DAVID VOORHIS & ASSOCIATES

Data Research, Regulatory & Petroleum Engineering Consulting

< Previous Page >.......**Page 9**.......< Next Page >

IV. Petroleum Engineering Consulting Service

Oilfield Brine Fluid Migration Evaluation -

Finite Difference Simulation Example 2

* * *

Oilfield brine migration is a domestic oil industry problem that is commonly caused by the operation of EPA Class II wells. Enhanced oil recovery projects (waterfloods, polymerfloods, CO2 floods, vaporizing gas drives, condensing gas drives and micellular floods) use EPA Class II injection wells to sweep insitu oil towards producing wells. Water disposal wells are also classified as EPA Class II injection wells and are used to dispose of the brine associated with oil and gas production. Existing Federal and State regulations require Area of Review (AOR) studies around EPA Class II injection and disposal wells. These AOR studies are used to identify wellbores and boreholes that might become conduits for injected fluid migration to fresh water sands.

Before any injection or disposal well has received government approval for injection, improperly plugged boreholes and poorly cemented cased wellbores around the injectors are to be identified. Once they are identified, measures are taken to ensure that they do not become a conduit for injected fluid migration to fresh water sands.

The domestic oil extraction industry has a problem with EPA Class II injection projects because older wellbore plugging practices have not been adequate to prevent plugged boreholes from becoming fluid conduits to fresh water sands when exposed to the pressures from injection operations. Many boreholes plugged prior to 1969 used mud as the plugging material. The mud within these boreholes has plastic characteristics that allows the mud to deform when exposed to high enough injection pressures. The plastic behavior of the settled mud is mainly due to its high water filled porosity. Laboratory tests indicate settled mud porosity (the water volume between clay particles) can be as high as 84 %. When the injection zone pressure is adequate for deformation, the mud used as plugging material elongates and/or compresses within the borehole. The space vacated by the elongation and/or compression becomes highly permeable flow channels. At this point, the improperly plugged borehole (i.e., one plugged with mud) can become a conduit for injection fluid migration to fresh water sands.

Oilfield brine migration is a problem because oilfield brine can have salinity concentrations as high as 324,000 parts per million (ppm). A typical upper limit for total dissolved solids concentration in municipal drinking water is 1,000 ppm. So, it is easy to see how oilfield brine migration into fresh water sands can increase the total dissolved solids of fresh water to be greater than 1,000 ppm.

This page provides 8 illustrations from an Engineering Report of an area in North Central Texas. This area has a high potential for oilfield brine migration to fresh water sands. The Texas Railroad Commission (TRRC), other state agencies and the EPA have been informed of these problems. A lawsuit related to these issues has been initiated. Disclosure of these type of problems to authorities is a requirement of the Texas Engineering Practice Act for licensed engineers in Texas. As a licensed engineer in Texas, it is illegal to plan or implement projects that endanger public health, safety, welfare and property. Because of the potential for fluid migration to fresh water sands, it illegal for engineers to implement these type of EPA Class II injection / disposal projects. It is also illegal for others to implement these projects. It should be noted that lease names, lease ID numbers, API numbers and abstract numbers have been altered to lessen the chance of a lawsuit The eight figures are described in greater detail below.

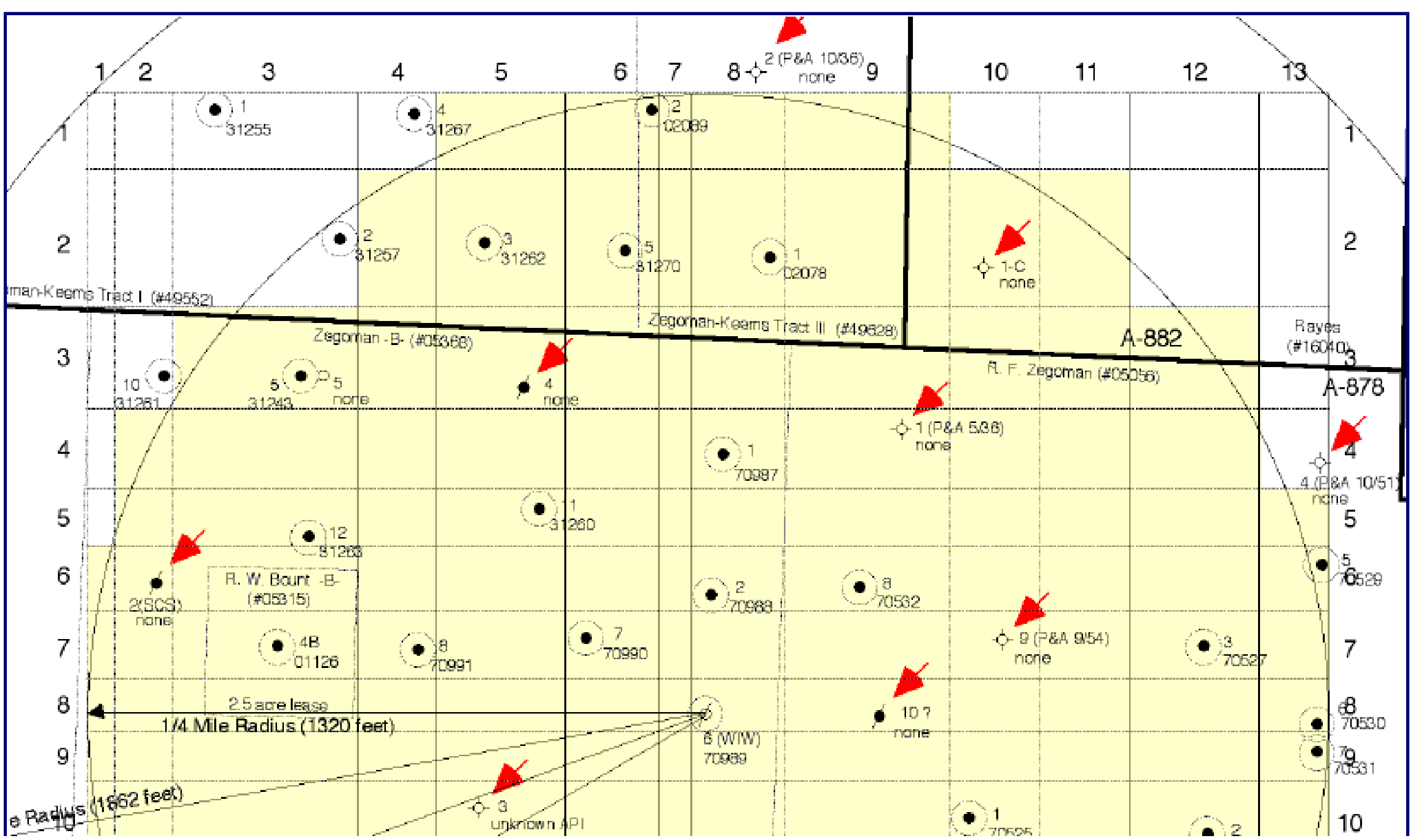
Figure 9.1	Illustrates one of the grid block configurations used to numerically simulate injected fluid migration to the region's deepest fresh water, artesian aquifer. The reservoir grid block configuration for this case is of the 1/4 Mile Area of Review for the Zegoman -B- Well No. 6.
Figure 9.2	Is a regional map that illustrates the geologic structure of the Cretaceous Base and the general location of the Area of Review for Injection Well No. 6.

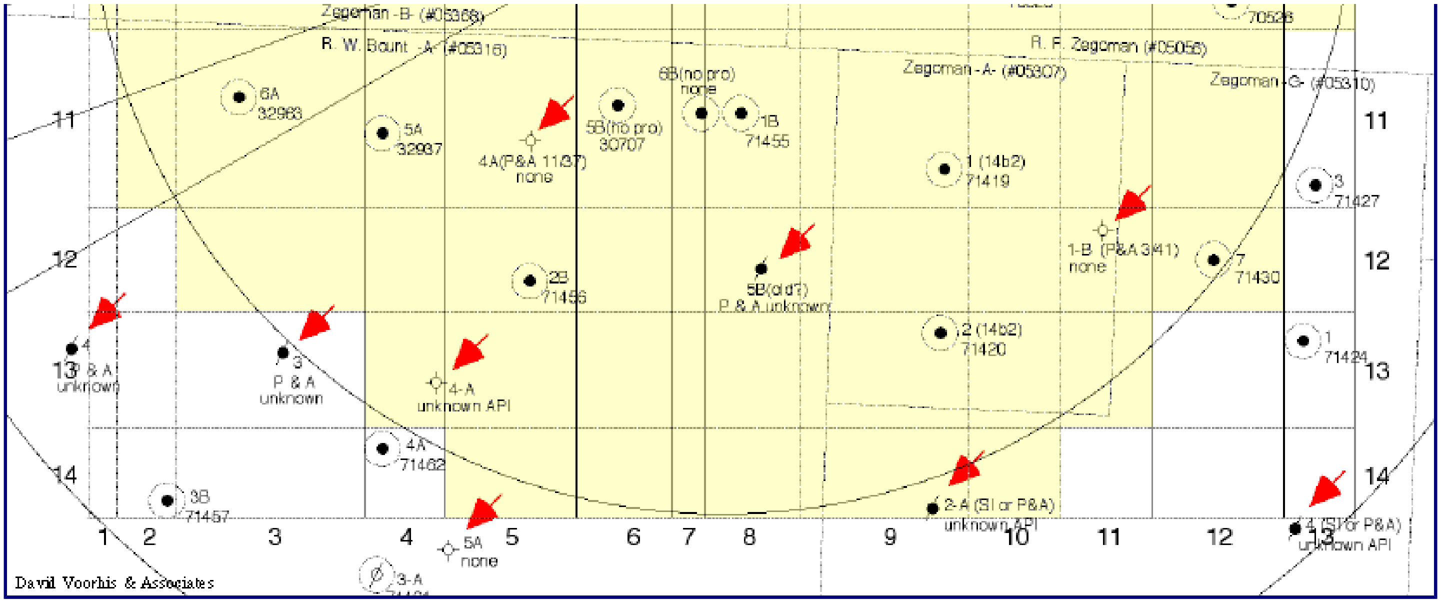
Figure 9.3	Is a regional cross-section that illustrates the geologic structure of the fresh water, artesian aquifers endangered by the injection operations. The lowest fresh water aquifer that can be affected by the injection operations is the Antlers formation.
Figure 9.4	Illustrates the typical condition of plugging materials in an improperly plugged well (R. F. Zegoman No. 9) affected by injection into the Zegoman -B- Well No. 6.
Figure 9.5	Illustrates the magnitude and the behavior of borehole permeability in an improperly plugged well, the R. F. Zegoman No. 9.
Figure 9.6	Illustrates the simulated fluid migration rates thought to be possible under existing physical conditions and the authorized injection parameters for the Zegoman -B- Well No. 6.
Figure 9.7	Is a computer output table of the possible fluid migration rates to the Antlers fresh water sand after 360 days of injection.
Figure 9.8	Reveals a histogram and table of approved Pre-1967 Plugged Wells (wells plugged with mud) within 1/4 Mile AOR's of Cooke County, Texas. The histogram and table were developed from a survey of 176 EPA Class II injection applications approved by the TRRC during the 1985 to 1998 time period. This figure reveals that 57.4% (100 - Cum.% = 57.4%) of the injectors approved during the 1985 - 1998 time period had wells that were predominately plugged with mud within their 1/4 mile AOR's. These wells, the ones plugged with mud, are likely to become conduits for oilfield brine migration to fresh water sands during injection operations.

Figure 9.1 is a reservoir grid block representation of a 1/4 mile Area of Review (AOR) study area around injection Well No. 6 (an approved injector). The grid blocks colored in yellow represent non-zero porosity grid blocks. The red arrows indicate suspected or known improperly plugged boreholes.

Reservoir simulations of the AOR were used to estimate the amount of oilfield brine migration that could result from injection operations into Well No. 6. As mentioned earlier, the improperly plugged wells have potential to develop into conduits for fluid migration when the the injection zone pressure exceeds the overburden stress of the borehole material. Within Figure 9.1, there are 12 suspected or known improperly plugged wells within (or just outside) the 1/4 mile AOR circle.

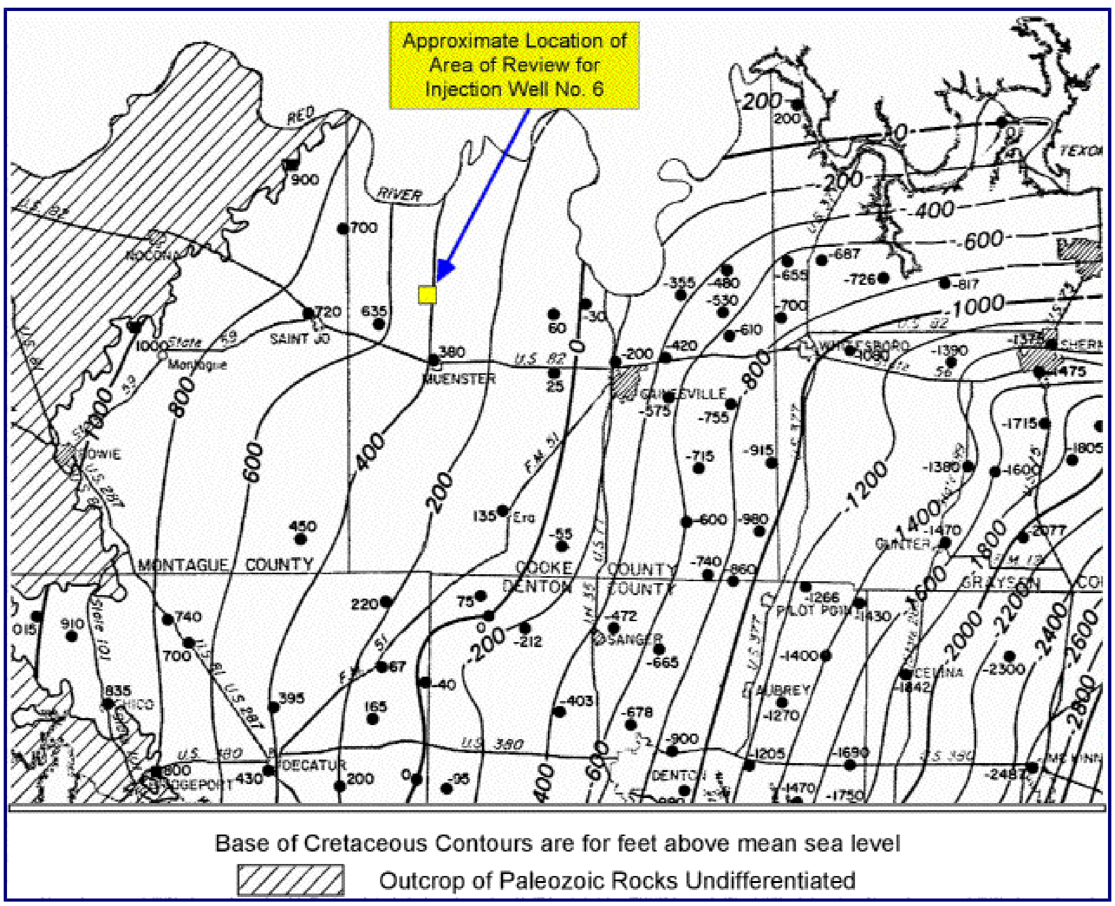
Figure 9.1 : 1/4 Mile Area Of Review (AOR) Map Reservoir Grid for the Zegoman -B- Injection Well No. 6 (RED ARROWS indicate Known or Suspected Improperly Plugged Wells)





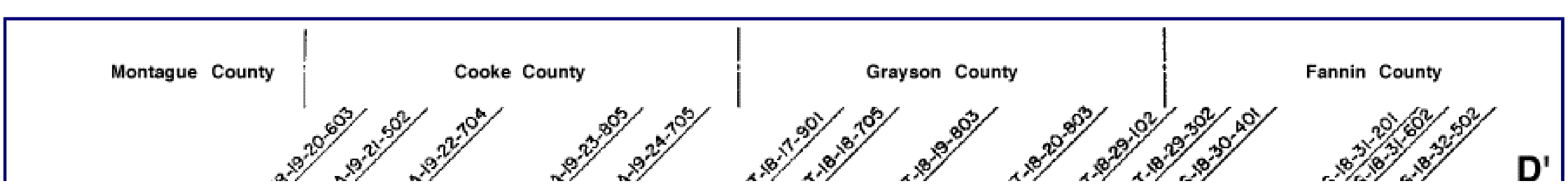
* * *

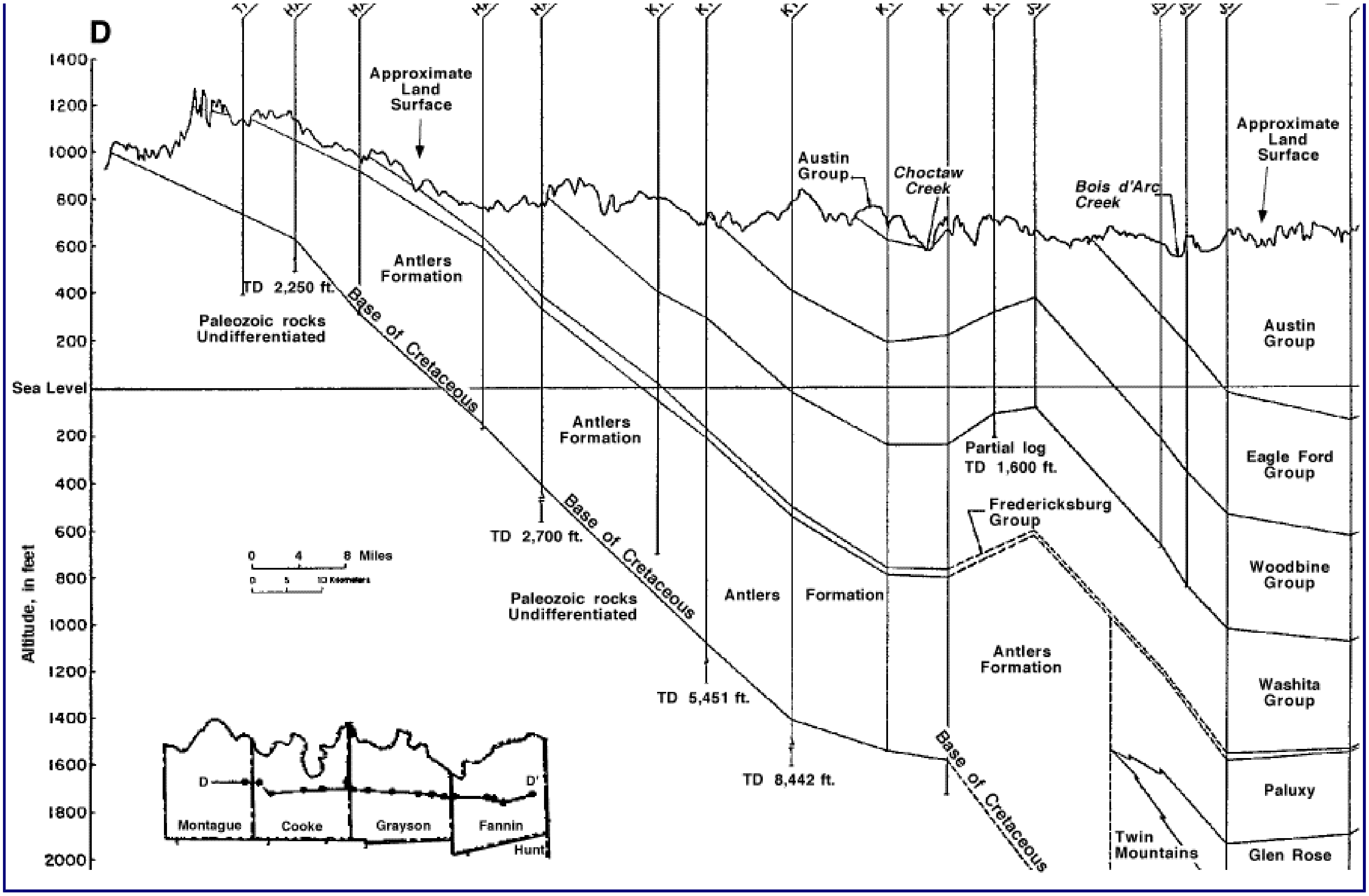
Figure 9.2 : Regional Map showing the General Area of Review location for the Zegoman -B- Well No. 6 Injector (adapted from P. L. Nordstrom, Report 269)



* * *

Figure 9.3 : Cross Section of Antlers Artesian Aquifer (Fresh Water Sand) Affected by Injection Well No. 6 (adapted from P. L. Nordstrom, Report 269)

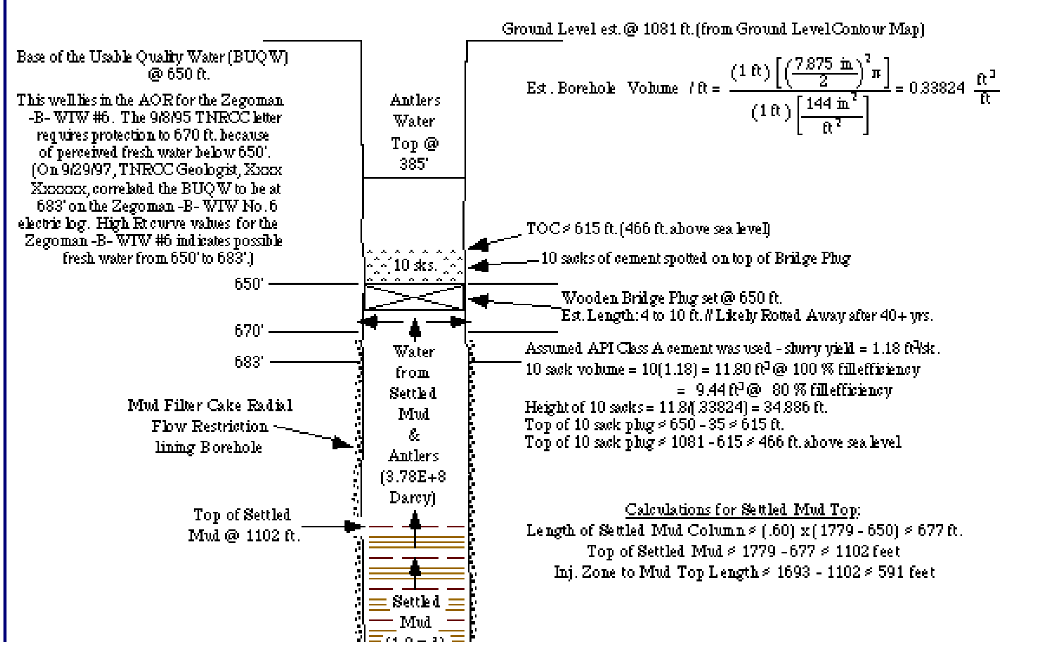


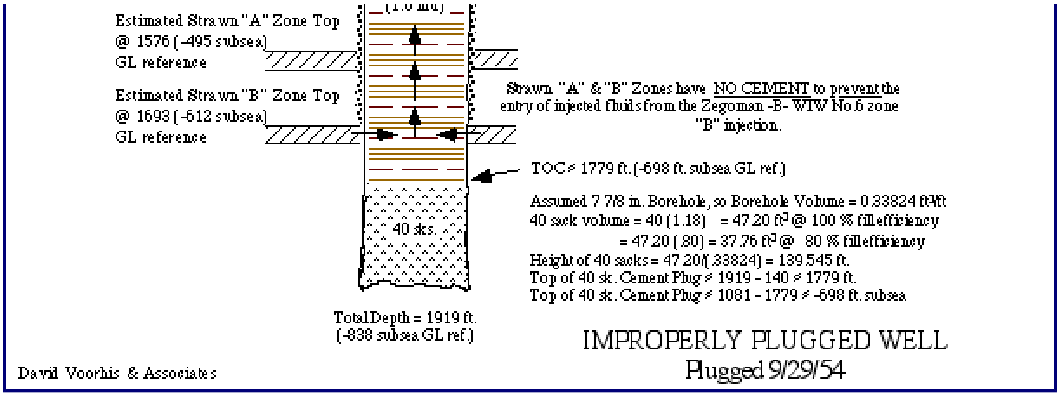


* * *

Figure 9.4 : Wellbore Diagram of a typical Improperly Plugged Well Affected by Injection Well No. 6

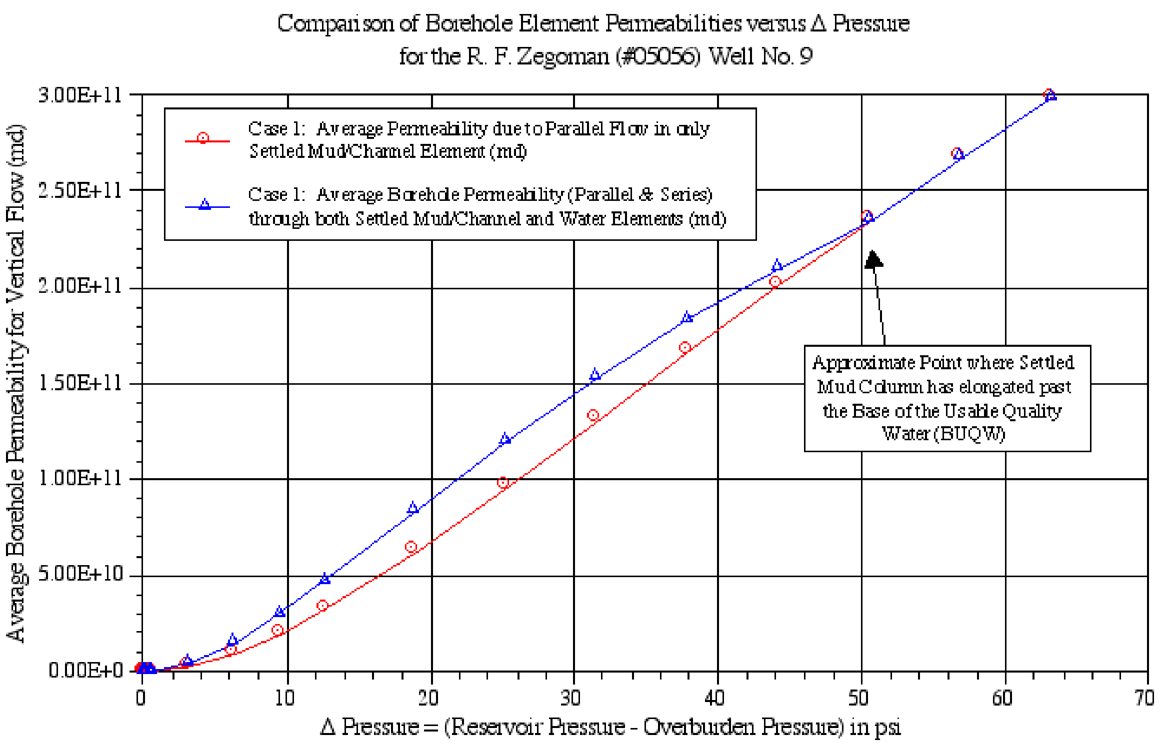
TRRC Lease Number Location	05056
Current Lease Name Location	R. F. Zegoman
Estimated Original Lease Name	R. F. Zegoman
Well No.	9
Approximate Distance (ft) From Zegoman -B- WIW No. 6	660
Injection/Salt Water Disposal Operations Plugging Status	Improperly Plugged
Wellbore Diagram is NOT drawn to SCALE.	





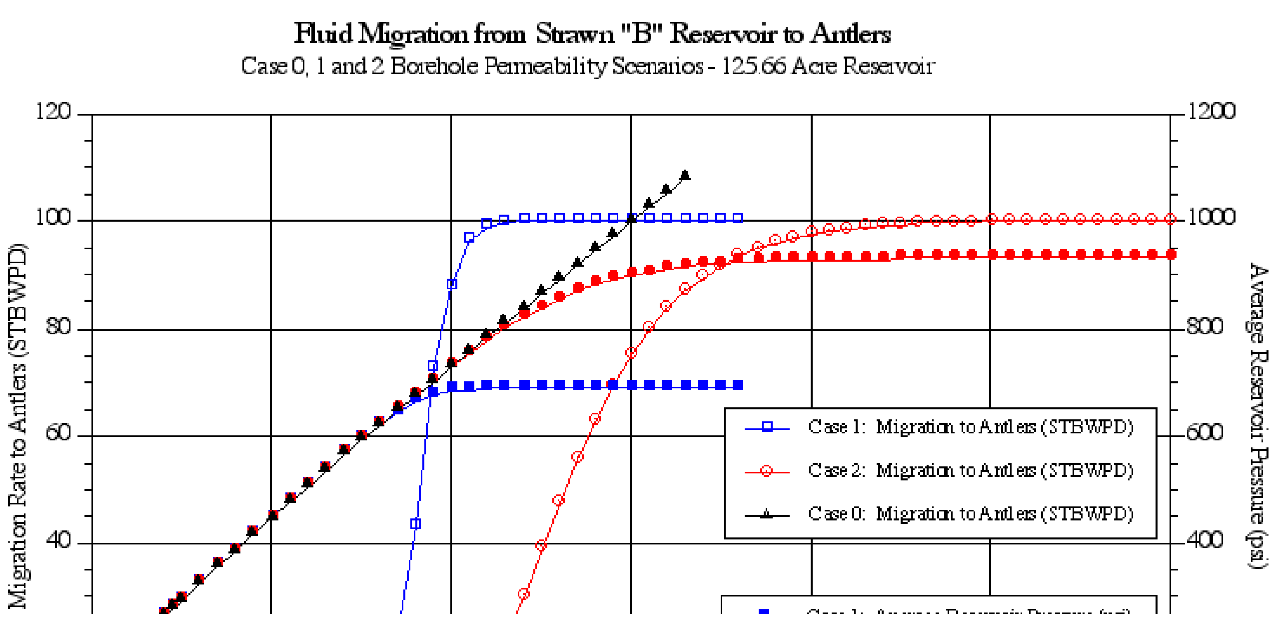
* * *

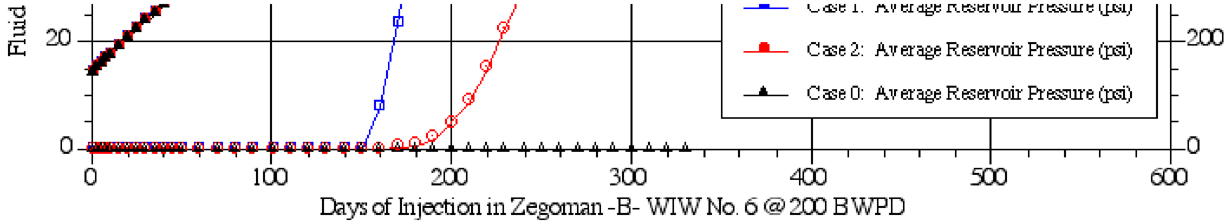
Figure 9.5 : Borehole Permeability VERSUS Pressure Plot of an Improperly Plugged Well



* * *

Figure 9.6 : Plot of Possible Fluid Migration Rates to the Antlers Formation due to Zegoman -B- Well No. 6 Injection





* * *

Figure 9.7 : Computer output table of possible oilfield brine migration rates after 360 days of injection in the Zegoman -B- Well No. 6

SUSPECTED OR KNOWN IMPROPERLY PLUGGED WELL STATUS REPORT AT TIME......= 360.000 DAYS
AVERAGE RESERVOIR PRESSURE..= 688.675 PSI

END OF THE INIFINITE ACTING FLOW PERIOD........= 2.029 DAYS
START OF THE PSEUDO STEADY STATE FLOW PERIOD...= 6.354 DAYS

Comparison of Numerically Simulated and Analytically Calculated Reservoir Pressures

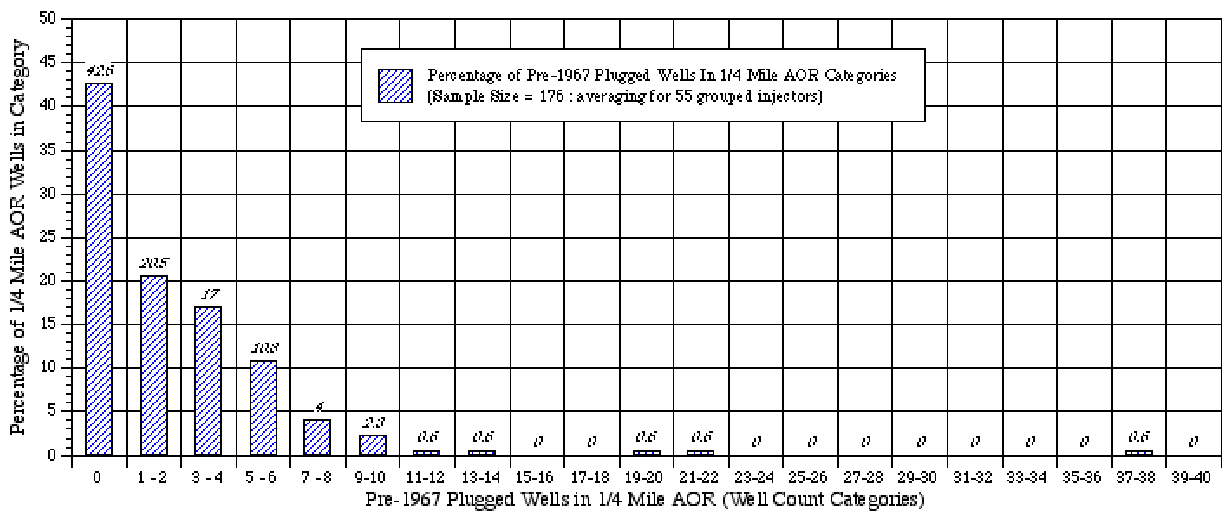
TRRC LEASE NO.	WELL NO.	GRID BLOCK NO.	GRID COL. NO.	GRID ROW NO.	DIST.TO INJECTOR (FT)	GRID BLK. AVG.PRES. (PSI)	ANALYTIC PRESSURE (PSI)	BH.OVER-BURD.PRES (PSI)	BH.INJECT ZN.PRES. (PSI)	BH.FW.SAND PRESSURE (PSI)	BH. EFF. (%)	MIGRATION TO FW SAND (STBWPD)	CUMULATIVE MIGRATION (STBW)
5056	1	95	9	4	740.0	701.9	1394.0	683.6	683.6	136.4	90.0	7.981958	1401.6070
5056	9	111	10	7	660.0	678.0	1396.9	632.0	632.0	123.4	90.0	21.393170	4098.7710
5056	10?	99	9	8	360.0	719.3	1415.2	668.7	668.7	123.4	90.0	22.760601	4309.2280
5368	2(SCS)	8	2	6	1200.0	675.7	1386.0	669.6	669.6	148.1	90.0	2.978832	461.4109
5368	3	45	5	10	530.0	686.6	1403.1	648.2	648.2	158.1	90.0	17.041130	2999.8002
5368	4	38	5	3	800.0	686.7	1392.2	663.0	663.0	179.7	90.0	10.337650	1799.9400
5307	1-B	128	13	12	1080.0	672.2	1387.0	657.7	657.7	136.4	90.0	6.485635	1114.7520
5310	2-A	105	9	14	1390.0	670.5	1385.8	657.1	657.1	190.6	90.0	5.740843	928.0809
5316	4-A	35	4	13	1210.0	661.7	1386.0	9999.0	661.7	125.0	90.0	.000000	.0000
5316	4A	46	5	11	680.0	682.3	1396.2	9999.0	682.3	125.0	90.0	.000000	.0000
5316	5B.old	89	8	12	825.0	697.7	1391.5	9999.0	697.7	125.0	90.0	.000000	.0000
16040	1-C	106	10	2	1120.0	698.9	1386.6	686.6	686.6	135.1	90.0	5.434729	948.6278

NON-DUPLICATED Total Fluid MIGRATION RATE To Fresh Water Sand (STBWPD)...= 100.154540
NON-DUPLICATED Cumulative Fluid MIGRATION To Fresh Water Sand (STBW).....= 18062.2100
NON-DUPLICATED Total Fluid MIGRATION RATE From Injection Zone (STBWPD)...= 111.282820
NON-DUPLICATED Cumulative Fluid MIGRATION From Injection Zone (STBW).....= 20069.1320

David Voorhis & Associates

* * *

Figure 9.8 : Histogram & Table of Approved Pre-1967 Plugged Wells (plugged with mud) within 1/4 Mile AOR's of Cooke County, TX (from Survey of 176 EPA Class II injection applications approved by TRRC during 1985 to 1998)



1/4 Mile AOR Pre-1967 Plgd. Well Count Categories	0	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30	31-32	33-34	35-36	37-38	39-40	Total
Injectors =	75	36	30	19	7	4	1	1	0	0	1	1	0	0	0	0	0	0	0	1	0	176
Percentage =	42.6	20.5	17.0	10.8	4.0	2.3	0.6	0.6	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	100
Cum. % =	42.6	63.1	80.1	90.9	94.9	97.2	97.7	98.3	98.3	98.3	98.9	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	100.0	100.0	
(100-Cum.%) =	57.4	36.9	19.9	9.1	5.1	2.8	2.3	1.7	1.7	1.7	1.1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.0	0.0	

* * *

Download PDF versions of PUBLIC RECORD documents describing EPA Class II Injection Program Problems in Texas.

(Click on Underlined ".pdf" LINKs Below)

1)	**Letter to Governor Bush.pdf**	Notice of EPA Class II Problems (4k)
2)	**Reply from Gov.Bush.pdf**	Scanned letter - delineation of authority (376k)
3)	**Letter to EPA#1-Hathaway.pdf**	Report of EPA Class II Problems @ TRRC (1,581k)
4)	**Letter to EPA#2-Wright.pdf**	Report of Regulatory Control Problems @ TRRC (232k)
5)	**Ltr.to Public Integ.Unit#1.pdf**	Letter #1 to the Travis Co. Public Integrity Unit (16k)
6)	**Ltr.to Public Integ.Unit#2.pdf**	Letter #2 to the Travis Co. Public Integrity Unit (8k)
7)	**Ltr.to Public Integ.Unit#3.pdf**	Letter #3 to the Travis Co. Public Integrity Unit (16k)
8)	**TX Engineering Board Reply.pdf**	Scanned letter - some problems corrected (488k)
9)	**Letter to EPA#3-Wright.pdf**	Continuing Discussion of EPA Class II Problems (12k)
10)	**Letter to EPA#4-Wright.pdf**	Continuing Discussion of EPA Class II Problems (20k)
11)	**Ltr.to Cooke Co. Officials.pdf**	Entity Affected by EPA Class II Problems (80k)
12)	**Brine Migration Simulation p9.pdf**	Partial Results of Engineering Study - Page 9 of web site (384k)

Click here to view Contact Information.

< Previous Page >.......**Page 9**.......< Next Page >

Table of Contents Page

< Page 1 > < Page 2 > < Page 3 > < Page 4 > < Page 5 >
< Page 6 > < Page 7 > < Page 8 > **< Page 9 >** < Page 10 >
<Page 11 > < Page 12 > < Page 13 > < E-mail - p.14> < Links - p.15 >

Low / High Screen Resolution Page