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July 22, 2016

OFFICE OF
RESEARCH AND DEVELOPMENT

Ms. Rodene Lamkin
MA Department of Environmental Protection
Bureau of Waste Site Cleanup
Site Management Section
205B Lowell Street
Wilmington, MA  01887

Subject:  Draft Phase III Remedial Action Plan, General Chemical Corporation, Framingham, Massachusetts

Dear Ms. Lamkin,

I have reviewed the Draft Phase III Remedial Action Plan (RAP) for General Chemical Corporation (GCC), located in Framingham, Massachusetts, dated February 15, 2016.  I focused my review on the thermal remediation aspects of the RAP, as this is my area of expertise.  I also did a very limited literature review on in situ biological treatment using butane sparging.  I understand that the cleanup goal for this site is to achieve a Temporary Solution, which would, at a minimum, include the following:  1) elimination of the infiltration of contaminants into the aqueduct, 2) mitigation of the discharge of contaminants into the drainage ditch and Course Brook, and 3) significant reduction in the mass of contaminants in the overburden, thereby shrinking the plume.  Thus, I have evaluated the RAP with regard to achieving these goals.  My comments are provided in detail below.

## Butane Sparging Comments

1.  Section 7.1.1.7 on page 20 provides this description of butane sparging: “Butane sparging is a co-metabolic biological process that is designed to degrade CVOCs and ethers such as 1,4-dioxane.”  While butane has been used successfully as a growth substrate for the aerobic cometabolism of chlorinated ethenes and ethanes, research has shown that fully chlorinated ethenes and ethanes such as tetrachloroethene (PCE) are not transformed by aerobic cometabolism processes. (Frascari, D., G. Zanaroli, and A. S. Danko, In situ aerobic cometabolism of chlorinated solvents:  A review, Journal of Hazardous Materials, 283:382-399, 2015.)

2. According to Frascari et al. (2015), aerobic cometabolism processes have not been widely used for bioremediation of chlorinated volatile organic compounds (CVOCs) because, for one thing, the toxic effect that the CVOC oxidation products may have on the microorganisms. Mahendra and Alvarez-Cohen (2006) studied the cometabolic biodegradation of 1,4,-dioxane and concluded, "Cometabolic transformation of dioxane was observed for monooxygenase-expressing strains that were induced with methane, propane, tetrahydrofuran, or toluene . . . Product toxicity resulted in incomplete dioxane degradation for many of the cometabolic reactions." (Mahendra, S. and L. Alvarez-Cohen, Kinetics of 1,4-dioxane biodegradation by monooxygenase-expressing bacteria, Environ Sci Technol., 40(17):5435-42, 2006.)

3. Frascari et al. (2015) also report that when the growth substrate for aerobic cometabolism is injected via air sparging (AS), a portion of the CVOCs will be stripped from the groundwater by the air and discharged to the atmosphere rather than degraded. At one site where methane sparging was used to remediate trichloroethene (TCE), 72 percent of the TCE removed was by air stripping, while 28 percent was biodegraded. In addition, experimental studies and modeling have shown that the dissolution during air sparging of gaseous growth substrates may be very low, allowing discharge of the growth substrate (in this case, butane) to the atmosphere. In order to avoid discharge of the CVOCs to the atmosphere, soil vapor extraction (SVE) would need to be incorporated into the design of the bioremediation system.

4. Thus, there are several potential problems with applying in situ bioremediation using butane sparging to Areas of Concern (AOC) #4 and #5, as is proposed in the RAP. Well CDW-19D, with PCE concentrations of approximately 12,000 μg/l in 2013, shows that substantial PCE is contained within this area. PCE may be volatilized by air sparging, however, Frascari et al. (2015) report that air sparging alone may not be able to recover all CVOCs, leaving behind 20 to 40 percent of the initial concentrations. Since most of AOC #4 is below the wetlands, there is no vadose zone in which to implement SVE, thus, the PCE and a potentially large percentage of the other contaminants that will be vaporized will be discharged to the wetlands via the air sparging. Well CDW-19D also contains 1,4-dioxane at a concentration of 280 μg/l in 2013, and it is not clear that this compound can be reduced sufficiently to achieve remedial goals using aerobic cometabolism. Due to the very high solubility of 1,4-dioxane in water, it may not be treated sufficiently by AS. PCE and 1,4-dioxane are both detected in the aqueduct, the drainage ditch and Course Brook. Thus it is critical that these contaminants be treated to protect the aqueduct and surface water. The proposed bioremediation may not be able to eliminate or mitigate the discharge of contaminants to the aqueduct, the drainage ditch, and Course Brook, and thus may not achieve a Temporary Solution.

## Thermal Remediation Comments

5. When evaluating in situ Thermal Remediation for AOC #1 (Section 7.2.1) and AOC #2 (Section 7.2.2) state, "*In situ* thermal treatment is a proven technology to remediate chlorinated solvents and 1,4-dioxane. This technology has the highest degree of certainty of all retained

technologies of reaching the cleanup standards." This statement is true and should be kept in mind when evaluating the technologies proposed for different areas of the site. Thermal remediation was the only technology considered in this RAP that is proven to treat DNAPL. Thermal remediation can also generally achieve lower residual contamination levels than the other remedial technologies considered. Section 5.0 on page 12 states that an estimated maximum amount of DNAPL in the source zone at the GCC facility is 9,260 pounds. This section also acknowledges that DNAPL likely left the GCC facility, but make no effort to estimate the amount of DNAPL mass that is downgradient.

6. Section 7.1.1.8 on page 20 states, "*in situ* thermal treatment generally takes a longer period of time . . ." However, the Preliminary Design and Cost Estimate provided by McMillan-McGee presents a schedule of approximately 17 months from the start of the design process until completion of the final report after remediation is complete, which is a shorter duration than the two years of operation for SVE/AS, ISCO and excavation shown in Tables 6 and 7. The '2' rating given to thermal remediation in these Tables is not justified.

7. Section 7.1.1.8 on page 20 states, "*in situ* thermal treatment generally . . . requires a uniform subsurface . . .". This statement is incorrect. Thermal technologies have been applied successfully in very heterogeneous subsurface setting.

8. Section 7.1.2 on page 23 states that in situ thermal remediation was not retained for further consideration for remediation of AOC #3 because it poses a risk to the structural integrity of the CSX railroad and the MWRA aqueduct. However, AOC #3 encompasses a relatively large area, and the offset of this technology in order to protect the railroad tracks and aqueduct is relatively small, likely in the range of 15 feet. Thus, thermal remediation could be used to treat the high concentrations at depth without harm to these structures. The wetlands, and the fully saturated soils below them, could cause significant difficulties for implementation of thermal remediation. According to the characterization data to date, it appears that DNAPL underlies a relatively small portion of the wetlands, and thermal treatment requires a relatively short time frame. Possible implementation of thermal technologies under the wetlands would depend on whether or not it is physically possible – and permissible - to lower the water table during the time of treatment.

9. Section 7.2.1 on page 30 states that Electro-Thermal-Dynamic Stripping Process ET-DSP requires significant resources, including electricity and water. It is likely that SVE/AS would require a similar or greater amount of electricity to attain the same level of remediation as can be achieved with thermal remediation. The ET-DSP technology evaluated here does require water addition at the electrodes, however, other in situ thermal technologies such as electrical resistive heating (ERH) would require less water, and thermal conductive heating does not require water addition to the subsurface, and either of these technologies are applicable to this site.

10. Section 7.2.1 states, "If the vapor/liquid recovery system is not adequate or subsurface heterogeneities result in unpredictable vapor movement, the adjacent elementary school and residential properties could be impacted by vapors." The water and VOC vapors generated by

thermal remediation would rapidly condense once outside of the heated zone, thus the possibility of vapors impacting adjacent properties are minimal. This is in contrast to a SVE/AS system, where VOC vapors would be carried with the injected air, and could travel much greater distances. As stated on page 31, "A potential risk with SVE/AS is preferential pathways of the injected air which could result in sparged air not being "captured" (i.e., extracted) by the SVE system." Uncontrolled vapor migration would be a potentially greater issue with the SVE/AS system than with the thermal system.

11. Some difficulties are encountered when comparing the costs of the different technologies for AOC #1 and AOC #2. AOC #1 as defined includes an area under the Garage. Although the proposal presented by McMillian-McGee for ET-DSP does not include treatment under the Garage, this area could be treated using thermal remediation likely without the removal of the Garage. AOC #1 is defined as ground surface to 5 foot depth, extending as much as 10 feet in some areas, but the shallow proposal provided by McMillian-McGee extends to 10 feet below ground surface throughout the treatment area. The deep treatment area described in AOC #2 extends from ground surface to 50 feet below ground surface, which would include all of AOC #1 and the portion of AOC #3 that is under the GCC facility.

## Specific Comments

12. Section 5.0 on page 12 states that upward flow and biodegradation stabilize further advancement of the plume to the southeast. Localized changes in groundwater flow direction may be occurring, as evidenced by the small concentrations of CVOCs appearing in well GZ-6, which is located close to the school, in 2014 and 2015. Also, it appears that the plume is migrating into bedrock at MW-105RR, which has had a ten-fold increase in CVOC concentrations from February 13, 2013 to November 12, 2015, from 4 to 50 μg/l.

13. Table 7 shows ISCO having a risk rating of '1'. This is not consistent with the discussion at the bottom of page 31 of potential damages to below grade utilities or surfacing of injected chemicals during treatment.

14. Section 7.6 on page 47 states, "The intent is to first implement activities in the source zones. The timing to address potential infiltration of impacted groundwater into the MWRA aqueduct will be based upon the effectiveness of remedial activities on the GCC facility property." If the AOCs are addressed sequentially, starting upgradient and moving downgradient, based on the estimated remedial timeframes given for the selected technology for each of the AOC, it would be at least 12 years before the migration of contamination into the aqueduct would be addressed. However, hydraulic containment by a technology such as pump-and-treat could be implemented in a much shorter time frame to control contaminant migration into the aqueduct, the drainage ditch, and Course Brook. Section 7.1.2 on page 23 states, "Hydraulic control was not retained for further consideration because it would not reduce the concentrations of CVOCs within a reasonable period of time. However, it may be used in conjunction with another remedial

alternative to limit further contaminant migration before the remedy achieves its objectives or to maintain objectives (i.e., a minimum Temporary Solution).”

15. Section 8.1 states, “it is the opinion of the LSP of record that the selected remedial alternative(s) for the GCC site can, at a minimum, achieve a Temporary Solution. This is based on the efficacy of any pilot tests that may be performed . . .”. In other words, pilot tests must be performed to verify that the selected remedies can achieve a Temporary Solution. While feasibility or pilot tests are recommended for the implementation of SVE/AS in AOC #1 (see page 39), for ISCO in AOC #2 and #3 (see pages 40 and 41), and for butane sparging in AOC #4 and #5 (see pages 43 and 44), a feasibility test is generally not required for thermal remediation.

If you would like to discuss any of these comments, I would be happy to do so. I can be reached at (580) 436-8548 or davis.eva@epa.gov.

Sincerely,

Eva L. Davis, Ph.D., Hydrologist
Applied Research and Technical Support Branch