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

22 October 2007

Mr. Steve Slaten
NASA Management Office – JPL
M/S 180-801
4800 Oak Grove Drive
Pasadena, CA 91109

Dear Mr. Slaten:

Enclosed are the comments of the U.S. Environmental Protection Agency to the National Aeronautics and Space Administration (NASA), Jet Propulsion Laboratory (JPL) - EPA ID #CA9800013030, Technical Memorandum: Additional Investigation Results.

If you have any questions please give me a call at (415) 972-3032.

Sincerely,

Lewis Mitani
Remedial Project Manager

Enclosure

cc: Mr. Michael Iskarous, CAL-EPA
Mr. Mohammad Zaidi, LA RWQCB
Mr. Bill Mabey, TLI

REVIEW OF TECHNICAL MEMORANDUM: ADDITIONAL INVESTIGATION RESULTS JANUARY 2007

GENERAL COMMENTS

The Technical Memorandum: Additional Investigation Results (TM/AIR) presents four lines of evidence that the perchlorate in groundwater in the downgradient Sunset Reservoir is not derived from the JPL site. The four lines of evidence are presented as follows:

- ✓ Groundwater Modeling
- ✓ Groundwater Geochemistry
- ✓ Groundwater Chemical Concentration Data
- ✓ Perchlorate Isotope Data

Together, the lines of evidence are interpreted in the TM/AIR to demonstrate that the perchlorate found in the downgradient wells does not originate from the JPL site. However, it is also important to recognize that none of the lines of evidence identify a specific, or even a major, source of perchlorate to these supply wells. The several lines of evidence do show an obvious complex pattern of the mixing of waters in the basin from both natural and anthropogenic sources. The following comments on the TM/AIR are provided to assist in ongoing discussions of whether JPL may have contributed perchlorate to the Sunset wells.

COMMENTS ON GROUNDWATER MODELING

1. The TM/AIR does not specifically discuss why the results of this groundwater modeling effort differ from information presented in the Final Operable Unit 3 Remedial Investigation RI Addendum Work Plan, Battelle 2004 (OU 3 RI Addendum WP). The OU 3 RI Addendum WP indicate that the Coupled Flow and Energy Solute Transport model was used to simulate groundwater flow in the Raymond Basin and that potential groundwater migration pathways and particle tracking from near the Arroyo Seco Spreading Grounds was performed for the period from 1989 to 2023. The simulation results found a flow path from the Arroyo Seco Spreading basins and the unsewered La Canada-Flintridge area towards the City of Pasadena production wells located near the Sunset Reservoir. However, the Tech Memo states that particle tracking indicates that groundwater originating to the west of JPL in La Canada Flintridge flows south of the JPL facility and then heads toward the Sunset Reservoir Wells. It is unclear why these two model results would differ and the Tech Memo does not provide an explanation. Please explain why these two models differ in their results.

2. As a general observation, it is unclear from the TM/AIR whether the model has been applied in a way that is specific enough to address the objective of an almost absolute capture of perchlorate originating from the JPL site. The objective(s) and the assumptions of the model used to predict capture are not described. For example, if the model

objective and assumptions were to predict the capture zones of the future pumping, it is not appropriate to make conclusions about the past capture zones of the same wells, especially if the pumping history of the wells is different. Please describe the model objective(s) and model assumptions regarding the pumping history, scale of the model, and the geohydrologic and other features that support an adequate capture zone analysis has been conducted. The comments below address some of these issues.

3. The RBMB model is a two layer regional model, and the JPL model is a more localized site model consisting of four layers. Figures 2, 3, and 4 show particle tracking simulation results. Considering the existence of the vertical hydraulic gradient, the particle paths would look different for each layer. The composite paths shown in Figures 2, 3, and 4 are then not sufficient to describe the three-dimensional nature of the particle paths. Please show the information for each layer rather than as a composite. Please show the particle paths in cross-section as well as forward paths originating at JPL.

4. A closer view of Figures 3 and 4 does not support the TM/AIR conclusion that the flow fields of the RBMB and JPL Models are "very similar." Considering the size of the grids, the number of layers, etc., it is not surprising that the results of the two models would be different. It is important to realize that we are not looking at the whole model domain, but rather a small (JPL) area within the large model domain. Please elaborate on how the two models can be regarded as similar when the grid sizes and layers are different.

5. The JPL model uses the average extraction rates observed between 1960 and 2000. The production wells "Arroyo Well" and "Well 52" are listed as the most important wells. However, these two wells were not operating for five years (1985-1990). It is not clear whether there are other periods when the wells were not operational, but the five-year period was mentioned as the "longest period" when the wells (and two other wells) were not pumping. Please also explain the basis for the statement that "...the chemicals would have been drawn back upon reinitiating operation of these wells..." (Page 11, first paragraph.) Each production well has a stagnation point downgradient from the well. If the well is shut down for some duration and the contaminant passes the stagnation point, restarting the well (assuming the same pumping rate and the same regional flow) will not recapture the escaped contaminant.

6. The TM/AIR does not adequately discuss the perchlorate detections in MW-25 in the context of why these additional monitoring wells were proposed in the OU 3 RI Addendum Work Plan. The OU 3 RI Addendum proposed installing MW-25 and MW026 to verify the location of the leading edge of the JPL perchlorate plume and discusses that these monitoring wells were specifically located between MW-20 and the Sunset Reservoir Wells to verify that the leading edge of the plume had traveled beyond the MW-20 location. Subsequently, the purpose of the TM/AIR appears to have changed from specifically verifying the location of the leading edge of the plume to a discussion of other perchlorate sources. Please discuss if the leading edge of the perchlorate plume was established.

7. The TM/AIR does not discuss the potential impact of the top of bedrock and its relationship to the perchlorate detections in MW-25 as well as the Sunset Reservoir wells. Perchlorate is detected at depth at the MW-25 location consistent with depths to bedrock in MW-19. Please provide a discussion of the potential for perchlorate to enter bedrock and then migrate toward the Sunset Reservoir Wells.

8. The assumption that groundwater contamination is contained by wells in the Monk Hill Subarea appears to be based on recent and current groundwater extraction rates and information rather than on historical conditions. In addition, although the text indicates that there were no periods "since the early 1940s of sustained shutdown of all of these Monk Hill Subarea wells," shutdown or intermittent operation of one or more wells may have allowed migration of perchlorate beyond the Monk Hill Subarea. In addition, it is likely that these water supply wells extracted water from the deeper portions of the aquifer, so perchlorate contamination may have migrated in the shallower layers. Further, historical pumping rates may have been less than current pumping rates; Table 2-1 of the OU 3 RI Addendum WP indicates that the maximum extraction rate in several of the wells occurred in the 1960s, 1990s or in 2000. Since many of the wells apparently pumped at lower rates in the 1940s and 1950s, it is likely that "containment" of the perchlorate plume was not achieved. Statements about containment of the perchlorate plume should either be deleted from the text or modified to specify the period of years to which the conclusion applies. In addition, historical low extraction rates could be used in the model to evaluate the potential that perchlorate migrated beyond the Monk Hill Subarea.

9. There are only a few wells in the area between JPL and the Sunset Reservoir Area, so this area cannot be considered well characterized and the potential for preferential migration pathways should be considered. Preferential migration pathways or channels are common in the depositional environments that resulted in the subsurface lithology between JPL and the Sunset Reservoir Area. These preferential migration pathways may have facilitated perchlorate migration to the Sunset Reservoir Area. The text should be revised to acknowledge this possibility.

10. The following statements in the TM/AIR are of concern for the accuracy of the results of the model, and should be addressed in any future modeling efforts.

    - Page 6, paragraph 2: "... vertical hydraulic head differences with depth are observed... this indicates that the aquifer does not exhibit truly unconfined conditions..." Please recognize that the existence of the vertical hydraulic gradient alone does not indicate whether the aquifer is confined or unconfined.

    - Page 6, paragraph 5: "...groundwater elevations have fluctuated up to 75 ft each year beneath JPL..." Such large water table fluctuations indicate strong transient conditions at the site. Any steady-state model that represents some "average conditions" in the future would be less reliable because of the fluctuations.

- Page 7, paragraph 1: "...as part of the steady-state model development, a transient model was constructed using data from 1996-2000." If the water levels at the Site fluctuated up to 75 ft, it needs to be clarified how the transient model calibration is similar to the steady-state model calibration.

COMMENTS ON GROUNDWATER GEOCHEMISTRY

1. This section provides a thorough discussion of the groundwater types, water imports, likely anthropogenic sources of constituents - including perchlorate - to groundwater, and an interpretation of how the general water quality has been impacted by such sources. While the section does present information suggesting that significant amounts of perchlorate in imported water reasonably were introduced into the Raymond basin by the Metropolitan Water District (MWD) distribution system, there is no information that assists in evaluating the respective contributions of perchlorate from various sources (MWD, JPL, fertilizer applications, etc.)

COMMENTS ON GROUNDWATER CHEMICAL CONCENTRATION DATA

1. The analysis that carbon tetrachloride is a reliable tracer for perchlorate originating from JPL is not a valid assumption for several reasons. One reason is that monitoring data indicate that the groundwater concentrations of perchlorate are typically higher than the carbon tetrachloride concentrations, and therefore simple dilution due only to advective flow and dispersion should result in carbon tetrachloride reaching non-detectable concentrations before perchlorate would similarly become nondetect.

2. The use of carbon tetrachloride (an organic compound) as a reliable tracer is also difficult to support because it can undergo transformation reactions whereas perchlorate (an inorganic ion) is more stable. As a measure of the ease of reduction of carbon tetrachloride, its reduction/oxidation half-reaction potential is relatively high, between that of denitrification (nitrate reduction to nitrogen) and reduction of tetrachloroethene (PCE, to trichloroethene.) Furthermore, the environmental literature has several citations of transformations of carbon tetrachloride by microbial processes and chemical processes (abiotic reactions); the latter processes are a result of residual effects of microbial processes that create chemical conditions (mineral surfaces, sulfides) where carbon tetrachloride is subsequently transformed (reduction reactions.) In the expected predominate aerobic subsurface it is expected that such reducing conditions will be present but sporadic, and probably due to localized leaching of constituents with infiltrating surface waters (maintenance, landscaping, irrigation, etc.); the sporadic presence and very low concentrations of such reactant systems and possible transformation products obviously makes the identifications of such adventitious processes almost impossible.

3. In summary, it is plausible to qualitatively consider carbon tetrachloride as a tracer for perchlorate originating from the JPL site as long as both constituents are detected in the groundwater sampling program, but the absence of carbon tetrachloride in a groundwater

sample cannot be the basis for the conclusion that perchlorate in the sample is not from the JPL site.

COMMENTS ON PERCHLORATE ISOTOPE DATA

1. The conclusion that the isotopic signature of perchlorate samples collected from the downgradient wells is different from the signature of perchlorate at the JPL site and therefore that JPL is not a source of perchlorate does not adequately take into consideration that the measurements on the downgradient water samples are possibly a composite from several sources of perchlorate to the Raymond basin. The TM/AIR does make a persuasive case that several sources are reasonably suspect, and that there may be other sources of perchlorate that cannot be identified. The complexity of the multiple sources, as well as the unknown contribution of these sources, does not eliminate JPL as one possible contributor of perchlorate to the downgradient wells based on the isotopic data alone.

   Review of the perchlorate isotope data indicate several uncertainties that confound an interpretation of the data that could be applied in source allocation. As discussed in the TM/AIR, the most reasonable suspected sources of perchlorate to the downgradient wells are the JPL, Colorado River water, and fertilizer perchlorate (dark blue diamonds in yellow shaded area, light blue circles, and orange squares, respectively, on Figures 16 and 17.) However, there is significant scatter of the isotopic signatures of samples from each suspected source which has been attributed to different batches of the source perchlorate. Additionally, the perchlorate samples from the multilevel well MW-25, show no clear trends that can be interpreted as hydrostratigraphic zones that have been impacted by discrete sources. For example, the isotopic signature of the shallowest sample (MW-25-1) most closely resembles the JPL source perchlorate, which would be expected to be at greater depths from a further upgradient source. Additionally, the isotopic signatures of the samples from the intermediate depths, MW-25-2 and MW-25-3, appear to resemble the Colorado River water samples in the $^{37}Cl/^{18}O$ plot (Figure 16), but the same two samples are the most anomalous in the $^{17}O/^{18}O$ plot.

   While, the perchlorate isotope data does not support a conclusion the perchlorate in the downgradient wells is solely due to JPL as the source. The data also does not eliminate JPL as a contributing source of perchlorate to the downgradient wells in an obviously complex geohydrologic system with several possible sources of perchlorate.