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1220 Pacific Highway
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Addressee: Ms. Glenna Clark, Code 06CA.GC

Contract: N62474-98-D-2076, Environmental Remedial Action Contract

Contract Task Order: 0060

Subject: Optimal Remediation Technique for DNAPL/Source Removals at IR Sites 4 and 5

Dear Ms. Clark:

We have just completed the preparation of the IR Sites 4 and 5 DNAPL Removal Action Work Plan. Per your request, we studied the existing data and the details of the proposed application of Six Phase Heating (SPH) to the seven high-concentration portions of the plumes within IR Sites 4 and 5. This letter summarizes the advantages of the technology choice made by the EECA and comments on the concerns voiced by RWQCB regarding collateral environmental impacts of applying SPH on a project of this scale.

Potential Negative Environmental Impacts of Applying SPH
The following concerns have been presented by RWQCB, either by letter or during the April 2001 BCT meeting held at Alameda Point:

- Six-Phase Heating is un-proven in the (San Francisco) Bay Area
- Saline water and geologic heterogeneity may adversely affect implementation at Alameda Point
- Time delays associated with pilot tests
- Steam-enhanced extraction as an alternate removal technology
- Discharge of groundwater (RWQCB resolution 88-060)
- Thermodynamic efficiency of applying heat electrically
- Increased cancer risks resulting from the operation of Diesel-fueled electrical generators

SPH is indeed un-proven in the San Francisco Bay Area. In fact, a pilot test at a south-bay location failed due to high corrosion on the electrodes. This should not be a problem at Alameda Point, however. The nature of the contamination, the geology and the hydrology are favorable to SPH at both sites 4 and 5. We have inquired as to the failed pilot test, and were told that the site groundwater was so corrosive (due to the contamination) that the electrodes were destroyed within a week. The electrodes were unfortunately made of galvanized steel, which was particularly vulnerable to the site's contaminants. Had the electrodes been of a more noble metallurgy (copper or brass), they would have survived. In fact, the monitoring-well casings and screens within the treatment zone were made of brass, and they did not suffer any appreciable corrosion. SPH technology has been successfully applied at over a dozen sites throughout the United States, in a variety of geologic and hydrologic settings. The success of the Steam Enhanced Extraction test at IR Site 5 proved that thermal enhancement can be very effective in the accelerated removal of VOCs. Six Phase Heating should work even better, since it does not depend on steam transport to distribute the heat.

IR Site 5 groundwater has very high salinity, and thus can be expected to have higher electrical conductivity than sites with low salinity. IR Site 4 is more in line with the bulk of other sites that have been treated with SPH. This should not present any problem: higher salinity translates into higher electrical conductivity (in other words: less electrical resistance per unit of distance). The high salinity at IR Site 5 should actually be beneficial: the lower resisitivity should allow larger spacing between electrodes, thus reducing the number of electrodes that must be installed to treat any given contaminated area. The hydraulic heterogeneity of the sites may be a problem for steam injection, but SPH is far more robust relative to this parameter. Steam injection relies on point sources of steam, which are inherently vulnerable to heterogeneities that route the steam through higher-permeability pathways, thereby by-passing some of the lower-permeability zones. SPH, in contrast, generates the heat as a result of current traveling through the sediments as well as through the groundwater. Thus, SPH generates the steam in a distributed manner, sometimes even preferentially in the lower-permeability volumes, so it should be able to deliver heat more evenly and faster than steam injection. This should, in turn result in a higher rate of contaminant removal for SPH.

The pilot tests will not result in significant project delays relative to steam injection. Although the pilot test phase of the work is expected to consume on the order of three to four months, this should not significantly impact the progress of the work as compared to the Steam Injection approach. The additional design data collection phase of the project, which must be performed regardless of the technology will consume at least that long, and the full-scale design cannot proceed without the data. Thus, the pilot tests will not add any significant time to the project timeline.

There is every expectation that SPH will be successful at both IR Site 4 and at IR Site 5. In fact, the test at IR Site 5 will test some potentially energy saving enhancements to the current state of the art. Steam Enhanced Extraction the alternative removal technology of choice.

Discharge of treated groundwater to storm sewers will be considered a last resort, in accordance with RWQCB resolution 88-060. The Work Plan expects that the POTW will be capable of accepting all the groundwater generated. In the event that the treated groundwater contains TDS in concentrations unacceptable to the POTW, and NPDES permit will be obtained and the treated groundwater will be discharged to the storm sewer.

It would appear, on first inspection, that SPH would be less thermodynamically efficient than steam heating. This is indeed true if the measure of efficiency is BTUs applied at the steam injection points or electrodes. The goal of this removal action, however, is not the application of a given number of BTUs, but rather the removal of mass. This purpose is better served by SPH, which distributes heat much more efficiently than steam injection. Since steam injection occurs at a limited number of point sources (the steam injection wells), the steam will preferentially follow the high-permeability pathways, potentially by-passing lower permeability volumes. These volumes that do not come in direct contact with the steam can eventually be heated by conduction of heat from the higher permeability volumes, but that requires a prolonged application of steam over a longer period of time than might otherwise be required to mobilize the contaminants. SPH generates steam in situ, throughout the saturated treatment volume, lessening the influence of preferential pathways. Thus, the bulk of the contaminant mass can be mobilized very rapidly after the treatment volume reaches boiling temperature. Even though SPH requires more energy per BTU delivered to the treatment volume, the removal action should require a much lower amount of energy (BTU's) than would be required by steam heating, so it is, in fact more energy efficient overall. The current state of the art of SPH has an energy efficiency advantage over steam injection. The enhancements that will be piloted at plume 5-1, if successful, will sharply increase the thermodynamic advantages of SPH over steam injection.

The excess cancer risk due to air-borne particulates from Diesel-powered generators (or, for that matter, Diesel-fired boilers) can be managed. A balance must be struck between the risk of leaving VOCs in the ground and any increased risks to human health and the environment that would be caused in the process of their removal. The Removal Action Work Plan considers a variety of electrical sources, such as purchase from the distribution grid (PG&E), on-site generation by Diesel-powered generators, on-site generation by Natural Gas-powered generators. Diesel-fuel is the optimal choice from the logistics, schedule and cost standpoint, while Natural Gas would have considerable health-risk advantages. Purchasing power from the grid may be difficult in light of the current energy situation in California. The final decision will be based on energy market conditions, estimated risk factors (for in-ground contaminants and for generator-produced air emissions), the estimated costs and timelines for each option and Air Permit Requirements. Should the risks posed by the use of Diesel fuel prove unacceptable, a more favorable solution may be the blending of some of the options (for example, buying power from the grid for the 16 off-peak hours of each day, and generating power on-site during the remaining, peak-use hours).

In summary, our review of the existing data, of the characteristics of the current state of the art in SPH and of the potential enhancements to that technology indicates that SPH is a highly viable option for aggressive VOC mass removal at Alameda Point.

Sincerely,
IT CORPORATION

Rudolph R. Millan, PE
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CTO 0060