UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

CERTIFIED MAIL: RETURN RECEIPT REQUESTED (7016 1370 0000 2234 7957)

December 3, 2019

Robin Shropshire
Asset Manager
Panoche Energy Center
43883 West Panoche Road
Firebaugh, California 93622

RE: Underground Injection Control (UIC) Permit Renewal Application
Class 1 Non-Hazardous (NH) Permit No. R9UIC-CA1-FY17-2R
Technical Review

Dear Ms. Shropshire,

We have reviewed your October 19, 2019 response letter and separate expert opinion memorandum dated November 7, 2019 submitted in response to EPA's letter of June 22, 2019 and associated follow-up telephone calls. A detailed evaluation of your response, and the required follow up and requests for additional information are outlined in the Enclosure.

Specifically, we request that you provide the information detailed in the Enclosure, which is necessary to clarify, modify, or supplement previously submitted application materials. Please submit the information requested in the Enclosure by January 6, 2020.

The current permit R9UIC-CA1-FY17-2R will continue to be in effect under 40 CFR § 144.37(a) & (b), until such time that EPA makes a final decision to either issue or deny renewal of the permit. Under EPA regulations at 40 CFR § 124.3(d), if an applicant fails or refuses to correct deficiencies in the application, the permit application may be denied. If, by January 6, 2020, we do not receive the additional information detailed in the Enclosure, EPA may initiate the process to deny your permit application. *See* 40 CFR § 124.3(d).

Thank you for your cooperation. If you have questions, please contact me at 415-972-3971, or Michele Dermer of my staff at 415-972-3417.

Sincerely,

David Albright
Groundwater Protection Section

Enclosure

cc: Cameron Campbell, CA DOGGR, Inland District
Clay Rodgers, Central Valley Regional Water Quality Control Board
Anita Thompkins, USEPA, Office of Groundwater and Drinking Water

Enclosure

Review of PEC's Response to USEPA's June 22, 2019 Technical Review Letter regarding PEC's March 2019 Updated Class I Permit Application, and Responses to Additional EPA Questions

Please note: The headers and comment numbers below reflect the organization of PEC's October 14, 2019 response to EPA.

USEPA Comment and Request #1

Evaluation of PEC Response to USEPA's Agenda Item 1a: EPA acknowledges PEC's response indicating that they have provided publicly available information on the wells in Attachment C Exhibits for the permit application resubmittal. **No follow up information is needed.**

Evaluation of PEC Response to USEPA's Agenda Item 1b: EPA acknowledges receipt of the Barker (1982) thesis. The UT thesis provides a discussion of the factors affecting gel strength and also notes that the often-used gel strength value (20 lbs/100ft^2) is based on professional judgment. This statement supports EPA's view that there is uncertainty regarding the gel strength for the particular wells in question. **No follow up information is needed.**

Evaluation of PEC Response to USEPA's Agenda Item 1c - on the 1996 USGS Report on the Aneth Field Salinity Study:

EPA has reviewed PEC's response and acknowledges there remains a difference of opinion on this matter. Due to the continued uncertainty, EPA will require that another approach be considered. See below for additional information describing a potential path forward.

Evaluation of PEC Response to USEPA Agenda Item 1c - paper written by J. T. Thornhill, et al. (1982)

PEC states that "[t]he paper has no statement disapproving the mud weight argument." EPA agrees that the PEC mud weight argument is not entirely disproved by the paper, but the statements in the paper also note that "mud laden fluid will, in time, tend to settle out thereby reducing its effectiveness as a plugging agent." This statement supports EPA's view. Furthermore, the paper states that "[t]he area of review would be the area around an injection well where, during injection, the hydrostatic head of the formation fluid in the injection zone is equal to or greater than the hydrostatic head of USDWs." Mud weight is not a consideration in the AOR determination, and the corrective action requirements described in this paper. **No follow up information is needed.**

Evaluation of PEC Response to USEPA Agenda Item 1d – Alternative Lines of Evidence

PEC did not provide suggestions for alternative lines of evidence, but provided a memorandum prepared by an expert petroleum engineer (Hadaway, 2019). The following are comments on the memorandum:

- As noted by Hadaway, EPA concurs that the mud column generally falls over time in an uncased wellbore, and in the open-hole section of a cased wellbore, if cement plugs were not placed in an abandoned wellbore.
- It is not clear if the cited re-entered wells lacked casing to total depth. If cased to total depth, the mud would perform differently than if the well were uncased to its total depth, or an intermediate depth. In an open hole, the mud column would tend to fall farther than in wells with casing installed to total depth, or with intermediate casing installed, or in an open hole completion. The properties of the mud would also tend to change more than in a cased wellbore. The mud could infiltrate a pressure depleted zone an open hole, or a cased hole with perforations in the depleted zone. If that occurred, the mud column could lose hydraulic head, and its ability to contain fluid entry from normally or under pressured formations exposed in the open hole, or the perforated portion of the wellbore would be affected.
- The wells described in the memo may have had cement plugs in the casing and casing set as deep as 12,000 feet (it is not clear how many of the re-entered wells had plugs). The mud column above any plugs would not be able to fall into the open hole section. The abandoned wells in the Panoche AOR were drilled with surface casing only, set at less than 1,000 feet, with a long open hole section to depths of over 10,000 feet. The long open hole section could allow the mud column to fall much further than in wells that are cased and plugged with cement below the surface casing. The alteration of mud properties in the open hole section may differ from alteration in the cased and plugged portion of the wellbore. Gravity segregation and stratification of the mud could be greater in wells with a long open hole section. Hadaway acknowledges that gravity settling and stratification of the mud column may occur, and would be heavier on the bottom, and lighter on the top, instead of uniform throughout. This condition may be more extreme in wellbores abandoned without cement plugs below the surface casing.
- Mud conditions and columns in wells abandoned decades ago can vary substantially, depending on well construction, depth of casing and plugs, formation pressures and permeabilities, and other factors. Gel strength and mud weight may increase over time, as observed and stated by Hadaway, with wellbore conditions conducive to those changes. Hadaway's observations are related to 20 wells in the midcontinent region, which may not be applicable to the abandoned wells within the PEC AOR for reasons discussed.
- As EPA found in the 2011 audit of the California Divison of Oil, Gas and Geothermal Resources Class II UIC program, oil and gas wells in California were historically plugged and abandoned with weaker protections for USDWs. The goal was to isolate fresh water aquifers with 3,000 mg/L TDS or less, not USDWs with 10,000 mg/L TDS or less. This practice has since been modified to ensure USDW protection, however, it has not been applied retroactively. Cement plugs are now generally required to be placed at the top of the injection or production zone, and at the base of USDWs, and to the surface in some wellbores, to isolate the injection or production zones in abandoned wells.

Summary and Path Forward:

EPA does not share PEC's view on the accuracy of modeling efforts to demonstrate that mud weight and gel strength will prevent fluid movement into the USDW. As EPA previously recommended, PEC could re-enter at least one of the abandoned wells to evaluate mud conditions and pressures in those wells to demonstrate the efficacy of the mud to prevent fluid movement into the USDW. This option has been

discussed extensively and EPA acknowledges that PEC believes this sampling is impractical, with PEC having stated concerns about locating the wells, obtaining access to the wells (which are not on PEC property), and that re-entering the wells to sample would pose a risk of sidetracking the borehole or disturbing the mud.

Since PEC considers this option infeasible and did not provide any other options or alternatives, EPA offers the following suggested approach: PEC should prepare a plan to install monitoring wells to demonstrate that the abandoned wells are not serving as conduits for fluid movement. We recommend one multi-level monitoring well near each of the three abandoned wells that are closest to the PEC injection wells (i.e., Silver Creek 18, Blue Agave 1, and England 1-31) and screened in the injection zone and the lowermost USDW. Each well should be equipped to measure static pressures in the injection zone and monitor pressure and take samples for water quality analysis in the lowermost USDW. If USDW pressures and water quality are shown to remain stable, within an acceptable range, this would indicate an absence of communication between the injection zone and the USDW.

Please prepare and submit a plan to install monitoring wells as described above.

Evaluation of PEC Response to USEPA Agenda Item 1e – other potential reservoir targets.

No follow up information is needed.

USEPA Comment #2

a) Are the shut-in pressures static?

Evaluation of response: PEC indicates that most of their quarterly shut-in pressure data were measured after a shut-in period of more than 24 hours. PEC states that a shut-in period of 24 hours is commonly used for static measurements. Because the turbines do not run continuously, some shut-in times exceeded 24 hours. It is not stated how many shut-in periods exceed 24 hours or by how long. PEC does state that when a shut-in period exceeded 24 hours, the "...change in psi compared to the 24-hour shut in period was minimal...", although "minimal" is not defined.

Questions/requests: By how much did the shut-in pressure change between 24-hour shut-in periods and longer shut-in periods?

b) How long were the wells shut-in before the pressures were measured?

Evaluation of response: Shut-in times vary, with longer shut-in times when the plant has not been operating as frequently. PEC indicates that, for quarterly sampling, most shut-in times were more than 24 hours. The shut-in times for fall-off tests are generally greater than 35 hours. The response provides minimum values, but does not indicate the full range of shut-in times, especially when the turbines have been offline.

Questions/requests: What is the range of shut-in times for quarterly measurements and fall-off testing?

c) Please describe how pressure dissipation is addressed in the modeling.

Evaluation of response: PEC provided a basic description of the processes used in MODFLOW to simulate fluid flow and the resulting pressure buildup. PEC's response attempts to answer the request and briefly notes the selection of boundary and initial conditions.

This question had arisen during review of the permit renewal application, where PEC stated, "The projected annual injection volumes over the next decade may result in a gradual dissipation of increased formation pressure due to the higher annual volumes injected before the use of the EWS." Because injection will still be continuing, and actually increasing by a small amount each year, ongoing pressure reduction seemed unlikely. Although the response does not clarify the statement made in the permit application about gradual dissipation, the graphs and discussion provided to address USEPA Question 3 resolves this issue (see below). **There are no additional comments on this response.**

d) Please note any uncertainties in the projected injection volume increase of 1.45% per year.

Evaluation of response: PEC has provided a detailed description of the information source (2016 and 2018 reports by the California Energy Commission) on which they based the 1.45% estimate. PEC describes the key economic assumptions underlying energy consumption demand scenarios (low, medium, and high) that informed PEC's estimate of future energy usage. The 1.45% estimate appears to be a reasonable upper limit for increased energy usage and associated increase in wastewater generation given the available information. **No additional information is required.**

USEPA Comment and Request #3

a) Please provide additional information from the model output in the form of graphs and tables of predicted pressures with time at the injection wells, and at the edge of the AOR.

Evaluation of response: PEC has provided the requested graphs and tables:

- An image of the model grid and domain used for the AOR modeling.
- Simulated historical and future net wellhead pressure increase trend at IW2 and historical net pressure increase data based on IW2 quarterly minimum shut-in pressure data (Figure 6).
- Simulated net formation pressure increase trends at the locations of Blue Agave #1 and Silver Creek 14X (Figure 7).

Figure 6 in particular illustrates the modeling results for the pressure trend through 2029. The existing data and simulation show a drop in wellhead pressure with the drop in injection volumes when the EWS came online. The graph then shows a simulated gradual upward trend through 2029, consistent with the anticipated slow (1.45% per year) increase in injection volumes.

The simulated pressures generally match the minimum values for the historical data, but the seasonal high peaks significantly exceed the data during the pressure buildup between 2009 and 2016. The simulations match the data better for the two years following startup of the EWS. The simulated trend after initiation of the EWS and up through 2029 shows a very slow, gradual increase, which is conceptually consistent with the anticipated 1.45% per year increase in injectate volumes. **No additional information is requested at this time. As additional data become available to verify the post-EWS simulations match the pressure data, this verification should be reviewed.**

b) Please provide maps of pressure contours over the time frames modeled

Evaluation of response: No additional information is requested.

c) Please provide the sources and magnitudes of uncertainties in the modeled pressures.

Evaluation of response:

For formation hydraulic parameters, PEC states that the injection rates at the four injection wells have been similar (180-250 gpm), and that minimum shut-in pressures for the wells from June 2019 are also similar, suggesting homogeneity in aquifer properties in the vicinity of the four injection wells. PEC also states that modeling results show that the simulated pressure buildup and dissipation trend at IW2 agrees well with the observations. PEC states that the uncertainties in the hydraulic parameters in the modeled pressures are, therefore, not considered significant.

While PEC's response does suggest a general lack of heterogeneity in the aquifer properties immediately around the four injection wells, it does not represent the entire AOR. Furthermore, PEC's response does not discuss other forms of uncertainty such as bias or error in the estimated formation parameters from the FOTs and plant operation data (e.g., error inherent in the measurements themselves). Furthermore, as noted above, the graph of simulated historical and future net wellhead pressure increase trend at IW2 (Figure 6) matches minimum values but not maxima during the period of greatest pressure buildup, although simulated values appear to match data better in the limited dataset for the years since the EWS came online.

Initial and boundary head conditions: PEC states that modeling pressure is not sensitive to the initial and boundary head conditions. PEC also states that "...the use of a different value for the initial and boundary head conditions resulted in very similar simulated and observed net pressure increase trends at IW2 (Figure 6). Therefore, the uncertainty introduced by the initial and boundary head conditions is considered insignificant."

The selection of the initial head appears reasonable. No information is provided, however, on the different value used for the initial and boundary head conditions.

Future wastewater volume to be injected: The uncertainties and method for determination of the anticipated wastewater injection volumes were addressed above (Question #2d).

Questions/requests:

- ***What is the estimated uncertainty in formation parameter measurements?***
- ***Was a sensitivity analysis done to test uncertainties inherent in formation parameter measurements?***
- ***What was the "different value" tested for the initial and boundary head conditions?***

USEPA Comment and Request #4

Please discuss why the results vary between Methods #1 and #2, and why PEC selected the results from Method #1 (i.e., calculation of Rw from log measurements of Ø and Rt) in determining the depth of the base of the lowermost USDW rather than Method #2.

Evaluation of response: No additional information is requested.

USEPA Comment and Request #5

Please provide data that support the determination of elastic properties of the injection zone.

Evaluation of response: No additional information is requested.

USEPA Comment and Request #6

Please provide oil/water saturation and compressibility data for IW1.

Evaluation of response: No additional information is requested.

USEPA Comment and Request #7

In Table 3, AMEC 2012, the data for IW3 and IW4 are identical. Is this correct?

Evaluation of response: No additional information is requested.

USEPA Comment and Request #8

Please revise the proposed drilling and completion procedures and Figures L-1 and L-2 to reflect surface casing that is installed to at least 3,500 feet in the IW5 and IW6 wells, and to provide two layers of casing and cement to protect the USDW.

Evaluation of response: PEC responded as follows: "As requested, PEC has revised the proposed drilling and completion procedures and Figures L-1 and L-2 to reflect that the surface casing will be installed to a depth of approximately 4,000 feet in proposed wells IW5 and IW6, thus providing two layers of casing and cement to protect the USDW. **Please replace the text for Attachment L and Figures L-1 and L-2 with the replacement pages included in Appendix H of this submittal."** Figures L-1 and L-2 have been changed as described.

USEPA Comment and Request #9

Please revise the proposed FOT procedures to include bottomhole pressure measurements, in accordance with Region 9 guidance.

Evaluation of response: The text on the use of a bottomhole gauge system has been added to the FOT

work plan. **No additional information is requested.**

Review of Response to EPA Comments/Questions Transmitted to PEC on August 26, 2019

USEPA QUESTIONS #1 AND #3

#1: The wellhead and bottomhole pressures track in the shape of the fall-off pressure data as presented in Figure 13, but the calculated bottomhole Pi is greater than the measured Pi by 64 to 73 psi according to our calculations: based on H = 675 feet and 245 feet, respectively. The measured WHP is 64 to 73 psi more than the calculated WHP based on the measured BHP at 7,500 feet and the specific gravity of the injectate of 1.0036.

#3: Using WHP data to calculate BHPs in future surface pressure fall-off tests will yield a static BHP that may be too high - by 64 to 73 psi, based on our calculations for the 2011 fall-off test and a specific gravity of the injectate of 1.0036.

Evaluation of response: For the most accurate determination of bottomhole pressure, the FOT should be based on bottomhole pressure measurements. The agreement to measure bottomhole pressures in the next FOT satisfies this concern. **No additional information is requested.**

USEPA QUESTION #2

Only the results for the net thickness values of 245 and 675 feet were provided in Table 4 of the report. There was no comparison of permeability calculations and results for wellhead versus bottomhole pressure data provided in the report. The discussion in Section 5.4, FOT Conclusions, states that similar results were obtained, but the comparison of results for permeability were not included.

Evaluation of response: No additional information is requested.

USEPA QUESTION #4

It is not clear from the information provided as to whether the IW1 well was shut-in or actively injecting during the FOT at the IW2 well, and whether it affected the results or not.

Evaluation of response: No additional information is requested.