ARCADIS G&M of Michigan, LLC
28550 Cabot Drive
Suite 500
Novi
Michigan 48377
Tel 248.994.2240
Fax 248.994.2241

Ms. Mary T. Aycock
Remedial Project Manager
U.S. Environmental Protection Agency
Region IX Superfund Division
75 Hawthorne Street (SFD-8-2)
San Francisco, CA 94105

ENVIRONMENT

Subject:
Technical Memorandum #3 – Summary of Injection Well IRZ-IW-05 Installation, Development, and Testing, for the Phase II Nano-Scale Zero Valent Iron Field Testing Program, Phoenix-Goodyear Airport-North Superfund Site Goodyear, Arizona

Date:
May 7, 2008

Contact:
Robert Ellis, LG

Phone:
248.994.2252

Email:
rellis@arcadis-us.com

Our ref:
AZ004987.0008.00002

Dear Ms. Aycock:

ARCADIS, on behalf of Crane Co., has prepared this Technical Memorandum #3 to summarize activities related to the Installation, Development, and Testing of Injection well IRZ-IW-5 in support of the Nano-Scale Zero Valent Iron (nZVI) Phase II Field Testing Program. As discussed in Technical Memorandum #2 (ARCADIS U.S., Inc., 2007) and presented during the First Quarter 2008 technical meeting with USEPA held on February 13, 2008, injection wells IRZ-IW-3 and IRZ-IW-4 did not perform as well as expected during the falling head tests and tracer test injection performed in late 2007. Aggressive redevelopment of the two injection wells on December 5 through 7, 2007, resulted in slight improvement in the well efficiency. However, ARCADIS concluded that finer grained sediments surrounding the IRZ-IW-3 and IRZ-IW-4 screened intervals were not suitable for the planned nZVI field injection testing. Therefore, installation of a new injection well IRZ-IW-5 was proposed. USEPA concurred with this course of action during the First Quarter 2008 technical meeting with USEPA held on February 13, 2008.

Activities completed recently include:

- Review of boring logs for existing wells in the vicinity of the target injection area;
- Installation and development of injection well IRZ-IW-05;
- Falling head tests and clean water injection;
- Injection well performance evaluation;

The following sections provide details and results for the field activities performed recently, as well as an updated project and reporting schedule.

Injection Well Installation and Development (IRZ-IW-05)

Prior to installation of IRZ-IW-05, ARCADIS reviewed boring logs for previously installed monitoring wells and injection wells in the target nZVI injection test area near the Main Dry Wells Area. The proposed location of IRZ-IW-5 was selected based on the occurrence of course grained sediments in the vicinity of IRZ-IW-1. The location of IRZ-IW-5 is illustrated on Figure 1.

Injection well IRZ-IW-05 was drilled and installed from March 24 through March 27, 2008. The total depth of the borehole was 125 feet below ground surface (bgs) and initial groundwater was encountered at approximately 90 feet bgs. In accordance with a written standard operating procedure (SOP), well injection well IRZ-IW-05 was installed to identify a permeable deposits of sand and gravel in the saturated zone that were identified during the drilling of IRZ-IW-01. Well IRZ-IW-05 was drilled by Layne Christensen using dual wall percussion hammer drilling techniques. Prior to drilling, Arizona Bluestake was contacted to locate subsurface utilities. The well installation SOP is attached in Attachment 1.

Borehole Drilling

Borehole drilling commenced on March 24, 2008 and was completed on March 25, 2008. As stated above, the borehole was drilled with percussion hammer drilling methodologies using a 9-inch drill bit to a depth of 125 feet bgs. The dual-wall percussion drilling rig advances a 9-inch dual walled drill pipe by means of a diesel-powered hammer. Drill cuttings are removed by air supplied by an on-board air compressor; the air is pumped down the space between the inner and outer walls of the drill pipe to the bit, where the cuttings are carried back to the surface through the center of the drill pipe. Cuttings are separated from the discharging air by a cyclone.

Lithologic Logging and Sampling

During the borehole drilling no *in-situ* soil samples were collected in the vadose zone. Also, no *in-situ* groundwater samples were collected in the saturated zone. To identify the permeable deposits in the saturated zone, continuous in-situ soil samples were collected using a 2-inch diameter spilt-spoon sample without the use of brass sleeve liners for accurate lithologic control from 105 feet bgs to 125 ft bgs. Field lithologic descriptions were based on the visual observations of depth-specific samples and drill cuttings, with considerations given to the impacts that occur during

the drilling process. Lithologic descriptions followed the USCS in accordance with ASTM Standard D2488. A copy of the lithologic log is attached in Attachment 2.

Well Installation and Development

The continuous soil core and lithologic logs were evaluated by ARCADIS and CH2MHill and a conference call conducted on March 26, 2008, with the USEPA to determine the final well design. Based on these results, it was agreed that well IRZ-IW-05 be constructed of 4-inch diameter Schedule 40 PVC casing and stainless steel wire wrap screen (0.030-inch slots), with the screen interval from 109 feet bgs to 119 feet bgs. Prior to the installation of the well casing and screen, bentonite chips were emplaced using a tremie pipe from the bottom of the borehole to a depth of approximately 121 feet bgs. When the lower portion of the borehole was sealed with bentonite, the well casing and screen were set to a depth of approximately 119 feet bgs with the screen interval extending from 109 feet bgs to 119 feet bgs. After the installation of the well casing and screen, the sand pack (8-12 Colorado silica sand) was emplaced from 119 feet bgs to 108 feet bgs. A bentonite seal was then emplaced from 108 feet bgs to 102 feet bgs. The remainder of the annulus was filled with a neat cement grout from 102 feet bgs to the surfaces. Additional completion details for IRZ-IW-05 are included in Attachment 2.

On April 4, 2008, the well was developed using swabbing, bailing, and pumping methods. The well screen was developed in 10-foot sections from bottom to top. During development, ARCADIS personnel monitored the progress of the development, noting color, pH, conductivity, temperature, and turbidity using a YSI water parameter meter.

ARCADIS carefully monitored the nearby observation wells during the installation of the injection wells (water levels, well sounding, turbidity field sampling, visual observations, etc.) to evaluate effects that drilling the additional observation wells within 5 feet did not impact the observation wells.

Falling Head Slug and Clean Water Injection Tests

Six falling head slug tests and one clean water injection test were conducted using injection well IRZ-IW-5. The falling head slug tests were conducted in order to estimate the relative hydraulic connection between IRZ-IW-5 and the aquifer as well as to estimate the proximal hydraulic conductivity of the Subunit A aquifer. The 500-gallon clean water injection was conducted to estimate the relative injectability of fluid into injection well IRZ-IW-5. The tests are described in the following paragraphs.

On April 14, 2008, six falling head slug tests were conducted in injection well IRZ-IW-5. The falling head tests were conducted by quickly pouring 5-gallons of clean water from the main treatment system into the well. The recovery of the water-level (head) was monitored with an electric water level meter and a pressure transducer datalogger. Three falling head tests were performed in the morning; however, due to a malfunction in the primary datalogger the three falling head tests were repeated in the afternoon. The three afternoon tests were successful. The falling head test data was analyzed using the Kansas Geological Survey (KGS) Model and the Bouwer-Rice solutions in AQTESOLV. The results of the analyses are presented in Figure 2. The estimated the hydraulic conductivity of the well / adjacent aquifer was estimated to range between 5 and 11 feet per day. Early time matches could not be achieved due to a delayed introduction of the falling water column; therefore, the estimates should be considered approximate.

On April 18, 2008, a 500-gallon clean water injection test was conducted in injection well IRZ-IW-5 in accordance with a written standard operating procedure, which is attached in Attachment 3. 500-gallons of clean water from the main treatment system was injected into the well through a 1.5-inch diameter drop pipe. The injection began at 8:30AM and was completed by 8:56AM. Following the injection, the well recovered approximately 98% by 9:17AM. The injection test was conducted as a semi-constant head step test. The first step averaged a head 19 feet above the static water level for approximately 11 minutes at an average flow of 15 gallons per minutes (GPM). The second step averaged a head of 33 feet above the static water level for 7 minutes at an average flow of 26 GPM. The third and final step averaged a head of 42 feet for 6 minutes at an average flow of 31 GPM. There was an approximate 2 minute delay between the first step and the second step. The semi-constant head step injection test injection data are graphically summarized in Figure 3. Based on the results, injection well IRZ-IW-5 appears to have a strong hydraulic connection to the Subunit A aquifer.

An average injection rate of 10 GPM was calculated by dividing the total injected volume (i.e., 500-gallons) by the time it took to pump the fluid into the well and achieve 98% recovery (i.e., 47 minutes). However as demonstrated by the step-test results, higher fluid injection flow rates may be sustainable without exceeding acceptable head pressures that would result in well or formation damage.

Schedule

The proposed revised schedule for completion of the nZVI kinetic and pilot testing is as follows:

- Preparation and submittal of final nZVI injection procedure – May 21, 2008
- Phase II nZVI injection event – June 2 through June 6, 2008
- Performance monitoring – June through September 2008
- Evaluate the potential for addition injection wells for Phase III nZVI pilot test – June through August 2008
- Submit pilot study completion report – December 2008

References

ARCADIS G&M, Inc. 2004. Final Main Drywells Source Area Investigation Work Plan, Phoenix-Goodyear Airport – North Superfund Site, Goodyear, Arizona. October 15, 2004

ARCADIS G&M, Inc. 2007a. Revised Nano-Scale Zero Valent Iron (nZVI) Kinetic and Phase II Field Testing Work Plan Phoenix-Goodyear Airport-North Superfund Site Goodyear, Arizona. January 30.

ARCADIS G&M, Inc. 2007b. Technical Memorandum #1 – Summary of Nano-Scale Revised Nano-Scale Zero Valent Iron (nZVI) Kinetic and Phase II Field Testing Work Plan Activities, Phoenix-Goodyear Airport-North Superfund Site Goodyear, Arizona. August 3.

ARCADIS G&M, Inc. 2007c. Technical Memorandum #2 – Summary of Nano-Scale Revised Nano-Scale Zero Valent Iron (nZVI) Kinetic and Phase II Field Testing Work Plan Activities, Phoenix-Goodyear Airport-North Superfund Site Goodyear, Arizona. December 14, 2008.

Please contact the undersigned with your questions or comments regarding these responses.

Sincerely,

ARCADIS G&M, Inc.

For Robert J. Ellis, LG
Senior Scientist

Harry S. Brenton, RG
Project Manager

Figures:

Figure 1 – Injection Well Location Map
Figure 2 – Falling Head Test Analyses
Figure 3 – Clean Water Injection Test Results

Attachments:

Attachment 1 – Well Installation SOP
Attachment 2 – Boring and Well Construction Logs
Attachment 3 – Clean Water Injection SOP

Copies:
Addressee (1)

Cathy O'Connell (1)
Arizona Department of Environmental Quality

Kevin Murdock, PE, RG
CH2M Hill

Leanne Austrins (electronic)
CH2M Hill

Chuck Coyle (electronic)
USACE

David Iwanski (electronic)
City of Goodyear

Ailiang Gu (electronic)
Burgess & Niple

David Becker, PG (electronic)
US Army Corp of Engineers

Roger Ferland, Esq. (electronic)
Quarles Brady Streich and Lang

Alan Bilzi (electronic)
Environmental Venture Group

Anthony Pantaleoni, Ph.D. (electronic)
Crane Co.