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ANL/EVS/AGEM/TR-12-06

Work Plan: Phase II Investigation at the Former CCC/USDA Grain Storage Facility in Montgomery City, Missouri

Environmental Science Division

USDA United States Department of Agriculture

Work sponsored by Commodity Credit Corporation,
United States Department of Agriculture

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Work Plan: Phase II Investigation at the Former CCC/USDA Grain Storage Facility in Montgomery City, Missouri

by
Applied Geosciences and Environmental Management Section
Environmental Science Division, Argonne National Laboratory

May 2012

United States Department of Agriculture

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BGL	below ground level
°C	degree(s) Celsius
CCC	Commodity Credit Corporation
DNAPL	dense non-aqueous phase liquid
DTL	default target level
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
gpm	gallon(s) per minute
hr	hour(s)
in.	inch(es)
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
mi	mile(s)
MDNR	Missouri Department of Natural Resources
psi	pound(s) per square inch
PVC	polyvinyl chloride
USDA	U.S. Department of Agriculture
VOC	volatile organic compound

Work Plan: Phase II Investigation at the Former CCC/USDA Grain Storage Facility in Montgomery City, Missouri

1 Introduction

From September 1949 until September 1966, the Commodity Credit Corporation of the U.S. Department of Agriculture (CCC/USDA) leased property at the southeastern end of Montgomery City, Missouri, for the operation of a grain storage facility. During this time, commercial grain fumigants containing carbon tetrachloride were commonly used by the CCC/USDA and the private grain storage industry to preserve grain in their facilities. In January 2000, carbon tetrachloride was detected in a soil sample and two soils gas samples collected at the former CCC/USDA facility, as a result of a pre-CERCLIS site screening investigation performed on behalf of the U.S. Environmental Protection Agency (EPA), Region VII (MDNR 2001).

The 2000 EPA study and subsequent investigations by the Missouri Department of Natural Resources (MDNR) confirmed the presence of carbon tetrachloride contamination in the soils and groundwater at the former CCC/USDA facility (MDNR 2001). The carbon tetrachloride levels identified were above the default target level (DTL) values established by the MDNR for this contaminant in soils of all types (79.6 μg/kg) and in groundwater (5.0 μg/L) (MDNR 2006a).

Because the observed contamination might be linked to the past use of carbon tetrachloride-based fumigants at its former grain storage facility, the CCC/USDA is conducting an investigation to (1) characterize the source(s), extent, and factors controlling the subsurface distribution and movement of the contamination and (2) evaluate the potential risks to human health, public welfare, and the environment. This work is being performed in accord with the Intergovernmental Agreement established between the Farm Service Agency of the USDA and the MDNR. The site characterization is being conducted on behalf of the CCC/USDA by the Environmental Science Division of Argonne National Laboratory.

The investigation at Montgomery City is being conducted in phases, so that information obtained and interpretations developed during each incremental stage can guide subsequent phases of the program. Phase I studies were conducted from October 2010 to September 2011.

This site-specific Phase II *Work Plan* provides a brief summary of the Phase I findings and outlines the technical objectives, investigation tasks, and investigation methods proposed for the Phase II study at Montgomery City.

2 Results of the Phase I Studies

With the approval of the MDNR (2010), the Phase I investigation was undertaken to address three primary technical objectives (Argonne 2010), as follows:

- Update the inventory and status of private and public drinking water wells in the immediate vicinity of the former CCC/USDA grain storage facility, sample selected wells for analyses for volatile organic compounds (VOCs) and geochemicals, and determine the present source(s) of drinking water for all residents within approximately 0.5 mi of the former facility.

- Obtain preliminary information on the site-specific lithologic and hydrologic characteristics of the unconsolidated sediments overlying bedrock at the former facility.

- Investigate for possible evidence of a soil source of carbon tetrachloride in the unconsolidated sediments beneath the former facility, which might affect the underlying bedrock aquifer units.

The Phase I field investigation began on October 18, 2010. The preliminary results demonstrated that broadening of the scope of work defined in the Phase I *Work Plan* (Argonne 2010) was technically warranted. On the basis of these findings, and with the approval of the MDNR program manager (MDNR 2011), an expanded program of studies was completed at Montgomery City between October 18, 2010, and September 2, 2011. The Phase I activities were conducted in four primary field sessions and numerous minor site visits.

The results of the Phase I studies were interpreted and integrated to develop a preliminary conceptual model of the factors controlling the distribution, possible movement, and potential risks associated with carbon tetrachloride identified in the unconsolidated sediments overlying bedrock at Montgomery City. The key findings of the 2010-2011 investigation are summarized as follows:

- The unconsolidated stratigraphic sequence in the study area (above the refusal limit of the direct-push technology employed in Phase I) is dominated by fine-grained, poorly sorted deposits interpreted as glacial till, containing little

coarser-grained material. No laterally continuous coarse-grained intervals were identified. Deposits of relatively clean silt or fine-medium sand appeared as occasional small pods, lenses, or thin bands, or as rare, discontinuous, thicker (up to approximately 1-2 ft) lenses in the till. Subtle lithologic variations, however, suggest the presence of vertical layering that is traceable across the area and is interpreted to represent four stratigraphic units (Figure 2.1).

- Saturated conditions were apparent in the unconsolidated sequence to approximately 1-8 ft BGL (below ground level). The distribution of groundwater levels suggests that vertical and lateral hydraulic communication also exists throughout the area; however, relatively complex apparent hydraulic gradients control the groundwater movement.

- Lateral groundwater flow in the unconsolidated sequence appears to be driven by a relative groundwater high near the southern margin of the investigation area, promoting groundwater movement predominantly to the north-northwest in the upper portion of the till. The influence of the high becomes progressively more localized with depth, resulting in an increasingly semi-radial pattern of lateral hydraulic gradients in the deeper tills, particularly near the remaining rectangular foundations (Figure 2.2).

- The apparent local driving force(s) for vertical groundwater flow vary across the site and might locally be upward or downward. Alternatively, little to no vertical hydraulic gradient might exist locally.

- Rates of groundwater recharge to monitoring wells were very slow at most locations. These rates, the fine-grained character of the tills, and the varying hydraulic gradients suggest that the potential rates of groundwater movement and contaminant migration through the fine-grained sediments are limited.

- The surficial soil and subsurface soil (vadose) zones, as defined by the MDNR (2006a), are together relatively thin (≤ 8 ft) or absent. Carbon tetrachloride detected in the soils deeper than 8 ft BGL might therefore be associated with both solid soil particles and pore water. With only one exception, no carbon

tetrachloride concentrations above 10 μg/kg were detected at 4 ft BGL. No carbon tetrachloride concentrations exceeding the DTL of 79.6 μg/kg were detected in soils in the uppermost 8 ft of the soil column.

- Carbon tetrachloride levels greater than the DTL occurred in soils primarily in hot-spot areas, as follows (Figure 2.3):

  - The most prominent hot spot, immediately west and northwest of the rectangular foundations (near SB01-SB41-SB46-SB47). This hot spot has the vertical profile of a source area for contamination in groundwater.

  - A hot spot in the southern portion of the former array of round grain bins (at SB17) that also has the vertical profile characteristics of a source area.

  - An apparent third hot spot identified only in soils > 28 ft BGL, approximately 70 ft east-northeast of the rectangular foundations (at boring SB50). This hot spot lacks the vertical profile of a source area.

- Pervasive, highly oxygen-depleted and chemically reducing conditions favorable to the widespread reductive dechlorination of carbon tetrachloride were not identified in the till sequence. Locally, however, such conditions might at times promote limited natural degradation of carbon tetrachloride in groundwater.

- The distribution of carbon tetrachloride in groundwater in the upper portion of the till sequence (stratigraphic Unit 1 and the upper portion of Unit 2; Figure 2.1) generally coincides with the footprint of the former CCC/USDA facility. Carbon tetrachloride concentrations above the DTL (5.0 μg/L) were detected at most of the locations sampled within this footprint or immediately northwest of the rectangular foundations (Figure 2.4).

- The carbon tetrachloride distributions in groundwater in the intermediate and lower portions of the till complex (in stratigraphic Units 2 and 4; Figure 2.1) are similar to that observed in the upper interval; however, the distribution

widens to the northeast in the intermediate interval and to both the northeast and southeast in the lower interval (Figures 2.5 and 2.6).

- The highest concentrations of carbon tetrachloride in groundwater, 6,226-10,616 µg/L, were identified in the northwestern hot-spot area at locations SB41 and SB01, in stratigraphic Unit 2 (Figure 2.5).

- The physical characteristics of the tills suggest that minor fine-scale lithologic variations might play a role in groundwater and contaminant migration, as follows:

  - More effective vertical hydraulic communication (relative to other areas) might exist in the hot spot near SB01-SB41-SB46.

  - Trends in carbon tetrachloride concentrations and groundwater levels suggest preferred migration pathways to the northeast in the intermediate interval (Figure 2.5) and to the northeast and southeast in the lower interval (Figure 2.6), in possible association with localized variations in the horizontal hydraulic conductivities of Units 2 and 4.

- Soil analyses indicated little to no horizontal contaminant migration in hydrostratigraphic Unit 3, because of its relatively uniform, generally fine-grained character (Figure 2.1). At least locally, however, Unit 3 does not preclude vertical groundwater and contaminant migration between Units 2 and 4.

- Despite the inference of preferred horizontal migration pathways, the maximum lateral extent of carbon tetrachloride contamination identified in the groundwater (and soils) to date is limited to within 100-250 ft of the footprint of the former CCC/USDA facility and the associated concentration hot spots. The areas of contamination are limited to the property owned by the Montgomery County Fair Society. Public access to the most contaminated areas on the site is restricted to activities authorized by the Fair Society Board. The most contaminated area is fenced and is locked except during authorized activities.

- Current risks related to the carbon tetrachloride and chloroform identified in soils and groundwater in the Phase I study area are summarized as follows:

  - The DTL values for soils reflect risk that might be associated with the residential indoor inhalation pathway. This potential exposure pathway is currently incomplete, and no receptors are presently at risk of exposure by this route.

  - The DTL values for groundwater reflect risk associated with the use of contaminated groundwater for domestic purposes, including consumption. The Phase I results demonstrated that no residents are currently at risk due to use of the contaminated groundwater identified in the saturated till units; no private or public wells are located in the identified area or depth interval of groundwater contamination. The tills hosting the carbon tetrachloride contamination are further recognized as having little capacity to produce groundwater, and hence they are unlikely to be tapped as a future source of groundwater for domestic or other purposes.

- No conclusive evidence of the presence of dense non-aqueous phase liquid (DNAPL) was identified in the groundwater or soil samples recovered in the Phase I investigations. Limited observations drawn from the vertical distribution and absolute concentrations of carbon tetrachloride in the tills suggest, however, that carbon tetrachloride migration in DNAPL form could have contributed, in part, to the present contaminant distribution.

- Elevated levels of carbon tetrachloride are present in the soils and groundwater at and near the base of the unconsolidated section (in Unit 4) penetrated by using direct-push techniques, to a maximum depth of 68 ft BGL. These results suggest a potential for deeper penetration of carbon tetrachloride beneath the identified areas of groundwater and soil contamination, if the permeability in the immediately underlying stratigraphic units is sufficient.

- Fractured and cherty limestones of the Mississippian aquifer represent the shallowest recognized bedrock aquifer units in the Montgomery City area.

The Mississippian aquifer typically yields relatively low quantities of water to wells (Argonne 2010). Historic well log and drilling log data available to Argonne and the results of the Phase I investigations suggest that the depths to the tops of these units might range from 65 ft to 120 ft BGL beneath the former CCC/USDA facility.

- Available information indicates that the identified active wells near the former CCC/USA facility primarily tap the deeper and more prolific water-bearing intervals in the regional Cambrian-Ordovician aquifer.

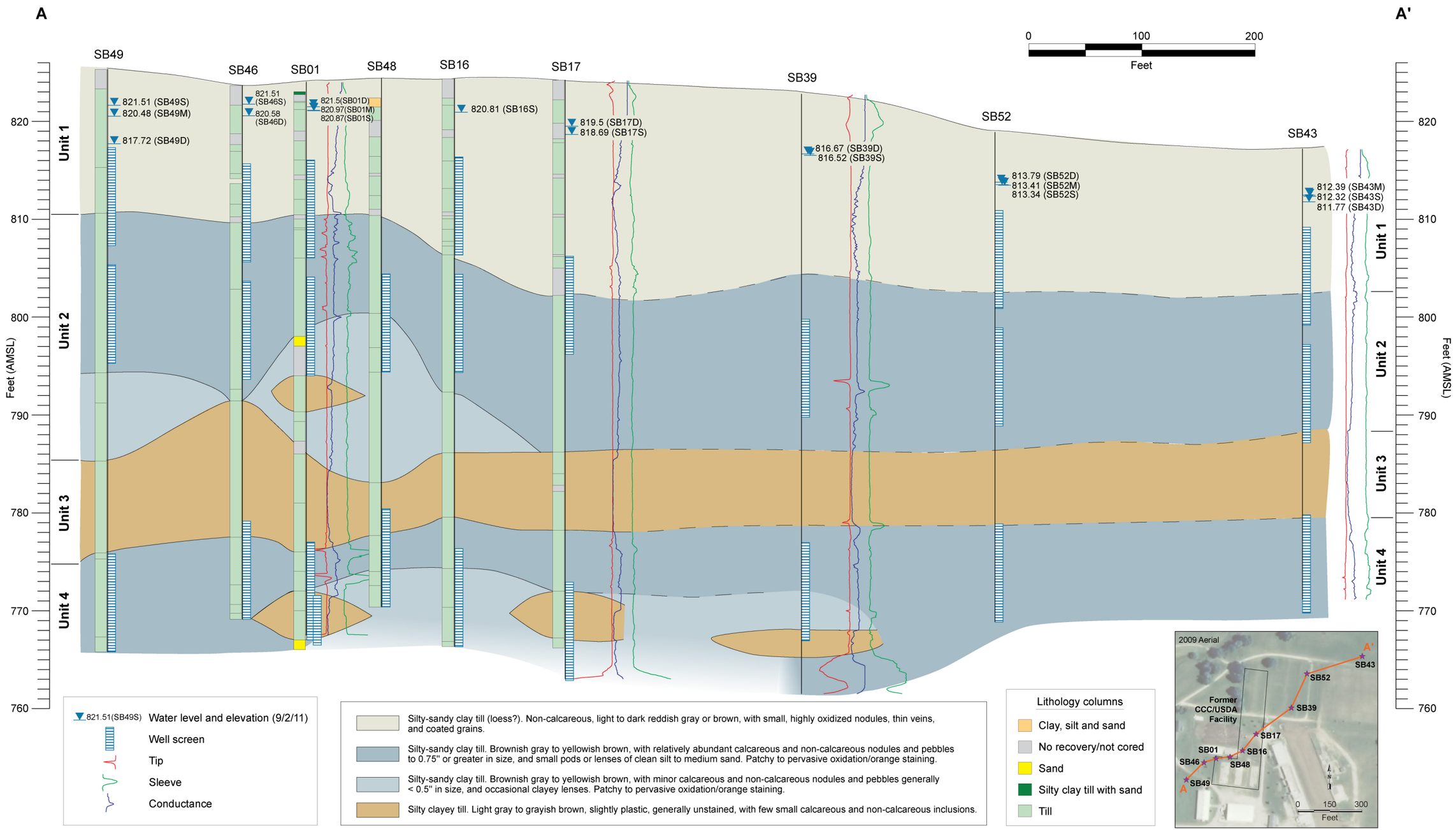

FIGURE 2.1 Southwest-to-northeast hydrogeologic cross section A-A′ (vertically exaggerated), showing the distribution of groundwater levels identified in the upper, intermediate, and lower portions of the unconsolidated sedimentary section.

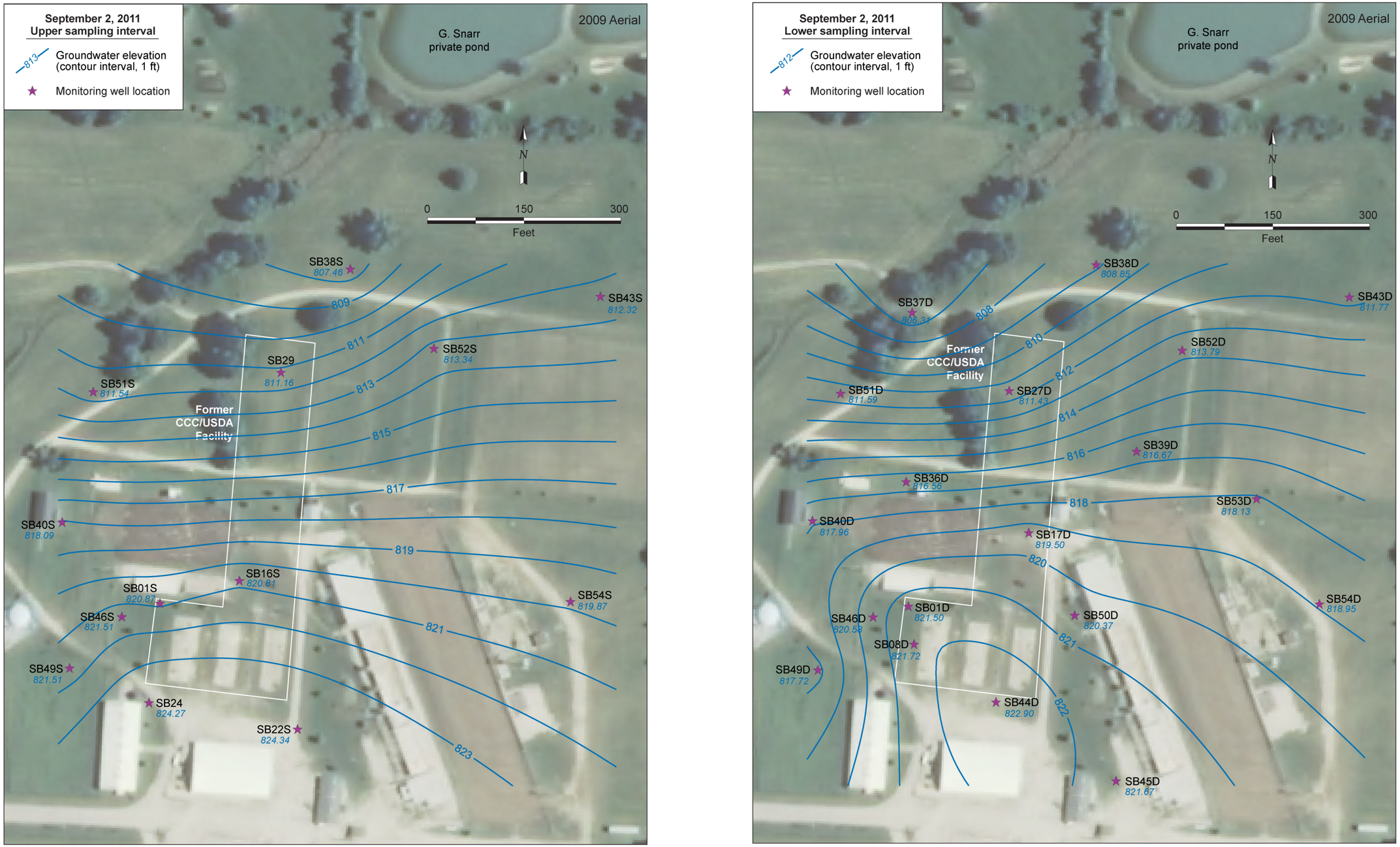

FIGURE 2.2 Interpreted potentiometric surfaces based on groundwater levels measured by hand in monitoring wells completed in the upper sampling interval (left) and the lower sampling interval (right) on September 2, 2011. Source of photograph: NAIP (2009).

FIGURE 2.3 Lateral distribution of carbon tetrachloride in deeper soils (> 20 ft BGL), as determined by purge-and-trap analysis. The maximum detected value is shown for each location. Source of photograph: NAIP (2009).

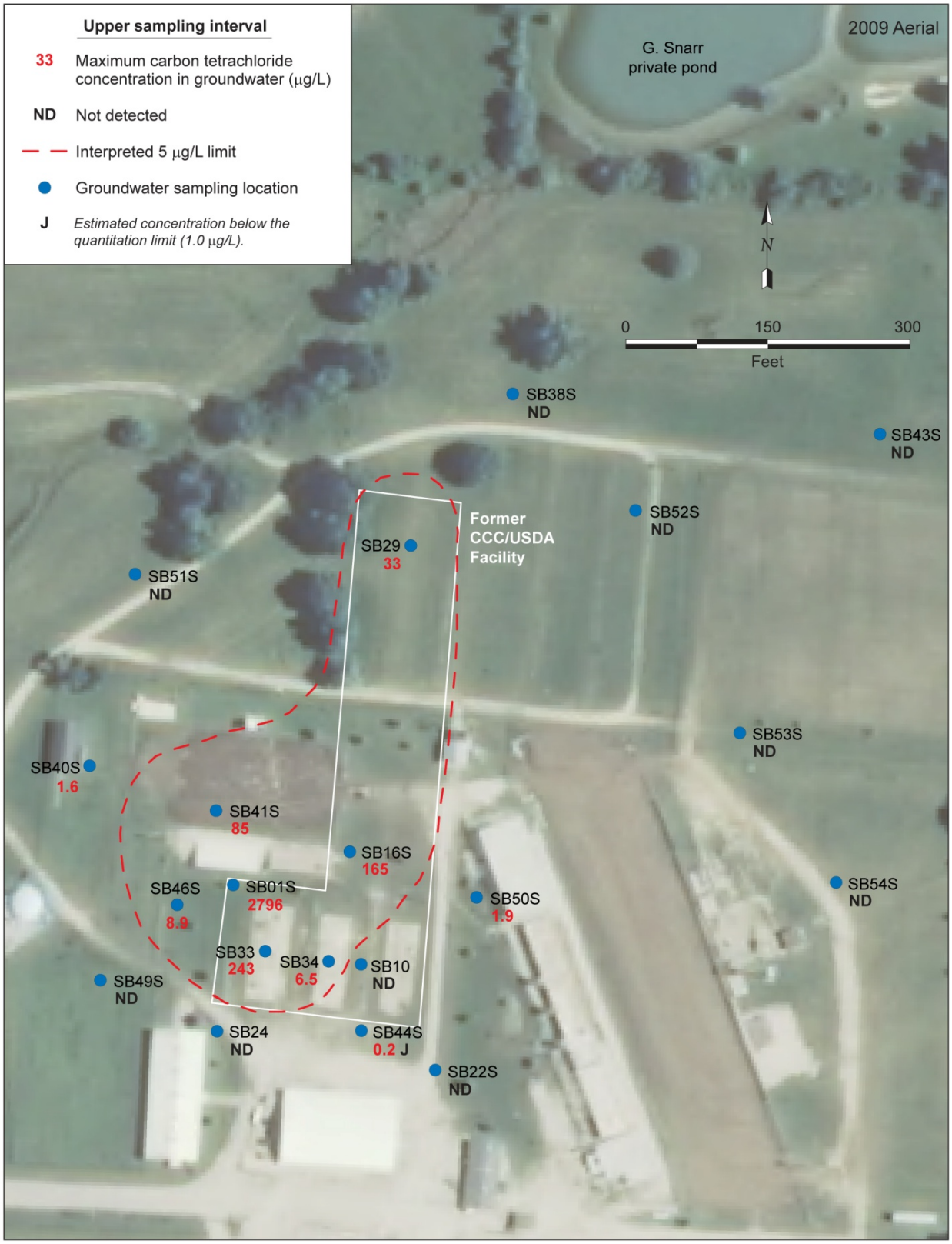

FIGURE 2.4 Maximum carbon tetrachloride concentrations detected in groundwater in the upper sampling interval (< 20 ft BGL). The outline indicates the interpreted 5-µg/L concentration limit. Source of photograph: NAIP (2009).

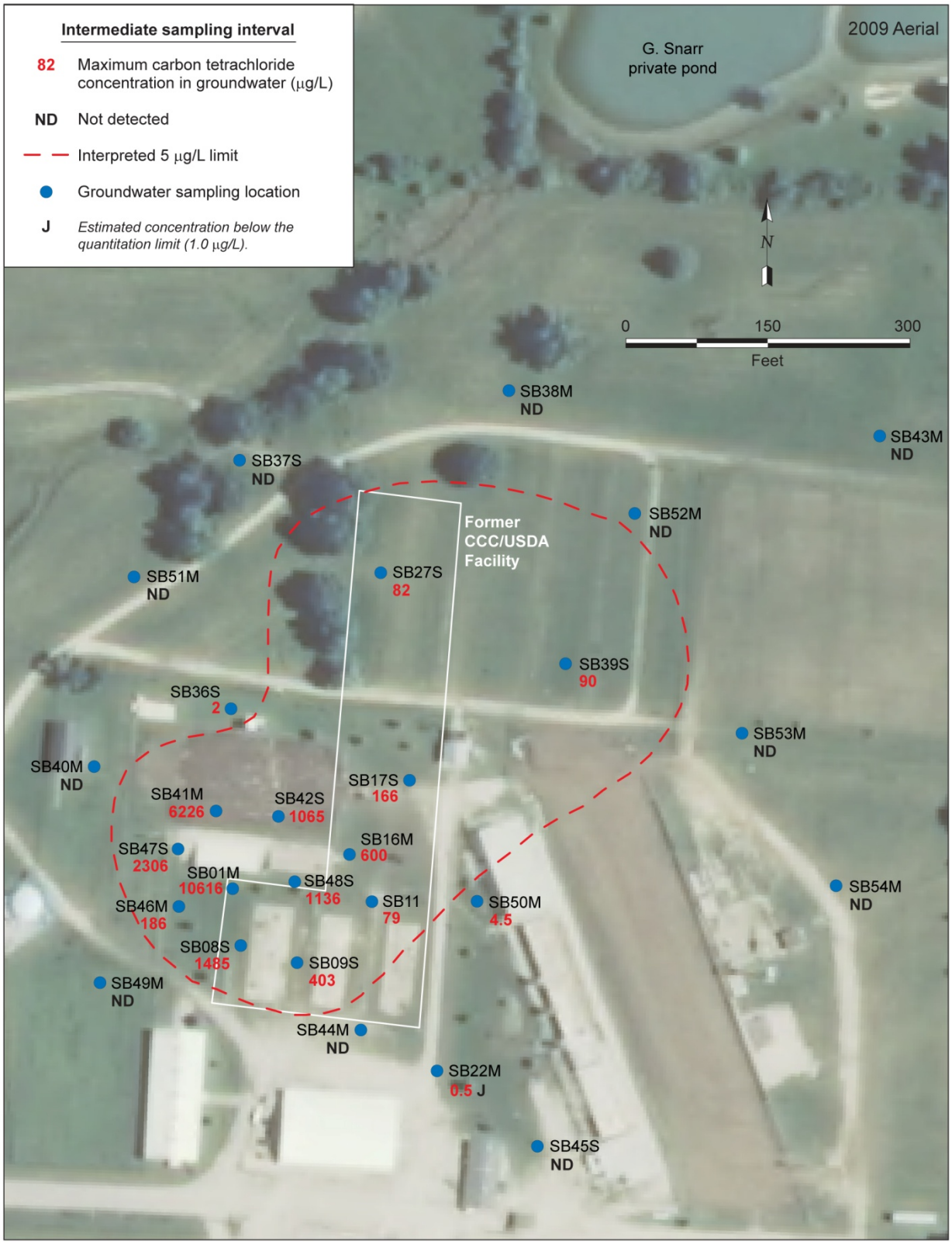

FIGURE 2.5 Maximum carbon tetrachloride concentrations detected in groundwater in the intermediate sampling interval (20-30 ft BGL). The outline indicates the interpreted 5-µg/L concentration limit. Source of photograph: NAIP (2009).

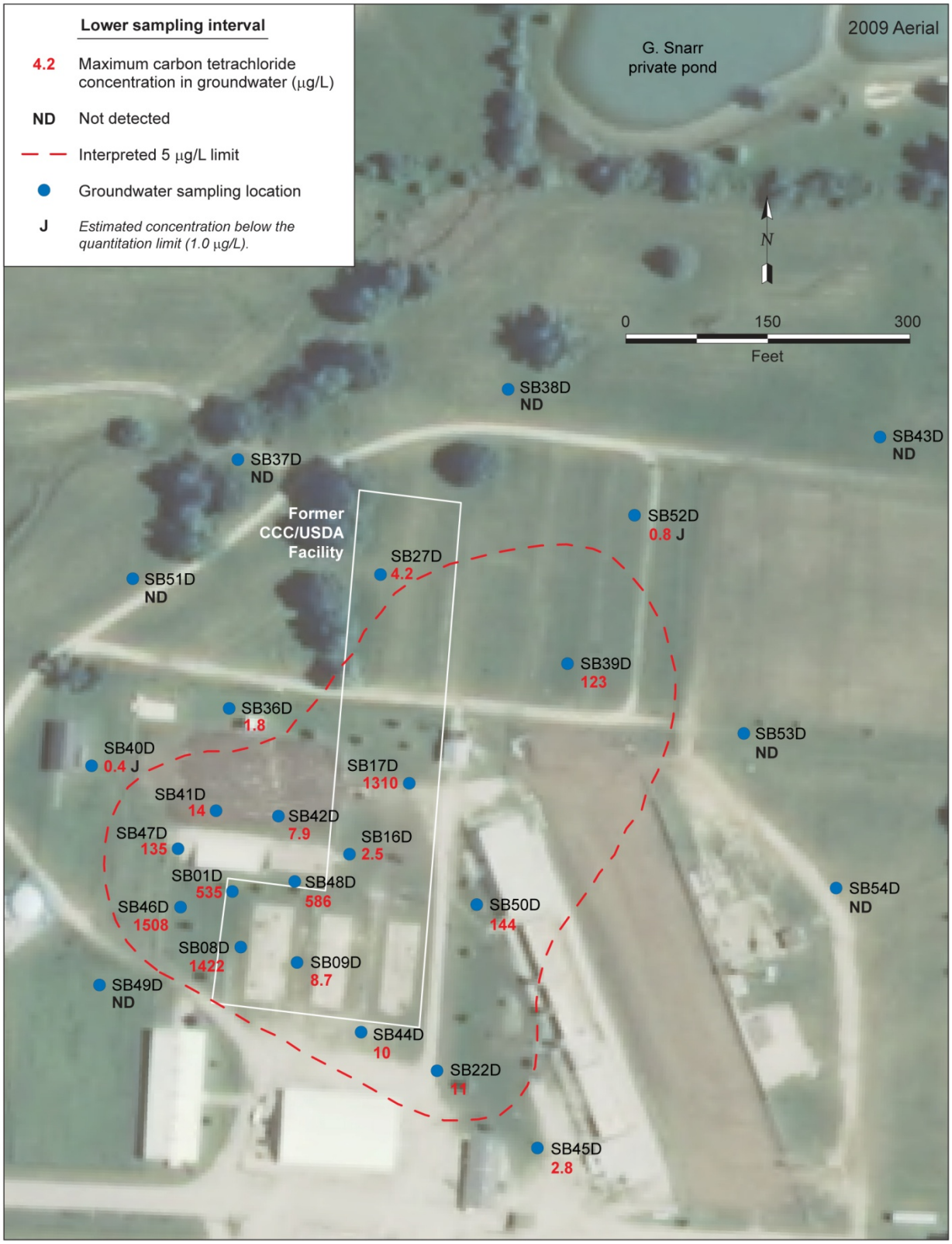

FIGURE 2.6 Maximum carbon tetrachloride concentrations detected in groundwater in the lower sampling interval (> 40 ft BGL). The outline indicates the interpreted 5-µg/L concentration limit. Source of photograph: NAIP (2009).

3 Phase II Investigation Objectives and Tasks

3.1 Technical Objectives of the Phase II Study

The results of the Phase I investigation demonstrate that carbon tetrachloride contamination in the unconsolidated soils and associated groundwater penetrated by using direct-push technology (to depths of 47-67 ft BGL) is areally restricted to the approximate footprint of the former grain storage facility, with relatively little evidence of lateral migration. The findings further suggest, however, a potential for deeper vertical contaminant migration if sufficient permeability exists in any deeper unconsolidated materials that might be present and/or in the underlying bedrock stratigraphic sequence. The bedrock sequence hosts several aquifer units that are of both local and regional significance as sources of groundwater (Argonne 2010).

In response to this concern, the Phase II studies at Montgomery City will focus on investigation of the shallow bedrock intervals in the vicinity of the former CCC/USDA facility. The proposed technical objectives for the Phase II program are as follows:

- Investigate the lithologic and hydrologic characteristics of potentially deeper unconsolidated sediments and the shallow bedrock sequence beneath the former CCC/USDA facility.

- Obtain preliminary information on the potential vertical and lateral distribution and concentrations of carbon tetrachloride in groundwater in the penetrated bedrock sequence.

The investigative activities recommended to address these technical objectives are discussed below. The investigative methods that will be used to implement this program are discussed in Section 4.

3.2 Phase II Task: Investigate the Lithologic and Hydrogeologic Characteristics of the Deeper Unconsolidated and Shallow Bedrock Sequence

3.2.1 Shallow Bedrock Aquifers

The general bedrock stratigraphy in the vicinity of the former CCC/USDA facility, as determined from lithologic logs for wells in the Montgomery City area, is illustrated in Figures 3.1 and 3.2 and was discussed in detail previously (Argonne 2010). Montgomery City lies along the southern edge of the northeastern Missouri groundwater province. Two principal bedrock aquifers are recognized in this area — the Cambrian-Ordovician and Mississippian aquifers (Miller and Vandike 1997; MDNR 2001). These aquifers are described briefly below.

3.2.1.1 Cambrian-Ordovician Aquifer

The Cambrian-Ordovician aquifer complex ranges in total thickness from approximately 900 ft to 1,800 ft in northeastern Missouri. Information compiled during Phase I indicates that all three of the active Montgomery City public water supply wells, as well as all of the operational private wells identified in the vicinity of the former CCC/USDA facility (Figure 3.1), are constructed to tap groundwater from one or more units within the Cambrian-Ordovician aquifer. The public water supply wells range in depth from 1,075 ft to 1,278 ft BGL.

Significant water-producing units in the Cambrian-Ordovician aquifer complex include the Eminence and Potosi dolomites (deeper Upper Cambrian intervals that are not shown in Figure 3.2), fractured dolomites and sandstones of the Lower Ordovician Gasconade dolomite and Roubidoux Formation, and the St. Peter Sandstone. Production rates from the Gasconade dolomite and Roubidoux Formation (penetrated by the Montgomery City public wells) typically range from 50 gpm to 500 gpm. These units are overlain by the Lower Ordovician Jefferson City, Cotter, and Powell dolomites, which together range from 400 ft to 500 ft in thickness and are unimportant as sources of groundwater. The St. Peter Sandstone can generally yield 25-75 gpm to wells (Miller and Vandike 1997; Imes 1985).

In the Montgomery City area, the St. Peter Sandstone is overlain by the Ordovician Kimmswick, Decorah Group, Plattin, and Joachim dolomites and limestones, as well as Devonian limestones and shale, which together reach a thickness of up to approximately 200 ft.

The latter units, which have been identified as having relatively little water-producing capacity, might locally serve as (possibly leaky) confining layers in the Montgomery City area (Imes 1985; Emmett and Imes 1984; Miller and Vandike 1997).

Because of their depth and areal extent and the presence of associated thick, generally non-water-bearing intervals that probably serve as confining layers, the aquifer units of the Cambrian-Ordovician aquifer complex are expected to be at minimal risk of contamination due to the carbon tetrachloride associated with the former CCC/USDA facility.

3.2.1.2 Mississippian Aquifer

Fractured, fossiliferous, cherty, and ferruginous to argillaceous ("brown bed") limestones and dolomitic limestones of the Burlington-Keokuk and undifferentiated Chouteau Group compose the primary lithologies of the Mississippian aquifer. In the Montgomery City area, these units have a combined thickness of approximately 95-195 ft, with the thickest deposits identified to date at municipal well PWS2, to the northwest of the former CCC/USDA facility (Figures 3.1 and 3.2). Reported yields of groundwater to wells from the Mississippian aquifer are typically low, however, ranging from 5 gpm to 15 gpm.

To date, no distinct units have been recognized locally that might restrict vertical groundwater infiltration from the unconsolidated sediments into the underlying Mississippian aquifer. This is in contrast to the situation for the deeper aquifer units of the Cambrian-Ordovician aquifer complex (Section 3.2.1.1).

Lithologic logs for the wells illustrated in Figure 3.2 and several others in the vicinity of the former CCC/USDA facility (included in Appendix B of the Phase I *Work Plan* [Argonne 2010]) frequently record approximately 10-40 ft of chert, clay, and limestone material, described as "residuum," beneath the unconsolidated till and directly overlying the Burlington-Keokuk limestones at Montgomery City. The reported depths to the tops of these deposits (approximately 50-85 ft BGL) generally correspond to the refusal depths achieved by the direct-push techniques used in the Phase I work.

Recent MDNR publications indicate that these "residuum" materials likely represent the Pennsylvanian Graydon Conglomerate, which predominantly contains residual chert derived

from the underlying Mississippian formations. The chert clasts in the Graydon reportedly range from gravel to boulder size, possibly occurring in a matrix of clay and silt to pebble-size particles (MDNR 2005, 2006b). The potential vertical (or horizontal) permeability of this unit is not documented for the Montgomery City area.

3.2.2 Installation of Investigative Borings

Conventional (sonic) drilling techniques will be used to determine the detailed characteristics of the deeper unconsolidated sequence (beyond the depths at which CPT refusal was encountered during the Phase I field investigation) and the shallow bedrock sequence in the vicinity of the former CCC/USDA facility. Investigative borings are proposed at up to five locations, to depths potentially ranging from 100 ft to 350 ft BGL. The actual depths penetrated will be determined in the field, on the basis of the specific lithologic and hydrogeologic conditions at each location. Recommended Phase II boring locations 1-5 are shown in Figures 3.3 and 3.4.

3.2.2.1 Borings 1 and 2

Proposed locations 1 and 2 correspond to the two primary carbon tetrachloride hot-spot areas identified in soil and groundwater during Phase I (Section 2). At each of these locations, the vertical profile of carbon tetrachloride identified and the local groundwater level relationships suggest that the locations represent preferred (source) areas for vertical contaminant migration through the unconsolidated soil column and hence possibly into the underlying shallow (Mississippian) bedrock units.

3.2.2.2 Borings 3 and 4

Relatively little is documented concerning the possible movement of groundwater in the Mississippian aquifer in the immediate Montgomery City area. Historic groundwater level data (Imes 1985) suggested that flow in the Mississippian aquifer near the former CCC/USDA facility might be toward the southwest, where erosion along the Loutre and Missouri Rivers (and their tributaries) has penetrated the Mississippian and deeper strata. In reviewing the Montgomery

City site, however, the MDNR noted that groundwater flow in this unit is "reportedly to the north" (MDNR 2001); no supporting data for this interpretation were provided.

To establish an array of investigative points suitable for the determination of potential groundwater flow direction(s) and to obtain hydrogeologic information related to the possible directions of groundwater flow suggested above, borings 3 and 4 will be positioned to the north-northwest and south-southwest, respectively, of the primary contamination hot-spot area to be tested at boring 1 (Figures 3.3 and 3.4).

3.2.2.3 Boring 5

Proposed boring 5 will be located near the interpreted downgradient margin of the carbon tetrachloride distribution in groundwater in the lower monitoring interval (Figure 3.4). This location was selected, at the request of the MDNR (2012), to help identify potential carbon tetrachloride contamination that might have migrated in the deeper stratigraphic sequence, beyond the limits of the groundwater plume identified in the Phase I studies.

3.2.2.4 Drilling Methods

At each of the proposed Phase II locations, conventional (sonic) drilling techniques will be used to obtain continuous cores of the bedrock sequence to a depth to be determined in the field, reflecting the first groundwater-bearing unit that is free of carbon tetrachloride contamination. The hydrogeologic sequence will be characterized, through hydraulic testing of selected intervals as necessary, to identify potential water-bearing and confining intervals. Samples of the cored materials might also be collected at selected depths (to be determined in the field) for laboratory measurements of porosity and permeability.

If the results of these analyses suggest that further investigation of the hydraulic properties of the bedrock units is warranted, the proposed installation of monitoring wells (Section 3.2.3) will provide an avenue for conducting single-well ("slug") or possibly multiple-well (pumping) tests to obtain additional *in situ* estimates of the local hydraulic conductivity, subject to the approval of the CCC/USDA and MDNR program managers.

3.2.3 Installation of Permanent Groundwater Monitoring Wells

At each proposed Phase II location, the installation of a permanent monitoring well is recommended if the hydrogeologic conditions are suitable. The wells will facilitate the measurement of groundwater levels, possible hydraulic testing, and groundwater sampling (see Section 3.3). The exact depth interval(s) to be screened will be determined during the field activities.

At each of the monitoring well locations, automatic sensors and data loggers will be installed to acquire records of groundwater level fluctuations and hence potential flow directions in the shallow bedrock. A minimum observation period of one year is recommended, to document possible short- or longer-term influences on the patterns of groundwater levels. Manual water level measurements will also be made periodically.

3.3 Phase II Task: Characterize the Distribution and Concentrations of Carbon Tetrachloride in Groundwater in the Bedrock Sequence

To the extent permitted by the hydrologic characteristics of the bedrock sequence penetrated, groundwater samples will be collected for VOCs analyses from each groundwater-bearing, permeable interval identified. If the hydrologic conditions warrant the installation of permanent monitoring wells, the wells will also be sampled for VOCs analyses after they have been completed and developed in accord with MDNR requirements (MDNR 2009), with the approval of the MDNR program manager.

3.4 Phase II Task: Conduct Sub-Slab Vapor Sampling

The MDNR (2012) has suggested sub-slab vapor sampling for buildings within 100 ft laterally of the identified groundwater contamination. In consultation with the MDNR program manager, suitable locations for sub-slab sampling will be identified at (1) the multi-purpose building and (2) the “4-H building” (as referred to by the Fairgrounds staff) at the southern margin of the investigation area. If access to suitable locations is granted by the Fair Society Board, the sub-slab sampling will be conducted as part of the Phase II investigation.

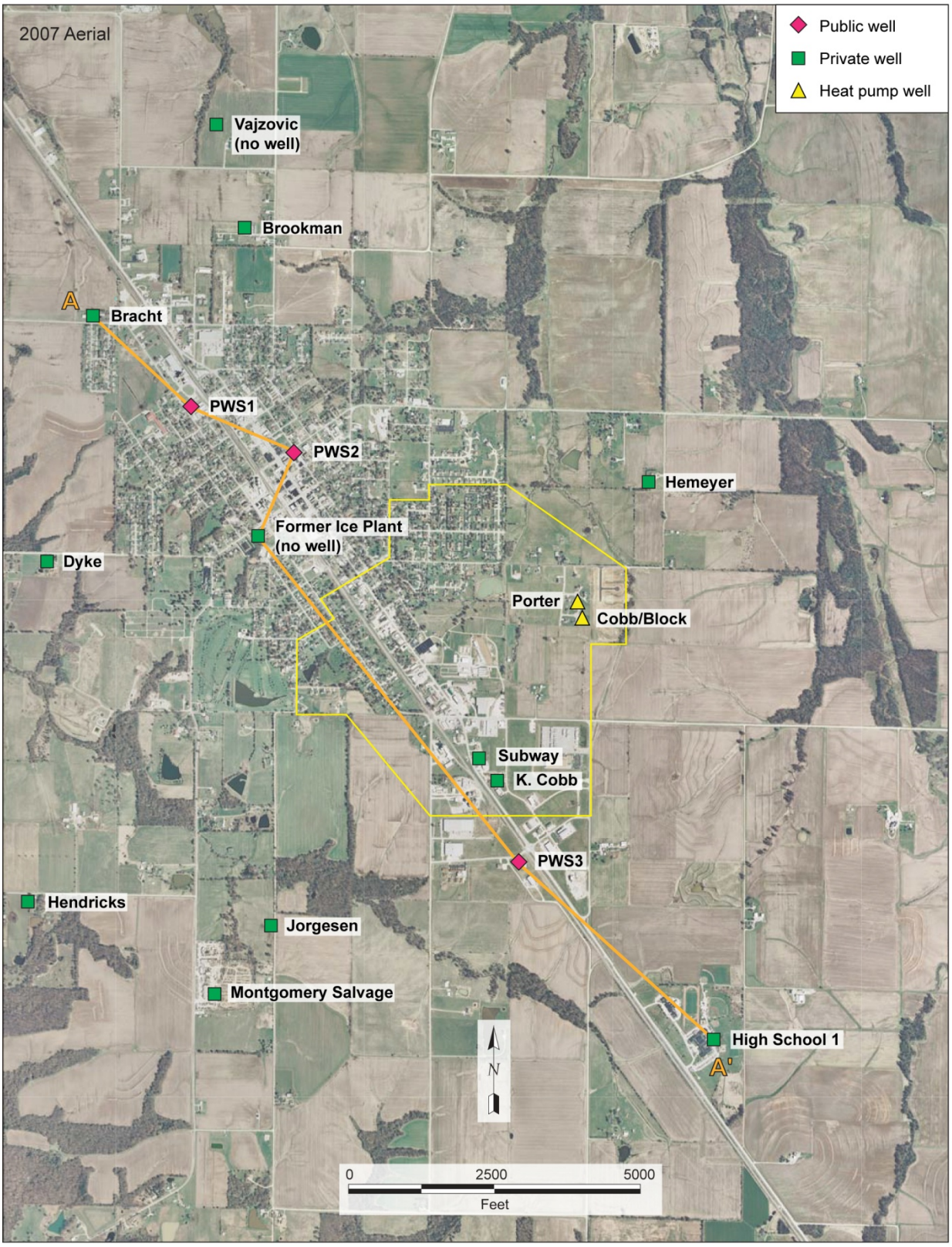

FIGURE 3.1 Locations of public water supply wells and private wells outside the Montgomery County Fairgrounds that were investigated in Phase I, with the location of hydrogeologic cross section A-A′. Source of photograph: NAIP (2007).

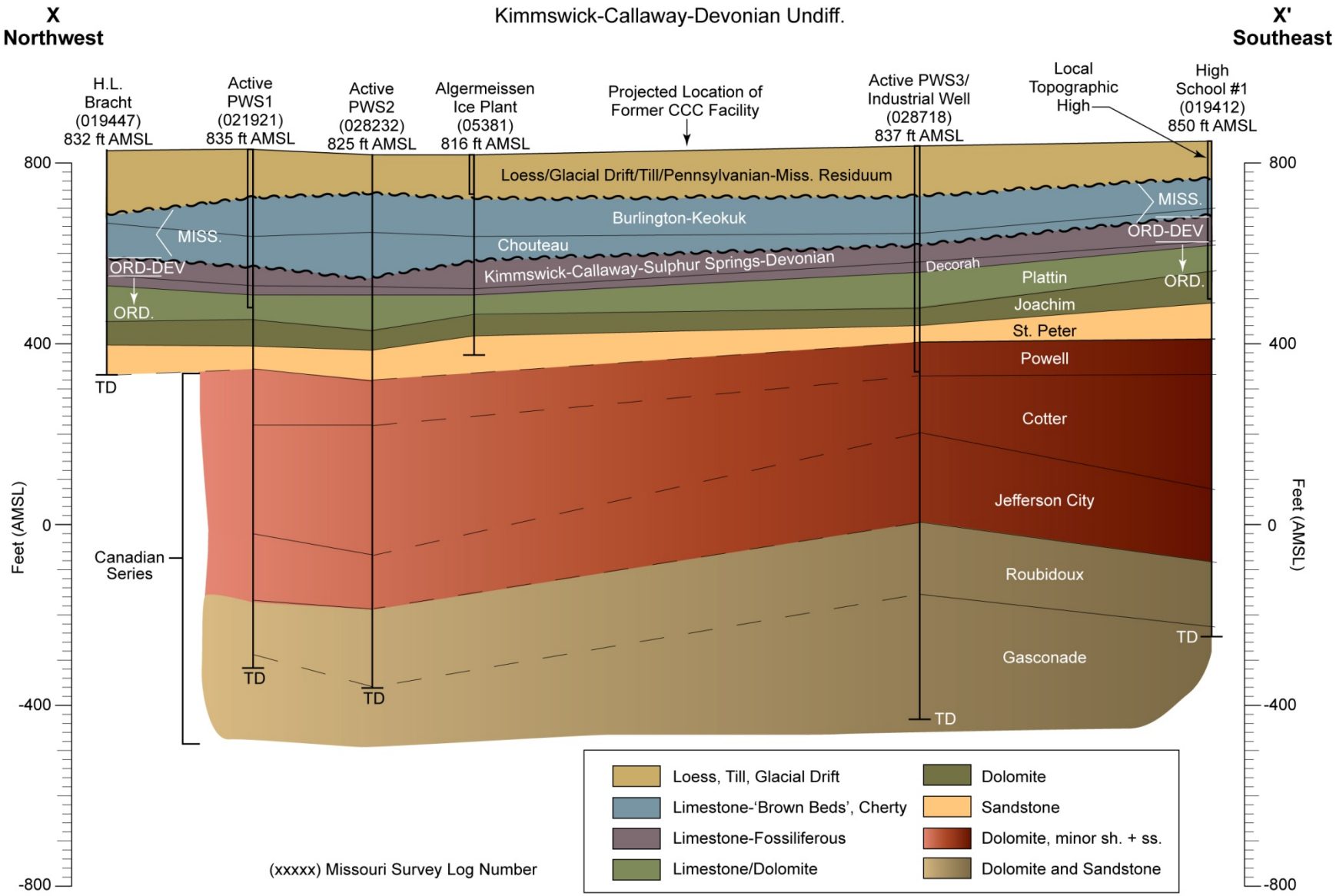

FIGURE 3.2 Northwest-to-southeast geologic cross section X-X′ (vertically exaggerated), illustrating the stratigraphic relationships near the former CCC/USDA facility.

FIGURE 3.3 Proposed bedrock boring locations relative to the maximum carbon tetrachloride concentrations identified in soils. Source of photograph: NAIP (2009).

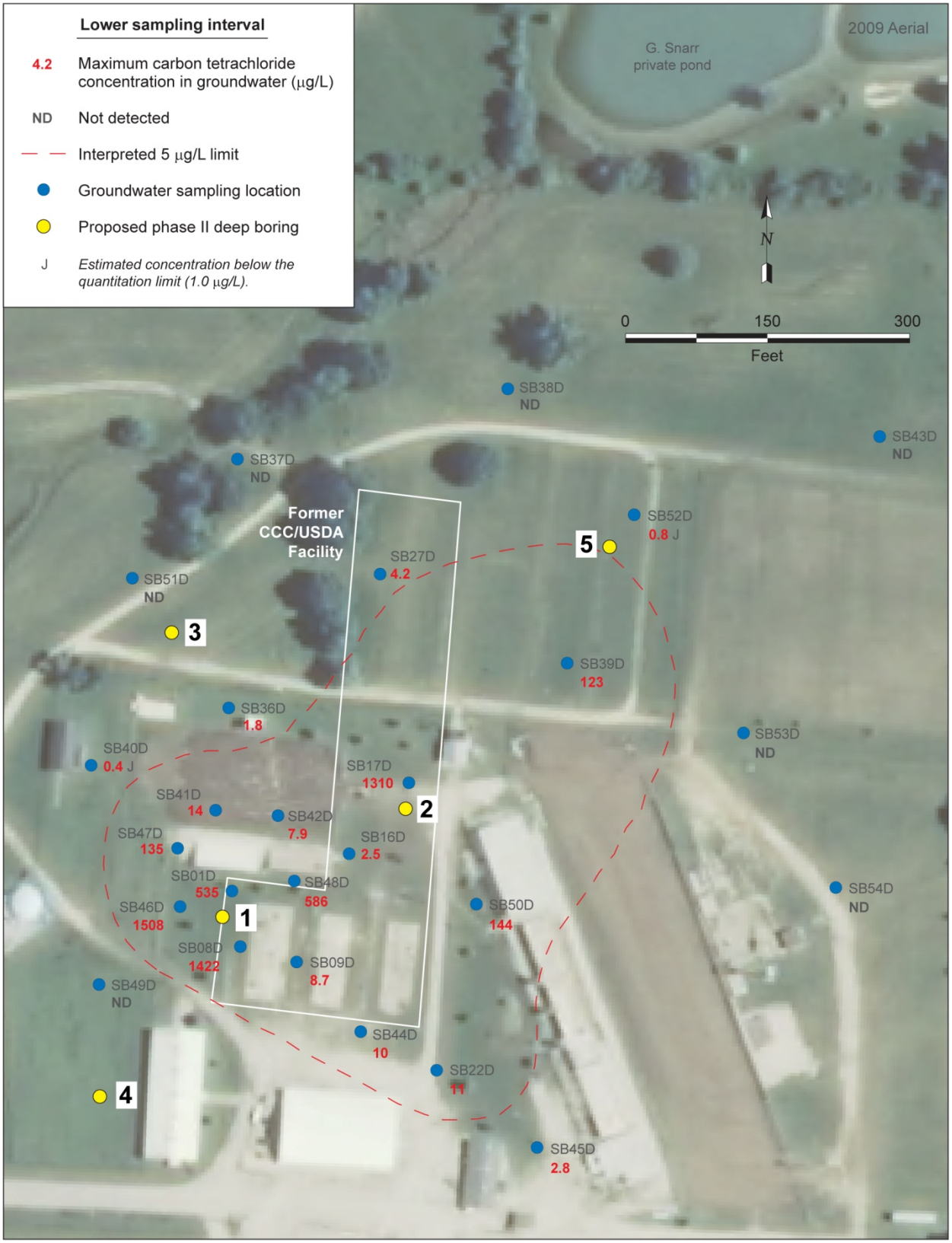

FIGURE 3.4 Proposed bedrock boring locations relative to the carbon tetrachloride concentrations identified in groundwater in the lower sampling interval (> 40 ft BGL). Source of photograph: NAIP (2009).

4 Investigative Methods

The Phase II work at Montgomery City will be implemented in accord with the standard operating procedures, quality assurance/quality control measures, and general health and safety policies outlined in the *Master Work Plan* (Argonne 2002) for operations in Kansas, which has been reviewed by the MDNR and accepted for current use. This section summarizes the site-specific approach, technologies, and methods recommended for the Phase II program outlined in Section 3. All work during the proposed Phase II activities will be conducted in accord with applicable Missouri regulations.

The Phase I *Work Plan* (Argonne 2010) describes the detailed, site-specific community relations procedures and health and safety information for use throughout the work at Montgomery City. That *Work Plan* was approved by the MDNR (2010). Brief updates to these site-specific procedures and information are in Sections 5 and 6.

4.1 Proposed Field Sessions and Scheduling

The Phase II investigation will be conducted in one primary field session. The activities will include (1) drilling and casing of the unconsolidated sequence and (2) drilling and coring of the shallow bedrock sequence for hydrogeologic characterization, the installation of permanent monitoring wells and automated groundwater level monitoring units (if technically warranted), and (3) the collection of groundwater samples for VOCs analyses.

Mobilization of the required equipment and personnel is expected on April 17-20, 2012. The investigative activities will begin on April 23, 2012, with MDNR oversight. The field work will be conducted in 10-days-on, 4-days-off cycles. Two 10-day work periods are projected for completion of the field program outlined here.

Groundwater level data accumulated by the automatic water level sensors and data loggers installed during Phase I and Phase II will be retrieved quarterly.

4.2 Methods for Drilling and for Collecting and Logging of Cores

Continuous cores obtained in Phase I provide a record of the unconsolidated sequence in the vicinity of each of the proposed Phase II boring locations, to the maximum depth of penetration achieved by the CPT. Near proposed locations 1, 2, and 4, penetration depths of 58-61 ft BGL were reached (at Phase I borings SB01, SB08, SB17, and SB49). Near proposed locations 3 and 5, the maximum depths achieved by the direct-push technology were approximately 50 ft BGL (at Phase I borings SB51 and SB52; Figures 3.3 and 3.4).

At each proposed boring location identified in Section 3.2.2, continuous cores of the deeper unconsolidated sequence (beyond the penetration depths noted above) and the shallow bedrock sequence will be obtained, to the extent possible. The objectives will be to determine the lithologies present and their stratigraphic distribution, to identify potential hydrostratigraphic zones, and possibly to sample for VOCs and physical properties analyses. The drilling and coring tasks will be performed by using a sonic drilling rig. The crew is licensed for operation in Missouri, per state requirements (Boart-Longyear Drilling Company; Missouri Certified Driller's License Permit #4484-M).

The drilling will be conducted by using a 6-in.-diameter inner core barrel and drill pipe to recover nominal 4-in.-diameter cores in approximate 10-ft depth increments. The drilling will take place within an 8-in.-diameter override casing, which will be advanced as the coring progresses to prevent potential cross-contamination of the deeper stratigraphic intervals by any contamination that might be present at shallower depths. Decontamination of the drilling rig, tools, and equipment will be performed, as needed, by the use of a hot-water pressure washer, to ensure the integrity of the media sampled for laboratory analyses at each boring (soils and/or groundwater; see Sections 4.5 and 4.6).

All cores will be logged in accord with procedures in the *Master Work Plan* (Argonne 2002). Representative materials from each boring will be archived at an Argonne facility upon completion of the field program for future reference.

4.3 Methods for Hydraulic Testing

Visual inspection will be used to identify the presence of fractured (or otherwise permeable) intervals potentially capable of hosting and conveying groundwater. If direct visual

methods prove insufficient for the identification of groundwater-bearing zones, testing will be conducted (as requested by the MDNR) to assess the hydraulic characteristics of the stratigraphic units penetrated. Equipment including suitable inflatable single packers and straddle packers, riser pipe, and pumps will be employed as necessary to permit the isolation of depth intervals of interest in the open 6-in. borehole. The specific testing to be conducted at each interval will be determined in the field, in consultation with the MDNR program manager.

Information about the inflatable packers to be used is at this location: http://www.tamintl.com/images/stories/pdfs/Hydro_Geo%20SD_LI.pdf.

4.4 Methods for the Construction of Monitoring Wells

At each proposed Phase II location, the installation of a permanent monitoring well is recommended if the hydrogeologic conditions are suitable. Each well will employ nominal 2-in.-diameter, Schedule 80, polyvinyl chloride (PVC) casing and a standard 10-ft screen, in accord with discussions with the MDNR program manager and applicable regulations for the installation of groundwater monitoring wells (MDNR 2005).

Each well will be constructed with a primary filter pack extending 2 ft above the top of the screened interval and a 2-ft-thick secondary filter pack. A 2-ft bentonite seal will be placed above the secondary filter pack, and the annulus will be grouted with bentonite grout slurry to at least 2 ft above the base of the outer 8-in. casing. A tremie pipe will be used to place the downhole materials. The remaining annulus will be pressure-grouted as the override casing is removed from the hole. In keeping with previous (Phase I) requests from the Montgomery County Fair Board, it is anticipated that the wells will be installed with flush-mounted surface completions.

4.5 Sampling and Analysis Methods for Unconsolidated Soils

As noted in Section 4.2, penetration depths of approximately 50-61 ft BGL were achieved in the Phase I investigation by using direct-push techniques. If additional, deeper unconsolidated soils are encountered at the proposed Phase II boring locations, these materials will be sampled, at intervals of 4-10 ft with depth, for VOCs analysis to provide a vertical profile of the potential contaminant distribution in these soils to the top of bedrock.

The soil samples will be placed immediately in jars, sealed, preserved on dry ice, and shipped by overnight service to the Applied Geosciences and Environmental Management (AGEM) Laboratory at Argonne for analysis by (1) a headspace method with a gas chromatograph and electron capture detector (modified EPA Method 5021) and (2) a purge-and-trap sample preparation method with analysis by gas chromatography-mass spectrometry (EPA Methods 5030B and 8260B; *Master Work Plan* [Argonne 2002], Sections 6.1.1, 6.2, and 6.3.1).

4.6 Sampling and Analysis Methods for Groundwater

To the extent possible, groundwater samples will be collected for VOCs analyses from the identified permeable intervals in the bedrock sequence at each boring location. If sufficient groundwater accumulates in the boring as it is advanced through an interval, groundwater will be sampled by using a bailer. If warranted, groundwater samples might also be obtained (in the open borehole) from selected depth intervals, by using the packer-and-riser techniques described in Section 4.3.

Groundwater samples for VOCs analyses will also be collected from any Phase II monitoring wells installed, after they have been completed and developed and the groundwater level in each well has stabilized. This sampling will be conducted by the low-flow purging and sampling technique described in EPA guidelines (Puls and Barcelona 1996; Yeskis and Zavala 2002). The low-flow sampling procedure to be used is in Appendix A.

Water samples collected for the determination of VOCs will be preserved on ice at 4°C and shipped overnight to the Applied Geosciences and Environmental Management Laboratory at Argonne for quantitation by the purge-and-trap sample preparation method and analysis on a gas chromatograph-mass spectrometer system (EPA Methods 5030B and 8260B; Argonne 2002). To ensure reproducibility, a minimum of 10% of the water samples will be selected for verification analysis by a second laboratory (TestAmerica Laboratories, South Burlington, Vermont) with the EPA's Contract Laboratory Program methods. An index to the EPA methods is online (http://www.epa.gov/epahome/index/).

4.7 Water Level Monitoring

Groundwater levels will be monitored continuously in the proposed new monitoring wells by using programmable downhole pressure sensing and data logging units (Instrumentation Northwest PT2X™ devices). These data loggers will be programmed to record one measurement every 4 hr, to coincide with the measurements currently being collected in selected Phase I monitoring wells. The data from the Phase I and Phase II loggers will be retrieved quarterly, in conjunction with the manual measurement of groundwater levels in the complete network of monitoring points at the site. Automated monitoring in the combined Phase I and Phase II wells is recommended for a minimum of one year, to document short- or long-term influences on the local groundwater levels (Argonne 2002).

5 Community Relations Plan

The detailed community relations plan in the Phase I *Work Plan* (Argonne 2010) describes the background of the Montgomery City community and outlines the site-specific community relations objectives and activities to be implemented by the CCC/USDA and Argonne throughout all phases of the investigation program at this site.

The updated contact list for use during Phase II work is below. This list includes federal, state, and local officials; interest groups; interested citizens; media representatives; individuals living or working near the site; and Argonne contacts.

Federal Elected Officials

Senator Claire McCaskill
Washington, D.C., Office
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Washington, DC 20510
202-224-6154

Senator Claire McCaskill
Columbia Office
915 East Ash Street
Columbia, MO 65201
573-442-7130
573-442-7140 (fax)

Senator Roy Blunt
Washington, D.C., Office
260 Russell Senate Office Building
Washington, DC 20510
202-224-5721

Senator Roy Blunt
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1001 Cherry Street, Suite 104
Columbia, MO 65201
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Congressman Blaine Luetkemeyer
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202-225-2956
202-225-5712 (fax)

Congressman Blaine Luetkemeyer
District Office
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Columbia, MO 65201
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753-886-8901 (fax)

State Elected Officials

Governor Jay Nixon
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Room 216, State Capitol Building
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573-751-3222
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State Senator Frank Barnitz
State Senate, District 16
Room 427, State Capitol Building
Jefferson City, MO 65101
573-751-2108
Frank.Barnitz@senate.mo.gov

State Representative Mike Sutherland
State House of Representatives, District 99
201 West Capitol Avenue
Room 112
Jefferson City, MO 65101
573-751-2689
Mike.Sutherland@house.mo.gov

Local Officials

Elected Montgomery City Officials

Mayor: Jeff Porter
Board of Aldermen:
Ward 1 Aldermen: Tom Benney, Mike Spirz
Ward 2 Aldermen: Dr. Tom Nichols, John Schneider
City Hall
723 N. Sturgeon
Montgomery City, MO 63361
Telephone 573-564-3160
Fax 573-564-3802
http://www.montgomerycitymo.org
Hours: Monday-Friday, 7:30 a.m. to 4:30 p.m.; closed for lunch, 12 noon to 1 pm.

Montgomery City Administration

City Administrator/Clerk: Steven Deves
City Treasurer: Linda Block
City Collector: Jill Dunlap
Police Chief: Phil Ahern
Superintendent of Public Works: Dorsey Stotler
Superintendent of Public Utilities: Russell Burton

Montgomery County Officials

Montgomery County Commission
211 East Third
Montgomery City, MO 63361
573-564-8091

Montgomery County Clerk
211 East Third
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Citizens and Other Interested Parties

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Joe VanBooven, Board Chairman
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573-690-3066 (cellular)
info@montgomerycountyfair.org

Mary Carroz (Rentals)
Montgomery County Fair Society
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Montgomery City, MO 63361
573-359-4941 (cellular)
info@montgomerycountyfair.org

Montgomery County Public Water Supply District #1
22673 NW Service Road
Warrenton, MO 63383
(636) 456-8227

Newspaper

The Montgomery Standard
115 West Second Street
Montgomery City, MO 63361
573-564-2339

Argonne Contacts

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6 Health and Safety Plan

The general health and safety plan for use at Montgomery City is in Section 3 of the *Master Work Plan* (Argonne 2002). The general plan addresses all anticipated safety issues for the activities to be conducted. Specific emergency information for use at Montgomery City is in Figure 6.1 and Table 6.1.

Montgomery City has 911 service for all emergency responses. The city has its own police force. In addition, personnel from the Montgomery County Sheriff's Office and Fire Protection District Station No. 1, located in the town, respond to 911 calls.

A local medical clinic (Associated Medical Arts) located within 1 mi of the former CCC/USDA facility is open Monday-Friday from 8:00 a.m. to 12:15 p.m. and from 1:00 p.m. to 5:00 p.m. Major medical services are provided by the Hermann Area Regional Hospital in Hermann, Missouri, approximately 23 mi southeast of the town (Figure 6.1).

TABLE 6.1 Emergency information for the investigation at Montgomery City.[a]

Resource	Telephone Number	Name
All Emergencies	911	Montgomery County 911
Hospital, Poison Control	573-486-2191	Hermann Area District Hospital[b] 509 West 18th St. Hermann, MO 65041
Medical Services	573-564-2990	Associated Medical Arts 504 North Sturgeon St. Montgomery City, MO 63361
Police (nonemergency)	573-564-2511	Montgomery City Police Department 723 North Sturgeon St. Montgomery City, MO 63361
Sheriff (nonemergency)	573-564-3378	Montgomery County Sheriff 211 East 3rd St. Montgomery City, MO
Industrial Hygiene	630-252-3310	Argonne-Industrial Hygiene
Safety	630-988-9706	EVS Division[c] Field Safety Coordinator (Monte Brandner)
	630-252-4878	EVS Division[c] Environmental, Safety, and Health Coordinator (Bill Gasper)
Management	630-252-7969	AGEM Program Manager (Lorraine LaFreniere)
	630-252-1275 630-408-7114	AGEM Field Project Manager (David Surgnier) (cellular)
	630-252-9609 402-465-9021	AGEM Technical Project Manager (Robert Sedivy)
Security		Argonne-Operations Security
	630-252-5737 630-252-5731	Workdays After hours and weekends
Utilities Survey	800-344-7483 800-DIG RITE	Missouri Location Service

[a] Post this table in the field operations base.
[b] The route from Montgomery City to the Hermann Area District Hospital is shown in Figure 6.1.
[c] Environmental Science Division at Argonne.

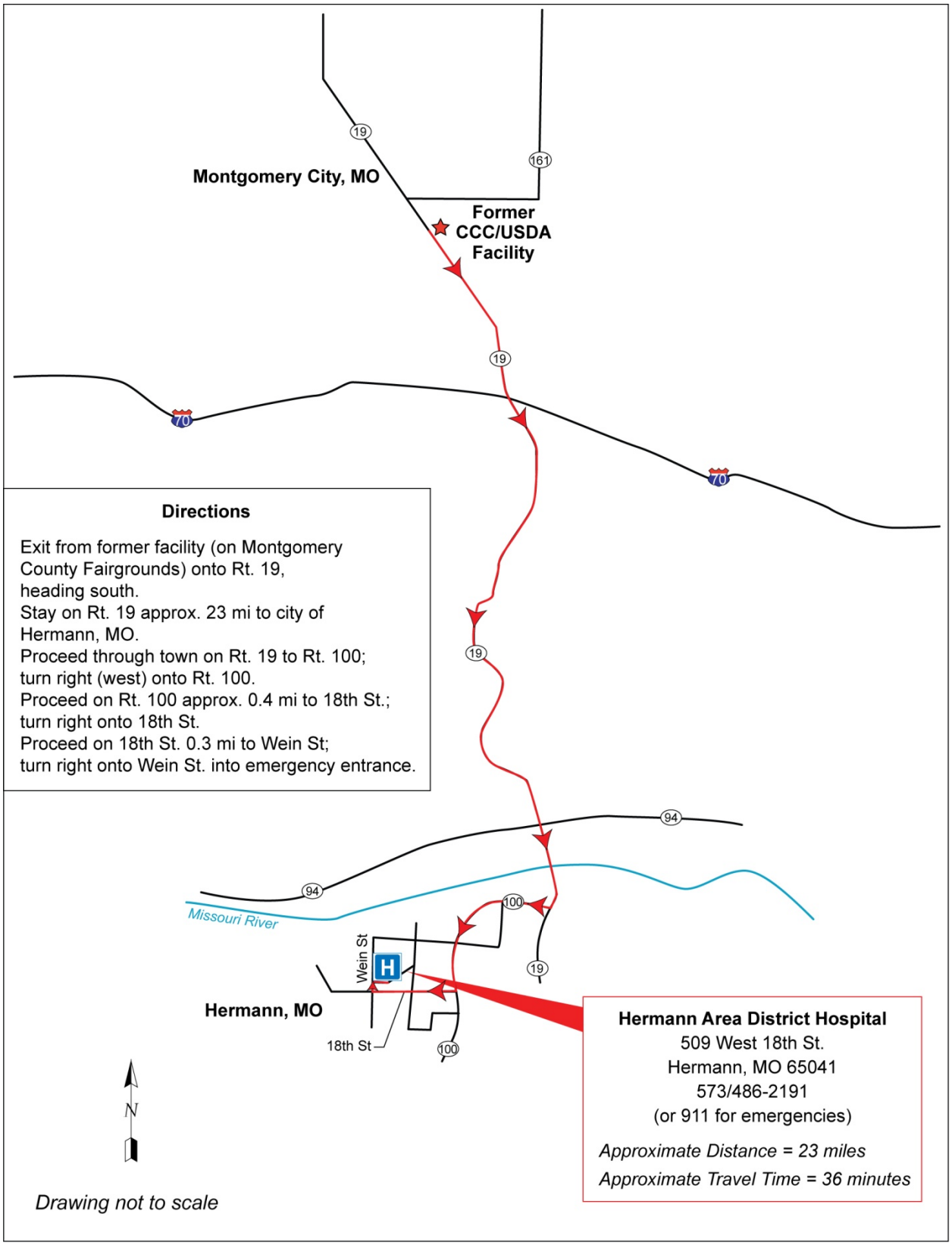

FIGURE 6.1 Emergency route from Montgomery City to the Hermann Area District Hospital, Hermann, Missouri.

7 References

Argonne, 2002, *Final Master Work Plan: Environmental Investigations at Former CCC/USDA Facilities in Kansas, 2002 Revision*, ANL/ER/TR-02/004, prepared for Commodity Credit Corporation, U.S. Department of Agriculture, Washington, D.C., by Argonne National Laboratory, Argonne, Illinois, December.

Argonne, 2010, *Final Work Plan: Phase I Investigation of Potential Contamination at the Former CCC/USDA Grain Storage Facility in Montgomery City, Missouri*, ANL/EVS/AGEM/TR-09-08, prepared for the Commodity Credit Corporation, U.S. Department of Agriculture, Washington, D.C., by Argonne National Laboratory, Argonne, Illinois, June.

Emmett, L., and J. Imes, 1984, *Ground-Water Resources of Audrain County, Missouri*, Open-File Report 84-245, U.S. Geological Survey, Washington, D.C., prepared in cooperation with Division of Geology and Land Survey, Missouri Department of Natural Resources, Rolla, Missouri.

Imes, J., 1985, *The Ground-Water Flow System in Northern Missouri with Emphasis on the Cambrian-Ordovician Aquifer*, Professional Paper 1305, U.S. Geological Survey, Washington, D.C.

MDNR, 2001, *Preliminary Assessment/Site Inspection Report, Montgomery City Former USDA Grain Bin Site, Montgomery County, Missouri*, Hazardous Waste Program, Division of Environmental Quality, Missouri Department of Natural Resources, Jefferson City, Missouri, September 19.

MDNR, 2005, *Bedrock Geologic Map of the New Florence 7.5' Quadrangle, Montgomery County*, OFM-05-504-GS, Division of Geology and Land Survey, Missouri Department of Natural Resources, Rolla, Missouri.

MDNR, 2006a, *Missouri Risk-Based Corrective Action (MRBCA): Departmental Technical Guidance*, Division of Environmental Quality, Missouri Department of Natural Resources, Jefferson City, Missouri, final draft with updates (http://www.dnr.mo.gov/env/hwp/mrbca/mrbca.htm).

MDNR, 2006b, *Bedrock Geologic Map of the Montgomery City 7.5' Quadrangle, Montgomery County*, OFM-06-516-GS, Division of Geology and Land Survey, Missouri Department of Natural Resources, Rolla, Missouri.

MDNR, 2009, *Missouri Well Construction Rules: Private Water Wells, Heat Pump Systems, Pump Installations, and Monitoring Wells*, Publication 2175, Division of Environmental Quality, Missouri Department of Natural Resources, Rolla, Missouri, August (http://www.dnr.mo.gov/pubs/pub2175.pdf).

MDNR, 2010, letter from S. Muenks (Hazardous Waste Program, Missouri Department of Natural Resources, Jefferson City, Missouri) to S. Gilmore (Commodity Credit Corporation, U.S. Department of Agriculture, Washington, D.C.), indicating MDNR approval of the Phase I *Work Plan* for the Montgomery City investigation, June 17.

MDNR, 2011, electronic mail message from S. Muenks (Hazardous Waste Program, Missouri Department of Natural Resources, Jefferson City, Missouri) to S. Gilmore (Commodity Credit Corporation, U.S. Department of Agriculture, Washington, D.C.), indicating MDNR approval of the additional activities recommended by Argonne for the Montgomery City investigation, April 7.

MDNR, 2012, letter from S. Muenks (Hazardous Waste Program, Missouri Department of Natural Resources, Jefferson City, Missouri) to S. Gilmore (Commodity Credit Corporation, U.S. Department of Agriculture, Washington, D.C.), regarding the draft Phase II *Work Plan*, April 9.

Miller, D., and J. Vandike, 1997, *Groundwater Resources of Missouri*, Missouri State Water Plan Series Volume II, Division of Geology and Land Survey, Missouri Department of Natural Resources, Rolla, Missouri.

Puls, R.W., and M.J. Barcelona, 1996, "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures," EPA/540/S-95/504, in *Ground Water Issue*, Superfund Technology Support Center for Ground Water, National Risk Management Research Laboratory, U.S. Environmental Protection Agency, Ada, Oklahoma, April (www.epa.gov/tio/tsp/download/lwflw2a.pdf).

Yeskis, D., and B. Zavala, 2002, *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers: Ground Water Forum Issue Paper*, EPA 542-S-02-001, Technology Innovative Office, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C., May (http://www.epa.gov/tio/tsp/download/gw_sampling_guide.pdf).

Appendix A:

SOP AGEM-35: Low-Flow Groundwater Sampling

Master Work Plan: Environmental Investigations at Former CCC/USDA Facilities

Volume 2: Standard Operating Procedures

SOP AGEM-35: Low-Flow Groundwater Sampling

Prepared by
Field Project Manager _____ Date: 7-08-09

Approved by
AGEM Program Manager _____ Date: 7/8/09

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1.0 Scope and Applicability

The purpose of this SOP is to establish a method for low-flow groundwater purging and sampling of monitoring wells. The objective of groundwater sampling is to generate reproducible, representative, verifiable, legally defensible data for concentrations of chemicals in groundwater. Monitoring wells are purged before sampling because water in the well casing is not considered representative of formation water in the aquifer (Puls and Barcelona 1996; Yeskis and Zavala 2002).

Purging a large volume or an arbitrary number of “well volumes” increases the pumping radius of influence in the aquifer and leads to analytical results for a sample that represents an average value in a large volume of water. Purging at rates in excess of site hydrogeologic conditions (1) causes excessive drawdown in the well; (2) pulls stagnant water into the screened interval; (3) mixes chemically distinct waters; and (4) causes aeration, turbulence, and redevelopment of the well. In thin or narrow contaminant plumes (which are common), the mixing of chemically distinct waters can result in dilution and yield misleading data concerning contaminant concentrations and concentration gradients. High-volume purging is time-consuming and costly, and it results in the generation of large volumes of potentially contaminated water that must be managed as investigation-derived waste.

Low-flow (also called low-stress) purging and sampling addresses the problems associated with historical large-volume well purging practices. “Low-flow” refers to the velocity at which water enters the pump intake from the formation water in the immediate vicinity of the well screen. The major objective of low-flow purging is to minimize stress by keeping the pumping rate consistent with the natural flow rate of groundwater in the aquifer or water-bearing zone.

2.0 Responsibilities

The field project manager, or another designee of the AGEM program manager, is responsible for

- Verifying that the personnel implementing this SOP understand the procedure and are capable of implementing it correctly and
- Overseeing all groundwater sampling and ensuring that it is performed in accordance with the *Master Work Plan*, the project-specific sampling plan, and this and other SOPs.

Personnel conducting the field sampling are responsible for

- Implementing this SOP as directed;
- Collecting, handling, and shipping samples in accordance with applicable SOPs; and
- Recording all pertinent data on the AGEM Low-Flow Groundwater Purging and Sampling Record (Attachment 1).

3.0 Health and Safety

General health and safety guidelines are in the *Master Work Plan*, Section 3. Site-specific health and safety information is issued in a site-specific health and safety plan for each field project.

Low-flow groundwater sampling requires Level D personal protection. Specific health and safety hazards include the following:

- Slips, trips, and falls at well locations.
- Dermal exposure to potentially contaminated groundwater.
- Possible injuries to arms, shoulders, and back resulting from transport of equipment to and from well locations with insufficient attention to good ergonomic practice.
- Weather-related heat or cold stress.

4.0 Method Summary

Before sampling, measure the groundwater level in each well and the well depth.

Implement low-flow groundwater sampling techniques according to U.S. Environmental Protection Agency guidelines (Puls and Barcelona 1996; Yeskis and Zavala 2002) by using a bladder pump and appropriate field equipment to determine when representative formation water is entering the well casing during pumping.

Periodically measure static water levels and monitor the levels of pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO), in order to determine when a sample representative of formation water can be collected.

5.0 Procedure

5.1 Supplies Needed

- Electronic water level indicator and weighted tape with marked intervals of 0.01 ft for measuring the depth to water.
- Submersible or bladder pump with adjustable rate control.
- Generator and extension cord.
- Polyethylene tubing.

- Multi-parameter meter with flow-through cell, graduated container, stop watch, and calculator for measuring flow.
- AGEM Low-Flow Groundwater Purging and Sampling Record (Attachment 1) and indelible pen.
- Sample containers, sample labels, and chain-of-custody forms.
- Decontamination equipment and supplies.
- Disposable gloves, resealable bags, and garbage bags.
- Shipping container and ice packs.
- Drum or container for purged water.
- Well keys.
- Map of well locations and summary of well construction details.

5.2 Preparations before Sampling

1. Assemble all equipment and supplies; ensure that they are clean and in working order. Calibrate field meters. Load vehicle with equipment and supplies needed for the planned sampling event.
2. Prepare and organize sample containers for each well site. Prepare waterproof sample labels containing the following information:
    a. Site identifier
    b. Well location identifier
    c. Date and time of collection
    d. Type of analysis
    e. Unique sample identification number
3. If necessary, place plastic sheeting on the ground around the well to keep the sampling equipment clean.
4. Position sampling equipment and field instruments.

5. Check the condition of the well for damage or evidence of tampering. Unlock the wellhead. Record location, time, date, and other appropriate information on the AGEM Low-Flow Groundwater Purging and Sampling Record (Attachment 1).

6. Check the known well construction data to determine the screen interval and to calculate the volume of water in the well casing.

5.3 Step-by-Step Implementation

1. Measure the static water level in the well with an electronic water level meter.

2. Measure the total depth of the well.

3. Slowly insert the bladder pump into the well to a depth midway between the top and bottom of the screen. Keep the pump above the bottom of the casing to minimize disturbance of the solids that are typically present at the bottom of a well. If the water depth in a well is inadequate to cover the screen interval, then the AGEM program manager will determine a suitable depth for the bladder pump intake.

4. Set the pumping rate for the bladder pump to minimize drawdown during pumping. Monitor the rate by measuring the static water level periodically throughout pumping.

5. Use polyethylene tubing to connect the bladder pump to an in-line flow cell that continuously measures formation parameters including pH, temperature, specific conductivity, ORP, and DO in the in-line flow cell during pumping. Record measurements every 4 min, until three successive measurements for each parameter are within a range indicating that the formation water is stable. The ranges for formation stabilization for the specific parameters are as follows:

    a. pH, within 0.1

    b. Temperature, within 3%

    c. Specific conductivity, within 3%

    d. ORP, within ±10 mV

    e. DO, within ±0.3 mg/L

6. After stabilization of the formation water parameters occurs, disconnect the polyethylene tubing from the in-line flow cell, and pump the representative groundwater sample through the tubing and into laboratory-approved containers.

7. Keep the polyethylene tubing for each well and dedicate it for reuse at that well. Record pumping rate data for each well as a reference for subsequent sampling events.

5.4 Field Quality Control

1. Begin sampling at well locations with the least contamination; proceed systematically to the wells with the most contamination.

2. Fill the sample containers for volatile organic compounds (VOCs) analysis first. Visually check these containers to ensure that no bubbles are present.

3. Fill sample containers for additional analytes, as required by the site-specific sampling plan, in the following order:

   a. Methane

   b. Semivolatile organic compounds

   c. Inorganics and water quality parameters

4. Temporarily place all samples in a cooler with ice immediately after collection. Verify that all sample types required for the well are present.

5. Verify that all information required on sample labels and field forms is complete and that the well is locked and secured, before proceeding to the next well location.

6. Decontaminate sampling equipment between wells.

7. Collect quality control samples as appropriate, including field blank, equipment rinsates, trip blanks, replicates, and verification samples.

8. Document adherence to this SOP by completing the AGEM Low-Flow Groundwater Purging and Sampling Record (Attachment 1).

6.0 References

Puls, R.W., and M.J. Barcelona, 1996, “Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures,” EPA/540/S-95/504, in *Ground Water Issue*, Superfund Technology Support Center for Ground Water, National Risk Management Research Laboratory, U.S. Environmental Protection Agency, Ada, Oklahoma, April (www.epa.gov/tio/tsp/download/lwflw2a.pdf).

Yeskis, D., and B. Zavala, 2002, *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers: Ground Water Forum Issue Paper*, EPA 542-S-02-001, Technology Innovative Office, Office of Solid Waste and Emergency Response, U.S. Environmental

Protection Agency, Washington, D.C., May (http://www.epa.govtio/tsp/download/ gw_sampling_guide.pdf).

7.0 Related Procedures

- SOP AGEM-02, Sample and Document Management
- SOP AGEM-08, Measuring Water Levels in Wells
- SOP AGEM-10, Groundwater Sampling
- SOP AGEM-16, Equipment Decontamination
- SOP AGEM-17, Field Sample Handling, Packing, and Shipping
- SOP AGEM-18, Investigation-Derived Waste Handling and Disposal
- SOP AGEM-28, Field Measurements and Photoionization Detector Operation

8.0 Revision History

Rev. No.	Date	Section	Changes	Previous Rev. Date
0	07/08/2009	All	New SOP	None

ATTACHMENT 1: AGEM LOW-FLOW GROUNDWATER PURGING AND SAMPLING RECORD Sampler's Initials:

Site	Date	Sample Time	Well -- ID #	Casing Size	Pump Type	Pump Intake	Water Level	Well Depth
						Ft.	Ft.	Ft.

Screen Interval	Amount Of Water In Well	Well Volume	Start Pump Time	1 – Volume Purge Time	Start Meter Recording	Seconds Per Cycle	1-Vol. Purged Per Cycle	Total Amount Purged
To Feet	Feet	Liters 3x					mL	Liters

Conversion Table	Casing Size	0.5"	1.0"	2.0"	4.0"	6.0"
1-Gallon = 3.7854 liters	Liters Of Volume Per Foot	0.039	0.154	0.618	2.470	5.565

Time	Water Level	PSI Setting	Discharge Setting	Fill Setting	Fill Rate	Temp. Deg. C	S. Cond µS/cm	DO Mg/L	pH	ORP mV
						----------	+ / - 3%	+ / - 0.3	+ / - 0.1	+ / - 10MV

Iron Sample: _____mg/L CO2 _____mg/L

Notes:

[ ] 4 X 20mL for VOC's to ANL [ ] 2 X 40mL for VOC's to Test America

[ ] ____ X _____mL for _____ to _____

[ ] ____ X _____mL for _____ to _____

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