California Regional Water Quality Control Board

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ENHANCED IN SITU BIOREMEDIATION, 1,2-DICHLOROETHANE SOURCE AREA, ADMINISTRATION AREA PLUME, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA), CROWS LANDING FLIGHT FACILITY, CROWS LANDING, CALIFORNIA, PROJECT PLANS

We have reviewed the *Enhanced In Situ Bioremediation, 1,2-Dichlorethane* (1,2-DCA) *Source Area, Administration Area Plume, NASA Crows Landing Flight Facility, Crows Landing, California, Project Plans* (Work Plan), received 31 October 2001. The Work Plan proposes the injection of a substrate material (Hydrogen Release Compound® or HRC®) at the 1,2-DCA source area of the Administration Area groundwater plume. The Work Plan proposes an up to twenty month long pilot study, to evaluate the effectiveness of adding a carbon and hydrogen source supplement to stimulate bacterial breakdown of chlorinated solvents. Carbon tetrachloride (CT), chloroform (CF), 1,2-DCA and 1,2-Dichloropropane (1,2-DCP) have previously been detected in the groundwater at the Administration Area Plume. The results of the pilot study may be used to determine the final remedy for the Administration Area Plume.

The Work Plan was prepared in response to a Board staff request for information needed to issue waste discharge requirements (WDRs) for injection of substrate into waters of the state. The Navy notified the Board, in a Time-Critical Removal Action (TCRA) Memo (Action Memo) received 20 August 2001, that they intended to inject substrate material into the aquifer to enhance biodegradation. The Navy stated that a TCRA was necessary because the Hydropunch™ groundwater sampling along Bell Road (site boundary) revealed that the groundwater contamination appeared to be nearer to Bell Road than previously estimated. Board staff disagreed with the TCRA rationale, and informed the Navy that WDRs were needed prior to injecting substrate. The Navy disagrees that WDRs are required, but agreed to provide the Board-requested additional information in the Work Plan.

General Comments

1. We have previously commented that there is insufficient evidence currently to support the proposed TCRA removal actions. We disagree with the Navy's rationale that since the groundwater plume was recently detected near the site boundary, substrate injection at the area(s) of highest concentration will minimize the potential for plume migration to adjacent properties. While we do not wish to minimize

the seriousness of discovering that the groundwater plume is near (less than 100 feet) the site boundary, we feel that pumping, at various locations (from groundwater hotspots with the highest concentrations and near Bell Road), and offsite treatment is appropriate for any groundwater removal actions.

2. We also raised concerns associated with the proposed substrate injections in our 17 September 2001 letter commenting on the Draft Feasibility Study. In that letter, we requested additional bench scale and pilot studies to assess the effectiveness of the substrate injection. Further, we indicated that WDRs would be necessary to conduct the pilot studies. In a Board Order dated 27 September 2001, we also required the following items in the Work Plan:

a. the chemical composition of the proposed substrate, and any anticipated transformation products,
b. the proposed concentration of all chemicals that may be injected into the aquifer,
c. a discussion of the background water quality and how the injected substrate is anticipated to affect it, including water quality parameters needed to monitor microbial degradation,
d. the method, locations, and duration of the injection,
e. the technical rationale and data supporting the feasibility of the proposed interim remedial action.

We have evaluated the Work Plan, to determine if all of the Board-required information is included and our concerns are adequately addressed. Our comments reflect the need for additional revisions to the Work Plan, to comply with the Board's Order.

3. The Board's Order also included a requirement for a detailed Contingency Plan that specifically addresses hydraulic control of the injected substrate and any degradation products, and removal of the injected substrate and restoration of the aquifer, if necessary. The Work Plan contains Section 3.5, Contingency Actions, which states that hydraulic control is not necessary, since there is no significant risk from the substrate and daughter products of the contaminants. The Work Plan continues that if adverse conditions do occur due to the substrate injection, then existing monitoring wells and new extraction wells will be pumped to remove the substrate. As a last resort, overdrilling of the injection points would be attempted. The Work Plan concludes that the removal of the substrate would require a separate Work Plan Addendum, which would not be developed until the problem is identified. The current Work Plan does not adequately address the Board Order requirement for a Contingency Plan. Our comments again reflect the need for additional revisions to the Work Plan, to comply with the Board's Order.

4. Laboratory analyses performed on the substrate products HRC®, lactic acid and molasses, show elevated levels of metals in excess of several Board Water Quality Objectives (WQOs). We are concerned that the injection of HRC®, lactic acid or molasses will violate State Water Resources Control Board (SWRCB) Resolution 68-16 and pose an unacceptable risk to water quality. Therefore, we cannot concur with the use of these substances as proposed in the Work Plan.

5. The Work Plan proposes a single passive injection test with twenty months of groundwater monitoring, to determine if biodegradation of the chlorinated solvents is feasible with the HRC® substrate injection. The groundwater flow rate at Crows Landing, at an estimated one foot per year, will severely limit the radius of influence from the injection points to the monitoring points five feet away. The Remediation Technologies Development Forum (RTDF) guidance[1] currently recommends an active pilot or remedial system, composed of a metered injection of the substrate, with extraction well(s) and

[1] "Accelerated Bioremediation of Chlorinated Solvents" (2001)

monitoring wells downgradient of the injection zone, to accelerate the pilot study and provide more meaningful data. The guidance also states that decreases in contaminant concentration in passive systems, which are monitored close to the injection points, may actually be the result of other transport mechanisms not related to biodegradation, including dispersion by displacement from the injected substrate. Therefore, if a suitable substrate can be identified, we request that the pilot test be redesigned as an active system that includes groundwater extraction.

6. The active pilot test system should be designed in conjunction with the contingency plan for removal by groundwater pumping of the substrate, if necessary.

7. Analytical results should be reported on a molar basis for a mass balance of all constituents (as recommended in the RTDF guidance), which will provide more meaningful data for the evaluation of the potential remedy.

8. The signatory page is not signed by either a California Registered Geologist or a California licensed Professional Engineer, as required by the Business Professions Code.

9. The inclusion of an aquifer tracer test would enhance the pilot test, by providing additional hydrogeological information, which could allow accounting for the various attenuation mechanisms.

Specific Comments

1. Section 1.0. Introduction, page 1-1, Bullet 5; with Section 2.0 Enhancement In Situ Bioremediation, page 2-3, Bullet 5; and Section 3.5 Contingency Actions, page 3-8: a). Section 1.0, Bullet 5 states that an attempt will be made to remove the substrate, if necessary. We previously stated that hydraulic containment of any injected substrate is a necessary component of the Pilot Study.

b). The Section 2.0 bullets list Objectives for activities described in the Work Plan. Section 2.0, Bullet 5 states that one goal is to determine if undesirable conditions occur as a result of the substrate injection, by monitoring geochemical changes resulting from the process in the aquifer. While monitoring baseline conditions before the injections has been proposed, the following Work Plan sections do not provide sufficient detail to determine what specific conditions, or at what concentrations of analyzed constituents, that will trigger the contingency plan removal response. Please provide a detailed explanation in the text of the triggers necessary for a substrate removal response.

c). The Section 1.0 text also states that if "eminent risk" is posed by the substrate treatment, substrate removal will be attempted. The text does not define "eminent risk". The contingency plan (Section 3.5 Contingency Actions) also refers to adverse conditions resulting from the substrate injections as the trigger for removal of the substrate. The text does not provide sufficient detail concerning how these actions will be initiated, and does not instill confidence that they can be initiated, since hydraulic containment is questionable. Please provide a detailed contingency plan, as required by the Board's 27 September 2001 Order, including the means for identification of, and resolution of, all potential problems with the injection and bioremediation. Integrate the contingency plan with the design of the active pilot study system.

2. Section 2.0. Enhancement In Situ Bioremediation, page 2-1: The text states that the Biotreatability Study (Study) was revised in 1999. Our 1999 copy of the Study does not show conclusive evidence for

complete degradation of Carbon Tetrachloride (CT). Please provide the Board with supporting data or a copy of a study that supports CT degradation.

3. Section 2.0. Enhancement In Situ Bioremediation, page 2-2, paragraph 4: The text states that HRC®, lactic acid and molasses contained detectable amounts of metals, as reported in Appendix D. The laboratory product analytical results for seventeen priority pollutant metals and hexavalent chromium show that:

- HRC® contains cadmium (Cd), total chromium (Cr), copper (Cu), molybdenum (Mo), nickel (Ni) and selenium (Se) at individual analyte concentrations exceeding one or more of the Board's WQOs by from one to three orders of magnitude. The analytical method reporting limits (RLs) for antimony (Sb), arsenic (As), beryllium (Be), cobalt (Co), lead (Pb), mercury (Hg), silver (Ag), thallium (Tl) and vanadium (V) are too high for comparison to the applicable WQOs, due to matrix interferences.

- For lactic acid, hexavalent chromium was detected at 10 µg/L; Cr, Mo, and Se exceeded the WQOs; while Sb, As, Be, Cd, Co, Pb, Hg, Ni, Ag, Tl, and V RLs were too high for comparison to the WQOs.

- Molasses analytical metals results showed that hexavalent chromium could not be analyzed due to severe matrix interference. Sb, As, Ba, Cd, Cr, Co, Cu, Pb, Hg, Mo, Ni, Se, Ag, and V exceeded the WQOs, while Be and Tl RLs were too high for comparison to the WQOs.

We are concerned that, due to the above exceedences of the WQOs, injection of HRC®, lactic acid, or molasses into a potential drinking water source may pose an unacceptable risk to water quality and violate SWRCB Resolution 68-16. Therefore, we cannot concur with the use of any products with the metals above the WQOs as proposed in the Work Plan. Please find an acceptable substrate for your proposal.

4. Section 2.0. Enhancement In Situ Bioremediation, page 2-2, paragraph 4: a). The text also states that the estimated concentrations of metals resulting from injection of the substrate will probably be below published drinking water standards. A table in Appendix D, titled "Dilution Concentrations of Metals After Introduction of HRC® at Site 117" compares estimated final concentrations of metals in the aquifer, with the California Maximum Contaminant Levels (MCLs) and undated results for monitoring well 117-MW-02. MDLs are not the only applicable WQOs. In some cases (e.g., Se), agricultural water quality goals are lower than MCLs and are applicable.

b). Board staff does not believe that groundwater dilution of the injected product to ensure that it meets the WQOs is acceptable. Additionally, the dilution calculation assumptions should be explained in the text. Other substrates are available with substantially lower concentration of metals than those presented in the Work Plan.

c). Finally, any comparison of resulting metal concentrations to existing groundwater conditions on the site, should be to previously identified background monitoring wells.

5. Section 3.0 Description of Work, page 3-1: The text states that the pilot study encompasses only a small 10 by 25 foot area. The 10' by 25' area only includes the injection area, not the monitoring points.

The actual area of the study will be larger. The text does not add the fact that the vertical extent of the injections involves approximately 60 feet of aquifer, which greatly increases the total three dimensional area. Please revise the area/volume estimates to include the entire portion of the aquifer that will be affected by the test.

6. Section 3.1.1 Permitting and Notification, page 3-1: The text states that no federal, state, or local permits are required for the activity, under the TCRA. The text also states that the Navy will comply with substantive state requirements. We will not repeat our previous comments on this point, but simply add that we have not changed our interpretation of the authority for, need for, and legitimacy of, WDRs at non-NPL sites for the injections into an aquifer. Once we have the necessary information, we will draft WDRs for Board adoption.

7. Section 3.1.2 Security, page 3-1: The text states that only authorized personnel with appropriate training will be allowed in the exclusion zone. This statement is vague and does not reference the location in the Health and Safety Plan (HASP) where authorized personnel and appropriate training are defined. Please add the reference.

8. Section 3.1.4 Temporary Well Installation and Development, page 3-2: The text states that the 1.5 inch diameter monitoring wells will use an inner and outer (prepacked) stainless steel well screen. Please describe the contingency plan to prevent or remove potential biofouling caused by iron or other bacteria in the wells.

9. Section 3.1.4 Temporary Well Installation and Development, page 3-2: The text states that the soil will be continuously cored and logged, using the Unified Soil Classification System. Those cores will be composited into a sample for offsite disposal. Please include screening the cores with a PID, and taking appropriate soil samples for laboratory analyses for contaminants, especially since the pilot study will take place within a suspected petroleum hydrocarbon contaminant spill source zone.

10. Section 3.1.5 Baseline Sampling and Analysis, page 3-4: The text references the Sampling and Analysis Plan (SAP) for additional details of the sample methods, but the SAP does not provide the parameters used for monitoring the injections. Some parameters are presented in the letter response from the manufacturer, Regenesis, which is included as Appendix F. Please include a table of all known baseline groundwater conditions used in the design phase of the injection in the text.

11. Section 3.2 Substrate Injection Using Direct Push Techniques, page 3-4: The text quantifies the amount of injected HRC® as 300 gallons or 3,240 pounds of product, heated and injected at a rate of 4.5 pounds per vertical foot of injection point under 200 to 1,500 pounds per square inch pressure. The HASP should stress the hazards associated with heating and injecting viscous products into the aquifer under high pressure.

12. Section 3.2 Substrate Injection Using Direct Push Techniques, page 3-5, paragraph 2: The text states that, although a cone penetrometer test (CPT) rig will install the injection points, no CPT data will be collected. This is unusual, since the data collected by the CPT can be used to determine the soil classification and optimal injection pressure for each lithological zone. Excess pressure might result in short circuiting of the surface seal around the drill pipe. Please take the CPT data, and use it to optimize the injection pressures.

13. Section 3.2 Substrate Injection Using Direct Push Techniques, page 3-5, paragraph 3: The text states that bentonite chips (grout) will be tremied through the CPT rods into the borehole, down to 50 feet below ground surface (above the water table), without mentioning hydration. There is little chance at those depths for complete hydration of the chips by infiltration of precipitation. Please use a pressurized hydrated bentonite mixture (slurry) injected through the rods, starting on the top of the substrate injections.

14. Section 3.3 Process Monitoring, page 3-6, paragraph 3: The text lists the analytes and frequency for sampling for the pilot test. The text also references the SAP. Please add the 17 priority pollutant metals and hexavalent chromium to the list, in order to help determine the fate and mobility of metals under the test conditions. Also, add that the contaminant results will be reported in molar quantities (moles of contaminants), and that a mass balance of contaminants and daughter products will be performed. Provide a figure showing the degradation pathways for 1,2-DCA, CT and CF. Finally, include a table listing all constituents of interest, anticipated daughter products, and anticipated changes in background aquifer conditions that indicate bioremediation may be occurring.

15. Section 3.4 Waste Management, page 3-7: The text lists the waste streams (soil, wastewater, construction debris), and merely states that local regulations will be the sole disposal criteria. In addition, all federal and state requirements for disposal of waste need to be identified and acknowledged as applicable in the text. Please add that all hazardous waste, regardless of the waste stream, will be properly disposed at an appropriately licensed (and not just Navy-approved, as the text now reads) disposal facility.

16. Section 4.1 Progress Report and 4.2 Enhanced In Situ Bioremediation Removal Action Report: The text states that all study reports, prior to the last report, are informational without interpretation of the effectiveness of the pilot study. Since the last report will be released nearly two years after the start of the pilot study, there seems to be an exceptionally long period of time without even preliminary evaluation of the data. More frequent reporting is needed. This extended passive evaluation period does not provide the mechanism to determine whether changes to the pilot test design [e.g., variations in the substrate dose or changes in remedial technologies (e.g., air sparging to change aquifer to aerobic conditions for total dechlorinization of carbon tetrachloride, the main sitewide contaminant of concern)] are needed.

17. Figure 2: Interpretation of the cross section would be enhanced by a scale that incorporates both sea level (as shown) and depth from surface in feet. Please modify the vertical scale to also include feet below surface.

18. Figures 3 through 8: The six plan view figures show the shallow and mid-shallow groundwater plumes for benzene, 1,2-DCA, and carbon tetrachloride/chloroform (CT/CF) on a scale of one inch equals 60 feet. The CT/CF plume boundary lines are hard to follow, since this is not a closed line figure. There is no shading (or other graphically means) of the contaminant side of the line. Additionally, the plume boundary lines are not always accurately drawn to scale based on the given contaminant groundwater concentrations. For example, Figure 7, monitoring well 17-MW-25(S) shows the CT non-detect line one inch from this non-detect well, while the detection result in 117-HP-01 is a quarter inch from the non-detect line. Please make Figures 7 and 8 more readable by shading contaminated areas or other graphic means, check the drawings for CT/CF boundary accuracy, and provide another figure at a larger scale (more area) that shows the entire CT/CF plume at the Administration Area, for comparison.

19. Figure 9: The figure shows the locations of the twelve proposed HRC® injection points at five foot centers, three new closely spaced (2 feet) upgradient and downgradient monitoring wells, and two existing monitoring wells 117-MW-02 and 117-MW-03. With this design, changes in concentrations of the surrounded monitoring wells may be due to contaminant transport by dispersion resulting from displacement by the substrate injections, not bioremediation of the contaminants. Please redesign the pilot test, using an active pilot treatment system, to reduce the possibility of dispersion effects.

20. Sampling and Analysis Plan, Section 2.1.1, Stating the Problem, paragraph 1, page 2-1: Please add the California Department of Toxic Substances Control to the list of participants.

21. Sampling and Analysis Plan, Section 2.1.2, Identifying the Decisions, page 2-2: The text does not include acquisition of data to determine if impacts to the aquifer (reduced porosity, increased metals) are occurring as a result of the substrate injections. Please add additional bullet(s) to address the "data acquisition decisions" and "questions to be answered" bulleted sections for impacts to the aquifer resulting from the pilot test.

22. Sampling and Analysis Plan, Section 2.1.3.1 Action Levels, page 2-3: The text states that a thirty (30) percent reduction in mass of 1,2-DCA will indicate a successful pilot study. a). We have previously stated that a reduction in mass alone does not indicate a successful pilot study. Incomplete degradation and test-related non-bioremediation contaminant transport processes, such as dispersion, could mask the results of the test. Only a mass balance of contaminants, including daughter products, can show that the pilot study is a success. Please change the success statement to include a reduction in mass of contaminants, as proven by the mass balance of all constituents.

b). There is no section in the Work Plan text that discusses evaluation criteria for a successful test. Add a section in the main Work Plan describing the evaluation criteria necessary for determining success.

c). This section of the SAP is labeled Action Levels. The first sentence in the text states that the Navy is developing decision documents to identify cleanup Objectives. The remaining text gives the Objectives of this pilot test, which are to confirm the existence of enhanced natural biodegradation, and gives the success criteria as 30% contaminant reduction. Since there are no action levels that require regulatory concurrence at this time, the section should be renamed.

23. Sampling and Analysis Plan, Section 2.1.4 Defining the Boundaries, page 2-4: Step 4 identifies the purpose of the section. Again, the text exceeds the name of the section, by adding the conclusion that if the pilot test is successful, a full scale treatment plan will include the entire Administration Area Plume. A general statement to this effect was made in the Introduction to the Work Plan. This conclusion does not belong in this section on test boundaries and needs. Please remove it.

24. Sampling and Analysis Plan, Section 2.1.4 Defining the Boundaries, page 2-4: The text states that the wells (presumably the new temporary monitoring wells) will be screened at the maximum depth of treatment, 110 feet below ground surface (bgs). The Work Plan, in Section 3.1.4 Temporary Well Installation and Development, page 3-2, and the SAP, Section 3.0 Sampling Analysis Strategy, page 3-1, both state that the five foot long well screens will be placed with mid-screen centers at 60, 80, and 100 feet bgs, with 100 feet as the maximum depth of the treatment. Please clarify what type of wells that SAP Section 2.1.4 refers to in the text, and make it consistent with the rest of the document.

25. Sampling and Analysis Plan, Section 2.1.5 Developing a Decision Rule, page 2-4: The text states that bioremediation is occurring when a statistically significant change in analytical results occurs. Please modify the text to say that analytical results will also be reported in molar quantities, and that all molar results will be evaluated by performing a mass balance of all constituents and daughter products, to determine whether bioremediation is, or is not, occurring.

26. Sampling and Analysis Plan, Section 2.1.5 Developing a Decision Rule, page 2-4: The text does not list all of the daughter products (here labeled degradation products) for 1,2-DCA and CT. As an example, chloroform, which is mentioned in the Work Plan text and figures, is not listed as a daughter/degradation product. Please include all daughter/degradation products in the text.

27. Sampling and Analysis Plan, Section 2.1.5 Developing a Decision Rule, page 2-5: The text repeats that 30% reduction in total contaminant mass signals successful bioremediation. Please see our previous comments on successful mass reduction using a mass balance, and revise the text.

28. Sampling and Analysis Plan, Section 2.1.5 Developing a Decision Rule, page 2-5: The text states that changes in natural attenuation parameters (parameters) will show that bioremediation is occurring. This statement is too general, and does not give details of the changes, including descriptions like increasing and decreasing, and the ranges of values for each parameter. Please develop a table of parameters showing pre-test background levels, what conditions that those background levels indicate, what affect(s) that bioremediation will have on each parameter, and expected new levels for each parameter, if bioremediation is occurring. Consult the USEPA guidance document(s) for an explanation of the parameter evaluation process.

29. Sampling and Analysis Plan, Section 2.2.1 Optimizing the Design for Obtaining Data, page 2-6: The text states that highest concentration areas of 1,2-DCA are the sole targets for the pilot study. Please add that CT (2.5 μg/L), CF (4.6 μg/L), and benzene (138 μg/L) also occur in the pilot study area.

30. Sampling and Analysis Plan, Section 3.1 Groundwater Sampling, page 3-2: The text makes a general statement that, at eight months into the twenty month project, if enough data exists to evaluate enhanced bioremediation for the pilot study, then sampling frequency will decrease or the pilot study will cease. The text does not explain what criteria will be used for this decision, and what is the purpose of early test termination or sampling reduction. Also, since the effects of the substrate injection may continue for years, the regulatory agencies need to be a part of the decision to reduce the frequency of groundwater sampling, or eliminate wells from groundwater monitoring. Please clarify this decision process. Also state that the regulatory agencies will play a part in the decision making process, by reviewing the groundwater analytical data, and providing concurrence to any decision involving groundwater monitoring.

31. Sampling and Analysis Plan, Section 3.2 Investigation-derived Waste Streams, page 3-2: The text states that soil and groundwater will be collected and analyzed for the following parameters, including the bullet California Code of Regulations (CCR). It appears that this term belong with the next bullet Title 22 metals. Please correct the reference.

32. Sampling and Analysis Plan, Tables 4 and 5, Reporting Limits for EPA analytical methods 8260B and 6000/7000 series: a). Please note that several of the reporting limits listed in these tables are not low

enough for comparison to the Board's WQOs. The Board's Water Quality Goals, which contain the WQOs may be downloaded from the Board's website at http://www.swrcb.ca.gov/~rwqcb5/. After comparing the RLs to the WQOs, please update Tables 4 and 5 with reporting limits comparable to the WQOs, or by using the best technically feasible reporting limits for these analytical methods.

b). Add hexavalent chromium by EPA method 7199 to the list of metals with a water matrix.

33. Sampling and Analysis Plan, Table 6: These Miscellaneous Parameters are used to track changes in the aquifer conditions consistent with biodegradation, or levels of final daughter products. The final daughter product parameters in Table 6 favor the reduction dechlorinization pathways for 1,2-DCA. Please include all daughter products of the degradation pathways for acetogenesis, co-metabolism, denitrification, and sulfate reduction of CT/CF/Dichloromethane in this table. Also, ensure that the reporting limits are low enough to perform the previously requested mass balance of all constituents of concern and daughter products.

If you have any questions please contact me at (916) 255-3050 or bartonj@rb5s.swrcb.ca.gov.

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