



Ms. Greta Lydecker
Vice President
San Joaquin Valley Business Unit
Chevron North America Exploration and Production Company
9525 Camino Media
Bakersfield, CA 93311

September 2, 2015

Dear Ms. Lydecker,

Thank you for taking the time to write to us and inquire about statements in our report, *An Independent Assessment of Well Stimulation Technologies in California*. We appreciate having the opportunity to explain our findings and research process to you. In addition, we thank Chevron for its assistance during the development of this report. We learned a great deal during our visit to Chevron's Lost Hills operation, and subsequently had a number of productive conversations with your staff.

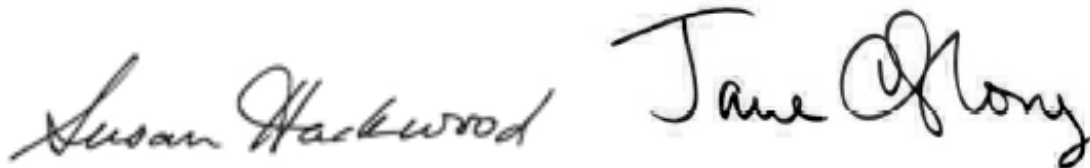
Our study was limited to publically available data. If Chevron has information that differs from the public record we would be interested in seeing and discussing it. However, we cannot revise the findings and recommendations of our report based on privately held information. As well, although we recognize the difference between frac-packing and hydraulic fracturing the legal definition of stimulation does require us to consider frac-packing in the same category as hydraulic fracturing. Given the number of stimulations, including frac-pacs in reservoirs where produced water was sent for reuse, it is not possible to rule out that stimulation chemicals were present in some unknown concentration in water used for irrigation. Our recommendation is to take actions to prevent harmful levels of stimulation chemicals in water used for irrigation.

In response to your letter, we asked two of our investigators, Preston Jordan of Lawrence Berkeley National Laboratory and Laura Feinstein of the California Council on Science and Technology to prepare a detailed memo in response.

Our research in response to your letter did identify one error in the report. We agree with Chevron's statement that the dates given in one sentence of the report in Volume II, Chapter 2, on p. 115 are erroneous, and we will issue a correction.

We appreciate having the opportunity to explain our findings, conclusions and recommendations in detail to Chevron. If you have any further questions or concerns, please contact us to set up a meeting for further discussion.

Sincerely,

The image shows two handwritten signatures in black ink. On the left is the signature of Susan Hackwood, and on the right is the signature of Jane Long. Both signatures are written in a cursive, flowing style.

Susan Hackwood
Executive Director
California Council on
Science and Technology

Jane Long
Steering Committee Chair, Well Stimulation Report
California Council on
Science and Technology

cc:

John Laird, California Secretary for Natural Resources, Natural Resources Agency David Bunn, Conservation Director, Department of Conservation

Steve Bohlen, State Oil and Gas Supervisor, Division of Oil, Gas and Geothermal Resources

Jonathan Bishop, Chief Deputy Director, State Water Resources Control Board

Clay Rodgers, Assistant Executive Director, Central Valley Regional Water Quality Control Board

Saul Gomez, Special Assistant for Oil, Gas and Geothermal Resources, California Natural Resources Agency

Memo

To: Jane Long and Susan Hackwood, CCST

From: Preston Jordan (LBNL), and Laura Feinstein (CCST)

Date: Sep 2, 2015

Subject: July 24 Letter from Chevron

Dear Jane and Susan,

We have read the letter from Chevron carefully, and we understand the major points Chevron makes to be that they do not use hydraulic fracturing at the Kern River oil field; that they have used frac-packing in this field in the past, which Chevron defines as different from hydraulic fracturing; and that therefore, in Chevron's view, produced water from Chevron's wells at Kern River does not contain hydraulic fracturing chemicals.

We have five points we wish to discuss explaining the findings and recommendations of the report and how they compare to Chevron's statements:

1. We found reports in public records of five hydraulic fracturing operations in the Kern River oil field, four in wells operated by Chevron.
2. For these five operations, the most recent estimated date should have been 2013. We *agree* with Chevron's statement that the dates given in one sentence of the report in Volume II, Chapter 2, on p. 115 are erroneous, and we suggest that CCST issue a correction.
3. Our report, and California law, classifies frac-packs as a type of hydraulic fracturing, and frac-packing employs processes similar to other forms of hydraulic fracturing.
4. Based on our understanding of frac-packing, this technology presents similar hazards for the reuse of produced water as other forms of hydraulic fracturing.
5. The conclusions and recommendations regarding the reuse of produced water potentially containing stimulation chemicals are relevant regardless of the dates of hydraulic fracturing operations and whether they were "ordinary" hydraulic fractures or frac-packs. Past regulations would not have prevented stimulation chemicals from being incorporated into irrigation waters. The CCST recommendation is to prohibit the reuse of produced water containing unsafe or unknown concentrations of stimulation chemicals in the future.

The following explores each point in more detail.

1. We found reports in public records of five hydraulic fracturing operations in the Kern River oil field, four in wells operated by Chevron.

Our report searched and compiled information from eight public sources of data on hydraulic fracturing in the state.¹ Public records showed hydraulic fracturing operations in five wells in the Kern River field, four of them operated by Chevron, as detailed in the following table. The first four were indicated in data considered for Volume I. The last was indicated in an update of one of the data sets considered for Volumes II and III.

Table 1. Public reports of hydraulic fracturing operations in wells in the Kern River oil field.

DOGGR API # (operator)	Information used in the report	Additional information gathered for this letter
0295157 7 (Chevron)	The well record search indicates a “frac” operation occurred. Date of operation taken as January 2002 (first production).	The well record ² indicates a four-stage “frac” was performed on January 2, 2003. The sand masses placed suggest this operation was a frac-pack.
0298569 7 (Chevron)	DOGGR’s January 2014 GIS well layer attributes* list this well as hydraulically fractured. Date of operation taken as 3/17/1990 drill start (spud date).	The record for this well indicates the well was frac-packed between April 20 and 26, 1995. The first production month was March 1990.
0304314 9 (Kern River Holdings)	DOGGR’s January 2014 GIS well layer attributes* list this well as hydraulically fractured. Date of operation taken	The record for this well does not record a hydraulic fracturing operation. DOGGR’s GIS well layer attributes* indicate this well was spud on February 24 and

² Well records are available on DOGGR’s web site at <http://www.conservation.ca.gov/dog/Pages/Wellfinder.aspx>.

)	as June 2012 (first production).	completed on July 1, 2011.
0304579	5	DOGGR's January 2014 GIS well layer attributes* list this well as hydraulically fractured. Date of operation taken as March 2012 (first production).	The record for this well does not record a hydraulic fracturing operation. DOGGR's GIS well layer attributes* indicate this well was spud on February 24 and completed on February 29, 2012.
0305215	2	DOGGR's November 2014 GIS well layer attributes* list this well as hydraulically fractured. Date of operation apparently taken as March 2014 (first production).	The record for this well does not record a hydraulic fracturing operation. DOGGR's GIS well layer attributes* indicate this well was spud on November 7, 2013 and completed on January 8, 2014.

*also available from DOGGR as an Excel file titled "AllWells"

There are important limitations to the public datasets used for the report that are described in detail in Volume I, Chapter 3. Most importantly, prior to 2014, there was no mandatory reporting of hydraulic fracturing in California. Therefore, data collected prior to 2014 is expected to be incomplete. In many cases a well noted as hydraulically fractured in one public dataset is not noted as hydraulically fractured in another. We regarded any well as hydraulically fractured if it was denoted as such in at least one public dataset.

The public data sets are not immune to errors such as incorrect reporting or data entry mistakes. This is not the first time that operators have communicated to us privately held information that differs from the public datasets (see Volume II, Appendix 2.E, which quotes communication from Chevron stating that they misreported data on produced water disposition to DOGGR). If Chevron regards any of these four records as erroneous we would be interested in hearing from them on the topic. However, the report was based on public databases available during report preparation as the most complete and verifiable data sources available.

- 2. For the five hydraulic fracturing operations listed in public records, the most recent estimated date should have been 2013. We *agree* with the letter that the dates given**

in one sentence of the report on Volume II, Chapter 2, p. 115 are erroneous, and we suggest that CCST issue a correction.

On p. 115 of Volume II, Chapter 2, the following sentence appears: “Although hydraulic fracturing was reported as recently as 2014 in the Kern River, only three hydraulic fracturing operations have been reported since 2012.” This sentence is incorrect. The public records indicate three hydraulic fracturing operations in the Kern River field since 2011, not 2012, and our best estimate of the date of the most recent of these is 2013, not 2014.

Publicly available datasets do not always give a date for the hydraulic fracturing operation, or if they do, it is not always supplied in a format amenable to analysis. For example, DOGGR’s GIS well layer attributes do not give a date for the hydraulic fracturing operations that it notes. Well records do not provide dates as searchable values, and given the thousands of well records we searched, we did not have the resources to enter the date of operation by hand for each record. As a result, when the date of the hydraulic fracturing operation was unavailable, we estimated the date of the operation by using the date of first production if available, or the date of first injection if there was no first production date available, if the resulting date fell in the 2002 to 2014 study period for which we had first production and injection dates supplied by DOGGR. Otherwise we used the date drilling commenced (spud date) from DOGGR’s GIS well layer attributes, if available. If none of these dates were available, we did not assign an estimated date.

Following our normal procedure would mean the estimated date of hydraulic fracturing for well 03052152 would be March 2014, the start of production. However, further consideration of the operation in this well prompted by Chevron’s letter leads us to conclude an estimated date of late 2013 is more reasonable. This is because mandatory reporting of hydraulic fracturing commenced on January 1, 2014. Since there is no record of a hydraulic fracturing operation in well 03052152 in the well stimulation notices, we infer that the operation more likely took place in late 2013.

We thank Chevron for drawing our attention to this sentence and sincerely apologize for the mistaken dates. We suggest substituting the following:

“In Kern River, there are five records of hydraulic fractures in the public data sets reviewed, four in wells operated by Chevron. Chevron is the only operator in Kern River with a permit to send produced water to the Cawelo water district for irrigation purposes. For the four reported operations in Chevron wells, estimated dates are during the period 1995 – 2013.”

We also recommend adding a footnote for the newly revised sentence as follows:

“Of the four reported hydraulic fractures in Chevron’s Kern River wells, the most recent report was in the November 19, 2014 version of DOGGR’s GIS well layer attributes for a well in which drilling commenced on November 7, 2013, and completion occurred on January 8, 2014. Given that the well was not reported as hydraulically fractured in the mandatory stimulation notices that commenced on January 1, 2014, it appears likely that the well was hydraulically fractured in late 2013.”

3. Our report, and California law, classifies frac-packs as a type of hydraulic fracturing, and frac-packing employs similar processes as other forms of hydraulic fracturing.

The letter states that hydraulic fracturing has not been used in the Kern River field, but that frac-packs have been used. We agree that frac-packs do differ in some respects from other forms of hydraulic fracturing. As opposed to hydraulic fracturing, which is intended to open permeable fracture pathways in unconventional reservoirs to enable oil or gas production, frac-packs are employed to bypass formation damage around a production well and/or limit sand production into the well.

However, frac-packing employs similar processes to other forms of hydraulic fracturing.³ Both “ordinary” hydraulic fracturing and frac-packs involve the injection of fluid at pressure sufficient to induce fractures in the reservoir, and both use proppant to retain

³ A table summarizing the similarities and differences in hydraulic fracturing and frac-packing is available at CCST and LBNL 2015, Summary Report, p. 4. The two techniques are discussed in depth in CCST and LBNL 2015, Volume I, Chapter 2.

fracture permeability.⁴ Both techniques typically inject a mixture of water and other chemicals,⁵ which can return to the surface as part of the recovered fluids and produced water.⁶

Under Senate Bill 4 (Pavley, Ch 313, Stats of 2013), an operation that exceeds the fracture pressure of the rock causing or enhancing oil or gas production is classified as a hydraulic fracture; this includes frac-packs.⁷ In addition, most public data sets do not distinguish between hydraulic fractures and frac-packs. Given the legal framework, the data available to us, and the fact that the two techniques employ similar processes, we routinely grouped frac-packs as a type of hydraulic fracture in our report.

4. Frac-packing presents similar hazards for the reuse of produced water as other forms of hydraulic fracturing.

The letter indicates hydraulic fracturing has not occurred, but rather 300 frac-packs were conducted in the period 1995-2003 and 2006-2007 inclusive. This suggests an average of 30 frac-packs were conducted per year. The letter indicates a frac-pack uses a water volume about 10% that of a hydraulic fracturing operation. Consequently in those years in which frac-packing occurred, the total fluid volume injected for 30 frac-packs on average would be similar to the two hydraulic fracturing operations per year we estimated occurred at the Kern River oil field based upon the well record search results.⁸

In addition, as indicated in the table above, we found reports of two operations that are outside the period during which the letter indicated frac-packs occurred. The operations

⁴ CCST and LBNL 2015, Summary Report, p. 4.

⁵ CCST and LBNL 2015, Volume I Chapter 2, p. 57.

⁶ CCST and LBNL 2015, Volume II Chapter 2, pp. 50, 86, and 90.

⁷ Pursuant to SB 4, the California Public Resources Code §3152 defines hydraulic fracturing as “a well stimulation treatment that, in whole or in part, includes the pressurized injection of hydraulic fracturing fluid or fluids into an underground geologic formation in order to fracture or with the intent to fracture the formation, thereby causing or enhancing, for the purposes of this division, the production of oil or gas from a well.”

⁸ CCST and LBNL 2015, Volume III Chapter 5, p. 300.

could not have occurred earlier than 2012 and 2013 respectively, based upon the dates drilling commenced. The reports of these operations support our estimate of two hydraulic fracturing operations per year in the period 2002 through late 2013.

As referenced above, literature reviewed in the report suggests the chemical types and concentrations used for frac-packing are similar to hydraulic fracturing. Consequently, based on the similar fluid volumes injected per year, the total chemical loading in the produced water aggregated from many wells may be similar to that from the two hydraulic fracturing operations per year we estimated.

Given the number of stimulations, including frac-pacs in reservoirs where produced water was sent for reuse, it is not possible to rule out that stimulation chemicals were present in some unknown concentration in water used for irrigation. There is very little information available on the chemistry of produced water following any form of stimulation, including hydraulic fracturing/frac-packs and acid stimulations.⁹ The Central Valley Regional Water Quality Control Board requires testing and treatment of produced water prior to reuse for irrigation, but the testing for stimulation chemicals is not required, and the required treatment would not necessarily remove hazardous stimulation chemicals if they were present. As a result, our steering committee recommended that reuse of produced water from hydraulically fractured wells (including wells that are frac-packed) cease until or unless testing the produced water specifically for hydraulic fracturing chemicals and breakdown products shows non-hazardous concentrations, or required water treatment reduces concentrations to non-hazardous concentrations.¹⁰ Implied, but unstated, is that non-hazardous concentrations would have to be established for these constituents as none currently exist to our knowledge.

5. The conclusions and recommendations regarding the reuse of produced water potentially containing stimulation chemicals are relevant regardless of the dates of hydraulic fracturing operations and whether they were “ordinary” hydraulic fractures or frac-packs. Past regulations would not have prevented stimulation chemicals from

⁹ CCST and LBNL, 2015, Summary Report, Conclusion 4.2, p. 44.

¹⁰ CCST and LBNL, 2015, Summary Report, Conclusion and Recommendation 4.3, pp. 45-46.

being incorporated into irrigation waters. The CCST recommendation is to prohibit the reuse of produced water containing unsafe or unknown concentrations of stimulation chemicals in the future.

We agree that there is no evidence of hydraulic fracturing more recent than late 2013 in Chevron's wells at the Kern River oil field. However, the key point is that regulations should prohibit the reuse of produced water containing unsafe or unknown levels of stimulation chemicals *in the future*. According to data from the Central Valley Regional Water Quality Control Board, there are currently five fields (Deer Creek, Jasmin, Kern River, Kern Front and Mount Poso) where produced water is reused to irrigate crops.¹¹ Of these fields, well stimulations have only been reported in Kern River and Mount Poso. In Mount Poso, the last reported hydraulic fracturing operation was in 2003¹², and none of the operations of which we are aware occurred in the portion of the field from which produced water is used for irrigation.¹³

¹¹ CCST and LBNL 2015, Volume II, Chapter 2, p. 115.

¹² CCST and LBNL 2015, Volume I, Appendix M.

¹³ CCST and LBNL 2015, Volume III, Chapter 5, p. 99.