

Lahontan Regional Water Quality Control Board

March 22, 2012

Interested Persons

COMMENTS REQUESTED BY APRIL 23, 2012 – CONSIDERATION OF AMENDMENT OF ORDER NO. R6V-2011-0005A1 (Order¹) ISSUED TO PACIFIC GAS AND ELECTRIC COMPANY (PG&E)

In October 2011, the Lahontan Water Board ordered Pacific Gas and Electric (PG&E) to provide replacement water to persons in the Hinkley area whose domestic wells contain levels of hexavalent chromium that exceeded 3.1 µg/L due to PG&E's discharge. PG&E was also required to submit a methodology to determine if levels of hexavalent chromium in individual domestic wells below 3.1 µg/L that are within one mile from the delineated plume were due, in part, to its discharge (see section 3.a. of the Order¹).

In letters dated November 23, 2011 and December 22, 2011 (both enclosed), PG&E provided its position that developing a methodology as required in section 3.a. of the Order was not possible. I am soliciting comments on whether this position is justified. Based on PG&E's position and comments received in response to this letter, I may consider amending the Order to, among other things: (1) eliminate the requirement for PG&E to provide replacement water to persons whose wells contain hexavalent chromium at levels less than 3.1 µg/L, based on PG&E's position; (2) require PG&E to consider specific methodologies included in comment letters; or, (3) impose a methodology that PG&E must use to determine its obligation to provide replacement water to those persons whose wells contain hexavalent at levels less than 3.1 µg/L.

Comments on this matter must be submitted to me, either by hard copy or electronically, by April 23, 2012. Based on comments received, I may take action, including amending the Order or requesting additional comments on a methodology that may be incorporated into an amended order. Please contact me at (530) 542-5412 or hsinger@waterboards.ca.gov if you have any questions.



Harold J. Singer
Executive Officer

Enclosures

PG&E Letters dated November 23, 2011 and December 22, 2011

¹ The Order can be viewed at:

http://www.waterboards.ca.gov/lahontan/water_issues/projects/pge/docs/r6v_2100_0005a1.pdf



**Pacific Gas and
Electric Company**

Robert C. Doss, P.E.
Principal Engineer
Chromium Remediation Program
Office
Shared Services

77 Beale Street, Mail Code B16A
San Francisco, CA 94105-1814

Phone: (415) 973-7601
Fax: (415) 973-0750
E-Mail: RLDI@pge.com

November 23, 2011

Mr. Harold J. Singer
Executive Officer
California Regional Water Quality Control Board
Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, California 96150-7704

Re: PG&E's Submittal Pursuant to Ordering Paragraph 3.a.
Amended Cleanup and Abatement Order No. R6V-2011-0005A1

Dear Mr. Singer:

Pacific Gas and Electric Company (PG&E) submits the following in compliance with Ordering Paragraph 3.a. of Amended Cleanup and Abatement Order No. R6V-2011-0005A1 (the "Order"), issued October 11, 2011 for the Hinkley Compressor Station.

PG&E has for many years acknowledged with genuine regret its responsibility for chromium contamination in the Hinkley community. PG&E is committed to working cooperatively with the Lahontan Water Board to expeditiously clean up groundwater contamination resulting from PG&E's historical operations at the Hinkley Compressor Station. We share the mutual goal of ensuring safe, reliable drinking water for the residents of Hinkley to ease their concerns for community health and well-being. To that end, PG&E will continue to honor our commitment to provide safe drinking water to the community through our voluntary bottled water program while we comply with the feasible provisions of the Order, including evaluation of whole house water treatment technologies and establishment of the Independent Review Panel (IRP) for the community.

To comply with the feasible provisions of the Order, PG&E has initiated a pilot study to evaluate water treatment technologies to determine if they can reliably and consistently treat hexavalent chromium to levels below 0.06 ppb. This pilot study is necessary because we understand, based on our discussions with the California Department of Public Health and water purveyors such as the City of Glendale, that there are currently no certified treatment systems that can consistently reach the 0.06 ppb limit for hexavalent chromium. As we indicated in our transmittal of the pilot study work plan to the Water Board on September 27, 2011, PG&E welcomes any input the Water Board may have regarding the testing protocols or monitoring programs outlined in that work plan. The pilot test facility has commenced operation, and we welcome community

Mr. Harold J. Singer

November 23, 2011

Page 2

members and others who wish to tour the facility; some Community Advisory Committee (CAC) members already have visited the facility. Preliminary results of our pilot study are expected to be available in late February/early March 2012, and we will share those results with the Board and the public as soon as possible. In addition, we have made significant progress on establishment of an IRP that meets the goals and objectives of the CAC members, and we anticipate signing a formal agreement with the CAC before the December 10, 2011 Order deadline.

While PG&E has been diligently working to comply with the feasible provisions of the Order as described above, we have submitted a petition to the State Water Resources Control Board on those provisions that are technically infeasible, including Ordering Paragraph 3.a. which is the subject of this submittal. Ordering Paragraph 3.a. requires PG&E to propose a method or methods to perform an initial and quarterly evaluation of every domestic or community well in the affected area to determine if detectable levels of hexavalent chromium between the maximum naturally occurring background level and the Public Health Goal (PHG) represent background conditions, or are more likely than not, partially or completely, caused by the discharge of waste by PG&E. The order states that the proposed method or methods should take into consideration the factors listed in Finding No. 26 of the Order; that finding provides that hexavalent chromium concentrations in each domestic well in the affected area must be evaluated separately, considering a number of factors, including, but not limited to: changes in hexavalent chromium levels over time, location of the well in relationship to the plume and groundwater flow direction, isotopic analysis of hexavalent chromium, and statistical analysis described in Title 27, California Code of Regulations (CCR), section 20415(e)(8). For reasons outlined in our petition and further discussed below, PG&E has found no technically sound and implementable methodology for determining impacts to domestic wells below naturally occurring background levels as required by Ordering paragraph 3.a.

As an initial matter, historic analytical detection limits for hexavalent and total chromium were higher than the maximum background concentrations set by the Water Board. Therefore, any historic data set would not allow PG&E to distinguish hexavalent chromium concentrations in the range of background levels, much less to the 0.06 ppb hexavalent chromium level mandated by the CAO, making meaningful data comparison to determine impacted wells impossible.

The Water Board's draft Order issued on June 10, 2011 included proposed requirements for determining impacted wells using three statistical methods. Our technical experts and statisticians discussed these methods with Board staff and with the Board's statistician, and concluded that a statistical method for determining PG&E impacts to domestic wells with hexavalent chromium levels below the background level of 3.1 ppb was not possible. We continued to discuss this issue with our experts after issuance of the final Order, but we could not develop a methodology that was implementable and technically sound. We welcome an opportunity to meet with Board staff to review our conclusions.

PG&E believes that the current background level for hexavalent chromium of 3.1 ppb, in the absence of a new peer reviewed background study, is the only appropriate concentration to compare to for determining impacts. California regulations support this assertion. As provided in 23 CCR section 2550.7(e), when a background study is performed that produces a 95 percent upper tolerance limit (UTL)—as was the case with the Hinkley background study—monitoring data are to be compared to the UTL, rather than to some other parameter for background. Further clarification is given by 23 CCR section 2550.7(e)(8)(C), which provides that the value for each

Mr. Harold J. Singer

November 23, 2011

Page 3

constituent of concern or monitoring parameter at each monitoring point is compared to the upper tolerance or prediction limit.

PG&E appreciates the Water Board's recent peer review comments on the Hinkley background study. We will be proposing an updated background study that takes into account those comments and the views of other experts, as well as builds on the significant advances in our understanding of this site that have taken place since the original background study was initiated in 2005. We look forward to discussing this with the Board and developing a mutually agreed upon approach for an updated peer reviewed background study.

I hereby certify that I have examined this report, and based on my examination and my inquiries of those individuals who assisted in the preparation of the report, I believe the report to be true, complete and accurate.

Please do not hesitate to contact me if you have any questions regarding this report, or if you need additional information.

Sincerely,

Robert C. Dass



**Pacific Gas and
Electric Company**

Robert C. Doss, P.E.
Principal Engineer
Chromium Remediation Program
Office
Shared Services

77 Beale Street, Mail Code B16A
San Francisco, CA 94105-1814

Phone: (415) 973-7601
Fax: (415) 973-0750
E-Mail: RLDL@pge.com

December 22, 2011

Mr. Harold J. Singer
Executive Officer
California Regional Water Quality Control Board
Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, California 96150-7704

Re: Water Board December 7, 2011 Response to
PG&E's November 23, 2011 Submittal Pursuant to Ordering Paragraph 3.a.
Amended Cleanup and Abatement Order No. R6V-2011-0005A1

Dear Mr. Singer:

Pacific Gas and Electric Company (PG&E) submits the following in response to your December 7, 2011 letter requesting additional details of our statistical method evaluation pursuant to Ordering Paragraph 3.a. of Amended Cleanup and Abatement Order No. R6V-2011-0005A1 (the "Order") for the Hinkley Compressor Station.

PG&E is firmly committed to complying with the feasible provisions of the Order as evidenced by our provision of interim replacement water of demonstrated high quality to all residents who have impacted wells, our significant progress on the pilot study for the point-of-entry water treatment systems and the signing of a memorandum of agreement with the Hinkley Community Advisory Committee to fund an independent review panel. However, as discussed in our November 23, 2011 letter report, PG&E has found no technically sound statistical method to determine whether PG&E's plume has affected domestic wells with concentrations below the naturally occurring hexavalent chromium maximum background concentration of 3.1 parts per billion (ppb) as required by Ordering Paragraph 3a.

The challenges of finding an applicable statistical method were evident several months ago when the Board issued the draft Order. As you may recall, the statisticians from PG&E and the statistician used by the Board, Dr. Willits, discussed several possible statistical methods proposed in the draft Order during a September 22, 2011, conference call. At the time, Dr. Willits stated that the Board staff had requested he propose a statistical method that is commonly used to determine if a release has occurred from a hazardous waste landfill or impoundment; however he was uncertain whether that method was applicable to determining if the hexavalent chromium detected below the naturally occurring background value of 3.1 ppb is indicative of a release as

required by the Order. Dr. Willits also indicated that he was asked to also provide a trend test, and that he had done his best to create such a test. However, he acknowledged that his proposed test would create many false positive results. The final Order did not include the statistical methods initially proposed in the draft Order.

Despite these challenges, PG&E's experts continued to research possible statistical methods that could be used to achieve the objectives stated in the Order. We have summarized these efforts and conclusions below.

The Use of Established Background Levels to Determine Whether a Well is Impacted

The 2007 Background Study used a statistical method to establish an Upper Tolerance Limit (UTL) for hexavalent chromium of 3.1ppb for the study area. The goal of the UTL statistic is to establish whether sampled concentrations at a given well are higher than naturally occurring background concentrations. It is based upon a statistical test of the null hypothesis that concentrations at a tested well do not exceed the maximum average concentration among the background wells. The background study statistical approach produced the maximum background value for 95 percent of the population of background wells. Implicit in this UTL approach is that one background well in 20 (*i.e.*, 5 percent) will have natural concentrations above 3.1 ppb hexavalent chromium. Therefore, concentrations above the UTL are assumed to represent plume water with a potential error of this assumption (false positive) of 5 percent.

The background study represents an inter-well comparison, which compares wells to background wells outside of the area affected by the plume. Interwell comparisons are necessary when there are not sufficient historical (pre-release) measurements available for the affected wells to allow the establishment of naturally occurring background levels at a given site, as is the case here. It is important to note that historic data for hexavalent chromium at the very low level of 0.06 ppb set forth in the final Order cannot and does not exist for the domestic wells in Hinkley; until very recently, laboratory methods that could quantify hexavalent chromium at that level had not been developed..

The current directive to "determine if detectable levels of hexavalent chromium between the maximum background level and the PHG represent background conditions" is at odds with the existing UTL statistic, as it tests the same null hypothesis as the test using the UTL. Any test (inter-well or intra-well), which uses a lower threshold than 3.1ppb is therefore not consistent with the current testing procedure and would effectively invalidate and reset the UTL. This would lead to an inflation of the false positive rate under the currently accepted statistical distributional assumptions underlying the UTL.

PG&E appreciates the Water Board's recent peer review comments on the Hinkley background study. In January, 2012 we will propose an updated background study that takes into account those comments and the views of other experts, as well as builds on the significant advances in

our understanding of this site that have taken place since the original background study was initiated in 2005. We look forward to discussing this with the Water Board and developing a mutually agreed upon approach for an updated peer-reviewed background study.

September 22, 2011 Discussion

Any additional hypothesis tests need to be consistent with the hypothesis test currently in place (*i.e.*, the UTL statistical test) and should not lead to a significant inflation of the site-wide false positive rate. During our discussions with Dr. Willits on September 22, 2011, and in follow-up discussions, we established that:

- the Nonparametric Discrete Retest Procedure, which is another interwell testing method based on the distribution in the background wells; and,
- the Spearman Rank Correlation Test, which is an intra-well testing method based on a sequence of measurements at a given well,

lead to an excessive inflation of the overall false positive rate. Further, the Spearman Correlation method does not differentiate between statistically and environmentally significant trends.

PG&E's Analysis Pursuant to Ordering Paragraph 3.a. of the Order

As stated above, the current directive to “determine if detectable levels of hexavalent chromium between the maximum background level and the PHG represent background conditions” is at odds with the existing test as it tests the same null hypothesis as the test using the UTL statistic.

As directed by the final Order, our experts then turned to “a consideration of a number of factors, including, but not limited to: changes in hexavalent chromium levels over time”, which are intra-well comparisons. The use of trend analysis is based on the scenario that a well originally outside the plume has been intercepted by the leading edge of the plume, as evidenced by a significant rise in chromium concentration. Because there are no pre-release monitoring data available, it is necessary to rule out any intra-well tests which rely on parameters estimated on data prior to release. We considered four different trend tests:

1. Sen Test: A simple non-parametric trend estimator, which calculates the median slope between any two data points at a given site. It requires a sample size of $n > 8$ at the very minimum to estimate the variance to make statements of statistical significance.
2. Mann-Kendall Test: This test counts the number of overall increases and decreases in a time series, without taking into account the magnitude in the change. As this test does not distinguish between large and small increases in concentrations it is therefore conceptually similar to the Spearman test in the sense that it is able to detect a statistically significant test, yet does not distinguish between environmentally significant and

insignificant trends. It requires a sample size of at least 10 in order to make statements of statistical significance.

3. Univariate or Box-Jenkins regression: This method fits a trend line through observed monitoring data and provides an estimate of the environmental magnitude and statistical significance of the trend. The sample size requirements are large ($n > 10$ at the very least). The slope estimate (environmental magnitude) of the trend can be biased by failure to properly account for confounders (*e.g.*, remediation activities). The estimate of statistical confidence is sensitive to distributional assumptions and the dependence structure of the residual terms (*e.g.*, temporal and spatial dependence).
4. Control Charts: The CUSUM or SHREWHART Control Charts provide a clear way to illustrate changes in a well over time, yet require the estimation of a mean and variance parameter, which requires $n > 8$. Control charts require the samples to be statistically independent, which is impossible to establish with small sample sizes. Further they are only valid methods if the background mean is stationary over time, which is not the case at impacted wells.

All of these statistical methods require sample sizes of 8 or greater. Given the fact that less than 10 percent of wells have seven or more consistent measurements, none of the available methods are broadly applicable to test whether a trend is statistically *and* environmentally significant. The most suited technique to detect an environmentally and statistically significant trend, regression analysis, does have bad power properties at small sample sizes. In fact, research has shown that for proper application of Box-Jenkins methods, 50-100 measurements at equally spaced time intervals are required.¹

The problem is more complex than this, as the Order recognizes. Even if a statistically significant trend was found at a given well, which is not possible given the current monitoring dataset, this significance needs to be evaluated in context of the hydrogeology. For example, are trends also detected at wells between the plume and the well with a detected trend? An isolated well with a statistically and environmentally significant trend that is reflected in none of the surrounding wells may be due to fluctuations in background. It is not clear how to define how many neighboring wells would also have to show a significant trend to determine that a well is impacted.

Further, remediation activities may affect background chromium levels, which are expected to lead to large fluctuations in background concentrations of chromium. These larger fluctuations

¹ Robert D. Gibbons, Dulal Bhaumik, Subhash Aryal. 2009. Statistical Methods for Groundwater Monitoring. Second Edition. Wiley. ISBN-10: 0470164964

Mr. Harold J. Singer
December 22, 2011
Page 5

differ from fluctuations during a background sample due to remediation activities, not due to a change in the location of the plume, and again increase the site-wide false positive rate.

Finally, if there are seasonal swings in concentrations in the entire aquifer (background and non-background wells), a trend may be detected in all wells, which is simply due to fluctuations in background at all wells.

Conclusion

For the reasons described above, PG&E has concluded that there is no valid statistical method to meet the requirements of the Order. Rather, the appropriate way to establish whether wells are impacted by PG&E's historic operations is through comparison with the Upper Tolerance Limit established under a background study. As noted above, PG&E will propose an updated background study in January, and looks forward to feedback from the Board and its peer reviewers on our proposal.

I hereby certify that I have examined this report, and based on my examination and my inquiries of those individuals who assisted in the preparation of the report, I believe the report to be true, complete and accurate.

Please do not hesitate to contact me if you have any questions regarding this report, or if you need additional information.

Sincerely,

Robert C. Dass