellhead injection pressure must be restricted such that downhole injection pressures are less than formation parting pressures. The best available data concerning formation parting pressure should be used in setting these limits. Formation fracture pressure data may be derived from: service company databases of area formation fracture gradients; instantaneous shut-in pressures from stimulation treatments; and step rate test data from similar or offsetting injection projects, or on the authorized injector in question. Other sources for formation parting pressures may exist that have not been mentioned.

## 2.0 Problems of When Injection Begins:

There may be a lack of regulatory control by the TRRC concerning when an applicant may begin injection. The ..... Well No 6 was approved for injection on November 6, 1995. The Annual Disposal/Injection Well Monitoring Report (TRRC Form H-10) indicates injection began in the ..... Well No. 6 in September 1995. The 1995 Form H-10 indicates the operator began injection approximately **2 months before** he received his permit for injection.

A copy of the TRRC permit approval letter and copies of the TRRC computer database record for the 1996 and 1997 Form H-10 injection reports are enclosed with this letter. Page 2 of the TRRC injection permit letter for the ..... Well No. 6 indicates the TRRC approved and issued the permit

for water injection on November 6, 1995. The 1996 H-10 data reveals injection in the ..... Well No. 6 started in September 1995.

### 3.0 Problems of Accurate Reporting of Injection Volumes and Pressures:

There may be a lack of regulatory control by the TRRC concerning accurate reporting of injection volumes and pressures for Class II injection projects. An example of this problem may exist in the reporting of injection volumes on TRRC Form H-10 for the ..... Well No. 6 injection. Reported injected volumes on Form H-10 are supposed to be the cumulative volume injected by **month** for the 12 month reporting period. The 1996 and 1997 Form H-10's for Well No. 6 reports cumulative monthly injection volumes ranged from 95 to 190 barrels of brine. These reported monthly injection volumes are believed to be too low.

The ..... Well No. 6 injection is believed to be used for disposing **all** produced water (brine) from the ..... lease. The TRRC does not require operators to report lease water production, so annualized water-oil ratios were used to estimate lease water production. This analysis assumes monthly lease brine production should equal the reported ..... Well No. 6 injection volume. The 1995, 1996 and 1997 Annual Oil Well Status Reports (TRRC Form W-10) indicate the ..... Lease had producing water-oil ratios of 5.80, 3.79 and 10.91, respectively. These water-oil ratios (WOR's) were used to estimate lease brine production based on reported monthly oil production. The resulting WOR based, monthly brine production ranged from 1118 to 3753 stbw during the 1996 and 1997 H-10 reporting period. These values are much greater than the 95 to 190 stbw reported on the 1996 and 1997 Form H-10's. A possible conclusion from this analysis is that injection volumes for the ..... lease are being **under-reported**.

Two tables have been prepared and are enclosed with this letter to help you follow the above analysis. It should be noted that the TRRC Form H-10 reporting period for this lease ranges from September to August. The titles for the enclosed analysis tables are listed below.

- 1) TRRC Computer Database Record of 1995 through 1997 W-10 Test Results for Wells in the ..... Lease (TRRC ID# .....)- used to estimate WOR
- 2) TRRC Production & Injection Data for the ..... Lease for 1995-1998

The last column of table 2) provides estimates of the monthly water volume not accounted for with existing Form H-10 reports for the lease. It is believed that all of the water (brine) produced from the lease is injected into the ..... Well No. 6. The discrepancy between the estimated water volumes produced and reported water volumes injected may be due to an error by the operator in completing the Form H-10 reports. The operator may think the injection is reported in daily volumes.

Please let me know if you have questions concerning the information in this letter. I can be reached by telephone at (512) 261-3476 or by mail at the address listed in the letterhead of page 1.

Yours truly,

ORIGINAL SIGNED by David Voorhis

David B. Voorhis, Ph.D., P.E.  
Owner

**List of Additional Documents to:**

DBV Letter to Larry Wright/Lack of Regulatory Control  
March 30, 1998

- 1) TRRC Letter permitting injection into the ..... Well No. 6 (2 pages)
- 2) TRRC Computer Database of 1996 Form H-10 Report for the ..... Well No. 6 (1 page)
- 3) TRRC Computer Database of 1997 Form H-10 Report for the ..... Well No. 6 (1 page)
- 4) Table: TRRC Computer Database Record of 1995 through 1997 W-10 Test Results for Wells in the ..... Lease (TRRC ID# ..... ) - (1 page)
- 5) Table: TRRC Production & Injection Data for the ..... Lease for 1995-1998 (1 page)

Scanned and Reduced Copy of TRRC Letter approving water injection operations into the  
..... Well No. 6, page 1 of 2.

BARRY WILLIAMSON, CHAIRMAN  
CAROLE KEETON RYLANDER, COMMISSIONER  
CHARLES R. MATTHEWS, COMMISSIONER



DAVID M. GARLICK  
ACTING DIRECTOR, OIL AND GAS DIVISION  
LORI WROTENBERY  
DEPUTY DIRECTOR, OIL AND GAS DIVISION  
ASSISTANT DIRECTOR—ENVIRONMENTAL SERVICES

## RAILROAD COMMISSION OF TEXAS

### OIL AND GAS DIVISION PERMIT TO INJECT FLUID INTO A RESERVOIR PRODUCTIVE OF OIL AND GAS

PROJECT NO. F [REDACTED]

[REDACTED]  
P. O. Box [REDACTED]  
[REDACTED], TX 7[REDACTED]

Based on information contained in your application (Forms H-1 and H-1A) dated September 14, 1995, you are hereby authorized to use the following well to inject fluid into the Strawn Formation:

[REDACTED] Lease, ([REDACTED]), Well No. 6, Cooke County Regular Field, Cooke County,  
RRC District 09

Authority is granted to inject in accordance with Statewide Rule 46 of the Railroad Commission of Texas and subject to the following special and standard conditions:

#### SPECIAL CONDITIONS:

1. Fluid shall only be injected into strata in the subsurface depth interval from 1654 feet to 1662 feet.
2. The injection volume of salt water shall not exceed 200 barrels per day.
3. The maximum operating surface injection pressure shall not exceed 650 psig.
4. The authority to inject fluid is limited to the injection of salt water.
5. An annual annulus pressure test must be performed and the results submitted in accordance with the instructions of Form H-5.
6. The tubing-casing annulus pressure must be monitored at least weekly and reported annually on Form H-10 to the Commission's Austin Office.

#### STANDARD CONDITIONS:


1. Injection must be through tubing set on a packer.
2. The District Office must be notified 48 hours prior to:
  - a. running tubing and setting packer;
  - b. beginning any workover or remedial operation;
  - c. conducting any required pressure tests or surveys.

Scanned and Reduced Copy of TRRC Letter approving water injection operations into the  
•••••••• Well No. 6, page 2 of 2.

3. The wellhead must be equipped with a pressure observation valve on the tubing and for each annulus.
4. Prior to beginning injection and subsequently after any workover, an annulus pressure test must be performed. The test pressure must equal the maximum authorized injection pressure or 500 psig, whichever is less, but must be at least 200 psig. The test must be performed and the results submitted in accordance with the instructions of Form H-5.
5. The injection pressure and injection volume must be monitored at least monthly and reported annually on Form H-10 to the Commission's Austin office.
6. Within 30 days after completion, conversion to fluid injection, or any workover which results in a change in well completion, a new Form W-2 or G-1 must be filed in duplicate with the District Office to show the current completion status of the well. The date of the injection permit and the project number must be included on the new Form W-2 or G-1.
7. Written notice of intent to transfer the permit to another operator must be submitted to the Commission at least 15 days prior to the date the transfer will occur by filing Form P-4.
8. A well herein authorized cannot be converted to a producing well and have an allowable assigned without filing an amended Form W-1 and receiving Commission approval.
9. Unless other wise required by conditions of the permit, completion and operation of the well shall be in accordance with the information represented on the application (Forms H-1 and H-1A).

Provided further that, should it be determined that such injection fluid is not confined to the approved strata, then the permission given herein is suspended and the fluid injection must be stopped until the fluid migration from such strata is eliminated.

APPROVED AND ISSUED ON November 6, 1995.

  
Lori Wrotenberg, Assistant Director  
for Environmental Services

PROJECT NO.  
Page No. 2

TRRC Computer Database of 1996 Form H-10 Report for the ..... Well No. 6 (1 page)

UIC NUMBER 0000 [REDACTED] DISTRICT 09 BATCH-ITEM: [REDACTED]-0004  
TYPE OIL WELL NUMBER 6  
OPERATOR [REDACTED] NAME: [REDACTED] COMPANY  
FIELD NUMBER [REDACTED] NAME: COOKE COUNTY REGULAR  
LSE/ID NUMBER [REDACTED] NAME: [REDACTED]

DATE	INJ PRESSURE		TOTAL VOLUME		ANNULUS		
	AVG	MAX	BBL	MCF	CNT	MIN	MAX
09/95	0400	0425	00000105	00000000	30	0000	0000
10/95	0400	0425	00000115	00000000	31	0000	0000
11/95	0400	0405	00000100	00000000	30	0000	0000
12/95	0400	0400	00000100	00000000	31	0000	0000
01/96	0400	0400	00000105	00000000	31	0000	0000
02/96	0400	0425	00000095	00000000	28	0000	0000
03/96	0400	0400	00000120	00000000	31	0000	0000
04/96	0400	0400	00000115	00000000	30	0000	0000
05/96	0400	0405	00000100	00000000	31	0000	0000
06/96	0400	0400	00000105	00000000	30	0000	0000
07/96	0400	0405	00000100	00000000	31	0000	0000
08/96	0400	0415	00000120	00000000	31	0000	0000

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4B [ ] LUA

GATEWAY2 7/4 NUM CAPS

R 3 C 56

CERTIFICATION NO.  
980303 JAN 27 98  
RAILROAD COMMIS  
OF TEXAS

TRRC Computer Database of 1997 Form H-10 Report for the ..... Well No. 6 (1 page)

UIC NUMBER [REDACTED] DISTRICT 09 BATCH-ITEM:  
TYPE OIL WELL NUMBER 6  
OPERATOR [REDACTED] NAME: [REDACTED] COMPANY  
FIELD NUMBER [REDACTED] NAME: COOKE COUNTY REGULAR  
LSE/ID NUMBER [REDACTED] NAME: [REDACTED]

DATE	INJ PRESSURE		TOTAL VOLUME		ANNULUS		
	AVG	MAX	BBL	MCF	CNT	MIN	MAX
09/96	0400	0450	00000175		30	0000	0000
10/96	0410	0450	00000185		31	0000	0000
11/96	0400	0450	00000180		30	0000	0000
12/96	0410	0440	00000180		31	0000	0000
01/97	0410	0440	00000180		31	0000	0000
02/97	0405	0430	00000170		28	0000	0000
03/97	0405	0430	00000180		31	0000	0000
04/97	0410	0440	00000180		30	0000	0000
05/97	0405	0440	00000180		31	0000	0000
06/97	0400	0430	00000190		30	0000	0000
07/97	0400	0410	00000170		31	0000	0000
08/97	0400	0420	00000180		31	0000	0000

ENTER=UPDATE PF1=CROSS INDEX PF4=MONITOR PF7=SCROLL BACK PF8=SCROLL FWD

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GATEWAY2 7/4 NUM CAPS

R 9 C 11

CERTIFICATION NO.  
980303 JAN 27 98  
RAILROAD COMMISS.  
OF TEXAS

TRRC Computer Database Record of 1995 through 1997 W-10 Test Results  
 for Wells in the ..... Lease (TRRC ID# .....)

Well Count	TRRC LEASE NO.	Map/Active WELL NO.	WELL API NO.	W-10 Test Results from TRRC Computer Database					Lease Water Cut (%)
				Test Date	Oil Rate (stb/d)	Water Rate (stb/d)	Gas Rate (mc fpd)	WOR stbw/stbo	
1	.....	1	097-.....	8/26/95	0.5	40.0	0.0	80.00	98.8
2		2	097-.....	8/26/95	0.4	30.0	0.0	75.00	98.7
3		5	097-.....	8/26/95	20.0	10.0	0.0	0.50	33.3
4		6	097-.....	8/26/95	0.5*	20*	0*	WIW9/95	WIW9/95
5		7	097-.....	8/26/95	1.0	85.0	0.0	85.00	98.8
6		8	097-.....	8/26/95	5.0	15.0	0.0	3.00	75.0
7		10	097-.....	8/26/95	2.0	0.0	0.0	0.00	0.0
8		11	097-.....	8/26/95	2.0	3.0	0.0	1.50	60.0
9		12	097-.....	8/26/95	1.0	2.0	0.0	2.00	66.7
APPROXIMATE Total Lease Values for Year =					31.9	185.0	0.0	5.80	85.3
1	.....	1	097-.....	9/18/96	1.0	5.0	0.0	5.00	83.3
2		2	097-.....	9/18/96	0.5	3.0	0.0	6.00	85.7
3		5	097-.....	9/18/96	1.5	1.0	0.0	0.67	40.0
4		6	097-.....	9/18/96	WIW	WIW	WIW	WIW	WIW
5		7	097-.....	9/18/96	2.0	30.0	0.0	15.00	93.8
6		8	097-.....	9/18/96	3.0	10.0	0.0	3.33	76.9
7		10	097-.....	9/18/96	2.0	0.0	0.0	0.00	0.0
8		11	097-.....	9/18/96	2.0	3.0	0.0	1.50	60.0
9		12	097-.....	9/18/96	2.0	1.0	0.0	0.50	33.3
APPROXIMATE Total Lease Values for Year =					14.0	53.0	0.0	3.79	79.1
1	.....	1	097-.....	9/21/97	0.5	20.0	0.0	40.00	97.6
2		2	097-.....	9/21/97	0.5	15.0	0.0	30.00	96.8
3		5	097-.....	9/21/97	1.0	10.0	0.0	10.00	90.9
4		6	097-.....	9/21/97	WIW	WIW	WIW	WIW	WIW
5		7	097-.....	9/21/97	1.0	50.0	0.0	50.00	98.0
6		8	097-.....	9/21/97	3.0	15.0	0.0	5.00	83.3
7		10	097-.....	9/21/97	2.0	5.0	0.0	2.50	71.4
8		11	097-.....	9/21/97	2.0	5.0	0.0	2.50	71.4
9		12	097-.....	12/25/97	1.0	0.0	0.0	0.00	0.0
APPROXIMATE Total Lease Values for Year =					11.0	120.0	0.0	10.91	91.6

\* Note: ..... Well No. 6, 1995 production test values are not included in the calculations for the estimated 1995 total WOR lease values.  
 By: David Voorhis & Associates, David Voorhis 3/27/98

TRRC Production & Injection Data for the \*\*\*\*\* Lease for 1995-1998  
 (TRRC Lease ID# \*\*\*\*\* // Source: TRRC Prod.Ledgers, Form P-1's & Form H-10 Records)

End of Month	Lessee / Operator	Oil Produced/ Disposals (stbo/month)	Approx. Oil Prod. (stbopd)	Gas Produced (mcf/month)	W-10 Test** WOR (stbw/stbo)	Est. Water Production (stbw/month)	Est. Water Production (stbwprd)	Reported H-10 Inj. Volume (stbw/month)	Unaccounted for Wtr. Volume (stbw/month)	
Jan-95	***** Company	206	6.6	1	5.80	1195	39	no injection	no injection	
Feb-95		126	4.5	1	5.80	731	26	no injection	no injection	
Mar-95		196	6.3	1	5.80	1137	37	no injection	no injection	
Apr-95		246	8.2	1	5.80	1427	48	no injection	no injection	
May-95		352	11.4	1	5.80	2042	66	no injection	no injection	
Jun-95		379	12.6	1	5.80	2198	73	no injection	no injection	
Jul-95		***** 7/27/95	334	10.8	1	5.80	1937	62	no injection	no injection
Aug-95		310	10.0	1	5.80	1798	58	no injection	no injection	
Sep-95		Converted #6 to WIW*	345	11.5	1	5.80	2001	67	105	1896
Oct-95		341	11.0	1	5.80	1978	64	115	1863	
Nov-95		* WIW approved 11/6/97	349	11.6	1	5.80	2024	67	100	1924
Dec-95		320	10.3	1	5.80	1856	60	100	1756	
	1995 Production Totals =	3,504	115	12		20,323	666	420	7,439	
Jan-96	*****	342	11.0	1	5.80	1984	64	105	1879	
Feb-96		276	9.9	1	5.80	1601	57	95	1506	
Mar-96		335	10.8	1	5.80	1943	63	120	1823	
Apr-96		388	12.9	1	3.79	1471	49	115	1356	
May-96		368	11.9	1	3.79	1395	45	100	1295	
Jun-96		366	12.2	1	3.79	1387	46	105	1282	
Jul-96		323	10.4	1	3.79	1224	39	100	1124	
Aug-96		381	12.3	1	3.79	1444	47	120	1324	
Sep-96		395	13.2	1	3.79	1497	50	175	1322	
Oct-96		315	10.2	1	3.79	1194	39	185	1009	
Nov-96		295	9.8	1	3.79	1118	37	180	938	
Dec-96		366	11.8	1	3.79	1387	45	180	1207	
	1996 Production Totals =	4,150	136	12		17,644	581	1,580	16,064	
Jan-97	***** (operations by ***** Co. 4/18/97)	318	10.3	1	3.79	1205	39	180	1025	
Feb-97		320	11.4	1	3.79	1213	43	170	1043	
Mar-97		368	11.9	1	3.79	1395	45	180	1215	
Apr-97		344	11.5	1	10.91	3753	125	180	3573	
May-97		322	10.4	1	10.91	3513	113	180	3333	
Jun-97		303	10.1	1	10.91	3306	110	190	3116	
Jul-97		309	10.0	1	10.91	3371	109	170	3201	
Aug-97		297	9.6	1	10.91	3240	105	180	3060	
Sep-97		194	6.5	1	10.91	2117	71	no report	na	
Oct-97		271	8.7	1	10.91	2957	95	no report	na	
Nov-97		258	8.6	1	10.91	2815	94	no report	na	
Dec-97		275	8.9	1	10.91	3000	97	no report	na	
	1997 Production Totals =	3,579	118	12		31,884	1,046	1,430	19,566	
Jan-98	***** Co. (operations by *****)	269	8.8	1	10.91	2935	95	no report	na	
Feb-98		no report	no report	no report	10.91	no report	no report	no report	na	
Mar-98		no report	no report	no report	10.91	no report	no report	no report	na	
Apr-98		no report	no report	no report	no report	no report	no report	no report	na	
May-98		no report	no report	no report	no report	no report	no report	no report	na	
Jun-98		no report	no report	no report	no report	no report	no report	no report	na	
Jul-98		no report	no report	no report	no report	no report	no report	no report	na	
Aug-98		no report	no report	no report	no report	no report	no report	no report	na	
Sep-98		no report	no report	no report	no report	no report	no report	no report	na	
Oct-98		no report	no report	no report	no report	no report	no report	no report	na	
Nov-98		no report	no report	no report	no report	no report	no report	no report	na	
Dec-98		no report	no report	no report	no report	no report	no report	no report	na	
	1998 Production Totals =	269	9	1		2,935	95	0	0	

\* Note: The filed 1996 Form H-10 indicates the operator began injection in September 1995, approximately 2 months before receiving TRRC approval for the water injection well. The TRRC approval date for the \*\*\*\*\* Well No. 6 injection was 11/6/95.

\*\* Note: The W-10 Test Water-Oil Ratio (WOR) data was used as an approximate annual mid-point for estimating the water produced from the lease.

By: David Voorhis & Associates; David Voorhis 3/27/98