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8 April 2016

Melanie Morash
Remedial Project Manager
U.S. Environmental Protection Agency
Region 9
75 Hawthorne Street (SFD-7-1)
San Francisco, CA 94105

RE: EPA Comments - Treatability Study for Bioremediation
Philips Site - 811 Arques Avenue, Sunnyvale, CA

Dear Ms. Morash:

This letter is submitted on behalf of Philips Semiconductors, Inc. (Philips) in response to the comments received on January 15 and March 9 of 2016 with regard to the Enhanced Bioremediation Treatability Study Workplan submitted to EPA on January 7, 2016.

Written responses to Preliminary, General, and Specific Comments are provided below.

<u>EPA Preliminary Comments</u>

1. Page 13 – Change “upon approval by Regional Board” to EPA approval

   Response: Text has been revised as suggested.

2. Page 17 – Change “Submitted to Regional Board” to EPA submittal

   Response: Text has been revised as suggested.

3. Page 17 – Community Relations – Update to reflect that Locus/Philips will participate in any additional outreach activities developed by EPA, such as review of fact sheet material or providing information for updates at community meetings regarding the groundwater treatability study activities.

   Response: Text has been updated with suggested information.

4. Please develop and provide EPA with a Quality Assurance Project Plan (QAPP) or an equivalent Quality Assurance/Quality Control (QA/QC) plan, for review and approval by EPA’s Quality Assurance (QA) Office.

Response: A QAPP for the Treatability Study is submitted with the updated work plan.

5. Please develop and provide EPA with a Health and Safety Plan (HASP) for implementation of this Treatability Study Work Plan.

   Response: A document titled *Health and Safety Plan - Field Work Activities for Operation and Maintenance* was submitted on 23 March 2016, which includes health and safety considerations for bioremediation projects.

6. Please prepare a methane contingency plan. See, for example, the 2013 Annual Methane Mitigation System Performance Report, for the Teledyne/Spectra-Physics enhanced reductive dechlorination (ERD) groundwater treatability study, available at: http://geotracker.waterboards.ca.gov/profile_report.asp?global_id=SL721281224

   At this site, soil gas monitoring was initially implemented as part of an emergency response when ERD activities began, in response to elevated methane concentrations above 10% of the lower explosive limit (LEL) detected in soil vapor along the property boundary (adjacent to the nearby residential neighborhood).

   A methane mitigation system and long-term soil gas monitoring plan was then developed and implemented to detect changes in the concentration of volatile organic compounds (VOCs) and methane in soil vapor that typically occur due to the strongly reducing conditions present during the active period of ERD.

   The objective of the methane mitigation system, which includes a total of 20 soil vapor extraction (SVE) wells, is to reduce methane concentrations in soil gas along the property boundary.

   Response: Given the proposed substrate and the addition of an iron-containing emulsion, it is expected that methane production will be minimal. Treatability study findings will determine whether that is the case. Given the proximity of existing buildings to the treatability study area, there appears to be no immediate risk to surrounding buildings as a result of excess methane production, if observed, within the treatability study area.

   The work plan already includes methane in the analytical suite for pre-and post-injection well sampling. Post-injection sampling is proposed monthly for the first three months, then quarterly for three more periods. Based on analytical results, screening levels and actions have been included as a part of the Treatability Study. Refer to Section 3.3.1. If excess methane generation is found to be a concern during the treatability study, a methane contingency plan may be prepared.

EPA General Comments

1. A brief description of the geology and hydrogeology at the proposed enhanced anaerobic bioremediation (EAB) treatment area is necessary for the workplan (WP) evaluation. Details on groundwater zones A, B1, B2, and B3, treatment area extraction/monitoring well screen intervals, and depth to groundwater data should be included so that EPA can fully evaluate the treatment design.

   Response: An additional section has been included in the report describing the geology and hydrogeology of the "A" groundwater aquifer. The deeper aquifers are outside the scope of this treatability study. Relevant groundwater elevation data can be found in Figure 15 for the "A" aquifer. Screen intervals of the monitoring wells are detailed on the construction diagrams in Appendix A of the Work Plan.

2. A description of the extraction trench near the former source area north of the 811 Arques Building (811T) is absent from the WP. The design details are required to evaluate usage of the trench as a substrate delivery conduit into the targeted area of the aquifer.

   Response: The trench will no longer be used as a substrate delivery conduit. Therefore, no change was made.

3. As presented, the treatability study does not appear adequate to significantly reduce trichloroethene (TCE) mass in the entire source area, and it does not appear that the study will provide a significant reduction of TCE flux downgradient. A corresponding reduction in the vapor intrusion risk for the downgradient area is not expected from the scope of the WP as currently presented. A larger treatment/study area is needed, with coverage by a triangular grid of injection points, including locations downgradient of well S049A.

   Response: The scope of this treatability study is limited to the study of the effectiveness of the reagents and bioaugmentation culture to reduce VOC mass within the boundaries described in Section 3. An extended remedial scope will be considered for a full-scale implementation of the system pending treatability study findings. Therefore, no change has been made.

4. Figures 3 through 14 present groundwater contaminant contours in zones, A, B1, B2, and B3 for the fourth quarter of 2014. The WP fails to address within which aquifer the treatment is being evaluated.

Response: The treatability study addresses the source within the "A" Aquifer. The objective has been clarified in Section 3.1.

5. The zone B1 aquifer within the source area does not appear to be a focus of the treatment, as wells S141B1 and S153B1 are not included in the study. If there is no vapor intrusion impact or risk associated with the B1 aquifer contamination, the support data should be discussed in the WP. Otherwise, substrate and microbial culture injections into the zone B1 aquifer should be included in the study.

   Response: The scope of this treatability study is limited to the study of the effectiveness of the reagents and bioaugmentation culture to reduce VOC mass within the "A" aquifer. Mitigation of the entire site will be addressed in a full-scale implementation, pending treatability study findings. Therefore, no change has been made.

6. The overall injection design needs to be clarified and detailed. Injection locations are unclear and conflicting throughout the WP. The proposed locations should be presented on a figure with TCE concentration contours to show the study treatment area relative to the source area.

   Response: Figure 17 has been revised to illustrate the locations of the injection points, and the injection design is described in greater detail in Section 3.

7. The injection technology and details are not clearly stated. EPA suggests direct-push technology (DPT) injection of the substrate, microbes, and other materials. DPT allows for an effective surface seal and pressurized injections to achieve a greater radius of influence at higher flowrates in less time as compared to well injections.

   Response: DPT injection methods are proposed for this treatability study. Methods and procedures have been revised to include more detail in Section 3.

<u>Specific Comments</u>

1. The acronym "EAB" and its definition, "In situ enhanced anaerobic bioremediation," should be added to the acronym list.

   Response: Acronym has been included in the list of acronyms.

2. Figure 1 is not referenced in the text.

   Response: Figure is now reference in Section 1.1

3. Tables 1 through 3 are not referenced in the text.

   Response: Unreferenced tables have been removed from list.

4. Freon 113 should be introduced by the chemical name, 1,1,2-trichloro-1,2,2-trifluoroethane, with Freon 113 as the acronym.

   Response: Freon 113 is now introduced by chemical name in Section 1.1.

5. Page 2, Section 1.2, second paragraph: Reference should be to volatile organic compound (VOC) mass reduction or mass removal, not VOC concentration reduction.

   Response: Paragraph has been revised per suggestion.

6. Page 2, second paragraph, first sentence: The existing remedial system is referenced but not described. Some brief description should be provided.

   Response: A brief description of the remedial system has been included in Section 1.2.

7. Page 3, Section 2.1, first sentence: The term should be revised from “less harmful by-products,” to “environmentally non-toxic by-products,” which more accurately describes the goal of the EAB application.

   Response: Text has been changed as suggested.

8. Page 5, Section 2.2, second paragraph:
   a) Third sentence: The statement that bioaugmentation will be incorporated to ensure that the subsurface microbial population remains adequate should be revised to state that bioaugmentation will be applied because baseline microbial populations are inadequate to support complete reductive dechlorination, as evidenced by the absence of ethene and low Dehalococcoides bacteria (DHC) populations (Table 4). Although present, the DHC concentrations should be augmented to the order of $5x10^6$ to $1x10^7$ cells per liter.

   Response: Sentence has been revised to clarify objective.

   b) The anaerobic biodegradation of Freon 113 should be evaluated separately from the proposed abiotic zero valent iron (ZVI) treatment. The proposed TCI-DC™ culture is a consortium of microorganisms that are suited for the simultaneous reduction of chlorinated ethenes and similar organic compounds, including Freon 113. The abiotic ZVI treatment to address the Freon 113 may not be necessary.

Response: ZVI will be applied to one portion of the treatability study area with elevated Freon 113 concentrations (Figure 5). If the degradation rates in the ZVI amended region (SW treatment area) are not significantly superior to degradation rates in the area treated only with SRS-SD/TCI (SE treatment area) then SRS-Z will not be considered for full scale application.

9. Page 6, Section 2.2, first paragraph: The general description of the injection process should detail the volume and composition of the injectate. These details are required to ensure that a sufficient substrate is added to create optimal reductive dechlorination conditions, but not result in significant aquifer displacement during injection.

   Response: Section 3.2 has been revised to include details of the injection process.

10. Page 6, Section 2.2, first sentence: The sentence should be revised. Pressure plays a factor in the potential mobilization of the contaminants, but bigger factors are the volume of injectate, and the injected substrate, especially oils, which dissolves chlorinated ethenes from soil matrix. The injectate volume has the potential to spread the plume, and the dissolution into the substrate has the potential to temporarily cause an increase in VOC concentrations. VOC desorption from soil is a positive process for the overall EAB effectiveness to enhance the surface area and microbial access to the chlorinated ethenes, thus leading to faster reductive dechlorination and contaminant mass reduction.

    Response: The paragraph has been expanded to include suggested details.

11. Page 6, Section 2.2, last sentence: The statement that the “rebound potential for EAB is lower than for some other remedial actions” is not necessarily true, and the statement that the “bacteria will grow correspondingly to counteract the increasing concentrations for more long-term control” is not correct. The rebound potential with EAB is tied to maintaining the optimal conditions for reductive dechlorination, which includes the presence of sufficient organic carbon, low dissolved oxygen, negative oxidation reduction potential, and near neutral pH. If the optimal conditions are not maintained, the necessary microorganisms will die, and rebound can be substantial. Rebound can only be addressed by restoring optimal conditions. Bioaugmentation may not be necessary, but degradation will be delayed until microbial populations are re-established.

    Response: The paragraph has been expanded to include suggested details.

12. Page 6, Section 2.3, second paragraph, first sentence: The section states that “The substrate and microbial cultures would be injected into the subsurface using existing monitoring/extraction wells and extraction trench, thus eliminating the

need for additional drilling activities during the treatability study." However, the next sentence states that a temporary boring is to be used to inject ZVI substrate. This contradiction needs to be clarified.

Response: The text has been revised to clarify injection locations.

13. Page 7, Section 2.5.1: This section states that "although the presence of sulfate is unlikely to completely inhibit the reduction of the target chlorinated compounds, the rate of dechlorination may be reduced." Rapid reductive dechlorination of chlorinated ethenes occurs when sulfate-reducing conditions are present. The statement should be revised to express that the sulfate concentrations in site groundwater are not excessively high and are not prohibitive for the reductive dechlorination of chlorinated ethenes.

    Response: The text has been revised as suggested.

14. Page 7, Section 2.5.2: As referenced, the proposed bioaugmentation culture TCI-DC™ is capable of degrading Freon 113. A performance comparison of Freon 113 degradation rates at locations of TCI-DC™ injection and SRS®-Z (ZVI) injection should be made.

    Response: Performance evaluations are identified in Section 3.1 and include the recommended performance comparison.

15. Page 8, second paragraph: The paragraph only discusses DHC concentrations. Suggest introducing a new section here, Section 2.5.3, entitled, "DHC Concentrations."

    Response: Section heading added as suggested.

16. Page 8, second paragraph, last sentence: Bioaugmentation is not conducted to ensure a "target microbial concentration." Bioaugmentation is necessary because of less than optimal DHC concentrations in groundwater, and no complete transformation to ethene detected in groundwater samples. DNA (deoxyribonucleic acid) analysis does not distinguish between live and dead bacteria. Moreover, not all DHC strains are capable of complete reductive dechlorination of TCE to ethene (special analysis needs to be done to check for DHC stains). TCI-DC™ culture is proven to contain the DHC strain capable of complete reductive dechlorination of chlorinated ethenes.

    Response: The text has been revised to clarify the objective.

17. Page 8, Section 2.6: A reference to SRS®-SD distribution in relatively low permeability conditions as far as 35 feet from an injection point was made. Substrate may sometimes be observed at locations 30 to 40 feet away from the injection point due to channeling in tight aquifers, and thus is not an indication of effective distribution. A 15-foot radius of distribution is more realistic for the DPT injection of an oil-based substrate. Again, a discussion of the site hydrogeology is necessary to assess soil permeability conditions.

    Response: Refer to revisions inSection 1.2 for a description of site hydrogeology. The subject paragraph has been modified to include a commonly observed radius of influence in locations with similar hydrogeological conditions.

18. Page 10, Section 3.1, last sentence: Suggest a change from “former source area” to “source area.. The source area plume may be reduced, but the source area does not change.

    Response: The text has been revised as suggested.

19. Page 10, Section 3.2, second paragraph: This section states that “direct push injection of SRS®-SD and TSI DC Bioaugmentation Culture into three injection wells is recommended to enhance the distribution of the amendments and cost effectiveness of the treatability study (refer to Figure 17).” If the three existing wells are to be used for the injection, to what does the reference to direct push imply?

    Response: The text has been revised to more clearly state that injections will be introduced via direct push injection over temporary injection boreholes.

20. Page 11, Section 3.2.1.2: This section states that “prior [to] implementation, well permit(s) (for turning an extraction well into an injection well)” will be obtained, which is reiterated in the section. Please clarify the method of injection throughout and add “to” to the referenced statement.

    Response: Well construction permits will not likely be required, but the SCVWD may interpret the injection points as temporary injection wells. The text has been revised for clarification.

21. Page 12, Section 3.2.1.3, last sentence: Suggest a change from “maintain downgradient capture of the source area,” to “maintain capture of the downgradient plume.”

    Response: The text has been revised as suggested.

22. Page 12, Section 3.2.2, first paragraph: This section states the "substrate SRS®-SD and TSI DC Bioaugmentation Culture will be delivered via direct push into three injection points located 10 feet upgradient of each of the extraction wells, S146A, S138A, and S139A." DPT well points will be used, which contradicts earlier statements that no new wells will be installed.

    Response: Substrates will be administered via DPT well points. Text has been revised to more clearly state the injection process.

23. Section 3.2.2.1: The substrate injection procedure provided is not sufficient for evaluation or field implementation. At a minimum the following should be presented:
    a) Injection point locations on a scaled figure.

    Response: Figure 17 now exhibits proposed injection locations.

    b) Target injection interval—Tables 6 and 7 suggest that the saturated thickness in the treatment area is approximately 20 feet. Assuming the entire saturated zone is the target treatment interval, injections into existing wells or via DPT point cannot effectively be performed over the entire 20-foot thickness in one application. The substrate will find a path of least resistance, and not distribute evenly through the interval. Several injection intervals will need to be distributed over the target injection interval. The injection screen length, sequence (bottom-up, top-down), and sealing methods if the injections are applied to a single well screened over the entire saturated thickness should be discussed.

    Response: Section 3.2.2.1 has been revised to include the details requested.

    c) The amount of substrate, make-up water, and microbial culture should be specified for each injection location. Each injection interval should be specified and the details on how the injections will be monitored.

    Response: Section 3.2.2.1 has been revised to include the details requested.

    d) Make-up water preparation discussion. A description of how the hydrant water will be pretreated to create reducing conditions and remove any disinfectants.

    Response: Section 3.2.2.1 has been revised to include the suggested elements.

    e) Provide injection event sequence. Simultaneous injection into three locations may not be possible.

    Response: Section 3.2.2.1 has been revised to include the suggested elements

f) Provide action triggers (pressure, flowrate, time, etc.) for field personnel to allow for efficient progress.

Response: Section 3.2.2.2 has been revised to include the suggested elements.

g) Address the possible surfacing of solution during injection and the ways to combat it.

Response: Section 3.2.2.2 has been revised to include the suggested elements.

h) If the injections are performed by DPT, detail the completion of the injection borings.

Response: Section 3.2.2.1 has been revised to detail the injection process.

24. Page 13, last bullet: The last bullet states that SRS-Z will be injected into the two locations, spaced 10 feet apart. This statement contradicts the earlier statement in Section 2.3, where the ZVI was to be injected into one location.

    Response: SRS-Z will be injected into two locations, the text has been revised for consistency.

25. Section 3.2.2.1: No procedural details are provided for the injections into the 811 Arques Building extraction trench. The use of a trench for substrate delivery, especially oil-based substrate, is not recommended for effective substrate distribution. The substrate will mix with groundwater, but should not be expected to penetrate deeper than the surface layer of soil outside the trench. The trench will likely become fouled with bacterial growth, and fermentation gases may become an issue within the trench.

    Response: The trench will no longer be used as a substrate conduit. Section 3.2.2.1 has been revised to include details of the treatment area design.

26. Section 3.2.2.1: The field-data collection needs to be discussed in more detail, for example, how will the effective radius of influence of the injections be measured? This is a key factor for the potential scale-up of the EAB technology.

    Response: Section has been updated with a description of breakthrough detection methods during and post injection. The proposed methods will assist in determining the radius of influence and/or substrate channeling.

27. Section 3.3, Analysis Table: A column should be added to specify the use for a given analysis and how the data will be evaluated. The list provided is suitable for a monitored natural attenuation evaluation, but may be more extensive than necessary for a treatability study evaluating the EAB with the direct injection of

organic carbon and microbial culture. Background chloride concentrations may greatly exceed any measured changes due to EAB. Ferrous iron analysis is not included in the table but it is recommended to check for iron-reducing conditions

Response: Sampling suite has been updated to only include parameters that are suitable for the evaluation of this treatability study. Data use and data interpretation is now described for each sampling parameter in Section 3.3.

28. Page 15, Section 3.3, first paragraph: The injection points and wells that will be used for the EAB treatability study should be identified on a figure and referenced in the text of this section. The first sentence states that wells S049A, S138A, S137A, S139A, and S141A will be sampled to establish baseline conditions. A statement should be added that references the use of these same wells for performance monitoring. It is unclear why well S146A is not also designated for sampling, since Section 3.2.2.1 states the three injection points will be upgradient of this well and wells S138A and S139A. In addition, the statement "following the injection, geochemical parameters and VOCs will be sampled for the first three months" does not specify sampling frequency within the first 3 months. Please add details and clarifications to this section.

    Response: Monitoring wells are now identified in the first paragraph of this section. Well S146A was erroneously missing from list of monitoring wells. The text was updated to clarify sampling locations and sampling intervals.

29. Tables 6: Parameters important for the EAB, such as pH, dissolved oxygen, and oxidation reduction potential are mentioned in table as averaged/estimated values. These parameters should be provided for each monitoring well within and near the treatability study area, as a means of monitoring EAB performance.

    Response: pH in Table 6 (now Table 3) is not an estimated value; it is based on measured treatment system effluent. The sampling and analysis plan includes measurement of pH, dissolved oxygen, and oxidation reduction potential, in addition to other relevant field measurements. Therefore, no change has been made.

If you have any questions regarding this correspondence, please call me at (415) 799-9937.

Sincerely,

J. Wesley Hawthorne, P.E., P.G.
Senior Vice President

JWH/njl

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