ARCADIS
Infrastructure, environment, buildings

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Subject:
Corrective Action Plan Addendum
Former BP Station #11133
2220 98th Avenue, Oakland, California
ACEH Case #RO0000403

ENVIRONMENT

Date:
May 10, 2010

Contact:
Hollis Phillips

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Hollis.Phillips@arcadis-us.com

Our ref:
GP09BPNA.C107

Dear Mr. Khatri:

ARCADIS U.S., Inc (ARCADIS) has prepared this letter as an addendum to Broadbent & Associates, Inc.'s (BAI) *Feasibility Study and Corrective Action Plan* (FS/CAP) dated on May 15, 2009, associated with the Former BP Station #11133 located at 2220 98th Avenue, in Oakland, California (Site) (Figure 1).

As described in the FS/CAP, the injection test will include an injection of an electron acceptor and dye tracer. The proposed injection test will be performed in the vicinity of AW-1 where elevated concentrations of contaminants of concern (COC) in Site groundwater are observed. Data collected during the injection test will be used to evaluate groundwater hydraulics in the subject area and to evaluate the full-scale implementation of the sulfate injection technology. This letter outlines proposed revisions to the pilot study work plan as described in the FS/CAP. Details regarding changes to the proposed injection test are provided below and include revisions to injection test objectives, injection and monitoring well installation details, injection design, and groundwater monitoring plan.

Injection Test Objectives

The purpose of the pilot study outlined in the above mentioned FS/CAP was to determine the effectiveness of sulfate/nitrate injections and to determine hydraulic conductivity of the injection location with other site wells. ARCADIS proposes instead the use of dissolved sulfate only and fluorescene dye tracer. The future use of nitrate will be evaluated based on results of the pilot study.

ARCADIS proposes that the pilot test objectives be met during the injection test by verifying and determining the following parameters:

1. Mobile porosity of the impacted Site soils;
2. Natural gradient groundwater velocity;
3. Volume of fluid required to achieve the target radius of influence (ROI); and,
4. Frequency of injections required to ensure sufficient quantities of magnesium sulfate are maintained in the target treatment areas.

Injection Test Well Network

ARCADIS proposes the below modifications to the injection well network established in the FS/CAP. These modifications are proposed to improve injection well and monitoring network effectiveness during the injection test.

- Installation of three injections wells (IW-1, IW-2 and IW-3) instead of one injection well for the pilot test. The installation of three wells will increase the area of influence and the mass removal of Site COCs during the injection testing prior to mobilization for installation of the full scale remedy. Injection wells IW-3 will also serve as downgradient observation wells for the proposed tracer test. Figure 1 presents the new proposed injection well layout.

- Installation of 4-inch injections wells instead of 6-inch injections wells for the pilot test. Based on ARCADIS experience at other sites with similar lithology, injection rates are expected to be below 25 gallons per minute (gpm) and friction losses across the well screen of a 4-inch injection well will not limit achievable flowrates.

- Injection wells will be completed with 0.02 slot polyvinyl chloride (PVC) wire wrapped screen or stainless steel wire wrapped screen from first encountered groundwater (approximately 18 feet below ground surface [bgs]) to approximately 40 ft bgs and then completed to ground surface with schedule 40 PVC casing. An appropriately sized filter pack will be placed from the bottom of the screen to approximately two feet above the top of the screen. The annular space above the screen will be filled with approximately three feet of transition sand overlain by 100-percent neat cement grout to the surface. The wells will be completed with three foot PVC well risers and water tight plugs. Upon completion of well construction, each well will be developed by surging/bailing or pumping until relatively silt free water is removed from the well.

- Installation of one additional observation well (OW-1) to more effectively monitor the injection event and to assess downgradient transport of magnesium sulfate and fluorescein dye following injection. The new proposed OW-1well location is shown in Figure 1.

Monitoring Network

A total of one injection well (IW-3), one observation well (OW-1) and three monitoring wells (AW-1, AW-2, and MW-1) will be utilized to monitor injection event dose response and to assess downgradient transport of magnesium sulfate and fluorescene dye following injection. Data collected from OW-1 and AW-1 wells will be used to monitor for the arrival of injected sulfate during the injection process. The injection will continue at IW-1 and IW-2 until down-hole field data (i.e., specific conductivity) demonstrate arrival of the injected solution at OW-1. The further downgradient observations wells IW-3, MW-1,and AW-2 will be used to establish tracer breakthrough curves and groundwater flow velocity. Groundwater flow velocity is not currently known and will be calculated by means of the tracer test. The time that the tracer center of mass takes to travel from the injection immediately following injection to the dose response wells and monitoring wells will be used to calculate the groundwater flow velocity.

Injection Test Design

The injection event will target the fine grained zone soils at approximately 16-36 feet bgs. The tracer and injection test in the vicinity of AW-1 will consist of a forced gradient injection into IW-1 and IW-2 to push the tracer and reagent to the desired radius, followed by a natural gradient advective flow test to verify groundwater flow velocity as the injected tracer is carried to downgradient monitoring wells. Injection well IW-3 will initially be used as downgradient dose response wells and eventually transitioned to injection wells after dye arrival. The following is a revised estimated solution volume required to demonstrate an effect at the targeted dose response well (AW-1 and OW-1) during injection is approximately 628 cubic feet (4,700 gallons), based on the equation below.

$$V_{inj} = \pi \times r_{inj}^2 \times h \times n_m$$

Where:

rinj = radius of injection = 10 ft

Vinj = volume of injection (cubic feet)

h = height of the well screen = 20 ft

n_m = mobile porosity (10 %; percentage of interconnected pore spaces carrying injection solution from the injection well)

The actual injection solution volume may vary depending on the formation mobile porosity (maximum value assumes the mobile porosity is equal to the total effective porosity of the soil or approximately 0.20). An injection quantity of 9,400 gallons based on a maximum effective porosity of 20% will be the limiting factor in sulfate injection feasibility. Injection quantities near this volume will require extended injection times and prolong cleanup activities at the site. Prior to injection, the solution (consisting of municipal water, magnesium sulfate, fluorescene) will be mixed within a holding tank using a trash pump to thoroughly mix the solution.

ARCADIS proposes a revised injection solution which will contain approximately 2.5 grams per liter (g/L) magnesium sulfate for a maximum total of 200 lbs of magnesium sulfate. Fluoresecene dye will be added to achieve a concentration of approximately 200 ppm. Fluorescene dye is proposed instead of potassium bromide due to the higher analytical accuracy and lower detection limits available for fluorescene.

Injection solution flow rate, cumulative injected volume, and wellhead pressure will be monitored and recorded on an injection log at IW-1 and IW-2. Down-hole water quality meters (e.g., YSI 600 XL multi-parameter water quality instrument or equivalent) will be used to monitor field parameters during and following the injection event. Real-time field parameters, including specific conductivity, will indicate the arrival of injection solution. Solution will continue to be injected until arrival is observed in data from the two adjacent dose-response wells AW-1 and OW-1. The injection volume may vary from the anticipated approximately 4,700 gallons, dependent upon field observations. In addition, water levels will be monitored throughout the injection test. Analysis of the injectability test will determine adequate well spacing.

Initial testing of dose response wells during the first injection may indicate that sulfate and dye breakthrough has occurred within target concentrations. If this occurs, injections will cease and initial injectablity data interpreted. Post-injection monitoring and sampling will occur for three to six months to confirm bio-attenuation is ongoing through sulfate reducing geochemical groundwater conditions. Based on the rate of sulfate depletion and COC concentrations during post-injection monitoring, ARCADIS will evaluate if one additional sulfate injection is necessary. If a second injection is necessary due to indicators of strong preferential sulfate utilization, the injectate concentration may need to be increased to within the range of 2.5 to 5 g/L of magnesium sulfate. Analysis of the post-injection monitoring results will provide the estimated sulfate loading for a full scale enhanced anaerobic bio-oxidation remedy.

ARCADIS is prepared to initiate field work upon ACEH approval of this Corrective Action Plan Addendum, the execution of necessary access agreements and the issuance of required permits.

If you have any questions or comments regarding the contents of this Work Plan, please contact either Hollis Phillips of ARCADIS at 415.374.2745 or by e-mail at Hollis.Phillips@arcadis-us.com.

Sincerely,
ARCADIS

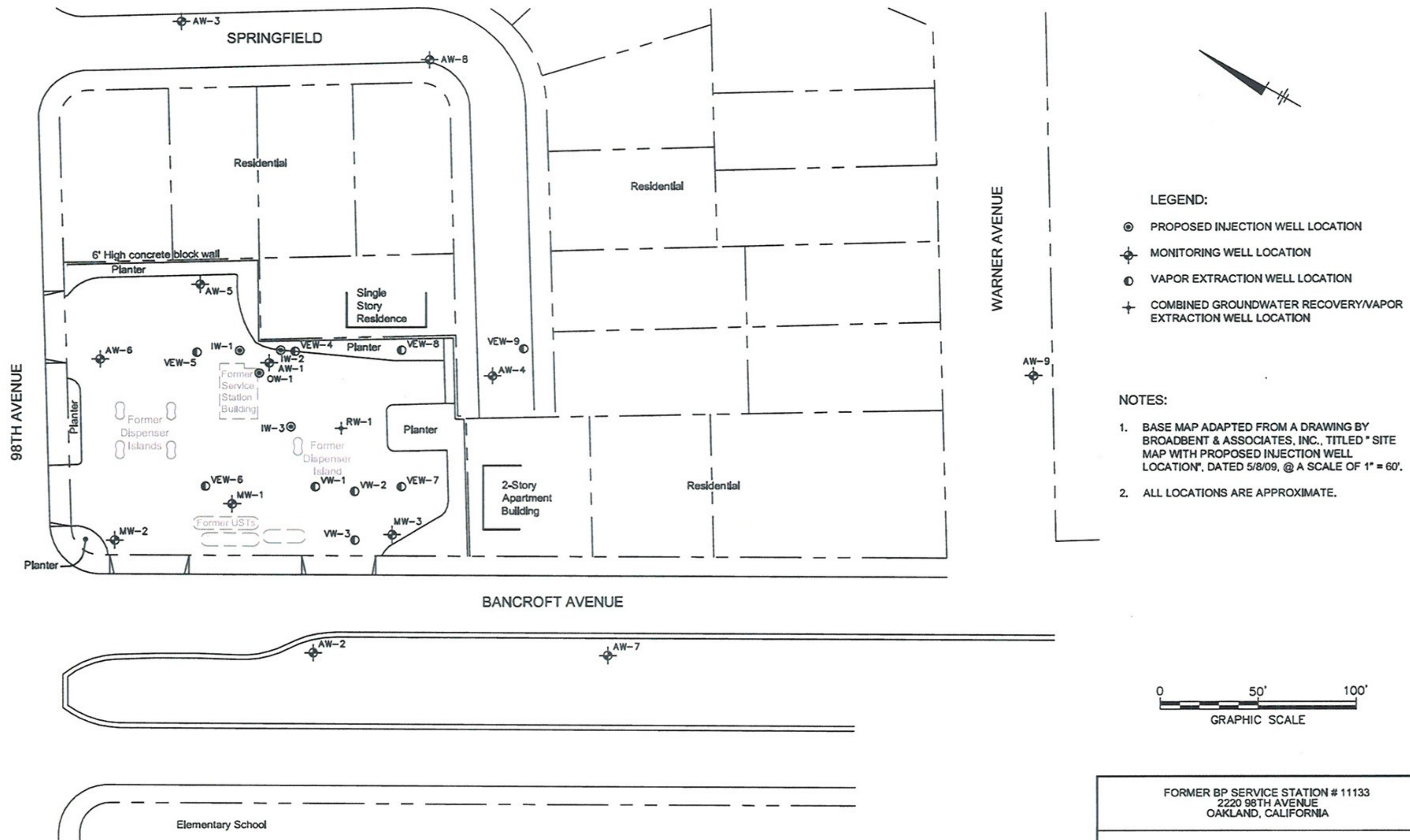
Kristin Mancini
Project Engineer

Hollis Phillips P.G.
Senior Geologist

Enc: Figure 1

cc: Ms. Shelby Lathrop, ConocoPhillips, 76 Broadway, Sacramento, California 95818

Electronic copy uploaded to GeoTracker



NOTES:

1. BASE MAP ADAPTED FROM A DRAWING BY BROADBENT & ASSOCIATES, INC., TITLED " SITE MAP WITH PROPOSED INJECTION WELL LOCATION", DATED 5/8/09, @ A SCALE OF 1" = 60'.
2. ALL LOCATIONS ARE APPROXIMATE.

FORMER BP SERVICE STATION # 11133
2220 98TH AVENUE
OAKLAND, CALIFORNIA

SITE MAP WITH PROPOSED WELL LOCATIONS

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FIGURE 1