Kellie Martinec

From:	Brian W. Stump <[redacted]>
Sent:	Friday, September 26, 2014 9:20 AM
To:	rulescoordinator
Cc:	Brian William Stump
Subject:	3.9 and 3.46: Amend to incorporate requirements related to seismic events for disposal wells
Attachments:	TRRC_Public_Comment_26Sept14.pdf; ATT00001.txt

We would like to submit the attached letter as a comment concerning the proposed rules related to seismic events for disposal wells.

Sincerely,

Brian Stump

26 September 2014

Railroad Commission of Texas
Office of General Counsel
P.O. Drawer 12967
Austin, TX 78711-2967

Dear Commission,

As practicing seismologists who have studied earthquake activity in the Dallas-Ft. Worth area, we were encouraged by the Commissions initial approach to developing and modifying rules related to injection wells in order to provide additional data for assessing whether these activities are linked to near-by earthquake activity. Injection well data in conjunction with subsurface properties including the location of faults are critical to assessing this linkage and mitigation of any associated effects. Based on our experience in both studying these events and developing initial fluid flow models, we have prepared a set of comments for consideration by the Railroad Commission of Texas.

First we would like to make some general comments concerning the fluid calculations that are proposed.

1.) Measurement of the 5 psi pressure front is dependent on several key parameters that we do not believe are well constrained, and thus an accurate assessment of the 5 psi pressure front cannot be conducted at the suggested cost. To be clear, an accurate assessment of the 5 psi pressure front requires all of the following:

(a) In situ initial bottom hole fluid pressure;
(b) A clear and accurate assessment of bottom hole pressure during injection with time;
(c) Volume/length and average effective permeability of the formation, in 3D, including micro fracture and high permeability zones, especially near faults. This is likely highly anisotropic;
(d) Fluid flow boundary conditions in 3D;
(e) The potential effects of other pressure drivers in the region that can work in concert to elevate or reduce the pressure (other nearby injection or production wells for example).

Given the current data that are available or collected by industry, pressure front predictions will likely be subject to large uncertainties in predicting where the pressure front is located as a function of time.

2.) It is unclear to us why the 5 psi front over 10 years has been chosen as the critical pressure number or time. Studies on critically stressed fault systems generally suggest pressure changes between .01-.1 MPa cause failure (1.4 - 14 psi). If this is considered standard, one should consider avoiding any pressure development near a major fault system that is active or appears critically stressed.

3.) Consideration should be given to situations where the reported pressures down hole are significantly in excess of 5 psi due to overpressure. Industry studies already suggest overpressures sometimes exist throughout some of the injection formations, and these overpressures may exceed tens of psi.

4.) Some of the faults that have activated in North Texas are small and not found in literature or even clearly resolvable in seismic data. Reporting where faults exist is a step forward but by no means fool proof. This is more of a comment illustrating the difficulty in reporting.

Specific comments linked to lines in the document released by the Texas Railroad Commission on 8/12/2014 follow. These comments deal with specific rule changes that focus on the spatial linkage of historic earthquake activity to proposed new injection wells as well as additional details related to the proposed fluid flow models.

Page 1, Lines 9-10: Therefore, the Commission proposes these rule amendments in order to require additional permit application information such as logs, geologic cross-sections, and/or structure maps, for an injection well in an area where conditions exist that may increase the risk that fluids will not be confined to the injection interval.

Comment: *The injected fluids may well stay confined in the injection interval but the pressure perturbation induced by the injection fluids can have farther reaching effects. The perturbation may well be more important in locally changing stress in a manner sufficient to allow earthquakes along pre-existing fault structures. An arguably much more valuable requirement is that bottom hole shut-in pressures at injection wells are measured and reported annually to determine if injection fluids are in fact having far-reaching effects on subsurface stress.*

Page 1, Lines 17-21: The Commission proposes amendments to §3.9(3) to add new subparagraph (B) to state that the applicant shall include with the application for a disposal well permit under this section the results of a review of information from the USGS regarding the locations of any historical seismic events within the estimated radius of the 10-year, five pounds per square inch (psi) pressure front boundary of the proposed disposal well location.

Comment: *Many of the earthquake sequences in Texas, such as those in Azle, DFW and Cleburne, only began after the injectors began operating in the area. Thus searching for earthquakes before the injection process begins may not be sufficient. Any information on the locations of subsurface faults and their orientation relative to the in-situ stress field might provide more effective permitting criteria based on some of the historical earthquake data. The imaging and location of subsurface faults may be problematic. Even small offset faults at the limit of high-quality 3D seismic data may generate small magnitude earthquakes based on data analysis in Azle.*

Page 1, Lines 22-23: A 10-year, five psi pressure front boundary is the boundary of increased pressure of five psi after 10 years of injection at the maximum requested permit injection volume.

Comment: *A characteristic radius for the search might be a better approach rather than one estimated from a model run for the following reasons: 1. The earthquake locations based on regional observations have a characteristic error in latitude and longitude of approximately 10 km which may be larger than*

estimated radius.
2. Few details described in models and an assessment of the errors in the calculation may necessitate a larger radius. For instance the bottom hole pressures and permeability used can greatly influence the estimated radius.
3. Model runs can be influenced by inclusion of faults.

Page 1, Lines 24-25: The USGS has the ability to detect and locate all seismic events larger than magnitude 2.0 throughout the continental United States.

Comment: *This magnitude threshold for the USGS catalog should be checked with the USGS. Experience with aftershock sequences in Azle, Cleburne and DFW airport suggests that this threshold is above 2.5 and possibly approaching 3.0.*

Page 2, Lines 4-7: Figure 1 shows an example with the following input values: (1) a start date and time of 1973-01-01 00:00:00; (2) a minimum magnitude of 2; (3) the center latitude and center longitude of the proposed disposal well location; and (4) an outside radius of 3.2 kilometers (two miles).

Comment: *As a result of the intrinsic errors in the USGS earthquake locations, this approach may lead to association of earthquakes in the USGS database from an earthquake sequence with multiple wells. Taking 11 injectors around the Azle area and applying a 3.2 km search radius resulted in earthquakes being associated with four injectors. More accurate locations derived using nearby seismic stations in Azle suggests only two injectors lie within 3.2 km of the event sequence.*

Page 2, Lines 12-16: The Commission proposes new §3.9(3)(C) to state that the Commission may require an applicant for a disposal well permit to provide the Commission with additional information, such as logs, geologic cross-sections, and/or structure maps, to demonstrate that fluids will be confined if the well is to be located in an area where conditions exist that may increase the risk that fluids will not be confined to the injection interval.

Comment: *There are a number of other critical data sets related to the fluids and the rock properties that control fluid migration. Some of these include downhole pressures in the injector, static pressures at injection depth, permeability and fault locations including there connection to layers above and below the injection interval. Again, we emphasize that routine, low-cost, non-invasive monitoring of shut-in pressures at injection sites on an annual basis will provide important insight into the extent and magnitude of subsurface stress change with time near injectors.*

Sincerely,

Brian W. Stump

Heather DeShon

Matthew J. Hornbach

Maria Beatrice Magnani

Christopher T. Hayward