Pacific Gas and Electric Company

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October 6, 2016

Patty Z. Kouyoumdjian
Executive Officer
Regional Water Quality Control Board Lahontan Region

Via Email: RB6enfproceed@waterboards.ca.gov

RE: Request for Information—Proposed Cleanup and Abatement Order for Desert View Dairy

Pacific Gas and Electric Company (PG&E) appreciates the opportunity to respond to the Water Board Advisory Team's request for information regarding the Proposed Cleanup and Abatement Order (CAO) for the Desert View Dairy (DVD).

PG&E is committed to full implementation of Water Board requirements to address impacts attributed to PG&E discharges. To that end, PG&E has been aggressively remediating historically impacted groundwater through the use of agricultural operations and other remedy operations. Unfortunately, groundwater in the Hinkley Valley is degraded from multiple sources, whether natural or man-made, with various constituents that exceed drinking water standards, and are not linked or otherwise attributed to PG&E's historic discharges or current remediation.

Attached please find information in response to the questions posed by the Advisory Team. Included in PG&E's response is technical evidence that impacted groundwater in the proposed CAO expanded area is caused by other sources upgradient and crossgradient to the DVD—and not by PG&E. We have also attached recent correspondence from Dr. Izbicki of the USGS that outlines some of the challenges his research is discovering in the region, such as water quality impairments caused by arsenic and uranium. These "other" constituents in Hinkley groundwater are unrelated to PG&E discharges and will continue to impact drinking water wells without a regional solution.

As PG&E has previously communicated to the Water Board, we are encouraged by various basin-wide opportunities to address these historic and unrelated impacts to groundwater such as the salt and nutrient management planning process or other potential regional solutions. Faced with water quality challenges such as arsenic, collaborative solutions are a critical component of addressing exceedances in groundwater that are not attributed to a current owner or operator of a facility or discharger. PG&E will be a participant in any Water Board led community discussion about addressing the basin wide water quality challenges, and we look forward to the discussion.

Please feel free to call me at 925-818-9069 with any questions about our response.

Respectfully,

Kevin Sullivan

Enclosure:

Attachment 1 - PG&E Response to Advisory Team September 2016 PROP DVD CAO Information Request
Attachment 2 - USGS Supply Well Sampling Letter and Summary of Dairy Orders
Attachment 3 - Conceptual Site Model for Impacts to Groundwater Related to the Desert View Dairy
Exhibit 1 - Supporting Documents
Exhibit 2 - Supporting Figures

ATTACHMENT 1

ATTACHMENT 1
PG&E Response to Advisory Team September 2016 PROP DVD CAO Information Request

Pacific Gas and Electric Company (PG&E) is providing information requested by the Water Board's Advisory Team in a letter dated September 8, 2016 titled: Request for Information – Proposed Cleanup and Abatement Order (PROP CAO) for Desert View Dairy.

Request 1. *Please provide specific references to a figure/cross section/conceptual site model depicting the lateral and vertical extent of the TDS, chloride, and sulfate plumes in groundwater that extend from the Desert View Dairy (DVD) property downgradient into the existing "affected area" and into the "Proposed Expansion of Affected Area" that support the proposed revisions in the amended CAO.*

Response 1:

The conceptual site model (CSM) does not support proposed expansion of affected area. Documents containing the requested information above that PG&E has are included as Exhibit 1 and listed below:

A. Conestoga-Rovers and Associates (CRA). 2008. Groundwater Investigation Data Report (October 2008), Desert View Dairy, Hinkley, California. October.
B. CRA. 2008. Letter Report: Waste Storage/Application Practices Desert View Dairy, Hinkley, California. July 30.
C. CRA. June 2011. Groundwater Investigation and Characterization Report, Desert View Dairy, Hinkley, California.
D. CH2M HILL. 2011. Groundwater Investigation and Characterization Report for Former Nelson-Diaz Dairy and Field Crop Parcel. June 30.
E. Stantec. 2013. Compliance with Provision 1.C. of Cleanup and Abatement Order R6V-2008-0002-A4 and Requirements of Investigation Order R6V-2013-0029. Appendix G Technical Memorandum – Supplemental Information Regarding the Presence of Chromium in Groundwater of the Hinkley Valley and Water Valley. October 29.
F. CH2M HILL. 2014. Hinkley Area Nitrate Data Summary and Distribution through Fourth Quarter 2013. March 11.

These documents were all previously submitted to the Water Board and show the distribution of total dissolved solids (TDS), chloride and sulfate in groundwater downgradient of the DVD that does not support an expansion of the affected area. A conceptual site model (CSM) summary developed from the documents listed above and additional information from PG&E's chromium remediation program is included as Attachment 3 to this information request.

Request 2. *Has a background study/historical practices impact evaluation been conducted as part of previous groundwater investigations in the vicinity of Desert View Dairy for the constituents of concern? If so, please provide specific references.*

Response 2:

Yes. See list of references provided in Response 1 and included in Exhibit 1 and the CSM summary provided as Attachment 3 to this information request. The documents listed in Response 1 and summarized in Attachment 3 show that background concentrations of nitrate exceed the maximum contaminant level (MCL) and that concentrations of TDS, chloride and sulfate exceed their respective secondary MCLs that are unrelated to historical DVD discharges.

Request 3. *Have the three technical submittals, dated June 30, 2011, Groundwater Investigation and Characterization Report for Former Nelson-Diaz Dairy and Field Crop Parcels, Hinkley, California, been evaluated in the context of the adequacy of the lateral and vertical extent of the constituents of concern? If so, please provide the staff comment letter.*

Response 3:

Lateral and vertical extent of constituents have been adequately characterized. Since the submittal of these documents in 2011, additional data has been collected by PG&E. Maps showing the lateral and vertical extent of constituents of concern that include additional PG&E monitoring data are included in Stantec Consulting Corporation (Stantec) 2013 and CH2M HILL 2014 in Exhibit 1. With this additional data, lateral and vertical extent of the constituents of concern has been adequately characterized, as illustrated on the figures excerpted from these documents and additional PG&E documents and included in Exhibit 2.

Request 4. *Please provide explanation/justification regarding the statistical validity of the site specific revision of the secondary MCLs, and provide justification/precedent/examples of revision of secondary MCLs based on site specific data.*

Response 4:

PG&E does not consider the site specific revision of the secondary MCL justified because it:

1. Does not consider legacy sources of salts from activities prior to DVD operation that could contribute to concentrations downgradient, and
2. Does not consider upgradient and cross gradient concentrations of TDS in groundwater over 1,000 mg/L.

For these reasons, PG&E recommends the use of the 1,000 mg/L secondary MCL for TDS as a trigger level for providing cooking and drinking replacement water with additional analysis conducted to evaluate if additional replacement water is warranted for scaling or corrosion as discussed in Response 8 below before whole house replacement water is provided.

As discussed in Attachment 3, farming operations began south of the DVD in the 1940s, then at the DVD in the 1950s. Consistent farming operations have occurred at the DVD property, surrounding properties, and properties south (upgradient) of the DVD since the 1950s. These operations would have required significant groundwater extraction and fertilizer and/or manure application to maintain cropland. The net effect of decades of farming, groundwater extraction, and irrigation at the DVD and vicinity for other farming operations (before the DVD discharges began in 1980s) could have resulted in elevated nitrate, TDS, chloride, and sulfate concentrations such as those observed north of Santa Fe Road and south of Thompson Road today which cannot fully be described by DVD discharges.

Finding 20 of the PROP CAO does not provide a sufficient basis to establish a revision to the secondary MCL from 500 mg/L to a 700 mg/L trigger level for replacement water, because it does not adequately tie the trigger to the discharge. Finding 20 does not fully establish that 60 percent of the TDS beneath the DVD was sourced from the DVD discharge because it does not take into account pre-existing TDS prior to DVD discharges. The Hinkley Valley has been farmed since the 1940s, however, dairy operations on the DVD property (DVD dairy and prior dairy operator) did not begin until the 1980s. Legacy agriculture operations, widespread septic system use, and the arid environment could explain some of the TDS (nitrate, chloride, and sulfate) concentrations in the vicinity of the DVD and north of Thompson Road. These previous activities indicate that legacy agricultural byproducts likely entered the Hinkley Valley aquifer, including the DVD vicinity, many decades before dairy operations at the DVD were initiated.

TDS concentrations are greater than the secondary MCL of 1,000 mg/L at most monitoring wells upgradient of the DVD (south of Santa Fe Avenue) and cross-gradient of the DVD (southeast, on and east of Summerset Road) with concentrations commonly in the 1,000 to 2,500 mg/L range (see orange dots on Figure 25 in Exhibit 2) that cannot be linked to DVD discharges. These data indicate that influent concentrations to the DVD property exceed the upper secondary MCL of 1,000 mg/L and that concentrations exceeding the 1,000 mg/L secondary MCLs downgradient of the DVD may not be associated with historical DVD discharges. Therefore, attributing all TDS concentrations of more than 700 mg/L within the current and proposed affected area to DVD discharges is inappropriate. Because TDS concentrations widely exceed 1,000 mg/L upgradient of the DVD, an appropriate base level for estimating if water quality impacts were from DVD discharges is greater than the secondary MCL of 1,000 mg/L.

Although PG&E does not consider a site specific revision of the secondary MCLs appropriate to link TDS to DVD discharges, it should be noted that the site specific revision of the secondary MCL in PROP CAO was not done correctly. If a downgradient concentration is estimated to be comprised of 60 percent TDS, then to theoretically compare this to the lower secondary MCL 500 mg/L threshold, the adjusted threshold should be 500/0.6 = 833 mg/L, not 500*1.4= 700 mg/L.

PG&E conducted a review of Water Board orders available on the Water Board website[1] and held discussions with our peers to assess available Orders at other sites with potential nitrate and TDS groundwater impairment. The findings are summarized in Table 1 of Attachment 2 and showed no requirements for whole house replacement water due to groundwater constituents with secondary MCLs. The Lahonton Regional Water Quality Control Board N&M Dairy site in Helendale, California, required replacement of cooking and drinking water for TDS at an adjusted site specific concentration of 815 mg/L, but the methodology for calculation of the adjusted 815 mg/L concentration was not included in the N&M Dairy Order. The N&M Dairy Order is also provided in Attachment 2. Chloride and sulfate concentrations were not identified to trigger replacement water of any kind in the Orders reviewed. No reference of replacement water for impacts to appliances, laundry, pipes, water heaters, or other similar issues was noted in the Orders reviewed.

Request 5. *How many properties within the current area and proposed expansion area are currently above the levels below:*

- *500 TDS*
- *250 sulfate*
- *700 TDS*

Response 5:

Data are not available for all domestic or agricultural wells located within the current and proposed CAO expansion areas. Of wells that have monitoring data, the following information is available in PG&E's database:

1. Greater than 500 TDS – 6 wells on 5 different properties
2. Greater than 250 sulfate – no wells; limited monitoring data are available
3. Greater than 700 TDS – no wells

Request 6. *How many homes are currently receiving bottled water? Have any homeowners/occupants*

[1] http://www.waterboards.ca.gov/lahontan/ssi/serp.shtml?cof=FORID%3A10&ie=UTF-8&q=&cx=001779225245372747843%3Attksqsdjfn4

declined the offer of bottled water?

Response 6:

No homes are currently receiving bottled water. No homes have declined receiving bottled water.

Request 7. *Have there been any documented reports from within the affected or proposed expansion area of household appliances, laundry, pipes, water heaters, etc. being affected, and if so, what are the dates of those reports?*

Response 7:

PG&E has not received such complaints.

Request 8. *Are you aware of any other regional board requiring replacement water for impacts to appliances, laundry, pipes, water heaters, etc.?*

Response 8:

See Response 4 and Attachment 3. PG&E is not aware of any other regional board requiring replacement water for impacts to appliances, laundry, pipes, water heaters, or other similar equipment.

It should also be noted that additional data beyond bulk TDS measurements would be needed to fully assess the potential for scaling and staining that are cited in Finding 16 as the basis for requirement of whole house replacement water to protect pipes and appliances based on the TDS secondary maximum contaminant level (SMCL). Additional considerations for the potential for these effect of scaling and staining are as follows:

Scaling. TDS is a bulk measurement of the cationic and anionic salt species in water. Formation of deposits, or scaling, is a function of specific species comprising TDS, most commonly calcium and magnesium (known collectively as hardness), carbonate alkalinity, and sulfate. These materials can cause scale in the form of carbonate, sulfate, or hydroxide minerals. Formation of scale is a function of site specific factors, such as the concentration of these individual species, as well as the water quality pH, ionic strength, and temperature. Although there may be noticeable effects of deposits above the SMCL (reference 5 in Finding 16), the composition of TDS can vary within water systems that exceed the SMCL, as can the concentration of the constituents comprising TDS that cause scaling.

Consider, for example, the water quality data that was collected from MW-117S1, located downgradient of the Gorman ATU (and DVD), which indicates a TDS concentration exceeding the SMCL of 500 mg/L and close to the proposed replacement water trigger of 700 mg/L (Table 1). The Langelier Saturation Index (LSI) is an approximate indicator of potential scale or corrosion based on pH, alkalinity, calcium concentration, total dissolved solids, and water temperature. The LSI value will indicate the following:

- If the LSI is negative, then the water is under saturated with calcium carbonate and exhibits a general propensity to induce pipe corrosion.
- If the LSI is positive, then the water is over saturated with calcium carbonate and will tend to deposit calcium carbonate forming scales in piping.
- If the LSI is close to zero, i.e. within the range from -1 to 1, then the water is just saturated with calcium carbonate and will neither be strongly corrosive or scale forming.

For the example MW-117S1 data set, when a full suite of cations and anions were collected the LSI is -0.4. This value is close to zero, indicating the water will be neither strongly corrosive nor scale forming, despite

TDS concentrations exceeding the SMCL of 500 mg/L and the proposed replacement water trigger of 700 mg/L.

Table 1. Water Quality Data for MW-117S1, April 2012

Component	Level
Alkalinity, Bicarbonate as $CaCO_3$, mg/L	142
Alkalinity, Carbonate as $CaCO_3$, mg/L	< 2.5
Calcium, Dissolved, mg/L	97.8
Chloride, mg/L	235
Iron, Dissolved, mg/L	0.01
Magnesium, Dissolved, mg/L	23.2
Manganese, Dissolved, mg/L	NA
Nitrate as Nitrogen, mg/L	0.682
Potassium, Dissolved, mg/L	6.5
Sodium, Dissolved, mg/L	114
Sulfate, mg/L	102
Total Dissolved Solids, mg/L	718
pH	7.39
Temperature, °C/°F	23.0/73.4
Langelier Saturation Index	-0.4

Notes:
NA- not analyzed
mg/L- milligrams per liter
°C- degrees Celsius
°F- degrees Fahrenheit
$CaCO_3$- calcium carbonate

Staining. Similar to TDS, staining is caused by particular constituents within the bulk TDS measurement, typically iron or manganese. The MW-117S1 data in Table 1 provides an example where iron concentrations are very low, while TDS is greater than the 500 mg/L SMCL and close to the proposed 700 mg/L replacement water trigger, indicating a low potential for staining.

Given that measurements of TDS are not reliable indicators for scaling and staining, PG&E recommends that the exceedance of the SMCL or other site specific adjusted trigger value for TDS does not automatically trigger a replacement water requirement. Rather, PG&E recommends that exceedance of the SMCL or other site specific adjusted trigger value requires sampling for additional water quality parameters directly related to scaling and staining, along with an evaluation of the potential for scale and stain formation based on that data, before whole house replacement water for protection of appliances and pipes.

Given that the solution to prevent scaling and staining of household appliances and piping will be specific to the water quality of a given supply well, PG&E recommends revising the CAO requirements to only require a plan after an exceedance has occurred, so that the evaluation of which technologies are appropriate for a given exceedance can be completed after the exceedance and based on additional data collection. It is important to understand which constituents may contribute to a potential problem in order to evaluate the appropriate technology to prevent the problem. For example, if the water quality indicates that calcium and magnesium hardness is likely to cause scale, then a water softener might be a solution. If the issues are specific to other species, like chloride or sulfate, then a simple solution like addition of a softener or filter may not be adequate.

Request 9. *Are you aware of any other regional board that has required replacement water for exceedances of Secondary MCLs? If so, at what level did the regional board require replacement water?*

Response 9:

PG&E is unaware of any other regional board's requiring replacement water for exceedances of secondary MCLs.

Recommended Changes to the Proposed DVD CAO

Based on the preceding discussion and the information presented in Attachment 3 PG&E makes the following recommended changes to the PROP CAO:

1. Do not expand the affected area to Sonoma Street. The current northern boundary at Salinas Street is adequate to encompass potential impacts from historic DVD discharges.
2. The secondary MCL of 1,000 mg/L should be used as the trigger level to begin providing drinking and cooking replacement water and that criteria include the language "due to the discharge" where defined in the order. TDS concentrations are greater than the secondary MCL of 1,000 mg/L at most monitoring wells upgradient of the DVD (south of Santa Fe Avenue) and cross-gradient of the DVD (southeast, on and east of Summerset Road) with concentrations commonly in the 1,000 to 2,500 mg/L range that cannot be linked to DVD discharges. These data indicate that concentrations exceeding the 1,000 mg/L secondary MCL for TDS downgradient of the DVD may not be associated with historical DVD discharges.
3. Given that measurements of TDS are not reliable indicators for scaling and staining, PG&E recommends that the exceedance of the SMCL or other site specific adjusted trigger value for TDS does not automatically trigger a replacement water requirement for impacts to appliances. Rather, PG&E recommends that exceedance of the SMCL or other site specific adjusted trigger value for TDS requires sampling for additional water quality parameters directly related to scaling and staining, along with an evaluation of the potential for scale and stain formation based on that data, before whole house replacement water for protection of appliances and pipes.

ATTACHMENT 2

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
California Water Science Center
San Diego Projects Office
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San Diego, CA 92101
Phone: (619) 225-6100 Fax: (619) 225-6101
http://water.wr.usgs.gov

IN REPLY REFER TO:

September 15, 2016

To: The Hinkley Independent Review Panel (IRP) Manager:

Between January 27 and 31, 2016, the U.S. Geological Survey (USGS) sampled 72 domestic and agricultural wells in the unincorporated community of Hinkley, CA. The data were collected as part of the USGS study of background hexavalent chromium, Cr(VI), concentrations in the Hinkley area http://ca.water.usgs.gov/pubs/2016/hinkley-chromium-ofr20161004.html. The wells were largely outside the area of the mapped Cr(VI) plume within Hinkley Valley.

Water from the wells was analyzed for a range of constituents including field parameters (temperature, pH, specific conductance, and dissolved oxygen), selected major and minor ions (chloride, sulfate, fluoride, and bromide), nutrients (nitrate, nitrite, orthophosphate), selected trace elements (iron, manganese, arsenic, total chromium, hexavalent chromium, uranium, and vanadium), and the stable isotopes of oxygen and hydrogen. Samples for major and minor ions, nutrients, and trace elements were filtered and preserved (if required) in the field at the time of collection.

Results of analyses were mailed to well owners in May 2016. Data are available through the U.S. Geological Survey's on-line data base NWIS-Web at http://waterdata.usgs.gov/nwis.

Several of the constituents measured, most notably arsenic, chromium (total and hexavalent), uranium, and nitrate have Maximum Contaminant Levels (MCLs) for drinking water. For the samples collected during January 2016, concentrations exceeded the US Environmental Protection Agency (US EPA) MCL for arsenic of 10 micrograms per liter (µg/L) in 28 of 72 wells, about 39 percent of sampled wells. The highest arsenic concentration in a sampled well was 300 µg/L, 30 times the MCL. Concentrations exceeded the MCL for uranium of 30 µg/L in 6 of 72 wells, about 8 percent of sampled wells; and concentrations exceeded the MCL for nitrate of 10 mg/L as nitrogen in 7 of 72 wells, about 10 percent of sampled wells. The highest uranium concentration in a sampled well was 62 µg/L, more than twice the MCL. The highest Cr(VI) concentration measured was 4 µg/L—less than half of the recently established California MCL for Cr(VI) of 10 µg/L. Water from 34 of 72 wells had concentrations of arsenic, uranium, and/or nitrate above a drinking water MCL. This represents about 47 percent of the wells sampled in the Hinkley, CA area by the USGS between January 27 and 31, 2016.

Sincerely

John Izbicki
Research Hydrologist
U.S. Geological Survey

TABLE 1

Summary of Dairy Orders

Farm/Dairy Name	CAO Order Number	CAO Date Issued	Recipients	Water Required: Bottled	Water Required: Whole House	Drinking and cooking: Nitrate as N mg/L	Drinking and cooking: TDS mg/L	Drinking and cooking: Chloride mg/L	Drinking and cooking: Sulfate mg/L	Whole House Water Replacement: Nitrate as N mg/L	Whole House Water Replacement: TDS mg/L	Whole House Water Replacement: Chloride mg/L	Whole House Water Replacement: Sulfate mg/L	Notes
Desert View Dairy	R6V-2008-0034	11/10/2008	Ryken, Estate of Nick Van Vliet, Flameling Dairy, PGE, Vliet Children	X	NA	10	NA	NA	NA	NA	NA	NA	NA	
	R6V-2008-034A2	3/9/2010		X	X	10	NA	NA	NA	10	NA	NA	NA	
	R6V-2008-034A3	2/24/2011		X	X	10	NA	NA	NA	10	NA	NA	NA	
Ryken DVD Heifer Farm	R6V-2011-0057	24-Aug-11	Paul Ryken and (PG&E)	X	NA	10	500	NA	NA	NA	NA	NA	NA	
	R6V-2011-0057-A2	24-Sep-14		X	NA	6	500	NA	NA	NA	NA	NA	NA	
Hinkley Dairy	R6V-2011-0059	24-Aug-11	Dale Ruisch and Ken DeVries	X	NA	10	500	NA	NA	NA	NA	NA	NA	
	R6V-2011-0059A1	19-Jan-12		X	NA	8	500	NA	NA	NA	NA	NA	NA	
Harmsen Dairy	R6V-2011-0058	24-Aug-11	Jim Harmsen	X	NA	10	500	NA	NA	NA	NA	NA	NA	
N&M Dairy	R6V-2011-0055	2-Aug-11	N&M Dairy (Neil and Mary DeVries)	X	NA	10	500	NA	NA	NA	NA	NA	NA	
	R6V-2011-0055A1	19-Jan-12		X	NA	7	700	NA	NA	NA	NA	NA	NA	
	R6V-2013-0103	12-Dec-13		X		7	815	NA	NA	NA	NA	NA	NA	
Hillmar Cheese Co.	R5-2004-0722	2-Dec-04	Hilmar Cheese Co, Inc, Hilmar Whey, Inc., and Kathy and Delton Nyman Cheese Processing Plant	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Order states that if an affected well is found, submit a work plan to provide the owner in-kind replacement.

Nitrate as N MCL = 10 mg/L
Nitrate as NO3 MCL = 45 mg/L
TDS SMCL = 500/1000/1500 mg/L
MCL = maximum contaminant level
SMCL = secondary maximum contaminant level
NA = not applicable, TBD = to be determined if affected well is identified
mg/L = milligrams per liter
X = required

ATTACHMENT 3

TECHNICAL MEMO

Arcadis U.S., Inc.
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To: Lahonton Regional Water Quality Control Board

Patty Z. Kouyoumdjian

Doug Smith

PROFESSIONAL GEOLOGIST
ISAAC ARABY WOOD
No. PG 8747
No. CHG 933
CERTIFIED HYDRO GEOLOGIST
STATE OF CALIFORNIA

From:

Isaac Wood, PG, CHG

Date:

October 6, 2016

Arcadis Project No.:

RC000699.0151

Subject:

Conceptual Site Model for Impacts to Groundwater Related to the Desert View Dairy

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Requests 1 and 2 of the California Lahontan Regional Water Quality Control Board letter *Request for Information – Proposed Cleanup and Abatement Order for Desert View Diary* September 8, 2016, sought references to previous documents that provide the Conceptual Site Model (CSM) used to define and depict the lateral and vertical extent of the total dissolved solids (TDS), chloride, and sulfate plumes in groundwater that extend from the DVD property and whether those impacts reached the expanded "Affected Area." The requests also sought information on historical practices that could have impacted groundwater with respect to these constituents of concern. The determination of the extent of impacts from the DVD is confounded by the presence of historical impacts from activities prior to dairy operations at the DVD and relies on a CSM incorporating historical information and multiple lines of evidence. A list of references containing data informing the CSM is provided in response to Request 1 as Exhibit 1. A summary of the CSM based on data in these references and additional PG&E monitoring data is provided below.

Time Line of Historical Operations at the DVD Property and Surrounding Properties

From approximately 1954 to 1981 the DVD property was farmland used by previous landowners to grow alfalfa and potentially other fodder crops. Established farms were also present in most of the area south and east of the DVD in 1952 or earlier. From 1981 to 1986, the Flameling Brothers used the DVD land to operate a dairy that was located on the western side of the DVD property. From 1986 to 1991, the DVD property was idle. The DVD began dairy operations in 1991. Waste storage and disposal actions at the DVD dairy are summarized in the July 30, 2008 technical report included in Exhibit 1 (CRA 2008). Besides the DVD property, several other large agricultural operations have operated in the immediate vicinity including the former Nelson-Diaz Dairy south of the DVD (upgradient), the former Leyerly Dairy southwest of the DVD (upgradient), large parcels of irrigated cropland, and a former hog facility operation near Hervey Road and Thompson Road (north and downgradient of the DVD) during the 1980s. These features are shown on Figure 2.4 from the Groundwater Investigation Data Report (October 2008), Desert View Dairy, Hinkley, California, (CRA 2008) provided in Exhibit 1, and also provided as Figure 1 of Exhibit 2.

Historical Land Use

Historical land use was reviewed through aerial photographs. Aerial photos from 1944 through 2002 are provided in Exhibit 3 as Figures 2 through 13. Aerial photographs show that widespread agricultural operations, including irrigated croplands and confined animal operations, have been occurring in the south and central Hinkley Valley since the 1940s. These activities have resulted in a legacy of widespread nitrate and TDS (agricultural byproduct) impacts to groundwater seen throughout the Hinkley Valley today.

The photograph from 1944 shows that at the time numerous established agricultural plots already covered sections of land in the Hinkley Valley, south of today's State Route 58 (photo unavailable for DVD vicinity). The photographs from 1952 and 1953 indicate that agricultural operations continued to expand from 1944 to 1953. By 1952, most of the area south of Thompson Road (near the DVD property), all the way south to Highcrest Road (south of the Hinkley Compressor Station), and from west to east from Serra Road to Dixie Road, had active agricultural operations. Based on available aerial photographs, widespread agricultural operations appeared to continue through the 1950s and into the 1960s.

In the 1970s the overall portion of the Hinkley Valley with active agricultural operations declined compared with the 1950s and 1960s, but farming continued at the DVD property and vicinity. The overall reduction in irrigated crop land is likely because groundwater extraction from the 1940s to 1960s used to support agricultural operations dewatered the aquifer so much that the magnitude of agricultural operations occurring in the 1960s could not continue (Stantec Consulting Corporation [Stantec] 2013; California State University-Fullerton [CSUF] 2007). Where PG&E's current remediation agricultural treatment units (ATUs) are present today, agricultural operations continued through the 1970s and into the 2000s. A rectangular feature near Thompson and Hervey Road (and west of Gorman North ATU) visible in the 1980s aerial photographs may be a former hog facility noted to be present before or about the same time Flameling Brothers dairy operations began at the DVD (CRA 2008).

Historical Groundwater Extraction

Historical groundwater extraction to support the consistent agricultural operations visible at the DVD and greater area in the aerial photographs discussed above is estimated to have reduced the flux of groundwater in the south Hinkley Valley, including the DVD area, from migrating downgradient and north of Thompson Road into the north Hinkley Valley. Appendix G of Stantec 2013 (provided in Exhibit 1) estimates the amount of groundwater extraction necessary to maintain the consistent croplands noted at the former DVD and other areas now farmed by PG&E for their ATU farms for chromium remediation. These data were used to estimate the possible scale of hydraulic containment from historical agricultural extraction in comparison to the capture zone derived from groundwater extraction for PG&E's chromium remediation extraction wells today.

Hinkley Valley crops were historically irrigated with groundwater supplied from water supply wells typically located within, adjacent to, or a short distance from each field and applied to the field via either furrow irrigation (the common practice in the Hinkley Valley in the 1950s and 1960s), and in more recent years, by using a center-pivot irrigation system. It is likely that these earlier irrigation wells would have been constructed with screens beginning at the water table because at that time since it is costlier to drill deeper. This is where the greatest nitrate and TDS impacts are observed. Annual groundwater withdrawals for a given parcel can be approximated by estimating the irrigated acreage of that parcel based upon the aerial photographs. Available aerial photographs for the Hinkley Valley, for the years spanning from 1944 to 2009, were examined (Exhibit 2, Figure 14) and annual groundwater extraction amounts for only PG&E's currently farmed areas were estimated by PG&E; these estimates appear in Appendix G of Stantec 2013 (Exhibit 1). Extensive agricultural extraction to support farming since the 1940s in the Hinkley Valley has been well documented by others (Stamos 2001; CSUF 2006; Todd 2013). Annual extraction amounts for years when aerial photographs are not available were interpolated based upon available photographs or based upon pumping records from the Water Master and PG&E remedial pumping records.

Selected Figures from Appendix G in Stantec 2013 are provided in Exhibit 2 as Figures 14 through 16. The complete Technical Memorandum is included in Exhibit 1. Figure 14 provides aerial photographs from 1953, 1970, and 1989 to illustrate the consistency of agricultural activities in the area where PG&E is currently conducting groundwater extraction for ATU remedial operations over time including the DVD area. As shown on the Figure 14, the area that PG&E is farming for remedial operations today (orange area on Figure 14) has been consistently used for agricultural purposes since the 1950s, as well as additional areas surrounding the areas PG&E currently farms. This indicates that some degree of the hydraulic containment that PG&E is currently achieving with focused groundwater extraction for chromium plume containment (groundwater contour maps discussed in following section) has also occurred since the 1950s due to agricultural groundwater extraction.

To estimate historical pumping versus current PG&E remedial pumping, Figures 15 and 16 show historical and recent agricultural pumping rates (estimated from aerial photographs 1952 to 2009) and recent remedial pumping rates in the area where PG&E is currently conducting remedial pumping operations at the DVD and adjacent ATUs. The area where historical pumping rates were estimated is comparable with the areas where PG&E is currently conducting remedial extraction shown as an orange area on Figure 14. Figures 15 and 16 show that recent combined remedial pumping rates for the DVD and the various ATUs are less than or comparable with the estimated historical agricultural pumping rates for these same areas (shown by hatched bars). Current groundwater level contours are presented in Exhibit 2 as Figure 17 through 20 along with the estimated capture zone (shown as a dashed blue line) developed from PG&E's groundwater extraction to support irrigation at the green shaded ATU areas that are currently farmed for chromium remediation. The historical pumping data in comparison to recent pumping data suggest that starting in the 1950s, or earlier, there has been some hydraulic containment of groundwater near the current DVD and other ATU areas that would have reduced northward groundwater flow from this area into the north Hinkley Valley (north of Thompson Road).

Vadose Zone Flow

To estimate when irrigation water applied at the ATUs would reach the water table, located approximately 80 feet below ground surface, and begin mixing into the aquifer, vadose zone modeling was conducted. These data were reported in the Agricultural Treatment Byproducts Investigation Report for Environment Impact Report Mitigation Measure WTR-MM-5, Pacific Gas and Electric Company, Hinkley Compressor

Station, Hinkley, California (CH2M HILL 2015). Modeling was conducted using HYDRUS-1D (Simunek et al.1998), a one-dimensional water and solute transport code, to simulate the movement of water and a conservative solute or tracer through the vadose zone of each ATU. At the currently operated DVD agricultural fields, the minimum travel time estimated for irrigation water to reach the aquifer was 3.1 years, while the maximum travel time was 9.5 years, and the average travel time was 6.4 years. These estimates were specifically performed to estimate infiltration rates for irrigated farmed areas, but they can also be used to estimate the potential vadose zone travel times for historic DVD dairy discharges to groundwater.

Given these estimates and that the Flameling Brothers dairy operations at the DVD property began in 1981 (DVD dairy began operations in 1991), the Flameling Brother's dairy discharges may have begun to enter the aquifer in 1984, with significant infiltration of dairy waste unlikely to have started until 1987. However, considering that all operations on the DVD property were idle from 1986 to 1991, limited waste from the earlier period of dairy operations from 1981 to 1986 may have been mobilized through the vadose zone and into the aquifer over this earlier period.

Because Hinkley, California, is located in an arid desert environment, little to no infiltration of rainfall to groundwater occurs. Therefore, there may have been no surface water discharges when the dairy was inactive from 1986 to 1991 resulting in minimal flux of vadose zone diary waste into groundwater during this time. Considering this information, significant DVD dairy discharges may not have begun to affect groundwater beneath the DVD property until the 1990s after there was sufficient surface water discharged to saturate the vadose zone, allowing for deep percolation of vadose zone dairy waste into groundwater. Additionally, from approximately 1952 to 1981, the DVD property and surrounding area was farmland used to grow alfalfa and potentially other fodder crops by previous landowners. Agricultural operations from this period before diary discharges began at the DVD property may also have impacted aquifer water quality beneath and downgradient of the DVD property.

Groundwater Velocity and Flow

Historical groundwater conditions in the Hinkley Valley were summarized in Appendix G of Stantec 2013 and provided in Exhibit 1. As shown on Figure G-4A in Appendix G, groundwater levels in the south and north Hinkley Valley rapidly declined in the 1950s and early 1960s in response to widespread agricultural groundwater extraction. Around 1965 groundwater levels in the north Hinkley Valley appear to have generally stopped declining and reached a level within approximately 5 feet of the groundwater levels measured in the 1990s. These data suggest that groundwater conditions (aquifer saturated thickness and groundwater gradient) in the north Hinkley Valley beginning around 1965 may not have been much different than what is observed today.

Based on a review of boring logs for the north Hinkley Valley, a hydraulic conductivity of 13.5 feet per day is estimated to apply to shallow groundwater within the affected and proposed affected areas of this area. This value is used in PG&E's groundwater flow model and provides a reasonable estimate of shallow groundwater flow since discharges began at the DVD property in the 1990s, and likely before DVD discharge began as well. As summarized in Table 1, using the hydraulic conductivity of 13.5 feet per day and current groundwater level measurements (Arcadis 2016) to estimate the groundwater gradient, an average groundwater velocity 0.3 feet per day or approximately 111 feet per year is estimated within the current and proposed affected areas from Thompson Road to Sonoma Street.

Table 1. Groundwater Velocity from Thompson Road to Salinas Road and Sonoma Street

Wells for Gradient Estimate	Upgradient Elevation (ft MSL)	Downgradient Elevation (ft MSL)	Distance (ft)	Hydraulic Gradient	Hydraulic Conductivity (ft/day)	Effective Porosity	Estimated Velocity (ft/day)	Estimated Velocity (ft/year)
MW-127S1/ MW-124S1	2078.8	2074.7	2337.2	0.0018	13.5	0.1	0.24	86
MW-123S1/ MW-113S1	2074.5	2066.3	2964.8	0.0028	13.5	0.1	0.37	136
		Average		**0.002**	**14**	**0.1**	**0.3**	**111**

Notes:

ft = feet

MSL = mean sea level

As shown on Figure 21 in Exhibit 2 the average groundwater velocity calculated using the average gradient from Salinas Road north to Mountain General Road is also estimated to be less than 0.5 feet per day or approximately 158 feet per year based on a larger range hydraulic conductivities to acknowledge uncertainty in aquifer properties in the north Hinkley Valley. PG&E has limited aquifer parameter data for the north Hinkley Valley, so the actual velocity could be even less than 158 feet per year, and closer to the 111 feet per year estimated using a hydraulic conductivity of 13.5 feet per day as suggested by the groundwater flow model.

Particle tracks were simulated using PG&E's groundwater flow model for 10 years starting in 2014 (2014 through 2023) in the scenario without PG&E remedial pumping to estimate the potential movement of nitrate and TDS in the absence of PG&E's remedial groundwater extraction. The MODPATH particle tracking software was used in conjunction with the Hinkley Groundwater Model (Arcadis and CH2M 2011), to follow the forecasted path of simulated particles of groundwater over time, starting at a designated point. Particle tracks represent the movement of water from the nitrate and TDS boundaries estimated at the time model simulations were run and approximate the movement of a conservative solute without taking into account attenuation mechanisms, including dispersion, diffusion, mixing (dilution), and biotic and abiotic degradation. Because these forms of attenuation would actually take place, the particle tracks do not necessarily represent the migration of the respective plume boundaries, rather they represent a conservative prediction of potential movement. Particles that move away from the center of mass (that is, beyond the plume and not into it) are indicative of areas where the plume boundary may be expected to expand. Plumes may be expected to shrink in areas where particles immediately move toward the center of the plumes, depending on sources.

Particle tracks simulated for 10 years starting in 2014 (2014 through 2023) in the scenario without PG&E remedial pumping were previously reported in the ROWD Addendum No.3 and Addition (Arcadis 2014a,b) and are provided as Figures 22 and 23 in Exhibit 2. These figures show that approximately 1,000 feet of groundwater movement (each red arrow represents 1 year of travel) is predicted to occur over a 10-year period north of Thompson Road without PG&E pumping. This indicates a slow groundwater velocity of approximately 100 feet per year even in the absence of PG&E's remedial groundwater extraction near Thompson Road.

The above groundwater velocity estimates by PG&E (100 to 158 feet per year, or less than 0.5 feet per day) are substantially less than the 2 feet per day (730 feet per year) groundwater velocity reported by the Water Board's Prosecution Team in their response to comments on the PROP DVD CAO to support expansion of the affected area to Sonoma Street (Water Board 2016b. The Prosecution Team estimated groundwater velocity of 2 feet per day does not consider the historic and current groundwater extraction in the south Hinkley Valley that would limit groundwater movement to the north through the greater DVD area into the north Hinkley Valley or the less permeable aquifer materials (and lower hydraulic conductivity) north of Thompson Road that would indicate a slower velocity than the south Hinkley Valley given the same hydraulic gradient.

The Prosecution Team commented on PG&E's initial comments on the PROP DVD CAO that "faster groundwater flow is factored in where the aquifer narrows near the DVD due to bedrock outcrops in the west at Mountain View Road and east at Summerset Road." The area where the bedrock outcrops occur in the west at Mountain View Road and east at Summerset Road is generally referred to as the Hinkley Gap that separates the south Hinkley Valley from the north Hinkley Valley (near Thompson Road). As shown on the groundwater elevation maps (Exhibit 2, Figures 17 and 21) the hydraulic gradient doesn't become greater in this area, although the aquifer width lessens, so the groundwater velocity does not increase as it passes through the 5,000-foot area bounded by these bedrock outcrops. The reason the narrowing of the aquifer does not cause groundwater velocity to increase, is because the volumetric flow is not constant upgradient and downgradient of the gap. This is because the groundwater extraction that is currently occurring south of the Hinkley gap and that has consistently occurred since the 1950s has reduced flow from the south Hinkley Valley into the north Hinkley Valley.

The estimated capture zone resulting from groundwater extraction to support PG&E's current farms is shown on the groundwater contour maps on Figures 17 through 20 in Exhibit 2 as a dashed dark blue line. This hydraulic data demonstrates that groundwater extraction in the greater DVD area captures a significant portion of the water flowing toward the Hinkley Gap, which results in groundwater flow slowing in the vicinity of Thompson Road rather than accelerating. Based on the historical aerial photographs, it is estimated that similar levels of historical groundwater extraction reduced northward movement of groundwater from the greater DVD area into north Hinkley Valley before PG&E's remedial extraction operations began.

Figures 18 through 20 of Exhibit 3 show more detailed groundwater contours developed to illustrate the capture zone from PG&E's remediation extraction wells. The north portion of the capture zone (depicted as a dashed blue line) shown on these maps is primarily developed from operation of extraction wells G-2R and EX-35 operating at a combined rate of approximately 100 gpm (Arcadis 2016). These contour maps show that 100 gpm of extraction from the shallower portion of the Upper Aquifer in the center of the Hinkley Gap results in significant hydraulic containment, and that limited historical groundwater extraction would have reduced groundwater movement north of Thompson Road. Based on aerial photographs previously discussed some to most of the areas PG&E currently farms for chromium remediation (green outlines on aerial photographs) have been in use since the 1950s indicating that some degree of hydraulic containment has likely been accomplished that would reduce northward movement of agricultural byproducts and maintain a groundwater velocity through and north of the Hinkley Gap that is comparable to today.

Figure 24 in Exhibit 2 shows groundwater contours developed from groundwater levels collected by the United States Geological Survey and the Department of Water Resources (http://nwis.waterdata.usgs.gov/nwis/gwlevels) during 1958 to 1959 when groundwater extraction to support farms in the DVD and greater area was occurring. As shown on this map a cone of depression was present in the greater DVD area at this time suggesting that limited groundwater in this area was migrating north of Thompson Road into north Hinkley Valley. Consistent agricultural activities at the DVD and vicinity since this time would have continued to limit northward groundwater movement although extraction rates may not have continued to be as high as they were during 1958 and 1959 in subsequent years.

Water Quality and Geochemical Data

As discussed above, intensive farming including fodder crops and confined animal operations have occurred in the south Hinkley Valley since the 1940s and the greater DVD area since at least 1952. These legacy agricultural operations have affected much of the groundwater in the south and central Hinkley Valley south of Thompson Road and south of the DVD property resulting in a large area with nitrate above maximum contaminant levels (MCLs) and TDS, chloride and sulfate above their respective secondary maximum contaminant levels (SMCLs). Additionally, septic systems are present at most, if not all, homes in the Hinkley Valley which could contribute the above constituents to groundwater resulting in localized areas with groundwater exceeding drinking water MCLs unrelated to historical DVD operations. Further, the arid environment naturally allows groundwater to become enriched in salts over time (due to limited recharge of freshwater into aquifer). Collectively these and other sources have resulted in groundwater that exceeds the lowest SMCL for TDS of 500 mg/L throughout most of the south central and eastern Hinkley Valley and parts of the north Hinkley Valley. As indicated in aerial photographs and maps showing the distribution of TDS, chloride, sulfate, and nitrate in Exhibit 2, freshwater recharging the Hinkley Valley from the Mojave River 15,000 feet south of the DVD encounters groundwater impaired by more than 60 years of legacy agricultural operations as it migrates towards the DVD and slowly into the north Hinkley Valley. Figures 25 through 35 in Exhibit 2 includes maps showing the distribution of nitrate, TDS, chloride, sulfate, and the stable isotopes of oxygen and deuterium throughout the Hinkley Valley and the greater DVD area. These maps are briefly summarized below.

TDS. As shown on Figures 25 through 29, the extent of TDS in the shallow and deep zones of the Upper Aquifer downgradient of the DVD has been defined with PG&E's chromium monitoring wells to the upper SMCL of 1,000 mg/L with higher concentrations reported for shallow screened monitoring wells as expected. As shown on Figure 25, TDS exceeds the upper SMCL of 1,000 mg/L in most monitoring wells south of Santa Fe Avenue (upgradient) and on and east of Summerset Road (cross-gradient of the DVD). Therefore, TDS concentrations exceeding 1,000 mg/L could be present north of the DVD (downgradient) that are unrelated to DVD discharges due to migration of TDS from legacy agricultural operations beginning in the 1940s and 1950s.

TDS concentrations exceeding the SMCL of 1,000 mg/L are detected in monitoring wells north of Thompson Road and as far north as Salinas Road (MW-156S). Additionally, TDS concentrations exceeding 1,000 mg/L were reported for wells west and northwest of the affected area and proposed affected area (15-02, 15-03,15-15, 15-16, and 22-43); these TDS detections are reported for wells too far west (cross-gradient of proposed and affected areas) to reasonably be associated with the DVD discharges, and illustrate the uncertainty of using the Prosecution Team proposed TDS value of 700 mg/L to require replacement water due to DVD discharges.

Chloride and Sulfate. Figures 29 and 30 show the distribution of available chloride and sulfate data, respectively. The most northern extent of chloride reported greater than the SMCL of 250 mg/L is at MW-156S near Salinas Road, while sulfate greater than the SMCL of 250 mg/L is limited to just south of Salinas Road (MW-123S1). However, the concentrations of both of these constituents are greater than the SMCLs at many wells up and cross gradient of the DVD so linking these detections in the north Hinkley

Valley with the DVD cannot be made without also considering that legacy agricultural operations beginning in the 1940s may be the source of north Hinkley Valley detections.

Chloride is present at concentrations above the SMCL of 250 mg/L in monitoring wells upgradient (MW-22A1, MW-23A, MW-24A1, MW-26, MW-28A) and cross-gradient (southeast) of the DVD property near Santa Fe Avenue, east of Summerset Road (MW-116S). The chloride concentration of 254 mg/L at MW-116S shows that chloride concentrations may exceed the SMCL in influent groundwater south of the DVD at a well too far upgradient to have any association with historical DVD discharges. If this well is representative of legacy agricultural operations, then chloride concentrations above 250 mg/L downgradient of the DVD may not be associated with DVD discharges.

Sulfate is present at concentrations equal to or greater than the SMCL of 250 mg/L in many monitoring wells upgradient (including MW-14S, MW-22A1, MW-23A, MW-24A1, MW-25A2, MW-27A, MW-28A, MW-49S, MW-64A, MW-95S and MW-108S) and cross-gradient (east) of the DVD property such as MW-110S east of Summerset Road. The sulfate concentration of 515 mg/L at MW-110S illustrates that sulfate concentrations may exceed the SMCL in groundwater east of the DVD at a well too far away to have any association with historical DVD discharges. If this well is representative of legacy agricultural operations, then chloride concentrations above 500 mg/L downgradient of the DVD may not be associated with DVD discharges.

Nitrate (as Nitrogen). As shown on Figures 31 through 34, the extent of nitrate in the shallow and deep zones of the Upper Aquifer downgradient of the DVD has been defined to the MCL of 10 mg/L with PG&E’s chromium monitoring wells, with higher concentrations reported for shallow screened monitoring wells as expected. Nitrate (as nitrogen) concentrations exceeding the MCL of 10 mg/L are not detected in monitoring wells north of Thompson Road. Nitrate exceeds the MCL of 10 mg/L in most monitoring wells upgradient (south, south west, and southeast) of the DVD, again illustrating that legacy agricultural operations may be the source of some of the nitrate downgradient of the DVD.

Stable Isotopes of Oxygen and Deuterium. Most of the world’s precipitation originates from the evaporation of seawater, and the ratio of concentrations of oxygen-18 to oxygen-16 (δ18O) and of deuterium (hydrogen-2) to hydrogen-1 (δD), both relative to ocean water standards, for precipitation throughout the world is linearly correlated and distributed along a line known as the global meteoric water line (Craig 1961). The δ18O and δD values for groundwater samples relative to the global meteoric water line provide evidence of the source of the water and fractionation processes (influenced primarily by evaporation and condensation) that have affected the water’s stable-isotope values. δ18O and δD abundances are expressed in per mil (parts per thousand [ppt]) difference relative to the standard Vienna Standard Mean Ocean Water (VSMOW). Therefore, the ratio of VSMOW is 0 per mil.

The primary processes that affect δ18O and δD are water evaporation and condensation. Water molecules containing the lighter isotopes tend to evaporate more readily, leaving the remaining water molecules relatively “enriched” in the heavier isotopes. Thus, water that has been subject to evaporation shows a heavier isotopic signature. Groundwater impacted by evaporation during irrigation return flow over more than 60 years of agricultural operations in the Hinkley Valley, shows groundwater enriched in the heavier isotopes. The aerial distribution of stable isotope data collected by PG&E is shown on Figure 35. Groundwater that has been partly evaporated as a result of agricultural use is commonly between -60 and -50 per mil (Izbicki 2004). Based on this report and the values for wells south of the Hinkley Compressor Station, that likely represent Mojave River recharge water that has not undergone extensive evaporation through irrigation return water, a value of -60 per mil was used as a distinguishing point to illustrate differences between groundwater subject to and not subject to extensive evaporation. The value used to distinguish between water that has undergone extensive evaporation or not was selected as a way to illustrate differences between groundwater sources and is not intended to indicate that this value represents sharp change between groundwater sources. For illustration purposes, the data points shown in brown squares on Figure 35 are considered to have a “heavier isotopic signature” (that is, they are enriched in the heavier isotopes, oxygen-18, and deuterium), while the data points shown in blue squares are considered to have a “lighter” isotopic signature.

The heavier isotopic signature in the south central and eastern Hinkley Valley (south of Thompson Road) is interpreted to have resulted from preferential enrichment as partially evaporated agricultural water has percolated back down to the groundwater table, been recaptured by pumping wells, and subsequently reapplied to crops. This cycle likely began in the 1940s when intensive agriculture in the Hinkley Valley began and was supported by high groundwater withdrawal rates. This process appears to have resulted in a distinct “heavy” isotopic signature in many wells of central and eastern Hinkley Valley (south of Thompson Road) compared with the north and western Hinkley Valley monitoring wells.

Notably the evaporative “heavy” signature present in the south central and eastern Hinkley Valley is not present in wells sampled north of Thompson Road. The lack of elevated nitrate (above the MCL of 10 mg/L) and an evaporative signature in groundwater north of Thompson Road as indicated by the “light” isotopic signature at MW-117S2 and MW-128S1/S2 supports the interpretation that groundwater in this area was recharged before legacy agricultural operations resulted in an evaporative “heavy” signature to groundwater and is not impacted by DVD discharges. The DVD discharges, which may have started in the 1980s or early 1990s, depending upon when significant infiltration of dairy waste reached the aquifer, would likely have an evaporative “heavy” isotopic signature due to 40 to 50 years of legacy agricultural operations occurring upgradient and at the DVD property before the DVD discharges began.

Summary and Conclusions

Aerial photographs show that widespread agricultural operations, including irrigated croplands and confined animal operations, have been occurring in the Hinkley Valley since the 1940s. Extensive groundwater extraction and fertilization, including manure application to fields for fodder crops, since this time would have been required to maintain these farmed areas. These activities have resulted in a legacy of widespread nitrate and TDS (including chloride and sulfate) impacts to groundwater seen today. The DVD is located near the northern most portion of the south Hinkley Valley where intensive historical agricultural operations have occurred so groundwater flowing into the DVD area has a long flow path to become enriched in nitrate, TDS, chloride, and sulfate before reaching the DVD and vicinity from these numerous upgradient sources. The majority of monitoring wells upgradient of the DVD contain TDS concentrations in the 1,000 to 2,500 mg/L range, with nitrate, chloride, and sulfate concentrations also present above screening levels at most monitoring wells.

Due to the natural boundary conditions created by the bedrock out crops located to the west and east of the DVD area forming the Hinkley Gap, hydraulic containment from extraction to support agricultural and confined animal operations is more easily achieved in this area than in the south and central Hinkley Valley. As a result, it is probable that part of the reason that TDS concentrations are elevated in the greater DVD area, in comparison to upgradient wells, is that the DVD is near the end of a flow path that received elevated TDS from numerous upgradient sources that were then captured by DVD area extraction wells and applied to fodder crops over many decades before DVD discharges began. Over time irrigation return water would slowly infiltrate back into the aquifer until extraction wells again captured the water. This recycling of already salty water would further increase TDS concentrations over time in comparison to upgradient wells and contribute to producing a “heavy” isotopic signature (as indicated by oxygen and deuterium) that is characteristic of extensive evaporation, while also reducing the flux of nitrate and TDS containing groundwater north of Thompson Road.

There are numerous factors that must be considered in associating TDS, sulfate, and chloride concentrations greater than the SMCLs to the former DVD operations, these include but are not limited to the following:

1. Farming began in the Hinkley Valley in the 1940s. The DVD property and greater area has been farmed since the 1950's. Assuming dairy discharges began at the DVD property in the 1980s during operations of the former Flameling Dairy, there were decades of discharge from previous operations when TDS (including chloride and sulfate) and nitrate originating from previous agricultural operations could have migrated through the DVD area and into north Hinkley Valley. Additionally, there was a hog facility north of the DVD near Thompson Road (west of the current Gorman North ATU) in the 1980s that may represent a downgradient source of TDS and nitrate.

   Unlike TDS, chloride, and sulfate which tend to be elevated together, nitrate can be absent or present at low concentrations upgradient/cross-gradient of the DVD when these other constituents are elevated, suggesting that legacy agricultural byproducts could have migrated north of Thompson Road before DVD discharges began resulting in the concentration distribution observed in this area today. For example, MW-112S located east of the DVD (east of Summerset Road) on Alcudia Road (and unaffected by DVD discharges) has a TDS concentration of 1,340 mg/L, chloride of 277 mg/L, and sulfate of 538 mg/L – all exceeding SMCLs, but a nitrate (as nitrogen) concentration of only 3 mg/L. This example illustrates how legacy agricultural byproducts could have migrated north of Thompson Road before DVD discharges migrated northwards resulting in the distribution seen today, with TDS, chloride, and sulfate exceeding SMCLs a greater distance north than nitrate exceeding MCLs.

2. The consistency of farming at the DVD and vicinity has been documented since the 1950s. Groundwater extraction to support these farming operations would have captured some of the legacy agricultural byproducts preventing them from migrating into the north Hinkley Valley, and reduced the groundwater gradient north of Thompson Road generally consistent with the capture created by PG&E's remedial extraction today.

3. TDS exceeds the Prosecution Team's adjusted concentration of 700 mg/L for defining affected domestic wells in some wells of the north Hinkley Valley that cannot be linked to DVD discharges. This includes numerous domestic wells located west and northwest (cross-gradient) of the affected area and proposed expansion to the affected area. TDS concentrations at these wells may be related to septic systems, the arid environment, or legacy agricultural operations before the DVD began operations or other sources. These data show that a TDS concentration of 700 mg/L measured within the affected or proposed affected area in the north Hinkley Valley may not be associated with DVD discharges.

4. The evaporative signature of the many decades of groundwater extraction and irrigation is expressed as a "heavy" isotopic signature by the stable isotopes of oxygen and deuterium in monitoring wells located on and south of Thompson Road in the central and eastern Hinkley Valley. Conversely, this "heavy" isotopic signature does not extend north of Thompson Road and nitrate concentrations quickly attenuate to levels below the MCL. The "light" isotopic signature north of Thompson Road supports the hypothesis that mostly legacy agricultural activities (pre 1980s) have affected groundwater north of Thompson Road (with a likely "lighter" isotopic signature being present in groundwater during earlier 1940s to 1980s agricultural operations), and that limited movement of DVD discharges north of Thompson Road has occurred. By the 1980s when DVD dairy operations began, the Hinkley Valley

had been farmed for 40 or more years so an evaporative signature would likely have been expressed in groundwater at the DVD by this time making stable isotopes a reasonable tracer of DVD discharges when combined with other lines of evidence discussed above. Therefore, DVD discharges would be expected to contain a “heavy” isotopic signature, and DVD discharges may be limited in northern extent to the vicinity of Thompson Road.

Figures (Exhibit 2)

Figure 1. Potential Source Areas Desert View Dairy

Figure 2. Hinkley Area Nitrate Data Summary and Distribution through Fourth Quarter 2013

Figure 3. 1952 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 4. 1954 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 5. 1956 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 6. 1963 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 7. 1968 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 8. 1970 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 9. 1971 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 10. 1984 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 11. 1989 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 12. 1994 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 13. 2002 Aerial Photograph. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 14. Land Use in the Hinkley Valley 1953, 1970 and 1989. Preliminary Conceptual Site Model for Groundwater Flow and the Occurrence of Chromium in Groundwater of the Hinkley Valley

Figure 15. Estimated and Actual Pumping Rates from 1952 through March 2013. Preliminary Conceptual Site Model for Groundwater Flow and the Occurrence of Chromium in Groundwater of the Hinkley Valley

Figure 16. Interpolated, Estimated and Actual Pumping Rates from 1952 through March 2013. Preliminary Conceptual Site Model for Groundwater Flow and the Occurrence of Chromium in Groundwater of the Hinkley Valley

Figure 17. Groundwater Elevation Contours in the Shallow Zone of the Upper Aquifer, South Hinkley Valley, Second Quarter 2016. Second Quarter 2016 Monitoring Report and Domestic Well Sampling Results

Figure 18. Groundwater Elevations in Shallow Zone of the Upper Aquifer April 2016. Second Quarter 2016. Second Quarter 2016 Hydraulic Capture Monitoring Report

Figure 19. Groundwater Elevations in Shallow Zone of the Upper Aquifer May 2016. Second Quarter 2016. Second Quarter 2016 Hydraulic Capture Monitoring Report

Figure 20. Groundwater Elevations in Shallow Zone of the Upper Aquifer June 2016. Second Quarter 2016. Second Quarter 2016 Hydraulic Capture Monitoring Report

Figure 21. Groundwater Elevation Contours in the Upper Aquifer, North Hinkley Valley and Water Valley, Second Quarter 2016. Second Quarter 2016 Groundwater Monitoring Report and Domestic Well Results Site-Wide Groundwater Monitoring Program

Figure 22. Model Prediction for Movement of Groundwater from Existing 10 mg/L-N Nitrate Areas, Shallow Zone of Upper Aquifer, 10 Years, without PGE Pumping (2014 through 2023)

Figure 23. Model Prediction for Movement of Groundwater from Existing 500 mg/LTDS Areas, Shallow Zone of Upper Aquifer, 10 Years, without PGE Pumping (2014 through 2023)

Figure 24. Groundwater Elevation Contours in Upper and Lower Aquifers, Winter 1958-1959. Preliminary Conceptual Site Model for Groundwater Flow and the Occurrence of Chromium in Groundwater of the Hinkley Valley

Figure 25. Total Dissolved Solids Concentrations for Selected Monitoring and Domestic Wells

Figure 26. Site-Wide Distribution of TDS in Shallow Zone of Upper Aquifer. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 27. TDS Concentrations in Shallow Zone of the Upper Aquifer, Most Recent Sample Result in 2011 through 2015

Figure 28. TDS Concentrations in Deep Zone of the Upper Aquifer, Most Recent Sample Result in 2011 through 2015

Figure 29. Dissolved Chloride for Selected Monitoring and Domestic Wells

Figure 30. Dissolved Sulfate for Selected Monitoring and Domestic Wells

Figure 31. Nitrate as Nitrogen for Selected Monitoring and Domestic Wells

Figure 32. Site-Wide Distribution of Nitrate (as Nitrogen) in Shallow Zone of Upper Aquifer. Agricultural Treatment Byproducts Investigation Report for Environmental Impact Report Mitigation Measure WTR-MM-5

Figure 33. Nitrate (as Nitrogen) Concentrations in Shallow Zone of the Upper Aquifer, Most Recent Sample Result 2011 through 2015

Figure 34. Nitrate (as Nitrogen) Concentrations in Deep Zone of the Upper Aquifer, Most Recent Sample Result 2011 through 2015

Figure 35. Distribution of Stable Isotopes of Oxygen and Deuterium. Preliminary Conceptual Site Model for Groundwater Flow and the Occurrence of Chromium in Groundwater of the Hinkley Valley

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