

**CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION**

MEETING OF MARCH 15, 2012

Barstow

ITEM: 12

**SUBJECT: PEER REVIEW OF PACIFIC GAS & ELECTRIC
COMPANY'S 2007 GROUNDWATER CHROMIUM
BACKGROUND STUDY, HINKLEY COMPRESSOR
STATION, SAN BERNARDINO COUNTY**

CHRONOLOGY: This chronology lists Water Board actions related to establishing background chromium concentrations in groundwater in the Hinkley area.

August 8,
2008

Cleanup and Abatement Order No. R6V-2008-0002 required PG&E to implement actions to achieve plume containment and propose a feasibility study to clean up groundwater to background water quality.

November 12,
2008

Amended Cleanup and Abatement Order No. R6V-2008-0002A1 established maximum and average background chromium concentrations for total and hexavalent chromium based on results of PG&E's 2007 Groundwater Chromium Background Study Report.

March 9, 2011

Water Board members heard public concerns related to the validity of the 2007 Background Study and its results. Water Board members directed staff to obtain scientific peer review of PG&E's 2007 Chromium Background Study Report.

DISCUSSION: Water Board staff received peer review comments in October 2011. The peer reviewers' comments were primarily critical of the 2007 Background Study Report. The criticisms are grouped into four categories:

- 1) Lack of aquifer-specific sampling
- 2) Statistical methods and assumptions
- 3) Uncertainty regarding historic plume migration
- 4) Sample analysis quality control procedures

Water Board staff has taken several steps to begin addressing the peer reviewers' comments and questions on the 2007 Background Study:

- 1) Requested technical reviews of the peer reviewer's laboratory quality control questions from the Water Board's independent contract laboratory, Excelchem (completed in December 2011).
- 2) Required PG&E to submit information on quality control procedures to determine the nature and extent of any analytical chemistry procedural problems, based on the technical review from the Water Board's laboratory. PG&E submitted its response in January 2012).
- 3) Met with Dr. John Izbicki of the US Geological Survey (expert in chromium sampling in the Mojave Desert area), to discuss techniques and approaches to determine anthropogenic versus naturally occurring chromium in groundwater.
- 4) Through the State Water Board's contract with the University of California – Davis Statistics Lab, are requesting a review of the statistical issues raised in the peer review of the 2007 Background Study, and the feasibility of re-evaluating existing datasets to re-evaluate the adopted background values.

In late February, PG&E submitted a *Proposed Work Plan for Evaluation of Background Chromium in the Upper Aquifer of the Hinkley Valley*. The work plan also contains an appendix with PG&E's responses to all peer review comments.

ISSUE: The Water Board must consider whether the background values established in 2008 are appropriate for setting

cleanup goals. If the Water Board decides they are not appropriate, two basic questions surface:

1. How should appropriate background values be established?
2. What value(s) should be used in the interim?

The enclosed staff report summarizes the peer review comments, and discusses options for the Water Board's consideration of established background values of chromium in groundwater in the Hinkley area. Water Board's staff recommendation is provided in the staff report.

RECOMMENDATION:

The Water Board may provide direction to staff as appropriate.

ENCLOSURES

Enclosure	Item	Bates Number
1	Staff Report, Summary and Discussion: Peer Review of PG&E's 2007 Chromium Background Study.	12-5
	Appendix 1: Copies of peer reviewers' comment letters	12-23
	Appendix 2: Technical reviews of laboratory quality control Issues, and related correspondence	12-65
2	Public comment letter from Hinkley residents, and signature petition, dated February 22, 2012.	12-135
3	Proposed Work Plan for Evaluation of Background Chromium in the Upper Aquifer of the Hinkley Valley. Prepared for PG&E by Stantec, Inc., dated February 22, 2012.	12-143

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ENCLOSURE 1

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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD,
LAHONTAN REGION



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Staff Report

Summary and Discussion:
Peer Review
of
Pacific Gas & Electric Company's
2007 Groundwater Chromium
Background Study Report

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March 2012

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I. Background

Site History

The Pacific Gas and Electric Company (PG&E) Compressor Station is located in the Hinkley Valley of San Bernardino County, just southeast of the town of Hinkley. The Compressor Station has operated since 1952. From 1952 to 1965, hexavalent chromium-based corrosion inhibitor was added to water used in the cooling towers, and the untreated cooling tower water was discharged to unlined evaporation ponds. The unlined ponds have since been closed, covered, and replaced by lined evaporation ponds. In 1987, PG&E reported to the State total chromium and hexavalent chromium concentrations exceeding the California drinking water standard of 50 parts per billion (ppb) total chromium in groundwater beneath and down gradient of the site.

Groundwater in the Hinkley Valley occurs in two aquifers, known as the upper aquifer and the lower aquifer, which are separated by a layer of fine-grained clay and silts. This layer, the “blue clay”, restricts or prevents groundwater flow between the two aquifers. The chromium plume (as currently defined) primarily exists in the upper aquifer, although in 2009 a limited area of the lower aquifer showed hexavalent chromium concentrations above background values where the blue clay is thin or absent. PG&E has determined the extent of this limited area of contamination in the lower aquifer, since the surrounding lower aquifer has no detectable chromium concentrations.

Currently, groundwater beneath the Compressor Station contains hexavalent chromium concentrations up to 4,100 ppb. There is no drinking water standard specific to hexavalent chromium; however, in July 2011 the state of California’s Office of Environmental Health Hazard Assessment (OEHHA) adopted a Public Health Goal (PHG) for hexavalent chromium in drinking water of 0.02 ppb. A PHG is not an enforceable standard, but an estimate of the level of a contaminant in drinking water that would pose no significant health risk from consuming the water on a daily basis over a lifetime. Adoption of a PHG is the first step in setting an enforceable standard for a contaminant in drinking water.

Background Study Development

State Water Board Resolution No. 92-49 requires that dischargers clean up waste to either background water quality, or the best water quality which is reasonable if background levels of water quality cannot be restored while at the same time restoring water quality to provide for existing and future beneficial uses. In July 2002, PG&E submitted a study proposal for determining background levels of total and hexavalent chromium in groundwater in the Hinkley area, entitled *Scope of the Background Chromium Study* (the 2002 Background Study Plan).

The 2002 Background Study Plan proposed collecting groundwater samples from twelve monitoring locations over four quarters in a year. Monitoring locations were

situated upgradient and crossgradient to the Compressor Station and the contaminated groundwater plume, up to 6,000 feet away. No samples were proposed in the lower aquifer, since data at the time indicated it was not impacted by chromium contamination.

In November 2003, Water Board staff sent the 2002 Background Study Plan to three University of California professors for review. The reviewers agreed that the approach contained in the 2002 Background Study Plan was generally appropriate, but each reviewer had suggestions regarding the plan. As a result of the 2003 peer review, the criteria for selecting wells for the study was refined, depth-discrete sampling within the upper aquifer was added, an assessment of groundwater flow paths was done, and additional statistical methods were included.

PG&E revised the 2002 Background Study Plan according to Water Board staff's direction and the peer reviewers' comments, and in 2004 submitted the *Revised Background Chromium Study at the PG&E Compressor Station, Hinkley, California* (the 2004 Revised Background Study Plan). In November 2004, Water Board staff conditionally approved the 2004 Revised Background Study Plan, including proposals to sample from fifteen to twenty wells over four consecutive quarters, and conduct depth-discrete sampling in five wells.

Background Study Sampling and Results

PG&E conducted sampling for the Background Study throughout 2006. In mid-2006, PG&E submitted a progress report stating that sampling was being conducted at 18 private well locations, and depth-discrete samples were collected at two of the five proposed wells. The report stated that additional wells would be evaluated for depth-discrete sampling where feasible. Other than the reduced number of depth-discrete samples, the progress report indicated that PG&E was following the 2004 Revised Background Study Plan approved by Water Board staff.

In February 2007, PG&E submitted the *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California*, prepared for PG&E by CH2MHill, dated February 28, 2007 (the 2007 Background Study Report). The 2007 Background Study Report presented the sampling data and the results of statistical analysis of the data.

At a public hearing in November 2008, the Lahontan Water Board adopted amended Cleanup Order No. R6V-2008-0002A1, establishing the following background chromium concentrations for the Hinkley area, based on data in the 2007 Background Study Report:

- Maximum background total/hexavalent chromium = 3.2/3.1 ppb
- Average background total/hexavalent chromium = 1.5/1.2 ppb

Except for those from PG&E, no public comments were received regarding the amended CAO and its recommended background chromium levels.

Peer Review of 2007 Background Study Report

In July 2010, PG&E's *Second Quarter 2010 Groundwater Monitoring Report* showed hexavalent and total chromium concentrations exceeding the maximum background concentrations in three residential supply wells and four shallow monitoring wells in the north and east of the formerly defined plume boundaries. In August 2010, Water Board staff received a Feasibility Study report from PG&E that presented alternatives for final cleanup of waste chromium in groundwater to the established average and maximum background levels. Water Board staff held public information meetings in Hinkley in December 2010 to discuss the plume expansion and PG&E's Feasibility Study alternatives.

Groundwater monitoring reports submitted by PG&E continue to indicate chromium above background values in areas to north, west and east of previously defined plume boundaries. The ongoing expansion of the plume and release of the Feasibility Study, followed by OEHHA's July 2011 adoption of a PHG for hexavalent chromium of 0.02 ppb, renewed public interest in the background chromium values and how they were derived.

Of particular concern were deviations from the 2004 Revised Background Study Plan, where PG&E added a significant number of wells concentrated in one area, without the specific locations or numbers accepted in advance by Water Board staff. The 2004 Revised Background Study Plan proposed sampling fifteen to twenty well locations during each sampling event. By the Study's end, a total of forty-eight well locations in the Hinkley area were sampled. Of these forty-eight wells, thirty were added after the first two sampling events, with twenty-three of those wells concentrated in one area near a well which showed the highest concentrations of chromium detected in the first two sampling events (well BGS-04). The explanation given in the 2007 Background Study Report was that the additional wells were added to compensate for not completing required depth-discrete sampling at three well locations.

In addition, since the chromium plume had expanded beyond the previously delineated boundaries, concerns were expressed that the background study had incorporated wells that did not represent background chromium, but instead were affected by PG&E's waste chromium discharges.

In response to public concerns heard at the March 2011 Water Board meeting, the Lahontan Water Board directed staff to obtain scientific peer review of the 2007 Background Study Report.

During summer 2011, three peer reviewers were identified through Cal/EPA's Scientific Peer Review Program. The reviewers were selected for their expertise in analytical chemistry, groundwater modeling, statistics, hydrogeology and chromium remediation, and underwent a rigorous conflict-of-interest disclosure process. Reviews were

completed in October 2011, and in December 2011, Water Board staff held a public meeting in Hinkley to summarize the peer reviewers' comments.

II. Regulatory and Planning Considerations

This section discusses the use of background values for the Water Board's regulatory and planning efforts at Hinkley, and how those efforts could be affected by changes to the adopted background values.

Environmental Impact Report for Comprehensive Groundwater Cleanup

Water Board staff are in the final steps of developing an Environmental Impact Report (EIR), as required by the California Environmental Quality Act (CEQA) to analyze the environmental effects of issuing General Waste Discharge Requirements to PG&E to implement comprehensive groundwater cleanup activities in Hinkley. The EIR must be finalized so that the General Waste Discharge Requirements and a new Cleanup and Abatement Order (CAO) can be considered by Water Board. The draft EIR is scheduled for public review in May 2012, and for Water Board consideration, along with the General Waste Discharge Requirements and a new CAO, in fall 2012. The background concentration values are important to the EIR in three ways:

1. Maximum background levels are used to depict the plume boundary, and to define the existing environment in terms of what is and what is not considered contamination. CEQA requires disclosure of the existing environmental conditions at the time of the EIR preparation.
2. They define the area of remedial action and the project study area. CEQA requires a clear and defined project description.
3. They define the proposed alternatives in terms of how much cleanup may occur, and where the impacts may be located.

If information about the existing environment or about the project description changes during the CEQA process, additional analysis may be required. The trigger is whether the new information or the change in the project results in a) new significant impacts; b) substantially more severe impacts; or c) is so fundamental to the environmental evaluation that review of the project would be fundamentally changed by consideration of the new information. Those circumstances could require either re-circulation of all or part of the document, or a supplemental or subsequent EIR if the changes occur after the EIR has been certified by the Board.

Water Board staff and its EIR consultant have taken the approach of defining the EIR project area and potential cleanup activities as broadly as reasonably foreseeable. If the Water Board chooses to reconsider the adopted background values based on peer review comments, the existing broadly-defined EIR study area is likely large enough to accommodate potential changes to plume boundary, if the background value was

changed as a result of the Water Board's action. Note that if the background chromium value was reduced (say, from 3.1 ppb to 2 ppb, for example), the plume boundary would be drawn larger than it is now; if the value were increased, to say, 4 ppb, the plume boundary would be drawn smaller. Changes to the depiction of the plume boundary due to changing background levels would not change the cleanup alternatives already developed and analyzed, but could change the estimates of time to achieve cleanup.

Any such changes would need specific evaluation in the context of CEQA regulations to determine if EIR re-circulation or supplemental analysis requirements would be triggered.

Amended Cleanup and Abatement Order (CAO) No. R6V-2011-0005A1

This amended CAO uses the adopted maximum background values as one trigger to require replacement drinking water, and to define an "affected area" for the purposes of assessing domestic wells for eligibility for replacement drinking water. The affected area, as defined in the CAO, is domestic wells within one mile downgradient or crossgradient from the 3.1/3.2 ppb maximum background hexavalent/total chromium plume boundaries, based on monitoring well data from the most recent quarterly site-wide monitoring report.

The amended CAO requires, in part, that PG&E provide replacement water to residents to whose wells exceed the maximum background levels, and to identify wells where chromium levels may be below the maximum background, but attributable to PG&E's discharge in the affected area. If a well in the affected area shows chromium above the hexavalent chromium Public Health Goal of 0.02 ppb, then PG&E is required to determine whether the chromium is partially or completely, more likely than not, due to PG&E's discharge of waste.

Changing the background values would change the extent of the affected area; for example, if the background values were adjusted upward, then the extent of the chromium plume boundary would be smaller than currently depicted, so the affected area would not extend out as far as it does now, and fewer homes may be assessed for replacement water. If the value were adjusted downward, then the plume boundary would be larger than depicted now, and more homes may be eligible.

Changing background values would not release PG&E from the requirement to assess wells in the affected area with values above the hexavalent chromium Public Health Goal of 0.02 ppb to determine if the chromium is due to PG&E's discharge of waste. The primary change would be to the extent of the affected area.

Background Values to Establish Cleanup Levels

The Water Board must establish background concentrations of chromium as one factor to consider when setting cleanup levels for a contaminated site. Cleanup levels are needed to assess remediation progress and to determine when cleanup is complete

and the restoration of affected water to background conditions (i.e., the water quality that existed before the discharge) or beneficial use standards has been attained.

Changing the adopted background concentrations would not affect the types of cleanup technologies or alternatives that would be analyzed in the EIR; the main impact would be to estimates of the time needed to achieve complete cleanup, and the area over which cleanup would occur, as discussed above regarding the EIR.

Given the large extent of the plume, it may be that a one-size-fits-all approach to background concentrations and cleanup levels will not prove appropriate for the Hinkley Valley. Based on our current understanding, a range of background and cleanup concentrations could be applicable for the Hinkley Valley, due to variations in geology, geochemical conditions, groundwater flow patterns, and feasibility of cleanup technologies. Advances in technology (for example, improvements in stable isotope techniques to trace the source of groundwater or chromium) could allow for a more refined application of different background values in the future. The Water Board may consider revising background values based on compelling new information or future technological improvements; therefore, background values are subject to Water Board revision. Recognizing the value of consistency and continuity in regulatory processes, it is also important to incorporate new and improved information.

III. Summary and Discussion of 2011 Peer Reviewers' Comments

Water Board staff outlined the following topics on which to focus the reviewers:

- 1) Quality of spatial sampling of background chromium
- 2) Quality of temporal sampling of background chromium
- 3) Assumption of statistical normality
- 4) Quality of groundwater modeling
- 5) Any additional scientific issues, including whether the 2007 Background Study Report was based on sound scientific knowledge, methods and practices.

A summary and discussion of the peer reviewers' key comments follows. Copies of the peer reviewers' comment letters are included in Appendix 1.

Quality of spatial sampling of background chromium

Summary of Peer Review Comment: Sampling wells screened over both upper and lower aquifers does not provide valid data for determining background concentrations. Laboratory data from wells containing mixed aquifer waters do not represent chromium concentrations from any specific aquifer (i.e., the upper or lower aquifer); therefore,

those data should not be used in a scientifically-based background study of chromium in groundwater.

Discussion: Of the wells used for the background study, most of them (44 out of 48 or 92%) were either screened over more than one aquifer zone (i.e., the upper and lower aquifer), or the screen depths were unknown and well construction information was unavailable.

The 2004 Revised Background Study Plan included a proposal for depth-discrete sampling of five wells, out of pool of 41 potential locations. Only two wells had depth-discrete samples collected during the background study, due to access and well construction issues. One well was screened only in the upper aquifer; the other was screened through the both aquifers. The results for both wells were non-detect for total and hexavalent chromium at all depths sampled. This dataset is too small to draw conclusions about differences in chromium concentrations between the upper and lower aquifers outside the plume area.

Geochemical differences at varying depths in the aquifer outside the plume area may result in naturally lower chromium concentrations in the lower aquifer versus the upper aquifer, but this has not been verified with Hinkley background study sampling data. Wells screened in each aquifer are needed to determine any differences in chromium concentrations between the two aquifers outside the plume area, and to set appropriate background values for each aquifer if needed.

Water Board staff note that the reduced amount of depth-discrete sampling reported in the 2007 Background Study Report was not consistent with the accepted 2004 Revised Background Study Plan.

Summary of Peer Review Comment: A statistical clustering effect could result from the uneven spatial distribution of wells. Chromium concentrations at a particular area (for example, well BGS-04) could be assigned a disproportionately large weight if those wells around BGS-04 sample higher concentration areas. This clustering effect could be tested for and removed through statistical techniques, which does not appear to have been done.

Discussion: PG&E added a significant number of wells concentrated in one area, without the specific locations or numbers accepted in advance by Water Board staff. The 2004 Revised Background Study Plan proposed sampling fifteen to twenty well locations during each sampling event. By the Study's end, a total of forty-eight well locations in the Hinkley area were sampled. Of these forty-eight wells, thirty were added after the first two sampling events, with twenty-three of those wells concentrated in one area near a well which showed the highest concentrations of chromium detected in the first two sampling events (well BGS-04), so the averaged results from these wells could be biased higher than if the samples were not clustered in these areas.

As noted by the peer reviewer, there are statistical methods to examine if this created bias in the dataset, and to correct for it. Another approach to correct for potential clustering bias could be to exclude the wells which were added after the second sampling event, and consider only the data obtained from the first and second sampling events.

The addition of thirty wells to the Background Study is not consistent with the accepted 2004 Revised Background Study Plan.

Quality of temporal sampling of background chromium and the assumption of statistical normality

Summary of Peer Review Comments: One reviewer stated the approach of averaging data from each well to compensate for the fact that four quarters of data were not available for each well is not recommended. However, another reviewer stated that the approach of averaging well data appeared reasonable.

Discussion: According to the 2007 Background Study Report, chromium sampling results for each well were averaged, and these averages were used in the final statistical evaluation of the data. Averaged values were used to address potential bias in the dataset since four quarters of data were not available for each well (this is referred to as “temporal imbalance”).

One reviewer stated that averaging data can alter the statistical nature of the data, leading to incorrect conclusions regarding the distribution of the data, specifically whether the data are “normally distributed” or not. This is important because concluding that data are normally distributed affects the choice of statistical analysis used to calculate average and maximum values.

Data that are normally distributed, when plotted on a graph, look like a “bell-shaped curve”, with the graph falling off evenly, or symmetrically, on either side of the average value of the data. Water quality datasets often do not show this bell-shaped curve pattern when graphed, mostly because of the presence of non-detect values. These non-detect values make a graph of the data look skewed, with the peak over to the left, rather than in the middle of the graph. Such datasets are called “non-normal” data in statistics, and often require different statistical tests than one would use for normal data, to accurately calculate summaries such as average and maximum values.

One peer reviewer stated that there is evidence for non-normal distribution in the data of the Background Study, such as differences between the mean and median of the data (with normally distributed data, the mean and median values would be the same). The peer reviewer recommends that the assumption of the data distribution be supported with additional evidence, such as more rigorous modeling of the aquifer.

Water Board staff note that the statistical analysis done for the 2007 Background Study Report was consistent with the accepted 2004 Revised Background Study Plan. However, since the number of wells and number of samples per well differed from the accepted 2004 Revised Background Study Plan, the statistical methods used may not be applicable to that expanded dataset.

Quality of groundwater modeling

Summary of Peer Review Comments: Not enough information is provided to confirm the adequacy of model calibration. No attempt is reported to test the model against the concentration data. The spatial variability of the hydrological parameters in the model was not reported.

Discussion: These comments relate to the issue of whether the groundwater modeling contained in Appendix B of the 2007 Background Study Report, and Appendix B of the 2004 Revised Background Study Plan are appropriate to assure that the background study wells are representative of naturally occurring chromium, (i.e., are located in areas that have not been affected by waste discharges of chromium).

The 2003 peer reviewers recommended that PG&E perform groundwater flow modeling to screen suitable sampling locations outside the influence of the chromium plume as defined at the time. PG&E did this in its 2004 Revised Background Study Workplan, and estimated past pumping rates from 1952 to 1991 by estimating the irrigated agricultural acreage in the Hinkley Valley based on historic aerial photographs and recorded pumping rates from the 1990s, the earliest time that such records were available. The groundwater model then predicted historical flow paths based on those pumping estimates, and the results of that modeling, with a buffer zone, were used to screen suitable locations for the Background Study sampling wells.

This approach was consistent with the 2003 peer reviewers' recommendations, and accepted by Water Board staff in the 2004 Revised Background Study Workplan.

Many of the questions that were posed by the peer reviewer had been answered in documents that were not part of the documents provided to the 2011 peer reviewers. PG&E, in its recently submitted *Proposed Work Plan for Evaluation of Background Chromium in the Upper Aquifer of the Hinkley Valley*, has provided responses to the modeling issues raised by the peer reviewers.

Summary of Peer Review Comment: It is possible that "undisturbed" hydrogeologic areas in the Hinkley Valley do not exist due to extensive groundwater pumping and irrigation in the area.

Discussion: A reviewer noted that historical groundwater flow patterns affected by pumping, irrigation, and climate events may have produced a different plume pattern than is observed now, leaving behind dispersed levels of waste chromium which could make background levels difficult to assess. The long period of time since the release of chromium from the cooling towers (between 1952 and 1966), and the lack of detailed information on the locations and rates of historical pumping constrain modeling attempts to accurately depict localized plume migration patterns since the 1950s.

As described above, PG&E modeled historic plume migration since the 1950s, and defined an acceptable area for background sampling outside the plume area based on that modeling. The modeling done by PG&E for the 2007 Background Study Report was consistent with that approved in the 2004 Revised Background Study Workplan, and incorporated the original (2003) peer reviewers' recommendations.

A finer-scale historical groundwater modeling effort could be investigated, although it is unclear if additional historical information or estimation methods would improve modeling beyond what PG&E already previously completed in 2006. There will always be uncertainty in any modeling effort. Determining, with acceptable confidence, areas of the Hinkley Valley to sample that are representative of chromium concentrations absent PG&E's discharge of waste will be challenging. Naturally occurring chromium concentrations vary over time due to differences in geologic materials, groundwater flow patterns, geochemical conditions in groundwater, and other factors. These factors make it difficult to use adjacent groundwater quality to determine what historic (pre-waste discharge) chromium levels were in the plume area.

Additional issues identified

Summary of Peer Review Comment: A peer reviewer noted issues related to analytical chemistry laboratory practices, including test method calibration, establishment of reporting limits, and quality control check procedures.

Discussion: The peer reviewer, through Water Board staff, posed specific questions to the two chemistry labs that performed the sample data analysis for PG&E's 2007 Background Study. Based on the answers received from the labs, the reviewer concluded that the data obtained from the labs may not be valid to determine the actual concentrations of chromium in certain samples.

Water Board staff requested a review of the peer reviewer's comments by our independent contract lab, Excelchem, and used that review to frame questions for additional information from PG&E on quality control issues. PG&E provided the additional information, and responses to the peer reviewer's comments, in a report dated January 20, 2012.

Excelchem staff reviewed PG&E's responses and the additional data provided by PG&E, and concluded that problems with instrument instability and calibration for up to sixteen hexavalent chromium results (out of a total of 122 results, not including duplicate samples) make those data unreliable, and should not be used. The rest of the data are adequate (relative to the quality of the analytical chemistry testing) for the purposes of the background study.

Excelchem's reviews and conclusions regarding the laboratory quality control issues, along with PG&E's January 20, 2012 report, are provided in Appendix 2.

IV. Options for Water Board Consideration

The Water Board must consider whether the existing background values are valid and defensible for the purposes of defining the chromium plume in groundwater and evaluating cleanup progress, in light of the peer reviewers' comments. If the Water Board decides they are not, should the adopted values be re-assessed, or rescinded? This section presents four options to consider.

1. Rescind the adopted background values.

Discussion: The Water Board could rescind the background values adopted in R6V-2008-0002A1 based on the results of the peer review.

If that were done, the question of determining interim concentrations to evaluate and communicate the plume's extent, and assess cleanup progress would still remain. Some options exist to set interim values: the Water Board could consider using 1) the previously approved interim chromium value of 4 ppb for both hexavalent and total chromium, or 2) existing regulatory limits or goals for chromium in drinking water as the level by which to characterize the plume boundary and cleanup progress.

The previous interim chromium value of 4 ppb came from a 2001 Water Board staff sampling program of domestic wells located beyond the plume. This value was used to define the plume prior to the Water Board's 2008 adoption of the current background values. These samples came from long-screened domestic wells with unknown well construction details, or screened across both upper and lower aquifers, an approach which was criticized by peer reviewers of the 2007 Background Study Report.

The issue becomes more complex when using existing regulatory limits or goals for setting interim background values. The existing drinking water standard for total chromium is 50 ppb. Based on Hinkley area data, this value is too high to realistically represent background total chromium, and not is specific to hexavalent chromium. The recently adopted PHG for hexavalent chromium of 0.02 ppb could be considered, but is likely too low to clearly define the boundary

between the chromium plume resulting from PG&E's past discharges and background chromium.

Substituting either the total chromium drinking water standard or the hexavalent chromium PHG for the adopted background values would not add clarity or promote effectiveness in the regulatory efforts of the Water Board to address cleanup of the site. This approach would also create the most uncertainty for the EIR project description, leading to potential significant delays in the release of the EIR.

2. *Retain the adopted background values.*

Discussion: While acknowledging the valid issues brought up by the peer review, the Water Board could determine that the adopted values should be retained, because of uncertainty in determining background values that are significantly different or more representative of "true" background values than those currently adopted. The current average and maximum chromium background values adopted in CAO R6V-2008-0002A1 will remain in place for defining the chromium plume in groundwater and assessing clean up.

This option would create the least uncertainty for the EIR process, as it does not change the current EIR approach. However, given the issues identified by the peer reviewers, this approach will likely not foster confidence in the regulatory efforts of the Water Board among project stakeholders.

3. *Retain the adopted values until a new sampling plan can be accepted, implemented, and new background values calculated.*

Discussion: Two main issues identified by peer reviewers drive the need to consider a new sampling effort: 1) the issue of using properly constructed monitoring wells that are screened specifically in the aquifer of interest; and 2) where to place monitoring wells that will, with acceptable confidence, represent the groundwater quality absent the discharge of waste chromium.

PG&E has submitted a *Proposed Work Plan for Evaluation of Background Chromium in the Upper Aquifer of the Hinkley Valley*, in anticipation of this option. The work plan proposes the collection and evaluation of additional data to expand on the 2007 Background Study Report, and to address comments that were provided by the peer reviewers. The work plan proposes a grid sampling approach, with 25 to 40 sampling locations and up to 96 monitoring wells screened at varying depths within the upper aquifer only. The work plan also contains a proposal to investigate additional methods such as stable isotope analysis to help determine sources of chromium or groundwater flow paths to support modeling efforts. The timeframe estimated to complete the study is at least two years from acceptance of the work plan.

Conducting a new background study has the advantage of fully addressing the shortfalls of the 2007 Background Study Report, and could generate a robust dataset on which appropriate statistical methods could be applied. It would probably not result in delays in the EIR adoption schedule since the existing background values would be retained, but could require future supplemental environmental analysis if a new study results in background values that would trigger such requirements.

This approach may not be preferred by Hinkley residents. Twenty-five Hinkley residents submitted a letter and signature petition to Water Board members to oppose this option. The residents would like an end to the uncertainty surrounding the background concentrations, and have requested that rather than start a new background study, the Water Board should use the only data in the 2007 Background Study that was fully compliant with the approved 2004 Revised Workplan to re-calculate a new background number that can be used in the immediate future. This option is discussed in number 4, below.

4. Retain the adopted values until re-assessment of data subsets from the 2007 Background Study Report can be done, to evaluate different background values.

Discussion: Many of the peer reviewers' questions or concerns may be addressed by re-evaluating the existing dataset. For example, statistical assumptions can be confirmed or rejected, different statistical tests suggested by the peer reviewers or others can be run, data with unacceptable lab quality control issues can be rejected, and the wells added in the third and fourth quarters of sampling can be excluded from the dataset. Data from background wells screened only in the upper aquifer could be exclusively considered, although this dataset (four wells and 15 sample results) may be too small to provide a representative background concentration.

Revising the background values by using a subset of the existing data reported in the 2007 Background Study Report could likely be done within six months, using the State Water Board's agreement for statistical consulting services with the University of California - Davis. Board staff would bring the re-calculated background values to a future meeting for the Water Board's consideration.

This option could also be done in conjunction with option 3, above, where Water Board staff would evaluate different datasets for the Board's consideration while pursuing a new background study plan in the longer term.

This approach may not result in delays to the EIR process, since the existing values would be retained for the immediate term. Any value calculated from the existing dataset may not be significantly different from the current values, so the project area and plume geometry would be within the existing project area of the EIR.

V. Recommendation

Water Board staff recommend moving forward using a combination of options 3 and 4: to retain the existing background values adopted in amended CAO R6V-2011-005A1, while staff investigates the feasibility of developing new background levels using subset(s) of the existing dataset generated from the 2007 Background Study Report. Staff would use the State Water Board's existing contract with University of California-Davis to expedite a review of the data and determine feasible datasets that can be used to re-calculate background values.

As noted above, in February 2012, PG&E submitted a proposal for a new background study sampling effort. Water Board staff would review this proposal, and consider the need for peer review and/or consultation with other experts, such as the US Geological Survey, so that any new study will yield a valid, credible and defensible result.

Water Board staff propose to bring any re-calculated background values, along with a recommendation on PG&E's new (February 2012) background study proposal for the Board's consideration no later than October 2012.

Appendix 1: Copies of Peer Reviewers' Comment Letters

A1-1: James Jacobs, Clearwater Group

A1-2: Stuart J. Nagourney, The College of New Jersey

A1-3: Yoram Rubin, University of California-Berkeley

A1-1: James Jacobs, Clearwater Group



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October 7, 2011

Ms. Lauri Kemper, P.E.
California Regional Water Quality Control Board
Lahontan Region
2501 Lake Tahoe Blvd.
South Lake Tahoe, CA 96150

Transmittal via email to: Lkemper@waterboards.ca.gov

Re: Task Order: PEER REVIEW OF CH2MHILL'S FEBRUARY 2007 *GROUNDWATER BACKGROUND STUDY REPORT, HINKLEY COMPRESSOR STATION, HINKLEY, CALIFORNIA* PREPARED FOR PACIFIC GAS AND ELECTRIC COMPANY (PG&E)

Dear Ms. Kemper:

This memorandum summarizes my review of CH2MHILL's February 2007 *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California* (BSP3) prepared for PG&E. In addition to the 7 documents initially furnished by your office, and the 2002 Workplan which you furnished upon request, you also furnished the link to the Lahontan Water Board webpage (to access additional information, including maps since August 2006), so the complete list of reports besides the review report is as follows:

Workplans

Scope of the Background Chromium Study at the PG&E Compressor Station, Hinkley California, CH2MHILL, 2002 (BSP1)

Revised Background Chromium Study at the PG&E Compressor Station, Hinkley, California, CH2MHILL, 2004 (BSP2)

Regulatory Correspondence

Comments on Revised Background Chromium Study at the PG&E Compressor Station, Hinkley, San Bernadino County, 2004 Workplan Review and Conditional Acceptance

Regulatory Staff Report

Dernbach, L., 2008, *Background Chromium Study, Pacific Gas and Electric Company, Compressor Station, 35863 Fairview Road, Hinkley, CRWQCB, Lahontan Region*.



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Peer Reviews

February 2004 reviews on 2002 BSP: 3 reviews

Letters of February 2004, on 2002 BSP1:

- Thomas C. Harmon, University of California, Merced
- James R. Hunt, University of California, Berkeley
- Timothy R. Ginn, University of California, Davis

Groundwater Monitoring Reports

Groundwater Monitoring Report; October 2007 Sampling Event; Site-wide Groundwater Monitoring Program, PG&E Hinkley Compressor Station, Hinkley, California, CH2MHILL, 2007

Second Quarter 2010, Groundwater Monitoring Report, Site-wide Groundwater Monitoring Program, PG&E Hinkley Compressor Station, Hinkley, California, CH2MHILL, 2010

Review Subject: *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California (BSP3) CH2MHILL, February 2007.*

Report Date: February 2007

Report Author: CH2MHILL, Oakland, California

Site of Release: Pacific Gas & Electric Company
Hinkley Natural Gas Compressor Station Site
35863 Fairview Road
Hinkley, California

Responsible Party: Pacific Gas & Electric Company (PG&E)

Requesting Agency: RWQCB, Lahontan Region (LRWQCB), Region 6
Review Program

Sponsor: US EPA

Representative: Ms. Anne Holden, aholden@waterboards.ca.gov, 530-542-5450

Representative: Ms. Lisa Dernbach, ldernbach@waterboards.ca.gov, 530-542-5424

Review sent to: Ms. Lauri Kemper, Lkemper@waterboards.ca.gov, 530-542-5400



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Agency providing

Reviewers: Cal/EPA Scientific Peer Review Program, Office of Research, Planning and Performance, State Water Resources Control Board

Due Date: October 7, 2011

Reviewer: James A. Jacobs, PG, CHG, is a Fulbright Scholar and has practiced geology for 30 years, teaches Sustainable Remediation Methods for Soils and Water at the UC Berkeley Extension and co-authored The Chromium (VI) Handbook, 2005, CRC Press.

Project Background

Per the LRWQCB staff letter of May 19, 2011 to Dr. Gerald Bowes, Manager of the Cal/EPA Scientific Peer Review Program, Office of Research, Planning and Performance, State Water Resources Control Board, the purpose of reviewing the 2007 report (BSP3) is as follows: "...to estimate the concentration of naturally occurring total chromium [Cr(T)] and hexavalent chromium [(Cr(VI)] in groundwater near the PG&E natural gas compressor station in Hinkley, California. The data contained in the 2007 Background Study Report are intended to assist the Lahontan Water Board in setting cleanup goals for chromium pollution in groundwater in the Hinkley area... At issue is whether the deviations in carrying out the Background Study from the conditionally approved background Study Workplan were appropriate or whether the deviations resulted in biased estimates of background chromium levels."

Project Report Setting

The method described in the 2007 report (BSP3) is premised on previous work. The purpose of the 2002 Background Study Plan (BSP1) was to determine background conditions as a cleanup goal for groundwater remediation. The BSP1 proposal to sample 12 wells over 4 quarters in the upper aquifer was amended in 2004 (BSP2) and resulted in the 2006 sampling and the 2007 reporting (BSP3).

According to Attachment 1 of the May 19, 2011 Lahontan RWQCB document, two aquifers are identified in the valley fill: the upper unconfined aquifer (referred to in this review as the Upper Aquifer) and the lower confined aquifer (referred to in this review as the Lower Aquifer). The aquifers are separated by an aquitard composed of fine-grained clay and silts, laid down as a lacustrine deposit, called the Blue Clay. As noted in previous studies, the Blue Clay and the Lower Aquifer pinch out to the north of Highway 58 and west of Mountain View Road (Dernbach, 2008).



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Current Status

The overall objective of the Background Study Plan is to provide a background threshold contaminant level so that a cleanup goal can be established. After 10 years with three background study workplans and reports, the background condition (the remediation or cleanup goal) has not yet been established. Recent reports (Stantec, 2011) document that vertical migration and lateral expansion of the Cr(T) and Cr(VI) plume appear to be occurring.

Sampling from Existing Domestic and Agricultural Wells

Groundwater samples were obtained from the domestic and agricultural wells chosen for the background well study because the wells were already installed and available for sampling. Many of the wells which were sampled for the background study were not intended to provide the highest quality groundwater samples due to construction design. Of the wells that were used in the background study, the agricultural wells (about 10 percent of the wells sampled) and domestic wells (about 90% of the wells sampled) were designed for irrigation and home water supply purposes, respectively. Given the age of most of the wells, the well construction likely predated the current California well standards. Most of these wells are many decades old, and the well construction details, such as perforation or screen depth information and geologic boring logs, are not available.

NOTE: For the purposes of this review, although it is likely that some of the wells installed have perforated well openings in the steel well casings rather than slotted screens, I will refer to the zones where groundwater enters the well bore as the “screened” interval.

As would be expected in a heavily agricultural area, many of the wells, especially wells used for irrigation, were designed for maximum groundwater flow, and the screened zones in the well may include both the unconfined Upper Aquifer and confined Lower Aquifer. Screening across two or more aquifers, thus commingling the aquifers, is common in wells where groundwater production is the objective. Of the wells used for the background study, most of them (44 out of 48 or 92%) were either screened over more than one aquifer zone, or the screen depths were unknown and well construction information is currently unavailable. Although specific wells may vary in well diameter, domestic wells can be about 6-inches in diameter, and agricultural wells can be about 14 to 18-inches in diameter.

As opposed to wells designed for groundwater production, monitoring wells are designed and installed for geochemical sampling and background studies. Monitoring wells require a fundamentally different well design. Many monitoring wells are a minimum of 2-inches in diameter which reflects the design purpose of high-quality groundwater sampling and not water production. Detailed geochemical studies including background studies provide geologic information about the subsurface conditions by isolating specific aquifer units from other



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groundwater bearing units. This isolation is a key concept in the design of the monitoring well so that a specific groundwater bearing zone in a specific geologic unit can be sampled and analyzed in the laboratory for Cr(T) and Cr(VI) and other chemicals of concern.

Sampling Data

Sampling of agricultural or domestic wells containing commingled groundwater aquifers provides useful information as to overall groundwater quality of that particular well and specific exposure and toxicity data related to Cr(T) and Cr(VI) to human health if the water is ingested, or the environment, if the water is applied to the land through irrigation.

For the purposes of a detailed geochemical background study, however, no useful geologic information on background concentrations can be obtained from mixed well waters that are available in a well which is screened over two aquifer zones. The laboratory sample results from wells containing 'mixed aquifer' waters cannot be considered reflective of any specific aquifer and, therefore, they should not be used in a scientifically based background study of Cr(T) and Cr(VI). All of the wells used in the CH2MHILL background study are either domestic or agricultural wells. The majority of these wells (92%) have well screens covering more than one aquifer zone (i.e. both the Upper Aquifer and the Lower Aquifer), or the screen intervals are unknown.

According to the United States Geological Survey (USGS) Water Supply Paper 2220 (Heath, 1983), groundwater occurs in aquifers under two different conditions. Where groundwater only partly fills an aquifer, the upper surface of the saturated zone is free to rise and decline. The water head in a well installed in an unconfined aquifer reflects the elevation differences between the water source and the elevation of the groundwater in the well. The groundwater in such aquifers is said to be unconfined, and the aquifers are referred to as unconfined aquifers. Unconfined aquifers are also widely referred to as water-table aquifers. The Upper Aquifer is an unconfined aquifer.

Where groundwater completely fills an aquifer that is overlain by a confining bed such as the Blue Clay in the Hinkley, California area, the groundwater in the aquifer is said to be confined. Such aquifers are referred to as confined aquifers or as artesian aquifers. In some cases, the confined aquifers come to the surface as artesian springs. The Lower Aquifer is a confined aquifer, and as such, the water will rise due to the elevation differences as noted above, as well as the pressure in the aquifer.

Depending on the water pressures associated with each aquifer, the Upper Aquifer Cr(T) and Cr(VI) concentrations in 'mixed aquifer' wells will likely be diluted by the cleaner Lower Aquifer. If the Lower Aquifer has significantly higher pressure than the Upper Aquifer, the



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overall concentrations of Cr(T) and Cr(VI) will be more diluted.

In wells where the groundwater is sourced from two aquifer zones at the same time, such as is found in the Hinkley area, laboratory analyses of those groundwater samples to define specific background levels of Cr(T), Cr(VI) or other chemicals is not scientifically valid as no vertical definition or aquifer specific continuity is possible. Comparing sample results from 'mixed aquifer' wells allows for evaluation of human or environment exposure, but the laboratory data are devoid of any specific geologic or aquifer significance. Statistics based on 'mixed aquifer' laboratory data are not valid or relevant as to the aquifer-specific levels for Cr(T), Cr(VI), or other chemicals.

Focused Groundwater Sampling

For the purpose of groundwater sampling and geochemical characterization, wells with proper screens covering only one aquifer zone are needed so aquifer-discrete samples can be collected and analyzed. This is necessary and important if the vertical and lateral migration of the Cr(T) and Cr(VI) in the subsurface is to be understood and properly documented. The isolation of these two aquifers (Upper Aquifer and Lower Aquifer) has not occurred in most of the wells used in the background study, and as such, these domestic and agricultural wells are useful in showing concentrations of Cr(T) and Cr(VI) in groundwater in wells with commingled aquifers. These concentrations of the well water reflect the overall water quality from the individual wells and the overall Cr(T) and Cr(VI) exposure potential to humans or the environment. However, these wells have almost no value in showing background levels of Cr(T), Cr(VI), or other chemicals. As such, detailed statistical evaluation of laboratory data from wells that are screened in more than one aquifer, or in wells where the screen and filter packs (if present) are unknown, do not and cannot accurately reflect true background concentration levels. Statistical methods applied to these types of well sample results, for the purpose of trying to identify a background Cr(T) and Cr(VI) concentration, provide mixed-well aquifer statistics, not background levels.

Format of Peer Review Tasks

As part of the overall Scientific Peer Review process, the reviewers were asked to address Specific Requested Comments (**Task I**), to make General Comments on (BSP3) to address any additional scientific issues (**Task II**), and to comment on whether the scientific portion of (BSP3) is based upon sound scientific knowledge, methods, and practices (**Task III**). All the Tasks and my responses are provided below:

Task I - Specific Requested Comments on BSP3

Background: Are the deviations in carrying out the Background Study, BSP3, (from the conditionally approved Background Study Workplan, BSP2) appropriate or did they result in



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biased estimates of background Cr levels? Make a determination of each of the following four (as expertise allows):

1. Quality of spatial sampling of background chromium in 21 square miles (sq. mi.)
Sampling Dataset: Total of 48 wells of which 14 were sampled all four quarters (see Table 3-1; CH2MHILL 2007 Study).
 - Event 1 - 17 well locations
 - Event 2 - 18 well locations
 - Event 3 - 45 well locations (original 17 wells, plus 8 wells, plus 23 new wells which are near chromium impacted well BGS-04 in <1 sq. mi.)
 - Event 4 – 38 well locations

Comments: The wells used for the background study reported in the CH2MHILL (2007) report show an inconsistent pattern of well sampling as shown above. The Hinkley Valley in the background study area can be divided into five main areas (see attached **Figure 1**; based on the Figure 4-1; CH2MHILL 2007 Study). The five main areas are as follows: Core Area, South Upgradient Area, East Cross Gradient Area, West Cross Gradient, and North Downgradient Area. Across these there is an Upper and a Lower Aquifer. These aquifers are separated in most areas by a confining clay aquitard, called the Blue Clay, except as noted below.

A. Core Area

This is the area of the Cr(VI) plume (Core Area) in 2006 (Figure 4-1; CH2MHILL, 2007), showing a Cr(VI) concentration of 4 micrograms per liter ($\mu\text{g/L}$). The Core Area has both Floodplain and Regional Aquifers as mapped on Figure 4-1. The Upper and Lower Aquifers are separated by a confining clay.

B. South Upgradient Area

This is the area south of the Core Area (shown on Figure 4-1; CH2MHILL, 2007), south of the hatched black line, reflecting an “upgradient boundary including buffer zone.” According to Figure 4-1, the Regional Aquifer lies below the South Upgradient Area. The Upper and Lower Aquifers are separated by a confining clay.

C. East Cross Gradient Area

This is the area east of the Core Area (shown on Figure 4-1; CH2MHILL, 2007) which is shown as having the Floodplain Aquifer. In the northern portion of the area, the Upper and Lower Aquifers are separated by a confining clay. A small area to the northeast contains the Regional Aquifer.



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D. West Cross Gradient Area

This is the area west of the Core Area (shown on Figure 4-1; CH2MHILL, 2007) containing the Regional Aquifer. A small portion of this area (to the southeast) contains Floodplain Aquifer. The Upper and Lower Aquifers are separated by a confining clay.

E. North Downgradient Area

This is the area north of the Core Area (shown on Figure 4-1; CH2MHILL, 2007), having both the Floodplain and Regional Aquifers as mapped on Figure 4-1. As with the confining clay layer called the Blue Clay, the Lower Aquifer also pinches out to the north of Highway 58 and west of Mountain View Road (Dernbach, 2008).

Table 1 summarizes the 48 background study wells within the five different areas based on the known, discrete aquifer differentiation. Of these wells, four wells are screened only in the Upper Aquifer. The remaining background study wells either have well screens over both the Upper and Lower Aquifer or there is no information available as to the screened zone. A monitoring well can be designed for sampling a specific aquifer or zone, but production wells, both irrigation and domestic, tend to be designed for maximum groundwater production and sometimes contain more than one aquifer or producing zone within their screened intervals. Consequently, the mixing of groundwater from the different aquifer zones in the production wells, where screen and filter pack information is either unknown or the wells are screened over both the Upper and Lower Aquifers, will provide a mixed well concentration for Cr(T) and Cr(VI); it will not accurately reflect the conditions of the specific aquifer zone. **Table 1** shows the background study wells based on the CH2MHILL (2007) report, Table 4-1.

Table 1 – Summary of Background Wells in Hinkley Area

Area	Primary Aquifers (as shown on Figure 4-1; CH2MHILL, 2007)	Specific Upper Aquifer Data (# of Wells)	Specific Lower Aquifer Data (# of Wells)	Background wells without specific aquifer screen information	Total # of Background Wells in CH2MHILL (2007) Study
Core Area	Regional and Floodplain	Not Evaluated	Not Evaluated	Not Applicable	Not Applicable
South Upgradient Area	Floodplain	1 well: 01-06	0	3	4
East Cross Gradient Area	Floodplain primarily with minor Regional Aquifer in northeast corner	0	0	14	14
West Cross	Regional and small	3 wells: BGS-01,	0	27	30



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Gradient Area	portion in the southeast of Floodplain Aquifer	BGS-04, and BGS-15			
North Downgradient Area	Regional and Floodplain	0	0	0	0
Totals		4 wells	0 wells	44 wells	48 wells

Of the areas shown in **Figure 1**, the South Upgradient Area is the most likely to provide natural or background levels of Cr(T) and Cr(VI). Samples from the Mojave River, although more than one mile from the PG&E facilities, may show less anthropogenic influences for background samples of Cr(T) and Cr(VI) for the region.

The Upper Aquifer has levels of Cr(T) and Cr(VI) as shown in Figure 4-1 (CH2MHILL, 2007). Dernbach (2008) noted that the chromium plume was detected only in the Upper Aquifer. At the time of this review in 2011, the Lower Aquifer had been found to contain elevated Cr(T) and Cr(VI) in one area north of Highway 58 as shown on the Stantec Figure 3, in the report *Chromium in Groundwater Lower Aquifer*, by Stantec, dated August 1, 2011.

Since the Upper Aquifer is likely to contain the majority of the Cr(T) and Cr(VI), collecting samples where the well screens are unknown provides little useful information. Although video camera surveys in wells and geophysical logging can assess the screened areas and well construction information based on the large number of wells screened in both Upper and Lower Aquifer, the agricultural wells with unknown screen depths are likely to have been screened in both aquifer zones. Data from wells that are screened in more than one aquifer or having unknown screen depths should not be used in studies to establish background concentrations of Cr(T) and Cr(VI). Installation of new monitoring wells with proper screens in specific and isolated aquifer zones is the best way to get accurate data on groundwater concentrations of Cr(T) and Cr(VI).

In summary, the natural Cr(VI) and Cr(T) levels will be difficult to assess since the entire area has had intense agricultural pumping from both Upper and Lower Aquifers for up to eight decades. Artificial recharge has also been occurring in certain locations, affecting the natural background conditions of Cr(T) and Cr(VI). The background study for both Cr(T) and Cr(VI) in the current form is inadequate and inaccurate for reasons given above.

2. Quality of temporal sampling of background chromium in the 2007 Background Study Report

Background: To address the potential to introduce bias into the overall summary statistics due to the temporally unbalanced nature of the data set (not all wells sampled in each quarter), the



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arithmetic average value of Cr (VI) and Cr(T) concentrations from each well were used; Each well is represented by one arithmetic mean result, not the actual number of samples taken at that well.

Comments: As noted above, in **Table 1**, for discrete data from specific areas or specific aquifer zones, there are only three wells from the West Cross Gradient area and one well from the Southern Upgradient Area that are known to be screened specifically in the Upper Aquifer. Regardless, one to three wells in specific aquifer zones do not provide enough information to evaluate background concentrations or even current concentrations. From my field experience and given the size of the Hinkley area, a minimum of 20 to 40 properly constructed groundwater monitoring wells should provide the minimal number of groundwater sampling locations for a scientifically reasonable background study. Each new monitoring well should be sealed so the screens and well design sample only one aquifer zone. Detailed statistical evaluation of geochemical data coming from a majority of wells with unknown screen intervals or of screens covering commingled aquifers does not provide much scientific value.

Background: Was the integrity of the study lost by the addition of wells mid-course/mid-year?

Comments: It was noted that 14 background study wells were sampled for 4 quarters. Various additional wells were added to the study. Statistical analyses should be run on the data from the original 14 wells. Statistics from one dataset cannot be combined with statistics from another dataset. These two datasets should be reported separately.

3. Assumption of statistical normality

Background: The Shapiro-Wilk normality test was applied to only a subset of the data, the detected chromium values in the dataset. The P-values (both higher than 0.05) suggest that the data subset (all detections of chromium, leaving out the non-detect values) are normally distributed.

Comment: Aquifer-specific information and detailed statistics from wells screened in specific aquifers is required to put the laboratory analytical data into a geologic perspective. Properly performed statistics on inaccurate geochemical data are not valid.

4. Quality of groundwater modeling

The plume core, Cr(VI) above the Maximum Contaminant Level (MCL) of 50 parts per billion (ppb), migrated (based on October 2007 data) approximately 300 feet to the west along at least a one-half-mile length of the northwestern plume boundary; Are the background study wells representative of naturally occurring chromium, given the data showing plume expansion?



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a) *Location of background wells must be upgradient and outside the range of influence of wells drawing the plume in.* Wells screened in unknown or multiple aquifer zones provide only limited information.

In addition to the issues listed above regarding the wells being screened in more than one aquifer, the chosen set of 'background' wells are not located adequately upgradient and outside the range of influence of actively pumping (historically or currently) extraction wells (which could be drawing the Cr(VI) plume in an upgradient direction) to be representative of background conditions. Virtually all of the chosen wells are located in a cross gradient position from the main plume with poorly defined cross gradient Cr(T) and Cr(VI) plume boundaries. As noted, well data should reflect specific aquifer zones, not mixed zones. Given the eight decades of intense agricultural pumping, it is possible that with preferred flow pathways (high permeability zones due to lithologic characteristics or geologic faults (Lockhart) or other potential conduits), some of the Cr(T) and Cr(VI) from the Core Area may have migrated over the past decades toward the east or west into the East Cross Gradient Area or the West Cross Gradient Area, respectively (see **Figure 1**).

b) *The role of actively pumping of current wells in the migration of the plume*
Groundwater flow and transport modeling are needed. Range of influence of individual pumping or injection wells should be mapped and modeled.

c) *Role of irrigation with Cr(VI) water in the increase of the plume*
Deposition of Cr(VI) throughout the basin land surface has not been mapped. Correlation between land irrigation of Cr(T) and Cr(VI) impacted groundwater at the Land Treatment Units and the presence of chromium in the underlying soil and groundwater needs more focused investigation. The mechanism of remediation of spraying Cr(VI) onto the soil and the conversion of the oxidized Cr(VI) into the reduced Cr(III) and ultimately into chromium hydroxide using soil as a treatment media are not well documented or verified. Peroxide and acids may clean the drip or irrigation lines, but may also help to mobilize and carry the Cr(T) and Cr(VI) deeper into the subsurface environment if the acids or peroxide are spilled onto the soil.

d) *Lack of control of groundwater extraction throughout the basin*
There has been none, and there is currently no hydraulic control over the groundwater basin, so the plume will continue to migrate. The Cr(VI) plume is expanding both laterally to the north, as well as vertically, as evidenced by plume maps from 2001 to current consultant studies.

e) *Historic patterns of Cr(VI) migration*
There may be historic patterns of Cr(VI) migration which have left residue available for future recapture and migration.



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f) *Lack of site conceptual model*

A detailed site conceptual model of the Cr(T) and Cr(VI) initial release(s), migration in the subsurface soils and aquifers, extraction at Land Treatment Units, and application of this untreated Cr(VI) and Cr(VI) impacted water onto the land surface should be developed. There is a concern that the lack of above-ground treatment of Cr(T) and Cr(VI), in which the extracted groundwater is removed from the aquifers at the Land Treatment Units and dripped or (historically) sprayed onto surface soils, is potentially creating another Cr(T) and Cr(VI) release, albeit, at lower Cr(T) and Cr(VI) concentrations. The concepts of groundwater extraction of Cr(T) and Cr(VI) impacted groundwater and the reapplication of this water onto the land without treatment has not been well proven or well documented as a method to immobilize Cr(T) and Cr(VI). Documentation should be provided showing the soil in these areas where untreated Cr(T) and Cr(VI) impacted groundwater is being released onto the land surface is a safe and effective remediation method for Cr(T) and Cr(VI) in groundwater. The documentation should also evaluate the potential for hyperaccumulation or uptake of Cr(T) and Cr(VI) in plants or deposition and concentration of Cr(T) and Cr(VI) in the shallow soil.

Although regionally the rain water has been low over the period of historic record keeping, large changes in climate and rain patterns could occur in the future, creating higher risks of remobilization of the Cr(T) and Cr(VI) in the shallow soil near the groundwater drip or spray systems at the Land Treatment Units. Sources at the PG&E Compressor Station must be mapped and plotted in relationship to the release and the current location of the contaminants in both the shallow soils as well as the Upper Aquifer and the Lower Aquifer.

g) *Well construction details and depth discrete sampling are critical*

Samples from agricultural or domestic wells which cross the Upper Aquifer and Lower Aquifer have little value in defining Cr(T) or Cr(VI) background concentrations based on aquifer or geologic units. Correlating the flows from the two different aquifer zones, one unconfined and the other confined, is not an appropriate or satisfactory method for determining background levels of Cr(T) and Cr(VI). Mixing within the wells that were screened over two aquifers is likely to occur by diffusion, and possibly by other mechanisms. If filter packs are part of the well construction, then additional groundwater flow pathways exist for mixing of two originally separated groundwater aquifers. Using decades old domestic and agricultural wells which were readily available but designed for water production is not appropriate for background studies of Cr(T) or Cr(VI) which are associated with two vertically discrete aquifer units.

Discussion:

Background: 4a) Background levels - Location of wells

The background wells were chosen by the following criteria (BSP2 2002 Workplan): "The position of the 0.05 mg/L limit line shown on BSP2 Figure 3 represents the *inferred extent of the*



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water bearing intervals that contain Cr(T) above the MCL within the Upper Aquifer.”

Background Study Criteria:

- Wells were in Hinkley Valley
- Wells were Cross/Upgradient of the 0.05 mg/L plume
- Wells were 500-2,000' outside of plume influence
- Wells were Historic Non-detect of Cr(VI) at 500' cross gradient
- Downgradient wells were excluded
- Criteria was based on 1995 study samples
- Wells chosen were only in the upper aquifer; they were chosen in the upper aquifer because the lower aquifer is confined and there is an upward vertical gradient; 'only upper aquifer should be used to establish the cleanup goal'.
- One of the 2004 reviewers (Harmon) states, “The Mojave River aquifer is the most logical source of groundwater flowing under and around the compressor station. Obtaining chromium levels in that water appears essential for determining the background chromium levels.”

Comments: Background wells were not excluded or screened for their proximity to extraction wells. If the background wells chosen for sampling were inside the radius of influence (ROI) of wells extracting contaminated groundwater, then they cannot be identified as background wells. A background well should not lie within the zone of influence of a pumping well, or within the influence of the wells in the Hinkley Compressor station or Land Treatment Unit extraction systems. In addition, the wells to be used as background wells should have screens in one of the aquifer zones, but not both.

Background: 4b) Groundwater modeling - One of the 2004 reviewers noted the following: Synthesis of existing data in a quantitative model would be beneficial to verify the current plume direction. Also, it was noted that the 2003 Appendices were not utilized.

Comment: All groundwater extraction volumes and their ROIs should be mapped. The above mapping should be evaluated with the ROI information. In the 2002 report, “...the Upper Aquifer hydraulic gradient...reflects no known pumping from irrigation wells or groundwater extraction wells.” pg 5. The Lockhart Fault and other faults in the Hinkley, California area may affect groundwater migration or influence preferred groundwater flow pathways. These elements should be evaluated in future hydrogeologic studies.

Background: 4c) Influence of land application of groundwater - Is there any relationship between the land-applied Cr(VI) water and the levels of Cr(VI) in the groundwater below those



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fields? What level of Cr(T) and Cr(VI) in spray (LTU's) was being aerosolized on the alfalfa fields.

Comment: All water applications from the Land Treatment Units should be mapped with detail on duration in time and volume of water of the applications. The deposition of wind-borne contaminants is discounted since there is low rainfall, yet Cr(VI) in dust can be an important exposure pathway if concentrations of Cr(VI) are high. In areas where Cr(T) and Cr(VI) are high in the shallow soil, plant hyperaccumulation of Cr(T) and Cr(VI) and the potential of livestock accumulation of chromium from ingesting impacted plants or impacted soil should be verified and documented with laboratory analysis.

Background: 4d) Groundwater recharge - How were the groundwater recharge areas mapped?

Comment: All injection wells and their ROI should be mapped for the whole basin.

Background: 4e) Historic groundwater migration - Previous patterns of migration

One of the 2004 reviewers (Harmon) noted the following: That historical groundwater flow patterns during, for example, remedial pumping periods or extreme climate events (drought and wet periods) may have produced a different plume than is now observed ...left behind anthropogenic Cr which could impact background concentration estimates which would be figured out with a groundwater modeling effort.

Comments: Heavy groundwater extraction since the 1930's supports this concept that the Cr(T) and Cr(VI) plume has migrated cross gradient through preferred flow pathways. Major geochemical changes in the Hinkley Valley caused by large water movements, including extraction, are likely to have occurred over the past several decades, altering background levels of Cr(T) and Cr(VI).

Background: 4f) Site Conceptual Model of the release - A site conceptual schematic of the release and migration of the Cr(VI) projected in cross section from 0-90' below ground surface (bgs).

Comments: A scientific site conceptual model of the release, migration, extraction, and reapplication of the impacted waters onto soil should be carefully and methodically performed. If needed, additional geologic cross sections should be prepared. To help establish well construction details and depths of screened intervals, well condition and other downhole information should be documented using a video camera and geophysical logging tools. This will help to establish whether the wells are acting as vertical conduits. All migration pathways should be mapped.



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Background: 4g) Producing contaminant concentration contours - Sampling of equivalent depths is critical.

Comments: The discrete depth sampling dataset is not sufficient. New monitoring wells should be constructed solely for the purpose of groundwater sampling. I recommend that 20 to 40 new groundwater monitoring wells be constructed to current California standards in the Upper Aquifer and Lower Aquifer. The wells should be constructed so only one aquifer is screened for each well.

Task II - List other scientific issues that are not addressed in Report BSP3 or in **Task I**, above.

Comments: The extraction of groundwater containing Cr(T) and Cr(VI) and application of this impacted water on to the land surface without above-ground treatment of the chromium-impacted water should be rigorously evaluated and scientifically justified and documented. The concern is whether the Cr(T) and Cr(VI) are really being cleaned up, or whether the Cr(T) and Cr(VI) are being smeared in the shallow subsurface and ultimately being allowed to impact deeper soil horizons and groundwater resources. Groundwater resources in the area are heavily used for agricultural and domestic water supplies. Any additional impact from Cr(T) and Cr(VI) on soil and groundwater resources should be examined, tested, and documented in a careful and systematic manner. The drip lines for the Land Treatment Units are being cleaned with hydrogen peroxide and acid. These chemicals, if in contact with heavy metals, including Cr(T) and Cr(VI), might allow for more impacts in the shallow soils by increasing heavy metal solubility and enhancing mobilization of Cr(T) and Cr(VI) in the shallow soils.

Task III- Critique of the scientific portion of the 2007 Background Study Report, for the following parameters: a) scientific knowledge, b) scientific methods, c) scientific practices.

Comments: On the basis of my understanding of the well construction information (or lack thereof) of the wells used for the background study of Cr(T) and Cr(VI), the scientific approach to this study is seriously flawed if wells used in the study do not have proper screens in one discrete aquifer zone. If these mixed-aquifer wells are used for the overall concentration maps for Cr(T) and Cr(VI), the maps will be in error and likely to underestimate the Cr(T) and Cr(VI) concentrations, since the wells screened over both the Upper and Lower Aquifer will have most of the water in the well bore derived from the cleaner Lower Aquifer.



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The wells currently in the background study were not designed for high-quality geochemical sampling, but rather they were probably designed for maximum water production. Applying detailed statistics to laboratory sample data from domestic and agricultural wells with 'mixed aquifer' water does not provide accurate results and likely underestimates the Cr(T) and Cr(VI) concentrations for reasons described above.

Although it might be economically attractive to use existing and available domestic and agricultural wells for a purpose for which they were not designed, the study does not meet the scientific objectives of trying to determine background concentrations of Cr(T) and Cr(VI). The use of statistical methods on the chemical data as well as averaging laboratory concentrations of Cr(T) and Cr(VI) from these wells does not provide accurate or correct results for background information.

RECOMMENDATIONS:

Natural background levels of Cr(T) and Cr(VI) for specific aquifers in the Hinkley, California, area can be determined with a significant drilling program of new wells with well screens limited to one aquifer zone in upgradient areas unaffected by historical pumping. It is possible that undisturbed hydrogeologic areas in the Hinkley, California, area do not exist due to the excessive groundwater pumping in the area. Samples upgradient toward the Mojave River may provide the best chance at finding what might be considered background Cr(T) and Cr(VI) concentrations.

Background levels are important to establish, but are very different from remediation goals or drinking water standards. The remediation goals are influenced by the best available technology to achieve a specific cleanup with regulatory oversight and public input. Maximum Contaminant Levels (MCLs) for Cr(T) and Cr(VI) or other drinking water standards are health based and provided by federal and state regulatory agencies. Together, these different levels (groundwater background levels, best available technology remediation levels, and the various drinking water standards and other exposure and toxicity concentrations) must be integrated to develop an appropriate and realistic remediation or cleanup goals for the site. After ten years of assessment and monitoring, remediation has been limited and the Cr(T) and Cr(VI) plume is expanding northward in the Upper Aquifer and there has been recent vertical migration into the Lower Aquifer as well (Stantec, 2011).

In summary, the following tasks are required:

- a. Site Conceptual Model - Create a scientifically valid site conceptual model of the release, migration, extraction, and reapplication to land of the groundwater containing Cr(T) and Cr(VI).



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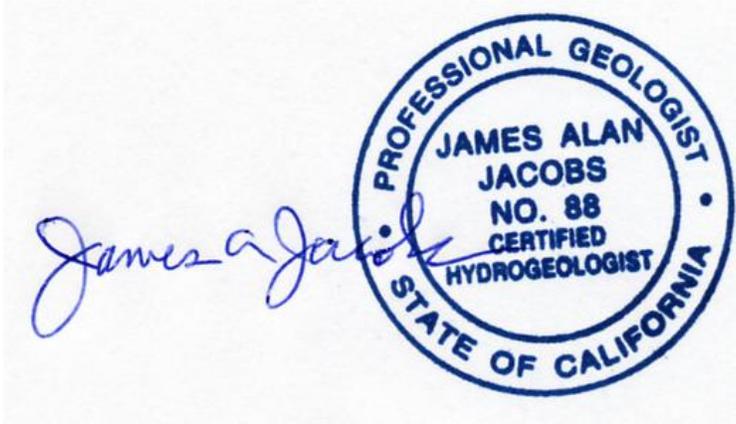
- b. Land Treatment Units - Map all the surface areas where groundwater containing chromium has been historically discharged to the land surface for irrigation purposes at the Land Treatment Units. Identify what levels (concentrations) of Cr(T) and Cr(IV) are in the shallow soil and the groundwater (besides the 5 foot lysimeters). Evaluate and verify the Land Treatment Unit extraction and water application process to document that Cr(T) and Cr(VI) are being properly immobilized.
- c. Pumping Influence - Map the radius of influence of pumping wells located within the Hinkley Valley and the extracted waters discharge areas.
- d. Obtain aquifer-specific background level data – Construct and install 20 to 40 new monitoring wells in accordance with current California well standards that are screened in one aquifer so that the Cr(T) and Cr(VI) aquifer contamination can be directly measured. A representative number of wells should be installed upgradient and outside the range of influence of historic or current pumping.
- e. Plume control - Gain hydraulic control on the chromium plume in the Upper Aquifer which appears to be expanding northward. Gain hydraulic control of the Lower Aquifer which appears to be impacted from vertical movement of the Cr(T)- and Cr(VI)-containing groundwater sourced from the Upper Aquifer. The vertical migration and spreading of the chromium plume are a concern and should be addressed.
- f. Identify background concentrations for Cr(T) and Cr(VI) in the area, and develop remediation goals.
- g. Initiate more aggressive hydraulic control and remediation to contain and shrink the currently expanding Cr(T) and Cr(VI) groundwater plume in both the Upper Aquifer and Lower Aquifer.



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I hope these comments are helpful to the Lahontan Regional Board. Please call me at (510) 590-1098 if you have any questions.

Sincerely,
CLEARWATER GROUP



James A. Jacobs, P.G.#4815, C.H.G.#88
Chief Hydrogeologist



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References Cited

CH2MHILL, 2002, *Scope of the Background Chromium Study at the PG&E Compressor Station, Hinkley California*, (BSP1).

CH2MHILL, 2004, *Revised Background Chromium Study at the PG&E Compressor Station, Hinkley, California*, (BSP2).

CH2MHILL, 2007, *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California* (BSP3).

CH2MHILL, 2007, *Groundwater Monitoring Report; October 2007 Sampling Event; Site-wide Groundwater Monitoring Program, PG&E Hinkley Compressor Station, Hinkley, California*.

CH2MHILL, 2010, *Second Quarter 2010, Groundwater Monitoring Report, Site-wide Groundwater Monitoring Program, PG&E Hinkley Compressor Station, Hinkley, California*.

Dernbach, L., 2008, *Background Chromium Study, Pacific Gas and Electric Company, Compressor Station, 35863 Fairview Road, Hinkley, CRWQCB, Lahontan Region*.

Guertin, J., Jacobs, J. A., and Avakian, C. P., 2005, *Chromium (VI) Handbook*, CRC Press.

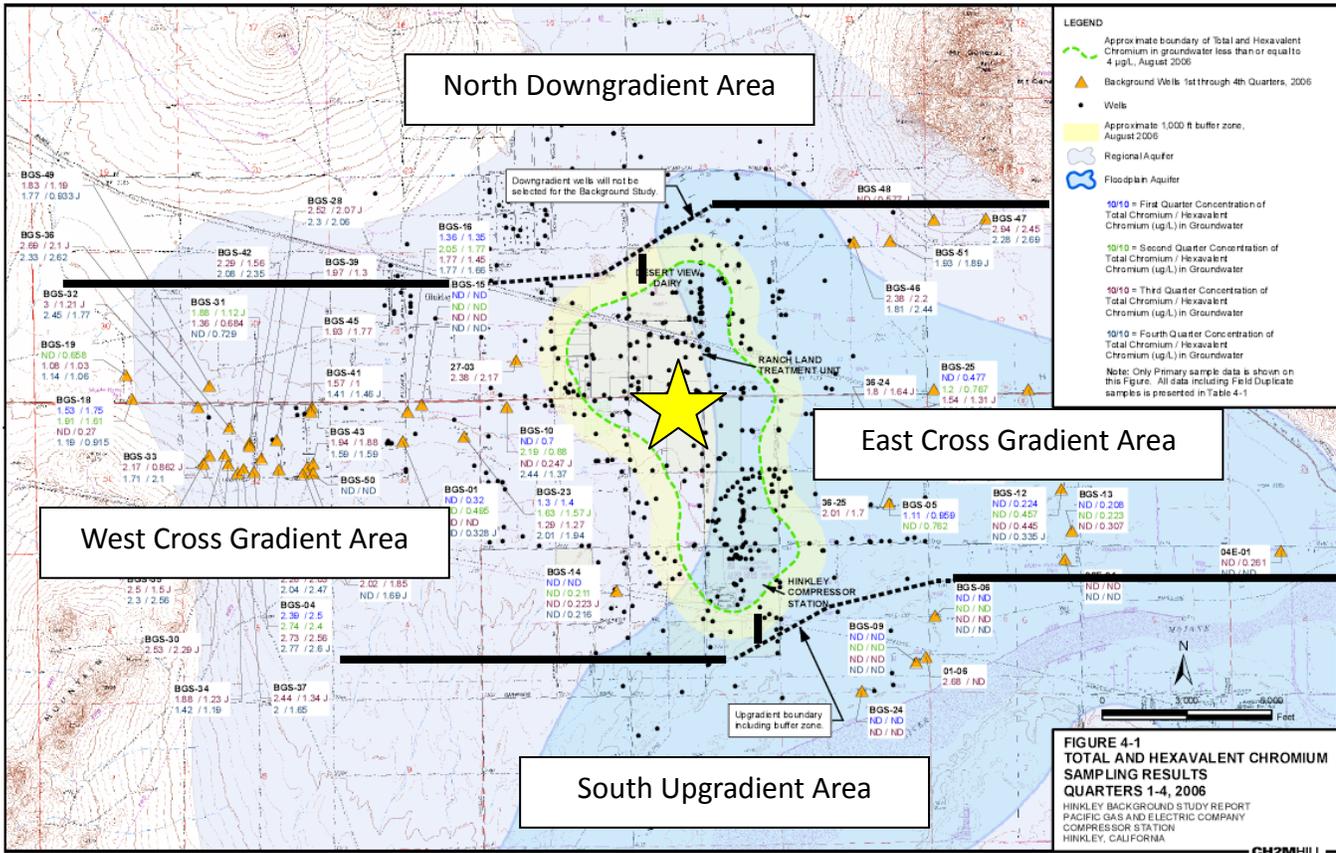
Heath, R.C., 1983, *Basic Ground-Water Hydrology*, United States Geological Survey Water-Supply Paper 2220, Washington, D.C., 86 p.

LRWQCB, 2004, *Comments on Revised Background Chromium Study at the PG&E Compressor Station, Hinkley, San Bernardino County*, Workplan Review and Conditional Acceptance.

Stantec, 2011, *Technical Report – Response to Investigation Order R6V-2011—0043-Delineation of Chromium in the Lower Aquifer*, Pacific Gas and Electric Company, Hinkley California, Stantec, August 1, 2011; from Geotracker web site.

US EPA, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Sept. 1995, Quick Reference Fact Sheet, “Establishing Background Levels,” Directive 9285.7 – 19FS PB94-963313 EPA/540/F-94/030.

US EPA, 1995, *Establishing Background Levels*, Office of Solid Waste and Emergency Response, Directive 9285.7-19FS, EPA/540/F-94/030, September 1995, 7 p.



1224.0 pt x 792.0 pt



Core Area; green line shows approximate boundary of Cr(T) and Cr(VI) in groundwater less than or equal to 4 µg/L, August 2006.

Figure 1 Map of Cr(T) and Cr(VI) Sampling Results; Background Study

Hinkley, California

(Modified after CH2MHILL, 2007, Figure 4-1)

Date: 10/5/11; James Jacobs, P.G., C.H.G., Clearwater Group

A1-2: Stuart J. Nagourney, The College of New Jersey



The College of New Jersey

Department of Chemistry

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Peer Review of Pacific Gas and Electric Company's Chromium Background Study Report, Hinckley Compressor Station

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Question 1. Quality of Spatial Sampling of Background Chromium

The sampling design is questionable. The purpose of this study was not to identify the primary source of Cr(VI) contamination, but to define the extent of the plume. To that end, more sampling should have occurred in the direction that the plume was believed to be directed toward rather than nearer to the known source. The sampling that did take place provides much more data than was required from sampling sites that were closest to the source, which biases the data summaries higher. This could seriously impact any conclusions based upon this data set regarding the extent and migration of the plume.

Question 2. Quality of Temporal Sampling of Background Chromium

The approach used in this study relative to the temporal trends appears to be reasonable. The use of an arithmetic mean to express the average concentrations of both total and hexavalent chromium is appropriate.

Question 3. Assumption of Statistical Normality

No comment, since this subject is outside my area of technical expertise

Question 4. Quality of Groundwater Modeling

As stated in the response to Question 1 above, the spatial sampling design that was used in this study is questionable.

The Big Picture – Additional Scientific Issues

The majority of my comments here are related to the efficacy and quality of the programmatic decisions regarding the choice of analytical methodologies and the quality of the data that was obtained.

The following questions were posed EMAX and Truesdale Laboratories, which were the two analytical laboratories that contributed to this study. The questions that were posed were:

1. What calibration ranges were used for Methods 6010B, 6020A and 7199?
2. For Method 6020A, what was the value of the CRQL Check Standard (CRI) and the method control limits?
3. Were Reporting Limit (RL) check samples analyzed for Methods 7199 and 6010B?; if

so what are the control limits and what were the actual recoveries?

4. How were RLs established for Methods 6010B, 6020A and 7199? What is the relationship between the Method Detection Limit (MDL) & RL for each method?
5. What SRM was used for QC for 7199 as per Section 5.4? This data was apparently not reported.
6. Why were the spiking levels for both Cr(T) and Cr(VI) analyses MUCH higher than the expected sample concentrations for all analytical methods?

EMAX's responses to these questions were:

1. Responses are satisfactory
2. Response is satisfactory
- 3,4. Information on the RLs for Method 6020A were provided, but no information was supplied for Method 7199 or on how these limits were derived.
5. Response is satisfactory
6. This response was not satisfactory. The laboratory should have chosen the concentration level of matrix spikes for both Cr(T) and Cr(VI) to closer to the actual sample levels (usually a multiple of 3-5 the expected value is applied). The choice of much higher spiking levels means that the calculated recoveries have little value in assessing the quality of the actual sample concentrations and the impact to those results from possible matrix interferences.

Truesdale's responses to these questions were:

1. It is unclear from the response if the low level calibration ranges cited in the response for Methods 6010B and 6020A was used for the analyses in this study. If not, the data for this study for Cr(T) would be questionable.
2. Truesdale admitted in their response that they failed to perform this quality assurance as required by the method during the time that data for this study were obtained.
3. Truesdale admitted in their response that they failed to analyze a RL check sample during the time that data for this study were obtained.
4. Truesdale's response of varying criteria for a quantitative relationship between the MDL and RL is too vague to be acceptable.
5. The use of a mid-range check sample is NOT acceptable as a QC material as per the criteria for quality control specified in Method 7199. This would make the data for this study for Cr(VI) questionable.
6. This response was not satisfactory. The laboratory should have chosen the concentration level of matrix spikes for both Cr(T) and Cr(VI) to closer to the actual sample levels (usually a multiple of 3-5 the expected value is applied). The choice of much higher spiking levels means that the calculated recoveries have little value in assessing the quality of the actual sample concentrations and the impact to those results from possible matrix interferences

Other concerns with the analytical data that directly impact the conclusions of the study are:

1. No criteria were provide from with either laboratory as to the criteria for data assigned U or J flags
2. Based upon my experience with examining data for the analysis of Cr(VI) in water samples and soil extracts, this data set showed an unusually high percentage of samples failed the quality control criteria for the Continuing Calibration Verification (CCV). An explanation for this anomaly should be provided so as to show that the conclusions drawn from these data have not been compromised.
3. How were samples chosen for matrix spiking (was this procedure randomized so as to not bias the results?)
4. The workplan (Item #2 of Additional Materials) specifies the use of Method 6010 for the analysis of Cr(T); Method 6020A was used instead. This may impact the ability to quantify for Cr(T) at low concentration levels since the RL for Method 6020A is much lower than that for Method 6010.
5. Some data for Cr(VI) in this study was reported by the USEPA determinative method 218.6, other data was reported by Method 7196A and still other data was reported by Method 7199. These methods all have different sensitivities and different capabilities to report Cr(VI) without analytical interferences. Why were different methods used to measure Cr(VI)?
6. The rationale for using median vs. mean for data summaries was never provided.
7. The authors of the report chose to use a method from the United States Geological Survey (USGS) to attempt to define specific Cr species present in samples, any specie interconversion [either oxidation of Cr(III) to Cr(VI) or reduction of Cr(VI) to Cr(III)]. This method is not certified by any State or national laboratory accreditation authority. Information that was supplied suggests that this USGS method has only been applied to speciation of As. USEPA Method 6800, Elemental and Speciated Isotope Dilution Mass Spectrometry allows the identification individual Cr species, the extent of any specie interconversion, and can correct final results for up to 80% conversion. USEPA Method 6800 is certified by State and national laboratory accreditation authorities. Why was Method 6800 not used for this application?

Respectfully submitted,



Stuart Nagourney
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October 11, 2011

Attachments

From Truesdail Laboratory:

1) What calibration ranges were used for Methods 6010B, 6020A and 7199?

SW 6010B: Standard Calibration: 0.01 to 10 ppm
Low Level Calibration: 0.001 to 0.100 ppm

SW 6020A: Normally 0.2 to 500 ppb, or 0.2 to 100 or 200 ppb.

SW 7199: 0.2 to 50 ppb

2) For Method 6020A, what was the value of the CRI and the method control limits?

We were following the QAAP and there was no mention of this criteria. We started performing the CRI on September 12, 2011 and the criteria is $\pm 30\%$

3) Were RL check samples analyzed for Methods 7199 and 6010B?; if so what are the control limits and what were the actual recoveries?

SW 7199: Yes, control limits of $\pm 20\%$. The raw data was provided to CH2M Hill for these analysis but we were not asked to report them. A PQL sample was analyzed at 0.15 ug/L with control limits of $\pm 20\%$. The recoveries for the PQL in the data packages of interest were 108%, 110%, 103%, and 108%.

SW 6010B: We were not analyzing RL check sample. The Initial calibration starts with the PQL level and every 24 hours we run a calibration curve.

4) How were RLs established for Methods 6010B, 6020A and 7199? What is the relationship between the MDL & RL for each method?

The RL is 2 to 10 times the MDL depending on the noise level.

5) What SRM was used for QC for 7199 as per Section 5.4? This data was apparently not reported.

The mid-range calibration check standard (MRCCS) is a second QC source and is our QCS. It is the same thing but named differently and it is included in the package.

6) Why were the spiking levels for both Cr(T) and Cr(VI) analyses MUCH higher than the expected sample concentrations for all analytical methods?

For Cr(VI), we spike the sample using concentrations of 1, 5, 10, 25, etc., and use the spike concentration that is the next increment that is greater than or equal to the sample concentration. Ex. a sample concentration of 4.2 is spiked with 5 ppb.

For Cr(T): From the PG&E QAPP: "The spike levels will be less than or equal to the mid-point of the calibration range."

From SW 6020A: The spike levels should be "at approximately the mid-point of the linear dynamic range".

Re: Clarification of Analytical Issues

From: Anne Holden
To: Nagourney, Stuart
CC: Dernbach, Lisa; Kemper, Lauri
Date: Friday - September 16, 2011 3:33 PM
Subject: Re: Clarification of Analytical Issues

Hi Stuart

Hopefully now you have everything you need from Emax. I have let Truesdail lab know we are still expecting their responses, and to email them to Lisa Dernbach and Lauri Kemper, my supervisors. I will be out of the office until Oct 23! Thank you for your diligence in conducting the peer review.

If you have any other clarifications/questions, please email Lisa (ldernbach@waterboards.ca.gov) and Lauri (lkemper@waterboards.ca.gov). When they get the responses to your outstanding questions from Truesdail, they will forward them on to you and help transmit any followup questions you may have.

thanks again,
Anne

Anne Holden, P.G.
Engineering Geologist
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>>> Stuart Nagourney <nagourne@tcnj.edu> 9/14/2011 3:53 AM >>>

Ask the lab. to provide the data that shows that they are full compliance with Section 10.2.3.1 of USEPA Method 6020A.

----- Original Message -----

From: "Anne Holden" <AHolden@waterboards.ca.gov>
To: "Stuart Nagourney" <nagourne@tcnj.edu>
Sent: Tuesday, September 13, 2011 5:05:56 PM GMT -05:00 US/Canada Eastern
Subject: Re: Clarification of Analytical Issues

Please see attached, and the text below [the lab's response to your additional questions (apparently they were able to figure out what samples you were referring to)]:

I was able to locate one of the SDGs 06K142. Please see attached file.

Included in the attached file are:

1. LCS report for 06K142 Method 6020A - Lab sample IDs for LCS/LCSD are IMK021WL and

IMK021WC respectively.

2. Analytical sequence - proof that LCS are analyzed with the samples
3. Digestion log - proof that the LCS are prepared the same way as the samples
4. Certificate of Analysis - proof that the standards used for LCS are purchased as certified standards from CPI

Please note that all samples received at EMAX are processed the same way. Should you have any question or need additional info please let me know.

>>> Stuart Nagourney <nagourne@tcnj.edu> 9/13/2011 11:09 AM >>>

I have this info. @ home; I will get it to you later today.

----- Original Message -----

From: "Anne Holden" <AHolden@waterboards.ca.gov>

To: "Stuart Nagourney" <nagourne@tcnj.edu>

Sent: Tuesday, September 13, 2011 1:55:12 PM GMT -05:00 US/Canada Eastern

Subject: Re: Clarification of Analytical Issues

Hi Stuart

Here is the lab's response - can you provide the needed information to help them narrow down the research?

--I need some specific info to help me go through archived records. We archive records per SDG and all related document from the SDG including preplogs (will prove that LCS was digested with the field samples) and standard logs(to trace for the LCS vendor)can be located. If you can provide me the SDG or at least the sample ID then it will be easier to search.

>>> Stuart Nagourney <nagourne@tcnj.edu> 9/13/2011 7:48 AM >>>

Thanks.

For Question 5, please ask EMAX for 2 additional pieces of information: (1) what vendor was used for the lab. control sample and (2)for documentation that this lab. control sample sample was prepared in an identical manner to which the samples were subjected.

So you know, several of EMAX's responses are factually incorrect and that may compromise their data. I will include this information as part of my testimony.

I look forward to other laboratory's comments.

----- Original Message -----

From: "Anne Holden" <AHolden@waterboards.ca.gov>

To: "Stuart Nagourney" <nagourne@tcnj.edu>

Sent: Tuesday, September 13, 2011 10:09:42 AM GMT -05:00 US/Canada Eastern

Subject: Re: Clarification of Analytical Issues

Hello Stuart

Below are responses to your questions from EMAX labs: Truesdail is still working on their responses, I will forward those to you ASAP.

1) What calibration ranges were used for Methods 6010B, 6020A and 7199?

Response: Method 6020A (please note that EMAX did not use method 6010B for this project) for CAM metals and others, calibration ranges are: 10, 50 and 100 ug/L.
for Cations, Al and Fe, the calibration ranges are: 1000, 5000 and 10000 ug/L.
Method 7199: calibration ranges are: 0, 0.2, 2.0 and 5.0 ug/L.

2) For Method 6020A, what was the value of the CRI and the method control limits?

Response: CRI is not required for method 6020A hence it was not performed. All method QC requirements are applied, e.g., IECs, LDRs, ICSA, ICSAB, ICV, CCVs, LCS, MB, MS/MD, Dilution Test, Analytical Spike.

3) Were RL check samples analyzed for Methods 7199 and 6010B?; if so what are the control limits and what were the actual recoveries?

Response: RL check was not required by the project QAPP or method 7199 hence no RL check was performed for this project. All method QC requirements were performed, e.g., ICV, CCVs(90-110% recovery), MB, LCS, MS/MD.

4) How were RLs established for Methods 6010B, 6020A and 7199? What is the relationship between the MDL & RL for each method?

Response: RLs are derived from the lowest calibration point.

5) What SRM was used for QC for 7199 as per Section 5.4? This data was apparently not reported.

Response: EMAX reported LCS (lab control samples) purchased as certified standards from independent source ~ SRM

6) Why were the spiking levels for both Cr(T) and Cr(VI) analyses MUCH higher than the expected sample concentrations for all analytical methods?

Response: Spiking levels are not specified by the method and the project QAPP, hence lab SOP was applied. Furthermore, for practical reasons LCS/MS laboratory spike levels are set the same for all samples. Sample concentration levels are unknown, hence analyzing samples to determine levels for spiking are deemed greatly onerous (and can be translated to a more costly analysis) with no scientific added value. If the analytical run is under control the sample result will be the same whether or not the spike level were (or were not) within the expected concentration levels.

>>> Stuart Nagourney <nagourne@tcnj.edu> 8/29/2011 12:03 PM >>>

Just the questions w/introduction will suffice for now. If it turns out that I need more detail, we can always ask for that later,

Thanks!

----- Original Message -----

From: "Anne Holden" <AHolden@waterboards.ca.gov>

To: "Stuart Nagourney" <nagourne@tcnj.edu>

Sent: Monday, August 29, 2011 2:24:31 PM GMT -05:00 US/Canada Eastern

Subject: Re: Clarification of Analytical Issues

thanks Stuart - is it necessary (or helpful) for me to provide the labs with the chain of custody or lab analytical results for context, or just send the questions with an introductory paragraph?

>>> Stuart Nagourney <nagourne@tcnj.edu> 8/29/2011 10:57 AM >>>

Please ask the analytical laboratories to clarify the following issues:

- What calibration ranges were used for Methods 6010B, 6020A and 7199?
- For Method 6020A, what was the value of the CRI and the method control limits?
- Were RL check samples analyzed for Methods 7199 and 6010B?; if so what are the control limits and what were the actual recoveries?
- How were RLs established for Methods 6010B, 6020A and 7199? What is the relationship between the MDL & RL for each method?
- What SRM was used for QC for 7199 as per Section 5.4? This data was apparently not reported.
- Why were the spiking levels for both Cr(T) and Cr(VI) analyses MUCH higher than the expected sample concentrations for all analytical methods?

>>> Michael Ngo <michaeln@truesdail.com> 10/06/11 2:34 PM >>>

Hi Anne,

Sorry for the long delay. Attached is list of QC questions and their answers.

>>>

>>>

>>

On 9/16/2011 3:15 PM, Anne Holden wrote:

> Hello Mona and Michael--

> We'll be looking forward to receiving Truesdail lab's responses. I will be out of the office from Sept 16 through Oct 23. In my absence, please email the responses to Lisa Dernbach (ldernbach@waterboards.ca.gov) and Lauri Kemper (lkemper@waterboards.ca.gov), both of whom are cc'ed on this email.

>

> thank you

> --Anne

>

>

> _____
> Anne Holden, P.G.

> Engineering Geologist

> Lahontan Water Board

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> 2501 Lake Tahoe Blvd.

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> 530-542-5450 tel

> 530-542-5470 fax

> aholden@waterboards.ca.gov

>

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>

>>>> Mona Nassimi<mona@truesdail.com> 9/12/2011 10:09 AM>>>>

>>>>

> Dear Anne,

> This project is very high profile and we are waiting for our client to obtain their permission to respond to your questions. We apologize for any inconvenient and delay.

>

> Sincerely,

>

>

> Mona Nassimi

> Truesdail Laboratories, Inc

> Manager Analytical Service Division

> 714-730-6239

> 714-730-6462 Fax

> mona@truesdail.com<mailto:mona@truesdail.com>

> 14201 Franklin Ave

> Tustin, CA 92780

>

> >>

>>>>> Michael Ngo<michaeln@truesdail.com> 8/29/2011 3:43 PM>>>>>

>>>>>

>> Hi Anne,

>> We are working on getting those answers for you. I should be able to
>> send you answers for all of your questions by tomorrow.

>>

>>

>> Sincerely

>> Michael Ngo

>> Project Manager/Quality Assurance Manager

>> Truesdail Laboratories Inc.

>> Environmental Services

>> (714)730-6239

>> michaeln@truesdail.com

>>

>>

>> ----- Original Message -----

>> Subject: Re: QC questions

>> Date: Thu, 8 Sep 2011 17:38:18 -0400

>> From: Anne Holden<AHolden@waterboards.ca.gov>

>> To: Michael Ngo<michaeln@truesdail.com>

>>

>>

>>

>> Hi Michael

>> just following up on the status of your answers - any ETA?

>> thanks!

>>

>>

>> _____

>> Anne Holden, P.G.

>> Engineering Geologist

>> Lahontan Water Board

>> <http://www.waterboards.ca.gov/lahontan/>

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>>>>> Michael Ngo<michaeln@truesdail.com> 8/29/2011 3:43 PM>>>

>>>>>

>> Hi Anne,

>> We are working on getting those answers for you. I should be able to

>> send you answers for all of your questions by tomorrow.

>>

>>

>> On 8/29/2011 1:18 PM, Anne Holden wrote:

>>

>>> Hello Mr Ngo:

>>>

>>> I work for the Lahontan Regional Water Quality Control Board, a state of California agency. Our agency oversees the cleanup of chromium contamination in groundwater at the Pacific Gas and Electric Company Hinkley Compressor Station in Hinkley, CA. In 2006, PG&E conducted groundwater sampling to examine background chromium concentrations in the Hinkley area. We are reviewing the quality control

data for this sampling effort, which took place over four quarters of calendar year 2006. Your lab performed analytical chemistry services for the groundwater sampling, and we have the following questions regarding the analytical testing.

>>>

>>> 1) What calibration ranges were used for Methods 6010B, 6020A and 7199?

>>> 2) For Method 6020A, what was the value of the CRI and the method control limits?

>>> 3) Were RL check samples analyzed for Methods 7199 and 6010B?; if so what are the control limits and what were the actual recoveries?

>>> 4) How were RLs established for Methods 6010B, 6020A and 7199? What is the relationship between the MDL& RL for each method?

>>> 5) What SRM was used for QC for 7199 as per Section 5.4? This data was apparently not reported.

>>> 6) Why were the spiking levels for both Cr(T) and Cr(VI) analyses MUCH higher than the expected sample concentrations for all analytical methods?

>>>

>>> Please reply to each question above as they pertain to the services your lab performed. I would very much appreciate your reply as soon as possible. Please contact me with any questions or if you need more information to respond to this request.

>>>

>>> Regards,

>>>

>>>

>>>

>>>

>>> _____

>>> Anne Holden, P.G.

>>> Engineering Geologist

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A1-3: Yoram Rubin, University of California-Berkeley



Prof. Yoram Rubin, Ph.D
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October 7th, 2011

Ms. Lauri Kemper, PE
Assistant Executive Officer
California Regional Water Quality Control Board
Lahontan Region

Re: Peer Review of PG&E's Chromium Background Study Report, Hinkley Compressor Station

This review provides my opinions on several questions related to the documents provided to me. The review is organized following the sequence of questions raised in the Scientific Peer Review Request (Sections 1-4). Additional comments of a more general nature are provided in Section 5. If I missed or misinterpreted any information, I would be glad to be informed about it.

1. Comments on quality of spatial sampling of background chromium

The first issue raised in the "Scientific Peer Review Request" concerns the large number of wells installed (and measurements taken) in the vicinity of well BGS-04. Looking at Figures 4-1 and 4-2, it is obvious to me that there are many measurements collected all over the site, and altogether they form a good basis for analysis and for making predictions. The challenge of course is how to analyze the data and how to use it for predictions. Specifically, there is a need to apply analysis that would take into consideration that uneven spatial distribution of the measurement locations (i.e., the sampling wells). Without taking this into account, the concentrations at a particular area (e.g., BGS-04) could be assigned a disproportionately large weight. If many or all the wells around BGS-04 sample a particularly high concentration area, the high concentration in that area could pull the spatial average higher (creating a positive bias), leading to averages that are not representative of the site. It could also happen that they all sample small values, and that would create a negative bias. This is known in geostatistics as the clustering effect. The clustering effect could be removed through declustering. It does not appear that declustering was applied to the data. To summarize, the uneven distribution of wells could lead to bias. There are known techniques that could handle the clustering effect, but none was carried out, to my understanding.

Additional comments:

1. The Background Study mentions on page 1-4 that “To compensate for the lack of discrete-depth-samples, PG&E proposed to expand the background study well network”. In response to that statement, this approach cannot work unless the concentration field is stationary and statistically isotropic, which cannot be the case. So, expanding the area being sampled cannot compensate for the lack of discrete-depth samples.
2. Table 3-1 indicates that several of the wells are screened over the upper (floodplain) and lower (regional) aquifer. From my understanding of the sampling procedures (Section 3.2), the concentrations represent (flux-) averages over the entire screen. This could lead to ambiguity as to what the concentration averages actually represent (i.e., which geological unit?). Furthermore, it could also lead to bias: it may be that a well that is screened over the two aquifers would mix clean water from one unit with contaminated water from the other unit, which would lead to biases when trying to assign the measured value to a particular aquifer and to biases in assessing the average concentrations. This ambiguity could be removed, to a large degree, through appropriate modeling, but to my understanding this has not been done.
3. Spatial averages are of little predictive value in the case of non-stationary variables such as the concentration. The population sample mixes measurements taken upstream (potentially low values) and downstream (potentially larger values) of the compression area. There also appears to be a trend of the concentrations increasing from east to west. All this could lead to biases. A physically-based analysis could take the trends in the concentration into account and provide better predictions.

2. Comments on quality of temporal sampling of background chromium.

The procedure used to account for gaps in the temporal sampling is described as follows (Scientific Peer Review Request, Attachment 2)

2. Quality of temporal sampling of background chromium

The 2007 Background Study Report acknowledges that the expansion of the well network after the second sampling event has the potential to introduce bias into the overall summary statistics due to the temporally unbalanced nature of the data set (i.e., four quarters of data are not available for all wells). To address this bias, the arithmetic average value of Cr(VI) and Cr(T) concentrations from each well were used in the statistical analysis. Therefore, each well is represented by one arithmetic mean result instead of by the actual number of samples taken at that well. See the 2007 Background Study Report, pages 5-5 through 5-7, and page 7-1.

I find this approach lacking in several respects, and I would recommend against it. My reasons are as follows. Averaging is known to alter the statistical nature of the variables being averaged. The primary effect is reducing variability. The consequence of that is that the averaged variables provide a “smoother” version of reality, and as a result the high and low values are averaged out. The elimination of high values of the concentration from consideration is obviously of concern in the context of this study because it would lead to biased estimates.

Appendix I of the Background Study Report refers to this issues and mentions the “..dampening the effect of the most elevated values in the sample set by averaging those results with lower results from other sampling” (page 7-1). I cannot see why dampening would be a desired outcome. To explain this issue consider the following example: if you are searching for gold, you will not average gold concentrations from your soil samples, because that one sample with very high concentrations could be very important in telling you where to dig. Similarly, the samples with high concentrations could indicate the presence of high-concentration areas and should not be averaged out.

There is another problem with averaging of measurements that is related to the test of statistical normality (discussed further in Section 3 below). Statistical tests are generally performed (unless stated otherwise) based on statistically homogenous populations (population samples), meaning that all samples in the population sample are drawn from (or representative of) the same underlying distribution. In many cases, the samples are assumed to be independent and identically distributed (what’s known in the statistical literature as i.i.d). The assumption of homogeneity is a key element of statistical inference. Averaging as done in the Background Study is inconsistent with this requirement, because the averaged concentrations and the non-averaged concentrations do not belong in the same underlying statistical distribution. I will discuss this issue further in Section 3, but in brief summary, the mixing of variables from different distributions violates one of the assumptions used to construct the Shapiro-Wilk test. The consequences of this violation were not evaluated and so cannot be ignored.

3. Comments on the assumption of statistical normality.

The normal distribution is a favorite model selection in applications because of its simplicity: one needs to infer only 2 parameters (the mean and variance) to be able to define the entire distribution, which could then be used for making predictions and associating them with confidence intervals. Given that in groundwater applications there is not a lot of data to begin with, and that inference of multi-parameter models is a challenge, there’s no wonder why one would want to adopt the normal model, as was done in the background study.

In order to test whether or not a normal model is acceptable, the background study elected to use the formalism of hypothesis testing. The underlying theory is documented in many textbooks. The approach is to state a null hypothesis (in this case, that the concentrations are normally distributed) and then to apply a test that would indicate whether this assumption could be rejected or not. A fundamental tenet of hypothesis

testing is that the test can only determine whether there's enough evidence to reject the null hypothesis. Hypothesis testing does not provide conclusive evidence that the null hypothesis is the right one. It can only determine whether or not there's enough evidence to reject it. Based on this, the statement made in Appendix I that "the probabilities (p-values) from the Shapiro-Wilk test (W test) provide evidence about whether the background total and hexavalent chromium concentrations are normally or log-normally¹ distributed" is very doubtful. The test does not provide such evidence, its power is only to state whether there's enough evidence to reject the assumption of normality.

Not having enough evidence to reject the null hypothesis (normality) does not mean that the normal model is the best one. It also does not mean that other evidence cannot be used. To use an analogy, not finding conclusive evidence with fingerprints does not mean that DNA samples cannot be used and shed a different light. In the case of the normal model assumption, it should be noted that the concentration is by definition non-negative, and hence non-normal by definition (exceptions can be made but I am not sure they are applicable here). There is evidence for asymmetry in Table 6.1 where differences between the mean and median of the distribution are shown to exist: in normal distributions these values should be equal (or at least very close to each other). Hence, there are indications against the assumption of normality.

The practice of hypothesis testing brings another issue to the surface. In hypothesis testing, the common thinking is that the null hypothesis should be a "safe" assumption, meaning an assumption that would not lead to damage if it is not rejected. This is because it is difficult to reject the null hypothesis: it is rejected only in the face of overwhelming evidence against it. Let me explain this with an example from the criminal law. I am not a jurist, but this example is commonly used and I think I understand it pretty well. The point is that legally a person is assumed innocent until proven guilty. So the null hypothesis in the legal system is that the person is innocent. The assumption of innocence is selected to be the safe assumption (null hypothesis) in most legal systems, and it will be rejected only in the face of overwhelming evidence to the contrary. How is that related to the Background Study? The question is whether the assumption of normality is the safe assumption and should it be used as the null hypothesis. In my opinion it is not a safe assumption because it could underestimate the probabilities of high concentrations. For example, a lognormal distribution has a longer "tail" and it assigns higher probabilities to the high concentrations, and so it could possibly be a safer assumption. This option and perhaps others need to be considered.

The quality of the sample population is obviously of primary consideration. Shapiro and Wilk (1965) assume that their samples are identically distributed. Section 2.2 in the Shapiro-Wilk paper states that "The objective is to derive a test for the hypothesis that this is a sample from a normal distribution with unknown mean μ and unknown variance σ^2 ." As discussed in Section 2, the sample population includes measured concentrations and averaged measured concentrations. Because averaging alters the statistical nature of the underlying distribution, the population sample appears to be inappropriate for this

¹ Shapiro and Wilk (1965) mention only the normal option, not lognormal. The log-normal option is a possibility after log-transformation of the measurements.

kind of test because differences in temporal averaging procedures (e.g., averaging over 2, or 3 or 4 measurements) will lead to different statistical distributions for the various samples within the population sample, in a violation of the requirements of the test. The consequences of such violation need to be analyzed, but in principle, inferences from such a hybrid sample population are not suitable for determining the nature of the underlying distribution.

The Background Study does not assume correlation between the concentration measurements. In other words, the measurements are assumed to be spatially-uncorrelated. This assumption, although not unreasonable for measurements with large distances in between, is not justified theoretically, and is particularly challenging for measurements at close proximity. It needs to be supported with evidence. I could not find such evidence in the study and I am concerned that the test is inconsistent with the underlying physics.

In another direction, the test of normality addresses the question of whether or not the population sample could be described as normally-distributed. It does not address the question of whether or not the normal model inferred from the population sample is a good model for prediction of regional or local averages of the concentration and its confidence intervals. More on that is provided in Section 5.

In light of this discussion, I believe that the outcome of the Shapiro-Wilk test is questionable. Additional comments on this matter are provided in Section 5.

4. Comments on quality of groundwater modeling

The groundwater model is discussed in Appendix B. Model calibration is discussed in Section B.1.4. Very little information is provided and whatever is given is not enough to confirm the adequacy of the calibration effort. Particular issues to consider are as follows:

1. The model was calibrated based on groundwater levels only. This raises several issues of concern:
 - a. Water levels alone cannot be used for calibrating the spatial distribution of the hydraulic conductivity because there is no unique relationship between water levels and conductivity. Without sound calibration of the hydraulic conductivity field and porosity, the groundwater model cannot be used to predict velocities, and concentrations.
 - b. No information is provided on the quality of the match between measured head and model-based predictions. It is important to remember in this context that even small errors in the predicted heads could lead to very large errors in the head gradients, and all that is related like velocities and concentrations.
 - c. Without reliable estimates for the hydraulic conductivity, the reliability of the water budget analysis cannot be established.
2. No attempt is reported to test the model against the concentration data. This could be a useful strategy to establish the credibility of the model. Methods for using concentration data are available (see Rubin, 2003 and Rubin et al., 2010).

3. No attempt to model spatial variability of the hydrologic parameters is reported. Assuming the hydraulic conductivity to be uniform within each of the hydrostratigraphic units would neglect the possible consequences of channeling effects that could be introduced by the "...interbedded gravels, sands, silts, and minor amounts of clay " (Section B.1.2). One possible consequence is that the channels could act as fast flow channels. Such channels would lead to faster downstream migration of chemicals.

My conclusion is that more work is needed in order to align the model calibration efforts with modern concepts on this topic. As discussed in Section 5, uncertainty quantification (UQ) should be an important part of the study. A groundwater model is the main vehicle for UQ. This line of thinking was not pursued here and no UQ that meets acceptable norms was carried out, to my understanding.

5. General comments

In Section 3 I addressed questions related to the normality test. Here I would like to provide additional perspective. The first point I would like to make is that, regardless of whether or not the Shapiro-Wilk test is applicable or not, there is a need to evaluate the predictive capabilities of the normal model, and that is a different issue altogether. In other words, even if one accepts that the population sample is normal (see Section 3 for discussion on the difficulties with this), this does not constitute a confirmation that the normal model could actually be used for predicting (at best) anything but the statistics of that population sample, until the predictive capability itself is tested. The main reason for that is the issue of ergodicity. For spatial averages to be representative, the population sample must be ergodic (see Rubin, 2003). That means that the population sample must cover all the possible states of the sampled system, and in the right proportions. If this condition is met, then the population sample would be sufficient for making inferences about spatial averages. For stationary problems, satisfying the condition of ergodicity requires extensive spatial sampling. How large the sampled domain needs to be? This can only be established through physically-based modeling of the aquifer, including modeling of the spatial variability of the hydraulic conductivity and the flow and transport fields related to the spatial variability model. The added complication here is that the concentration field is non-stationary. This could be compensated through physically-based stochastic modeling strategies (Rubin, 2003). Another strategy to evaluate the model's predictive capability is through cross-validation (Rubin, 2003).

Another issue to consider is the no-detect concentrations. Figures 5-4 and 5-5 and associated discussion indicate that locations where the concentrations were measured below the detect limits were assigned values equal to half the detection limit. This is speculative. It may be a good speculation, but it is still a speculation, nonetheless. The speculation is in considering and analyzing the concentration from the perspective of a spatially-uncorrelated variable rather than a spatially-correlated variable. The point is that if one adopts the spatial correlation perspective, the no-detects could be interpreted in different ways. For example, one could also speculate that the no-detects could be indications of fast-flow channels with very high concentrations further downstream

(Wilson and Rubin, 2002), or that the wells with no-detects were placed in low-conductivity areas with by-pass flow nearby.

At times one must resort to speculations when it comes to groundwater applications, but there is a need to establish their likelihood. What is needed here is to substantiate this speculation by evaluating it using a physically-based flow and transport model. Another important point is that including speculative values in the population sample used to test normality is not warranted. Without accounting for the uncertainty around this speculation, one cannot assign any confidence intervals to any prediction that is based on a population sample that includes these values. This adds further doubts to the value of the normality test (see Section 3 for additional discussion).

The next comment is with regard to uncertainty quantification (UQ). UQ is the idea that all sources of uncertainty must be accounted for when making predictions. It is known that the sources for uncertainty are spatial variability and data scarcity, and the challenge is how to quantify that uncertainty. To be specific with regard to the analysis carried out in the Background Study, we would want to model the model uncertainty (in other words, how likely or unlikely is the normal model and alternative models?) and the parameter uncertainty (in other words, what is the uncertainty associated with the parameters of the normal model?). UQ is a fundamental concept in modern hydrogeology and its importance is in that it allows us to assess the quality of the prediction. In the Background Study, once a decision was made to accept the normal model, it was viewed as a certain model and that does not model realistically the uncertainty.

Respectfully,

Yoram Rubin

References

Rubin, Y., 2003, *Applied Stochastic Hydrogeology*, Oxford University Press.

Rubin, Y., X. Chen, H. Murakami, and M. Hahn, 2010, A Bayesian approach for data assimilation and conditional simulation of spatial random fields. *Water Resources Research*, 46, W10523, doi:10.1029/2009WR008799.

Shapiro, S.S., and M.B. Wilk, 1965, *Biometrika*, Vol. 52, No. 3/4, pp. 591-611.

Wilson, A., and Y. Rubin, 2002, Characterization of aquifer heterogeneity using indicator variables for solute concentrations, *Water Resour. Res.*, 38(12).

Appendix 2: Technical Reviews of Laboratory Quality Control Issues

- A2-1: December 15, 2011: Excelchem Laboratories review of Peer review comments
- A2-2: December 22, 2011: Addendum to December 15, 2011 Excelchem review
- A2-3: December 29, 2011: Water Board Investigative Order No. R6V-2011-0105, Requiring PG&E to provide Information on Laboratory Quality Control Data
- A2-4: January 20, 2012: PG&E's Response to Investigative Order No. R6V-2011-0105. Includes responses to Dr. Nagourney's peer review comments in attachment A.
- A2-5: February 23, 2012: Excelchem Laboratories review of PG&E's Response to Investigative Order No. R6V-2011-0105

A2-1: December 15, 2011: Excelchem Laboratories review of Peer review comments



Excelchem Environmental Labs

1135 W Sunset Boulevard Suite A
Rocklin, CA 95765
Phone # 916-543-4445
Fax # 916-543-4449

12/15/11

Re: Technical Consultation on Scientific Peer Review Comments for Pacific Gas and Electric Company's 2007 Groundwater Chromium Background Study

To Whom It May Concern:

The peer reviewer noted that there were a large number of CCV failures for Cr(VI). I agree with the peer reviewer that there are an excessive number of CCV failures. EPA Method 7199, Section 7.3.2 clearly states that if the CCV is not within 10% the instrument must be recalibrated and the samples must be re-analyzed. If the CCV fails after recalibration, the analysis should be terminated until the source of the problem is identified and corrected (EPA Method 7199, Section 7.3.1). Sample results associated with failing CCVs are unacceptable, not legally defensible, and of questionable accuracy and usefulness.

The Cr(IV) analysis performed by the laboratory seems to be out of control. The laboratory reported data associated with failing CCVs on April 24, July 26, July 27, September 26, October 23, and November 14, 2006. There is an ongoing problem with the analysis that the laboratory failed to correct. The laboratory is blatantly ignoring EPA Method 7199 criteria by reporting data with failing CCVs and is providing its customers with data that is useless. The laboratory should explain the CCV failures and why they did not follow the method and recalibrate and re-analyze the samples.

The laboratory flagged Cr(IV) results as estimated due to failing CCV recoveries. The method has no provision to accommodate this practice and therefore the laboratory is not adhering to EPA Method 7199. Consequently they are not truly running EPA Method 7199. For CCVs that failed high, the analytical results would most likely be reduced. For Cr(IV) results flagged as estimated due to low CCV recoveries, the analytical results would most likely be increased. Data reported as ND may actually have detectable Cr(IV) if the CCV was low.

For the analysis of Cr (IV), Truesdail stated that the MRCCS is a QCS. They should provide proof that the MRCCS was prepared from a second source standard (certificate of analysis/standard logbook entries). If the MRCCS was prepared from a secondary standard as Truesdail implies then the data is not affected. The purpose of the QCS is to validate the accuracy of the primary standard and the calibration curve. Failure to run a QCS as required by EPA Method 7199, sections 7.3.1 and 8.7 invalidates the calibration curve and the associated results.

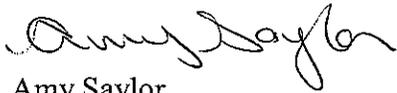
The peer reviewer noted that reporting limit check samples were not analyzed for EPA Methods 7199 and 6010B. A reporting limit check sample is not required for EPA Methods 7199 or 6010B.

The peer reviewer noted that a reporting limit check sample was not analyzed for EPA Method 6020A. The samples were analyzed in 2006. A reporting limit check sample was not required for this method until the 2007 revision.

Truesdail did not specify which calibration curve was used for EPA Method 6010B. This could affect the data if the standard curve was used, but the RL came from the low level curve. Truesdail was unclear about which curve was used so the data is questionable until Truesdail is more specific about which calibration curve was used.

The peer reviewer noted that the MS/MSD spike amounts chosen were too high for EPA Methods 7199, 6010B, and 6020A. The methods do not stipulate spike amounts. No information was given regarding matrix spike amounts and recoveries so I cannot comment on whether the amounts were too high.

Sincerely,



Amy Saylor
QA/QC Officer
Excelchem Environmental Labs

A2-2: December 22, 2011: Addendum to December 15, 2011 Excelchem review



Excelchem Environmental Labs

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Rocklin, CA 95765
Phone # 916-543-4445
Fax # 916-543-4449

12/22/11

ADDENDUM TO THE LETTER DATED 12/15/2011: Technical Consultation on Scientific Peer Review Comments for Pacific Gas and Electric Company's 2007 Groundwater Chromium Background Study

To Whom It May Concern:

More information needs to be provided for an accurate determination of the quality of the hexavalent chromium results associated with failing CCVs. If the CCVs were failing by a small amount, then the data is still usable. The raw data needs to be provided for a more accurate evaluation of the hexavalent chromium data.

Sincerely,

A handwritten signature in cursive script that reads "Amy Saylor".

Amy Saylor
QA/QC Officer
Excelchem Environmental Labs

A2-3: December 29, 2011: Water Board Investigative Order No. R6V-2011-0105,
Requiring PG&E to provide Information on Laboratory Quality Control Data



Matthew Rodriguez
Secretary for
Environmental Protection

California Regional Water Quality Control Board Lahontan Region

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Edmund G. Brown Jr.
Governor

December 29, 2011

Tom Wilson
Director, Remediation Program Office
Pacific Gas and Electric Company
3401 Crow Canyon Road
San Ramon, CA 94105-1814

INVESTIGATIVE ORDER NO. R6V-2011-0105, REQUEST FOR INFORMATION ON LABORATORY QUALITY CONTROL DATA FOR 2007 GROUNDWATER BACKGROUND STUDY REPORT, PACIFIC GAS AND ELECTRIC COMPANY (PG&E), HINKLEY COMPRESSOR STATION, SAN BERNARDINO COUNTY

This Investigative Order requires PG&E to submit a technical report concerning quality control procedures associated with groundwater sample analyses conducted by Emax Laboratories and Truesdail Laboratories, contracted by PG&E for its 2007 Groundwater Background Study Report. This investigative order is issued pursuant to California Water Code section 13267.

Background

In response to direction by the Lahontan Water Board, PG&E's *2007 Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California* (hereafter, the 2007 Background Study Report) underwent scientific peer review in the summer of 2011. As a result of that peer review, quality control issues were identified related to the procedures used by Emax Laboratories and Truesdail Laboratories, the two chemistry laboratories that analyzed groundwater samples from the Hinkley Valley for the 2007 Background Study Report. The peer reviewer expressed doubt regarding the validity of the data from the labs due to certain quality control procedural irregularities.

Requirement

Pursuant to section 13267 of the Water Code, PG&E is hereby required to submit a technical report to the Water Board by **January 20, 2012** that includes the following items. Responses should include information for all samples analyzed for the 2007 Background Study Report:

- 1) For the continuing calibration verification (CCV) failures for EPA Method SW 7199, discuss what percentage out of range were the CCV recoveries.
- 2) Provide raw data, including calibration curves, CCVs, and quality control (QC) samples, from hexavalent chromium analysis.

- 3) Provide information on matrix spike amounts and recoveries for hexavalent chromium.
- 4) A description of how samples were chosen for matrix spiking.
- 5) Provide evidence that Mid-Range Calibration Check Standards (MRCCSs) were prepared from a second source standard. Provide NIST (National Institutes of Standards Traceability) documentation for MRCCSs.
- 6) Verify which calibration curve was used for EPA Method 6010B (was the standard or low level calibration curve used?). Provide documentation showing calibration curve.
- 7) Provide valid Environmental Laboratory Accreditation Program certificates for each lab for total and hexavalent chromium analysis for the calendar year 2006.
- 8) Discuss why EPA Method 6800 was not used for chromium species identification.
- 9) Discuss why EPA Method 6020A was used instead of Method 6010 for total chromium.

The technical report required by this Investigative Order is necessary to determine whether the analytical data from the laboratories in question is valid and reliable for determining background chromium concentrations in the Hinkley Valley. The need for this information outweighs the burden on PG&E to produce the information it already possesses, including the costs to produce the technical reports.

Any failure to furnish the required technical or monitoring reports subjects PG&E up to \$1,000 a day in administrative civil liability for each violation pursuant to Water Code section 13268.

Please contact me at 530-542-5436, or Anne Holden at 530-542-5450 if you have any questions.



LAURI KEMPER
ASSISTANT EXECUTIVE OFFICER

Enclosure: 13267 Fact Sheet

cc: Kevin Sullivan, Hinkley Remediation Project Manager

ALH/adw/T:Background Study QC information 13267.docx
File Under: 6B369107001

A2-4: January 20, 2012: PG&E's Response to Investigative Order No. R6V-2011-0105. Includes responses to Dr. Nagourney's peer review comments in attachment A.



**Pacific Gas and
Electric
Company**

Kevin M. Sullivan
Hinkley Remediation
Project Manager
Shared Services Dept

3401 Crow Canyon Rd
San Ramon, CA 94583
(925) 818-9069 (cell)
kmsu@pge.com

January 20, 2012

Ms. Lauri Kemper, Assistant Executive Officer
Ms. Lisa Dernbach, Senior Engineering Geologist
California Regional Water Quality Control Board, Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, California 96150

Subject: Investigative Order No. R6V-2011-0105, Request For Information On
Laboratory Quality Control Data For 2007 Background Study Report,
Pacific Gas And Electric Company, Hinkley Compressor Station, San
Bernadino County

Dear Ms. Kemper and Ms. Dernbach:

Pacific Gas and Electric Company (PG&E) respectfully submits the enclosed Technical Memorandum, which presents the response to Investigative Order No. R6V-2011-0105, issued by the Regional Water Quality Control Board, Lahontan Region (Water Board) on December 29, 2011. This Order requested responses to nine specific comments related to laboratory quality control data for Hinkley Groundwater Background Study Report (CH2M Hill, 2007) and requested submittal of the raw analytical data, which is provided on a compact disc (CD). In addition, the Technical Memorandum presents responses to comments provided by Dr. Stuart Nagourney in the Peer Review received by the Water Board on October 14, 2011.

Please contact me if you have questions regarding the information provided in the enclosed Technical Memorandum.

Sincerely,

Kevin Sullivan
Hinkley Remediation Project Manager

Attachments:

Technical Memorandum – Response to Investigative Order No. R6V-2011-0105 and Peer Review Comments on Laboratory Quality Control Data for 2007 Groundwater Background Study Report, Hinkley Remediation Project

Compact Disc (CD) – Hexavalent Chromium Analytical Data, Truesdail Laboratories, Inc. and EMAX Laboratories, Hinkley Groundwater Background Study (CH2M HILL, 2007)

Response to Investigative Order No. R6V-2011-0105 and Peer Review Comments on Laboratory Quality Control Data for 2007 Groundwater Background Study Report, Hinkley Remediation Project

PREPARED FOR: Pacific Gas and Electric Company

COPY TO: Eliana Makhoulouf
Shawn Duffy

PREPARED BY: CH2M HILL

DATE: January 19, 2012

PROJECT NUMBER: 432629

This technical memorandum presents the response to Investigative Order No. R6V-2011-0105 issued by the California Regional Water Quality Control Board, Lahontan Region (Water Board) (Water Board, 2011), which requested information on laboratory quality control data for the Groundwater Background Study Report (CH2M HILL, 2007), prepared on behalf of Pacific Gas and Electric Company (PG&E) for the Hinkley Remediation Project. In addition, this memorandum presents responses to comments provided by Dr. Nagourney in the Peer Review received by the Water Board on October 14, 2011.

The responses to questions one through nine in Investigative Order R6V-2011-0105 are provided below.

- 1) **Comment:** For the continuing calibration verification (CCV) failures for EPA Method SW 7199, discuss what percentage out of range were the CCV recoveries.

Response: During the first Groundwater Background Study sampling event, (January/February 2006) all Method SW 7199 sample analyses were performed by Truesdail Laboratories, Inc. (TLI) and the CCV recoveries for all analyses were within the method criteria of 90 – 110% recovery.

For the three subsequent sampling events, all Method SW7199 sample analyses were performed by EMAX Laboratory (EMAX). Of the 129 sample analyses performed by EMAX, 31 (26 samples and 5 field duplicates) or 24 percent had one or more of the bracketing CCVs with recoveries that were outside the method criteria. CCV recoveries for the out of control sample analyses ranged from a low of 72 percent to a high of 123 percent with 19 results biased low and 12 biased high. In accordance with the PG&E program Quality Assurance Project Plan (QAPP) (CH2M HILL, 2008) that cites USEPA National Functional Guidelines for Inorganic Data Review (2002), the range of the out of control CCV recoveries was not significant enough to warrant data rejection, but did require data qualification by applying “J/UJ” flags to out of control results. Therefore, the results were determined to be of sufficient quality to be used for purposes of the Groundwater Background Study.

- 2) **Comment:** Provide raw data, calibration curves, CCVs, and quality control (QC) samples, from hexavalent chromium analysis.

Response: All analytical data for hexavalent chromium are provided on the enclosed CD. The data are organized by sample delivery groups (SDGs) provided to CH2M HILL by the laboratories. There are 17 SDGs from EMAX and four SDGs from TLI. The table below identifies each SDG number associated with hexavalent chromium analysis associated with the Groundwater Background Study.

EMAX SDG Numbers	TLI SDG Numbers
06D180, 06D191, 06D205, 06D215, 06G152, 06G165, 06G182, 06G200, 06I248, 06I262, 06I280, 06J236, 06J257, 06J279, 06K142, 06K156, 06K180	951265, 951327, 951368, 951421

3) **Comment:** Provide information on matrix spike amounts and recoveries for hexavalent chromium.

Response: The spike concentration at TLI for hexavalent chromium was 1.0 microgram per liter (µg/L). There were four SDGs of data with three different site specific matrix spike samples in three of the four SDGs. The SDG without the site specific matrix spike has a matrix spike completed on a non-site sample. The recoveries were all in control with 98, 94, and 106 percent recovery. The acceptance limits used by the laboratory were 90 – 110 percent. The concentration of the matrix spike was five times the reporting level and applicable to the majority of sample concentrations determined over the study.

The spike concentration at EMAX Laboratory for hexavalent chromium was 1.0 µg/L. There were 17 SDGs of data with 18 different site specific matrix spike samples in 15 of the 17 SDGs. The SDG without the site specific matrix spike has a matrix spike completed on a non-site sample. The recoveries were predominantly in control ranging from 76 to 115 percent recovery. The acceptance limits used by the laboratory were 85 – 115 percent. Two of the 18 matrix spikes were out of control with a low bias but still provide data that met project data quality objectives for evaluating background hexavalent chromium concentrations. The concentration of the matrix spike was five times the reporting level and applicable to the majority of sample concentrations determined over the study.

4) **Comment:** A description of how samples were chosen for matrix spiking.

Response: The matrix spikes were randomly selected by the laboratory as part of the analytical batch control requirements.

5) **Comment:** Provide evidence that Mid-Range Calibration Check Standards (MRCCSs) were prepared from a second source standard. Provide National Institute of Standards Traceability (NIST) documentation for MRCCSs.

Response: MRCCSs were prepared from a different lot number source from the initial calibration stock at TLI as well as at EMAX Laboratory as shown in files provided on the attached CD. This same standards traceability documentation is also available in each of the SDGs provided in response to Question Number 2.

6) **Comment:** Verify which calibration curve was used for EPA Method 6010B (was the standard or low level calibration curve used?). Provide documentation showing calibration curve.

Response: Method 6010B was not used by either lab for the Hinkley Groundwater Background Study rather Method 6020 was used for total chromium analysis as explained in the response to Question Number 9.

7) **Comment:** Provide valid California Environmental Laboratory Accreditation Program (ELAP) certificates for each lab for total and hexavalent chromium analysis for the calendar year 2006.

Response: Both TLI and EMAX were ELAP certified in 2006. Copies of the certifications for 2006 are provided in Attachment A.

8) **Comment:** Discuss why EPA Method 6800 was not used for chromium species identification.

Response: The Hinkley Background Study was conducted from January to November 2006 and therefore pre-dated the promulgation of Method 6800, which was posted in February 2007.

9) **Comment:** Discuss why EPA method 6020A was used instead of Method 6010 for total chromium.

Response: USEPA method 6020A achieves a lower level of detection for total chromium than that of EPA Method 6010B and therefore was used for the project.

Attachment B to this technical memorandum provides additional responses to comments provided by Dr. Nagourney regarding the quality control procedures used by the laboratory for chromium analysis. In summary, based on a review of the laboratory methods and data obtained for the study, the quality of the laboratory analysis performed for the study was appropriate and met all of the requirements of the USEPA methods employed. The issues raised by the reviewer can be explained by 1) the incomplete answers provided to the reviewer by the laboratories, 2) expectations of the reviewer for quality control measures that were slightly different or beyond the requirements of the USEPA methods, or 3) a misunderstanding on the part of the reviewer about which methods were applied to the data set. As summarized in Attachment B, the data yielded through these analyses are deemed of high quality and the use of these data for the purposes of the background study was appropriate. A detailed response to comments on the laboratory chemistry comments is provided in Attachment B.

References

CH2M Hill. 2007. *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California*. February.

_____. 2008. *PG&E Program Quality Assurance Project Plan*. December.

United States Environmental Protection Agency (USEPA). 2002. *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review*. July.

Regional Water Quality Control Board, Lahontan Region (Water Board), 2011. *Investigative Order R6V-2011-0105, Request for Information on Laboratory Quality Control Data for 2007 Groundwater Background Study Report, Pacific Gas and Electric Company (PG&E), Hinkley Compressor Station, San Bernardino County*. December.

Attachments

Attachment A	California ELAP Certificates for Truesdail Laboratories, Inc. and EMAX Laboratories
Attachment B	Response to Comments on Laboratory Chemistry and Quality Control Data
Compact Disc (CD)	Hexavalent Chromium Analytical Data, Truesdail Laboratories, Inc. and EMAX Laboratories, Hinkley Groundwater Background Study (CH2M HILL, 2007)

Attachment A
California ELAP Certificates – Truesdail
Laboratories, Inc. and EMAX Laboratories



STATE OF CALIFORNIA
DEPARTMENT OF HEALTH SERVICES
ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM

ENVIRONMENTAL LABORATORY CERTIFICATION

Is hereby granted to

TRUESDAIL LABORATORIES, INC.

14201 FRANKLIN AVENUE

TUSTIN, CA 92780

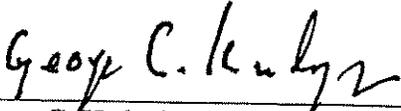
Scope of certification is limited to the
"Accredited Fields of Testing"
which accompanies this Certificate.

Continued certification status depends on successful completion of site visit,
proficiency testing studies, and payment of applicable fees.

This Certificate is granted in accordance with provisions of
Section 100825, et seq. of the Health and Safety Code.

Certificate No: 1237
Expiration Date: 07/31/2006
Effective Date: 07/01/2004

Berkeley, California
subject to forfeiture or revocation.



George C. Kulasingam, Ph.D.
Program Chief
Environmental Laboratory Accreditation Program



ARNOLD SCHWARZENEGGER
Governor

July 1, 2004

Certificate No.: 1237

NORMAN E. HESTER, Ph.D
TRUESDAIL LABORATORIES, INC.
14201 FRANKLIN AVENUE
TUSTIN, CA 92780

Dear NORMAN E. HESTER, Ph.D:

This is to advise you that the laboratory named above continues to be certified as an environmental testing laboratory pursuant to the provisions of the California Environmental Laboratory Improvement Act (Health and Safety Code (HSC), Division 101, Part 1, Chapter 4, Section 100825, et seq.). Certification for all currently certified Fields of Testing that the laboratory has applied for renewal shall remain in effect until **07/31/2006** unless revoked.

Please note that the renewal application for certification is subject to an on-site visit, and continued use of the certificate is contingent upon:

- * **successful completion of the site visit;**
- * **acceptable performance in the required performance evaluation (PE) studies;**
- * **timely payment of all fees, including an annual fee due before July 31, 2005;**
- * **compliance with Environmental Laboratory Accreditation Program (ELAP) statutes (HSC, Section 100825, et seq.) and Regulations (California Code of Regulations (CCR), Title 22, Division 4, Chapter 19).**

An updated "Approved Fields of Testing" will be issued to the laboratory upon completion of the renewal process. The application for the next renewal must be received 90 days before the expiration of this certificate to remain in force according to the CCR, Section 64801 through 64827.

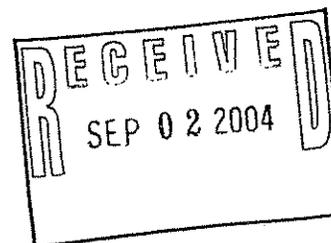
Please note that the laboratory is required to notify ELAP of any major changes in the laboratory such as the transfer of ownership, change of laboratory director, change in location, or structural alterations which may affect adversely the quality of analyses (HSC, Section 100845(b)(d)). Please include the above certificate number in all your correspondence to ELAP.

If you have any questions, please contact ELAP at (510) 540-2800.

Sincerely,

A handwritten signature in black ink that reads "George C. Kulasingam".

George C. Kulasingam, Ph.D.
Program Chief
Environmental Laboratory Accreditation Program



CALIFORNIA DEPARTMENT OF HEALTH SERVICES
ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM
List of Approved Fields of Testing and Analytes

TRUESDAIL LABORATORIES, INC.
14201 FRANKLIN AVENUE
TUSTIN, CA

PHONE No. (714) 730-6239
COUNTY ORANGE

Certificate No. 1237

01 Microbiology of Drinking Water and Wastewater

- 01.01A - Total and Fecal Coliform in Drinking Water by Multiple Tube Fermentation
- 01.02A Total and Fecal Coliform in Drinking Water by Membrane Filtration
- 01.03 Total Coliform and E. coli in Drinking Water by Chromogenic/Fluorogenic Substrate
- 01.04A Total and Fecal Coliform in Drinking Water by Clark's Presence/Absence
- 01.05 Heterotrophic Plate Count
- 01.06 Total Coliform in Wastewater by Multiple Tube Fermentation
- 01.07 Fecal Coliform in Wastewater by Multiple Tube Fermentation
- 01.08 Total Coliform in Wastewater by Membrane Filtration
- 01.09 Fecal Coliform in Wastewater by Membrane Filtration
- 01.10 Fecal Streptococci or Enterococci by Multiple Tube Fermentation
- 01.12 Total Coliform in Source Water by Multiple Tube Fermentation
- 01.13 Fecal Coliform in Source Water by Multiple Tube Fermentation
- 01.14 Total Coliform in Source Water by Membrane Filtration
- 01.16 Total Coliform in Source Water by Chromogenic/Fluorogenic Substrate

02 Inorganic Chemistry and Physical Properties of Drinking Water

- 02.01 Alkalinity
- 02.02 Calcium
- 02.03 Chloride
- 02.04 Corrosivity
- 02.05 Fluoride
- 02.06 Hardness
- 02.07 Magnesium
- 02.08 MBAS
- 02.09 Nitrate
- 02.10 Nitrite
- 02.11 Sodium
- 02.12 Sulfate
- 02.13A Total Dissolved Solids
- 02.13B Conductivity
- 02.16 Phosphate, ortho
- 02.17 Silica
- 02.18 Cyanide
- 02.19 Potassium
- 02.24 Perchlorate
- 02.31 UV 254

03 Analysis of Toxic Chemical Elements in Drinking Water

- 03.01 Arsenic
- 03.02 Barium
- 03.03 Cadmium
- 03.04 Chromium, total
- 03.05 Copper
- 03.06 Iron
- 03.07 Lead

As of 12/10/2001, this list supersedes all previous lists for this certificate number.

Page 1 of 5

- 03.08 Manganese
- 03.09 Mercury
- 03.10 Selenium
- 03.11 Silver
- 03.12 Zinc
- 03.13 Aluminum
- 03.15 Antimony
- 03.16 Beryllium
- 03.17 Nickel
- 03.18 Thallium
- 03.19 Chromium (VI)
- 04 Organic Chemistry of Drinking Water by GC/MS
 - 04.02 EPA Method 524.2
 - 04.03C EPA Method 525.2 Polynuclear Aromatic Hydrocarbons
 - 04.03D EPA Method 525.2 Adipates
 - 04.03E EPA Method 525.2 Phthalates
 - 04.08 EPA Method 525.2 PAH/Adipates/Phthalates only
- 05 Organic Chemistry of Drinking Water (excluding GC/MS)
 - 05.04 EPA Method 502.2
 - 05.06 EPA Method 504.1 EDB, DBCP
 - 05.07 EPA Method 505
 - 05.09 EPA Method 507 N,P Pesticides
 - 05.10A EPA Method 508
 - 05.10B EPA Method 508.1
 - 05.11 EPA Method 508A PCBs Quantitation
 - 05.13-1 EPA Method 515.1 Chlorophenoxy Herbicides
 - 05.20A-1 EPA Method 551 Chlorinated Hydrocarbons
 - 05.21A EPA Method 552.1 Dalapon
 - 05.26-1 EPA Method 552.2 Haloacetic Acids
 - 05.26-2 Standard Methods 6251B Haloacetic Acids
- 06 Radiochemistry
 - 06.01 Gross Alpha and Beta Radiation in Drinking Water
EPA Method 900.0
 - 06.02 Total Radium
EPA Method 903.0
 - 06.03 Radium 226
EPA Method 903.1
SM 7500 Ra-B
 - 06.04 Uranium
EPA Method 908.0
 - 06.05 Radon 222
EPA Method 913.0
 - 06.09 Tritium
EPA Method 906.0
SM 7500³H - B
 - 06.10 Gross Alpha by Co-precipitation
SM 7110C
- 09 Physical Properties Testing of Hazardous Waste
 - 09.01 Ignitability by Flashpoint Determination
 - 09.02 Corrosivity - pH Determination
 - 09.03 Corrosivity - towards steel
 - 09.04 Reactivity
- 10 Inorganic Chemistry and Toxic Chemical Elements of Hazardous Waste
 - 10.01 Antimony
 - 10.02 Arsenic
 - 10.03 Barium

- 10.04 Beryllium
 - 10.05 Cadmium
 - 10.06 Chromium, total
 - 10.07 Cobalt
 - 10.08 Copper
 - 10.09 Lead
 - 10.10 Mercury
 - 10.11 Molybdenum
 - 10.12 Nickel
 - 10.13 Selenium
 - 10.14 Silver
 - 10.15 Thallium
 - 10.16 Vanadium
 - 10.17 Zinc
 - 10.18 Chromium (VI)
 - 10.19 Cyanide
 - 10.20 Fluoride
 - 10.21 Sulfide
- 11 Extraction Tests of Hazardous Waste**
- 11.01 California Waste Extraction Test (WET)
 - 11.02 Extraction Procedure Toxicity
 - 11.03 Toxicity Characteristic Leaching Procedure (TCLP) All Classes
- 12 Organic Chemistry of Hazardous Waste by GC/MS**
- 12.01 EPA Method 8240B Volatile Compounds
 - 12.02 EPA Method 8250A Semi-volatile compounds
 - 12.03A EPA Method 8270C Extractable Organics
 - 12.06A EPA Method 8260B Volatile Compounds
- 13 Organic Chemistry of Hazardous Waste (excluding GC/MS)**
- 13.01 EPA Method 8010B Halogenated Volatiles
 - 13.02A EPA Method 8015B
 - 13.03 EPA Method 8020A Aromatic Volatiles
 - 13.05A EPA Method 8041
 - 13.06C EPA Method 8061A
 - 13.10A EPA Method 8120A Chlorinated Hydrocarbons
 - 13.10B EPA Method 8121 Chlorinated Hydrocarbons
 - 13.11B EPA Method 8141A
 - 13.12A EPA Method 8150B Chlorinated Herbicides
 - 13.12C EPA Method 8151A Chlorinated Herbicides
 - 13.13 EPA Method 8310 Polynuclear Aromatic Hydrocarbons
 - 13.14B EPA Method 8318
 - 13.15 Total Petroleum Hydrocarbons - Gasoline (LUFT)
 - 13.16 Total Petroleum Hydrocarbons - Diesel (LUFT)
 - 13.17 EPA Method 418.1 TRPH - Screening by IR
 - 13.18 EPA Method 8011 EDB and DBCP
 - 13.19A EPA Method 8021B Halogenated Volatiles only
 - 13.19B EPA Method 8021B Aromatic Volatiles only
 - 13.19C EPA Method 8021B BTEX and MTBE only
 - 13.24A EPA Method 8080A PCBs only
 - 13.24C EPA Method 8082 PCBs only

As of 12/10/2001, this list supersedes all previous lists for this certificate number.

- 13.25A EPA Method 8080A Organochlorine Pesticides only
- 13.25C EPA Method 8081A Organochlorine Pesticides only
- 13.26 EPA Method 8031 Acrylonitrile
- 13.27A EPA Method 8032A
- 13.29A EPA Method 8315A
- 14 **Bulk Asbestos Analysis**
 - 14.01 Bulk Asbestos, 1% or greater concentrations (Title 22, CCR, 66261.24(a)(2)(A))
- 16 **Wastewater Inorganic Chemistry, Nutrients and Demand**
 - 16.01 Acidity
 - 16.02 Alkalinity
 - 16.03 Ammonia
 - 16.04 Biochemical Oxygen Demand
 - 16.05 Boron
 - 16.06 Bromide
 - 16.07 Calcium
 - 16.09 Chemical Oxygen Demand
 - 16.10 Chloride
 - 16.11 Chlorine Residual, total
 - 16.12 Cyanide
 - 16.13 Cyanide amenable to Chlorination
 - 16.14 Fluoride
 - 16.15 Hardness
 - 16.16 Kjeldahl Nitrogen
 - 16.17 Magnesium
 - 16.18 Nitrate
 - 16.19 Nitrite
 - 16.20 Oil and Grease
 - 16.21 Organic Carbon
 - 16.22 Oxygen, Dissolved
 - 16.23 pH
 - 16.24 Phenols
 - 16.25 Phosphate, ortho
 - 16.26 Phosphorus, total
 - 16.27 Potassium
 - 16.28 Residue, Total
 - 16.29 Residue, Filterable (Total Dissolved Solids)
 - 16.30 Residue, Nonfilterable (Total Suspended Solids)
 - 16.31 Residue, Settleable (Settleable Solids)
 - 16.32 Residue, Volatile
 - 16.33 Silica
 - 16.34 Sodium
 - 16.35 Specific Conductance
 - 16.36 Sulfate
 - 16.37 Sulfide (includes total & soluble)
 - 16.38 Sulfite
 - 16.39 Surfactants (MBAS)
 - 16.40 Tannin and Lignin
 - 16.41 Turbidity
 - 16.44 Total Recoverable Petroleum Hydrocarbons by IR
 - 16.45 Total Organic Halides

As of 12/10/2001, this list supersedes all previous lists for this certificate number.

- 17 Toxic Chemical Elements in Wastewater
- 17.01 Aluminum
 - 17.02 Antimony
 - 17.03 Arsenic
 - 17.04 Barium
 - 17.05 Beryllium
 - 17.06 Cadmium
 - 17.07 Chromium (VI)
 - 17.08 Chromium, total
 - 17.09 Cobalt
 - 17.10 Copper
 - 17.11 Gold
 - 17.12 Iridium
 - 17.13 Iron
 - 17.14 Lead
 - 17.15 Manganese
 - 17.16 Mercury
 - 17.17 Molybdenum
 - 17.18 Nickel
 - 17.20 Palladium
 - 17.21 Platinum
 - 17.24 Selenium
 - 17.25 Silver
 - 17.27 Thallium
 - 17.28 Tin
 - 17.29 Titanium
 - 17.30 Vanadium
 - 17.31 Zinc
- 18 Organic Chemistry of Wastewater by GC/MS
- 18.01 EPA Method 624
 - 18.02 EPA Method 625
- 19 Organic Chemistry of Wastewater (excluding GC/MS)
- 19.01 EPA Method 601
 - 19.02 EPA Method 602
 - 19.03 EPA Method 603 Acrolein, Acrylonitrile
 - 19.04 EPA Method 604
 - 19.05 EPA Method 605 Benzidine
 - 19.06 EPA Method 606 Phthalate Esters
 - 19.07 EPA Method 607 Nitrosamines
 - 19.08 EPA Method 608
 - 19.09 EPA Method 609 Nitroaromatics and Cyclic Ketones
 - 19.10 EPA Method 610
 - 19.11 EPA Method 611 Haloethers
 - 19.14 EPA Method 612 Chlorinated Hydrocarbons

As of 12/10/2001, this list supersedes all previous lists for this certificate number.

CALIFORNIA DEPARTMENT OF HEALTH SERVICES
ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM
Accredited Fields of Testing

TRUESDAIL LABORATORIES, INC.
14201 FRANKLIN AVENUE
TUSTIN, CA 92780

Lab Phone (714) 730-6239

Certificate No: I-1237

Field of Testing: 04 - Organic Chemistry of Drinking Water by GC/MS

04.02 355 1,2,3-Trichloropropane

CDHS SRL PT/GCMS

As of 12/02/2002, this list supersedes all previous lists for this certificate number.
Customers: Please verify the current accreditation standing with the State.



STATE OF CALIFORNIA
DEPARTMENT OF HEALTH SERVICES
ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM

NELAP - RECOGNIZED

ACCREDITATION

Is hereby granted to

EMAX LABORATORIES, INC.

1835 WEST 205th STREET
TORRANCE, CA 90501

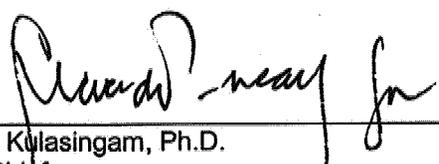
Scope of accreditation is limited to the
"NELAP Fields of Accreditation"
which accompanies this Certificate.

Continued accredited status depends on successful
ongoing participation in the program.

This Certificate is granted in accordance with provisions of
Section 100825, et seq. of the Health and Safety Code.

Certificate No.: **02116CA**
Expiration Date: **08/31/2006**
Effective Date: **08/31/2005**

Richmond, California
subject to forfeiture or revocation


George C. Kulasingam, Ph.D.
Program Chief
Environmental Laboratory Accreditation Program



CALIFORNIA DEPARTMENT OF HEALTH SERVICES
ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM - NELAP RECOGNIZED
 Fields of Accreditation



EMAX LABORATORIES, INC.

Lab Phone (310) 618-8889

1835 WEST 205th STREET
 TORRANCE, CA 90501

Certificate No: 02116CA Renew Date: 08/31/2006

102 - Inorganic Chemistry of Drinking Water

102.030	001	EPA 300.0	Bromide
102.030	002	EPA 300.0	Chlorate
102.030	003	EPA 300.0	Chloride
102.030	005	EPA 300.0	Fluoride
102.030	006	EPA 300.0	Nitrate
102.030	007	EPA 300.0	Nitrite
102.030	008	EPA 300.0	Phosphate, Ortho
102.030	010	EPA 300.0	Sulfate
102.040	004	EPA 300.1	Bromate
102.045	001	EPA 314.0	Perchlorate
102.100	001	SM2320B	Alkalinity
102.120	001	SM2340B	Hardness
102.121	001	SM2340C	Hardness
102.130	001	SM2510B	Conductivity
102.140	001	SM2540C	Total Dissolved Solids
102.145	001	EPA 160.1	Total Dissolved Solids
102.150	001	SM4110B	Chloride
102.150	002	SM4110B	Fluoride
102.150	003	SM4110B	Nitrate
102.150	004	SM4110B	Nitrite
102.150	005	SM4110B	Phosphate, Ortho
102.150	006	SM4110B	Sulfate
102.200	001	SM4500-F C	Fluoride
102.260	001	SM5310B	Total Organic Carbon
102.261	001	SM5310B	DOC
102.270	001	SM5540C	Surfactants
102.520	001	EPA 200.7	Calcium
102.520	002	EPA 200.7	Magnesium
102.520	003	EPA 200.7	Potassium
102.520	004	EPA 200.7	Silica
102.520	005	EPA 200.7	Sodium

103 - Toxic Chemical Elements of Drinking Water

103.130	001	EPA 200.7	Aluminum
103.130	002	EPA 200.7	Arsenic
103.130	003	EPA 200.7	Barium
103.130	004	EPA 200.7	Beryllium
103.130	005	EPA 200.7	Cadmium
103.130	007	EPA 200.7	Chromium
103.130	008	EPA 200.7	Copper

As of 09/13/2005, this list supersedes all previous lists for this certificate number.
 Customers: Please verify the current accreditation standing with the State.

103.130	009	EPA 200.7	Iron
103.130	011	EPA 200.7	Manganese
103.130	012	EPA 200.7	Nickel
103.130	015	EPA 200.7	Silver
103.130	017	EPA 200.7	Zinc
103.140	001	EPA 200.8	Aluminum
103.140	002	EPA 200.8	Antimony
103.140	003	EPA 200.8	Arsenic
103.140	004	EPA 200.8	Barium
103.140	005	EPA 200.8	Beryllium
103.140	006	EPA 200.8	Cadmium
103.140	007	EPA 200.8	Chromium
103.140	008	EPA 200.8	Copper
103.140	009	EPA 200.8	Lead
103.140	010	EPA 200.8	Manganese
103.140	011	EPA 200.8	Mercury
103.140	012	EPA 200.8	Nickel
103.140	013	EPA 200.8	Selenium
103.140	014	EPA 200.8	Silver
103.140	015	EPA 200.8	Thallium
103.140	016	EPA 200.8	Zinc
103.161	001	EPA 245.2	Mercury
103.310	001	EPA 218.6	Chromium (VI)

104 - Volatile Organic Chemistry of Drinking Water

104.030	001	EPA 504.1	1,2-Dibromoethane
104.030	002	EPA 504.1	1,2-Dibromo-3-chloropropane
104.040	001	EPA 524.2	Benzene
104.040	002	EPA 524.2	Bromobenzene
104.040	003	EPA 524.2	Bromochloromethane
104.040	006	EPA 524.2	Bromomethane
104.040	007	EPA 524.2	n-Butylbenzene
104.040	008	EPA 524.2	sec-Butylbenzene
104.040	009	EPA 524.2	tert-Butylbenzene
104.040	010	EPA 524.2	Carbon Tetrachloride
104.040	011	EPA 524.2	Chlorobenzene
104.040	012	EPA 524.2	Chloroethane
104.040	014	EPA 524.2	Chloromethane
104.040	015	EPA 524.2	2-Chlorotoluene
104.040	016	EPA 524.2	4-Chlorotoluene
104.040	018	EPA 524.2	Dibromomethane
104.040	019	EPA 524.2	1,3-Dichlorobenzene
104.040	020	EPA 524.2	1,2-Dichlorobenzene
104.040	021	EPA 524.2	1,4-Dichlorobenzene
104.040	022	EPA 524.2	Dichlorodifluoromethane
104.040	023	EPA 524.2	1,1-Dichloroethane
104.040	024	EPA 524.2	1,2-Dichloroethane
104.040	025	EPA 524.2	1,1-Dichloroethene
104.040	026	EPA 524.2	cis-1,2-Dichloroethene

104.040	027	EPA 524.2	trans-1,2-Dichloroethene
104.040	028	EPA 524.2	Dichloromethane
104.040	029	EPA 524.2	1,2-Dichloropropane
104.040	030	EPA 524.2	1,3-Dichloropropane
104.040	031	EPA 524.2	2,2-Dichloropropane
104.040	032	EPA 524.2	1,1-Dichloropropene
104.040	033	EPA 524.2	cis-1,3-Dichloropropene
104.040	034	EPA 524.2	trans-1,3-Dichloropropene
104.040	035	EPA 524.2	Ethylbenzene
104.040	036	EPA 524.2	Hexachlorobutadiene
104.040	037	EPA 524.2	Isopropylbenzene
104.040	038	EPA 524.2	4-Isopropyltoluene
104.040	039	EPA 524.2	Naphthalene
104.040	040	EPA 524.2	Nitrobenzene
104.040	041	EPA 524.2	N-propylbenzene
104.040	042	EPA 524.2	Styrene
104.040	043	EPA 524.2	1,1,1,2-Tetrachloroethane
104.040	044	EPA 524.2	1,1,2,2-Tetrachloroethane
104.040	045	EPA 524.2	Tetrachloroethene
104.040	046	EPA 524.2	Toluene
104.040	047	EPA 524.2	1,2,3-Trichlorobenzene
104.040	048	EPA 524.2	1,2,4-Trichlorobenzene
104.040	049	EPA 524.2	1,1,1-Trichloroethane
104.040	050	EPA 524.2	1,1,2-Trichloroethane
104.040	051	EPA 524.2	Trichloroethene
104.040	052	EPA 524.2	Trichlorofluoromethane
104.040	053	EPA 524.2	1,2,3-Trichloropropane
104.040	054	EPA 524.2	1,2,4-Trimethylbenzene
104.040	055	EPA 524.2	1,3,5-Trimethylbenzene
104.040	056	EPA 524.2	Vinyl Chloride
104.040	057	EPA 524.2	Xylenes, Total
104.045	001	EPA 524.2	Bromodichloromethane
104.045	002	EPA 524.2	Bromoform
104.045	003	EPA 524.2	Chloroform
104.045	004	EPA 524.2	Dibromochloromethane
104.045	005	EPA 524.2	Trihalomethanes
104.050	002	EPA 524.2	Methyl tert-butyl Ether (MTBE)
104.050	004	EPA 524.2	tert-Amyl Methyl Ether (TAME)
104.050	005	EPA 524.2	Ethyl tert-butyl Ether (ETBE)
104.050	006	EPA 524.2	Trichlorotrifluoroethane

108 - Inorganic Chemistry of Wastewater

108.016	001	EPA 110.2	Color
108.020	001	EPA 120.1	Conductivity
108.030	001	EPA 130.1	Hardness
108.040	001	EPA 130.2	Hardness
108.050	001	EPA 150.1	pH
108.060	001	EPA 160.1	Residue, Filterable
108.070	001	EPA 160.2	Residue, Non-filterable

108.080	001	EPA 160.3	Residue, Total
108.090	001	EPA 160.4	Residue, Volatile
108.100	001	EPA 160.5	Residue, Settleable
108.110	001	EPA 180.1	Turbidity
108.112	001	EPA 200.7	Boron
108.112	002	EPA 200.7	Calcium
108.112	004	EPA 200.7	Magnesium
108.112	005	EPA 200.7	Potassium
108.112	006	EPA 200.7	Silica
108.112	007	EPA 200.7	Sodium
108.120	001	EPA 300.0	Bromide
108.120	002	EPA 300.0	Chloride
108.120	003	EPA 300.0	Fluoride
108.120	004	EPA 300.0	Nitrate
108.120	005	EPA 300.0	Nitrite
108.120	006	EPA 300.0	Nitrate-nitrite, Total
108.120	007	EPA 300.0	Phosphate, Ortho
108.120	008	EPA 300.0	Sulfate
108.130	001	EPA 305.1	Acidity
108.140	001	EPA 310.1	Alkalinity
108.172	001	EPA 330.3	Chlorine Residual, Total
108.180	001	EPA 335.1	Cyanide, amenable
108.181	001	EPA 335.2	Cyanide, Total
108.191	001	EPA 340.2	Fluoride
108.201	001	EPA 350.2	Ammonia
108.212	001	EPA 351.3	Kjeldahl Nitrogen
108.234	001	EPA 353.3	Nitrate-nitrite, Total
108.235	001	EPA 353.3	Nitrate calc.
108.262	001	EPA 365.2	Phosphate, Ortho
108.263	001	EPA 365.2	Phosphorus, Total
108.270	001	EPA 370.1	Dissolved Silica
108.290	001	EPA 376.1	Sulfide
108.291	001	EPA 376.2	Sulfide
108.300	001	EPA 377.1	Sulfite
108.310	001	EPA 405.1	Biochemical Oxygen Demand
108.323	001	EPA 410.4	Chemical Oxygen Demand
108.330	001	EPA 413.1	Oil and Grease
108.340	001	EPA 415.1	Total Organic Carbon
108.350	001	EPA 418.1	Total Recoverable Petroleum Hydrocarbons
108.360	001	EPA 420.1	Phenols, Total
108.370	001	EPA 425.1	Surfactants
108.380	001	EPA 1664	Oil and Grease
108.390	001	SM2130B	Turbidity
108.400	001	SM2310B	Acidity
108.410	001	SM2320B	Alkalinity
108.420	001	SM2340B	Hardness (calc.)
108.421	001	SM2340C	Hardness
108.430	001	SM2510B	Conductivity

108.440	001	SM2540B	Residue, Total
108.441	001	SM2540C	Residue, Filterable
108.442	001	SM2540D	Residue, Non-filterable
108.443	001	SM2540F	Residue, Settleable
108.480	001	SM4500-F C	Fluoride
108.490	001	SM4500-H+ B	pH
108.590	001	SM5210B	Biochemical Oxygen Demand
108.602	001	SM5220D	Chemical Oxygen Demand
108.610	001	SM5310B	Total Organic Carbon
108.630	001	SM5520B	Oil and Grease

109 - Toxic Chemical Elements of Wastewater

109.010	001	EPA 200.7	Aluminum
109.010	002	EPA 200.7	Antimony
109.010	003	EPA 200.7	Arsenic
109.010	004	EPA 200.7	Barium
109.010	005	EPA 200.7	Beryllium
109.010	007	EPA 200.7	Cadmium
109.010	009	EPA 200.7	Chromium
109.010	010	EPA 200.7	Cobalt
109.010	011	EPA 200.7	Copper
109.010	012	EPA 200.7	Iron
109.010	013	EPA 200.7	Lead
109.010	015	EPA 200.7	Manganese
109.010	016	EPA 200.7	Molybdenum
109.010	017	EPA 200.7	Nickel
109.010	019	EPA 200.7	Selenium
109.010	021	EPA 200.7	Silver
109.010	023	EPA 200.7	Thallium
109.010	024	EPA 200.7	Tin
109.010	025	EPA 200.7	Titanium
109.010	026	EPA 200.7	Vanadium
109.010	027	EPA 200.7	Zinc
109.020	001	EPA 200.8	Aluminum
109.020	002	EPA 200.8	Antimony
109.020	003	EPA 200.8	Arsenic
109.020	004	EPA 200.8	Barium
109.020	005	EPA 200.8	Beryllium
109.020	006	EPA 200.8	Cadmium
109.020	007	EPA 200.8	Chromium
109.020	008	EPA 200.8	Cobalt
109.020	010	EPA 200.8	Lead
109.020	011	EPA 200.8	Manganese
109.020	012	EPA 200.8	Molybdenum
109.020	013	EPA 200.8	Nickel
109.020	014	EPA 200.8	Selenium
109.020	015	EPA 200.8	Silver
109.020	016	EPA 200.8	Thallium
109.020	017	EPA 200.8	Vanadium

109.020	018	EPA 200.8	Zinc
109.104	001	EPA 218.6	Chromium (VI)
110 - Volatile Organic Chemistry of Wastewater			
110.040	001	EPA 624	Benzene
110.040	002	EPA 624	Bromodichloromethane
110.040	003	EPA 624	Bromoform
110.040	004	EPA 624	Bromomethane
110.040	005	EPA 624	Carbon Tetrachloride
110.040	006	EPA 624	Chlorobenzene
110.040	007	EPA 624	Chloroethane
110.040	008	EPA 624	2-Chloroethyl Vinyl Ether
110.040	009	EPA 624	Chloroform
110.040	010	EPA 624	Chloromethane
110.040	011	EPA 624	Dibromochloromethane
110.040	012	EPA 624	1,2-Dichlorobenzene
110.040	013	EPA 624	1,3-Dichlorobenzene
110.040	014	EPA 624	1,4-Dichlorobenzene
110.040	015	EPA 624	1,1-Dichloroethane
110.040	016	EPA 624	1,2-Dichloroethane
110.040	017	EPA 624	1,1-Dichloroethene
110.040	018	EPA 624	trans-1,2-Dichloroethene
110.040	019	EPA 624	1,2-Dichloropropane
110.040	020	EPA 624	cis-1,3-Dichloropropene
110.040	021	EPA 624	trans-1,3-Dichloropropene
110.040	022	EPA 624	Ethylbenzene
110.040	023	EPA 624	Methylene Chloride
110.040	024	EPA 624	1,1,2,2-Tetrachloroethane
110.040	025	EPA 624	Tetrachloroethene
110.040	026	EPA 624	Toluene
110.040	027	EPA 624	1,1,1-Trichloroethane
110.040	028	EPA 624	1,1,2-Trichloroethane
110.040	029	EPA 624	Trichloroethene
110.040	030	EPA 624	Trichlorofluoromethane
110.040	031	EPA 624	Vinyl Chloride
110.040	042	EPA 624	Oxygenates
111 - Semi-volatile Organic Chemistry of Wastewater			
111.100	001	EPA 625	Acenaphthene
111.100	002	EPA 625	Acenaphthylene
111.100	003	EPA 625	Anthracene
111.100	004	EPA 625	Benzidine
111.100	005	EPA 625	Benz(a)anthracene
111.100	006	EPA 625	Benzo(b)fluoranthene
111.100	007	EPA 625	Benzo(k)fluoranthene
111.100	008	EPA 625	Benzo(g,h,i)perylene
111.100	009	EPA 625	Benzo(a)pyrene
111.100	010	EPA 625	Benzyl Butyl Phthalate
111.100	011	EPA 625	Bis(2-chloroethoxy)methane
111.100	012	EPA 625	Bis(2-chloroethyl) Ether

As of 09/13/2005, this list supersedes all previous lists for this certificate number.
Customers: Please verify the current accreditation standing with the State.

111.100 013	EPA 625	Bis(2-chloroisopropyl) Ether
111.100 014	EPA 625	Di(2-ethylhexyl) Phthalate
111.100 015	EPA 625	4-Bromophenyl Phenyl Ether
111.100 016	EPA 625	4-Chloro-3-methylphenol
111.100 017	EPA 625	2-Chloronaphthalene
111.100 018	EPA 625	2-Chlorophenol
111.100 019	EPA 625	4-Chlorophenyl Phenyl Ether
111.100 020	EPA 625	Chrysene
111.100 021	EPA 625	Dibenz(a,h)anthracene
111.100 022	EPA 625	1,2-Dichlorobenzene
111.100 023	EPA 625	1,3-Dichlorobenzene
111.100 024	EPA 625	1,4-Dichlorobenzene
111.100 025	EPA 625	3,3'-Dichlorobenzidine
111.100 026	EPA 625	2,4-Dichlorophenol
111.100 027	EPA 625	Diethyl Phthalate
111.100 028	EPA 625	2,4-Dimethylphenol
111.100 029	EPA 625	Dimethyl Phthalate
111.100 030	EPA 625	Di-n-butyl phthalate
111.100 031	EPA 625	Di-n-octyl phthalate
111.100 032	EPA 625	2,4-Dinitrophenol
111.100 033	EPA 625	2,4-Dinitrotoluene
111.100 034	EPA 625	2,6-Dinitrotoluene
111.100 035	EPA 625	Fluoranthene
111.100 036	EPA 625	Fluorene
111.100 037	EPA 625	Hexachlorobenzene
111.100 038	EPA 625	Hexachlorobutadiene
111.100 039	EPA 625	Hexachlorocyclopentadiene
111.100 040	EPA 625	Hexachloroethane
111.100 041	EPA 625	Indeno(1,2,3-c,d)pyrene
111.100 042	EPA 625	Isophorone
111.100 043	EPA 625	2-Methyl-4,6-dinitrophenol
111.100 044	EPA 625	Naphthalene
111.100 045	EPA 625	Nitrobenzene
111.100 046	EPA 625	2-Nitrophenol
111.100 047	EPA 625	4-Nitrophenol
111.100 048	EPA 625	N-nitrosodimethylamine
111.100 049	EPA 625	N-nitrosodi-n-propylamine
111.100 050	EPA 625	N-nitrosodiphenylamine
111.100 051	EPA 625	Pentachlorophenol
111.100 052	EPA 625	Phenanthrene
111.100 053	EPA 625	Phenol
111.100 054	EPA 625	Pyrene
111.100 055	EPA 625	1,2,4-Trichlorobenzene
111.100 056	EPA 625	2,4,6-Trichlorophenol
111.170 001	EPA 608	Aldrin
111.170 002	EPA 608	a-BHC
111.170 003	EPA 608	b-BHC
111.170 004	EPA 608	d-BHC

111.170	005	EPA 608	g-BHC (Lindane)
111.170	006	EPA 608	Chlordane
111.170	007	EPA 608	4,4'-DDD
111.170	008	EPA 608	4,4'-DDE
111.170	009	EPA 608	4,4'-DDT
111.170	010	EPA 608	Dieldrin
111.170	011	EPA 608	Endosulfan I
111.170	012	EPA 608	Endosulfan II
111.170	013	EPA 608	Endosulfan Sulfate
111.170	014	EPA 608	Endrin
111.170	015	EPA 608	Endrin Aldehyde
111.170	016	EPA 608	Heptachlor
111.170	017	EPA 608	Heptachlor Epoxide
111.170	018	EPA 608	Toxaphene
111.170	019	EPA 608	PCB-1016
111.170	020	EPA 608	PCB-1221
111.170	021	EPA 608	PCB-1232
111.170	022	EPA 608	PCB-1242
111.170	023	EPA 608	PCB-1248
111.170	024	EPA 608	PCB-1254
111.170	025	EPA 608	PCB-1260
111.170	031	EPA 608	PCBs

114 - Inorganic Chemistry of Hazardous Waste

114.010	001	EPA 6010B	Antimony
114.010	002	EPA 6010B	Arsenic
114.010	003	EPA 6010B	Barium
114.010	004	EPA 6010B	Beryllium
114.010	005	EPA 6010B	Cadmium
114.010	006	EPA 6010B	Chromium
114.010	007	EPA 6010B	Cobalt
114.010	008	EPA 6010B	Copper
114.010	009	EPA 6010B	Lead
114.010	010	EPA 6010B	Molybdenum
114.010	011	EPA 6010B	Nickel
114.010	012	EPA 6010B	Selenium
114.010	013	EPA 6010B	Silver
114.010	014	EPA 6010B	Thallium
114.010	015	EPA 6010B	Vanadium
114.010	016	EPA 6010B	Zinc
114.020	001	EPA 6020	Antimony
114.020	002	EPA 6020	Arsenic
114.020	003	EPA 6020	Barium
114.020	004	EPA 6020	Beryllium
114.020	005	EPA 6020	Cadmium
114.020	006	EPA 6020	Chromium
114.020	007	EPA 6020	Cobalt
114.020	008	EPA 6020	Copper
114.020	009	EPA 6020	Lead

114.020	010	EPA 6020	Molybdenum
114.020	011	EPA 6020	Nickel
114.020	012	EPA 6020	Selenium
114.020	013	EPA 6020	Silver
114.020	014	EPA 6020	Thallium
114.020	015	EPA 6020	Vanadium
114.020	016	EPA 6020	Zinc
114.031	001	EPA 7041	Antimony
114.040	001	EPA 7060A	Arsenic
114.081	001	EPA 7131A	Cadmium
114.091	001	EPA 7191	Chromium
114.103	001	EPA 7196A	Chromium (VI)
114.106	001	EPA 7199	Chromium (VI)
114.121	001	EPA 7211	Copper
114.131	001	EPA 7421	Lead
114.140	001	EPA 7470A	Mercury
114.141	001	EPA 7471A	Mercury
114.170	001	EPA 7740	Selenium
114.181	001	EPA 7761	Silver
114.191	001	EPA 7841	Thallium
114.222	001	EPA 9014	Cyanide
114.230	001	EPA 9034	Sulfides, Total
114.240	001	EPA 9040	pH
114.241	001	EPA 9045	pH
114.250	001	EPA 9056	Fluoride
115 - Extraction Test of Hazardous Waste			
115.020	001	EPA 1311	Toxicity Characteristic Leaching Procedure (TCLP)
115.030	001	CCR Chapter 11, Article 5, Appendix II	Waste Extraction Test (WET)
115.040	001	EPA 1312	Synthetic Precipitation Leaching Procedure (SPLP)
116 - Volatile Organic Chemistry of Hazardous Waste			
116.010	001	EPA 8011	1,2-Dibromoethane
116.010	002	EPA 8011	Dibromochloropropane
116.020	011	EPA 8015B	Ethylene Glycol
116.030	001	EPA 8015B	Gasoline-range Organics
116.040	002	EPA 8021B	Benzene
116.040	039	EPA 8021B	Ethylbenzene
116.040	041	EPA 8021B	Methyl tert-butyl Ether (MTBE)
116.040	047	EPA 8021B	Toluene
116.040	056	EPA 8021B	Xylenes, Total
116.080	001	EPA 8260B	Acetone
116.080	002	EPA 8260B	Acetonitrile
116.080	003	EPA 8260B	Acrolein
116.080	004	EPA 8260B	Acrylonitrile
116.080	005	EPA 8260B	Allyl Alcohol
116.080	006	EPA 8260B	Allyl Chloride
116.080	007	EPA 8260B	Benzene
116.080	009	EPA 8260B	Bromoacetone
116.080	010	EPA 8260B	Bromochloromethane

As of 09/13/2005, this list supersedes all previous lists for this certificate number.
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116.080	011	EPA 8260B	Bromodichloromethane
116.080	012	EPA 8260B	Bromoform
116.080	013	EPA 8260B	Bromomethane
116.080	014	EPA 8260B	n-Butyl Alcohol
116.080	015	EPA 8260B	Carbon Disulfide
116.080	016	EPA 8260B	Carbon Tetrachloride
116.080	018	EPA 8260B	Chlorobenzene
116.080	019	EPA 8260B	Chloroethane
116.080	020	EPA 8260B	2-Chloroethyl Vinyl Ether
116.080	021	EPA 8260B	Chloroform
116.080	022	EPA 8260B	Chloromethane
116.080	023	EPA 8260B	Chloroprene
116.080	024	EPA 8260B	3-Chloropropionitrile
116.080	025	EPA 8260B	Crotonaldehyde
116.080	026	EPA 8260B	Dibromochloromethane
116.080	027	EPA 8260B	Dibromochloropropane
116.080	028	EPA 8260B	1,2-Dibromoethane
116.080	030	EPA 8260B	Dibromomethane
116.080	031	EPA 8260B	1,2-Dichlorobenzene
116.080	032	EPA 8260B	1,3-Dichlorobenzene
116.080	033	EPA 8260B	1,4-Dichlorobenzene
116.080	034	EPA 8260B	cis-1,4-Dichloro-2-butene
116.080	035	EPA 8260B	trans-1,4-Dichloro-2-butene
116.080	036	EPA 8260B	Dichlorodifluoromethane
116.080	037	EPA 8260B	1,1-Dichloroethane
116.080	038	EPA 8260B	1,2-Dichloroethane
116.080	039	EPA 8260B	1,1-Dichloroethene
116.080	040	EPA 8260B	trans-1,2-Dichloroethene
116.080	041	EPA 8260B	cis-1,2-Dichloroethene
116.080	042	EPA 8260B	1,2-Dichloropropane
116.080	043	EPA 8260B	1,3-Dichloropropane
116.080	044	EPA 8260B	2,2-Dichloropropane
116.080	045	EPA 8260B	1,1-Dichloropropene
116.080	046	EPA 8260B	cis-1,3-Dichloropropene
116.080	047	EPA 8260B	trans-1,3-Dichloropropene
116.080	048	EPA 8260B	1,3-Dichloro-2-propanol
116.080	049	EPA 8260B	1,2,3,4-Diepoxybutane
116.080	050	EPA 8260B	1,4-Dioxane
116.080	053	EPA 8260B	Ethylbenzene
116.080	055	EPA 8260B	Ethyl Methacrylate
116.080	056	EPA 8260B	Hexachlorobutadiene
116.080	058	EPA 8260B	2-Hexanone (MBK)
116.080	059	EPA 8260B	Iodomethane
116.080	060	EPA 8260B	Isobutyl Alcohol
116.080	061	EPA 8260B	Malononitrile
116.080	062	EPA 8260B	Methacrylonitrile
116.080	064	EPA 8260B	Methyl tert-butyl Ether (MTBE)
116.080	065	EPA 8260B	Methylene Chloride

116.080	066	EPA 8260B	Methyl Ethyl Ketone
116.080	067	EPA 8260B	Methyl Methacrylate
116.080	068	EPA 8260B	4-Methyl-2-pentanone (MIBK)
116.080	069	EPA 8260B	Naphthalene
116.080	070	EPA 8260B	Nitrobenzene
116.080	072	EPA 8260B	N-nitrosodi-n-butylamine
116.080	074	EPA 8260B	Pentachloroethane
116.080	075	EPA 8260B	Pentafluorobenzene
116.080	076	EPA 8260B	2-Picoline
116.080	078	EPA 8260B	Propionitrile
116.080	079	EPA 8260B	N-propylamine
116.080	080	EPA 8260B	Pyridine
116.080	081	EPA 8260B	1,1,1,2-Tetrachloroethane
116.080	082	EPA 8260B	1,1,2,2-Tetrachloroethane
116.080	083	EPA 8260B	Tetrachloroethene
116.080	084	EPA 8260B	Toluene
116.080	086	EPA 8260B	1,2,3-Trichlorobenzene
116.080	087	EPA 8260B	1,2,4-Trichlorobenzene
116.080	088	EPA 8260B	1,1,1-Trichloroethane
116.080	089	EPA 8260B	1,1,2-Trichloroethane
116.080	090	EPA 8260B	Trichloroethene
116.080	091	EPA 8260B	Trichlorofluoromethane
116.080	092	EPA 8260B	1,2,3-Trichloropropane
116.080	093	EPA 8260B	Vinyl Acetate
116.080	094	EPA 8260B	Vinyl Chloride
116.080	095	EPA 8260B	Xylenes, Total
116.080	096	EPA 8260B	tert-Amyl Methyl Ether (TAME)
116.080	097	EPA 8260B	tert-Butyl Alcohol (TBA)
116.080	098	EPA 8260B	Ethyl tert-butyl Ether (ETBE)
116.080	099	EPA 8260B	Bromobenzene
116.080	100	EPA 8260B	n-Butylbenzene
116.080	101	EPA 8260B	sec-Butylbenzene
116.080	102	EPA 8260B	tert-Butylbenzene
116.080	103	EPA 8260B	2-Chlorotoluene
116.080	104	EPA 8260B	4-Chlorotoluene
116.080	105	EPA 8260B	Isopropylbenzene
116.080	106	EPA 8260B	N-propylbenzene
116.080	107	EPA 8260B	Styrene
116.080	108	EPA 8260B	1,2,4-Trimethylbenzene
116.080	109	EPA 8260B	1,3,5-Trimethylbenzene
116.100	001	LUFT GC/MS	Total Petroleum Hydrocarbons - Gasoline
116.100	002	LUFT GC/MS	Benzene
116.100	003	LUFT GC/MS	Toluene
116.100	004	LUFT GC/MS	Xylenes
116.100	005	LUFT GC/MS	Methyl tert-butyl Ether (MTBE)
116.110	001	LUFT	Total Petroleum Hydrocarbons - Gasoline

117 - Semi-volatile Organic Chemistry of Hazardous Waste

117.010	001	EPA 8015B	Diesel-range Total Petroleum Hydrocarbons
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As of 09/13/2005, this list supersedes all previous lists for this certificate number.
Customers: Please verify the current accreditation standing with the State.

117.015	001	LUFT GC/MS	Diesel-range Total Petroleum Hydrocarbons
117.016	001	LUFT	Diesel-range Total Petroleum Hydrocarbons
117.017	001	EPA 418.1	TRPH Screening
117.110	001	EPA 8270C	Acenaphthene
117.110	002	EPA 8270C	Acenaphthylene
117.110	003	EPA 8270C	Acetophenone
117.110	004	EPA 8270C	2-Acetylaminofluorene
117.110	005	EPA 8270C	1-Acetyl-2-thiourea
117.110	006	EPA 8270C	4-Aminobiphenyl
117.110	007	EPA 8270C	Aniline
117.110	008	EPA 8270C	Anthracene
117.110	010	EPA 8270C	Benzidine
117.110	011	EPA 8270C	Benz(a)anthracene
117.110	012	EPA 8270C	Benzo(b)fluoranthene
117.110	013	EPA 8270C	Benzo(k)fluoranthene
117.110	014	EPA 8270C	Benzo(g,h,i)perylene
117.110	015	EPA 8270C	Benzo(a)pyrene
117.110	016	EPA 8270C	Benzoic Acid
117.110	018	EPA 8270C	Benzyl Alcohol
117.110	019	EPA 8270C	Benzyl Butyl Phthalate
117.110	020	EPA 8270C	Bis(2-chloroethoxy)methane
117.110	021	EPA 8270C	Bis(2-chloroethyl) Ether
117.110	022	EPA 8270C	Bis(2-chloroisopropyl) Ether
117.110	023	EPA 8270C	Di(2-ethylhexyl) Phthalate
117.110	024	EPA 8270C	4-Bromophenyl Phenyl Ether
117.110	025	EPA 8270C	Carbazole
117.110	026	EPA 8270C	4-Chloroaniline
117.110	027	EPA 8270C	4-Chloro-3-methylphenol
117.110	029	EPA 8270C	2-Chloronaphthalene
117.110	030	EPA 8270C	2-Chlorophenol
117.110	031	EPA 8270C	4-Chlorophenyl Phenyl Ether
117.110	032	EPA 8270C	Chrysene
117.110	033	EPA 8270C	2-Cyclohexyl-4,6-dinitrophenol
117.110	034	EPA 8270C	2,4-Diaminotoluene
117.110	036	EPA 8270C	Dibenz(a,h)anthracene
117.110	037	EPA 8270C	Dibenzofuran
117.110	038	EPA 8270C	Dibenzo(a,e)pyrene
117.110	039	EPA 8270C	1,2-Dichlorobenzene
117.110	040	EPA 8270C	1,3-Dichlorobenzene
117.110	041	EPA 8270C	1,4-Dichlorobenzene
117.110	042	EPA 8270C	3,3'-Dichlorobenzidine
117.110	043	EPA 8270C	2,4-Dichlorophenol
117.110	044	EPA 8270C	2,6-Dichlorophenol
117.110	045	EPA 8270C	Diethyl Phthalate
117.110	050	EPA 8270C	p-Dimethylaminoazobenzene
117.110	051	EPA 8270C	7,12-Dimethylbenz(a)anthracene
117.110	052	EPA 8270C	a,a-Dimethylphenethylamine
117.110	053	EPA 8270C	2,4-Dimethylphenol

117.110	054	EPA 8270C	Dimethyl Phthalate
117.110	055	EPA 8270C	Di-n-butyl phthalate
117.110	056	EPA 8270C	Di-n-octyl phthalate
117.110	060	EPA 8270C	2,4-Dinitrophenol
117.110	061	EPA 8270C	2,4-Dinitrotoluene
117.110	062	EPA 8270C	2,6-Dinitrotoluene
117.110	063	EPA 8270C	Diphenylamine
117.110	064	EPA 8270C	1,2-Diphenylhydrazine
117.110	066	EPA 8270C	Ethyl Methanesulfonate
117.110	067	EPA 8270C	Fluoranthene
117.110	068	EPA 8270C	Fluorene
117.110	069	EPA 8270C	Hexachlorobenzene
117.110	070	EPA 8270C	Hexachlorobutadiene
117.110	071	EPA 8270C	Hexachlorocyclopentadiene
117.110	072	EPA 8270C	Hexachloroethane
117.110	073	EPA 8270C	Hexachlorophene
117.110	074	EPA 8270C	Hexachloropropene
117.110	075	EPA 8270C	Indeno(1,2,3-c,d)pyrene
117.110	076	EPA 8270C	Isophorone
117.110	077	EPA 8270C	Isosafrole
117.110	078	EPA 8270C	Maleic Anhydride
117.110	079	EPA 8270C	3-Methylcholanthrene
117.110	080	EPA 8270C	2-Methyl-4,6-dinitrophenol
117.110	082	EPA 8270C	Methyl Methanesulfonate
117.110	083	EPA 8270C	2-Methylnaphthalene
117.110	084	EPA 8270C	2-Methylphenol
117.110	085	EPA 8270C	3-Methylphenol
117.110	086	EPA 8270C	4-Methylphenol
117.110	087	EPA 8270C	Naphthalene
117.110	088	EPA 8270C	1,4-Naphthoquinone
117.110	089	EPA 8270C	1-Naphthylamine
117.110	090	EPA 8270C	2-Naphthylamine
117.110	092	EPA 8270C	2-Nitroaniline
117.110	093	EPA 8270C	3-Nitroaniline
117.110	094	EPA 8270C	4-Nitroaniline
117.110	095	EPA 8270C	Nitrobenzene
117.110	096	EPA 8270C	2-Nitrophenol
117.110	097	EPA 8270C	4-Nitrophenol
117.110	098	EPA 8270C	N-nitrosodi-n-butylamine
117.110	099	EPA 8270C	N-nitrosodiethylamine
117.110	100	EPA 8270C	N-nitrosodimethylamine
117.110	101	EPA 8270C	N-nitrosodi-n-propylamine
117.110	102	EPA 8270C	N-nitrosodiphenylamine
117.110	103	EPA 8270C	N-nitrosomethylethylamine
117.110	104	EPA 8270C	N-nitrosomorpholine
117.110	105	EPA 8270C	N-nitrosopiperidine
117.110	106	EPA 8270C	N-nitrosopyrrolidine
117.110	107	EPA 8270C	5-Nitro-o-toluidine

117.110	108	EPA 8270C	Pentachlorobenzene
117.110	109	EPA 8270C	Pentachloronitrobenzene
117.110	110	EPA 8270C	Pentachlorophenol
117.110	111	EPA 8270C	Phenacetin
117.110	112	EPA 8270C	Phenanthrene
117.110	113	EPA 8270C	Phenol
117.110	116	EPA 8270C	2-Picoline
117.110	119	EPA 8270C	Pyrene
117.110	120	EPA 8270C	Pyridine
117.110	122	EPA 8270C	Safrole
117.110	124	EPA 8270C	1,2,4,5-Tetrachlorobenzene
117.110	125	EPA 8270C	2,3,4,6-Tetrachlorophenol
117.110	128	EPA 8270C	o-Toluidine
117.110	129	EPA 8270C	1,2,4-Trichlorobenzene
117.110	130	EPA 8270C	2,4,5-Trichlorophenol
117.110	131	EPA 8270C	2,4,6-Trichlorophenol
117.110	132	EPA 8270C	1,3,5-Trinitrobenzene
117.111	025	EPA 8270C	Dimethoate
117.111	026	EPA 8270C	Dinoseb
117.111	036	EPA 8270C	Famphur
117.111	039	EPA 8270C	Isodrin
117.111	040	EPA 8270C	Kepone
117.111	054	EPA 8270C	Parathion Ethyl
117.111	055	EPA 8270C	Parathion Methyl
117.111	056	EPA 8270C	Phorate
117.111	058	EPA 8270C	Sulfotepp
117.111	061	EPA 8270C	O,O,O-triethyl Phosphorothioate
117.140	001	EPA 8310	Acenaphthene
117.140	002	EPA 8310	Acenaphthylene
117.140	003	EPA 8310	Anthracene
117.140	004	EPA 8310	Benz(a)anthracene
117.140	005	EPA 8310	Benzo(a)pyrene
117.140	006	EPA 8310	Benzo(b)fluoranthene
117.140	007	EPA 8310	Benzo(k)fluoranthene
117.140	008	EPA 8310	Benzo(g,h,i)perylene
117.140	009	EPA 8310	Chrysene
117.140	010	EPA 8310	Dibenz(a,h)anthracene
117.140	011	EPA 8310	Fluoranthene
117.140	012	EPA 8310	Fluorene
117.140	013	EPA 8310	Indeno(1,2,3-c,d)pyrene
117.140	014	EPA 8310	Naphthalene
117.140	015	EPA 8310	Phenanthrene
117.140	016	EPA 8310	Pyrene
117.170	001	EPA 8330	4-Amino-2,6-dinitrotoluene
117.170	002	EPA 8330	2-Amino-4,6-dinitrotoluene
117.170	003	EPA 8330	1,3-Dinitrobenzene
117.170	004	EPA 8330	2,4-Dinitrotoluene
117.170	005	EPA 8330	2,6-Dinitrotoluene

117.170	006	EPA 8330	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
117.170	007	EPA 8330	Methyl-2,4,6-trinitrophenylnitramine
117.170	008	EPA 8330	Nitrobenzene
117.170	009	EPA 8330	2-Nitrotoluene
117.170	010	EPA 8330	3-Nitrotoluene
117.170	011	EPA 8330	4-Nitrotoluene
117.170	012	EPA 8330	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
117.170	013	EPA 8330	1,3,5-Trinitrobenzene
117.170	014	EPA 8330	2,4,6-Trinitrotoluene
117.190	001	EPA 8332	Nitroglycerine
117.210	001	EPA 8081A	Aldrin
117.210	002	EPA 8081A	a-BHC
117.210	003	EPA 8081A	b-BHC
117.210	004	EPA 8081A	d-BHC
117.210	005	EPA 8081A	g-BHC (Lindane)
117.210	007	EPA 8081A	a-Chlordane
117.210	008	EPA 8081A	g-Chlordane
117.210	009	EPA 8081A	Chlordane (tech.)
117.210	010	EPA 8081A	Chlorobenzilate
117.210	011	EPA 8081A	Chloroneb
117.210	012	EPA 8081A	Chlorothalonil
117.210	013	EPA 8081A	4,4'-DDD
117.210	014	EPA 8081A	4,4'-DDE
117.210	015	EPA 8081A	4,4'-DDT
117.210	016	EPA 8081A	Diallate
117.210	020	EPA 8081A	Dieldrin
117.210	021	EPA 8081A	Endosulfan I
117.210	022	EPA 8081A	Endosulfan II
117.210	023	EPA 8081A	Endosulfan Sulfate
117.210	024	EPA 8081A	Endrin
117.210	025	EPA 8081A	Endrin Aldehyde
117.210	026	EPA 8081A	Endrin Ketone
117.210	027	EPA 8081A	Heptachlor
117.210	028	EPA 8081A	Heptachlor Epoxide
117.210	029	EPA 8081A	Hexachlorobenzene
117.210	033	EPA 8081A	Methoxychlor
117.210	039	EPA 8081A	Toxaphene
117.220	001	EPA 8082	PCB-1016
117.220	002	EPA 8082	PCB-1221
117.220	003	EPA 8082	PCB-1232
117.220	004	EPA 8082	PCB-1242
117.220	005	EPA 8082	PCB-1248
117.220	006	EPA 8082	PCB-1254
117.220	007	EPA 8082	PCB-1260
117.220	008	EPA 8082	2-Chlorobiphenyl
117.220	009	EPA 8082	2,3-Dichlorobiphenyl
117.220	010	EPA 8082	2,2',5-Trichlorobiphenyl
117.220	011	EPA 8082	2,4',5-Trichlorobiphenyl

117.220	012	EPA 8082	2,2',3,5'-Tetrachlorobiphenyl
117.220	013	EPA 8082	2,2',5,5'-Tetrachlorobiphenyl
117.220	014	EPA 8082	2,3',4,4'-Tetrachlorobiphenyl
117.220	015	EPA 8082	2,2',3,4,5'-Pentachlorobiphenyl
117.220	016	EPA 8082	2,2',4,5,5'-Pentachlorobiphenyl
117.220	017	EPA 8082	2,3,3',4',6-Pentachlorobiphenyl
117.220	018	EPA 8082	2,2',3,4,4',5'-Hexachlorobiphenyl
117.220	019	EPA 8082	2,2',3,4,5,5'-Hexachlorobiphenyl
117.220	020	EPA 8082	2,2',3,5,5',6-Hexachlorobiphenyl
117.220	021	EPA 8082	2,2',4,4',5,5'-Hexachlorobiphenyl
117.220	022	EPA 8082	2,2',3,3',4,4',5-Heptachlorobiphenyl
117.220	023	EPA 8082	2,2',3,4,4',5,5'-Heptachlorobiphenyl
117.220	024	EPA 8082	2,2',3,4,4',5',6-Heptachlorobiphenyl
117.220	025	EPA 8082	2,2',3,4',5,5',6-Heptachlorobiphenyl
117.220	026	EPA 8082	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl
117.240	001	EPA 8141A	Atrazine
117.240	002	EPA 8141A	Azinphos Methyl
117.240	004	EPA 8141A	Chlorfenvinphos
117.240	005	EPA 8141A	Chlorpyrifos
117.240	006	EPA 8141A	Chlorpyrifos Methyl
117.240	007	EPA 8141A	Demeton-O
117.240	008	EPA 8141A	Demeton-S
117.240	009	EPA 8141A	Diazinon
117.240	010	EPA 8141A	Dimethoate
117.240	012	EPA 8141A	EPN
117.240	013	EPA 8141A	Ethion
117.240	014	EPA 8141A	Famphur
117.240	015	EPA 8141A	Malathion
117.240	016	EPA 8141A	Mevinphos
117.240	017	EPA 8141A	Naled
117.240	018	EPA 8141A	Parathion Ethyl
117.240	019	EPA 8141A	Parathion Methyl
117.240	020	EPA 8141A	Phorate
117.240	022	EPA 8141A	Ronnel
117.240	024	EPA 8141A	Sulfotepp
117.240	026	EPA 8141A	Thionazin
117.250	001	EPA 8151A	2,4-D
117.250	002	EPA 8151A	2,4-DB
117.250	003	EPA 8151A	2,4,5-T
117.250	004	EPA 8151A	2,4,5-TP
117.250	006	EPA 8151A	Dalapon
117.250	007	EPA 8151A	Dichlorprop
117.250	008	EPA 8151A	Dinoseb
117.250	009	EPA 8151A	MCPA
117.250	010	EPA 8151A	MCPP
117.250	011	EPA 8151A	4-Nitrophenol
117.250	012	EPA 8151A	Pentachlorophenol
117.250	013	EPA 8151A	Picloram

117.250	014	EPA 8151A	Dicamba
117.250	015	EPA 8151A	3,5-Dichlorobenzoic Acid
117.250	016	EPA 8151A	Acifluorfen
117.250	017	EPA 8151A	Bentazon
117.250	018	EPA 8151A	Chloramben
117.250	019	EPA 8151A	DCPA

120 - Physical Properties of Hazardous Waste

120.010	001	EPA 1010	Ignitability
120.040	001	Section 7.3 SW-846	Reactive Cyanide
120.050	001	Section 7.3 SW-846	Reactive Sulfide
120.070	001	EPA 9040B	Corrosivity - pH Determination
120.080	001	EPA 9045C	Corrosivity - pH Determination



STATE OF CALIFORNIA
DEPARTMENT OF HEALTH SERVICES
ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM

NELAP - RECOGNIZED

ACCREDITATION

Is hereby granted to

EMAX LABORATORIES, INC.

1835 WEST 205th STREET
TORRANCE, CA 90501

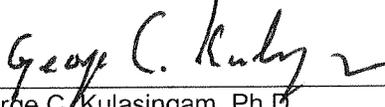
Scope of accreditation is limited to the
"NELAP Fields of Accreditation"
which accompanies this Certificate.

Continued accredited status depends on successful
ongoing participation in the program.

This Certificate is granted in accordance with provisions of
Section 100825, et seq. of the Health and Safety Code.

Certificate No.: **02116CA**
Expiration Date: **08/31/2007**
Effective Date: **08/31/2006**

Richmond, California
subject to forfeiture or revocation



George C. Kulasingam, Ph.D.
Program Chief
Environmental Laboratory Accreditation Program



CALIFORNIA DEPARTMENT OF HEALTH SERVICES
ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM - NELAP RECOGNIZED
 Fields of Accreditation



EMAX LABORATORIES, INC.

Lab Phone (310) 618-8889

1835 WEST 205th STREET
 TORRANCE, CA 90501

Certificate No: 02116CA Renew Date: 08/31/2007

102 - Inorganic Chemistry of Drinking Water

102.030	001	EPA 300.0	Bromide
102.030	002	EPA 300.0	Chlorate
102.030	003	EPA 300.0	Chloride
102.030	005	EPA 300.0	Fluoride
102.030	006	EPA 300.0	Nitrate
102.030	007	EPA 300.0	Nitrite
102.030	008	EPA 300.0	Phosphate, Ortho
102.030	010	EPA 300.0	Sulfate
102.040	004	EPA 300.1	Bromate
102.045	001	EPA 314.0	Perchlorate
102.100	001	SM2320B	Alkalinity
102.120	001	SM2340B	Hardness
102.121	001	SM2340C	Hardness
102.130	001	SM2510B	Conductivity
102.140	001	SM2540C	Total Dissolved Solids
102.145	001	EPA 160.1	Total Dissolved Solids
102.150	001	SM4110B	Chloride
102.150	002	SM4110B	Fluoride
102.150	003	SM4110B	Nitrate
102.150	004	SM4110B	Nitrite
102.150	005	SM4110B	Phosphate, Ortho
102.150	006	SM4110B	Sulfate
102.200	001	SM4500-F C	Fluoride
102.260	001	SM5310B	Total Organic Carbon
102.261	001	SM5310B	DOC
102.270	001	SM5540C	Surfactants
102.520	001	EPA 200.7	Calcium
102.520	002	EPA 200.7	Magnesium
102.520	003	EPA 200.7	Potassium
102.520	004	EPA 200.7	Silica
102.520	005	EPA 200.7	Sodium

103 - Toxic Chemical Elements of Drinking Water

103.130	001	EPA 200.7	Aluminum
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As of 09/20/2006, this list supersedes all previous lists for this certificate number.
 Customers: Please verify the current accreditation standing with the State.

103.130	003	EPA 200.7	Barium
103.130	004	EPA 200.7	Beryllium
103.130	005	EPA 200.7	Cadmium
103.130	007	EPA 200.7	Chromium
103.130	008	EPA 200.7	Copper
103.130	009	EPA 200.7	Iron
103.130	011	EPA 200.7	Manganese
103.130	012	EPA 200.7	Nickel
103.130	015	EPA 200.7	Silver
103.130	017	EPA 200.7	Zinc
103.140	001	EPA 200.8	Aluminum
103.140	002	EPA 200.8	Antimony
103.140	003	EPA 200.8	Arsenic
103.140	004	EPA 200.8	Barium
103.140	005	EPA 200.8	Beryllium
103.140	006	EPA 200.8	Cadmium
103.140	007	EPA 200.8	Chromium
103.140	008	EPA 200.8	Copper
103.140	009	EPA 200.8	Lead
103.140	010	EPA 200.8	Manganese
103.140	011	EPA 200.8	Mercury
103.140	012	EPA 200.8	Nickel
103.140	013	EPA 200.8	Selenium
103.140	014	EPA 200.8	Silver
103.140	015	EPA 200.8	Thallium
103.140	016	EPA 200.8	Zinc
103.161	001	EPA 245.2	Mercury

104 - Volatile Organic Chemistry of Drinking Water

104.030	001	EPA 504.1	1,2-Dibromoethane
104.030	002	EPA 504.1	1,2-Dibromo-3-chloropropane
104.040	000	EPA 524.2	Volatile Organic Compounds
104.040	001	EPA 524.2	Benzene
104.040	002	EPA 524.2	Bromobenzene
104.040	003	EPA 524.2	Bromochloromethane
104.040	006	EPA 524.2	Bromomethane
104.040	007	EPA 524.2	n-Butylbenzene
104.040	008	EPA 524.2	sec-Butylbenzene
104.040	009	EPA 524.2	tert-Butylbenzene
104.040	010	EPA 524.2	Carbon Tetrachloride
104.040	011	EPA 524.2	Chlorobenzene
104.040	012	EPA 524.2	Chloroethane

As of 09/20/2006, this list supersedes all previous lists for this certificate number.
Customers: Please verify the current accreditation standing with the State.

104.040	014	EPA 524.2	Chloromethane
104.040	015	EPA 524.2	2-Chlorotoluene
104.040	016	EPA 524.2	4-Chlorotoluene
104.040	018	EPA 524.2	Dibromomethane
104.040	019	EPA 524.2	1,3-Dichlorobenzene
104.040	020	EPA 524.2	1,2-Dichlorobenzene
104.040	021	EPA 524.2	1,4-Dichlorobenzene
104.040	022	EPA 524.2	Dichlorodifluoromethane
104.040	023	EPA 524.2	1,1-Dichloroethane
104.040	024	EPA 524.2	1,2-Dichloroethane
104.040	025	EPA 524.2	1,1-Dichloroethene
104.040	026	EPA 524.2	cis-1,2-Dichloroethene
104.040	027	EPA 524.2	trans-1,2-Dichloroethene
104.040	028	EPA 524.2	Dichloromethane
104.040	029	EPA 524.2	1,2-Dichloropropane
104.040	030	EPA 524.2	1,3-Dichloropropane
104.040	031	EPA 524.2	2,2-Dichloropropane
104.040	032	EPA 524.2	1,1-Dichloropropene
104.040	033	EPA 524.2	cis-1,3-Dichloropropene
104.040	034	EPA 524.2	trans-1,3-Dichloropropene
104.040	035	EPA 524.2	Ethylbenzene
104.040	036	EPA 524.2	Hexachlorobutadiene
104.040	037	EPA 524.2	Isopropylbenzene
104.040	038	EPA 524.2	4-Isopropyltoluene
104.040	039	EPA 524.2	Naphthalene
104.040	040	EPA 524.2	Nitrobenzene
104.040	041	EPA 524.2	N-propylbenzene
104.040	042	EPA 524.2	Styrene
104.040	043	EPA 524.2	1,1,1,2-Tetrachloroethane
104.040	044	EPA 524.2	1,1,1,2-Tetrachloroethane
104.040	045	EPA 524.2	Tetrachloroethene
104.040	046	EPA 524.2	Toluene
104.040	047	EPA 524.2	1,2,3-Trichlorobenzene
104.040	048	EPA 524.2	1,2,4-Trichlorobenzene
104.040	049	EPA 524.2	1,1,1-Trichloroethane
104.040	050	EPA 524.2	1,1,2-Trichloroethane
104.040	051	EPA 524.2	Trichloroethene
104.040	052	EPA 524.2	Trichlorofluoromethane
104.040	053	EPA 524.2	1,2,3-Trichloropropane
104.040	054	EPA 524.2	1,2,4-Trimethylbenzene
104.040	055	EPA 524.2	1,3,5-Trimethylbenzene

As of 09/20/2006, this list supersedes all previous lists for this certificate number.
Customers: Please verify the current accreditation standing with the State.

104.040	056	EPA 524.2	Vinyl Chloride
104.040	057	EPA 524.2	Xylenes, Total
104.045	001	EPA 524.2	Bromodichloromethane
104.045	002	EPA 524.2	Bromoform
104.045	003	EPA 524.2	Chloroform
104.045	004	EPA 524.2	Dibromochloromethane
104.045	005	EPA 524.2	Trihalomethanes
104.050	002	EPA 524.2	Methyl tert-butyl Ether (MTBE)
104.050	004	EPA 524.2	tert-Amyl Methyl Ether (TAME)
104.050	005	EPA 524.2	Ethyl tert-butyl Ether (ETBE)
104.050	006	EPA 524.2	Trichlorotrifluoroethane

108 - Inorganic Chemistry of Wastewater

108.016	001	EPA 110.2	Color
108.020	001	EPA 120.1	Conductivity
108.030	001	EPA 130.1	Hardness
108.040	001	EPA 130.2	Hardness
108.050	001	EPA 150.1	pH
108.060	001	EPA 160.1	Residue, Filterable
108.070	001	EPA 160.2	Residue, Non-filterable
108.080	001	EPA 160.3	Residue, Total
108.090	001	EPA 160.4	Residue, Volatile
108.100	001	EPA 160.5	Residue, Settleable
108.110	001	EPA 180.1	Turbidity
108.112	001	EPA 200.7	Boron
108.112	002	EPA 200.7	Calcium
108.112	004	EPA 200.7	Magnesium
108.112	005	EPA 200.7	Potassium
108.112	006	EPA 200.7	Silica
108.112	007	EPA 200.7	Sodium
108.120	001	EPA 300.0	Bromide
108.120	002	EPA 300.0	Chloride
108.120	003	EPA 300.0	Fluoride
108.120	004	EPA 300.0	Nitrate
108.120	005	EPA 300.0	Nitrite
108.120	006	EPA 300.0	Nitrate-nitrite, Total
108.120	007	EPA 300.0	Phosphate, Ortho
108.120	008	EPA 300.0	Sulfate
108.130	001	EPA 305.1	Acidity
108.140	001	EPA 310.1	Alkalinity
108.172	001	EPA 330.3	Chlorine Residual, Total
108.181	001	EPA 335.2	Cyanide, Total

108.191	001	EPA 340.2	Fluoride
108.201	001	EPA 350.2	Ammonia
108.212	001	EPA 351.3	Kjeldahl Nitrogen
108.234	001	EPA 353.3	Nitrate-nitrite, Total
108.235	001	EPA 353.3	Nitrate calc.
108.262	001	EPA 365.2	Phosphate, Ortho
108.263	001	EPA 365.2	Phosphorus, Total
108.270	001	EPA 370.1	Dissolved Silica
108.290	001	EPA 376.1	Sulfide
108.291	001	EPA 376.2	Sulfide
108.300	001	EPA 377.1	Sulfite
108.310	001	EPA 405.1	Biochemical Oxygen Demand
108.323	001	EPA 410.4	Chemical Oxygen Demand
108.330	001	EPA 413.1	Oil and Grease
108.340	001	EPA 415.1	Total Organic Carbon
108.350	001	EPA 418.1	Total Recoverable Petroleum Hydrocarbons
108.360	001	EPA 420.1	Phenols, Total
108.370	001	EPA 425.1	Surfactants
108.380	001	EPA 1664	Oil and Grease
108.390	001	SM2130B	Turbidity
108.400	001	SM2310B	Acidity
108.410	001	SM2320B	Alkalinity
108.420	001	SM2340B	Hardness (calc.)
108.421	001	SM2340C	Hardness
108.430	001	SM2510B	Conductivity
108.440	001	SM2540B	Residue, Total
108.441	001	SM2540C	Residue, Filterable
108.442	001	SM2540D	Residue, Non-filterable
108.443	001	SM2540F	Residue, Settleable
108.480	001	SM4500-F C	Fluoride
108.490	001	SM4500-H+ B	pH
108.590	001	SM5210B	Biochemical Oxygen Demand
108.602	001	SM5220D	Chemical Oxygen Demand
108.610	001	SM5310B	Total Organic Carbon
108.630	001	SM5520B	Oil and Grease

109 - Toxic Chemical Elements of Wastewater

109.010	001	EPA 200.7	Aluminum
109.010	002	EPA 200.7	Antimony
109.010	003	EPA 200.7	Arsenic
109.010	004	EPA 200.7	Barium
109.010	005	EPA 200.7	Beryllium

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109.010	007	EPA 200.7	Cadmium
109.010	009	EPA 200.7	Chromium
109.010	010	EPA 200.7	Cobalt
109.010	011	EPA 200.7	Copper
109.010	012	EPA 200.7	Iron
109.010	013	EPA 200.7	Lead
109.010	015	EPA 200.7	Manganese
109.010	016	EPA 200.7	Molybdenum
109.010	017	EPA 200.7	Nickel
109.010	019	EPA 200.7	Selenium
109.010	021	EPA 200.7	Silver
109.010	023	EPA 200.7	Thallium
109.010	024	EPA 200.7	Tin
109.010	025	EPA 200.7	Titanium
109.010	026	EPA 200.7	Vanadium
109.010	027	EPA 200.7	Zinc
109.020	001	EPA 200.8	Aluminum
109.020	002	EPA 200.8	Antimony
109.020	003	EPA 200.8	Arsenic
109.020	004	EPA 200.8	Barium
109.020	005	EPA 200.8	Beryllium
109.020	006	EPA 200.8	Cadmium
109.020	007	EPA 200.8	Chromium
109.020	008	EPA 200.8	Cobalt
109.020	009	EPA 200.8	Copper
109.020	010	EPA 200.8	Lead
109.020	011	EPA 200.8	Manganese
109.020	012	EPA 200.8	Molybdenum
109.020	013	EPA 200.8	Nickel
109.020	014	EPA 200.8	Selenium
109.020	015	EPA 200.8	Silver
109.020	016	EPA 200.8	Thallium
109.020	017	EPA 200.8	Vanadium
109.020	018	EPA 200.8	Zinc
109.104	001	EPA 218.6	Chromium (VI)

110 - Volatile Organic Chemistry of Wastewater

110.040	001	EPA 624	Benzene
110.040	002	EPA 624	Bromodichloromethane
110.040	003	EPA 624	Bromoform
110.040	004	EPA 624	Bromomethane
110.040	005	EPA 624	Carbon Tetrachloride

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110.040	006	EPA 624	Chlorobenzene
110.040	007	EPA 624	Chloroethane
110.040	008	EPA 624	2-Chloroethyl Vinyl Ether
110.040	009	EPA 624	Chloroform
110.040	010	EPA 624	Chloromethane
110.040	011	EPA 624	Dibromochloromethane
110.040	012	EPA 624	1,2-Dichlorobenzene
110.040	013	EPA 624	1,3-Dichlorobenzene
110.040	014	EPA 624	1,4-Dichlorobenzene
110.040	015	EPA 624	1,1-Dichloroethane
110.040	016	EPA 624	1,2-Dichloroethane
110.040	017	EPA 624	1,1-Dichloroethene
110.040	018	EPA 624	trans-1,2-Dichloroethene
110.040	019	EPA 624	1,2-Dichloropropane
110.040	020	EPA 624	cis-1,3-Dichloropropene
110.040	021	EPA 624	trans-1,3-Dichloropropene
110.040	022	EPA 624	Ethylbenzene
110.040	023	EPA 624	Methylene Chloride
110.040	024	EPA 624	1,1,2,2-Tetrachloroethane
110.040	025	EPA 624	Tetrachloroethene
110.040	026	EPA 624	Toluene
110.040	027	EPA 624	1,1,1-Trichloroethane
110.040	028	EPA 624	1,1,2-Trichloroethane
110.040	029	EPA 624	Trichloroethene
110.040	030	EPA 624	Trichlorofluoromethane
110.040	031	EPA 624	Vinyl Chloride
110.040	042	EPA 624	Oxygenates

111 - Semi-volatile Organic Chemistry of Wastewater

111.100	001	EPA 625	Acenaphthene
111.100	002	EPA 625	Acenaphthylene
111.100	003	EPA 625	Anthracene
111.100	004	EPA 625	Benzidine
111.100	005	EPA 625	Benz(a)anthracene
111.100	006	EPA 625	Benzo(b)fluoranthene
111.100	007	EPA 625	Benzo(k)fluoranthene
111.100	008	EPA 625	Benzo(g,h,i)perylene
111.100	009	EPA 625	Benzo(a)pyrene
111.100	010	EPA 625	Benzyl Butyl Phthalate
111.100	011	EPA 625	Bis(2-chloroethoxy)methane
111.100	012	EPA 625	Bis(2-chloroethyl) Ether
111.100	013	EPA 625	Bis(2-chloroisopropyl) Ether

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111.100	014	EPA 625	Di(2-ethylhexyl) Phthalate
111.100	015	EPA 625	4-Bromophenyl Phenyl Ether
111.100	016	EPA 625	4-Chloro-3-methylphenol
111.100	017	EPA 625	2-Chloronaphthalene
111.100	018	EPA 625	2-Chlorophenol
111.100	019	EPA 625	4-Chlorophenyl Phenyl Ether
111.100	020	EPA 625	Chrysene
111.100	021	EPA 625	Dibenz(a,h)anthracene
111.100	022	EPA 625	1,2-Dichlorobenzene
111.100	023	EPA 625	1,3-Dichlorobenzene
111.100	024	EPA 625	1,4-Dichlorobenzene
111.100	025	EPA 625	3,3'-Dichlorobenzidine
111.100	026	EPA 625	2,4-Dichlorophenol
111.100	027	EPA 625	Diethyl Phthalate
111.100	028	EPA 625	2,4-Dimethylphenol
111.100	029	EPA 625	Dimethyl Phthalate
111.100	030	EPA 625	Di-n-butyl phthalate
111.100	031	EPA 625	Di-n-octyl phthalate
111.100	032	EPA 625	2,4-Dinitrophenol
111.100	033	EPA 625	2,4-Dinitrotoluene
111.100	034	EPA 625	2,6-Dinitrotoluene
111.100	035	EPA 625	Fluoranthene
111.100	036	EPA 625	Fluorene
111.100	037	EPA 625	Hexachlorobenzene
111.100	038	EPA 625	Hexachlorobutadiene
111.100	039	EPA 625	Hexachlorocyclopentadiene
111.100	040	EPA 625	Hexachloroethane
111.100	041	EPA 625	Indeno(1,2,3-c,d)pyrene
111.100	042	EPA 625	Isophorone
111.100	043	EPA 625	2-Methyl-4,6-dinitrophenol
111.100	044	EPA 625	Naphthalene
111.100	045	EPA 625	Nitrobenzene
111.100	046	EPA 625	2-Nitrophenol
111.100	047	EPA 625	4-Nitrophenol
111.100	048	EPA 625	N-nitrosodimethylamine
111.100	049	EPA 625	N-nitrosodi-n-propylamine
111.100	050	EPA 625	N-nitrosodiphenylamine
111.100	051	EPA 625	Pentachlorophenol
111.100	052	EPA 625	Phenanthrene
111.100	053	EPA 625	Phenol
111.100	054	EPA 625	Pyrene

111.100	055	EPA 625	1,2,4-Trichlorobenzene
111.100	056	EPA 625	2,4,6-Trichlorophenol
111.170	001	EPA 608	Aldrin
111.170	002	EPA 608	a-BHC
111.170	003	EPA 608	b-BHC
111.170	004	EPA 608	d-BHC
111.170	005	EPA 608	g-BHC (Lindane)
111.170	006	EPA 608	Chlordane
111.170	007	EPA 608	4,4'-DDD
111.170	008	EPA 608	4,4'-DDE
111.170	009	EPA 608	4,4'-DDT
111.170	010	EPA 608	Dieldrin
111.170	011	EPA 608	Endosulfan I
111.170	012	EPA 608	Endosulfan II
111.170	013	EPA 608	Endosulfan Sulfate
111.170	014	EPA 608	Endrin
111.170	015	EPA 608	Endrin Aldehyde
111.170	016	EPA 608	Heptachlor
111.170	017	EPA 608	Heptachlor Epoxide
111.170	018	EPA 608	Toxaphene
111.170	019	EPA 608	PCB-1016
111.170	020	EPA 608	PCB-1221
111.170	021	EPA 608	PCB-1232
111.170	022	EPA 608	PCB-1242
111.170	023	EPA 608	PCB-1248
111.170	024	EPA 608	PCB-1254
111.170	025	EPA 608	PCB-1260
111.170	031	EPA 608	PCBs

114 - Inorganic Chemistry of Hazardous Waste

114.010	001	EPA 6010B	Antimony
114.010	002	EPA 6010B	Arsenic
114.010	003	EPA 6010B	Barium
114.010	004	EPA 6010B	Beryllium
114.010	005	EPA 6010B	Cadmium
114.010	006	EPA 6010B	Chromium
114.010	007	EPA 6010B	Cobalt
114.010	008	EPA 6010B	Copper
114.010	009	EPA 6010B	Lead
114.010	010	EPA 6010B	Molybdenum
114.010	011	EPA 6010B	Nickel
114.010	012	EPA 6010B	Selenium

114.010	013	EPA 6010B	Silver
114.010	014	EPA 6010B	Thallium
114.010	015	EPA 6010B	Vanadium
114.010	016	EPA 6010B	Zinc
114.020	001	EPA 6020	Antimony
114.020	002	EPA 6020	Arsenic
114.020	003	EPA 6020	Barium
114.020	004	EPA 6020	Beryllium
114.020	005	EPA 6020	Cadmium
114.020	006	EPA 6020	Chromium
114.020	007	EPA 6020	Cobalt
114.020	008	EPA 6020	Copper
114.020	009	EPA 6020	Lead
114.020	010	EPA 6020	Molybdenum
114.020	011	EPA 6020	Nickel
114.020	012	EPA 6020	Selenium
114.020	013	EPA 6020	Silver
114.020	014	EPA 6020	Thallium
114.020	015	EPA 6020	Vanadium
114.020	016	EPA 6020	Zinc
114.103	001	EPA 7196A	Chromium (VI)
114.106	001	EPA 7199	Chromium (VI)
114.140	001	EPA 7470A	Mercury
114.141	001	EPA 7471A	Mercury
114.222	001	EPA 9014	Cyanide
114.230	001	EPA 9034	Sulfides, Total
114.240	001	EPA 9040B	Corrosivity - pH Determination
114.241	001	EPA 9045C	Corrosivity - pH Determination
114.250	001	EPA 9056	Fluoride

115 - Extraction Test of Hazardous Waste

115.020	001	EPA 1311	Toxicity Characteristic Leaching Procedure (TCLP)
115.030	001	CCR Chapter11, Article 5, Appendix II	Waste Extraction Test (WET)
115.040	001	EPA 1312	Synthetic Precipitation Leaching Procedure (SPLP)

116 - Volatile Organic Chemistry of Hazardous Waste

116.010	001	EPA 8011	1,2-Dibromoethane
116.010	002	EPA 8011	Dibromochloropropane
116.020	011	EPA 8015B	Ethylene Glycol
116.030	001	EPA 8015B	Gasoline-range Organics
116.040	002	EPA 8021B	Benzene
116.040	039	EPA 8021B	Ethylbenzene
116.040	041	EPA 8021B	Methyl tert-butyl Ether (MTBE)

116.040	047	EPA 8021B	Toluene
116.040	056	EPA 8021B	Xylenes, Total
116.080	001	EPA 8260B	Acetone
116.080	002	EPA 8260B	Acetonitrile
116.080	003	EPA 8260B	Acrolein
116.080	004	EPA 8260B	Acrylonitrile
116.080	005	EPA 8260B	Allyl Alcohol
116.080	006	EPA 8260B	Allyl Chloride
116.080	007	EPA 8260B	Benzene
116.080	009	EPA 8260B	Bromoacetone
116.080	010	EPA 8260B	Bromochloromethane
116.080	011	EPA 8260B	Bromodichloromethane
116.080	012	EPA 8260B	Bromoform
116.080	013	EPA 8260B	Bromomethane
116.080	014	EPA 8260B	n-Butyl Alcohol
116.080	015	EPA 8260B	Carbon Disulfide
116.080	016	EPA 8260B	Carbon Tetrachloride
116.080	018	EPA 8260B	Chlorobenzene
116.080	019	EPA 8260B	Chloroethane
116.080	020	EPA 8260B	2-Chloroethyl Vinyl Ether
116.080	021	EPA 8260B	Chloroform
116.080	022	EPA 8260B	Chloromethane
116.080	023	EPA 8260B	Chloroprene
116.080	024	EPA 8260B	3-Chloropropionitrile
116.080	025	EPA 8260B	Crotonaldehyde
116.080	026	EPA 8260B	Dibromochloromethane
116.080	027	EPA 8260B	Dibromochloropropane
116.080	028	EPA 8260B	1,2-Dibromoethane
116.080	030	EPA 8260B	Dibromomethane
116.080	031	EPA 8260B	1,2-Dichlorobenzene
116.080	032	EPA 8260B	1,3-Dichlorobenzene
116.080	033	EPA 8260B	1,4-Dichlorobenzene
116.080	034	EPA 8260B	cis-1,4-Dichloro-2-butene
116.080	035	EPA 8260B	trans-1,4-Dichloro-2-butene
116.080	036	EPA 8260B	Dichlorodifluoromethane
116.080	037	EPA 8260B	1,1-Dichloroethane
116.080	038	EPA 8260B	1,2-Dichloroethane
116.080	039	EPA 8260B	1,1-Dichloroethene
116.080	040	EPA 8260B	trans-1,2-Dichloroethene
116.080	041	EPA 8260B	cis-1,2-Dichloroethene
116.080	042	EPA 8260B	1,2-Dichloropropane

116.080	043	EPA 8260B	1,3-Dichloropropane
116.080	044	EPA 8260B	2,2-Dichloropropane
116.080	045	EPA 8260B	1,1-Dichloropropene
116.080	046	EPA 8260B	cis-1,3-Dichloropropene
116.080	047	EPA 8260B	trans-1,3-Dichloropropene
116.080	048	EPA 8260B	1,3-Dichloro-2-propanol
116.080	049	EPA 8260B	1,2,3,4-Diepoxybutane
116.080	050	EPA 8260B	1,4-Dioxane
116.080	053	EPA 8260B	Ethylbenzene
116.080	055	EPA 8260B	Ethyl Methacrylate
116.080	056	EPA 8260B	Hexachlorobutadiene
116.080	058	EPA 8260B	2-Hexanone (MBK)
116.080	059	EPA 8260B	Iodomethane
116.080	060	EPA 8260B	Isobutyl Alcohol
116.080	061	EPA 8260B	Malononitrile
116.080	062	EPA 8260B	Methacrylonitrile
116.080	064	EPA 8260B	Methyl tert-butyl Ether (MTBE)
116.080	065	EPA 8260B	Methylene Chloride
116.080	066	EPA 8260B	Methyl Ethyl Ketone
116.080	067	EPA 8260B	Methyl Methacrylate
116.080	068	EPA 8260B	4-Methyl-2-pentanone (MIBK)
116.080	069	EPA 8260B	Naphthalene
116.080	070	EPA 8260B	Nitrobenzene
116.080	072	EPA 8260B	N-nitrosodi-n-butylamine
116.080	074	EPA 8260B	Pentachloroethane
116.080	075	EPA 8260B	Pentafluorobenzene
116.080	076	EPA 8260B	2-Picoline
116.080	078	EPA 8260B	Propionitrile
116.080	079	EPA 8260B	N-propylamine
116.080	080	EPA 8260B	Pyridine
116.080	081	EPA 8260B	1,1,1,2-Tetrachloroethane
116.080	082	EPA 8260B	1,1,2,2-Tetrachloroethane
116.080	083	EPA 8260B	Tetrachloroethene
116.080	084	EPA 8260B	Toluene
116.080	086	EPA 8260B	1,2,3-Trichlorobenzene
116.080	087	EPA 8260B	1,2,4-Trichlorobenzene
116.080	088	EPA 8260B	1,1,1-Trichloroethane
116.080	089	EPA 8260B	1,1,2-Trichloroethane
116.080	090	EPA 8260B	Trichloroethene
116.080	091	EPA 8260B	Trichlorofluoromethane
116.080	092	EPA 8260B	1,2,3-Trichloropropane

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116.080	093	EPA 8260B	Vinyl Acetate
116.080	094	EPA 8260B	Vinyl Chloride
116.080	095	EPA 8260B	Xylenes, Total
116.080	096	EPA 8260B	tert-Amyl Methyl Ether (TAME)
116.080	097	EPA 8260B	tert-Butyl Alcohol (TBA)
116.080	098	EPA 8260B	Ethyl tert-butyl Ether (ETBE)
116.080	099	EPA 8260B	Bromobenzene
116.080	100	EPA 8260B	n-Butylbenzene
116.080	101	EPA 8260B	sec-Butylbenzene
116.080	102	EPA 8260B	tert-Butylbenzene
116.080	103	EPA 8260B	2-Chlorotoluene
116.080	104	EPA 8260B	4-Chlorotoluene
116.080	105	EPA 8260B	Isopropylbenzene
116.080	106	EPA 8260B	N-propylbenzene
116.080	107	EPA 8260B	Styrene
116.080	108	EPA 8260B	1,2,4-Trimethylbenzene
116.080	109	EPA 8260B	1,3,5-Trimethylbenzene

117 - Semi-volatile Organic Chemistry of Hazardous Waste

117.010	001	EPA 8015B	Diesel-range Total Petroleum Hydrocarbons
117.015	001	LUFT GC/MS	Diesel-range Total Petroleum Hydrocarbons
117.016	001	LUFT	Diesel-range Total Petroleum Hydrocarbons
117.017	001	EPA 418.1	TRPH Screening
117.110	001	EPA 8270C	Acenaphthene
117.110	002	EPA 8270C	Acenaphthylene
117.110	003	EPA 8270C	Acetophenone
117.110	004	EPA 8270C	2-Acetylaminofluorene
117.110	005	EPA 8270C	1-Acetyl-2-thiourea
117.110	006	EPA 8270C	4-Aminobiphenyl
117.110	007	EPA 8270C	Aniline
117.110	008	EPA 8270C	Anthracene
117.110	010	EPA 8270C	Benzidine
117.110	011	EPA 8270C	Benz(a)anthracene
117.110	012	EPA 8270C	Benzo(b)fluoranthene
117.110	013	EPA 8270C	Benzo(k)fluoranthene
117.110	014	EPA 8270C	Benzo(g,h,i)perylene
117.110	015	EPA 8270C	Benzo(a)pyrene
117.110	016	EPA 8270C	Benzoic Acid
117.110	017	EPA 8270C	p-Benzoquinone
117.110	018	EPA 8270C	Benzyl Alcohol
117.110	019	EPA 8270C	Benzyl Butyl Phthalate
117.110	020	EPA 8270C	Bis(2-chloroethoxy)methane

As of 09/20/2006, this list supersedes all previous lists for this certificate number.
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117.110	021	EPA 8270C	Bis(2-chloroethyl) Ether
117.110	022	EPA 8270C	Bis(2-chloroisopropyl) Ether
117.110	023	EPA 8270C	Di(2-ethylhexyl) Phthalate
117.110	024	EPA 8270C	4-Bromophenyl Phenyl Ether
117.110	025	EPA 8270C	Carbazole
117.110	026	EPA 8270C	4-Chloroaniline
117.110	027	EPA 8270C	4-Chloro-3-methylphenol
117.110	029	EPA 8270C	2-Chloronaphthalene
117.110	030	EPA 8270C	2-Chlorophenol
117.110	031	EPA 8270C	4-Chlorophenyl Phenyl Ether
117.110	032	EPA 8270C	Chrysene
117.110	033	EPA 8270C	2-Cyclohexyl-4,6-dinitrophenol
117.110	034	EPA 8270C	2,4-Diaminotoluene
117.110	036	EPA 8270C	Dibenz(a,h)anthracene
117.110	037	EPA 8270C	Dibenzofuran
117.110	038	EPA 8270C	Dibenzo(a,e)pyrene
117.110	039	EPA 8270C	1,2-Dichlorobenzene
117.110	040	EPA 8270C	1,3-Dichlorobenzene
117.110	041	EPA 8270C	1,4-Dichlorobenzene
117.110	042	EPA 8270C	3,3'-Dichlorobenzidine
117.110	043	EPA 8270C	2,4-Dichlorophenol
117.110	044	EPA 8270C	2,6-Dichlorophenol
117.110	045	EPA 8270C	Diethyl Phthalate
117.110	050	EPA 8270C	p-Dimethylaminoazobenzene
117.110	051	EPA 8270C	7,12-Dimethylbenz(a)anthracene
117.110	052	EPA 8270C	a,a-Dimethylphenethylamine
117.110	053	EPA 8270C	2,4-Dimethylphenol
117.110	054	EPA 8270C	Dimethyl Phthalate
117.110	055	EPA 8270C	Di-n-butyl phthalate
117.110	056	EPA 8270C	Di-n-octyl phthalate
117.110	060	EPA 8270C	2,4-Dinitrophenol
117.110	061	EPA 8270C	2,4-Dinitrotoluene
117.110	062	EPA 8270C	2,6-Dinitrotoluene
117.110	063	EPA 8270C	Diphenylamine
117.110	064	EPA 8270C	1,2-Diphenylhydrazine
117.110	066	EPA 8270C	Ethyl Methanesulfonate
117.110	067	EPA 8270C	Fluoranthene
117.110	068	EPA 8270C	Fluorene
117.110	069	EPA 8270C	Hexachlorobenzene
117.110	070	EPA 8270C	Hexachlorobutadiene
117.110	071	EPA 8270C	Hexachlorocyclopentadiene

117.110	072	EPA 8270C	Hexachloroethane
117.110	073	EPA 8270C	Hexachlorophene
117.110	074	EPA 8270C	Hexachloropropene
117.110	075	EPA 8270C	Indeno(1,2,3-c,d)pyrene
117.110	076	EPA 8270C	Isophorone
117.110	077	EPA 8270C	Isosafrole
117.110	078	EPA 8270C	Maleic Anhydride
117.110	079	EPA 8270C	3-Methylcholanthrene
117.110	080	EPA 8270C	2-Methyl-4,6-dinitrophenol
117.110	082	EPA 8270C	Methyl Methanesulfonate
117.110	083	EPA 8270C	2-Methylnaphthalene
117.110	084	EPA 8270C	2-Methylphenol
117.110	085	EPA 8270C	3-Methylphenol
117.110	086	EPA 8270C	4-Methylphenol
117.110	087	EPA 8270C	Naphthalene
117.110	088	EPA 8270C	1,4-Naphthoquinone
117.110	089	EPA 8270C	1-Naphthylamine
117.110	090	EPA 8270C	2-Naphthylamine
117.110	091	EPA 8270C	Nicotine
117.110	092	EPA 8270C	2-Nitroaniline
117.110	093	EPA 8270C	3-Nitroaniline
117.110	094	EPA 8270C	4-Nitroaniline
117.110	095	EPA 8270C	Nitrobenzene
117.110	096	EPA 8270C	2-Nitrophenol
117.110	097	EPA 8270C	4-Nitrophenol
117.110	098	EPA 8270C	N-nitrosodi-n-butylamine
117.110	099	EPA 8270C	N-nitrosodiethylamine
117.110	100	EPA 8270C	N-nitrosodimethylamine
117.110	101	EPA 8270C	N-nitrosodi-n-propylamine
117.110	102	EPA 8270C	N-nitrosodiphenylamine
117.110	103	EPA 8270C	N-nitrosomethylethylamine
117.110	104	EPA 8270C	N-nitrosomorpholine
117.110	105	EPA 8270C	N-nitrosopiperidine
117.110	106	EPA 8270C	N-nitrosopyrrolidine
117.110	107	EPA 8270C	5-Nitro-o-toluidine
117.110	108	EPA 8270C	Pentachlorobenzene
117.110	109	EPA 8270C	Pentachloronitrobenzene
117.110	110	EPA 8270C	Pentachlorophenol
117.110	111	EPA 8270C	Phenacetin
117.110	112	EPA 8270C	Phenanthrene
117.110	113	EPA 8270C	Phenol

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117.110	116	EPA 8270C	2-Picoline
117.110	119	EPA 8270C	Pyrene
117.110	120	EPA 8270C	Pyridine
117.110	122	EPA 8270C	Safrole
117.110	124	EPA 8270C	1,2,4,5-Tetrachlorobenzene
117.110	125	EPA 8270C	2,3,4,6-Tetrachlorophenol
117.110	128	EPA 8270C	o-Toluidine
117.110	129	EPA 8270C	1,2,4-Trichlorobenzene
117.110	130	EPA 8270C	2,4,5-Trichlorophenol
117.110	131	EPA 8270C	2,4,6-Trichlorophenol
117.110	132	EPA 8270C	1,3,5-Trinitrobenzene
117.111	025	EPA 8270C	Dimethoate
117.111	026	EPA 8270C	Dinoseb
117.111	036	EPA 8270C	Famphur
117.111	039	EPA 8270C	Isodrin
117.111	040	EPA 8270C	Kepone
117.111	054	EPA 8270C	Parathion Ethyl
117.111	055	EPA 8270C	Parathion Methyl
117.111	056	EPA 8270C	Phorate
117.111	058	EPA 8270C	Sulfotepp
117.111	061	EPA 8270C	O,O,O-triethyl Phosphorothioate
117.140	001	EPA 8310	Acenaphthene
117.140	002	EPA 8310	Acenaphthylene
117.140	003	EPA 8310	Anthracene
117.140	004	EPA 8310	Benz(a)anthracene
117.140	005	EPA 8310	Benzo(a)pyrene
117.140	006	EPA 8310	Benzo(b)fluoranthene
117.140	007	EPA 8310	Benzo(k)fluoranthene
117.140	008	EPA 8310	Benzo(g,h,i)perylene
117.140	009	EPA 8310	Chrysene
117.140	010	EPA 8310	Dibenz(a,h)anthracene
117.140	011	EPA 8310	Fluoranthene
117.140	012	EPA 8310	Fluorene
117.140	013	EPA 8310	Indeno(1,2,3-c,d)pyrene
117.140	014	EPA 8310	Naphthalene
117.140	015	EPA 8310	Phenanthrene
117.140	016	EPA 8310	Pyrene
117.170	001	EPA 8330	4-Amino-2,6-dinitrotoluene
117.170	002	EPA 8330	2-Amino-4,6-dinitrotoluene
117.170	003	EPA 8330	1,3-Dinitrobenzene
117.170	004	EPA 8330	2,4-Dinitrotoluene

117.170	005	EPA 8330	2,6-Dinitrotoluene
117.170	006	EPA 8330	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
117.170	007	EPA 8330	Methyl-2,4,6-trinitrophenylnitramine
117.170	008	EPA 8330	Nitrobenzene
117.170	009	EPA 8330	2-Nitrotoluene
117.170	010	EPA 8330	3-Nitrotoluene
117.170	011	EPA 8330	4-Nitrotoluene
117.170	012	EPA 8330	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
117.170	013	EPA 8330	1,3,5-Trinitrobenzene
117.170	014	EPA 8330	2,4,6-Trinitrotoluene
117.190	001	EPA 8332	Nitroglycerine
117.210	001	EPA 8081A	Aldrin
117.210	002	EPA 8081A	a-BHC
117.210	003	EPA 8081A	b-BHC
117.210	004	EPA 8081A	d-BHC
117.210	005	EPA 8081A	g-BHC (Lindane)
117.210	007	EPA 8081A	a-Chlordane
117.210	008	EPA 8081A	g-Chlordane
117.210	009	EPA 8081A	Chlordane (tech.)
117.210	010	EPA 8081A	Chlorobenzilate
117.210	011	EPA 8081A	Chloroneb
117.210	012	EPA 8081A	Chlorothalonil
117.210	013	EPA 8081A	4,4'-DDD
117.210	014	EPA 8081A	4,4'-DDE
117.210	015	EPA 8081A	4,4'-DDT
117.210	016	EPA 8081A	Diallate
117.210	020	EPA 8081A	Dieldrin
117.210	021	EPA 8081A	Endosulfan I
117.210	022	EPA 8081A	Endosulfan II
117.210	023	EPA 8081A	Endosulfan Sulfate
117.210	024	EPA 8081A	Endrin
117.210	025	EPA 8081A	Endrin Aldehyde
117.210	026	EPA 8081A	Endrin Ketone
117.210	027	EPA 8081A	Heptachlor
117.210	028	EPA 8081A	Heptachlor Epoxide
117.210	029	EPA 8081A	Hexachlorobenzene
117.210	033	EPA 8081A	Methoxychlor
117.210	039	EPA 8081A	Toxaphene
117.220	001	EPA 8082	PCB-1016
117.220	002	EPA 8082	PCB-1221
117.220	003	EPA 8082	PCB-1232

117.220	004	EPA 8082	PCB-1242
117.220	005	EPA 8082	PCB-1248
117.220	006	EPA 8082	PCB-1254
117.220	007	EPA 8082	PCB-1260
117.220	008	EPA 8082	2-Chlorobiphenyl
117.220	009	EPA 8082	2,3-Dichlorobiphenyl
117.220	010	EPA 8082	2,2',5-Trichlorobiphenyl
117.220	011	EPA 8082	2,4',5-Trichlorobiphenyl
117.220	012	EPA 8082	2,2',3,5'-Tetrachlorobiphenyl
117.220	013	EPA 8082	2,2',5,5'-Tetrachlorobiphenyl
117.220	014	EPA 8082	2,3',4,4'-Tetrachlorobiphenyl
117.220	015	EPA 8082	2,2',3,4,5'-Pentachlorobiphenyl
117.220	016	EPA 8082	2,2',4,5,5'-Pentachlorobiphenyl
117.220	017	EPA 8082	2,3,3',4',6-Pentachlorobiphenyl
117.220	018	EPA 8082	2,2',3,4,4',5'-Hexachlorobiphenyl
117.220	019	EPA 8082	2,2',3,4,5,5'-Hexachlorobiphenyl
117.220	020	EPA 8082	2,2',3,5,5',6-Hexachlorobiphenyl
117.220	021	EPA 8082	2,2',4,4',5,5'-Hexachlorobiphenyl
117.220	022	EPA 8082	2,2',3,3',4,4',5-Heptachlorobiphenyl
117.220	023	EPA 8082	2,2',3,4,4',5,5'-Heptachlorobiphenyl
117.220	024	EPA 8082	2,2',3,4,4',5',6-Heptachlorobiphenyl
117.220	025	EPA 8082	2,2',3,4',5,5',6-Heptachlorobiphenyl
117.220	026	EPA 8082	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl
117.240	001	EPA 8141A	Atrazine
117.240	002	EPA 8141A	Azinphos Methyl
117.240	004	EPA 8141A	Chlorfenvinphos
117.240	005	EPA 8141A	Chlorpyrifos
117.240	006	EPA 8141A	Chlorpyrifos Methyl
117.240	007	EPA 8141A	Demeton-O
117.240	008	EPA 8141A	Demeton-S
117.240	009	EPA 8141A	Diazinon
117.240	010	EPA 8141A	Dimethoate
117.240	012	EPA 8141A	EPN
117.240	013	EPA 8141A	Ethion
117.240	014	EPA 8141A	Famphur
117.240	015	EPA 8141A	Malathion
117.240	016	EPA 8141A	Mevinphos
117.240	017	EPA 8141A	Naled
117.240	018	EPA 8141A	Parathion Ethyl
117.240	019	EPA 8141A	Parathion Methyl
117.240	020	EPA 8141A	Phorate

117.240	022	EPA 8141A	Ronnel
117.240	024	EPA 8141A	Sulfotepp
117.240	026	EPA 8141A	Thionazin
117.250	001	EPA 8151A	2,4-D
117.250	002	EPA 8151A	2,4-DB
117.250	003	EPA 8151A	2,4,5-T
117.250	004	EPA 8151A	2,4,5-TP
117.250	006	EPA 8151A	Dalapon
117.250	007	EPA 8151A	Dichlorprop
117.250	008	EPA 8151A	Dinoseb
117.250	009	EPA 8151A	MCPA
117.250	010	EPA 8151A	MCPP
117.250	011	EPA 8151A	4-Nitrophenol
117.250	012	EPA 8151A	Pentachlorophenol
117.250	013	EPA 8151A	Picloram
117.250	014	EPA 8151A	Dicamba
117.250	015	EPA 8151A	3,5-Dichlorobenzoic Acid
117.250	016	EPA 8151A	Acifluorfen
117.250	017	EPA 8151A	Bentazon
117.250	018	EPA 8151A	Chloramben
117.250	019	EPA 8151A	DCPA

120 - Physical Properties of Hazardous Waste

120.010	001	EPA 1010	Ignitability
120.040	001	Section 7.3 SW-846	Reactive Cyanide
120.050	001	Section 7.3 SW-846	Reactive Sulfide
120.070	001	EPA 9040B	Corrosivity - pH Determination
120.080	001	EPA 9045C	Corrosivity - pH Determination

Attachment B
Responses to Comments on Laboratory
Chemistry and Quality Control Data

Attachment B: Responses to Comments on Laboratory Chemistry and Quality Control Data

CH2M HILL has reviewed the Peer Review comments on the Hinkley Groundwater Background Study (CH2M HILL, 2007) related to laboratory methods and quality control data prepared by Dr. Stuart Nagourney of the College of New Jersey on behalf of the Regional Water Quality Control Board, Lahontan Region (Water Board), dated October 14, 2011. Based on this review, the quality of the laboratory analyses was determined to be appropriate and to meet all of the requirements of the USEPA methods employed.

Detailed Response to Comments

The issues raised by Dr. Nagourney fall into three general categories: method calibration, establishment of reporting limits (RLs) and method detection limits (MDLs), and quality control (QC) check procedures. Dr. Nagourney posed six questions to the Truesdail Laboratories, Inc. (TLI) and EMAX Laboratories (EMAX). Based on the responses to these questions, Dr. Nagourney provided additional questions and comments regarding QC procedures, including questions on method calibration, RLs, and MDLs. Presented below are responses to each of the additional questions and comments provided by Dr. Nagourney.

- 1) What calibration ranges were used for Methods 6010B, 6020A and 7199?

Comment on information provided by TLI: It is unclear from the response if the low level calibration ranges cited in the response for Methods 6010B and 6020A were used for the analyses in this study. If not, the data for this study for total chromium (Cr(T)) would be questionable.

Response:

- Method 6010B was not used by either lab for the Hinkley Groundwater Background Study.
- For Method 6020A, the laboratories used the following calibration ranges:
 - TLI used 0.2 micrograms per liter ($\mu\text{g/L}$) to an upper range of 100, 200 or 500 $\mu\text{g/L}$.
 - EMAX used 10 $\mu\text{g/L}$ to an upper range of 100 $\mu\text{g/L}$.
- For Method 7199, the laboratories used the following calibration ranges:
 - TLI used a calibration range of 0.2 to 50 $\mu\text{g/L}$. As noted here, TLI did use a low concentration standard, 0.2 $\mu\text{g/L}$, for the low end of the calibration range.
 - EMAX used 0.2 $\mu\text{g/L}$ to an upper range of 5.0 $\mu\text{g/L}$.

- 2) For Method 6020A, what was the value of the Contract Required Quantitation Limit Check Standard (CRI) and the method control limits?

Comment on information provided by TLI: TLI admitted in their response that they failed to perform this quality assurance as required by the method during the time that data for this study were obtained.

Response:

- CRI is not a required criterion of 6020A, and as such the failure of TLI to perform this check did not compromise the quality of the data obtained.

- Regarding method control limits, the PG&E Program Quality Assurance Project Plan (QAPP) (CH2M HILL, 2008) requires the following:
 - Laboratory Control Sample (LCS) of 85 – 115% (method requires 80 – 120%). An LCS is a reagent water blank fortified with the compound(s) of interest that is processed through the entire method process just like a sample.
 - Matrix Spike/Matrix Spike Duplicate (MS/MSD) of 75 – 125%
 - The relative percent difference (RPD) or precision between the MS and MSD or sample and sample duplicate 20%RPD
 - Post spike and serial dilution are also required per the method requirements.
- 3) Were reporting limit (RL) check samples analyzed for Methods 7199 and 6010B? If so what are the control limits and what were the actual recoveries?

Comment on information provided by TLI: TLI admitted in their response that they failed to analyze a RL check sample during the time that data for this study were obtained.

Response:

- 6010B was not used for the Hinkley Groundwater Background Study.
 - RL checks are not required by either method, and as such the failure of TLI to perform this check did not compromise the quality of the data obtained.
- 4) How were RLs established for Methods 6010B, 6020A and 7199? What is the relationship between the method detection limit (MDL) & RL for each method?

Comment on information provided by TLI: TLI's response of varying criteria for a quantitative relationship between the MDL and RL is too vague to be acceptable.

Response:

- MDL studies are performed annually and are required to meet the 40 CFR Part 136B criteria.
- The California Environmental Laboratory Accreditation Program (ELAP) states the RL must be defensible, be greater than the MDL, and will be specified by the end user of the data.
- The RL is defined by the CDPH as the concentration at which an analyte can be detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision. The CDPH defined reasonable as $\pm 20\%$ accuracy and 20% RSD for replicate determinations. The acceptable ranges depend somewhat on the analytical methodology used. The CDPH states that for samples that do not pose a particular matrix problem, the RL is typically about three to five times higher than the MDL.
- The RLs used by the labs for the Hinkley Groundwater Background Study were derived from reporting limits specified in the June 29, 2001 Cleanup and Abatement Order (CAO) (Water Board, 2001), also specified in the QAPP (subsequent Waste Discharge Requirements [WDRs] such as R6V-2004-0034 actually specified a higher RL of 1 $\mu\text{g/L}$ for Cr(VI) and 5 $\mu\text{g/L}$ Cr(T)).
- In accordance with the project QAPP, an RL level low standard is used in the calibration curve.
- No data are reported below the RL. (Non-detects are reported at the RL.)

- 5) What standard reference material (SRM) was used for QC for 7199 as per Section 5.4? This data was apparently not reported.

Comment on information provided by TLI: The use of a mid-range check sample is not acceptable as a QC material as per the criteria for quality control specified in Method 7199. This would make the data for this study for Cr(VI) questionable.

Response:

- Section 5.4 of the method requires a QCS (quality control sample) defined as “a mid-range standard, prepared from an independent commercial source” (i.e., a secondary source, separate from the initial calibration standards) be used to verify the instruments performance. It does not require Standard Reference Material (SRM), only a standard from a secondary source as defined by the QCS. The procedures used were in keeping with the method and the data obtained is therefore not questionable.
 - TLI uses a second source material for both their LCS and the second source mid-range calibration check standard.
 - EMAX uses a second source for their LCSs.
 - Both laboratories report LCS data in the lab reports.
- 6) Why were the spiking levels for both Cr(T) and Cr(VI) analyses much higher than the expected sample concentrations for all analytical methods?

Comment on information provided by EMAX and TLI: This response was not satisfactory. The laboratory should have chosen the concentration level of matrix spikes for both Cr(T) and Cr(VI) to closer to the actual sample levels (usually a multiple of 3-5 the expected value is applied). The choice of much higher spiking levels means that the calculated recoveries have little value in assessing the quality of the actual sample concentrations and the impact to those results from possible matrix interferences.

Response:

- Method 6020A specifics – “MS/MSD samples should be spiked at the same level, and with the same spiking material, as the corresponding laboratory control sample that is at the project-specific action level or, when lacking project-specific action levels, at approximately mid-point of the linear dynamic range.” No project specific action level was specified for the background study; therefore, the labs followed the spiking levels specified by the method.
- Both laboratories used 1.0 µg/L as the spike concentration for Method 7199. The concentration of the matrix spike was five times the reporting level and applicable to the majority of sample concentrations determined over the study.

In addition to the initial six questions, Dr. Nagourney noted six additional concerns with analytical data in comments. The following are the concerns and the responses to those concerns.

1. **Comment:** No criteria were provided from either laboratory as to the criteria for data assigned “U” or “J” flags.

Response: Laboratory analytical data was reviewed by CH2M HILL’s project chemists to assess data quality and to identify deviations from analytical requirements. The flags provided in the Groundwater Background Study were assigned by the project chemists and the criteria associated to a specific result/flag are listed in Appendix F (Data Requiring Validation Flags).

2. **Comment:** “unusually high percentage of samples failed the quality control criteria for the Continuing Calibration Verification (CCV).”

Response: During the first Hinkley Background Study sampling event, (January/February 2006) all Method SW 7199 sample analyses were performed by TLI and the CCV recoveries for all analyses were within the method criteria of 90 – 110% recovery. For the three subsequent sampling events, all Method SW7199 sample analyses were performed by EMAX Laboratory (EMAX). Of the 129 sample analyses performed by EMAX, 31 (26 samples, 5 field duplicates) or 24 percent had one or more of the bracketing CCVs with recoveries that were outside the method criteria. CCV recoveries for the out of control sample analyses ranged from a low of 72 percent to a high of 123 percent with 19 results biased low and 12 biased high. In accordance with the PG&E program Quality Assurance Program Plan (QAPP) (CH2M HILL, 2008) that cites USEPA National Functional Guidelines for Inorganic Data Review (2002), the range of the out of control CCV recoveries was not significant enough to warrant data rejection, but did require data qualification by applying “J/UJ” flags to out of control results. Therefore, the results were determined to be of sufficient quality to be used for purposes of the background study.

3. **Comment:** How were samples chosen for matrix spiking (was this procedure randomized so as to not bias the results?)

Response: The matrix spikes were randomly selected by the laboratory.

4. **Comment:** The work plan specifies the use of method 6010 for the analysis of Cr(T); Method 6020A was used instead. This may impact the ability to quantify for Cr(T) at low concentration levels since the RL for Method 6020A is much lower than that for Method 6010.

Response: Both methods use an Inductively Coupled Plasma (ICP) however Method 6020A pairs that with a mass spectrometer (measuring mass weight) which allows for lower concentration reporting for most metals. Method SW6020A met the RL objectives for the project.

5. **Comment:** Some data for Cr(VI) in this study were reported by USEPA determinative method 218.6, other data was reported by Method 7196A and still other data was reported by Method 7199. These methods all have different sensitivities and different capabilities to report Cr(VI) without analytical interferences. Why were different methods used to measure Cr(VI)?

Response: Only Method 7199 was used during the Hinkley Groundwater Background Study to analyze and report standard Cr(VI) results. There is no reference in the background study to either Method 218.6 or 7196.

6. **Comment:** The authors of the report chose to use a method from the USGS to attempt to define specific Cr species present in samples. This method is not certified by the State or NELAP. Information that was supplied suggests that this USGS method has only been applied to speciation of arsenic. USEPA Method 6800, Elemental and Speciated Isotope Dilution Mass Spectrometry allows the identification of individual Cr species... USEPA Method 6800 is certified by State and NELAP. Why was Method 6800 not used for this application?

Response: Method 6800 was posted in February 2007, and the Hinkley Groundwater Background Study samples were collected quarterly from January 2006 to November 2006 and the report was submitted to the Water Board in Feb 2007 and therefore pre-date promulgation of Method 6800.

A2-5: February 23, 2012: Excelchem Laboratories review of PG&E's Response to Investigative Order No. R6V-2011-0105



Excelchem Environmental Labs

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2/23/12

Re: Request for Technical Consultation on Response to Investigative Order No. R6V-2011-0105 and Peer Review Comments on Laboratory Quality Control Data for 2007 Groundwater Chromium Background Study Report, Pacific Gas and Electric Company's (PG&E's) Hinkley Remediation

To Whom It May Concern:

The hexavalent chromium results provided by Truesdail Laboratories follow the QA/QC requirements of EPA Method 7199.

The quality of some of the results provided by EMAX Laboratory is suspect. Sample Delivery Groups 06G182, 06G200, 06I248, 06J236, 06K156, and 06K180 had failing CCVs. EMAX Laboratory analyzed two CCVs every ten samples instead of one. If one of the CCVs passed and the other failed EMAX accepted the data. Section 7.3.2 of EPA Method 7199 states that if a CCV is not within 10% the CCV can be re-analyzed. The intent of the method is to allow the occasional re-analysis of a failing CCV. Routine CCV failures and poor precision are an indication that an incompetent analyst is preparing the calibration check standards or there is an instrument problem that needs to be corrected. It was not the EPA's intention to allow the routine re-analysis of failing CCVs. The precision and accuracy of the analysis is poor in this type of situation.

The CCVs from Sample Delivery Group 06G182 range from 64% recovery to 100% recovery. Eight of the seventeen CCVs are failing. CCVs analyzed back to back have poor precision. CCV18 had a percent recovery of 64%. The re-analysis of CCV18 had a percent recovery of 92%. CCV19 had a percent recovery of 76%. The re-analysis had a percent recovery of 92%. All of the samples were analyzed in duplicate for this sample delivery group and the results have good precision. This leads me to believe that there is something wrong with the preparation of the CCV standards and possibly the calibration standards. If that is the case the data is of uncertain accuracy and it is my opinion that none of the data in Sample Delivery Group 06G182 should be used.

The CCVs for Sample Delivery Group 06I248 range from 0% recovery to 114% recovery. All of the samples were analyzed in duplicate. Poor precision was observed for two of the samples. Sample I248-02 had results of 0.397 ppb, 1.042 ppb, 1.208 ppb, and 1.189 ppb. Sample I248-05 had results of 1.493 ppb and ND (less than 0.2 ppb). Section 7.4 of EPA Method 7199 states that duplicate samples should have a relative standard deviation of less than 20%. The relative standard deviation for sample I248-05 is greater than 150%. The accuracy of the data in Sample Delivery Group 06I248 is highly suspect.

The CCVs for Sample Delivery Group 06K156 and 06K180 range from 80% to 112%. Poor precision was observed for sample K180-08. The results for this sample were less than 0.2 ppb, 2.689 ppb, and 2.580 ppb.

Sample Delivery Group 06J236 had one failing CCV. The CCV was failing by 4%. The CCV was re-analyzed in accordance with EPA Method 7199 and passed. All samples were analyzed in duplicate and the precision was good.

Sample Delivery Group 06G200 had one CCV fail by 9% and one fail by 1%. All samples were analyzed in duplicate and the precision was good. The CCVs were re-analyzed in accordance with EPA Method 7199 and passed.

Review of Pacific Gas and Electric Company's Response dated January 19, 2012

Pacific Gas and Electric Company's response states that the CCV recoveries ranged from 72% to 123%. In actuality the CCVs ranged from 0% to 123%.

PG&E stated that according to the USEPA National Functional Guidelines for Inorganic Data Review (2002) the hexavalent chromium results were of sufficient quality for the background investigation. The USEPA National Functional Guidelines for Inorganic Data Review (2002) discusses data quality for ICP, ICP-MS, mercury, and cyanide. It does not address hexavalent chromium or analyses performed by ion chromatography; therefore I don't believe it is relevant in this case. It is beyond my expertise to determine whether the USEPA National Functional Guidelines for Inorganic Data Review (2002) is appropriate for evaluating data quality. For low CCV recoveries and poor duplicate precision the guidelines are vague and say only to "use professional judgment". Had the QA/QC criteria of EPA Method 7199 been met, the quality of the data would have been much higher. There is no way to know if the results from Sample Delivery Group 06G182 are biased low by more than 36% or if the results accurately represent what is in the samples.

PG&E's response stated that all the hexavalent chromium analytical data was provided on the enclosed CD. The chromatograms for most of the failing CCVs were not on the CD and questionable integrations may be an issue.

PG&E stated that the laboratory analysis performed met all the requirements of the EPA methods employed. Sample Delivery Groups 06G182, 06I248, 06K156, and 06K180 do not meet EPA Method 7199 criteria for acceptable CCV recoveries. The precision of the CCVs and some of the sample duplicates do not meet the precision requirements of EPA Method 7199. Results with much higher accuracy and confidence levels would have been obtained if EPA Method 7199 had been followed.

Sincerely,



Amy Saylor
QA/QC Officer

Excelchem Environmental Labs

ENCLOSURE 2

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Concerned Hinkley Residents
Hinkley, California 92347

22 February 2012

Harold J. Singer, Executive Officer
California Regional Water Quality Control Board
2501 Lake Tahoe Boulevard
South Lake Tahoe, CA 96150

Dear Mr. Singer,

We, the people who live and/or work or own property in Hinkley, respectfully request the Water Board to conclude the 2007 Background Chromium Study by PG&E in accordance with the approved 2004 revised workplan. We want the range of naturally-occurring background chromium values in groundwater recalculated using just the wells, information, and statistics that had been approved by the Water Board. We also request that the Water Board adopt this range of background values for use in the investigation and cleanup of chromium in groundwater of the Hinkley Valley and for determining impacts to domestic, community, and agricultural wells. Further delay in concluding the study is detrimental to the Hinkley residents and the entire Hinkley Valley.

Chromium Background Values for the Hinkley Valley

The Hinkley residents shown on the enclosed lists request that the Lahontan Water Board revise the chromium background values in groundwater for the Hinkley Valley from those originally adopted in November 2008. This request is based upon the October 2011 peer review comments which criticized PG&E's 2007 Background Chromium Study.

Specifically, Hinkley residents respectfully request that the Water Board adopt non-detect levels as background values for hexavalent chromium (CrVI) and total chromium (CrT) based on depth-discrete water samples results in the 2007 Background Study. Or, that the Water Board recalculate background values using just the data obtained from the original wells approved in PG&E's 2004 revised workplan.

History

As the Water Board heard at its March 8, 2011, meeting in Barstow, Hinkley residents are concerned about the chromium background values that were adopted in November 2008. These values were 1.2 ppb average and 3.2 ppb maximum for hexavalent chromium (CrVI) and 1.5 ppb average and 3.2 ppb total chromium (CrT). The adopted values were from a background study conducted in 2006 by PG&E but significantly changed from the revised workplan approved by Board staff in 2004. After review, several residents suspected bias sample collection by PG&E during the 2006 field work and suggested that the Water Board revisit the background study.

During the summer of 2011, the Water Board contracted to have three outside parties provide peer review of the 2007 Background Study. As expected, the peer reviewers were critical of the Background Study, including the type and location of wells sampled, lab QA/QC practices, and statistical assumptions made. Based upon these comments, Hinkley residents have asked Board staff on numerous occasions what will be their recommendation to the Water Board. The answer we usually heard back was "we don't know."

Significance of Background Values

Hinkley residents are very concerned about the numbers representing the chromium background values in groundwater in the Hinkley Valley. Water Board staff have consistently told the public that background values will be used to set cleanup standards for PG&E's chromium plume. Yet, we all know that the background values are used in other applications, including those directly affecting Hinkley residents' daily lives.

As you know, the background values are used to draw the chromium plume boundaries in quarterly reports. PG&E uses these boundaries to decide who is offered bottled water and who isn't, beyond that listed in the Board's October 2011 cleanup and abatement order. PG&E also uses the plume boundaries and chromium values in domestic wells when deciding who to make offers of property purchase and the amount of purchase. Last, background values will be used in the near future for determining which residents will be offered whole house replacement water required in the Board's October 2011 cleanup and abatement order. Use of the chromium background values for the last three reasons listed is of more immediate concern to Hinkley residents than is the overall plume cleanup, which is projected to occur over many decades.

Therefore, the need to set un-biased, revised chromium background values in the Hinkley Valley is one that residents prefer happen sooner rather than later.

Residents' Recommendation

Hinkley residents are recommending that the Water Board use only those portions of the 2007 Background Study that follow PG&E's September 2004 revised workplan. This means that only data obtained from depth-discrete samples and wells sampled during all four quarters in 2006 are valid. As you will recall, the 2004 revised workplan was prepared based on the comments of three University of California peer reviewers. PG&E's deviation in implementing the workplan was not subject to peer review.

The revised workplan stated that PG&E would collect depth-discrete samples from a total of five wells. Since depth-discrete water samples were collected from only two wells, the Water Board should focus on the results from such wells, 36-01 and BGS-24 (located in the upgradient and cross directions of the plume), in which the lab reported non-detect concentrations (0.2 ppb CrVI and 1.0 ppb CrT). There appears to be no evidence in the Background Study that PG&E tried to collect samples from three more wells. This makes Hinkley residents question whether PG&E just abandoned the effort when it became obvious that all depth-discrete samples might end up being non-detect—the true natural chromium background levels in the Hinkley groundwater.

If depth-discrete well sample results are ignored, the Water Board should then focus on just wells that were sampled in all four quarters during 2006. In this case, only data from the original 14 wells would be used for calculating background values and the data from the 34 added wells would be ignored. It is obvious that PG&E included the latter wells to artificially raise the chromium background values, especially since 23 of the 34 wells were from one specific location west of the chromium plume. Using the data obtained from just the original 14 wells, we recommend that the Water Board arrange for someone from academia to apply the appropriate statistical analyses mentioned in the peer review for calculating background values. If these results should show a 5 percent or greater change from the 2008 adopted background values, the new numbers should be adopted by the Water Board as revised background chromium values.

In Conclusion

The results of the October 2011 peer review suggest that PG&E conducted a biased background study that yielded questionable data and statistical results. The unauthorized additions made by PG&E to the

2006 field work over that listed in the 2004 revised workplan were obviously done to promote biased background values greater than what was intended in the workplan approved by Water Board staff.

Given this history, PG&E and its easily-manipulated consultant, CH2MHill, cannot be trusted to conduct a supplemental background study. Furthermore, as one of the peer reviewers noted, extensive agricultural pumping in the Hinkley Valley and the length of time since chromium discharge (now over 50 years), makes it impossible to know what is background groundwater and what isn't. The Hinkley residents fear that PG&E will try to manipulate the Water Board with the suggestion that they will concoct another background study. This would be absurd as who in their right mind would actually believe the results of a new study conducted by PG&E? Most certainly not the Hinkley residents!

In conclusion, the only recourse that is fair to the Hinkley residents is to salvage as much of the 2007 Background Study as possible. This means using only data that was obtained from following the revised workplan approved by Board staff - and nothing else. This data would yield chromium background values which are more realistic and more likely to be accepted by the Hinkley residents. The apparent biases reflected in current background values from PG&E's flawed background study will never be accepted by the Hinkley residents. Using relevant data from the 2007 Background Study will provide revised background values that can be used in the *immediate* future as well as the long-term future.

Hinkley residents look forward to your decision on evaluating the adoption of revised chromium background values.

Sincerely,

Carmela Spasojevich, a Hinkley property owner
On behalf of the Hinkley Residents (Please see attached petitions)

Enclosure: Signed Petitions Listing Hinkley Residents Supporting this Letter (2 pages)

To: The California Regional Water Quality Control Board, Lahontan Region

We, the people who live and/or work in Hinkley, respectfully request the Water Board to conclude the 2007 Background Chromium Study by PG&E, in accordance with the approved 2004 revised workplan. We want the range of naturally-occurring background chromium values in ground water re-calculated using just the wells, information, and statistics that had been approved. And we want the Water Board to adopt this range of background values for use in the investigation and cleanup of chromium in ground waters of the Hinkley Valley and for determining impacts to domestic, community, and agricultural wells. Further delay in concluding the study is detrimental to Hinkley.

Printed Name	Signature	I Live in Hinkley (check here)	I work in Hinkley (check here)
1. Karen Dodd	<i>Karen Dodd</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2. JAMES DODD	<i>James Dodd</i>	<input checked="" type="checkbox"/>	
3. Jackie Sones	<i>Jackie Sones</i>	<input checked="" type="checkbox"/>	
4. NAZ AWAD	<i>Naz Awad</i>	<input checked="" type="checkbox"/>	
5. Richard L'EVEALY	<i>Richard L'Evealy</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
6. Patricia Dickmann	<i>Patricia Dickmann</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
7. Elaine Kearney	<i>Elaine L. Kearney</i>	<input checked="" type="checkbox"/>	
8. Barbara Groveau	<i>Barbara Groveau</i>	<input checked="" type="checkbox"/>	
9. Greg Kearney	<i>Greg Kearney</i>	<input checked="" type="checkbox"/>	
10. PAUL GREENBERG	<i>Paul Greenberg</i>	<input checked="" type="checkbox"/>	
11. Sandra K. Wetherington	<i>Sandra K. Wetherington</i>	<input checked="" type="checkbox"/>	
12. ROGER SANDOZ	<i>Roger Sandoz</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
13. Joyce White	<i>Joyce White</i>	<input checked="" type="checkbox"/>	
14. YVONNE NETHERY	<i>Yvonne Nethery</i>	<input checked="" type="checkbox"/>	
15. HERBERT NETHERY	<i>Herbert Nethery</i>	<input checked="" type="checkbox"/>	
16. Scott Haislip	<i>Scott Haislip</i>	<input checked="" type="checkbox"/>	
17. SHARON HAISLIP	<i>Sharon Haislip</i>	<input checked="" type="checkbox"/>	
18. Daron Banks	<i>Daron Banks</i>	<input checked="" type="checkbox"/>	

To: The California Regional Water Quality Control Board, Lahontan Region

We, the people who live and/or work in Hinkley, respectfully request the Water Board to conclude the 2007 Background Chromium Study by PG&E, in accordance with the approved 2004 revised workplan. We want the range of naturally-occurring background chromium values in ground water re-calculated using just the wells, information, and statistics that had been approved. And we want the Water Board to adopt this range of background values for use in the investigation and cleanup of chromium in ground waters of the Hinkley Valley and for determining impacts to domestic, community, and agricultural wells. Further delay in concluding the study is detrimental to Hinkley.

Printed Name	Signature	I Live in Hinkley (check here)	I work in Hinkley (check here)
1. JAY POTTER	<i>J Potter</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2. McHENRY Cooke	<i>Matthew Cooke</i>	<input checked="" type="checkbox"/>	
3. Gina Romero	<i>Gina Romero</i>	<input checked="" type="checkbox"/>	
4. Gilbert Romero	<i>Gilbert Romero</i>	<input checked="" type="checkbox"/>	
5. Amber Dodd	<i>Amber Dodd</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
6. IAN FRAZIER	<i>Ian Frazier</i>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
7. Virginia A. Davis	<i>Virginia A. Davis</i>	<input checked="" type="checkbox"/>	
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ENCLOSURE 3

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**Pacific Gas and
Electric
Company**

Kevin M. Sullivan
Principal Remediation
Specialist
Hinkley Remediation
Project

3401 Crow Canyon Rd
San Ramon, CA 94583
(925) 818-9069 (cell)
kmsu@pge.com

February 22, 2012

Ms. Lauri Kemper, Assistant Executive Officer
Ms. Lisa Dernbach, Senior Engineering Geologist
California Regional Water Quality Control Board, Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, California 96150

Subject: Proposed Work Plan for Evaluation of Background Chromium in the Upper
Aquifer of the Hinkley Valley, Pacific Gas and Electric Company's Hinkley
Compressor Station, Hinkley, California

Dear Ms. Kemper and Ms. Dernbach:

Pacific Gas and Electric Company (PG&E) is pleased to submit this draft Work Plan for Evaluation of Background Chromium in the Groundwater of the Upper Aquifer in the Hinkley Valley (Work Plan). The Work Plan proposes the collection and evaluation of additional data to expand on the 2007 *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California*.

In 2011, Water Board staff submitted the 2007 study to three technical individuals with expertise in the fields of hydrogeology, statistics, and laboratory analysis. Many of the concerns raised by the peer reviewers were shared by PG&E and their technical staff, and this Work Plan addresses the comments that were provided by the reviewers. PG&E anticipates the Work Plan will undergo independent peer review, and we look forward to receiving that input and working with the Water Board to finalize the scope of work. Since the cleanup goal for the Hinkley chromium groundwater plume is background (presently as defined by the 2007 study), it is critical to address the peer review comments of the 2007 study, and to further assess the background conditions in Hinkley in a manner that fosters consensus.

Please feel free to call me if you have any questions regarding the information presented in the attached report.

Sincerely,

Kevin M. Sullivan
Hinkley Remediation Project Manager

**Work Plan for Evaluation of
Background Chromium in the
Groundwater of the Upper Aquifer in
the Hinkley Valley, Pacific Gas and
Electric Company, Hinkley California**

Stantec PN: 185702482



February 22, 2012

WORK PLAN FOR EVALUATION OF BACKGROUND CHROMIUM IN THE GROUNDWATER OF THE UPPER AQUIFER IN THE HINKLEY VALLEY, PACIFIC GAS AND ELECTRIC COMPANY, HINKLEY CALIFORNIA

Limitations and Certifications

February 22, 2012

Limitations and Certifications

This Work Plan was prepared for the exclusive use of Pacific Gas and Electric Company. Any re-use of this report for a different purpose or by others not identified above shall be at the user's sole risk without liability to Stantec. To the extent that this report is based on information provided to Stantec by third parties, Stantec may have made efforts to verify this third party information, but Stantec cannot guarantee the completeness or accuracy of this information. The opinions expressed and data collected are based on the conditions of the site existing at the time of the field investigation. No other warranties, expressed or implied are made by Stantec.

Prepared by:



Chris R. Maxwell, P.G.
Principal Geologist

Reviewed by:



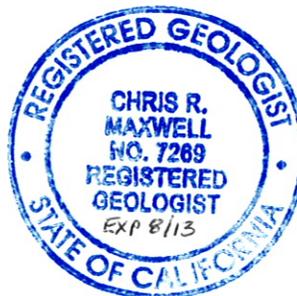
William DeBoer
Geologic Associate

Information, conclusions, and recommendations provided by Stantec in this document has been prepared under the supervision of and reviewed by the licensed professional whose signature appears below.

Licensed Approver:



Chris R. Maxwell, P.G., #7269
Principal Geologist



WORK PLAN FOR EVALUATION OF BACKGROUND CHROMIUM IN THE GROUNDWATER OF THE UPPER AQUIFER IN THE HINKLEY VALLEY, PACIFIC GAS AND ELECTRIC COMPANY, HINKLEY CALIFORNIA

Executive Summary

February 22, 2012

Executive Summary

On February 28, 2007, Pacific Gas and Electric Company (PG&E) submitted the *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California* (CH2M HILL, 2007). The report presented the data, analysis, and conclusions of a study completed by PG&E to estimate the 95 percent upper tolerance limit (95UTL) concentrations of total dissolved chromium (CrT) and hexavalent chromium (Cr6) in groundwater of the upper aquifer in the Hinkley Valley. The study was conducted following Lahontan Regional Water Quality Control Board (Water Board) staff approval of the *Revised Background Study Work Plan, PG&E Compressor Station, Hinkley, California* (CH2M HILL, 2004). The approved work plan incorporated comments from Water Board staff, and input from three University of California (UC) peer reviewers.

The February 2007 Background Study Report concluded that the 95UTL concentrations for CrT and Cr6 in groundwater of the Hinkley Valley are 3.23 micrograms per liter ($\mu\text{g/L}$) and 3.09 $\mu\text{g/L}$, respectively. These values were intended to describe the upper range of chromium concentrations that are unrelated to the historic release of chromium at the PG&E Compressor Station (*i.e.*, background concentrations). On November 18, 2008, the Water Board adopted amended Cleanup and Abatement Order (CAO) No. R6V-2008-0002A1. The amended CAO requires, for the purposes of evaluating remediation strategies, that the maximum background concentrations of CrT and Cr6 shall be 3.2 and 3.1 $\mu\text{g/L}$, respectively.

Since adoption of the amended CAO in November 2008, PG&E has installed approximately 157 new short-screened (*i.e.*, typically 10 to 20 feet in length) monitoring wells in the Upper Aquifer at 85 locations, in an effort to further define the distribution of chromium at concentrations above the established background values. Assuming the established background values are representative of conditions in the upper aquifer, the lateral boundaries of the PG&E plume are now depicted as approximately five (5) miles long (north to south) and up to two and three-quarters (2.75) miles wide (east to west). This area is three (3) miles further to the north and one (1) mile further to the east than was depicted in November 2008. The change in plume depiction is based on the inclusion of data from the new short-screen monitoring wells installed by PG&E since November 2008 in areas where data did not previously exist (primarily north of Thompson Road and east of Summerset Road). Cr6 concentrations for the majority of these new data are less than 5.0 $\mu\text{g/L}$.

Peer Review of the Background Study Report

In 2011, Water Board staff submitted the February 2007 Background Study Report to three technical individuals with expertise in the fields of hydrogeology, statistics, and laboratory analysis. Peer reviewer comments were provided by Water Board staff on October 14, 2011. Many of the concerns raised by the reviewers were shared by PG&E and their technical staff; other concerns can be resolved by considering the entirety of the work performed before, during, and after the background study. The peer reviewer comments, along with PG&E responses, are included in this document as Appendix A. The scope of

WORK PLAN FOR EVALUATION OF BACKGROUND CHROMIUM IN THE GROUNDWATER OF THE UPPER AQUIFER IN THE HINKLEY VALLEY, PACIFIC GAS AND ELECTRIC COMPANY, HINKLEY CALIFORNIA

Executive Summary

February 22, 2012

work proposed herein was developed in consideration of these comments. Peer reviewer comments can generally be summarized as follows:

Sampling was Performed Using Wells not constructed for Discrete Sampling in the Upper Aquifer – Data was collected from long-screened domestic or agricultural wells, for which in most cases PG&E does not have documentation of well construction. It is likely the majority of these wells have very long screens, some of which penetrate both the upper and lower aquifers. Data collected from these long-screened wells is not comparable to data collected from the monitoring wells installed by PG&E to evaluate the boundaries of the chromium plume, which have short screens (typically 10 to 20 feet) and do not penetrate multiple aquifers.

The Spatial Distribution of Wells was Uneven – The background study relied on samples collected from existing domestic and agricultural wells, many of which are clustered in specific geographic areas. The clustering of wells in some areas, and the absence of wells in others, may have resulted in spatial bias of the 95UTL values (*i.e.*, statistical weight was given to a few geographic areas of the Hinkley Valley).

The Statistical Analysis of Data was Inappropriate – Several issues were identified pertaining to how the groundwater data was statistically evaluated. Some wells were sampled four times in the study (quarterly for one year), while others were sampled only one or two times. The average concentration for each well (regardless of the number of samples collected) was used to develop single 95UTL values for the entire population of wells.

Laboratory Analytical Methods were Inconsistent and Quality Control was Inadequate – Several concerns were noted with the laboratory analysis for CrT and Cr6, including potential quality control issues with one of the two laboratories used during the study. Three different Environmental Protection Agency (EPA) laboratory methods for Cr6 were used for the study (218.6, 7199, and 7196A), and the varying methods could provide different results – especially at the low detection concentrations.

Areas thought to be Outside the Plume May Have Been Effectuated by Historic Pumping for Agriculture – Groundwater affected by the chromium plume has historically been used to irrigate crops in the Hinkley Valley, both by farmers in the past and by PG&E as part of the historic and current remedial actions. There is a concern raised by reviewers that historic agricultural pumping by farmers in areas outside the current plume boundary may have pulled the plume to these areas in the past.

Chromium Data Collected Since the Prior Background Study Report

The Hinkley Valley is approximately five and one-half (5.5) miles north to south, and three (3) miles east to west at its widest point. With the installation and sampling of approximately 157 monitoring wells since November 2008, PG&E has assessed chromium concentrations across the majority of the valley, including wells at the far northern extent near Red Hill (where chromium concentrations exceed the established maximum background values). If these established maximum background values are accurate, and if one assumes that all detections above these values are attributable to PG&E's chromium

WORK PLAN FOR EVALUATION OF BACKGROUND CHROMIUM IN THE GROUNDWATER OF THE UPPER AQUIFER IN THE HINKLEY VALLEY, PACIFIC GAS AND ELECTRIC COMPANY, HINKLEY CALIFORNIA

Executive Summary

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plume, then PG&E's plume would essentially extend from the compressor station in the south to the northern end of the valley.

However, there are lines of evidence suggesting that maximum background values for Cr6 and CrT could be higher in some areas of the Hinkley Valley than the levels established in the 2007 background study.

These include:

- ❑ The absence of a south to north concentration gradient north of Thompson Road (*i.e.*, wells throughout the northern part of the basin contain similar chromium concentrations, rather than decreasing concentrations in the downgradient direction);
- ❑ The tendency for Cr6 and CrT to be present at concentrations above established background levels primarily in wells installed at or near the water table; and,
- ❑ The presence of chromium at concentrations above established background levels in at least one domestic well (34-65) that is hydraulically upgradient of PG&E's plume. Three samples collected in 2011 from well 34-65 exhibited Cr6 concentrations above 3.1 µg/L. After thoroughly assessing the potential for this well to be affected by the chromium plume, PG&E and the Water Board staff concluded that it was infeasible for the plume to have migrated to this location (based on several factors, including historic and current groundwater flow direction, and the projection of the Lockhart Fault between the plume and the well).

Proposed Additional Evaluation of Background Chromium Conditions

This Work Plan proposes the collection and evaluation of additional data to further assess background chromium concentrations in the groundwater of the Hinkley Valley. The scope of work proposed herein expands upon the prior background study, and addresses the comments that were provided by the peer reviewers.

The proposed scope consists of the installation and sampling of short screen monitoring wells in the upper aquifer. New short-screened monitoring wells will be installed and sampled outside the boundaries of PG&E's chromium plume (as defined by the established background levels). Well locations will be based upon a grid pattern. The number of locations for new wells will depend upon access, and is estimated to be between 25 and 40. Considering multiple wells will be installed at most locations (each screened in a discrete interval of the upper aquifer), the total number of new wells will likely be greater than 50.

A select number of the new short-screen monitoring wells will be located in immediate proximity to long-screen wells sampled during the prior background study. Sampling of both the new short-screen wells and the existing long-screen wells sampled during the 2007 study will provide data to assess background chromium concentration variability in the upper aquifer, and allow comparison with the findings of the prior study.

WORK PLAN FOR EVALUATION OF BACKGROUND CHROMIUM IN THE GROUNDWATER OF THE UPPER AQUIFER IN THE HINKLEY VALLEY, PACIFIC GAS AND ELECTRIC COMPANY, HINKLEY CALIFORNIA

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New monitoring wells will be sampled quarterly for at least one year (4 samples), with all wells sampled an equal number of times and during the same quarters (*i.e.*, sampling will generally not be initiated until all the wells are in-place and ready for sampling). Using these new data, statistical analyses will be performed with the objective of identifying 95UTL values for maximum background CrT and Cr6 concentrations. Average results will not be used as part of the statistical evaluation.

Schedule

Upon completion of the study, PG&E will prepare a technical report that presents the methods, data, statistical analysis, and conclusions of the assessment. Considering the time required to complete biological clearance and secure property access, install numerous new short-screened monitoring wells, and collect at least four quarters of groundwater data, the timeframe to perform the study and prepare a technical report will be at least two years. PG&E will provide semi-annual progress reports to the Water Board, beginning 180 days following approval of this Work Plan. Each report will provide an update to the schedule for completion of the study and submittal of a technical report.

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List of Acronyms

AU	agricultural unit
BDRK	bedrock
CAO	Cleanup and Abatement Order
CCL	confining clay layer
Cr3	trivalent chromium
Cr6	hexavalent chromium
CrT	total chromium
DCU	deep clay unit
DVD	Desert View Dairy
DWR	Department of Water Resources
ft-bgs	feet below ground surface
ft/ft	feet per foot
LA	lower aquifer
LTU	Land Treatment Unit
MCL	maximum contaminant level
µg/L	micrograms per liter
MWA	Mojave Water Agency
ND	non-detect
NHVB	North Hinkley Valley Basin
PVC	polyvinyl chloride
SED	sedimentary deposits
SHVB	South Hinkley Valley Basin
TDS	total dissolved solid
UA	upper aquifer
UC	University of California
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
Water Board	Regional Water Quality Control Board
WBRK	weathered bedrock material
95 UTL	95 percent upper tolerance limit

1.0 Introduction

On February 28, 2007, Pacific Gas and Electric Company (PG&E) submitted the *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California* (CH2M HILL, 2007). The report concluded that the 95 percent upper tolerance limit (95UTL) concentrations for background (non-PG&E plume) concentrations of total dissolved chromium (CrT) and hexavalent chromium (Cr6) in the Hinkley Valley are 3.23 micrograms per liter ($\mu\text{g/L}$) and 3.09 $\mu\text{g/L}$, respectively. On November 18, 2008, the Lahontan Regional Water Quality Control Board (Water Board) adopted amended Cleanup and Abatement Order (CAO) No. R6V-2008-0002A1 requiring that the values of 3.2 $\mu\text{g/L}$ for CrT and 3.1 $\mu\text{g/L}$ for Cr6 be used to represent maximum background chromium conditions in remedial evaluations for the Site.

In 2011, Water Board staff provided the 2007 Background Study Report to three individuals for peer review. In summary, the peer reviewers expressed concern regarding the methods and findings of the study and suggested the established CrT and Cr6 background values may not be supported by the technical data. In summary, the concerns included:

- ❑ ***Sampling was Performed Using Wells not Constructed for Discrete Sampling in the Upper Aquifer*** – Data was collected for the study from long-screened domestic or agricultural wells, for which in most cases PG&E does not have any documentation of well construction. Data collected from these long-screened wells is not comparable to data collected from monitoring wells installed by PG&E to evaluate the boundaries of the chromium plume, which have short-screens (typically 10 to 20 feet) and do not penetrate multiple aquifers;
- ❑ ***The Spatial Distribution of Wells was Uneven*** – The background study relied on samples collected from existing domestic and agricultural wells, many of which are clustered in specific geographic areas. The clustering of wells in some areas, and the absence of wells in others, may have resulted in spatial bias;
- ❑ ***The Statistical Analysis of Data was Inappropriate*** – Several issues were identified pertaining to how the groundwater data was statistically evaluated. Wells were not sampled an equal number of times; the average concentration for each well was used to develop single 95UTL values;
- ❑ ***Laboratory Analytical Methods were Inconsistent and Quality Control was Inadequate*** – There were potential quality control issues with one of the two laboratories used during the study, and three different Environmental Protection Agency (EPA) laboratory methods for Cr6 were used (218.6, 7199, and 7196A). The varying methods could provide different results – especially at the low detection concentrations; and,

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- ❑ ***Areas thought to be Outside the Plume May Have Been Affected by Historic Pumping for Agriculture*** – Groundwater affected by the chromium plume has historically been used to irrigate crops in the Hinkley Valley, both by farmers in the past and by PG&E as part of the historic and current remedial actions. There is a potential that historic agricultural pumping by farmers in areas outside the current plume boundary may have pulled the plume to these areas in the past.

In response to the peer reviewer comments and in consideration of data collected since the 2007 Background Study Report was prepared, PG&E has prepared this *Work Plan for Evaluation of Background Chromium in the Groundwater of the Upper Aquifer in the Hinkley Valley* (Work Plan). This Work Plan proposes additional assessment to more thoroughly evaluate the background concentrations of CrT and Cr6 in the Hinkley Valley. Background concentrations are defined here as any and all chromium concentrations that are present in groundwater in the Hinkley Valley as a result of natural and anthropogenic sources unrelated to releases from PG&E's compressor station.

Figure 1 shows the site location. Figure 2 shows the site layout, including select monitoring well locations and lines of geologic cross-section illustrated in this report. Table 1 lists the groundwater laboratory analyses and methods that may be conducted during the investigation.

As discussed in Section 3, new short-screened monitoring wells will be installed and sampled at 25 to 40 locations outside the boundaries of the chromium plume as it is currently depicted using the established background values. New monitoring wells will be sampled quarterly for at least one year (4 samples), and data will be statistically evaluated. A select number of the short-screen wells will be placed in immediate proximity to long screen wells sampled during the prior background study.

Section 4 discusses several factors to consider in assessing background chromium in the groundwater of the upper aquifer in the Hinkley Valley. Items discussed in Section 4 are: (1) sediment mineralogy and groundwater geochemistry; (2) tracers in groundwater, including chromium isotopes; and, (3) chromium at the water table and the potential effects of unsaturated zone and capillary fringe pore water.

2.0 Background Information

The following provides background information for the proposed scope of work.

2.1 GEOLOGIC AND HYDROLOGIC SETTING

The geologic and hydrologic conditions of the Hinkley Valley and surrounding areas likely have a substantial effect on background chromium in groundwater. Several historic and recent reports submitted to the Water Board by PG&E provide a discussion on the geologic and hydrologic setting for the Hinkley Valley and surrounding areas. These reports include:

- ❑ *Revised Background Study Work Plan* (CH2M HILL, September 2004);
- ❑ *Groundwater Background Study Report* (CH2M HILL, February 2007);
- ❑ *Feasibility Study and Remedial Action Plan* (Haley and Aldrich, August 2010);
- ❑ *Technical Report – Response to Investigation Order No. R6V-2011-0043 – Delineation of Chromium in the Lower Aquifer* (Stantec, August 2011);
- ❑ *Technical Report – Response to Investigation Order No. R6V-2011-0043 – Delineation of Chromium in the Upper Aquifer* (Stantec, September 2011); and,
- ❑ *Technical Memorandum – Update to Upper Aquifer Groundwater Investigation Activities* (Stantec, February 2012).

The documents prepared by Stantec in 2011 and 2012 present the findings of recent investigations performed by PG&E. The following incorporates information from these documents, to provide a comprehensive overview of the geologic and hydrologic setting as they relate to the studies proposed herein.

2.1.1 Geology

Figure 3 illustrates the geology of the Hinkley Valley and surrounding areas as interpreted by others. The Hinkley Valley is an alluvial basin bounded by mapped and/or inferred fault structures and bedrock highlands. Exposed bedrock surrounding the Hinkley Valley includes:

- ❑ **East** – Mesozoic igneous and metamorphic rocks (primarily quartz diorite gneiss, quartz monzonite/diorite, and latite/felsite) and Tertiary volcanic rocks (intrusive dacite and andesitic to rhyolitic tuff breccia);

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- ❑ **South** – Tertiary sedimentary and volcanoclastic rocks;
- ❑ **Southwest** – Mesozoic diorite, gabbro, and older granitic and metamorphic rocks (gneiss, schist, and marble); and,
- ❑ **Northwest** – Mesozoic quartz monzonite and quartz diorite gneiss.

The Lockhart Fault has been inferred by others to be present along the western margin of the valley, and may be a bounding geologic structure for the Hinkley Valley basin. The Mt. General Fault has been mapped by others along the eastern margin of the valley, and may also be a bounding geologic structure.

A generalized stratigraphic column for the geology of the Hinkley Valley is provided on Figure 4, including descriptions of the various geologic units encountered during the most recent investigations by PG&E (Stantec, 2011 and 2012). The study area includes the South Hinkley Valley Basin (SHVB) and the North Hinkley Valley Basin (NHVB). The conceptual geographic boundary for these two basins is illustrated on Figure 5.

2.1.1.1 Upper Aquifer Sediments

The following discusses the upper aquifer geologic units, from oldest to youngest (bottom to top of the stratigraphic column – Figure 4). Geologic cross-sections along the north-south (A-A') and east-west (B-B') axes of the valley are provided as Figures 6 and 7, respectively. The lines of section are shown on Figure 2.

- ❑ **Consolidated Bedrock (BDRK)** – In some areas, the base of the upper aquifer is defined by consolidated bedrock. A relatively thin layer of weathered bedrock materials (WBRK) is typically found overlying the rock. The BDRK unit is the base of the upper aquifer where the Lower Aquifer Confining Clay Layer (LA CCL) is absent. Bedrock encountered during PG&E investigations is typically granite, diorite, gneiss, and silicic limestone. Other types of bedrock encountered in the Hinkley Valley are discussed in Section 2.1.1 above, including volcanic rocks.
- ❑ **Lower Aquifer Confining Clay Layer (LA CCL, the “Blue Clay”)** – The base of the upper aquifer is defined in most areas by the LA CCL, which was deposited in a shallow lacustrine environment. In most areas, the clay was deposited directly on top of BDRK (or WBRK). In some areas, sedimentary deposits are present beneath the LA CCL (lower aquifer sedimentary deposits – LA SED).
- ❑ **Upper Aquifer Lower Zone (A2 Zone)** – The blue clay was eroded by streams that generally trended from south to north as they flowed through the SHVB and into the NHVB. The streams deposited sandy materials on top of the LA CCL, which are the sediments of the A2 zone. The sandy materials are much thicker and coarser grained in some areas than in others.

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In the NHVB, the A2 zone is relatively thin, and is absent in some areas. A deeper unit consisting of brown and red-brown clay with minor sand lenses and clasts of weathered bedrock is present below the A2 sandy sediments (primarily in the NHVB). This unit is referred to herein as the A2 Deep Clay Unit (A2 DCU), and appears to reside directly over BDRK in most areas where the A2 DCU is present.

- ❑ **Upper Aquifer Confining Clay Layer (UA CCL, the “Brown Clay”)** – A second clay (UA CCL) unit was deposited on top of the A2 zone sands, also likely in a lacustrine environment. The bottom of the UA CCL defines the top of the A2 zone, and the top of the UA CCL defines the base of the A1 zone (see below). Note that the thickness and topography reflect both the deposition of the clay and the subsequent erosion that occurred during the deposition of the A1 sediments. The UA CCL is absent in some areas, and the A1 and A2 deposits may be in direct contact.

- ❑ **Upper Aquifer Shallow Zone (A1 Zone)** – The UA CCL was subsequently eroded by streams, similar to the depositional environment of the A2 zone. The streams that deposited A1 sediments also generally trended from south to north, as they flowed through the SHVB and into the NHVB.

The primary route of the A1 zone streams appears to have been in the eastern part of the SHVB, extending northward to the Gorman Agricultural Unit (AU) and through the bedrock choke point at the north end of the SHVB. This is in contrast to the A2 sediments, which appear to have been deposited primarily in the SHVB. The areas of thick A1 sediments coincide with thin UA CCL sediments in this area.

In contrast to the A2 sediments, the streams that deposited the A1 sandy sediments appear to have extended significantly northward into the NHVB. The current thickness of saturated A1 sandy sediments ranges from 30 to 50 feet in the central portion of the NHVB. When groundwater levels were historically higher (20 to 30 feet higher in 1960 compared to current levels), the A1 saturated sediments were upwards of 50 to 80 feet thick in some areas.

Where bedrock is relatively shallow, the UA CCL is not present and the UA has been separated using the following nomenclature: a shallow (S) zone that is primarily silt and sand with some clay, and a deeper (D) zone that is primarily silt and clay. Depending on location, these sediments may have similar age to the A1 or A2 zones. Shallow bedrock is typically found near the east, west, and north margins of the basin and at the boundary between the SHVB and NHVB basins (at the “choke point” near the Desert View Dairy [DVD] and Gorman AU).

2.1.1.2 Lower Aquifer Sediments

The Lower Aquifer sediments are those unconsolidated materials below the LA CCL (Blue Clay) and above the consolidated bedrock. PG&E has installed several monitoring wells into the lower aquifer, and these investigations are documented in several reports, the most recent being the *Technical Report* –

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Response to Investigation Order No. R6V-2011-0043 – Delineation of Chromium in the Lower Aquifer (Stantec, 2011).

In most areas where the lower aquifer has been investigated by PG&E, the materials are primarily WBRK that immediately overlies the consolidated rock. The thickness of weathered rock varies from a few feet to tens of feet. In some areas of the Hinkley Valley (primarily east of Summerset Road), the lower aquifer is reported to include relatively thick sections of coarse-grained sediments (LA SED) that lie between the overlying LA CCL and the consolidated rock.

2.1.2 Hydrology

The following provides a discussion of groundwater hydrology for the Hinkley Valley basin.

2.1.2.1 Regional Hydrology

As designated by the California Department of Water Resources (DWR), the Hinkley Valley lies within the Harper Valley Groundwater Basin. The Harper Valley Basin is bounded: (1) to the east by non-water-bearing rocks of Fremont Peak, Black Mountain, Gravel Hills, and the Mud Hills; and (2) to the west by a combination of surface drainage divides; portions of the Harper, Kramer Hills, and Lockhart Faults; and non-water-bearing rocks of the Kramer Hills and other low-lying basement hills (DWR, 2004). The Harper Valley Groundwater Basin (Number 6-47) comprises approximately 410,000 acres or 640 square miles.

The United States Geological Survey (USGS) considers the entire Mojave River groundwater basin to be a topographically closed basin that drains towards various playas (USGS, 2004). The primary source of natural recharge to the basin is the Mojave River. The river contributes more than 80 percent of the natural recharge to the basin. The climate of the Mojave Desert is typical of arid regions characterized by low precipitation, low humidity, and high summer temperatures. As a result, there is essentially little to no groundwater recharge from precipitation due to the high rate of evapotranspiration. The typical amount of rainfall is approximately less than 5 inches per year, and the evaporation rates are approximately over 100 inches per year. In the vicinity of the site, the regional groundwater flow direction is to the north, from the Mojave River towards Harper Lake.

2.1.2.2 Groundwater Occurrence and Flow

The depth-to-groundwater in the upper aquifer, as measured in the investigation wells installed by PG&E throughout the Hinkley Valley, ranges from approximately 65 to 100 feet below ground surface (ft-bgs). The saturated Upper Aquifer thickness ranges from approximately 15 feet where bedrock is relatively shallow, to upwards of 100 feet thick where the top of the LA CCL is relatively deep (170 to 180 ft-bgs).

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The horizontal component of groundwater flow at the site is similar to the regional flow direction. Groundwater in the Upper and Lower Aquifers generally flows in a north-northwesterly direction, from the compressor station to the northern end of the Hinkley Valley. Horizontal gradients in the upper aquifer, in the absence of pumping or injection, generally range from 0.002 to 0.004 feet per foot (ft/ft). Based on tracer studies completed by PG&E as part of remedial activities, groundwater velocity (not influenced by gradients induced by pumping or injection) ranges from approximately 1 to 3 feet per day.

Groundwater flow in the shallow and deep portions of the Upper Aquifer is shown on Figures 8 and 9, respectively. Groundwater flow in both zones is influenced by PG&E's remedial pumping at the DVD Land Treatment Unit (LTU), and at several AUs located in the vicinity of the DVD LTU.

2.1.2.3 USGS Tritium Studies

The USGS has performed analysis of the tritium composition of water to evaluate sources and movement of groundwater in the Mojave groundwater basin (USGS, 2004). The USGS considered groundwater containing detectable tritium as water that recharged the aquifer after 1952. The compressor station is located in an area with detectable tritium (see Figure 10), suggesting groundwater in this area is from recent recharge along the Mojave River. The downgradient areas exhibit conditions of older groundwater (where tritium was not detected).

2.1.3 Hydrologic Effects of Fault Structures

The Lockhart Fault is considered to be a partial barrier to groundwater flow, as discussed by Mendez and Christensen (1997) in California's groundwater Bulletin 118 (DWR, 2003). Figure 11 shows the mapped and projected/inferred location of several fault structures, including the Lockhart Fault, which is a northwest-trending, right-lateral, strike-slip fault. The Lockhart Fault and other strike-slip faults in the Mojave River groundwater basin are described to be "...barriers or partial barriers to groundwater flow...resulting in stair-step like drops in the water table across the fault zones," (USGS, 2001).

The location of the Lockhart Fault is approximate and based on published reports (California Division of Mines and Geology, 1994; USGS, 2001). The section of fault that is inferred or projected to be present in the Hinkley Valley is estimated to be of Quaternary-age, with no evidence of historic or Holocene Fault movement or surface offset within the study area (Jennings, 1994).

The Mt. General Fault is mapped and inferred in some areas to be located along the eastern flank of the Hinkley Valley. To date, PG&E has not installed many monitor wells on the eastern side of the inferred or mapped portions of the fault. The hydrologic effect of the fault on the saturated alluvial sediments, if any, has not been fully assessed by PG&E.

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2.1.4 Historic Changes in Groundwater Levels

The Hinkley Valley lies within the Basin and Range groundwater system, which is naturally arid with high evapotranspiration rates, such that little to no precipitation infiltrates to the water table. The dominant natural hydrogeologic processes are recharge to the groundwater system from the Mojave River from the south (upgradient), and groundwater flow towards Harper Lake in the north (downgradient) – where the groundwater evaporates.

Historically, depth-to-groundwater in much of the valley was less than 60 feet. Groundwater flow has been significantly influenced by groundwater withdrawals for irrigation (Durbin and Hardt, 1974). Pumping, primarily for the irrigation of alfalfa, began in the early 1930s and peaked in the mid-1950s, when about 278,000 acre-feet per year were extracted for irrigation. The irrigation pumping significantly dewatered the shallow aquifer; water level changes from 1930 to 1970 were over 60 feet in the center of the valley (DWR, 1967; Mojave Water Agency, 1983). Pumping included wells screened in the upper and lower aquifers, and in some areas, wells were likely extended into the bedrock.

Water levels exhibited a significant downward trend from 1950 to at least 1970. These long-term trends effectively reduced well yields. As a result, much of the irrigated land was abandoned during the next three decades. In the early 1990s, only about 130,000 acre-feet per year were extracted for irrigation, less than 50 percent of mid-1950s withdrawal rates.

In the 1990s several parties in the downstream areas of the Mojave River filed suit against several parties in the upstream areas over declining groundwater levels in the downstream areas. The Mojave Water Agency (MWA) took on the role of mediator, and eventually a Stipulated Agreement (Agreement) was signed by most parties throughout the Mojave River watershed. The Agreement mandated reduced annual pumping volumes throughout the basin. Since implementation of these efforts, coupled with periodic discharges by the MWA of surface water from Silverwood Lake into various recharge basins (one of the basins is located about one (1) mile southeast of the compressor station), groundwater levels have risen approximately 5 to 15 feet in most parts of the Hinkley Valley.

2.2 2007 BACKGROUND STUDY

The 2007 background study consisted of a statistical analysis of chromium concentrations in groundwater samples obtained from 48 long-screened private supply wells. Well construction information for these wells was in many cases unavailable, as the information is private (CH2M HILL, 2007). The maximum detected CrT value was 3.15 µg/L at well BGS-32. The maximum detected Cr6 value was 2.69 µg/L at well BGS-47. The lowest chromium concentrations in the prior background study (several results were below the laboratory method reporting limit) were typically observed in samples collected near the Mojave River.

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Construction details and well logs were available for only 20 of the 48 wells that were sampled during the study. The available information indicates that wells were often screened across both the Upper and Lower Aquifers with well screens up to 320 feet long. It is likely some wells extend into BDRK. According to the available logs, only four wells were screened exclusively across the Upper Aquifer.

In the *Revised Background Chromium Study Work Plan, PG&E Compressor Station, Hinkley, California* (CH2M HILL, 2004), depth-specific groundwater sample collection was planned at up to 41 wells. However, depth-specific groundwater samples were collected at only one well, located adjacent to the Mojave River and south of the Hinkley Compressor Station. Lack of access for depth-discrete sampling devices in private domestic wells identified for this activity prevented further sample collection.

The 2007 background study also included collection of groundwater samples for analysis of chromium isotopes and various geochemical parameters, including base ions and cations. Neither the isotope nor geochemical data conclusively demonstrated a clear correlation between any of these parameters and background versus PG&E-related sources of chromium.

On October 14, 2011, the Water Board issued peer review comments on the 2007 Background Study Report. The peer review was provided by three individuals: Dr. Yoram Rubin, a professor at University of California Berkeley specializing in hydrogeology and geostatistics; James Jacobs, PG, CHG of the Clearwater Group; and Dr. Stuart Nagourney, a chemistry professor at The College of New Jersey (Water Board, 2011). The peer reviewer comments are summarized in Section 1 of this report. The comments, along with PG&E's responses, are provided in Appendix A. The scope of work proposed in this Work Plan address the issues raised by the reviewers.

2.3 CHROMIUM STUDIES PERFORMED BY OTHERS

The following discusses chromium information that has been collected by others, including studies in the Mojave River Basin. In summary, these studies indicate that Cr6 is present in groundwater of the Mojave River Basin over a relatively wide range of concentrations. Table 2 provides a listing of references for independent chromium studies, many of which were conducted in the western Mojave Desert. Table 2 also includes a summary of the findings of each study, and the CrT and/or Cr6 concentration(s) that were reported.

Chromium is the seventeenth most abundant element in the earth's crust (Hem, 1989) and occurs naturally in groundwater in alluvial aquifers of the western part of the Mojave Desert (Ball and Izbicki, 2004), in the southwestern United States (Robertson, 1975, 1991), and in other parts of the United States (Izbicki et al., 2008). Background chromium exists in the environment in several forms, most notably as trivalent chromium (Cr3), which typically exists as a simple cation or as various hydroxide ions, and Cr6, which typically exists as the chromate or dichromate oxide anions (Hem, 1989).

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Chromium concentrations exceeding the California maximum contaminant level (MCL) of 50 µg/L have been reported to naturally occur in the groundwater of alkaline and oxic alluvial aquifers in the western Mojave Desert, with lower concentrations found in less alkaline groundwater (Izbicki, 2008). Cr6 was detected above 1 µg/L by California's Department of Public Health in 3,156 out of 5,943 (about 53%) of the potable water supply sources tested throughout California between 1997 and 2008 (SWRCB, 2009).

California water suppliers (including the Mojave Basin municipalities that manage drinking water) collect samples from their systems and report results to their customers in annual water quality reports. Table 2 lists data from recent annual reports for municipalities throughout the western Mojave Desert. Because there is no California MCL for Cr6 (only for CrT), some municipalities typically report results only for CrT, and many municipalities do not regularly analyze for chromium. Some municipalities use laboratory methods with reporting limits as high as 10 µg/L (City of Hesperia Water District, 2010).

Drinking water extracted from the upper and middle portions of the Mojave River Basin (generally Apple Valley to Barstow) exhibits Cr6 in supply wells at levels higher than those encountered during the 2007 background study in Hinkley. Cr6 concentrations ranged up to 6.3 µg/L in the Apple Valley South system (Golden State Water Company, 2010a-b) to 16.1 µg/L in Hesperia (City of Hesperia Water District, 2010).

Results of the drinking water supply reports listed in Table 2 are consistent with scientific studies conducted by the USGS that have identified the presence of background Cr6 in the western Mojave Desert (Ball and Izbicki, 2004; Izbicki et al., 2008; Izbicki, 2008; Nishikawa et al., 2004; Robertson, 1975 and 1991). A study of groundwater conducted by the USGS in 2008 to "...provide a spatially unbiased assessment of the quality of untreated groundwater used for public water supplies within the Mojave study unit..." found that Cr6 was detected in over half of the wells that were analyzed (15 out of 22) at concentrations ranging from 1 to 16 µg/L (Schmitt et al., 2008).

2.4 CHROMIUM CONCENTRATIONS ABOVE ESTABLISHED BACKGROUND LEVELS IN THE HINKLEY VALLEY

Three samples collected in 2011 from domestic well 34-65 exhibited chromium concentrations above the background levels found in the 2007 study. After thoroughly assessing the potential for this well to be affected by PG&E's chromium plume, PG&E and the Water Board staff concluded that it was infeasible for the plume to have migrated to this location (based on several factors including historic and current groundwater flow direction, and the presence of the Lockhart Fault between the plume and the well).

3.0 Collection and Analysis of Chromium Data from Short Screened Wells

The purpose of the work scope proposed in Section 3 is to collect a sufficiently robust set of groundwater samples, using new short-screened monitoring wells, to perform an appropriate statistical analysis on the range and maximum expected values of background chromium concentrations of the upper aquifer.

The 2007 background study (CH2M HILL, 2007) utilized existing long-screened private domestic and agricultural wells for the collection of groundwater samples. This approach was selected in lieu of installing new short-screened monitoring wells, primarily in consideration of time and property access constraints. The peer reviewers commented, and PG&E concurs, that the data collected from the long-screened wells may not be fully representative of background chromium conditions in the upper aquifer in the Hinkley Valley.

This work plan proposes the installation of short-screened monitoring wells on a gridded pattern in the upper aquifer, for sampling and laboratory analysis. The proposed layout of wells addresses peer reviewer comments regarding the need for data from short-screened monitoring wells rather than long-screened wells, and the need for a more evenly spaced distribution of sample locations.

3.1 INSTALLATION OF SHORT SCREENED MONITORING WELLS

Figure 13 illustrates a grid of 32 conceptual locations where short-screened monitoring wells could be installed for collection of new groundwater samples (one well location per grid). The grid size is one square mile (a BLM Section). Grids were placed outside the existing boundaries of the chromium plume, based on the established background values of 3.1 µg/L for Cr6 and 3.2 µg/L for CrT. Areas where surface geologic information suggests saturated alluvium is not present (*i.e.*, shallow bedrock) were not included.

Monitoring wells are proposed as close as reasonably possible to the center point of each grid. Locations may be adjusted within each grid in consideration of property access and other access limitations (such as biologically or culturally sensitive areas). At a select number of locations, short-screen wells will be installed in immediate proximity to long-screen wells that were sampled during the prior study.

Proposed monitoring well drilling and installation procedures are provided in Appendix B and summarized as follows.

A borehole will be advanced at each well location to the total depth of the upper aquifer, to be defined by the blue clay or bedrock – whichever is encountered first. The borehole will be continuously cored from the water table (estimated at 65 to 75 ft-bgs) to total depth.

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A 4-inch-diameter polyvinyl chloride (PVC) monitoring well with 15-feet of screen length will be set at the water table for each location. Additional two and one-half inch diameter PVC monitoring wells may be installed at each location at depth in the upper aquifer (*i.e.*, below the water table), depending upon the thickness and nature of the encountered saturated alluvial sediments. The number of monitoring wells installed by PG&E at each location during recent investigations has ranged from one (single 4-inch well across the water table) to three (single 4-inch well across the water table, and two 2½-inch wells nested in an adjacent borehole at depth within the upper aquifer). Up to 96 monitoring wells could be installed under this element of the study, assuming up to three monitoring wells are installed at each location and access is obtained for all 32 grids.

Following installation, the new monitoring wells will be developed, surveyed, and sampled. The procedures for these activities are detailed in Appendix B, along with methods for the management of investigations-derived materials (soils generated during drilling and groundwater generated during development and sampling).

3.2 LABORATORY ANALYSIS OF GROUNDWATER SAMPLES

Groundwater samples will be collected from these new wells for Cr6 and CrT analysis using the methods listed on Table 1. Select samples may also be analyzed for additional parameters, and these parameters and the analytical methods are also listed on Table 1.

On December 29, 2011, the Water Board issued Investigation Order R6V-2011-0105. The Order required submittal of technical information in response to several questions raised by the peer reviewers with respect to the laboratory analyses used in the 2007 background study. The Order, and PG&E responses submitted to the Water Board on January 20, 2011, are included with this report as Appendix C. The laboratory analysis to be conducted as part of this proposed study will be conducted consistent with this work plan and PG&E's responses to the Order.

3.3 STATISTICAL ANALYSIS OF CHROMIUM DATA

A minimum of four quarterly sampling events will be conducted as part of the evaluations. In general, sampling will not be initiated until all of the new wells are installed, so the sampling time frame and the number of samples collected is the same for all the wells. For each event, the statistical methodology proposed will be used to determine 95UTL values for CrT and Cr6 that are representative of each sampling event. Multiple sample results from individual wells will not be averaged (as was done for the 2007 study).

3.3.1 J-Flag and Non-Detect Values

All J-flagged detections will be assumed to be quantitative, and the J-flag value will be used accordingly in the statistical analysis of the data.

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If the chromium detection rate is 85 percent or greater for the entire data set during a single sampling event, non-detect (ND) values will be substituted with half the detection limit. If the chromium detection rate is 50 percent or greater, but less than 85 percent, then the ND values will not be used in the testing for normality; rather, an adjustment will be applied to the sample mean and standard deviation using Cohen's Method (USEPA, 2009). If the chromium detection rate is less than 50 percent, then the data set will be assumed to be non-normally distributed, and a non-parametric method will be used to compute the 95UTL.

3.3.2 Testing for Normality

The population distribution will be tested for normality if the chromium detection frequency is 50 percent or greater. If the chromium detection frequency is between 50 percent and 85 percent, the population distribution will be determined from the detections only. If the chromium detection frequency is 85 percent or greater, all of the data points will be used (ND values will be substituted with one-half the detection limit).

The method for testing the data set for normality will be the Shapiro-Wilk test, as recommended by the USEPA (2009, p.8-13). If the data are not found to be normally distributed, then a series of transformations will be attempted until the data pass the normality test at 5 percent significance. The series of transformations will be square root, cube root, and logarithmic in that order (Box and Cox, 1964). In the event that none of the transformations lead to normally distributed data (that is, a data set that passes the Shapiro-Wilk normality test), then a non-parametric method will be used.

3.3.3 Outliers

Following the establishment of normality (if normality is determined), a test will be run to identify statistical outliers. If there are 25 data points or less, then Dixon's test for outliers will be used (USEPA, 2009, p.12-14). If there are more than 25 data points, then Rosner's test for outliers will be used (USEPA, 2009, p.12-14).

3.3.4 Calculation of the 95UTL Values

Once the questions of non-detections, outliers, and normality are resolved, the 95UTL will be computed. 95 UTL values will be determined with and without outliers in the data set, if present. If parametric methods are justified, the UTL will be computed from the sample mean (\bar{x}) and sample standard deviation (s), using the formula:

$$UTL = \bar{x} + s \kappa$$

The tolerance factor κ can be found on a table provided by the USEPA for the appropriate confidence level and capture (95% and 95% in this case), and the sample size. If Cohen's adjustment was needed, then \bar{x} and s will be the adjusted values. If transformations were required, then the UTL will be computed

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using the mean and standard deviation of the transformed data. The resulting UTL will be back-transformed.

3.3.5 Evaluation of Multiple Data Populations

The new data set will be statistically evaluated to assess the potential for multiple populations of chromium data. This effort will include a linear analysis, in which a change in slope of the chromium concentrations suggests different data populations. If the analyses suggest multiple chromium data populations are present, the data will be evaluated spatially to assess the potential for other lines of evidence (such as location or geology,) that would provide a direct correlation with the observed populations.

4.0 Background Chromium in Groundwater

This section discusses several factors that will be considered when assessing background chromium concentrations in the groundwater of the upper aquifer in the Hinkley Valley. Items discussed in Section 4 include:

1. Sediment mineralogy and groundwater geochemistry;
2. Tracers and chromium isotopes in groundwater; and,
3. Chromium concentrations at the water table, and the potential effects of unsaturated zone and capillary fringe pore water.

4.1 MINERALOGY AND GROUNDWATER GEOCHEMISTRY

The following provides a discussion of mineralogical and groundwater geochemical factors that will be considered during the study.

4.1.1 Mineralogy

The USGS conducted a geohydrochemical study in the southern portion of the western Mojave Desert (Ball and Izbicki, 2004; Izbicki, et al., 2008) that investigated the relationship between the chromium content of rocks and alluvial sediments with concentrations of CrT and Cr6 in groundwater. The basement rocks in the Hinkley Valley contain various concentrations of mafic minerals (pyroxene, amphibole, mica) that appear as dark grains in the rock and associated alluvium. In general, the materials with higher mafic mineral content exhibit higher chromium concentrations. The chromium in these minerals is predominantly in the trivalent state.

Manganese is also associated with the mafic minerals, and the weathered surface of rocks and minerals typically contains secondary manganese oxide mineral coatings. Oxidation of Cr3 to Cr6 can occur when water is in contact with these solids under oxic conditions. A slight amount of Cr3 is dissolved and becomes oxidized on the surface of the manganese oxides, creating Cr6, while manganese is reduced and partially dissolves. With the oxidizing of Cr3, more dissolution occurs at the mafic mineral surface and the process continues, concentrating Cr6 in the surrounding water.

In the presence of manganese oxides, chromium-containing mafic minerals can produce natural Cr6 in unsaturated zone pore water and groundwater. Analysis of the various geologic materials found in the Hinkley Valley aquifer matrix may provide an improved understanding of the origin and distribution of natural Cr6 in groundwater. The range of natural chromium sources and concentrations known to exist in alluvial basin settings from other Mojave desert studies (Ball and Izbicki, 2004; Izbicki et al., 2008) can be summarized as follows:

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- The highest chromium concentrations are generally found in basaltic, ultramafic and mafic rock debris that contains chromite and relatively high mafic mineral content;
- Lower chromium concentrations are generally found in felsic rock debris (granitic, dioritic, and associated source rocks);
- The lowest chromium concentrations are associated with highly weathered, non-mafic rocks, which are often found in fluvial deposits; and,
- The chromium content tends to be higher in fine-grained sediment and soil than in coarser-grained deposits.

The geologic conditions in the Hinkley Valley are complex, due to different bedrock types (source rock for the aquifer alluvial materials), regional and local faulting, and the various geologic environments under which the unconsolidated aquifer sediments were deposited. Bedrock in the Hinkley Valley provides the source material for some of the unconsolidated alluvium through which groundwater flows. The majority of bedrock in the valley is described as plutonic and metamorphic rocks (identified as bc, basement complex, on Figure 3).

Where core holes have been drilled to bedrock by PG&E, the encountered materials have been described primarily as granite, diorite, monzonite, and gneiss. Bedrock on the eastern side of Hinkley Valley, in the area of Mount General, includes tertiary volcanic rocks (Tv on Figure 3). Granitic and metamorphic rocks typically contain varying ranges of mafic minerals such as pyroxene, amphibole, and mica. Volcanic rocks, such as basalt and andesite, can also contain an abundance of mafic minerals.

In addition to the bedrock, materials in the Hinkley Valley also include semi-consolidated sediments typically referred to as "older sediments." As shown on Figure 3, these older sedimentary materials on the periphery of the PG&E chromium plume include older alluvium (Qoa), playa deposits (Qp), and old lake and lakeshore deposits (Qol). As shown on Figure 3, the ancient shoreline of Harper Lake extends well into the northern portion of the Hinkley Valley.

4.1.2 Groundwater Geochemistry

The presence of Cr₆ in groundwater from natural sources is partly a function of groundwater geochemistry. Hexavalent chromium requires oxic conditions to be stable in water. If conditions become mildly reducing, Cr₆ is readily reduced to relatively insoluble Cr₃, which precipitates out of solution. There is no single redox state of a solution, as many processes that influence redox occur simultaneously in natural waters. Conditions to be considered include:

- 1) The presence of dissolved manganese and/or iron in groundwater is indicative of conditions conducive to the reduction of Cr₆ to Cr₃;
- 2) The presence of total organic carbon in groundwater is indicative of the potential to reduce Cr₆ and other mineral species, usually by microbial assisted methods; and,
- 3) Redox conditions that are nitrate-reducing will not support the presence of Cr₆. If nitrate is absent and any or all of the other redox indicators are present, Cr₆ would not be expected to persist.

4.2 TRACERS (INCLUDING CHROMIUM ISOTOPES)

A “tracer” is any chemical constituent that provides an indication of the original source of, or geochemical influence on, the groundwater sample. Tracers fall into the three broad categories: general chemical parameters (major ions, total dissolved solid or TDS, and pH), conservative trace elements (for example, boron or bromide), and stable isotopes (for example, ^{18}O , ^2H , ^{53}Cr). It is possible that multiple lines of evidence can be drawn from these parameters (in connection with geologic and hydraulic data) to indicate a source of chromium in individual samples.

The two most abundant isotopes of chromium in nature are ^{52}Cr (83.8 percent) and ^{53}Cr (9.5 percent), with the superscript indicating the atomic mass (Izbicki et al., 2008). Recent scientific literature has shown that comparison of the relative amounts of these two isotopes in water samples can be useful in distinguishing natural and anthropogenic sources of chromium (Ellis et al., 2002, 2004; Izbicki et al., 2008). A water sample is prepared and analyzed with a mass spectrometer to measure the ratio of $^{53}\text{Cr}/^{52}\text{Cr}$. This ratio is compared to the ratio reported for an international chromium standard, and the difference in the sample ratio from the standard is reported in parts per thousand (ppt, equivalent to a percent difference multiplied by 10) and expressed as $\delta^{53}\text{Cr}$.

Natural chromium contained in solid mineral phases is in the form of Cr3, and has a $\delta^{53}\text{Cr}$ of around 0 parts per thousand (ppt). When this chromium is released by weathering and oxidized to Cr6 in solution, the $\delta^{53}\text{Cr}$ is still 0 ppt. However, when the water containing Cr6 flows through a groundwater system, a portion of the Cr6 is reduced back to Cr3. Because the lighter ^{52}Cr is more easily reduced, the remaining Cr6 in the groundwater becomes slightly enriched in ^{53}Cr along the flow path, and this mechanism increases the $\delta^{53}\text{Cr}$ value above 0 ppt. This process of reactions favoring one isotope over another is known as isotopic fractionation. The more partial the reduction occurs, the higher the $\delta^{53}\text{Cr}$ value is expected. Reported values for $\delta^{53}\text{Cr}$ in Mojave Desert samples have been observed as high as 5.1 ppt (Izbicki et al., 2008).

Anthropogenic Cr6 in the form of chromate solution has a $\delta^{53}\text{Cr}$ value of around 0 ppt, similar to natural mineral sources. Plume samples by definition have chromium elevated above background concentrations, such that the relative amount of Cr6 reduction is smaller than what occurs with natural concentrations in groundwater. In other words, the higher concentrations of Cr6 in the plume tend to overwhelm and mask the small degree of isotopic fractionation that occurs due to the propensity of ^{52}Cr to be chemically reduced to Cr3. As a result, plume $\delta^{53}\text{Cr}$ values tend to be lower than those observed in natural groundwater.

4.2.1 Previous Results for Isotopic analysis

The first set of Hinkley chromium isotope data was collected by the USGS in 2006, and has since been submitted for publication (Izbicki et al., 2011). The data are illustrated on Figure 14. The study identified 10 wells within the plume area. Cr6 concentrations ranged from 15.4 to 2,660 $\mu\text{g}/\text{L}$, and $\delta^{53}\text{Cr}$ signatures were measured at 0 to 1.9 ppt. Samples from three wells that were defined as outside the plume

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exhibited Cr6 concentrations from 0.8 to 3.7 µg/L, and $\delta^{53}\text{Cr}$ signatures ranging from 2.7 to 4.1 ppt (at that time, the interim maximum Cr6 background value was 4.0 µg/L).

The isotope data generally support the hypothesis that natural Cr6 has a higher isotopic signature than anthropogenic sources, due to its greater degree of partial reduction. Within the plume, the $\delta^{53}\text{Cr}$ values generally increased northward, consistent with observed decreasing Cr6 concentrations. The authors pointed out that the data do not follow the same pattern of fractionation observed in laboratory-controlled reduction experiments (Ellis et al., 2002 and 2004), and offered that the data suggested a combination of reduction and mixing with low-Cr groundwater (i.e., dilution). The results were not conclusive at the relatively low chromium concentrations that are considered to be in the likely range of background conditions for the Hinkley Valley. The USGS concluded that additional samples in the Cr6 concentration range of ND to 5 µg/L would be needed to improve resolution of the data interpretations at these low chromium levels.

Additional data were collected by PG&E between 2008 and 2011, primarily in areas east and north of the DVD, where Cr6 is detected at relatively low concentrations. The previous and new data are shown together on Figure 15.

Some sample results suggest a source(s) of Cr6 other than the PG&E plume. For example, samples from wells MW-96S, MW-97S, and MW-97D have lower $\delta^{53}\text{Cr}$ values than other nearby wells, suggesting that chromium in these samples may be derived from source rocks to the east (Note: Cr6 results for these three wells are less than 3.1 µg/L). These three (3) wells are located close to a bedrock outcrop. The lower $\delta^{53}\text{Cr}$ values suggest the bedrock may be contributing Cr6. The differences noted in the three (3) samples as compared to other samples suggest that chromium isotopes may be useful in the differentiation of chromium from different sources.

4.2.2 Other Natural Tracers

There are several naturally occurring parameters that could provide an indication of groundwater origin and/or flow path. One of these parameters alone may not fully elucidate origin or flow path, but multiple parameters could provide helpful insight to assist in the overall evaluation of correlations between local conditions and background chromium in groundwater.

Oxygen and Hydrogen - In addition to chromium isotopes, stable isotopes of oxygen (^{18}O) and hydrogen (^2H , also known as deuterium) together can prove valuable as a tracer for identifying waters by their historic flow paths (such as groundwater that has been subject to partial evaporation). The data illustrated in Figure 16 suggest that waters were derived from different sources, possibly including agricultural irrigation. Combined with the chromium isotope data, along with other geochemical data such as general minerals (see below), ^{18}O and deuterium may help to distinguish water types.

Boron – This parameter is a conservative element found in nearly all natural waters. Under normal pH range (up to pH 10), boron exists in solution as an uncharged ion (H_3BO_3^0), and is not prone to adsorption

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like many charged species. With its high solubility, boron moves conservatively through groundwater systems, similar to ^{18}O and deuterium, and therefore its concentration can be tied to water sources and potential water mixing.

Dissolved Silica – This parameter (expressed as SiO_2 in laboratory reports) is a neutral ion over nearly the entire pH spectrum (in the form of H_4SiO_4^0). Though there are limits on its solubility, silica can be useful in identifying and verifying different sources of water in mixed geologic systems.

General Minerals - The general mineral “fingerprint” of groundwater can be used, when combined with other more specific tracers, to assess different origins and flow paths of waters. Data evaluation tools such as Piper and Stiff Diagrams can be used to assess the potential for distinct populations, including mixing of groundwater from different recharge areas.

4.3 CHROMIUM CONCENTRATIONS AT THE WATER TABLE

Dissolved natural Cr_6 concentrations in groundwater have been observed in the Mojave Desert (Ball and Izbicki, 2004; Izbicki et al., 2008; and Izbicki, 2008), in the Paradise Valley near Phoenix, Arizona (Robertson, 1975), and in arid basins elsewhere in the Southwestern United States (Robertson, 1991). In the western Mojave Desert, background Cr_6 concentrations have been observed to vary with depth, with generally higher concentrations found at the water table and decreasing concentrations (often to below detection limits) encountered at greater depths.

Figure 17 (from Izbicki 2008) illustrates the vertical profiles for background chromium along with other constituents in water obtained from core samples from the western Mojave Desert. In the Izbicki study, the highest concentrations of Cr_6 , specific conductance, and certain trace metals occurred either just above or at the water table. The authors cited the leaching of background Cr_6 from unsaturated zone soil by infiltration (from agricultural irrigation) as the likely mechanism for the higher Cr_6 concentrations observed at the water table. Deeper in the saturated zone, the Cr_6 concentrations were observed to decrease, as the water became less affected by agricultural practices, and was less oxic (Izbicki et al., 2008).

A later study conducted by the USGS and funded by the Water Board, specifically focused on the source of Cr_6 in shallow water table wells near El Mirage in the Mojave Desert (Izbicki et al., 2008). In the study, authors suggested that high-nitrate concentrations in dairy wastewater may interfere with the bacterially mediated reduction of Cr_6 to Cr_3 , thereby allowing chromium in the form of Cr_6 to move through the unsaturated zone to the water table.

These USGS studies have important implications for the interpretation of Cr_6 data from the Hinkley site. In areas where irrigation has been conducted, the upper aquifer could exhibit higher concentrations of Cr_6 associated with the infiltration of irrigation water from agriculture irrigation, as noted by the USGS (Izbicki et al., 2008). Wells screened deeper in the upper aquifer may have lower concentrations of Cr_6 ,

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because these portions of the aquifer have less influence from irrigation water, and/or due to the presence of reducing conditions.

5.0 Schedule

PG&E is prepared to initiate the work scope detailed in this Work Plan within 90 days of receiving written approval from the Water Board to proceed. Upon completion of the study, PG&E will prepare a technical report that presents the methods, data, statistical analysis, and conclusions of the assessment. Considering the time required to obtain biological clearances and secure property access, install numerous new short screen monitoring wells, and collect at least four quarters of groundwater data, the timeframe to complete the study and prepare a technical report will be at least 2 years. PG&E will provide semi-annual progress reports to the Water Board beginning 180 days following approval of this Work Plan. Each report will provide an update to the schedule for completion of the study and submittal of a technical report.

6.0 References

American Water Works Association Research Foundation (AWWARF). 2004. *Occurrence of Boron and Hexavalent Chromium*.

Ball, J.W. and J.A. Izbicki. 2004. Occurrence of hexavalent chromium in ground water in the western Mojave Desert, California. *Applied Geochemistry*. Vol. 19: 1123–1135.

Box, G.E.P. and D.R. Cox. 1964. An analysis of transformations (with discussion). *Journal of Royal Statistical Society Series B*, 26, 211-252.

California Department of Water Resources (DWR). 1967. *Local Participation in Ground Water Basin Management Studies*.

California Department of Water Resources (DWR). 1967. *Mojave River Ground Water Basins Investigation*. Bulletin 84. Sacramento, California.

_____. 2003. *California's Ground Water*. State of California. Bulletin No. 118. September 1975. Reprinted January 1994. Updated October 2003.

California Regional Water Quality Control Board, Lahontan Region (Water Board). 2008. Adopted Amended Cleanup and Abatement Order No. R6V-2008-0002A1 for Pacific Gas and Electric Company's Compressor Station, Hinkley, San Bernardino County.

_____. 2011. *Peer Review Results for Background Chromium Study, PG&E Compressor Station, Hinkley, San Bernardino County*. October 14.

CH2M HILL. 2004. *Revised Background Chromium Study Work Plan, PG&E Compressor Station, Hinkley, California*. September.

_____. 2007. *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California*. February.

_____. 2011. *Third Quarter 2008 Groundwater Monitoring Report, PG&E Compressor Station, Hinkley, California*. October 30.

City of Hesperia Water District. 2010. *2009 Consumer Confidence Report*. July 1.

Durbin, T. J. and W. F. Hardt. 1974. Hydrologic analysis of the Mojave River, California using a mathematical model. *USGS Water-Resources Investigations*. Vol. 17-74. Menlo Park, California. November.

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References

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- Ellis, A.S., T.M. Johnson, and T.D. Bullen. 2002. Chromium isotopes and the fate of hexavalent chromium in the environment. *Science*. Vol. 295, pp. 2060–2062.
- Ellis, A.S., T.M. Johnson, and T.D. Bullen. 2004. Using chromium stable isotope ratios to quantify Cr 6 reduction; lack of sorption effects. *Environmental Science and Technology*. Vol. 38, p. 3604-3607.
- Golden State Water Company. 2010a. *Water Quality Report, Desert View Dairy*.
- _____. 2010b. *Water Quality Report, Apple Valley South Water System*.
- Hardt, W. F. 1971. *Hydrologic Analysis of Mojave River Basin, California using Electric Analog Model*. USGS Open-File Report, Menlo Park, August 18.
- Hem, J.D. 1989. *Study and Interpretation of the Chemical Characteristics of Natural Water*. Third Edition. U.S. Geological Survey Water-Supply Paper 2254.
- Izbicki, J.A. 2008. Chromium concentrations, chromium isotopes, and nitrate in the unsaturated zone at the water-table interface, El Mirage, California. Written communication to the Lahontan Regional Water Quality Control Board. December 24.
- Izbicki, J.A., J.W. Ball, T.D. Bullen, and S.J. Sutley. 2008. Chromium, chromium isotopes and selected trace elements, western Mojave Desert, USA. *Applied Geochemistry*. Vol. 23, pp 1325-1352.
- Izbicki, J.A., T.D. Bullen, P. Martin, and B. Schroth. 2011. Delta chromium-53/52 isotopic composition of native and contaminated groundwater, Western Mojave Desert, USA. Submitted to *Applied Geochemistry*.
- Jennings, Charles W. 1994. *Fault Activity Map of California and Adjacent Areas with Location and Ages of Recent Volcanic Eruptions*. California Geologic Data Map Series, Map No. 6. California Division of Mines and Geology.
- Mendez, G.O. and A.H. Christensen. 1997. Regional water table (1996) and water-level changes in the Mojave River, the Morongo, and the Fort Irwin groundwater basins, San Bernardino County, California. U.S. Geological Survey Water-Resources Investigations Report 97-4160. 34 p.
- Mojave Water Agency. 1983. *Mojave River Ground Water Basins, Historic and Present Conditions, Helendale Fault to Calico-Newberry Fault*. Apple Valley, California. December.
- Manheim, F.T., E.G. Brooks, and J.W. Williams. 1994. *Description of a Hydraulic Sediment Squeezer*. U.S. Geological Survey Open-File Report 94-584, 39 p.
- Nishikawa, Tracy., J.A. Izbicki, J.A. Hevesi, C.L. Stamos, and P. Martin. 2004. *Evaluation of Geohydraulic Framework, Recharge Estimates, and Ground-Water Flow of the Joshua Tree Area, San Bernardino County, California*.

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References

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Pacific Gas and Electric Company (PG&E). 2011. Technical Memorandum. Well 34-65.

Robertson, F.N. 1975. Hexavalent chromium in the ground water, in Paradise Valley, Arizona. *Ground Water*. Vol. 13, 516–527.

_____. 1991. Geochemistry of ground water in alluvial basins of Arizona and adjacent parts of Nevada, New Mexico, and California. U.S. Geological Survey Professional Paper 1406-C.

Schmitt, S.J., Milby Dawson, B.J., and K. Belitz, 2008. Groundwater-quality data in the Antelope Valley Study Unit, 2008: Results from the California GAMA Program. United States Geological Survey. Data Series 479.

Stantec. 2011. *Response to Investigative Order No. R6V-2001-0043. Delineation of Chromium in the Upper Aquifer, Pacific Gas and Electric Company's Hinkley Compressor Station, Hinkley, California*. Technical Report. September.

_____. 2012. Update to Upper Aquifer Groundwater Investigation Activities, Pacific Gas and Electric Company's Hinkley Compressor Station, Hinkley, California. Technical Memorandum. February

State Water Resources Control Board Division of Water Quality GAMA Program. 2009. *Groundwater Information Sheet Chromium VI*. September.

United States Environmental Protection Agency. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. Office of Resource Conservation and Recovery, Program Implementation and Information Division, U.S. Environmental Protection Agency. EPA 530-R-09-007. March, 2009

United States Geological Survey (USGS). 1960. *Data on Water Wells in the Eastern Part of the Middle Mojave Valley Area, San Bernardino County, California*. State of California Department of Water Resources, Bulletin No. 91-3, Sacramento, California, August 3.

_____. 2004. *USGS Water Data for California*. National Water Information System Web Interface (NWISWeb). <http://waterdata.usgs.gov/ca/nwis/nwis>.

_____. 2001. Simulation of Ground Water Flow in the Mojave River Basin, California. United States Geological Survey Water Resources Investigation Report 01-4002 version 3. 125p. Stamos, C.L., Martin P., Nishikawa T., and Cox B.F.

TABLES

Work Plan for Evaluation of Background
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Pacific Gas and Electric Company
Stantec PN# 185702482
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Table 1
Proposed Laboratory Analysis Methods
Pacific Gas and Electric Company - Hinkley Chromium Remediation Project
Hinkley, California

GROUNDWATER ANALYTES	
Analyte	Laboratory Analytical Method
General Chemistry	
Na	SW 846 Method 6010B or C
K	SW 846 Method 6010B or C
Ca	SW 846 Method 6010B or C
Mg	SW 846 Method 6010B or C
Fe	SW 846 Method 6010B or C
Mn	SW 846 Method 6020A
NH3	SM ¹ 4500-NH3
NO3	USEPA Method 300.0
TKN	SM ¹ 4500-N _{org} B
Cl	USEPA Method 300.0
Alkalinity	SM ¹ 2320 B
SO4	USEPA Method 300.0
SiO2	SM ¹ 4500-Si C or D
TDS	SM ¹ 2540 C
TOC	SM ¹ 5310
PO4	SM ¹ 4500-P E or F
Natural Tracers	
$\delta^{53}\text{Cr}$	SW846 6800 or equivalent
$\delta^{18}\text{O}$	CF-IRMS
$\delta^2\text{H}$	CF-IRMS
B	SW 846 Method 6020A
Metals	
Title 22 Suite (includes CrT) Cr(VI)	SW 846 6010B or C, 6020A, 7470 (Title 22 Metals incl. CrT) USEPA Method 218.6 (Cr6)

¹SM - Standard Methods 18th, 19th, or 20th edition

Table 2
Published Studies by Others
Pacific Gas and Electric Company - Hinkley Chromium Remediation Project
Hinkley, California

Study/Report	Naturally Occurring Total Chromium (µg/L)	Naturally Occurring Hexavalent Chromium (µg/L)	Description
^a USGS Western Mojave Desert	NM	Cr6 Range = ND to 61 µg/L	Approximately 200 wells were sampled. In addition, depth discrete samples were collected, which indicated that Cr6 concentrations could vary from <0.1 to 36 µg/L in a single well due to variable redox conditions. Cr6 concentrations were low near mountain recharge areas where pH values were neutral and low in discharge areas where there was low dissolved oxygen. The highest Cr6 concentrations (up to 61 µg/L) were reported for wells completed within alluvium derived from mafic rocks, with lower concentrations (up to 36 µg/L) reported for alluvium derived from less mafic granitic, volcanic and metamorphic rocks.
^b USGS Western Mojave Desert, Sheep Creek Fan and Surprise Springs Area	NM	Cr6 Range = 0.2 to 60 µg/L	Results for 157 public supply, irrigation and observation wells in the Western part of the Mojave desert were included. Cr6 did not exceed 5 µg/L at pH < 7.5 in any geologic conditions. Cr6 range for all wells was 0.2 - 60 µg/L. Study indicated that majority of chromium detected was in the form of Cr6. Cr6 distribution in soil samples was found to be greatest above and near the water table, and concentrations rapidly decreased with depth. This observation was supported with chromium groundwater sample results.
^c ADEQ Sacramento Valley Arizona Study	Confidence Interval Range of 1 to 83 µg/L	NM	Regional Arizona Department of Environmental Quality (ADEQ) groundwater study of basin in NW Arizona (immediately east of the Mojave Basin) comprising 1,500 square miles east of the Colorado River. The upper 95% confidence interval for CrT was 83 µg/L, and the lower 95% confidence interval for CrT was 1 µg/L.
^d USGS Regional Aquifer System Analysis Program	CrT Range = ND to 300 µg/L	NM	436 samples were collected from 72 basins in central and southern Arizona, southeastern California and Nevada, and western New Mexico. Results for 5 percent of samples collected were greater than 50 µg/L. Range in CrT concentrations was 0 to 300 µg/L, standard deviation = 30.7 µg/L.
^e CA State Water Resources Control Board, GAMA Program	NM	53% of wells > than 1.0	California Department of Health Services data for 1997-2008 were evaluated. 3,156 out of 5,943 tested public water wells (active and standby) throughout CA have detected Cr6 at concentrations greater than the laboratory reporting limit of 1 µg/L. Los Angeles, San Bernardino, and Fresno counties had the highest number of detections greater than 1 µg/L.
^f Joshua Tree and Copper Mountain Groundwater Sub-Basins, San Bernardino County	NM	Cr6 Range = 0.6 to 36.6 µg/L	Cr6 concentrations for 6 wells (23 samples total) ranged from 0.6 to 36.6 µg/L, with a median of 13.1 µg/L.
^g Cadiz and Fenner Valleys, Mojave Desert (south eastern CA)	NM	Cr6 Range = 15 to 26 µg/L	Chromium concentrations were generally uniform throughout study area, indicating that Cr6 was naturally occurring.

Table 2
Published Studies by Others
Pacific Gas and Electric Company - Hinkley Chromium Remediation Project
Hinkley, California

Study/Report	Naturally Occurring Total Chromium (µg/L)	Naturally Occurring Hexavalent Chromium (µg/L)	Description
Los Angeles Waterworks, District No. 40 Antelope Valley, 2009 Annual Water Quality Report	NM	Cr6 Range = ND to 12.1 µg/L	Public water supply system. Range in Cr6 concentrations was ND to 12.1 µg/L.
^h Twentynine Palms Water District	NM	Cr6 Range = ND to 29 µg/L	Public water supply system. Range in Cr6 concentrations was ND to 29 µg/L.
ⁱ Golden State Water Company, Barstow	NM	Cr6 Range = ND to 1.1 µg/L	Public water supply system. Range in concentrations was ND to 1.1 µg/L in 2006 samples reported in 2008. 2010 report did not include data for Cr6 or CrT.
^j Golden State Water Company, Victorville Desert View Water System	NM	Cr6 Range = 5.0 to 5.1 µg/L	Public water supply system. Range in concentrations was 5.0 to 5.1 µg/L.
^k Golden State Water Company, Victorville Apple Valley South Water System	NM	Cr6 Range = ND to 6.3 µg/L	Public water supply system. Range in concentrations ND to 6.3 µg/L.
^l Golden State Water Company, Lucerne Water System	NM	Cr6 Range = ND to 4.6 µg/L	Public water supply system. Range in concentrations ND to 4.6 µg/L.
City of Hesperia Water District, 2009 Consumer Confidence Report	NM	Cr6 Range = ND to 19 µg/L	Public water supply system. Range in concentrations ND to 19 µg/L. Laboratory reporting limit of 10 µg/L. Range in 2008 report concentrations was ND to 16.1 µg/L.
2009 Summary of Water Quality Data Rosamond Community Services District Water System	NM	Cr6 Mean = 9.0 µg/L	Public water supply system. No range reported. 2008 report indicated a mean of 9.0 µg/L, based on samples from 2006.

Table 2
Published Studies by Others
Pacific Gas and Electric Company - Hinkley Chromium Remediation Project
Hinkley, California

Study/Report	Naturally Occurring Total Chromium (µg/L)	Naturally Occurring Hexavalent Chromium (µg/L)	Description
^m Victorville Water District	NM	Cr6 Range = ND to 9.3 µg/L	Public water supply system. Range in concentrations ND to 9.3 µg/L.
nTopock Background Study	CrT Mean = 9.37	Cr6 Mean = 7.8	Six sampling events (25 wells) were used to develop background concentrations from mostly long screened supply wells in the greater Topock area. Fluvial materials were commonly associated with reducing conditions and low to non-detect chromium concentrations, therefore the UTLs may be conservatively low for wells screened in the alluvial aquifer under oxic conditions.
nTopock Background Study, UTL	CrT UTL = 34.1	Cr6 UTL = 31.8	

References:

- ^a Ball James W., and Izbiki, J.A., 2004. Occurrence of Hexavalent Chromium in Groundwater in the Western Mojave Desert, California
- ^b Izbiki, James A., Ball, James W., Bullen, Thomas, D., Sutley, Stephen J. Sutley. 2008. Chromium, Chromium Isotopes, and Selected Trace Elements, Western Mojave Desert, USA
- ^c Arizona Department of Environmental Quality (ADEQ) Open File Report June 2001. Ambient Groundwater Quality of the Sacramento Valley Basin: A 1999 Baseline Study
- ^d Robertson, Frederick N. 1991. Geochemistry of Ground Water in Alluvial Basins of Arizona, and Adjacent Parts of Nevada, New Mexico, and California. U.S. Geological Survey Professional Paper 1406-C.
- ^e State Water Resources Control Board Division of Water Quality GAMA Program. September 2009. Groundwater Information Sheet Chromium VI.
- ^f Evaluation of Geohydraulic Framework, Recharge Estimates, and Ground-Water Flow of the Joshua Tree Area, San Bernardino County, California. 2004. Nishikawa, Tracy., Izbiki, John A., Hevesi, Joesph A., Stamos, Christina L., and Martin, Peter.
- ^g Metropolitan Water District of Southern California (MWD) and Bureau of Land Management. 2001. Cadiz Groundwater Storage and Dry-Year Supply Program, Final EIR/EIS response to Comments.
- ^h Twentynine Palms Water District. 2010. June 2009 Consumer Confidence Report. June
- ⁱ Golden State Water Company. 2008 and 2010. Water Quality Report. Barstow Water System.
- ^j Golden State Water Company. 2010. Water Quality Report. Desert View Water System.
- ^k Golden State Water Company. 2010. Water Quality Report. Apple Valley South Water System.
- ^l Golden State Water Company. 2010. Water Quality Report. Lucerne Water System.
- ^mVictorville Water District June 2011, The Water Resource 2010 Consumer Confidence Report
- nCH2M HILL, 2007. Groundwater Background Study, Steps 3 and 4: Final Report of Results PG&E Topock Compressor Station, Needles, California

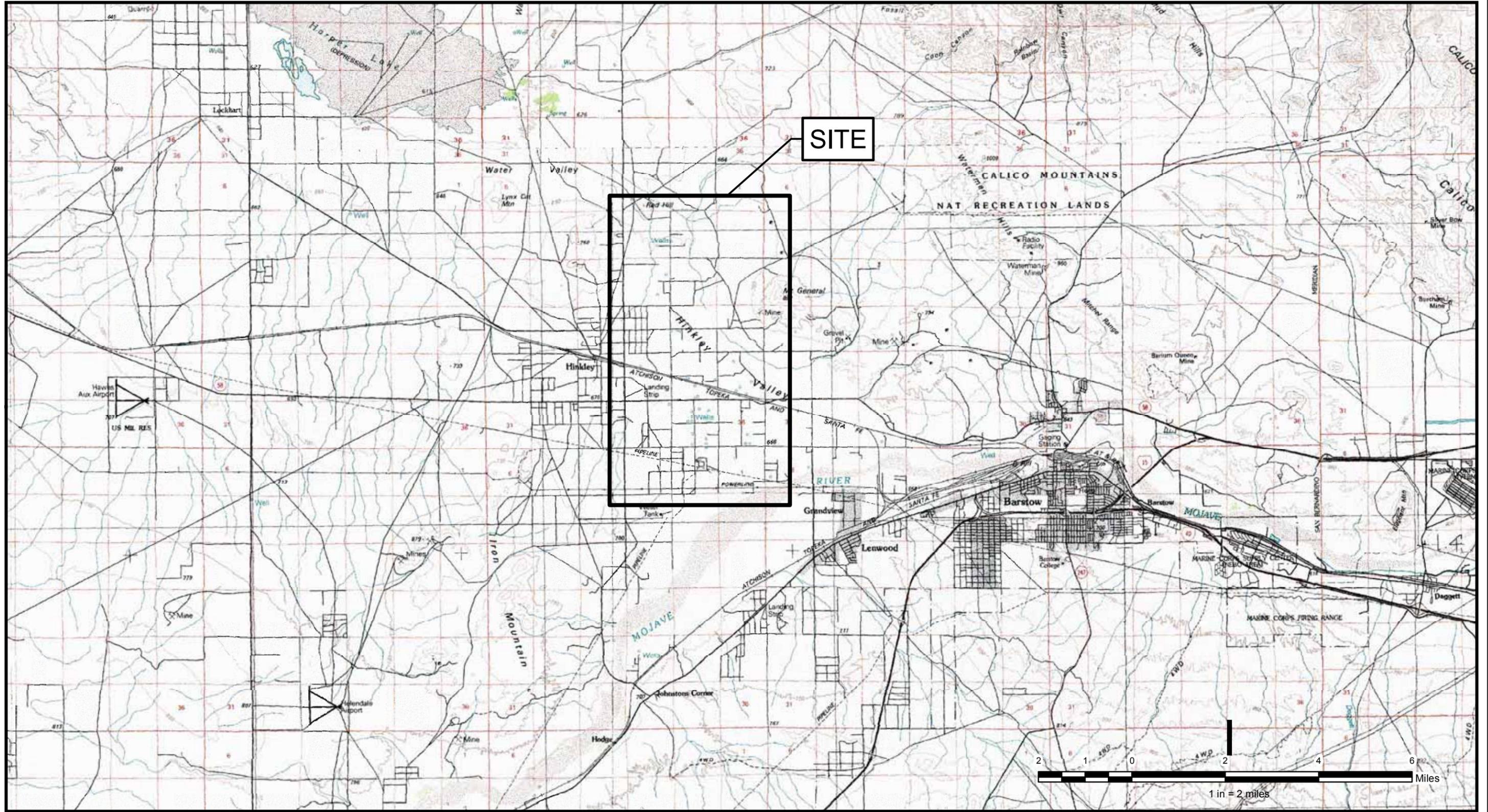
Abbreviations:

- µg/L = micro-grams per liter
- CrT = total chromium, dissolved
- Cr6 = hexavalent chromium, dissolved
- ND = not detected at laboratory reporting limits
- NM = not measured
- UTL= upper tolerance limit
- USGS = United States Geological Survey

FIGURES

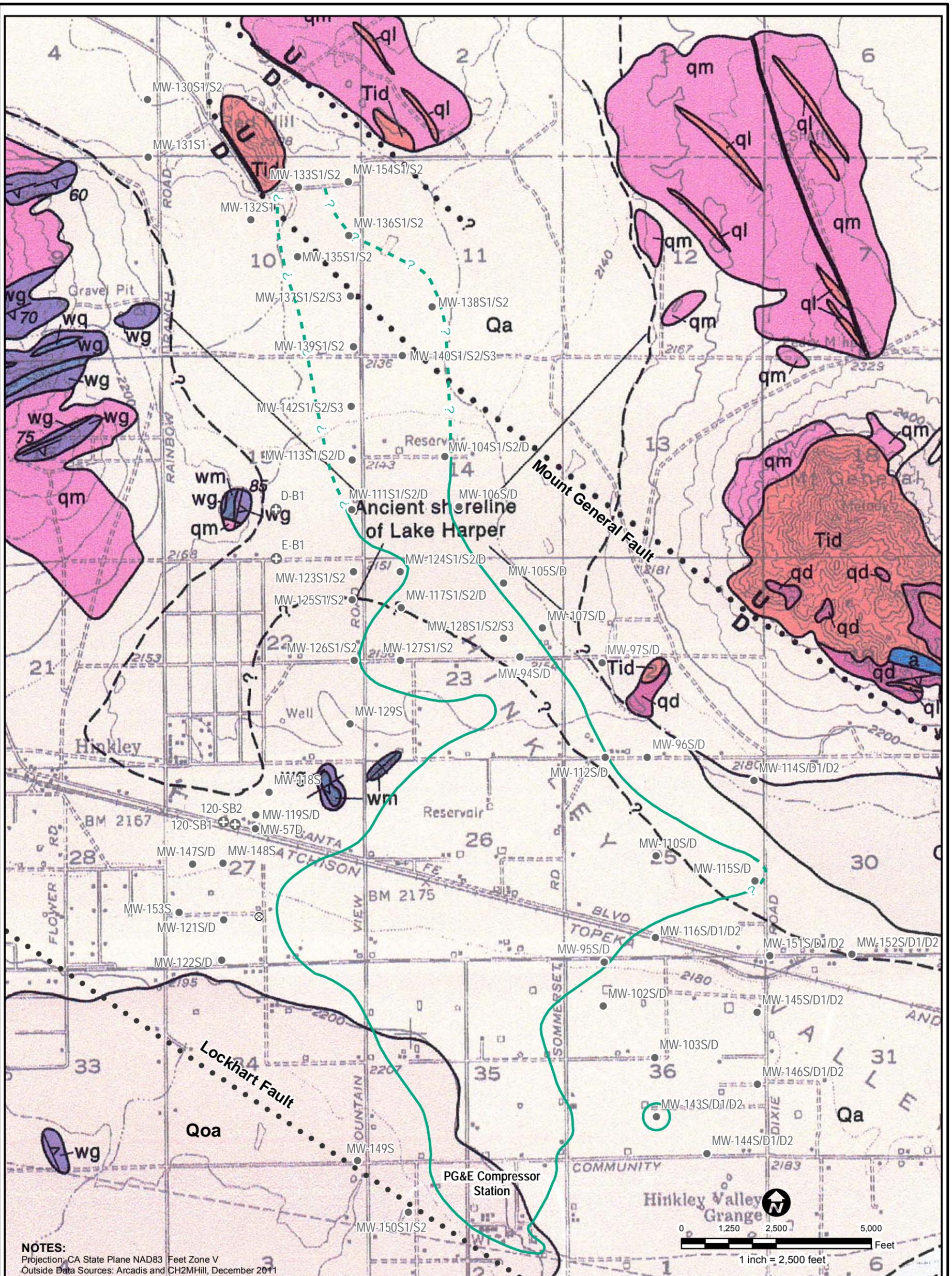
Work Plan for Evaluation of Background
Chromium in the Groundwater of the Upper Aquifer in the Hinkley Valley
Pacific Gas and Electric Company
Stantec PN# 185702482
February 22, 2012

Z:\PGE\EMXD_Files\January 2012\Background Study\Figure 1 (Site Location Map) (2012-2-17).mxd

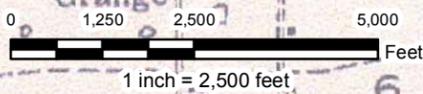


Source: USGS, 1993

 Stantec 57 LAFAYETTE CIRCLE, 2ND FLOOR LAFAYETTE, CALIFORNIA PHONE: (925) 299-9300 FAX: (925) 299-9302	FOR: Pacific Gas & Electric Groundwater Remediation Project Hinkley, California		FIGURE: 1	
	JOB NUMBER: 185702482	DRAWN BY: TF	CHECKED BY: BD	APPROVED BY: CM



NOTES:
 Projection: CA State Plane NAD83 Feet Zone V
 Outside Data Sources: Arcadis and CH2MHill, December 2011



- Mesozoic Igneous Rocks**
- ql - Quartz Latite
 - a - Aplite
 - qd - Quartz Diorite
 - qm - Quartz Monzonite
- Older Metamorphic Rocks**
- wm - Marble
 - wq - Quartzite
 - wg - Quartz Diorite Gneiss

- Quarternary Deposits**
- Qa - Alluvial Sand of Valley Areas
 - Qoa - Older Alluvial Gravel

Chromium Plume (Fourth Quarter 2011)
 Concentration of Hexavalent Chromium (ug/l)
 3.1 ug/l
 (Dashed Where Inferred)

Fault Features
 Fault Features; Dotted where concealed;
 Arrows indicate relative movement
 U = Uplthrown Side
 D = Downthrown Side

Note:
 1) Topographic base map used on this Dibblee geologic map is from 1956. Road names and other features shown may have changed and current information is shown on Figure 2
 2) Location of Lockhart Fault from USGS

- Upper Aquifer Chromium Investigation Monitoring Wells Installed Since December 2010 (MW-94 through MW-154)
- ⊕ Chromium Investigation Borings Advanced Since December 2010 (120-SB1, 120-SB2, D-B1, E-B1)

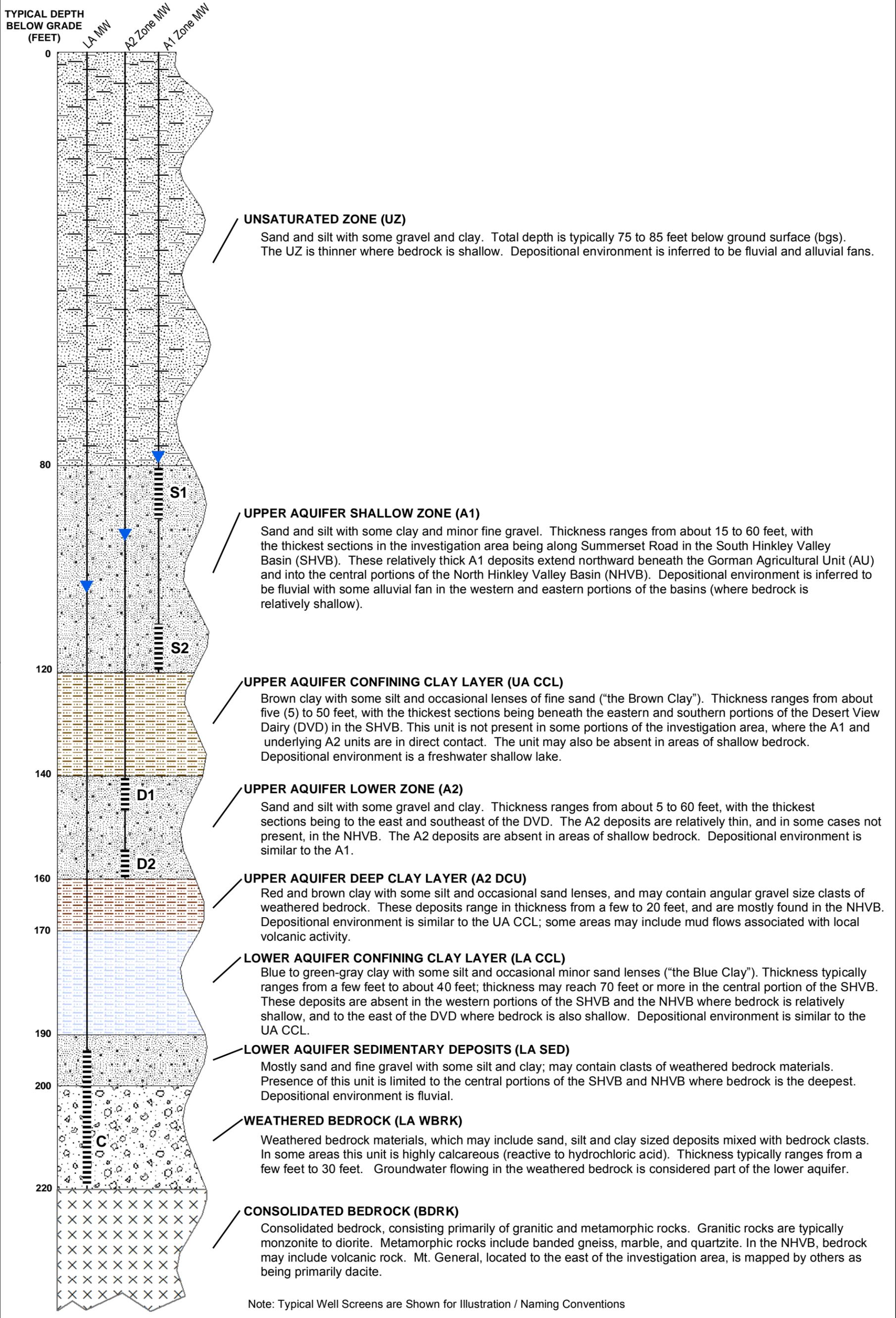
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 Pacific Gas & Electric
 Groundwater Remediation Project
 Hinkley, California

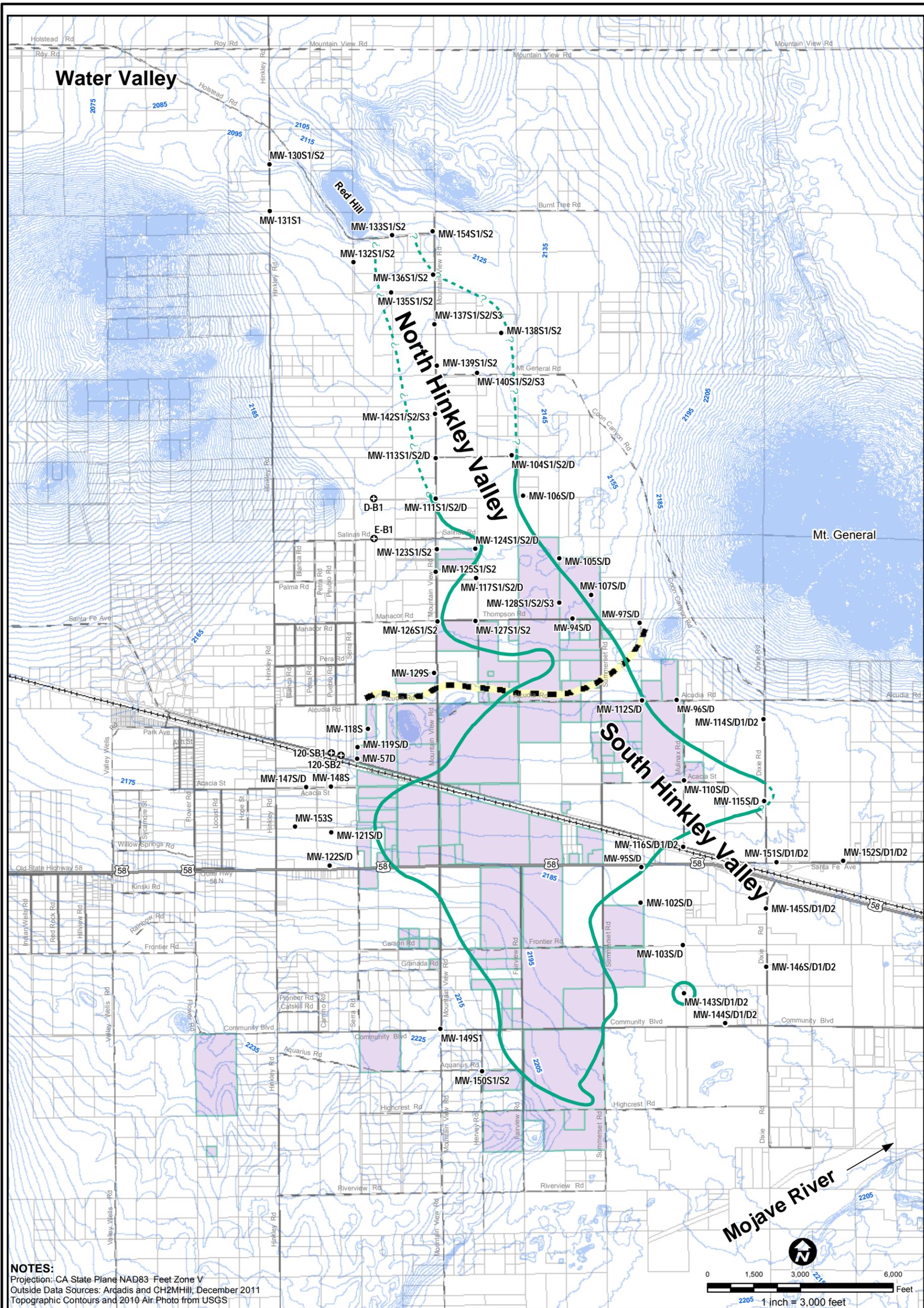
JOB NUMBER: 185702482
 DRAWN BY: TF
 CHECKED BY: BD
 APPROVED BY: CM
 DATE: 02/17/12

GEOLOGIC MAP OF THE HINKLEY VALLEY AND SURROUNDING AREAS

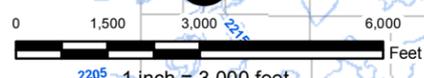
FIGURE:
3
 DATE: 02/17/12



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	JOB NUMBER: 185702482	DRAWN BY: TF			CHECKED BY: BD



NOTES:
 Projection: CA State Plane NAD83 Feet Zone V
 Outside Data Sources: Arcadis and CH2MHill, December 2011
 Topographic Contours and 2010 Air Photo from USGS



- Upper Aquifer Chromium Investigation Monitoring Wells Installed Since December 2010 (MW-94 through MW-154)
- ⊕ Chromium Investigation Borings Advanced Since December 2010 (120-SB1, 120-SB2, D-B1, E-B1)
- ⊗ Piezometer Completed During the Most Recent Investigation
- Ground Surface (5 ft AMSL)
- Conceptual Boundary for the North and South Hinkley Valley Basins
- PGE Property Boundaries

Note:
 Monitoring Well MW-134 was subsequently damaged during installation and destroyed. This well was replaced with MW-154.

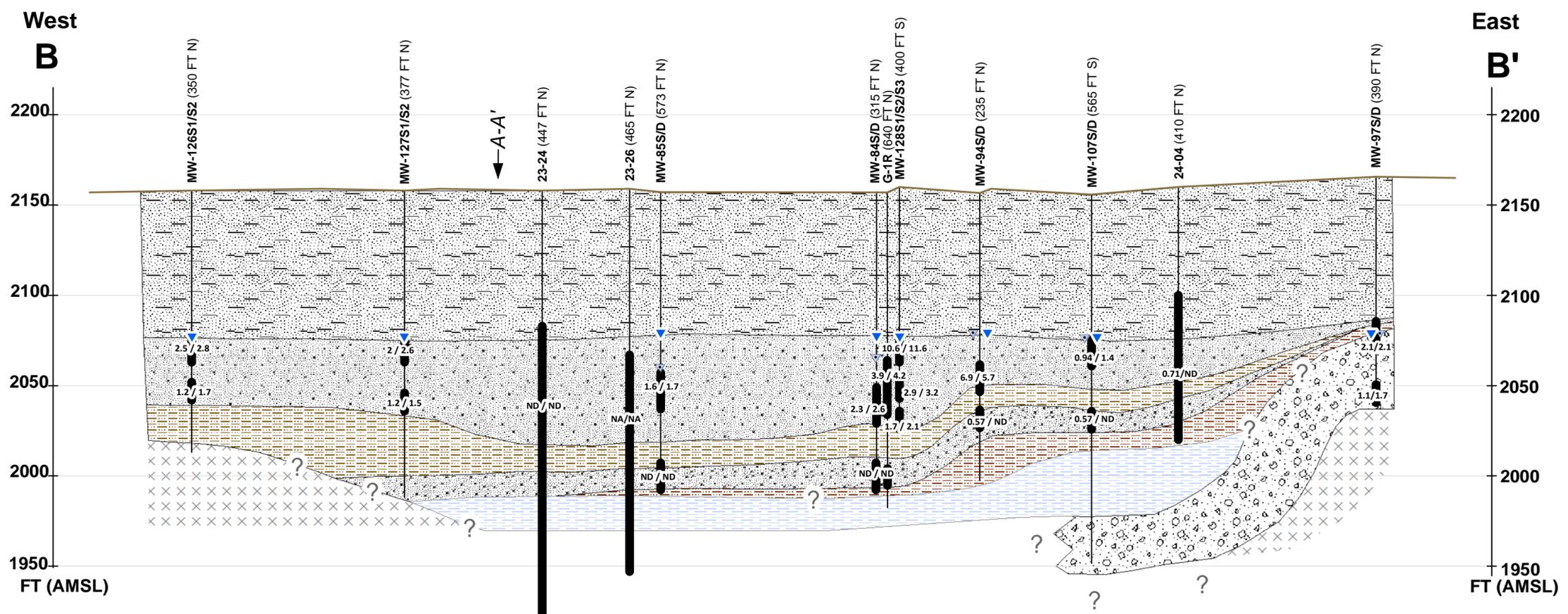
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 Hinkley, California**

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 DATE: 02/17/12

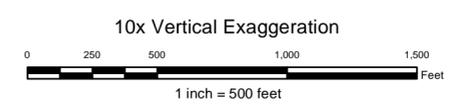
**CONCEPTUAL BOUNDARY FOR THE
 NORTH AND SOUTH HINKLEY
 VALLEY BASINS**

FIGURE:
5
 DATE: 02/17/12



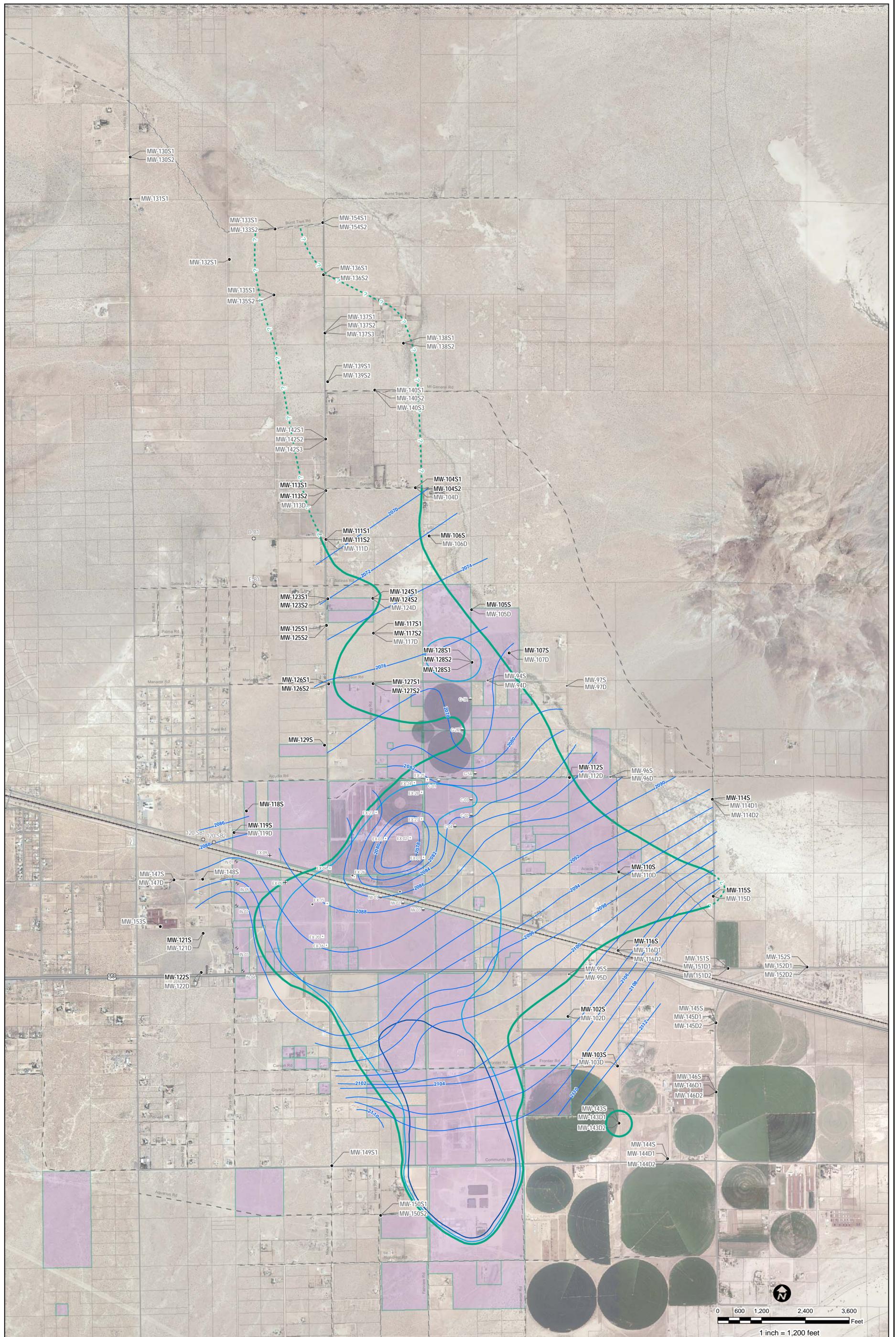
Geologic Contacts

- Unsaturated Zone (UZ)
- Upper Aquifer Shallow Zone (A1)
- Upper Aquifer Confining Clay layer (UA CCL) "The Brown Clay"
- Upper Aquifer Lower Zone (A2)
- Upper Aquifer Deep Clay Layer (A2 DCU)
- Upper Aquifer / Lower Aquifer (LA CCL) "The Blue Clay"
- Lower Aquifer - Weathered Bedrock (LA WBR)
- Bedrock (BDRK)

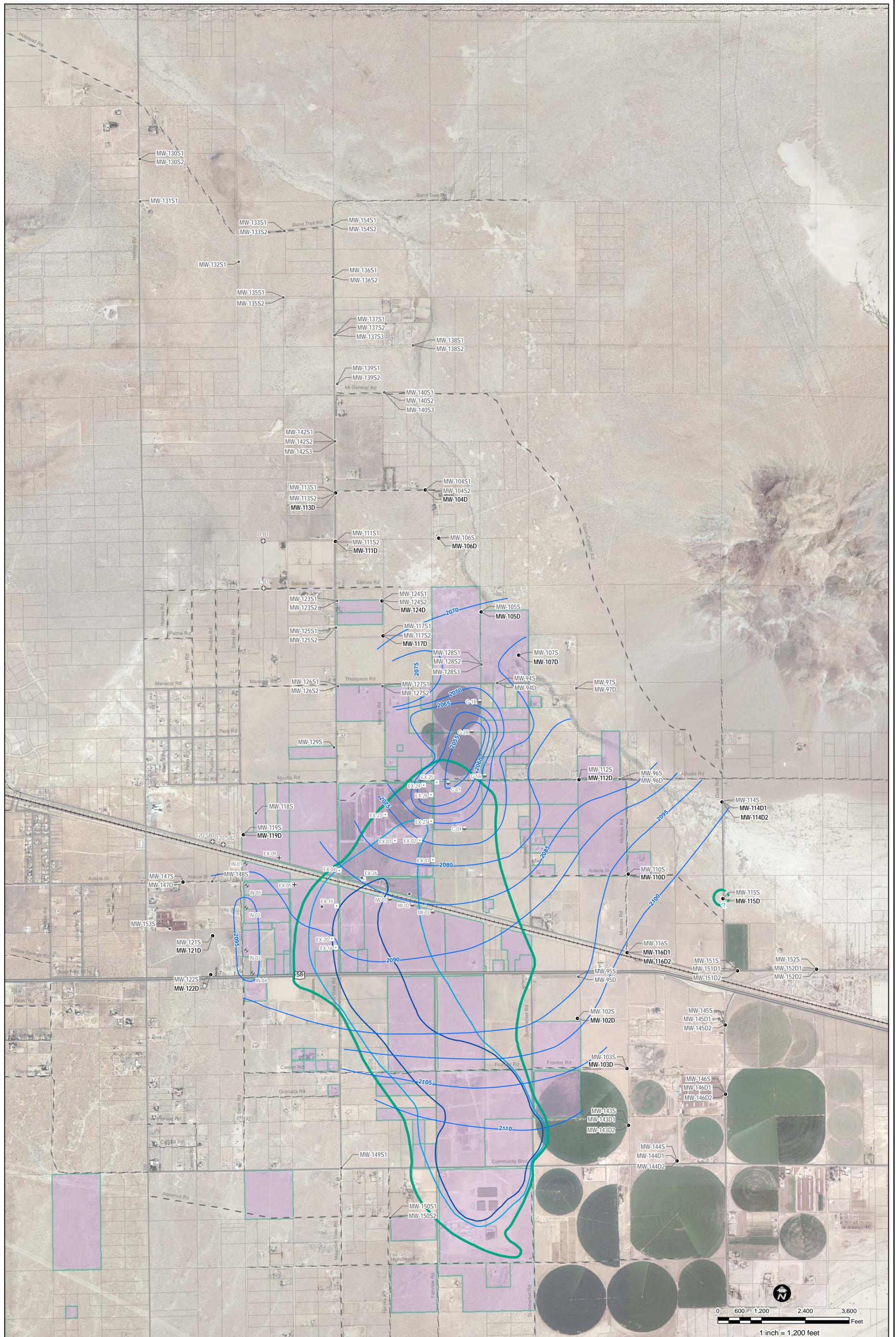


	Well / Borehole		Water Level A1 Zone Well (October 2011)	NA/NA	Not Available. Well has either not been sampled or has been sampled but validated results are not yet available as of the date of this report.
	Screen Interval		Water Level A2 Zone Well (October 2011)		
	Ground Surface				
	Projected Distance From Line of Cross Section	1.70 / 2.70	Cr6 / CrT		Concentrations in micrograms per liter (µg/L) (4th Quarter 2011, or if 4th Quarter 2011 data unavailable then most recent)

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	JOB NUMBER: 185702482	DRAWN BY: TF	CHECKED BY: BD	APPROVED BY: CM	DATE: 02/17/12

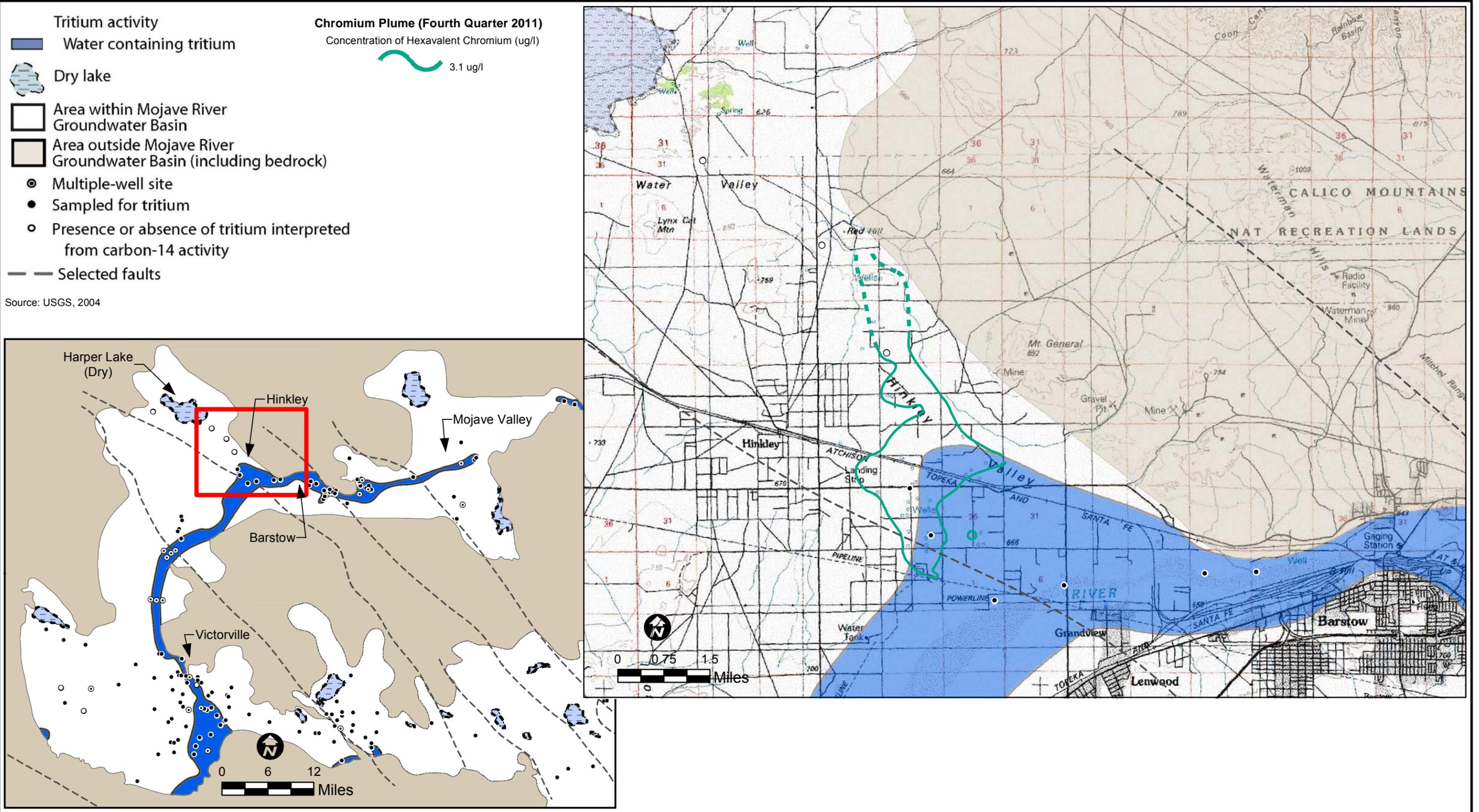


<p>Wells by Well Type</p> <ul style="list-style-type: none"> ● Groundwater Monitoring Well ⊕ Domestic Supply Well ⊖ Agricultural Supply Well ⊕ Freshwater Extraction Well ⊖ Freshwater Injection Well ⊕ Soil Boring ⊕ Multi-Use, Test Well, Inactive Groundwater Extraction Well 	<p>■ PGE Property Boundaries</p>	<p>● Upper Aquifer Chromium Investigation Monitoring Wells Installed Since December 2010 (MW-94 through MW-154)</p> <p>⊕ Chromium Investigation Borings Advanced Since December 2010 (120-SB1, 120-SB2, D-B1, E-B1)</p> <p>⊕ Potentiometric Surface of Shallow Zone Elevation Contour (ft above MSL)</p> <p>Note Well labels shown in gray scale text are for reference only and were not used to contour the potentiometric surface illustrated on this figure.</p>	<p>Shallow Zone Chromium Plume (Fourth Quarter 2011) Concentration of Hexavalent Chromium (ug/l)</p> <p>50 ug/l</p> <p>10 ug/l</p> <p>3.1 ug/l</p> <p>(Dashed Where Interred)</p> <p>Source: CH2MHill Fourth Quarter 2011 Groundwater Monitoring Report and Domestic Well Sampling Results, January 30, 2012</p>	<p>57 LAFAYETTE CIRCLE, 2ND FLOOR LAFAYETTE, CALIFORNIA PHONE: (925) 299-8300 FAX: (925) 299-8302</p>	<p>FOR: Pacific Gas & Electric Groundwater Remediation Project Hinkley, California</p> <p>JOB NUMBER: 185702482</p> <p>DRAWN BY: TF</p> <p>CHECKED BY: BD</p> <p>APPROVED BY: CM</p> <p>DATE: 02/17/12</p>	<p>POTENTIOMETRIC GROUNDWATER SURFACE FOR THE UPPER AQUIFER SHALLOW ZONE FOURTH QUARTER 2011</p> <p>FIGURE: 8</p>
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<p>Wells by Well Type</p> <ul style="list-style-type: none"> ● Groundwater Monitoring Well ⊕ Domestic Supply Well ⊖ Agricultural Supply Well ⊕ Freshwater Extraction Well ⊖ Freshwater Injection Well ⊕ Soil Boring ⊕ Multi-Use, Test Well, Inactive Groundwater Extraction Well 	<p>■ PGE Property Boundaries</p>	<p>● Upper Aquifer Chromium Investigation Monitoring Wells Installed Since December 2010 (MW-94 through MW-154)</p> <p>⊕ Chromium Investigation Borings Advanced Since December 2010 (120-SB1, 120-SB2, D-B1, E-B1)</p> <p>⊕ Potentiometric Surface of Deep Zone Elevation Contour (ft above MSL)</p> <p>Note Well labels shown in gray scale text are for reference only and were not used to contour the potentiometric surface illustrated on this figure.</p>	<p>Deep Zone Chromium Plume (Fourth Quarter 2011) Concentration of Hexavalent Chromium (ug/l)</p> <ul style="list-style-type: none"> 50 ug/l 10 ug/l 3.1 ug/l <p>Source: CH2MHill Fourth Quarter 2011 Groundwater Monitoring Report and Domestic Well Sampling Results, January 30, 2012</p>	<p>Stantec 57 LAFAYETTE CIRCLE, 3RD FLOOR LAFAYETTE, CALIFORNIA PHONE: (925) 299-8300 FAX: (925) 299-8302</p>	<p>FOR: Pacific Gas & Electric Groundwater Remediation Project Hinkley, California</p> <p>JOB NUMBER: 185702482</p> <p>DRAWN BY: TF</p> <p>CHECKED BY: BD</p> <p>APPROVED BY: CM</p> <p>DATE: 02/17/12</p>	<p>POTENTIOMETRIC GROUNDWATER SURFACE FOR THE UPPER AQUIFER DEEP ZONE FOURTH QUARTER 2011</p> <p>FIGURE: 9</p>
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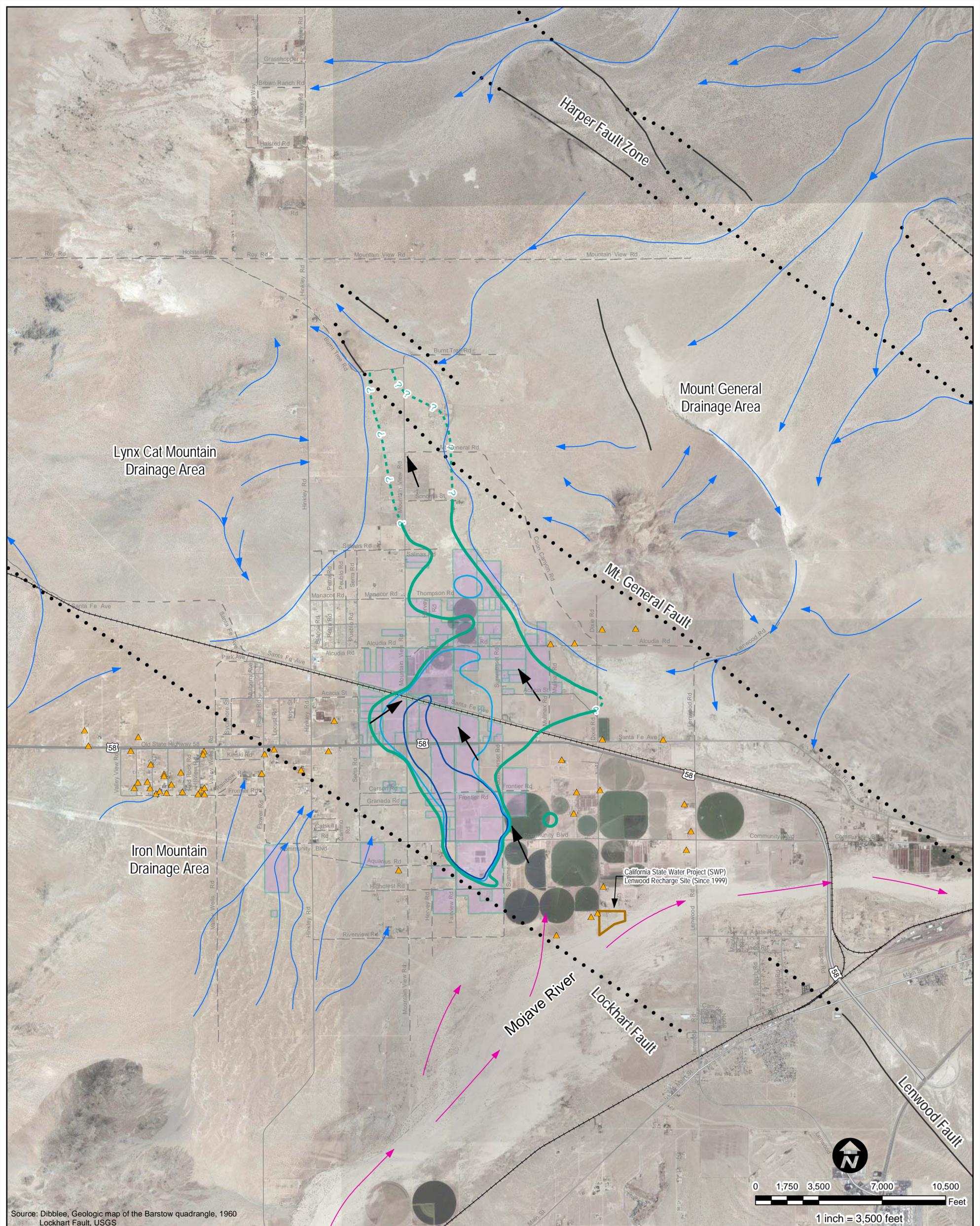
Z:\PG&E\MXD_Files\January 2012\Background Study\Figure 10 (Tritium in GW) (2012-2-17)8x11.mxd



Source: USGS, 2004

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	JOB NUMBER: 185702482	DRAWN BY: TF	CHECKED BY: BD	APPROVED BY: CM

Z:\P&E\EMWD_Final\January 2012\Background Study\Figure 11 (GW recharge to Hinkley Valley) [2012-2-10] size.mxd



Source: Dibblee, Geologic map of the Barstow quadrangle, 1960
Lockhart Fault, USGS

- Generalized Upper Aquifer Groundwater Flow Direction
 - Simplified Surface Drainage in and Around the Hinkley Valley
 - Mojave River Flow and Recharge to Hinkley Valley
 - ▲ Well from Prior Background Study
 - PGE Property Boundaries
 - Geologic Fault
 - - - Dashed Where Indefinite
 - Dotted Where Concealed
- Chromium Plume (Fourth Quarter 2011)**
Concentration of Hexavalent Chromium (ug/l)
- 50 ug/l
 - 10 ug/l
 - 3.1 ug/l (Dashed Where Inferred)

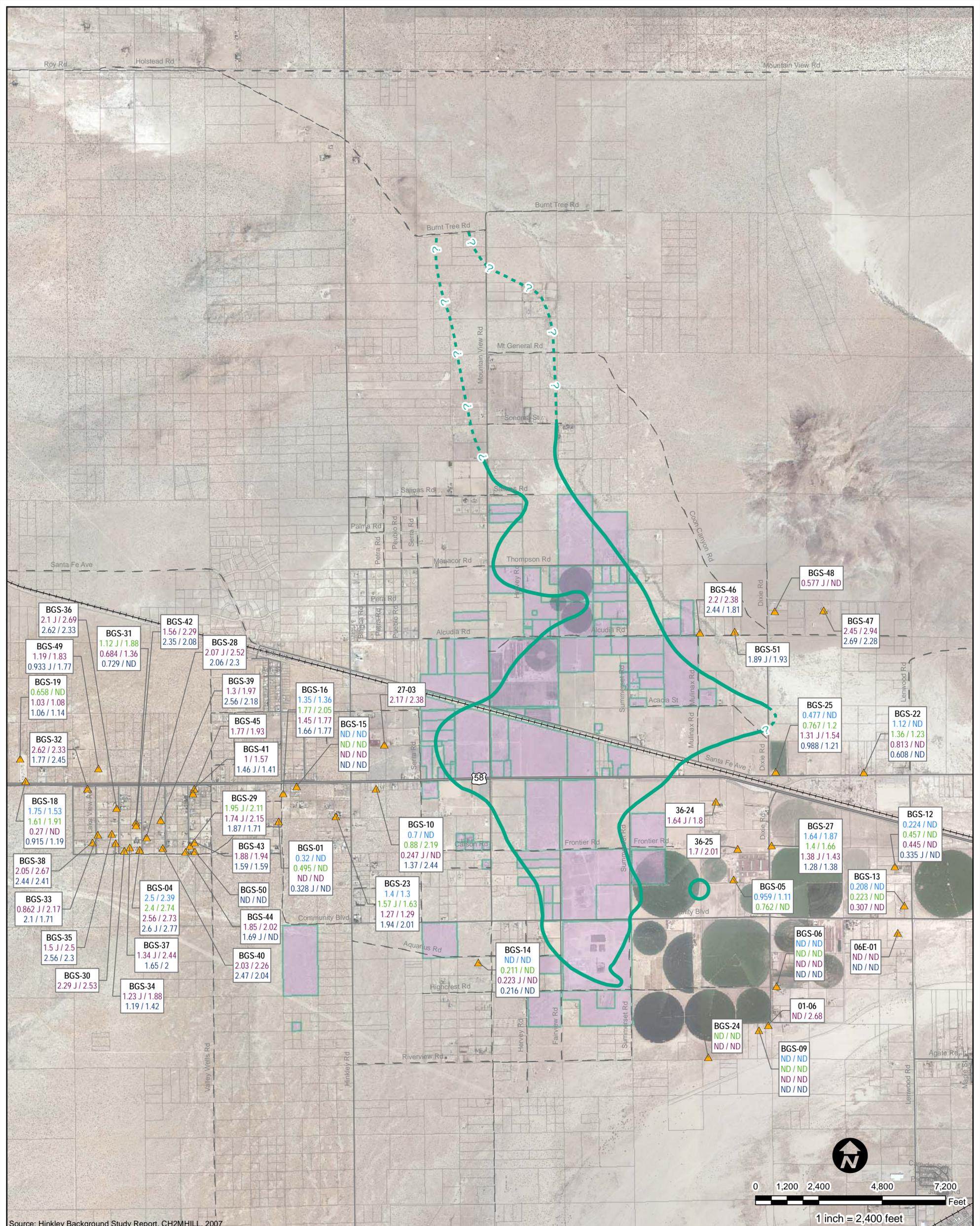
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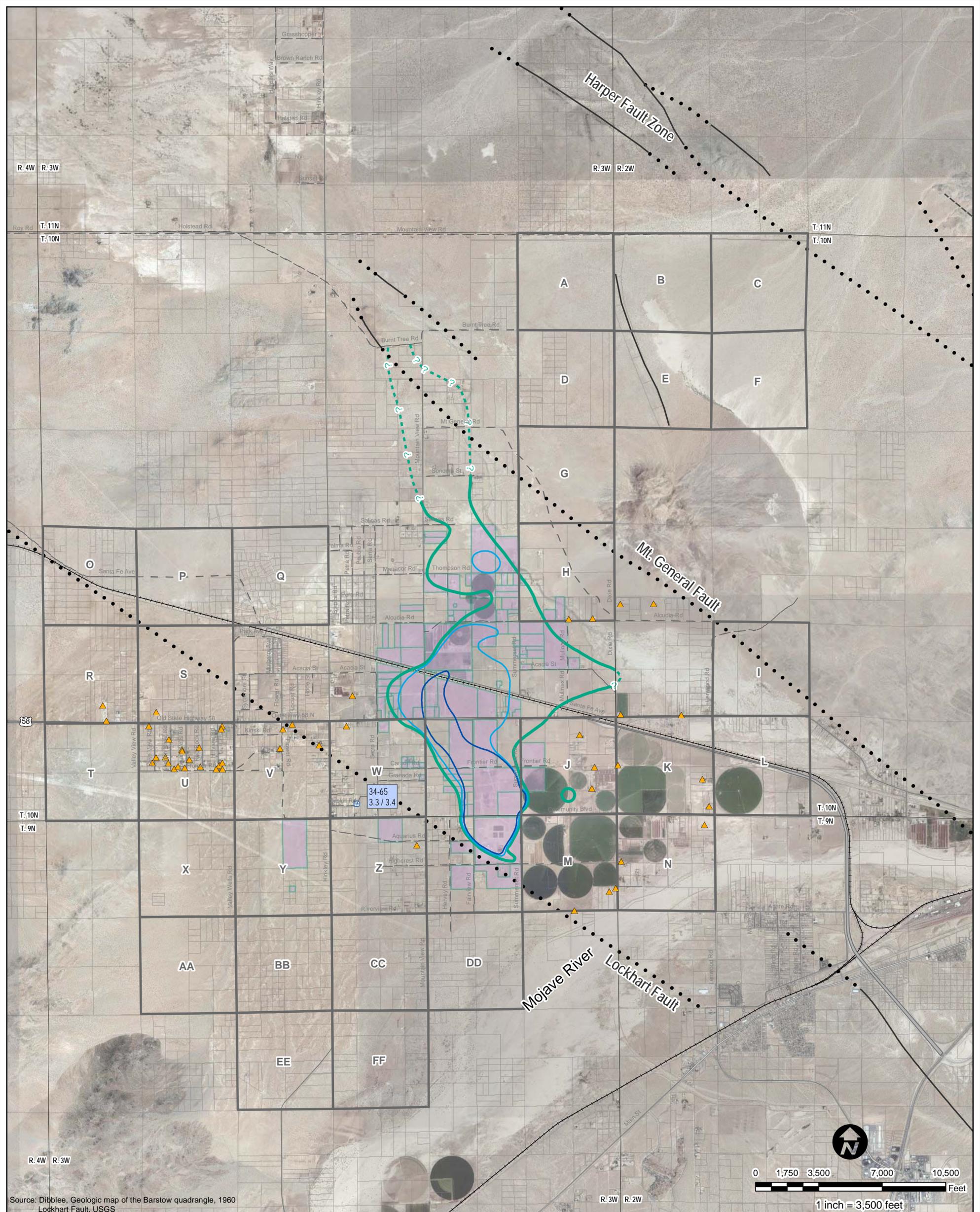
FIGURE:
11

DATE: 02/10/12

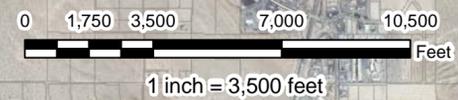


Source: Hinkley Background Study Report, CH2MHILL, 2007

<p>Background Wells 1st through 4th Quarters, 2006</p> <p>ND / ND First Quarter Cr6 / CrT (ug/L)</p> <p>ND / ND Second Quarter Cr6 / CrT (ug/L)</p> <p>ND / ND Third Quarter Cr6 / CrT (ug/L)</p> <p>ND / ND Fourth Quarter Cr6 / CrT (ug/L)</p>	<p>PGE Property Boundaries</p>	<p>Chromium Plume (Fourth Quarter 2011)</p> <p>Concentration of Hexavalent Chromium (ug/L)</p> <p>3.1 ug/L (Dashed Where Inferred)</p>	<p>Stantec</p> <p>57 LAFAYETTE CIRCLE, 2ND FLOOR LAFAYETTE, CALIFORNIA PHONE: (925) 299-9300 FAX: (925) 299-9302</p>	<p>FOR: Pacific Gas & Electric Groundwater Remediation Project Hinkley, California</p> <p>JOB NUMBER: 185702482 DRAWN BY: TF</p>	<p>CHECKED BY: BD APPROVED BY: CM</p>	<p>FIGURE: 12</p> <p>DATE: 02/17/12</p>
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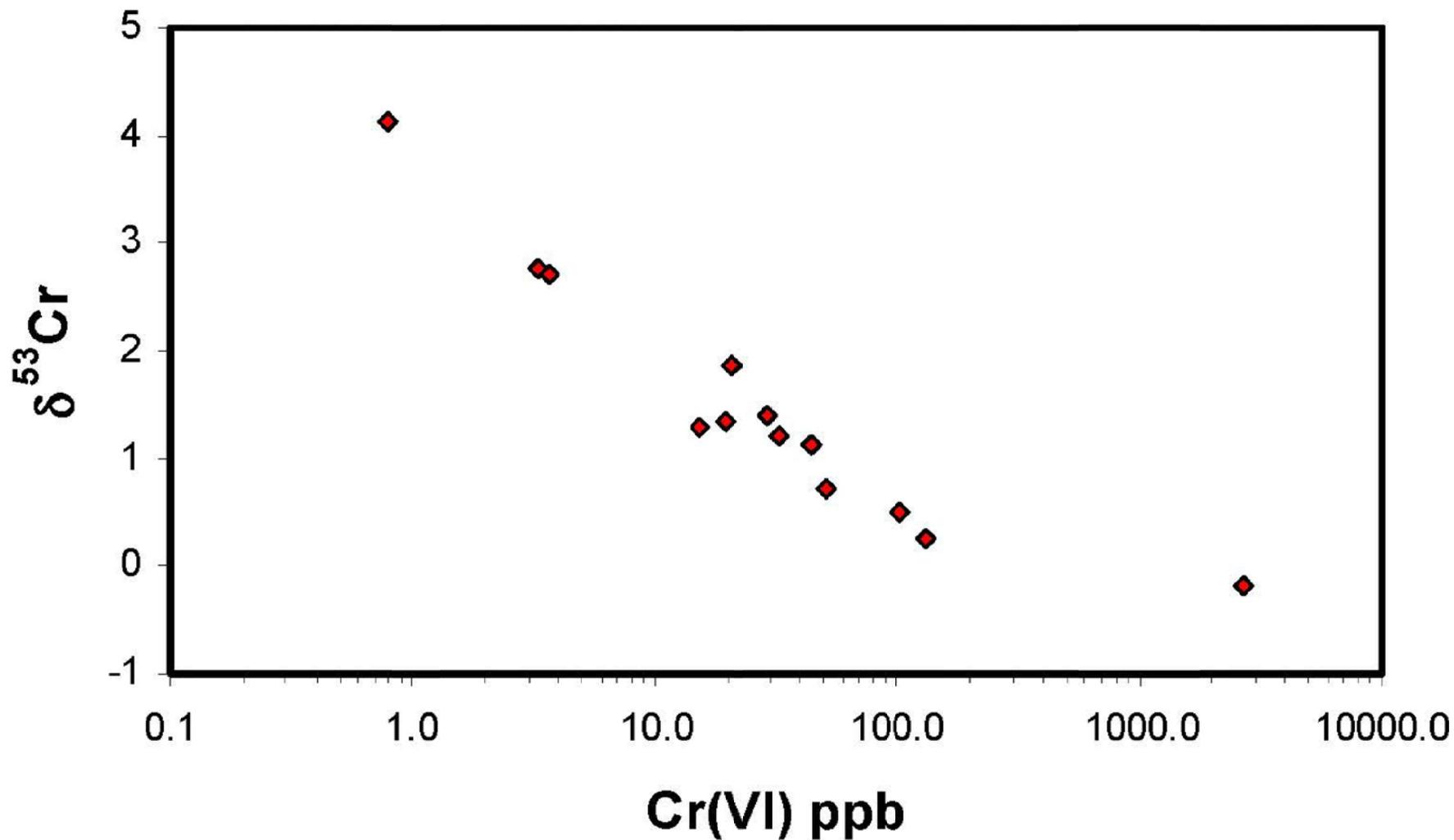


Source: Dibblee, Geologic map of the Barstow quadrangle, 1960
Lockhart Fault, USGS



<p>34-65 3.3 / 3.4</p> <p>▲ Well from Previous Background Study</p> <p>⊕ Domestic Supply Well</p> <p>Ⓐ Sampling Grid</p> <p>Ⓜ PGE Property Boundaries</p>	<p>— Geologic Fault</p> <p>- - - Dashed Where Indefinite</p> <p>••••• Dotted Where Concealed</p>	<p>Chromium Plume (Fourth Quarter 2011) Concentration of Hexavalent Chromium (ug/l)</p> <p>50 ug/l</p> <p>10 ug/l</p> <p>3.1 ug/l (Dashed Where Inferred)</p>
<p>Note</p> <p>1) One groundwater monitoring well is proposed within each grid. The well will be located as close as reasonable possible to the center point of each grid, in consideration of property access as well as biological and cultural sensitivities."</p>		

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	JOB NUMBER:	185702482	DRAWN BY:	TF	CHECKED BY:	BD	APPROVED BY:	CM	DATE:



Source: Hinkley Background Study Report, CH2MHILL, 2007



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Hinkley, California

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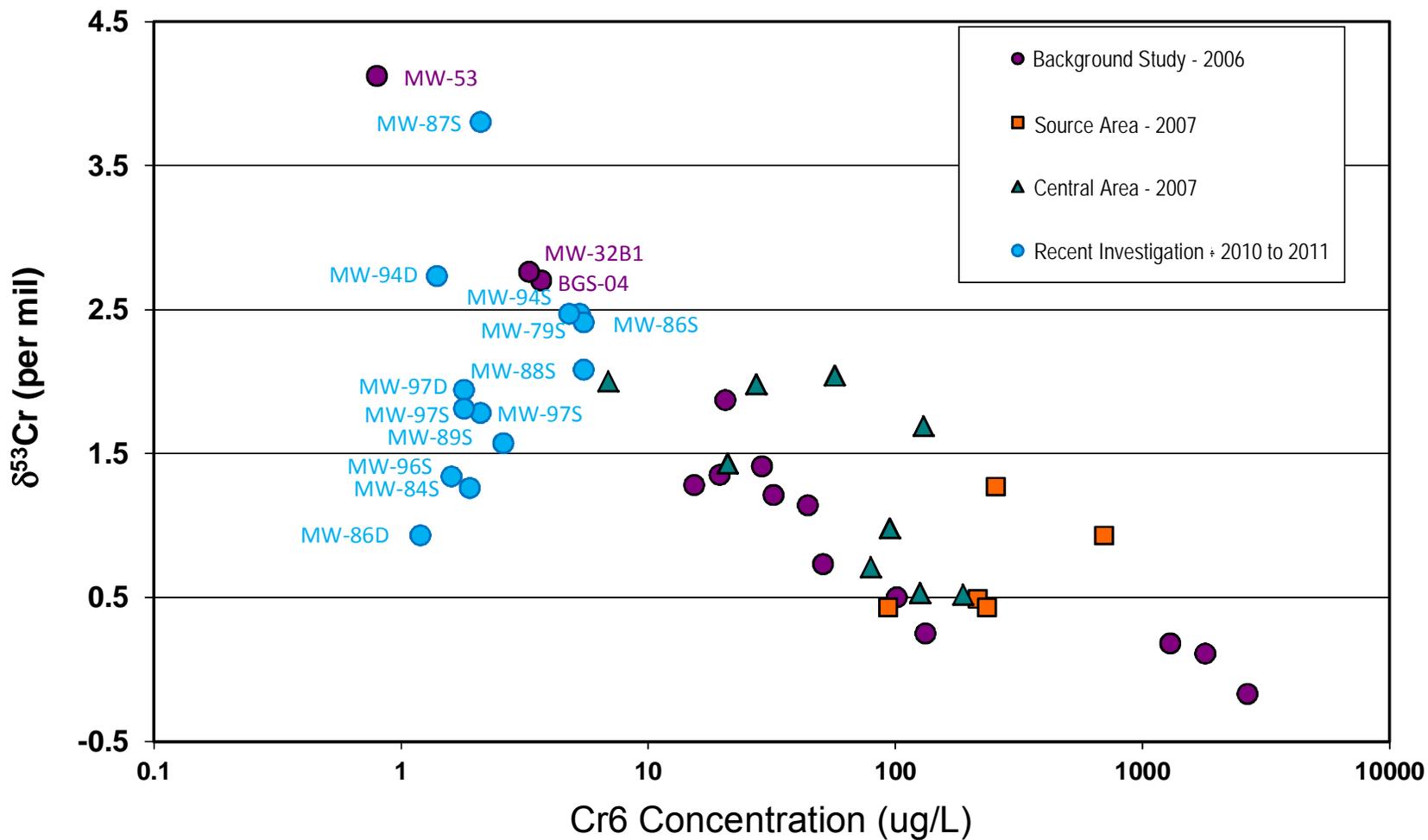
**CHROMIUM ISOTOPE
DATA FROM PRIOR
BACKGROUND STUDY**

CHECKED BY: BD
APPROVED BY: CM

FIGURE:

14

DATE: 02/17/12




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JOB NUMBER: 185702482
 DRAWN BY: TF

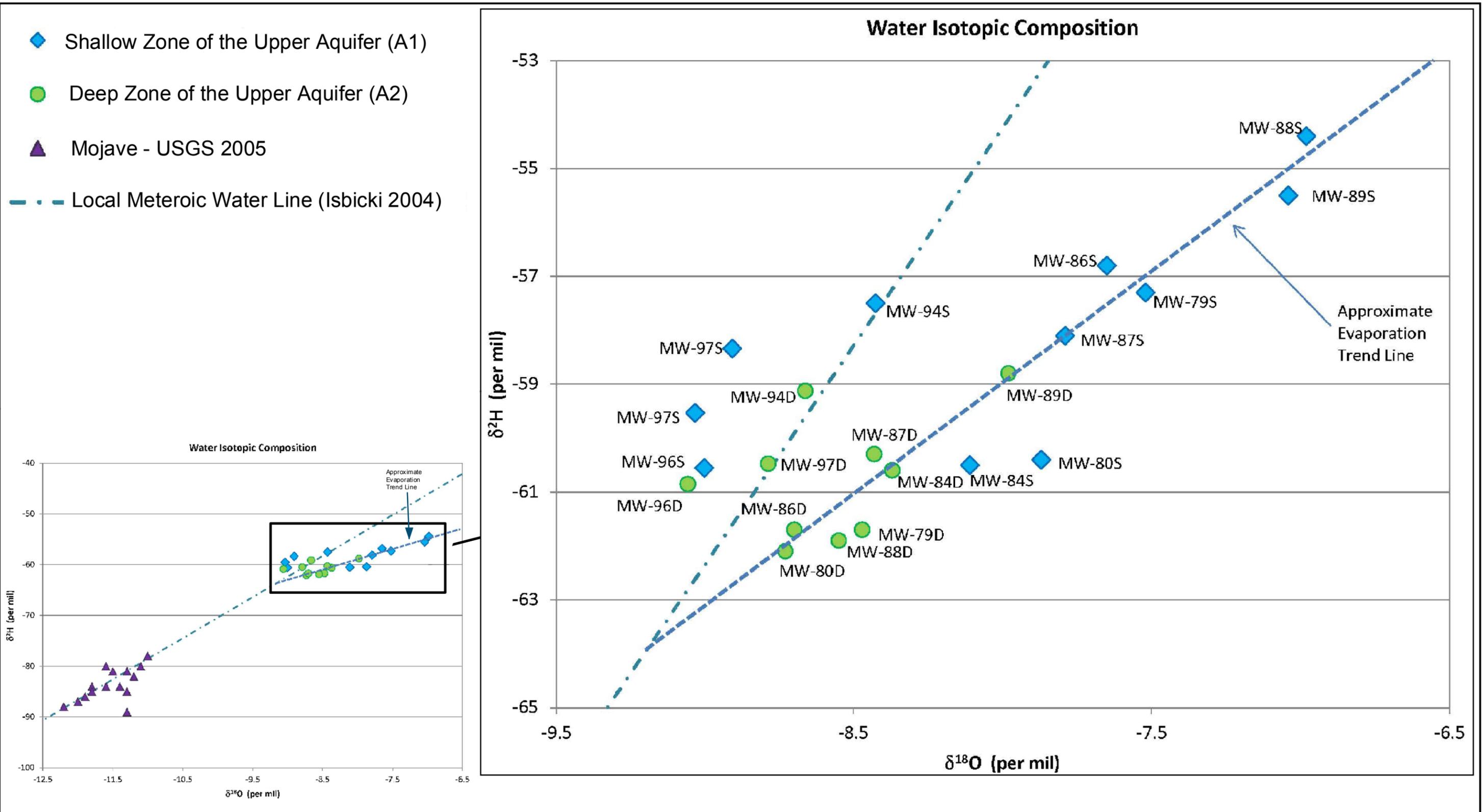
CHROMIUM ISOTOPE DATA

CHECKED BY: BD
 APPROVED BY: CM

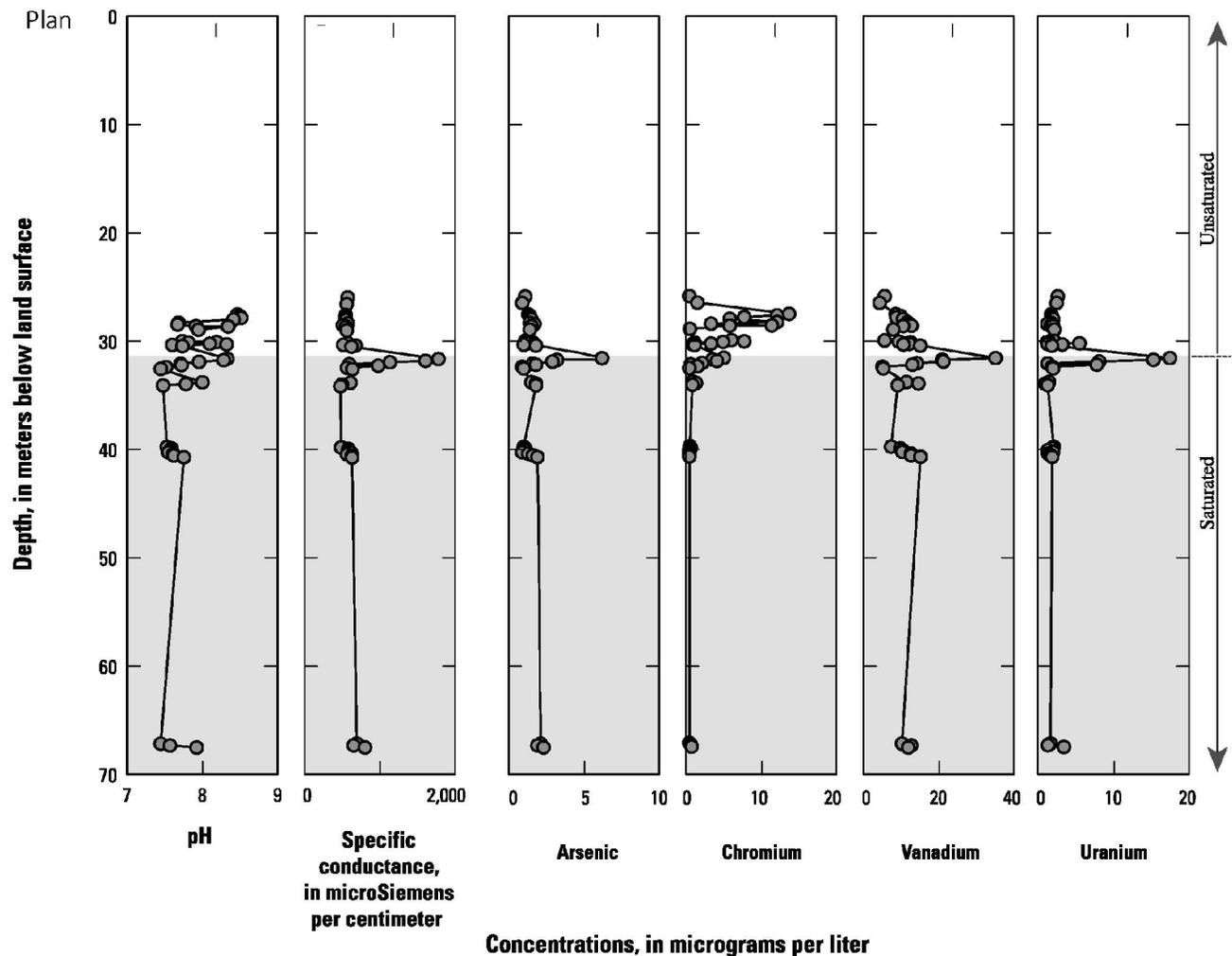
FIGURE:
15

DATE: 02/17/12

Z:\PG&E\MXD_Files\January 2012\Background Study\Figure 16 (O and H Isotope) (2012-2-17)1X17.mxd



 Stantec 57 LAFAYETTE CIRCLE, 2ND FLOOR LAFAYETTE, CALIFORNIA PHONE: (925) 299-9300 FAX: (925) 299-9302	FOR: Pacific Gas & Electric Groundwater Remediation Project Hinkley, California		OXYGEN AND HYDROGEN ISOTOPE DATA FROM MOST RECENT EVALUATIONS		FIGURE: 16
	JOB NUMBER: 185702482	DRAWN BY: TF	CHECKED BY: BD	APPROVED BY: CM	DATE: 02/17/12



Notes:

1. Figure taken from: J.A. Izbicki et al., Applied Geochemistry 23 (2008) 1325-1352.
2. Data collected from core material from Sheep Creek fan upgradient from El Mirage, western Mojave Desert, southern California.



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Hinkley, California

JOB NUMBER:
185702482

DRAWN BY:
TF

**PROFILE OF GROUNDWATER
DATA FROM IZBICKI**

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Stantec

**WORK PLAN FOR EVALUATION OF BACKGROUND CHROMIUM IN THE GROUNDWATER OF THE
UPPER AQUIFER IN THE HINKLEY VALLEY, PACIFIC GAS AND ELECTRIC COMPANY, HINKLEY
CALIFORNIA**

APPENDIX A

Work Plan for Evaluation of Background
Chromium in the Groundwater of the Upper Aquifer in the Hinkley Valley
Pacific Gas and Electric Company
Stantec PN# 185702482
February 22, 2012

Item No.	Comment	Peer	Location (Page)	Category	PG&E Responses
1	The uneven distribution of measurement locations (sampling wells) could lead to bias when using the data for predictions unless analysis is applied to take this into account. There are known techniques to handle the clustering effect. It does not appear that declustering was applied to the data.	UC Berkeley	Spatial Sampling UCB Page 1	Spatial Distribution	PG&E agrees. Additional data analysis could be conducted to evaluate the potential effect of clustering. However, in our view, such efforts would best be applied to data that are more representative of the physical system (i.e., depth discrete data collected in a more even manner in the Hinkley Valley [comments in rows 2 and 3]).
2	PG&E proposed to expand the well network (area being sampled) to compensate for the lack of discrete-depth samples (page 1-4). This approach cannot work unless the concentration field is stationary and statistically isotropic, which cannot be the case.	UC Berkeley	Spatial Sampling UCB Page 2 (Additional comment 1)	Discrete-depth sampling	PG&E agrees that the depth discrete sampling was not adequately conducted in the original study, and potentially biased results. This issue warrants additional investigation.
3	Table 3-1 indicates that several wells are screened over the upper (floodplain) and lower (regional) aquifer. ... This could lead to ambiguity as to what the concentration averages actually represent (i.e. which geologic unit?). Furthermore, it could also lead to bias ... The ambiguity could be removed to a large degree through appropriate modeling, but to my understanding this has not been done.	UC Berkeley	Spatial Sampling UCB Page 2 (Additional comment 2)	Discrete-depth sampling	PG&E agrees that the depth discrete sampling was not adequately conducted in the original study and potentially biased results. This issue warrants additional investigation.
4	Spatial averages are of little predictive value in the case of non-stationary variables such as the concentration. The population sample mixes measurements taken upstream (potentially low values) and downstream (potentially larger values) of the compression area. There also appears to be a trend of the concentrations increasing from east to west. All this could lead to biases. A physically-based analysis could take the trends in the concentration into account and provide better predictions.	UC Berkeley	Spatial Sampling UCB Page 2 (Additional comment 3)	Spatial Distribution	Sampling locations for the background study were selected outside of the known potential compressor station plume. As a result, the concern regarding the mixing of data collected "upstream" and "downstream" of the compressor station does not apply. While the recommendation to use a physically-based model has technical merit in concept, such analysis at this scale is not practical. Current models do not have the capability to incorporate a stochastic physical model with a transient description of groundwater flow and geochemical processes that naturally contribute hexavalent chromium to groundwater. It is recognized that the statistics applied were an approximation, but they were consistent with industry practices for background determination and the methods presented in the work plan.
5	To address the bias of a temporally unbalanced data set (due to expansion of the well network, same amount of data not available for all wells), the average value of Cr 6 and Cr T concentrations from each well were used in the statistical analysis. Each well is represented by one arithmetic mean result instead of by the actual number of samples taken at that well. I find this approach lacking in several respects, and I would recommend against it. My reasons are as follows. Averaging is known to alter the statistical nature of the variables being averaged. The primary effect is reducing variability. The consequence of that is that the averaged variables provide a "smoother" version of reality, and as a result the high and low values are averaged out. The elimination of high values of the concentration from consideration is obviously of concern in the context of this study because it would lead to biased estimates.	UC Berkeley	Temporal Sampling UCB Page 2-3	Statistics Averaging and Use of Physically Based Model	The reviewer indicates that temporal averaging may have biased the background numbers low. PG&E concurs that temporal averaging of data is not the most statistically accurate method to address the uneven temporal data sets that resulted from sampling access issues during the study. However, by "smoothing" out the dataset, the method that was used resulted in a lower (i.e., more conservative) estimate of background. Temporal averaging is not proposed in the next study.
6	The normal distribution is a favorite model selection in applications because of its simplicity... In order to test whether or not a normal model is acceptable, the background study elected to use the formalism of hypothesis testing. The underlying theory is documented in many textbooks. The approach is to state a null hypothesis (in this case, that the concentrations are normally distributed) and then to apply a test that would indicate whether this assumption could be rejected or not. A fundamental tenet of hypothesis testing is that the test can only determine whether there's enough evidence to reject the null hypothesis. Hypothesis testing does not provide conclusive evidence that the null hypothesis is the right one. It can only determine whether or not there's enough evidence to reject it. Based on this, the statement made in Appendix I that "the probabilities (p-values) from the Shapiro-Wilk test (W test) provide evidence about whether the background total and hexavalent chromium concentrations are normally or log-normally distributed" is very doubtful. The test does not provide such evidence, its power is only to state whether there's enough evidence to reject the assumption of normality. Not having enough evidence to reject the null hypothesis (normality) does not mean that the normal model is the best one. ... There is evidence for asymmetry in Table 6.1 where differences between the mean and median of the distribution are shown to exist: in normal distributions these values should be equal (or at least very close to each other). Hence, there are indications against the assumption of normality. ... The question is whether the assumption of normality is the safe assumption and should it be used as the null hypothesis. In my opinion it is not a safe assumption because it could underestimate the probabilities of high concentrations. For example, a lognormal distribution has a longer "tail" and it assigns higher probabilities to the high concentrations, and so it could possibly be a safer assumption. This option and perhaps others need to be considered.	UC Berkeley	Statistical Normality UCB Page 3 (paragraph 1,2), Page 4 (paragraph 5)	Statistics Normality Model	In several paragraphs, the reviewer questions the use of hypothesis testing and selection of the normal model, indicating that the normal model may have been accepted even though it does not necessarily completely describe the data set. The reviewer indicates that acceptance and the use of the normal model based on hypothesis testing may have biased the background number low. PG&E agrees that biasing the data low is not ideal and should be improved upon.

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7	The quality of the sample population is obviously of primary consideration. Shapiro and Wilk (1965) assume that their samples are identically distributed. Section 2.2 in the Shapiro-Wilk paper states that "The objective is to derive a test for the hypothesis that this is a sample from a normal distribution with unknown mean μ and unknown variance σ^2 ." As discussed in Section 2, the sample population includes measured concentrations and averaged measured concentrations. Because averaging alters the statistical nature of the underlying distribution, the population sample appears to be inappropriate for this kind of test because differences in temporal averaging procedures (e.g., averaging over 2, or 3 or 4 measurements) will lead to different statistical distributions for the various samples within the population sample, in a violation of the requirements of the test. The consequences of such violation need to be analyzed, but in principle, inferences from such a hybrid sample population are not suitable for determining the nature of the underlying distribution.	UC Berkeley	Statistical Normality UCB Page 4 (paragraph 4)	Statistics	PG&E agrees. As discussed in response to the comment on item 5, the need to average individual well concentrations overtime was an unfortunate consequence of having uneven temporal data for individual sampling locations due to difficulties accessing wells in the sampling program. This issue could be addressed through additional investigation work.
8	The Background Study does not assume correlation between the concentration measurements (ie, the measurements are assumed to be spatially-uncorrelated). This assumption, although not unreasonable for measurements with large distances in between, is not justified theoretically, and is particularly challenging for measurements at close proximity. It needs to be supported with evidence (could not be found in Study). There is concern that the test is inconsistent with the underlying physics.	UC Berkeley	Statistical Normality UCB Page 5 (paragraph 2)	Statistics	Additional geostatistical evaluation of the data (see response to comment in item 1 [declustering evaluation]) may be warranted to confirm the Study assumption of sample independence. It is important to note that, although the background wells appear relatively close together on the figures, minimum distance between the wells was typically on the order of 100s or 1000s of feet. These distances, and the relatively slow rate of groundwater movement, tend to support the assumption of sample independence. Additional investigation would confirm or refute this assumption.
9	The test of normality addresses the question of whether or not the population sample could be described as normally-distributed. It does not address the question of whether or not the normal model inferred from the population sample is a good model for prediction of regional or local averages of the concentration and its confidence intervals. The outcome of the Shapiro-Wilk test is questionable.	UC Berkeley	Statistical Normality UCB Page 5 (paragraphs 3 and 4)	Statistics	PG&E is open to a more rigorous statistical evaluation of the data generated for the background study, and welcomes specific input regarding suggested additional evaluations of this type. However, in our view, such efforts would best be applied to data that are more representative of the physical system (i.e., depth discrete data [comments 2 and 3]).
10	Very little information is provided regarding model calibration (Appx B; Section B.1.4) and is not enough to confirm the adequacy of the calibration effort. 1. The model was calibrated based on groundwater levels only. (a) Water levels alone cannot be used for calibrating the spatial distribution of the hydraulic conductivity because there is no unique relationship between water levels and conductivity. Without sound calibration of the hydraulic conductivity and field porosity, the groundwater model cannot be used to predict velocities and concentrations. (b) No information is provided on the quality of the match between measured head and model-based predictions. Even small errors in the predicted heads could lead to large errors in the head gradients, velocities, and concentrations. (c) Without reliable estimates for the hydraulic conductivity, the reliability of the water budget analysis cannot be established.	UC Berkeley	Quality of GW Modeling UCB Page 5 (Paragraph 1)	GW Modeling	The groundwater model referenced in the Groundwater Background Study Report was deemed to be sufficiently calibrated for the purposes used in the report, although it is acknowledged that sufficient documentation was not provided. Calibration efforts included comparison of observed and calculated groundwater elevations, relationships between predicted and observed heads across various portions of the aquifer (gradients across the plume), and sensitivity analysis for hydraulic parameters. The residual mean error for the model was less than 1 foot, the root mean squared error about 5 feet, and the scaled root mean squared error less than 0.04 feet.
11	No attempt is reported to test the model against the concentration data (useful strategy to establish the credibility of the model). Methods for using concentration data are available.	UC Berkeley	Quality of GW Modeling UCB Page 5 (Paragraph 2)	GW Modeling	Simulated contaminant transport was not evaluated at the time of the Background Study. Due to the size and history of the site, an accurate simulation is not possible.
12	No attempt to model spatial variability of the hydrologic parameters is reported. Assuming the hydraulic conductivity to be uniform within each of the hydrostratigraphic units would neglect the possible consequences of channeling effects (fast flow channels would lead to faster downstream migration of chemicals). More work is needed in order to align the model calibration efforts with modern concepts. Uncertainty quantification (UQ) should be an important part of the study. No UQ that meets acceptable norms was carried out.	UC Berkeley	Quality of GW Modeling UCB Page 6 (Paragraph 1)	GW Modeling	The hydraulic conductivity was not assumed to be uniform within each stratigraphic unit as the reviewer implies in this comment. Each layer has several different hydraulic conductivity zones that were developed and varied based on calibration efforts.

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13	The first point I would like to make is that, regardless of whether or not the Shapiro-Wilk test is applicable or not, there is a need to evaluate the predictive capabilities of the normal model, and that is a different issue altogether. In other words, even if one accepts that the population sample is normal (see Section 3 for discussion on the difficulties with this), this does not constitute a confirmation that the normal model could actually be used for predicting (at best) anything but the statistics of that population sample, until the predictive capability itself is tested. The main reason for that is the issue of ergodicity. For spatial averages to be representative, the population sample must be ergodic (see Rubin, 2003). That means that the population sample must cover all the possible states of the sampled system, and in the right proportions. If this condition is met, then the population sample would be sufficient for making inferences about spatial averages. For stationary problems, satisfying the condition of ergodicity requires extensive spatial sampling. How large the sampled domain needs to be? This can only be established through physically-based modeling of the aquifer, including modeling of the spatial variability of the hydraulic conductivity and the flow and transport fields related to the spatial variability model. The added complication here is that the concentration field is non-stationary. This could be compensated through physically-based stochastic modeling strategies (Rubin, 2003). Another strategy to evaluate the model's predictive capability is through cross-validation (Rubin, 2003).	UC Berkeley	General Comments UCB Page 6 (paragraph 1)	Statistics Ergodicity, Physically based model	While the recommendation to use a physically-based model has technical merit in concept, such analysis at this scale is not practical. Current models do not have the capability to incorporate a stochastic physical model with a transient description of groundwater flow and geochemical processes that naturally contribute hexavalent chromium to groundwater. It is recognized that the statistics applied were an approximation, but they were consistent with industry practices for background determination and the methods presented in the work plan.
14	Another issue to consider is the no-detect concentrations. Figures 5-4 and 5-5 and associated discussion indicate that locations where the concentrations were measured below the detect limits were assigned values equal to half the detection limit. This is speculative. It may be a good speculation, but it is still a speculation, nonetheless. The speculation is in considering and analyzing the concentration from the perspective of a spatially-uncorrelated variable rather than a spatially-correlated variable. The point is that if one adopts the spatial correlation perspective, the no-detects could be interpreted in different ways. For example, one could also speculate that the no-detects could be indications of fast-flow channels with very high concentrations further downstream (Wilson and Rubin, 2002), or that the wells with no-detects were placed in low- conductivity areas with by-pass flow nearby. At times one must resort to speculations when it comes to groundwater applications, but there is a need to establish their likelihood. What is needed here is to substantiate this speculation by evaluating it using a physically-based flow and transport model. Another important point is that including speculative values in the population sample used to test normality is not warranted. Without accounting for the uncertainty around this speculation, one cannot assign any confidence intervals to any prediction that is based on a population sample that includes these values. This adds further doubts to the value of the normality test (see Section 3 for additional discussion).	UC Berkeley	General Comments UCB Page 6, Section 5 (paragraph 2) and Page 7 (paragraph 1)	Statistics	As the reviewer notes, there are multiple options for treatment of non-detect values for statistical analyses. In the background study, the non-detect values were treated as half the reporting limit, consistent with the work plan. This treatment may have biased the background number high or low. As noted above in response to the comment in item 4, the application of a physically based model, as the reviewer suggests, to this issue is not feasible.
15	Uncertainty quantification (UQ) is the idea that all sources of uncertainty must be accounted for when making predications. Modeling the model (normal and alternative) uncertainty and the parameters associated with the model is needed. In the Background Study, once a decision was made to accept the normal model, it was viewed as a certain model and that does not model realistically the uncertainty.	UC Berkeley	General Comments UCB Page 7 (paragraph 2)	Statistics	PG&E is open to a more rigorous statistical evaluation of the data generated for the background study, and welcomes specific input regarding suggested additional evaluations of this type. However, in our view, such efforts would best be applied to data that are more representative of the physical system (i.e., depth discrete data [comments 2 and 3]).
16	The Hinkley Valley in the Background Study area can be divided into 5 main areas: Core Area, South Upgradient Area, East Cross Gradient Area, West Cross Gradient Area, and North Downgradient Area (see Clearwater Figure 1). Of the 48 background study wells, 4 wells are screened only in the Upper Aquifer. The remaining background study wells (well screens over both the Upper and Lower Aquifer or no information available as to the screened zone) provide a mixed well concentration for CrT and Cr6 and do not accurately reflect the conditions of the specific aquifer zone.	Clearwater Group	Spatial Sampling CWG Pages 7 and 8	Sampling Program: Vertical Distribution	PG&E agrees that sampling of mixed aquifer wells introduced bias into the data set, and recommends additional investigation to correct this bias.
17	Of the 5 areas (shown in Figure 1), the South Upgradient Area is the most likely to provide natural or background levels of CrT and Cr6. Samples from the Mojave River, although more than one mile from the PG&E facilities, may show less anthropogenic influences for background samples of CrT and Cr6 for the region.	Clearwater Group	Spatial Sampling CWG Page 9 (paragraph 1)	Sampling Program: Spatial Distribution	The background number should reflect chromium concentrations in the area that are occurring outside of the inputs from PG&E's discharges of hexavalent chromium-bearing water to unlined ponds at the compressor station. As such, anthropogenic influences from sources other than the compressor station, e.g. agriculture, should not be discounted in the background study.

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18	Since the Upper Aquifer is likely to contain the majority of the CrT and Cr6, collecting samples where the well screens are unknown provides little useful information. The agricultural wells with unknown screen depths are likely to have been screened in both aquifer zones. Data from wells that are screened in more than one aquifer or having unknown screen depths should not be used in studies to establish background concentrations of CrT and Cr6. Installation of new monitoring wells with proper screens in specific and isolated aquifer zones is the best way to get accurate data on groundwater concentrations of CrT and Cr6.	Clearwater Group	Spatial Sampling CWG Page 9 (paragraph 3)	Sampling Program: Vertical Distribution	PG&E agrees that sampling of mixed aquifer wells likely introduced bias into the data set, and recommends additional investigation to correct this bias.
19	The natural Cr6 and CrT levels will be difficult to assess since the entire area has had intense agricultural pumping from both Upper and Lower Aquifers for up to eight decades. Artificial recharge has also been occurring in certain locations, affecting the natural background conditions of CrT and Cr6. The background study for both CrT and Cr6 in the current form is inadequate and inaccurate.	Clearwater Group	Spatial Sampling CWG Page 9 (paragraph 4)	Sampling Program: Spatial Distribution	PG&E agrees that potential anthropogenic impacts that are not related to compressor station discharges of Cr6 should be considered/addressed in further background studies. It is important to note that any non-PG&E impacts that historic land use may have had on Cr6 and CrT concentrations in groundwater in the Hinkley Valley should be considered part of the background condition of the groundwater.
20	There are only three wells from the West Cross Gradient area and one well from the Southern Upgradient Area that are known to be screened specifically in the Upper Aquifer. One to three wells in specific aquifer zones do not provide enough information to evaluate background concentrations or even current concentrations. From my field experience and given the size of the Hinkley area, a minimum of 20 to 40 properly constructed groundwater monitoring wells (designed to sample only one aquifer zone) should provide the minimal number of groundwater sampling locations for a scientifically reasonable background study. Detailed statistical evaluation of geochemical data coming from a majority of wells with unknown screen intervals or of screens covering commingled aquifers does not provide much scientific value.	Clearwater Group	Temporal Sampling CWG Page 10 (paragraph 1)	Sampling Program: Vertical Distribution	PG&E agrees that sampling of mixed aquifer wells introduced bias into the data set, and recommends additional investigation to correct this bias. The sampling program suggested by the reviewer was considered in the development of a work plan for additional investigation.
21	It was noted that 14 background study wells were sampled for 4 quarters. Various additional wells were added to the study. Statistical analyses should be run on the data from the original 14 wells. Statistics from one dataset cannot be combined with statistics from another dataset. These two datasets should be reported separately.	Clearwater Group	Temporal Sampling CWG Page 10 (paragraph 2)	Statistics	PG&E is open to a more rigorous statistical evaluation of the data generated for the background study, and welcomes specific input regarding suggested additional evaluations of this type. However, in our view, such efforts would best be applied to data that are more representative of the physical system (i.e., depth discrete data [comments 2 and 3]).
22	With regard to the assumption of statistical normality, aquifer-specific information and detailed statistics from wells screened in specific aquifers is required to put the laboratory analytical data into a geologic perspective. Properly performed statistics on inaccurate geochemical data are not valid.	Clearwater Group	Statistical Normality CWG Page 10 (paragraph 3)	Statistics	PG&E agrees. Additional investigation is appropriate.
23	The chosen set of 'background' wells are not located adequately upgradient and outside the range of influence of actively pumping (historically or currently) extraction wells (which could be drawing the Cr6 plume in an upgradient direction) to be representative of background conditions. Virtually all of the chosen wells are located in a cross gradient position from the main plume with poorly defined cross gradient CrT and Cr6 plume boundaries. Well data should reflect specific aquifer zones, not mixed zones. Given the eight decades of intense agricultural pumping, it is possible that with preferred flow pathways (high permeability zones due to lithologic characteristics or geologic faults (Lockhart) or other potential conduits), some of the CrT and Cr6 from the Core Area may have migrated over the past decades toward the east or west into the East Cross Gradient Area or the West Cross Gradient Area, respectively.	Clearwater Group	Quality of GW Modeling CWG Page 11 (comment a)	Sampling Program: Spatial Distribution	An analysis of historical pumping was performed in an attempt to locate background study well locations outside the historic plume migration pathway. Background study wells were located outside of areas that were known or predicted to be influenced by the plume. PG&E recognizes that there is uncertainty in this analysis, and that additional work is required to establish background concentrations for the Hinkley Valley.
24	Groundwater flow and transport modeling are needed to evaluate the role of actively pumping of current wells in the migration of the plume. Range of influence of individual pumping or injection wells should be mapped and modeled.	Clearwater Group	Quality of GW Modeling CWG Page 11 (comment b)	GW Modeling	As discussed in Section B2 of Appendix B on Groundwater Modeling, recent historic pumping was incorporated into the modeling effort, based on data collected by the Watermaster since the adjudication of the basin.
25	Correlation between land irrigation of CrT and Cr6 impacted groundwater at the Land Treatment Units and the presence of chromium in the underlying soil and groundwater needs more focused investigation. The mechanism of remediation of spraying Cr6 onto the soil and the conversion of the oxidized Cr6 into the reduced Cr3 and ultimately into chromium hydroxide using soil as a treatment media are not well documented or verified. Peroxide and acids may clean the drip or irrigation lines, but may also help to mobilize and carry the CrT and Cr6 deeper into the subsurface environment if the acids or peroxide are spilled onto the soil.	Clearwater Group	Quality of GW Modeling CWG Page 11 (comment c)	Remediation	Since the initiation of operation of the Desert View Dairy Land Treatment Unit in 2004, chromium data have been collected annually from 5 foot deep lysimeters. These data demonstrate the consistent and complete treatment of Cr6 in the root zone of the soil. The reviewer was likely unaware of this information, because it was outside the scope of the documents provided for the background study review.

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26	There has been none, and there is currently no hydraulic control over the groundwater basin, so the plume will continue to migrate. The Cr6 plume is expanding both laterally to the north, as well as vertically, as evidenced by plume maps from 2001 to current consultant studies.	Clearwater Group	Quality of GW Modeling CWG Page 11 (comment d)	Remediation	In 2011, additional studies were conducted to delineate the Cr6 plume to the north, and in the Lower Aquifer near monitor well MW-23C. The investigations revealed additional areas where elevated concentrations of Cr6 are present in groundwater beyond what was previously understood. Groundwater extraction and treatment were greatly increased through the operation of three new agricultural units in 2011, which improved hydraulic capture of the plume. As additional areas of elevated Cr6 have been discovered, plans for expansion of the groundwater extraction and treatment have been proposed to the Water Board.
27	There may be historic patterns of Cr6 migration which have left residue available for future recapture and migration.	Clearwater Group	Quality of GW Modeling CWG Page 11 (comment e)	Remediation	See responses to comment 19 on potential historical anthropogenic influences, and comment 25 on the lack of residual Cr6 from historic land treatment unit application of Cr6-bearing groundwater.
28	A detailed site conceptual model of the CrT and Cr6 initial release(s), migration in the subsurface soils and aquifers, extraction at Land Treatment Units, and application of this untreated CrT and Cr6 impacted water onto the land surface should be developed. The lack of above-ground treatment of CrT and Cr6, in which the extracted groundwater is removed from the aquifers at the Land Treatment Units and dripped or (historically) sprayed onto surface soils, is potentially creating another CrT and Cr6 release, albeit, at lower CrT and Cr6 concentrations. The concepts of groundwater extraction of CrT and Cr6 impacted groundwater and the reapplication of this water onto the land without treatment has not been well proven or well documented as a method to immobilize CrT and Cr6. Documentation should be provided showing the soil in these areas where untreated CrT and Cr6 impacted groundwater is being released onto the land surface is a safe and effective remediation method for CrT and Cr6 in groundwater. The documentation should also evaluate the potential for hyperaccumulation or uptake of CrT and Cr6 in plants or deposition and concentration of CrT and Cr6 in the shallow soil.	Clearwater Group	Quality of GW Modeling CWG Page 12 (comment f; first paragraph)	Remediation	Since the initiation of operation of the Desert View Dairy Land Treatment Unit in 2004, chromium data have been collected annually from 5 foot deep lysimeters. These data demonstrate the consistent and complete treatment of Cr6 within the root zone of the soil. The reviewer was likely unaware of this information, because it was outside the scope of the documents provided for the background study review.
29	Large changes in climate and rain patterns could occur in the future, creating higher risks of remobilization of the CrT and Cr6 in the shallow soil near the groundwater drip or spray systems at the Land Treatment Units. Sources at the PG&E Compressor Station must be mapped and plotted in relationship to the release and the current location of the contaminants in both the shallow soils as well as the Upper Aquifer and the Lower Aquifer.	Clearwater Group	Quality of GW Modeling CWG Page 12 (comment f; 2nd paragraph)	Remediation	The main factor influencing the potential remobilization of Cr3 that is formed through treatment in the Land Treatment Unit is re-oxidation by manganese oxides. The extent of oxidation is not expected to be significant, based on site geochemical conditions. Changes in climate and rain patterns would not affect this potential mechanism for remobilization. Soil sources at the compressor station have previously been investigated and remediated.
30	Samples from agricultural or domestic wells which cross the Upper Aquifer and Lower Aquifer have little value in defining CrT or Cr6 background concentrations based on aquifer or geologic units. Correlating the flows from the two different aquifer zones, one unconfined and the other confined, is not an appropriate or satisfactory method for determining background levels of CrT and Cr6. Mixing within the wells that were screened over two aquifers is likely to occur by diffusion, and possibly by other mechanisms. If filter packs are part of the well construction, then additional groundwater flow pathways exist for mixing of two originally separated groundwater aquifers. Using decades old domestic and agricultural wells which were readily available but designed for water production is not appropriate for background studies of CrT or Cr6 which are associated with two vertically discrete aquifer units.	Clearwater Group	Quality of GW Modeling CWG Page 12 (comment g)	Sampling Program: Vertical Distribution	PG&E agrees that sampling of mixed aquifer wells introduced bias into the data set, and recommends additional investigation to correct this bias. The sampling program suggested by the reviewer was considered in the development of a work plan for additional investigation.
31	Wells inside the radius of influence (ROI) of wells extracting contaminated groundwater cannot be identified as background wells. A background well should not lie within the zone of influence of a pumping well, or within the influence of the wells in the Hinkley Compressor station or Land Treatment Unit extraction systems. In addition, the wells to be used as background wells should have screens in one of the aquifer zones, but not both.	Clearwater Group	Additional Comments - Background Well Selection CWG Page 13 (comment 4a)	Groundwater Modeling	It was not the intention of the background study to include monitoring wells within the radius of influence of wells extracting contaminated groundwater. Future investigation activities would also be designed to place monitoring wells outside of the ROI of such extraction wells.
32	All groundwater extraction volumes and their ROIs should be mapped. The plume/gradient map should be evaluated with the ROI information. The Lockhart Fault and other faults in the Hinkley, California area may affect groundwater migration or influence preferred groundwater flow pathways. These elements should be evaluated in future hydrogeologic studies.	Clearwater Group	Additional Comments - Effects of GW Extraction CWG Page 13 (comment 4b)	Groundwater Modeling	Providing ROI for extraction and injection wells requires defining the time frame over which the influence is evaluated. Since pumping rates and extraction configurations are constantly changing, this is not a simple or straightforward analysis. However, we agree that there may be merit to this approach moving forward.

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33	All water applications from the Land Treatment Units should be mapped with detail on duration in time and volume of water of the applications. The deposition of wind-borne contaminants is discounted since there is low rainfall, yet Cr6 in dust can be an important exposure pathway if concentrations of Cr6 are high. In areas where CrT and Cr6 are high in the shallow soil, plant hyperaccumulation of CrT and Cr6 and the potential of livestock accumulation of chromium from ingesting impacted plants or impacted soil should be verified and documented with laboratory analysis.	Clearwater Group	Additional Comments - Influence of LTUs CWG Page 14 (comment 4c)	Remediation	As discussed above, the treatment of Cr6 by the Land Treatment Units is well documented and, therefore, there is no need for a detailed tracking Cr6 applied to the LTUs as part of the conceptual site model development. In addition, Cr6 within the LTU is applied sub-surface, limiting the chance for airborne exposure to Cr6. Within the soil, the Cr6 is documented to be converted to Cr3, alleviating the reviewer's concern over airborne Cr6 in dust.
34	All injection wells and their ROI should be mapped for the whole basin.	Clearwater Group	Additional Comments - GW Recharge CWG Page 14 (comment 4d)	Groundwater Modeling	Providing ROI for extraction and injection wells requires defining the time frame over which the influence is evaluated. Since pumping rates and extraction configurations are constantly changing, this is not a simple or straightforward analysis. However, PG&E agrees that there may be merit to this approach moving forward.
35	Heavy groundwater extraction since the 1930's supports the concept that the CrT and Cr6 plume has migrated cross gradient through preferred flow pathways. Major geochemical changes in the Hinkley Valley caused by large water movements, including extraction, are likely to have occurred over the past several decades, altering background levels of CrT and Cr6.	Clearwater Group	Additional Comments - Influence of Historic GW Extraction CWG Page 14 (comment 4e)	Groundwater Modeling	As discussed in the response to the comment on line 23, historical pumping estimates were incorporated into the groundwater modeling effort that supported the sampling location selection. For future work, additional assumptions could be applied to aid in placement of monitoring wells. Changes in Cr6 and CrT concentrations that have occurred due to regional agricultural pumping are a part of background conditions. The effects of these activities should not be removed from the background determination.
36	A scientific site conceptual model of the release, migration, extraction, and reapplication of the impacted waters onto soil should be carefully and methodically performed. If needed, additional geologic cross sections should be prepared. To help establish well construction details and depths of screened intervals, well condition and other downhole information should be documented using a video camera and geophysical logging tools. This will help to establish whether the wells are acting as vertical conduits. All migration pathways should be mapped.	Clearwater Group	Additional Comments - Site Conceptual Modeling CWG Page 14 (comment 4f)	Remediation	Much of this work has already been completed. As mentioned above, reapplication of impacted waters for agricultural irrigation is not a significant migration pathway.
37	The discrete depth sampling dataset is not sufficient. New monitoring wells should be constructed solely for the purpose of groundwater sampling. It is recommend that 20 to 40 new groundwater monitoring wells be constructed to current California standards in the Upper Aquifer and Lower Aquifer. The wells should be constructed so only one aquifer is screened for each well.	Clearwater Group	Additional Comments - Discrete Sampling CWG Page 14 (comment 4g)	Sampling Program: Vertical Distribution	PG&E agrees that sampling mixed aquifer wells introduced bias into the data set, and recommends additional investigation to correct this bias. The sampling program suggested by the reviewer was considered in the development of a work plan for additional investigation.
38	The extraction of groundwater containing CrT and Cr6 and application of this impacted water on to the land surface without above-ground treatment should be rigorously evaluated and scientifically justified and documented. The concern is whether the CrT and Cr6 are really being cleaned up, or whether the CrT and Cr6 are being smeared in the shallow subsurface and ultimately being allowed to impact deeper soil horizons and groundwater resources. Groundwater resources in the area are heavily used for agricultural and domestic water supplies. Any additional impact from CrT and Cr6 on soil and groundwater resources should be examined, tested, and documented in a careful and systematic manner. The drip lines for the Land Treatment Units are being cleaned with hydrogen peroxide and acid. These chemicals, if in contact with heavy metals, including CrT and Cr6, might allow for more impacts in the shallow soils by increasing heavy metal solubility and enhancing mobilization of CrT and Cr6 in the shallow soils.	Clearwater Group	Additional Comments - LTUs/Remediation CWG Page 14 (Task II)	Remediation	Since the initiation of operations of the Desert View Dairy Land Treatment Unit in 2004, chromium data has been collected annually from 5 foot deep lysimeters. These data demonstrate the consistent and complete treatment of Cr6 within the root zone of the soil. The re-oxidation of chromium will be limited, as concurred upon in a review of the Hinkley Feasibility Study by the DTSC, and is not expected to be affected by changes in climate. Data collected to date do not indicate any overall impact of the application of hydrogen peroxide and acid on chromium treatment.
39	The scientific approach to this study is seriously flawed if wells used in the study do not have proper screens in one discrete aquifer zone. If the mixed-aquifer wells are used for the overall concentration maps for CrT and Cr6, the maps will be in error and likely to underestimate the CrT and Cr6 concentrations (most of water derived from cleaner Lower Aquifer). The wells currently in the background study were not designed for high-quality geochemical sampling. Applying detailed statistics to laboratory sample data from domestic and agricultural wells with mixed aquifer water does not provide accurate results and likely underestimates the CrT and Cr6 concentrations. Although it might be economically attractive to use existing and available domestic and agricultural wells, the study does not meet the scientific objectives of trying to determine background concentrations of CrT and Cr6. The use of statistical methods on the chemical data as well as averaging laboratory concentrations of CrT and Cr6 from these wells does not provide accurate or correct results for background information.	Clearwater Group	Additional Comments - Well selection CWG Page 14 and 15 (Task III)	Vertical Distribution	PG&E agrees that sampling mixed aquifer wells introduced bias into the data set, and recommends additional investigation to correct this bias. The sampling program suggested by the reviewer was considered in the development of a work plan for additional investigation.

Appendix A - Peer Reviewer Comments and Response to Comments for Groundwater Background Study Report (CH2MHILL, February 2007)

Reviewers
 James A. Jacobs, PG, CHG, Chief Hydrologist, **Clearwater Group**, Richmond, CA
 Yorman Ruban, PhD, Professor Civil and Environmental Engineering, **UC Berkeley**, Berkeley, CA
 Stuart J. Nagourney, Adjunct Professor of Chemistry, **The College of New Jersey**, NJ

Item No.	Comment	Peer	Location (Page)	Category	PG&E Responses
40	Natural background levels of CrT and Cr6 for specific aquifers in the Hinkley, California, area can be determined with a significant drilling program of new wells with well screens limited to one aquifer zone in upgradient areas unaffected by historical pumping. It is possible that undisturbed hydrogeologic areas in the Hinkley, California, area do not exist due to the excessive groundwater pumping in the area. Samples upgradient toward the Mojave River may provide the best chance at finding what might be considered background CrT and Cr6 concentrations.	Clearwater Group	Recommendations CWG Page 16	Spatial Distribution	PG&E agrees that sampling mixed aquifer wells introduced bias into the data set, and recommends additional investigation to correct this bias. The sampling program suggested by the reviewer was considered in the development of a work plan for additional investigation.
41	Background levels are important to establish, but are very different from remediation goals or drinking water standards. Groundwater background levels, best available technology remediation levels, and the various drinking water standards and other exposure and toxicity concentrations must be integrated to develop an appropriate and realistic remediation or cleanup goals for the site. After ten years of assessment and monitoring, remediation has been limited and the CrT and Cr6 plume is expanding northward in the Upper Aquifer and there has been recent vertical migration into the Lower Aquifer.	Clearwater Group	Recommendations CWG Page 16	Remediation	PG&E is working towards gaining complete capture of the Cr6 plume delineated in 2011, including the Lower Aquifer, as documented in plans proposed to the Water Board.
42	Create a scientifically valid site conceptual model of the release, migration, extraction, and reapplication to land of the groundwater containing CrT and Cr6.	Clearwater Group	Recommendations (a) Site Conceptual Model CWG Page 16	Remediation	see response to comment on item 36.
43	Map all the surface areas where groundwater containing chromium has been historically discharged to the land surface for irrigation purposes at the Land Treatment Units. Identify what levels (concentrations) of CrT and Cr(IV) are in the shallow soil and the groundwater (besides the 5 foot lysimeters). Evaluate and verify the Land Treatment Unit extraction and water application process to document that CrT and Cr6 are being properly immobilized.	Clearwater Group	Recommendations (b) LTUs CWG Page 17	Remediation	Since the initiation of operations of the Desert View Dairy Land Treatment Unit in 2004, chromium data have been collected annually from 5 foot deep lysimeters. These data demonstrate the stable treatment of Cr6 within the root zone of the soil.
44	Map the radius of influence of pumping wells located within the Hinkley Valley and the extracted waters discharge areas.	Clearwater Group	Recommendations (c) Pumping Influence CWG Page 17	Groundwater Modeling	As part of the groundwater modeling effort to support the background study workplan, historical pumping in the area was evaluated and calibrated with known pumping data available from the Watermaster since the adjudication of the basin.
45	Construct and install 20 to 40 new monitoring wells in accordance with current California well standards that are screened in one aquifer so that the CrT and Cr6 aquifer contamination can be directly measured. A representative number of wells should be installed upgradient and outside the range of influence of historic or current pumping.	Clearwater Group	Recommendations (d) Aquifer-Specific Data CWG Page 17	Sampling Program: Vertical Distribution	PG&E agrees that additional investigation work is warranted, and looks forward to working with the Water Board and third party scientific peer reviewers to develop a plan for additional work.
46	Gain hydraulic control on the chromium plume in the Upper Aquifer which appears to be expanding northward. Gain hydraulic control of the Lower Aquifer which appears to be impacted from vertical movement of the CrT- and Cr6-containing groundwater sourced from the Upper Aquifer. The vertical migration and spreading of the chromium plume are a concern and should be addressed.	Clearwater Group	Recommendations (e) Plume Control CWG Page 17	Remediation	PG&E is working towards gaining complete capture of the Cr6 plume delineated in 2011, including the Lower Aquifer, as documented in plans proposed to the Water Board.
47	Identify background concentrations for CrT and Cr6 in the area, and develop remediation goals.	Clearwater Group	Recommendations (f) CWG Page 17	Remediation	PG&E agrees.
48	Initiate more aggressive hydraulic control and remediation to contain and shrink the currently expanding CrT and Cr6 groundwater plume in both the Upper Aquifer and Lower Aquifer.	Clearwater Group	Recommendations (g) CWG Page 17	Remediation	PG&E is working towards gaining complete capture of the Cr6 plume delineated in 2011, including the Lower Aquifer, as documented in plans proposed to the Water Board.
49	The sampling design is questionable. Since the purpose of the study was to define the extent of the plume (not identify the primary source), more sampling should have occurred in the direction that the plume was believed to be directed toward rather than nearer to the known source. The sampling that did take place provides much more data than was required from sampling sites that were closest to the source, which biases the data summaries higher. This could seriously impact any conclusions upon this data set regarding the extent and migration of the plume.	College of New Jersey	Spatial Sampling CNJ Page 1 (Response 1)	Sampling Program: Spatial Distribution	PG&E asserts that all areas should be considered in an additional investigation. The changing geologic environment and anthropogenic influences other than discharge of Cr6 by PG&E may influence background concentrations, and are important considerations that must be considered in the analysis.
50	The approach used in this study relative to the temporal trends appears to be reasonable. The use of an arithmetic mean to express the average concentrations of both total and hexavalent chromium is appropriate.	College of New Jersey	Temporal Sampling CNJ Page 1 (Response 2)	Statistics	Comment noted.
51	The spatial sampling design that was used in this study is questionable (as stated in Response 1).	College of New Jersey	Quality of GW Modeling CNJ Page 1 (Response 4)	Spatial Distribution	PG&E agrees that the sampling network could be improved, and looks forward to working with the Water Board and third party scientific peer reviewers to develop a plan for additional work.

Appendix A - Peer Reviewer Comments and Response to Comments for Groundwater Background Study Report (CH2MHILL, February 2007)

Reviewers
 James A. Jacobs, PG, CHG, Chief Hydrologist, **Clearwater Group**, Richmond, CA
 Yorman Ruban, PhD, Professor Civil and Environmental Engineering, **UC Berkeley**, Berkeley, CA
 Stuart J. Nagourney, Adjunct Professor of Chemistry, **The College of New Jersey**, NJ

Item No.	Comment	Peer	Location (Page)	Category	PG&E Responses
52	EMAX and Truesdale Laboratories (the two analytical laboratories involved with the Study) were asked what calibration ranges were used for Methods 6010B, 6020A and 7199. EMAX's responses were satisfactory. It is unclear from Truesdale's response if the low level calibration ranges for Methods 6010B and 6020A were used for the analyses in this study.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Pages 1 and 2 issue 1	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
53	EMAX and Truesdale Laboratories were asked what the value of the CRQL Check Standard (CRI) and the method control limits were for Method 6020A. EMAX's response was satisfactory. Truesdale admitted in their response that they failed to perform this quality assurance as required by the method during the time that data for this study were obtained.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Pages 1 and 2 issue 2	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
54	EMAX and Truesdale Laboratories were asked if Reporting Limit (RL) check samples were analyzed for Methods 7199 and 6010B and if so, what were the control limits and what were the actual recoveries. Information on the RLs for Method 6020A were provided by EMAX, but no information was supplied for Method 7199 or on how these limits were derived. Truesdale admitted in their response that they failed to analyze a RL check sample during the time that data for this study were obtained.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Pages 1 and 2 issue 3	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
55	EMAX and Truesdale Laboratories were asked how the RLs were established for Methods 6010B, 60220A and 7199 and what is the relationship between the Method Detection Limit (MDL) and RL for each method. Information on the RLs for Method 6020A were provided by EMAX, but no information was supplied for Method 7199 or on how these limits were derived. Truesdale's response of varying criteria for a quantitative relationship between the MDL and RL is too vague to be acceptable.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 2 issue 4	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
56	EMAX and Truesdale Laboratories were asked what SRM was used for QC for 7199 as per Section 5.4 as this data was apparently not reported. EMAX's response was satisfactory. Truesdale's use of a mid-range check sample is NOT acceptable as a QC material as per the criteria for quality control specified in Method 7199. This would make the data for this study for Cr6 questionable.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 2 issue 5	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
57	EMAX and Truesdale Laboratories were asked why the spiking levels for both CrT and Cr6 analyses MUCH higher than the expected sample concentrations for all analytical methods. EMAX's response was not satisfactory. The laboratory should have chose the concentration level of matrix spikes for both CrT and Cr6 closer to the actual sample levels (usually a multiple of 3-5 the expected value is applied). The choice of much higher spiking levels means that the calculated recoveries have little value in assessing the quality of the actual sample concentrations and the impact to those results from possible matrix interferences. Truesdale's response was not satisfactory for the exact same reason.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 2 issue 6	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
58	No criteria were provided from either laboratory as to the criteria for data assigned U or J flags.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 3 issue 1	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
59	Based upon experience with examining data for the analysis for Cr6 in water samples and soil extracts, this data set showed that an unusually high percentage of samples failed the quality control criteria for the Continuing Calibration Verification (CCV). An explanation for this anomaly should be provided so as to show that the conclusions drawn from these data have not been compromised.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 3 issue 2	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
60	How were samples chosen for matrix spiking (was this procedure randomized so as to not bias the results)?	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 3 issue 3	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
61	The workplan (Item #2 of Additional Materials) specifies the use of Method 6010 for the analysis of CrT; Method 6020A was used instead. This may impact the ability to quantify for CrT at low concentration levels since the RL for Method 6020A is much lower than that for Method 6010.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 3 issue 4	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
62	Some data for Cr6 in this study was reported by the USEPA determinative method 218.6, other data was reported by Method 7196A and still other data was reported by Method 7199. These methods all have different sensitivities and different capabilities to report Cr6 without analytical interferences. Why were different methods used to measure Cr6?	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 3 issue 5	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.
63	The rationale for using median vs. mean for data summaries was never provided.	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 3 issue 6	Statistics	Per USEPA guidance, the 95% upper threshold limit was based on the mean and standard deviation of the data set.
64	The authors of the report chose to use a method from the United States Geological Survey (USGS) to attempt to define specific Cr species present in samples, any specie interconversion (either oxidation of Cr3 to Cr6 or reduction of Cr6 to Cr3). This method is not certified by any State or national laboratory accreditation authority. Information that was supplied suggests that this USGS method has only been applied to speciation of As. USEPA Method 6800, Elemental and Speciated Isotope Dilution Mass Spectrometry allows the identification individual Cr species, the extent of any specie interconversion, and can correct final results for up to 80% conversion. USEPA Method 6800 is certified by State and national laboratory accreditation authorities. Why was Method 6800 not used for this application?	College of New Jersey	Additional Comments Quality of Analytical Data CNJ Page 3 issue 7	Lab Chemistry	See responses on Laboratory Chemistry in Appendix C.

Stantec

**WORK PLAN FOR EVALUATION OF BACKGROUND CHROMIUM IN THE GROUNDWATER OF THE
UPPER AQUIFER IN THE HINKLEY VALLEY, PACIFIC GAS AND ELECTRIC COMPANY, HINKLEY
CALIFORNIA**

APPENDIX B

Work Plan for Evaluation of Background
Chromium in the Groundwater of the Upper Aquifer in the Hinkley Valley
Pacific Gas and Electric Company
Stantec PN# 185702482
February 22, 2012

Appendix B

Installation, Development, and Sampling of Monitoring Wells

Section 3 of this Work Plan includes proposed installation, development, and sampling of short screened monitoring wells. The following presents proposed methods for the installation and development of new wells, and for the sampling of new and existing wells.

SOIL BORING ADVANCEMENT AND LOGGING

Well permits will be obtained from San Bernardino County prior to the start of drilling activities. The following describes the standard methods to be used during installation of the upper aquifer monitoring wells.

Boreholes for the new monitoring wells will be advanced using hollow-stem auger methods. Core sampling will be completed using eight-inch outside-diameter (OD) augers and single 2.5-inch diameter schedule 80 polyvinyl chloride (PVC) wells will be installed in this sized borehole. The borehole will be reamed to 10-inch OD for the installation of four-inch diameter single completion schedule 40 PVC wells and 2.5-inch diameter schedule 80 PVC nested wells, as appropriate. All soil cuttings generated during these activities will be transported to the approved Ranch Land Treatment Unit (Ranch AU) for management.

All encountered soils will be logged according to the Unified Soil Classification System (USCS) by a qualified PG&E representative under the direct supervision of a California Professional Geologist (PG). Unsaturated zone soils (grade to approximately 70 feet below ground surface, or ft-bgs) will be logged from auger cuttings at a minimum of every five feet. Continuous split-spoon or split-core barrel sampling will be performed from first encountered water to the total depth of the boring. Borings will be advanced to a maximum depth based on the occurrence of the confining clay layer separating the upper and lower aquifers (*i.e.*, the LA CCL or “blue clay”) or bedrock, whichever is encountered first.

MONITORING WELL CONSTRUCTION

Monitoring wells installed at the water table will be completed with 4-inch diameter schedule 40 PVC and will not be nested with deeper wells. All wells completed below the water table surface will be constructed using 2.5-inch-diameter schedule 80 (PVC) as single or nested wells depending on local lithology. The following describes the installation of the single completion and nested wells.

Single Completion Wells

Single completion monitoring wells will be installed by placing the PVC well materials in the borehole and placing filter pack sand, hydrated bentonite, and cement/grout slurry in the annular space. All wells screens will be constructed with 0.020-inch machine slotted perforations and #2/12 filter sands. Wells near the water table will be completed using 15 feet of screen and those completed below the water table will have 10-feet of screen. The filter pack sand will be placed in the well annulus from the bottom of the boring (*i.e.*, bottom of the well screen) to approximately two feet above the top of the well screen. Hydrated bentonite will be placed above the filter sand and continue into the unsaturated zone to a level

of at least 20 feet above the water table surface. Wells will be backfilled to the ground surface using cement grout slurry and completed at surface grade with a flush-mounted Christy well box and bolted steel cover.

Nested Dual Completion Wells

Both screen sections in a nested pair will be completed with 10-feet of 0.020-inch machine slotted perforations and #2/12 filter sands. The deeper well casing will first be placed in the borehole and the filter pack sand and bentonite will be used as annulus as described above for the single completion wells. Hydrated bentonite will be placed in the borehole to within two feet of the depth of the bottom of the shallow well. Approximately two feet of additional filter pack sand will be placed in the borehole, and then the shallow well casing will be set on the top of the sand. Filter pack sand will be placed to approximately two feet above the top of the slotted screen and hydrated bentonite will be placed above the filter sand continuing into the unsaturated zone to a level of at least 20 feet above the water table surface. The remaining annular space will be backfilled to the ground surface using cement grout slurry and completed at surface grade with a flush-mounted Christy well box and bolted steel cover.

WELL DEVELOPMENT, SAMPLING, ANALYSIS, AND SURVEYING

The following discusses the development, sampling and laboratory analysis, and surveying for the new monitoring wells.

Well Development

Each of the new monitoring wells will be developed using mechanical surging, and bailing and/or pumping. A minimum of ten casing volumes of water will be removed from each well during development, unless the well goes dry and does not recharge at a rate that would facilitate the removal of ten casing volumes. At these locations, bailing and pumping will be conducted when feasible, within the confines of the well recharge rate. In some cases, more than ten casings volumes of water may be removed in an effort to reduce turbidity. Each well will be developed twice prior to sampling to optimize well development and achieve the lowest turbidity feasible prior to sampling..

Water generated during development will be transferred directly into a trailer-mounted holding tank. The water will then be transferred to the Central *In Situ* Reactive Zone (IRZ), where it will be placed in a permanent holding tank for ethanol amendment and injection.

New Well Sampling and Laboratory Analysis

A minimum of 72 hours after the second development, each of the new monitoring well will be sampled by qualified PG&E representatives. Wells will be sampled according to the approved low-flow sampling procedures detailed in Appendix A of the *Second Semiannual Monitoring Report—Year 2006, Hinkley Compressor Station, Hinkley, California* (CH2MILL, February 28, 2007), or in accordance with the three-volume purge methods detailed in the *Purging and Sampling of Monitoring Wells with Temporary*

Submersible Pumps / Stabilized Drawdown Method, Standard Operating Procedure SOP-A2 (CH2MHILL, January 10, 2012). Both methodologies are summarized below.

- ❑ Wells will be sampled using either an air bladder pump or a portable electric submersible pump with dedicated tubing. The pump/tubing inlet will be set near the center point of the well screen;
- ❑ Wells purged and sampled using the low-flow, minimal-drawdown method, will follow U.S. Environmental Protection Agency (US EPA) guidelines (US EPA, 1996);
- ❑ Wells purged and sampled using three-volume purge method will be purged until a minimum of three well casing volumes have been removed;
- ❑ A Horiba model U-22 field water quality meter will be used to measure pH, electrical conductivity, temperature, dissolved oxygen, and redox potential of the purge water. Each well will be purged until these parameters stabilized;
- ❑ Prior to sampling, the static water level will be measured; and,
- ❑ Samples will be filtered in the field to remove fine sediment, prior to placement in the sample bottles.

Samples will be delivered to an independent, state-certified laboratory under appropriate chain-of-custody procedures and analyzed for both Cr6 using EPA Method 218.6 and CrT using US EPA Method 6010B.

Sampling Existing Long Screen Wells

The prior background study (CH2MHILL, 2007) included the sampling of previously existing domestic or agricultural long screen production wells. PG&E currently samples numerous domestic wells in the Hinkley Valley on a regular basis. The scope of work presented in this Work Plan may include the sampling of select long screen domestic or agricultural wells to compare to the new short screen well data. Sampling methods for the long screen wells are described in the *Purging and Sampling of Active Domestic Wells with Dedicated Pumps, Standard Operating Procedure for PG&E Hinkley Groundwater Monitoring Program (SOP-A6)*. Water Board concurrence with these methods was provided to PG&E in a letter dated February 10, 2012. The sampling methods and Water Board concurrence letter are included as Attachment B-1.

SURVEYING

Each of the new monitoring wells will be surveyed to a common datum to record elevation above mean sea level.



Matthew Rodriguez
Secretary for
Environmental Protection

California Regional Water Quality Control Board Lahontan Region

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(530) 542-5400 • FAX (530) 544-2271
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Edmund G. Brown Jr.
Governor

February 10, 2012

To Interested Persons,

This letter discusses procedures for domestic well sampling in Hinkley related to chromium contamination in groundwater.

Background

At the December 8, 2011 meeting held at the Hinkley Elementary School, members of the public voiced concern about sampling procedures being employed by the Pacific Gas and Electric Company (PG&E) for domestic wells. Water Board staff promised to look into PG&E's sampling procedures and compare it to those that are considered standard for the industry and follow up with a response.

PG&E's Well Sampling Procedures

PG&E is under orders by the California Regional Water Quality Control Board, Lahontan Region, (Water Board), to conduct a domestic well sampling program within one mile of the chromium plume boundary. As part of that program, PG&E's consultant, CH2MHill, developed a Standard Operating Procedures (SOP) (Enclosure 1) for purging and sampling domestic and community wells.

The SOP states that domestic wells with active pumps "can be sampled directly without satisfying extensive purging criteria after water contained in the pump and associated tubing/ plumbing has been purged." Wells are generally purged for approximately 5 minutes. However, final purge time and volume will depend on the specific well system and the dedicated pump flow rate. For wells installed with a sampling port before a holding tank, a water sample is collected directly from this location.

Comparing PG&E SOP with Other SOPs

Water Board staff researched guidelines and standards within government agencies and professional organizations for appropriate purging and sampling of domestic wells. In California, the Department of Water Resources' (DWR) Well Standards provide minimum requirements for the construction, maintenance (including sampling), and destruction of private water wells to prevent pollution to groundwater. DWR's Well Standards are used by laboratories when collecting samples of private wells and are enforced by local governments, such as county health departments.

For chemical sampling of domestic wells, Section 15, Appendix D of the Well Standards (Enclosure 2) describes minimum requirements for the collection of water samples:

“The sample should be collected after the well has been pumped long enough to remove standing water and development and disinfectant chemicals, and to ensure that water from the producing formation(s) has entered the well...”

The above-referenced Well Standard is not specific in the length of time for purging domestic wells before sampling but does state that it is the formation (aquifer materials outside the well) and not standing water within the well that is sampled.

Well Standards are used as a framework by other state agencies in developing standard procedures for private well sampling. One example is the SOP prepared by the California Department of Pesticide Regulation (Enclosure 3). The SOP states the purpose for purging is to eliminate standing water from a well and allow the system to be recharged with fresh water from the aquifer. Purging time is based on the minutes the pump runs. For sampling before a storage or pressure tank, the SOP advises to purge the well casing by opening enough faucets to force the pump to run for a minimum of 10 minutes. After which, water should flow through a sampling port for at least 20 seconds to clear potential debris before collecting a sample. If a pump is already running, the time the well has been running may be applied to the required purging time.

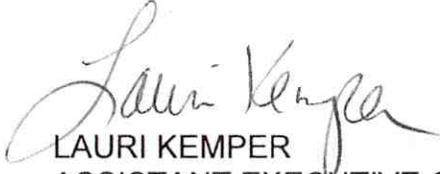
Water Board staff also researched standard procedures or guidance for private well purging and sampling from the U.S. EPA and water well associations. Our findings determined that purging of water wells for approximately five minutes is reasonable for the collection of water samples for chemical analyses. However, final purge time and volume was dependent on knowledge of the specific well system and the pump flow rate for the well being sampled.

Conclusion

Water Board staff finds that PG&E's SOP for purging and sampling of domestic wells in Hinkley is consistent with DWR's Well Standards and guidance issued by other agencies and professional associations. Purging of wells for approximately five minutes as a general rule of thumb appears reasonable, especially when well designs and pump specifics are unknown. Yet, where the well design and well volume and pump rate are known, purging needs to be modified to ensure that standing water is removed prior to sampling. For instance, purging time may be reduced for a well having a short screen length or having a pump with a large flow rate. All such relevant factors should be taken into consideration by PG&E when the purge volume and time is being implemented during sampling of Hinkley domestic wells.

If you have any questions concerning PG&E's well sampling program, you may contact its Community Center in Hinkley at (760) 253-7888 or toll free at 1-855-816-9722.

Should you have questions concerning this letter, please contact Lisa Dernbach of the Water Board at (530) 542-5424 or at ldernbach@waterboards.ca.gov.



LAURI KEMPER
ASSISTANT EXECUTIVE OFFICER

- Enclosures:
1. PG&E's Well Sampling Standard Operating Procedures
 2. California Water Well Standards, Section 15, Appendix D
 3. California Department of Pesticide Regulations Well Sampling SOP

CC: PG&E Hinkley Technical Mailing List and Lyriss List

LSD/adw/T: Dernbach/PG&E Hinkley/PG&E domestic well sampling letter 1-12
Send to file: WDID (VVL) 6B369107001

ENCLOSURE 1

SOP-A6

Purging and Sampling of Active Domestic Wells with Dedicated Pumps Standard Operating Procedure for PG&E Hinkley Groundwater Monitoring Program

This standard operating procedure (SOP) describes the procedures and equipment to be used for groundwater sampling of active domestic wells that are equipped with dedicated and functional well pumps at the PG&E Hinkley site.

Samples for water quality measurement and laboratory analysis are collected directly from existing or installed sampling ports at the well head/discharge piping. Samples should not be collected from holding tanks.

The active domestic wells are typically larger in diameter and usually have long perforated/screen intervals. Therefore, the purging and sampling procedures for these wells are different from the procedures used for sampling conventional groundwater monitoring wells. Wells that are actively pumping on a regular basis (e.g., domestic wells) can be sampled directly without satisfying extensive purging criteria after water contained in the pump and associated tubing/plumbing has been purged.

REQUIRED DOCUMENTS

- Event-specific "planned sampling and analysis table" (PST).
- Applicable project work plan or monitoring plan, and related Hinkley SOPs as needed.
- Hinkley Program Health and Safety Plan (HSP).
- Well construction and depth to water information, if available.
- Previous purge and sampling log sheets, if available.
- Well Survey Form
- Blank purge and sampling log sheets and field logbook.

PREPARATION AND SETUP

- 1) Review event-specific PST or event-specific field instructions, HSP, previous sampling logs, and initiate field logbook for sampling activity.
- 2) Field-check and setup sampling equipment: water level (WL) meter, water quality (WQ) meters, flow-through cell, field filter, purge water container, health and safety equipment, etc. Inspect and calibrate field equipment prior to use according to SOP-A11, *Calibration of Field Instruments*.
- 3) Inventory sample bottles, review required analyses, confirm the lab courier schedule, and prepare groundwater sampling log.
- 4) Conduct a well survey. Confirm and note the operation status (e.g., active) of the domestic well from wellhead meter (if present) or well owner information. When possible, inspect and/or confirm the condition of the well, well's pump, wellhead and associated piping.

- 5) Confirm the presence/absence of a sampling port (a.k.a. spigot), pressure relief valve, holding tank, and backflow valve in the tank. Determine whether a well retrofit is needed for the installation of a sampling port before the holding tank. Consult with the well owner before modifying the well and pump system and request his/her consent. If needed, install a sampling port as close as possible to the wellhead. The most common procedure for this retrofit is to remove the pressure relief valve from the wellhead or pipe and install a small pipe extension with a sampling port and re-install the pressure relief valve at the end of the pipe extension.
- 6) If a backflow valve is missing at the holding tank or does not work properly to prevent water from running back into the sampling port and well during sampling, the holding tank will be emptied before purging and sampling begins.
- 7) If the domestic well has been inactive for more than 24 hours, a water level measurement can be taken. Measure initial static WL according to SOP-A9, *Water Level Measurements*. Record WL value on sampling log.

PURGING AND SAMPLING PROCEDURES -ACTIVE DOMESTIC WELLS

- 8) Install a flow-through cell to the sampling port and record a set of water quality parameters (pH, conductivity, temperature, turbidity, dissolved oxygen, temperature, and ORP). If it is not possible to connect the flow-through cell, a clean 5-gallon bucket may be used by filling the bucket with purge water and inserting the instrument probes directly into the bucket. If the bucket is used, turbulence in the bucket should be minimized and only pH, conductivity, ORP, and temperature need to be recorded. Record units and time for all measurements collected. Record on the sampling log if any parameter readings are anomalous or unstable due to instrument problems.
- 9) Purge the well for approximately five minutes to ensure that water contained in the pump and associated tubing/plumbing has been purged. The final purged volume and purge time will depend on the specific well system and the dedicated pump flow rate.
- 10) Samples will be collected directly from the sampling port. A single set of field parameters should be recorded (collecting stabilized field parameters is not required). Record observations on sample appearance, clarity, and odors.
- 9) Collect samples for analyses according to the PST and/or event-specific field instructions. Sample containers are to be filled by transferring water directly from the sampling port to the appropriate sample container. If the PST calls for filtered and/or preserved samples, refer to SOP-A7, *Sample Field Filtration and Preservation for Metals*.
- 10) Complete the field sampling log, including description of samples collected, final WL, and purge volume of discharge or purge. If the pump is equipped with a flow meter, record the flow rate as well. Close and secure the well including access gates or fences.

INVESTIGATION-DERIVED WASTE MANAGEMENT

Different types of potentially-contaminated investigation-derived waste (IDW) will be generated during groundwater sampling efforts. These may include:

- Used personal protective equipment (PPE).
- Disposable sampling equipment.
- Decontamination fluids.
- Purged groundwater and excess groundwater collected for sample container filling.

Used PPE and disposable equipment will be placed in a municipal refuse dumpster. These wastes are not considered hazardous and can be sent to a municipal landfill. Any PPE and disposable equipment that is to be disposed of that could still be reused will be rendered inoperable before disposal in the refuse dumpster.

Regarding disposal of wastewater (decontamination water, and purge and excess groundwater), all wastewater generated during sampling of active domestic wells will be discharged directly to the ground at the well site.

ENCLOSURE 2

Water Well Standards

CHAPTER II. STANDARDS

Section 15. Water Quality Sampling.^{Note 18}

The requirements to be followed with respect to water quality sampling are:

- A. *Community Water Supply Wells and Certain Industrial Wells.* The water from all community water supply wells and industrial wells which provide water for use in food processing shall be sampled immediately following development and disinfection, and appropriate analysis made. Rules and regulations governing the constituents to be tested, type of testing, etc, for community water supply systems are contained in Chapter 15, "Domestic Water Quality and Monitoring", of Title 22, California Administrative Code. Water analysis shall be performed by a laboratory certified by the California Department of Health Services. A copy of the laboratory analysis shall be forwarded to the California Department of Health Services or to the local health department. Approval of the enforcing agency must be obtained before the well is put into use.

Except where there is free discharge from the pump (that is, there is no direct connection to the water delivery system such as to a sump), a sample tap (see Figure 7) shall be provided on the discharge line so that water representative of the water in the well may be drawn for laboratory analysis. The tap shall be located so as to prevent back siphonage to the pump discharge when the pump is shut off (e.g., on the system side of the check valve).

- B. *Other Types of Wells.* To determine the quality of water produced by a new well it should be sampled immediately following construction and development. Appropriate analyses shall be made based upon the intended uses of the water.

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Water Well Standards

APPENDIX D

COLLECTION OF WATER QUALITY SAMPLES

Water from all new wells should be sampled in order to determine the quality of the water that is being produced. The type of analysis that will be made is dependent on the expected use of the water. For example, individual domestic wells should be sampled for determination of bacterial quality and chemical quality. The water from agricultural wells is generally examined only for the presence of specific chemicals unless there is the likelihood that there will be incidental domestic use of the water, in which case the bacterial quality ought to be determined too.

Recommendations regarding the types of analyses to be performed for the various uses of water will be found in numerous references on water quality and groundwater; however, it is best to consult with local agencies such as county farm advisors, health departments or water service agencies (irrigation or water districts). Sampling of community water supply wells is covered by requirements of the California Department of Health Services. ^{Note 28}

Bacterial Sampling

For individual domestic wells, technical advice regarding the collection of bacteriological samples may be obtained from the local health departments or from the laboratories that will examine the sample. If no technical assistance is available, the following procedure will suffice: A sterile sample bottle, preferably one provided by the laboratory, must be used. It is extremely important that nothing except the water to be analyzed come in contact with the inside of the bottle or the cap; the water must not be allowed to flow over an object or over the hands and into the bottle while it is being filled. If the water is collected from a sample tap, turn on the tap and allow the water to flow for 2 or 3 minutes before collecting the sample. ^{Note 29} Do not rinse the sample bottle. The sample should be delivered to the laboratory as soon as possible and in no case more than 30 hours after its collection. During delivery, the sample should be kept as cool as possible (but not frozen).

Chemical Sampling

Generally, a routine mineral analyses (determination of the concentrations of the common minerals such as calcium, sodium, chloride, sulfate, etc.) plus analyses for selected minor elements will suffice, particularly where there is no prior knowledge of the chemical quality of the water in the area where the well is located. Where quality conditions in the surrounding area are known, a more selective analysis may be made. For specified uses it may also be desirable to make analysis for concentrations of certain constituents (such as iron and manganese in the case of domestic water or boron in irrigation water). Organic chemicals are not routinely determined. Information or advice on chemical quality conditions may be obtained from local agencies such as the county farm advisors, health departments, etc.

The sample should be collected after the well has been pumped long enough to remove standing water and development and disinfectant chemicals, and to ensure that water from the producing formation(s) has entered the well. The water sample should be collected in a chemically clean container, preferably one obtained from the laboratory that will perform the analysis. The container should be rinsed several times with the water to be sampled prior to collecting the sample. The laboratory performing the analysis should issue instructions regarding the quantity of sample required and whether or not preservatives are needed. However, one-half gallon (1.9 litres) is usually sufficient for a routine mineral analysis; one gallon (3.8 litres) when analyses for minor elements (i.e., iron, manganese, etc.) is also required. Sample quantities for organic chemicals vary according to the type of analysis, and range from very small amounts up to several gallons (litres). In addition, where organic chemicals are to be determined, special sampling procedures and equipment may be required. This is particularly true for volatile organic compounds.

In all cases the temperature of the water should be determined immediately upon collection of the sample.

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ENCLOSURE 3

STANDARD OPERATING PROCEDURE
Obtaining and Preserving Well Water Samples

1.0 INTRODUCTION

1.1 Purpose

This SOP provides instructions for obtaining permission, purging and collecting a water sample from a well, and then how to preserve the sample. With a two-person crew, staff may divide the tasks by one person conducting sampling (section 3.3) and the other conducting the documentation (section 3.11).

1.2 Definitions

1.2.1 **Purging**-eliminates standing water from a well and allows the system to be recharged with fresh water from the aquifer.

2.0 MATERIALS

- 2.1 A copy of this and other appropriate SOP's and the study protocol
- 2.2 Phone numbers for your supervisor, other teams, and the Department of Pesticide Regulation (DPR) Business Services Office (BSO)
- 2.3 DPR permission form to sample well ([Appendix 1](#)) in English and Spanish
- 2.4 DPR ground water brochures ("Your Water—Our Commitment to Safety") in English and Spanish
- 2.5 Plastic bag (18 in by 24 in) for ground cover
- 2.6 Plastic bag (6 in by 12 in) to cover electrical points
- 2.7 Replacement (Schrader[®]) snifter valves
- 2.8 Replacement snifter valve core stems
- 2.9 Alligator valve caps (Gator[®])
- 2.10 Snifter valve core stem remover
- 2.11 Snifter valve sampling tube
- 2.12 Locking pliers to secure Teflon[®] tube to snifter valve while sampling if unable to use the alligator valve caps
- 2.13 5/16 and 7/16 box end wrenches for replacing snifter valve if needed
- 2.14 Teflon[®] tape
- 2.15 Sample containers (refer to section 4.3)

STANDARD OPERATING PROCEDURE
Obtaining and Preserving Well Water Samples

- 2.16 De-ionized or distilled water for field blanks and equipment rinses (refer to section 3.7)
- 2.17 Polystyrene foam holders for one-liter sample bottles (6-packs) or appropriate packing for other size containers
- 2.18 1 half-pint Mason jar
- 2.19 pH meter or pH litmus paper
- 2.20 Preservative, if necessary (refer to section 4.4)
- 2.21 Ice chests
- 2.22 Ice materials (refer to section 4.4.3)
- 2.23 Chain of Custody form ([Appendix 5](#))
- 2.24 Department of Water Resources (DWR) form 429 ([Appendix 4](#))
- 2.25 Well information form ([Appendix 2](#))
- 2.26 Digital camera
- 2.27 Global Positioning System (GPS) unit
- 2.28 Water level meter
- 2.29 Measuring wheel
- 2.30 Rangefinder
- 2.31 Extra sample bottles
- 2.32 Latex gloves (in sizes appropriate for sampling crew)
- 2.33 Duct tape and/or rubber bands to secure plastic bag around points box
- 2.34 Tool box which has check list for above items attached
- 2.35 Garden hose
- 2.36 Bucket

3.0 PROCEDURES

3.1 Obtain Permission to Sample Well

You must obtain the well owner's permission to collect samples before beginning any part of the sampling procedure, including evaluating the suitability of the well.

STANDARD OPERATING PROCEDURE

Obtaining and Preserving Well Water Samples

3.4 Purging Procedures

Purging is required prior to collecting any samples. Purging time is based on the minutes the pump runs. If the pump cycles on and off during the purging process be sure to keep track of the total time the pump is running. If the well is already running when the crew arrives at the well, the time the well has been running may be applied to the required purging time. To speed up the process of purging make sure the well tank is emptying as fast as the pump can fill it. Do this by opening enough faucets around the house and monitoring the pressure gauge on the storage tank. If the output is equal to the inflow, the gauge will hold at a steady level below the pump's shutoff pressure.

3.4.1 **Sampling prior to the tank:** Purge the well casing by opening enough faucets to force the well pump to run for a minimum of 10 minutes.

3.4.2 **Sampling after the tank:** Drain three tank volumes prior to sampling. Purging time must be calculated based on tank volume and outflow rate. Check to make sure the owner will permit such water use before flushing the tank. For larger storage tanks, it is preferable to locate a different well in the area or arrange to return at a later date when the well is scheduled to run for an extended period. If the well has already been running long enough to have drained the three tank volumes (i.e., running an irrigation system for several hours), it is possible to collect the sample after the tank without purging. Always note that the sample was obtained after the tank on the Well Information form and other relevant information regarding pump run-time and tank purging.

3.5 Preparing a Snifter Valve Sample Port for Sample Collection

3.5.1 After the purging cycle, turn faucets off and turn off the power at the circuit box or switch box. A final method to shut off a well is by interrupting the points in the point's box. Staff should not attempt this procedure until an experienced staff member has trained them.

3.5.2 Before removing or replacing the snifter valve, cover the electrical point box (Figure 2) with a plastic bag and secure with duct tape to avoid getting water in the points and short-circuiting the system (Figure 9).

APPENDIX C

Work Plan for Evaluation of Background
Chromium in the Groundwater of the Upper Aquifer in the Hinkley Valley
Pacific Gas and Electric Company
Stantec PN# 185702482
February 22, 2012

Appendix C is PG&E's response to Investigative Order No R6V-2011-0105. Please see page 75 (Bates stamp number 12-75) of this PDF to view that document.