ARCADIS U.S., Inc.
126 North Jefferson Street
Suite 400
Milwaukee, WI 53202
Tel 414.276.7742
Fax 414.276.7603
www.arcadis-us.com

Mike Schmoller
Project Manager
Wisconsin Department of Natural Resources
South Central Region
3911 Fish Hatchery Rd
Fitchburg, WI 53711

ENVIRONMENT

Subject:
In-Situ Chemical Oxidation Groundwater Pilot Test Work Plan,
Madison-Kipp Corporation, 201 Waubesa Street, Madison, Wisconsin.
Facility ID No. 113125320, BRRTS No. 02-13-001569

Date:
October 17, 2012

Contact:
Jennine Trask

Phone:
414.277.6203

Email:
Jennine.trask@arcadis-us.com

Phone:
414.277.6203

Our Ref:
WI001283.0006

Dear Mr. Schmoller:

On behalf of Madison-Kipp Corporation, ARCADIS has prepared this *In-situ Chemical Oxidation (ISCO) Groundwater Pilot Test Work Plan* (Work Plan) to present an approach for treatment of volatile organic compounds (VOCs) within a groundwater plume that is present at the Madison-Kipp property located at 201 Waubesa Street (Site). This pilot test is designed to determine the geologic and hydraulic design parameters necessary for full-scale remedial implementation while evaluating the effectiveness of ISCO as a potential groundwater remedy and initiating source removal. This pilot test will gain critical information concerning aquifer characteristics such as fracture flow, hydraulics, bedrock storage capacity and aquifer contaminant mass delineation. ISCO is a method of in-situ remediation that adds a chemical oxidant to the subsurface to break the carbon bonds in VOCs and allow complete degradation of chlorinated ethenes (e.g. PCE and TCE) to their non-toxic daughter products.

This Work Plan summarizes the design and implementation of the groundwater pilot test including the installation of two wells in the shallow soil unit, four wells in the bedrock unit, and pre- and post-injection event groundwater sampling. The pilot test design has been developed based on ARCADIS' current understanding of the potential source areas and contaminant mass distribution in bedrock and groundwater at the Site.

Pilot Test Objectives

Contaminant containment and groundwater restoration are two of the ultimate goals for the Site. Three key components to developing a successful groundwater remedial strategy to achieve these objectives include the following: 1) determine the extent of VOC mass that resides in both bedrock fracture pore water and within the bedrock matrix within the source areas; 2) understand the orientation and hydraulic connection of the bedrock fracture network; and 3) understand the direction and velocity of bedrock groundwater to address and control contaminant mass flux in groundwater. Based on existing data, a key element of the conceptual site model (CSM) is that chlorinated VOCs released at the Site have migrated in groundwater in the fractured sandstone bedrock aquifer with the bulk of the contaminant mass in the rock being observed above a terminal depth of approximately 160 feet below land surface (ft bls).

The objectives of the pilot study are to gain information sufficient to answer the questions above and to evaluate the delivery dynamics, treatment, and permanence of the ISCO remedial approach for removal of VOC mass from the groundwater.

Pilot Test Hydraulic Parameters

To fully determine effectiveness of the pilot test, the preliminary injections will include both hydraulic tracer testing in conjunction with the ISCO injection event to monitor the migration of both tracers and oxidant under ambient groundwater conditions following injection. The pilot test will collect data and information to assist in determining the following design parameters for potential full-scale design and implementation:

- Interconnectivity or lack of interconnectivity of the bedrock fractures;
- The distribution of tracer and oxidant in the shallow soil and bedrock groundwater units;
- Hydraulic design parameters such as:
  - Mobile porosity (i.e., the fraction of the geology that participates in fluid flow)
  - Advective groundwater flow velocity
  - Maximum allowable injection rate
  - Injection radius of influence
  - Injection duration (time required for each injection event)

- The injection pressures and flow rates required to deliver the estimated volume of injection solution into the subsurface.
- The rate of oxidant consumption relative to the destruction of chlorinated compounds.
- The rate of groundwater wash-out of the injection solution from the treatment area.
- The extent of destruction and permanence of chlorinated VOC treatment post-injection.

Description of Well Network

The proposed injection and monitoring well network for the pilot test implementation will be located in the Monitoring Well MW-3 nest area, as shown on Figure 1. The pilot test well network will consist of two new injection wells, three new monitoring wells, one new injection dose response well, and one existing monitoring well (MW-3S) that will be utilized as an injection dose response well. The injection wells will be used to deliver a combined solution of chemical oxidant and non-reactive hydraulic tracers within the subsurface. Through the injection process, the oxidant and tracer will be delivered radially from the injection well via existing bedrock fracture features and permeable soil intervals to the associated radius of influence, following which the oxidant and tracer will either migrate downgradient via advective groundwater flow or remain localized to the well locations, depending on the specific conductivity within the injection zone. In order to monitor the migration of the oxidant and tracers during injection and post-injection monitoring phases, the injection wells have been proposed so that they are located approximately 10 feet from the dose response wells and approximately 20 feet from the monitoring wells.

Well Installation Details

Six boreholes will be advanced within the vicinity of the Monitoring Well MW-3 nest area using a combination of hollow stem auger and rotary (sonic or mud) drilling methods. The boreholes will be blind drilled and well screen depths have been selected based on data collected during previous onsite bedrock characterization activities. Based on the results of the Characterization of Rock Environments (CORE^{DFN}™) data collected at Monitoring Wells MW-3D3 and MW-5D3, the bulk of the contaminant mass in the rock was observed above a terminal depth of approximately 160 ft bls. The primary VOC mass in bedrock was observed in two discrete vertical intervals, located between 60 to 90 ft bls and 110 to 135 ft bls. The proposed injection and monitoring wells selected for this test focus on each of these bedrock intervals to address primary VOC impacts observed.

Contaminant mass will be targeted at three separate intervals (one interval in the shallow soil unit and two intervals in the bedrock unit); therefore, the proposed borings will be advanced to the following depths:

- Two borings will be advanced to approximately 35 feet;
- Three borings will be advanced to approximately 140 feet;
- One boring will be advanced to approximately 170 feet.

After the boreholes are advanced, wells will be installed in each borehole in accordance with the following well design:

- Two shallow soil wells will be constructed of 4-inch Schedule 80 polyvinyl chloride (PVC) pipe and will be screened from approximately 25 to 35 ft bls with 10-slot PVC screens. One well will be utilized as an injection well (IW-1S) and one well will be utilized as a monitoring well (MW-18S).
- Two bedrock wells will be constructed of 4-inch Schedule 80 PVC pipe and will be screened at two intervals from approximately 60 to 90 ft bls and 110 to 140 ft bls with 10-slot PVC, wire-wrapped screens. One well will be utilized as a monitoring well (MW-19D/19D2) and one well will be utilized as an injection dose response well (MW-20D/20D2).
- One bedrock well will be constructed of 6-inch Schedule 80 PVC pipe and will be screened at two intervals from approximately 60 to 90 ft bls and 110 to 140 ft bls with 10-slot PVC, wire-wrapped screens. This well will be utilized as an injection well (IW-2D/2D2).
- One bedrock well will be constructed of 4-inch Schedule 80 PVC pipe and will be screened at two intervals from approximately 60 to 90 ft bls and 110 to 170 ft bls with 10-slot PVC, wire-wrapped screens. This well will be utilized as a monitoring well (MW-21D/21D2).

The wells will be completed at the surface with a flush mount well vault set in concrete and each well will be developed to produce water free of sediment, drill cuttings and drilling fluids.

Pilot Test Implementation and Monitoring

Baseline Monitoring

Prior to initiation of the injection event, baseline water levels and groundwater samples will be collected from two new shallow soil wells (MW-18S and IW-1S), four new bedrock wells (IW-2D/2D2, MW-19D/19D2, MW-20D/20D2, and MW-21D/21D2), and eight existing monitoring wells (Monitoring Well MW-3 and MW-5 series wells) for laboratory analysis using low-flow sampling techniques, as summarized in Table 1.

The groundwater samples will be submitted for laboratory analysis of VOCs, total metals (arsenic, chromium, manganese and iron), dissolved metals (manganese, iron and Resource Conservation Recovery Act (RCRA) metals), three tracers (deuterated water, bromide and chloride), total organic carbon and total dissolved solids.

Pilot Test Injection Event

The ISCO injection and hydraulic tracer testing event will include separate injection tests conducted at one interval in the shallow soil unit and two intervals in the bedrock unit. A different tracer will be used in each injection interval to clearly monitor subsurface tracer distribution. Deuterated water, bromide, and chloride salts will be utilized as tracers. The pilot test injection event will consist of injection of a known volume and concentration of oxidant solution and an inert tracer in each injection interval. Up to approximately 3,000 gallons of sodium permanganate solution in the shallow target interval and up to approximately 8,000 gallons in each bedrock target interval will be injected.

The solution will be mixed in temporary polyethylene batch tanks staged on site and will be plumbed through above-grade piping manifolds to the injection wells under gravity-feed conditions. Each injection well manifold will be equipped with a pressure gauge to monitor the specific wellhead pressure over the course of the injection event. A totalizing flow meter will also be plumbed in line with the above-grade piping manifolds to allow monitoring of the total volume and specific flow rates during the event. As necessary, an incremental amount of pressure (less than 5 pounds per square inch gauge) may be added using a centrifugal pump to enhance flow rates based on the observed injection response in the field.

During the injection event, the injection, dose response and monitoring wells will be monitored regularly for the breakthrough of sodium permanganate and tracers.

Water level measurements and groundwater quality parameters will also be regularly collected at similar intervals. Conductivity and pH data loggers will be installed in injection and monitoring wells to provide continuous logging during and following the injection event to capture changes in vertical conductivity and pH profiles within the dose response well network.

Groundwater grab samples will be collected from two shallow soil monitoring wells (MW-3S and MW-18S) and three bedrock monitoring wells (MW-19D/19D2, MW-20D/20D2, and MW-21D/21D2) for laboratory analysis every other day of the injection event, as summarized in Table 1. Groundwater samples will be submitted for laboratory analysis of dissolved metals (arsenic, chromium, manganese and iron), three tracers (deuterated water, bromide and chloride), total organic carbon and total dissolved solids.

Post-Injection Monitoring

Following the completion of the injection event, a post-injection monitoring program will be initiated. Post-injection event performance monitoring will be conducted weekly for three weeks and bi-weekly for two months following the injection event. Please refer to Table 1 for the pilot test monitoring schedule. Water levels and groundwater samples from two shallow soil wells (MW-3S and MW-18S), three bedrock wells (MW-19D/19D2, MW-20D/20D2, and MW-21D/21D2), one multi-port bedrock well (MW-13) and eight existing monitoring wells (Monitoring Well MW-3 and MW-5 series wells) will be collected for laboratory analysis using low-flow or grab sampling techniques.

Groundwater samples will be submitted for laboratory analysis of VOCs, total metals (arsenic, chromium, manganese and iron), dissolved metals (manganese, iron and RCRA metals), three tracers (deuterated water, bromide, and chloride), total organic carbon and total dissolved solids. In addition, water level measurements and field measurements of groundwater quality parameters, including pH, temperature, dissolved oxygen, and conductivity, will be collected at each well.

The overall objectives of the performance monitoring phase is to characterize the distribution of oxidant and tracer, characterize the rate of oxidant consumption relative to the destruction of chlorinated ethenes, and to evaluate the rate of groundwater wash-out of the injection solution from the treatment area. These data will allow characterization of the oxidant dosing strength and the frequency of oxidant application.

Surveying

A Wisconsin-licensed surveyor will locate the horizontal location to Wisconsin state plane coordinates and vertical elevation for each newly installed well location.

Investigative Derived Waste

Investigative-derived waste will include soil and rock cuttings and water from drilling, sampling, and decontaminating equipment. Arrangements will be made with a licensed disposal facility for the transportation and disposal of the wastes. Based on data collected to date, it is assumed that soil and groundwater will be treated as a non-hazardous waste.

Reporting

Field observations and monitoring results collected during the course of the pilot test will be summarized in a remedial summary letter. This letter will include an evaluation of injection operations and treatment performance observed during monitoring activities and will include recommendations regarding application of the ISCO technology for treatment of chlorinated ethenes at the Site.

Permitting and Schedule

Due to the injection of remedial material into the waters of the state, a temporary exemption under Chapter NR 140.28(5) and a Wisconsin Pollutant Discharge Elimination System permit will be required to complete the pilot test activities. In addition, notification of the injection well inventory will be made to the Underground Injection Control program.

Following receipt of Wisconsin Department of Natural Resources (WDNR) approval of this Work Plan, preparation of the necessary permits applications will begin. A schedule for the commencement of the pilot test activities will be determined based on receipt of approval of the permits from WDNR, the availability of the multiple subcontractors needed to complete the work, and weather conditions.

Closing

Should you have any questions relating to the information presented herein, please call either of the undersigned.

Sincerely,

ARCADIS U.S, Inc.

Jennine L. Trask, PE
Certified Project Manager

Richard L. Studebaker Jr., PE
Vice President

Table 1. Groundwater Pilot Test Monitoring Program, Madison-Kipp Corporation, Madison, Wisconsin

Monitoring Location	VOCs	Total Metals[1]	Dissolved Metals[2]	Total Organic Carbon	Total Dissolved Solids	Tracers		
						Deuterated Water	Bromide	Chloride
IW-1S	B	B	B	B	B	B	B	B
IW-2D/2D2	B	B	B	B	B	B	B	B
MW-3S	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 5T, 2P	B, 5T, 2P	B, 5T, 2P
MW-3D	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 5T, 2P	B, 5T, 2P	B, 5T, 2P
MW-3D2	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 5T, 2P	B, 5T, 2P	B, 5T, 2P
MW-3D3	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P
MW-5S	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P
MW-5D	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P
MW-5D2	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P
MW-5D3	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P
MW-13[3]	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P	B, 2P
MW-18S	B, 2P	B, 2P	B, I, 2P	B, I, 2P	B, I, 2P	B, I, 5T, 2P	B, I, 5T, 2P	B, I, 5T, 2P
MW-19D/19D2	B, 2P	B, 2P	B, I, 2P	B, I, 2P	B, I, 2P	B, I, 5T, 2P	B, I, 5T, 2P	B, I, 5T, 2P
MW-20D/20D2	B, 2P	B, 2P	B, I, 2P	B, I, 2P	B, I, 2P	B, I, 5T, 2P	B, I, 5T, 2P	B, I, 5T, 2P
MW-21D/21D2	B, 2P	B, 2P	B, I, 2P	B, I, 2P	B, I, 2P	B, I, 5T, 2P	B, I, 5T, 2P	B, I, 5T, 2P

1 Total metals include arsenic, chromium, manganese and iron

2 Dissolved metals include manganese, iron, arsenic, barium, cadmium, chromium, mercury, lead, silver, and selenium.

3 Baseline sampling of MW-13 will occur during well installation activities prior to the pilot test.

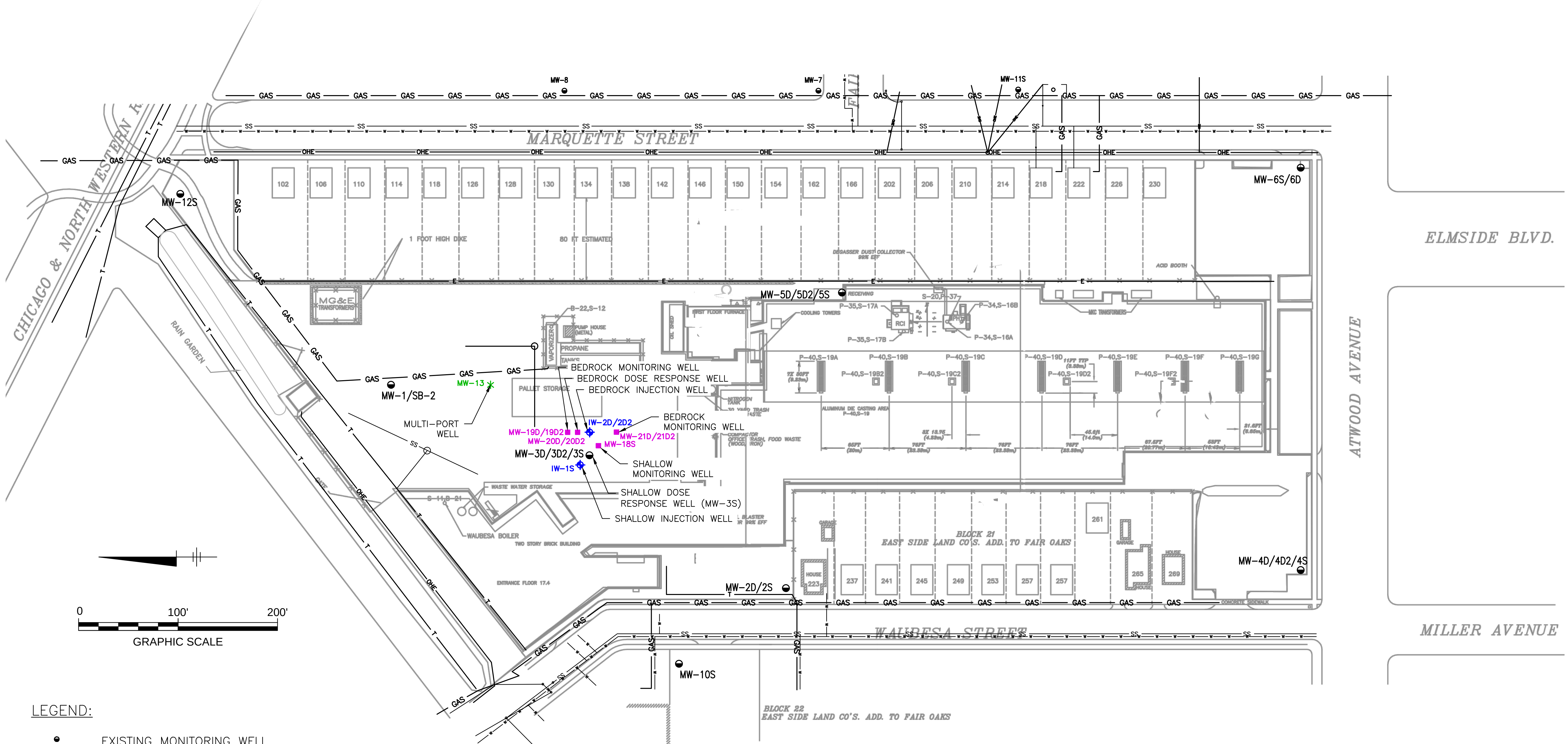
5T Five post-injection monitoring events for tracers only (deuterated water, bromide and chloride).

2P Two post-injection monitoring events for VOCs, total metals, dissolved metals, total organic carbon, total dissolved solids, deuterated water, bromide and chloride.

B Baseline sampling.

I Injection event sampling.

VOCs Volatile Organic Compounds.



LEGEND:

- EXISTING MONITORING WELL
- PROPOSED INJECTION WELL
- PROPOSED MONITORING WELL
- PROPOSED MULTI-PORT WELL

T	FIBER OPTIC AT&T TELEPHONE
GAS	GAS
SS	SANITARY SEWER 8"
W	WATER
E	ELECTRIC
OHE	OVERHEAD ELECTRIC

SOURCE: MADISON KIPP CORPORATION

MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

PROPOSED PILOT TEST WELL LOCATIONS

ARCADIS

FIGURE 1

CITY:COSTA MESA DIV/GROUP:ENVCAD DB:ENVCAD LAYOUT: 1 SAVED: 10/10/2012 2:47 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: BLACKGRAY.CTB PLOTTED: 10/11/2012 11:17 AM BY: SEPPANEN, MAIJA
G:\aproject\MadisonKipp\WI001283\cadd\Design\Pilot Test Well Layout.dwg