10/8/03-03486

## Stevens, Kirk (EFDLANT)

**From:** Rich Bonelli [RBONELLI@mbakercorp.com]
**Sent:** Wednesday, October 08, 2003 11:17 AM
**To:** cbozzini@CH2M.com; Hood, Daniel R. (EFDLANT); Stevens, Kirk (EFDLANT); townsend.gena@epa.gov; burtonth@lejeune.usmc.mil; rainesrh@lejeune.usmc.mil; mklausmeier@micropact.com; Diane.Rossi@ncmail.net; randy.mcelveen@ncmail.net; ron.kenyon@shawgrp.com
**Cc:** Christine Harwood
**Subject:** Re: Site 73 conference call

Response_to_EPA_Comm_Site 73.d...

Good morning all:

Attached are responses to selected comments from Gena's EPA contractor on the Draft Site 73 Project Plans. Although there are other comments from their contractor, these are primary ones that require some explanation as they relate to the design of the sparging system. We will go through some of these tomorrow for our 2:00 conference call.

Rich

## MEMORANDUM

**TO:** Camp Lejeune Partnering Team

**FROM:** Christine Harwood, Michael Baker, Jr., Inc./
Travis McGuire, Charles J. Newell, Groundwater Services, Inc.

**RE:** Response to EPA Comments on Hydrogen Biosparge Detailed Design Draft, Site 73, Camp Lejeune, Jacksonville, North Carolina

The US Environmental Protection Agency (EPA) provided comments regarding the design on September 4, 2003. This memorandum provides written responses to the comments.

**EPA Comment 21.** *Attachment B, Page 2. Please provide a discussion of how and why the vertical location of the horizontal well was selected. The current configuration immediately below the base of the plume limits the radius of influence in the lower portion of the plume. This discussion should also be in Section 3.3.2 of the pilot test work plan.*

**Response to Comment 21.** The zone of hydrogen influence depends on several factors including: i) the flow rate of the injected gas; ii) the depth of the sparge point below the water table; and iii) subsurface heterogeneities. Since the zone of influence is controlled by small-scale stratigraphic features it cannot be predicted precisely. However, an estimate for the zone of influence is required to calculate the sparge volume. An estimated zone of influence of 40 feet vertically and 40 feet horizontally in each direction was made in order to calculate the sparge volume, this does not, however imply gas will be completely distributed within or confined to this zone. The estimated zone of influence was based on the following evidence:

- DOE study in which the sparge zone of influence was approximately 40 to 60 feet (20 to 30 feet on each side of the well), with some gas channels extending up to 100 feet from the well;
- Air sparging through vertical wells typically reaches less than 15 feet;
- Cape Canaveral biosparging study in which hydrogen delivery was 15 feet.

The estimated zone of influence for the current study is between the values presented in these sparging applications.

In the DOE demonstration of air injection through a horizontal well located 55 feet below the water table, gas was primarily distributed within a 40 to 60 foot wide zone (Brian B. Looney, personal communication, September 19, 2003), although, gas channels extended up to 100 feet from the injection point (USDOE, 1995). The proposed hydrogen flow rate for the current demonstration has been set equal to the equivalent air flow rate used in that study. Furthermore, the proposed horizontal injection well will be 70 to 80 feet below the water table, as opposed to 55 feet below the water table in the referenced study, which may provide additional gas distribution.

At the Cape Canaveral hydrogen injection project, three vertical injection wells, spaced 12 ft apart and screened 16-19 ft below the water table, delivered hydrogen at > 100,000 times naturally occurring hydrogen concentrations with distance of at least ~6 ft from the sparge wells. Tracer gas results indicate hydrogen was delivered at > 1,000 times naturally occurring hydrogen concentrations at monitoring points located 15 ft upgradient and 15 ft downgradient of the injection points. The monitoring points were screened at the same depth level as the sparge points.

Significant biodegradation of chlorinated solvents (i.e., 50% reduction in concentrations compared to 1% to 12% reduction in control wells at the same monitoring rows) was observed in monitoring wells located 15 ft downgradient of the hydrogen sparge wells. This may be due to production of acetate which is then used as an electron donor for reductive dechlorination.

The location of the well should be directly below the highest TCE concentration zone since hydrogen concentration will be highest in the area above the sparge point. Further review of the conservatively estimated zone of hydrogen influence in relation to the plume indicates that delivery of hydrogen gas to the high TCE concentration areas may be maximized by moving the proposed location of the well approximately 10 feet upgradient (north) and 10 feet deeper, as shown on attached Figure 1.

Figure 1 demonstrates that two wells containing high TCE concentrations (73-MW49DW and 73-MW13DW) are on the fringe of the conservatively estimated zone of hydrogen influence from the current proposed horizontal well location. Figure 1 also illustrates that moving the horizontal well 10 feet upgradient and 10 feet deeper should result in the two wells being fully encompassed within the conservatively estimated zone of hydrogen influence.

**EPA Comment 22.** *Attachment B, Page 2, Section-Sparge Volume. The plume is only about 10 feet thick and directly above the sparge well the sparge volume calculation appears to be in error. Please explain why a 40 foot vertical thickness was chosen. Additionally, the plume has a horizontal dimension of 130 to 250 feet either side of the sparge well for a total width of 380 feet. Using the 80 foot width for the treatment zone provided in the document, that still leaves approximately 75% of the plume untreated.*

**Response to Comment 22.** As stated in the response to EPA comment 21 above, the zone of hydrogen influence was estimated based on previous experience and the proposed design parameters, and was primarily used only to calculate a reasonable sparge volume.

GSI does agree that the location of the well is such that a small volume of the plume is treated, however, since the location of the well targets the highest concentration zone, a larger proportion of the plume mass may be treated.

**EPA Comment 23.** *Attachment B, Page 3, third paragraph, third sentence. Please correct the volume to indicate 1,000 $ft^3$ rather than 10,000. Also the conversion to determine the volume at 70 feet below the water table is in error. If starting with 1000 $ft^3$ at one atmosphere then the volume at 70 feet of water column (i.e., 3 atm. total) is 333 $ft^3$ according to Boyle's Law.*

**Response to Comment 23.** The correction to indicate 1,000 $ft^3$ rather than 10,000 $ft^3$ has been made. We also appreciate the correction of pressure at 70 feet below the water table as 3 atm rather than 2.1 atm. The gas volume at 1 atm required to achieve the desired volume in the subsurface is recalculated below using the corrected pressure:

$$P_1V_1 = P_2V_2$$

where, $P_1$ = hydrostatic and atmospheric pressure (3 atm)
$V_1$ = volume of hydrogen required at 3 atm (1100 to 2100 $ft^3$)
$P_2$ = atmospheric pressure (1 atm)
$V_2$ = volume of hydrogen at 1 atm to achieve required volume at 3 atm

This relationship implies a given volume of gas at atmospheric pressure will be 3 times its volume under hydrostatic pressure of 3 atm. Therefore, the resulting sparge volume required to achieve delivery of 1100 $ft^3$ to 2100 $ft^3$ to the subsurface at the given pressure at 70 feet below the water table is calculated to range from approximately 3,300 $ft^3$ to 6,300 $ft^3$.

EPA's calculated injection volume of 333 $ft^3$ assumed a gas volume of 1,000 $ft^3$ at one atm. However, 1,000 $ft^3$ is required at a depth of 70 ft below the water table according to the assumed zone of influence, which is at a pressure of 3 atm. Therefore, the actual injection volume should be approximately 3,000 $ft^3$ as calculated above.

A 12-cylinder pack containing approximately 2,600 $ft^3$ of hydrogen was proposed in the design draft. Since this volume no longer falls within the proposed range, a 16-cylinder pack containing approximately 3,500 $ft^3$ of hydrogen will be used for each sparge event.

**EPA Comment 24.** *Attachment B, Page 4, Section-Sparge Time. Using the corrected sparge volume of 333 $ft^3$ produces a sparge time of 0.33 minutes, or about 20 seconds, rather than 2 minutes. If the sparge volume calculation using 40 feet vertically is excessive, then the injection pulse will be even shorter.*

**Response to Comment 24.** As discussed above, the real volume of gas that will be sparged is approximately 3,500 $ft^3$. The new sparge volume of 3,500 $ft^3$ will require a 3.5 minute (3,500 scf $H_2$ / 1000 scfm flow rate) sparge time.

**EPA Comment 25.** *Attachment B, Page 4, Section-Sparge Frequency. It was assumed in this report that the time required to dissolve the hydrogen gas into the aqueous phase was one week. If that is correct, then increasing the sparging frequency should not have a large effect on the mass of hydrogen available to the biomass. It would seem that the limiting factor for delivering electron donor to the biomass is the dissolution rate for hydrogen, not the sparging frequency. If more monitoring points were used vertically near the injection point, then one could monitor for upward migration of hydrogen beyond the limits of the plume at the higher sparging frequency.*

**Response to Comment 25.** Previous studies have shown hydrogen gas persistence in the subsurface is approximately 4 days initially. As biomass consuming hydrogen increases, the demand for hydrogen also increases, which leads to increased hydrogen dissolution rate and decreased hydrogen persistence (1 to 2 days). Therefore hydrogen is depleted from the subsurface faster as time progresses and additional sparging events to replenish the hydrogen may be beneficial.

**EPA Comment 26.** *Attachment B, Page 4. References were cited in the text, but none were provided. Please provide the references.*

**Response to Comment 26.** References have been included in the design document.