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Groundwater Potability Determination Report for Sylvan Grove, Kansas

Environmental Science Division

USDA United States Department of Agriculture

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

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Groundwater Potability Determination Report for Sylvan Grove, Kansas

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

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United States Department of Agriculture

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Notation

AGEM	Applied Geosciences and Environmental Management
AMSL	above mean sea level
BER	Bureau of Environmental Remediation
BGL	below ground level
CAS	Corrective Action Study
CCC	Commodity Credit Corporation
d	day(s)
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
GC-MS	gas chromatograph-mass spectrometer
gpm	gallon(s) per minute
hr	hour
in.	inch(es)
KDHE	Kansas Department of Health and Environment
Kh	hydraulic conductivity
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
meq/L	milliequivalents per liter
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
mi	mile(s)
MCL	maximum contaminant level
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RBSL	risk-based screening level
SMCL	secondary maximum contaminant level
TDS	total dissolved solid(s)
s	second(s)
USDA	U.S. Department of Agriculture
VOC	volatile organic compound
yr	year(s)

Groundwater Potability Determination Report for Sylvan Grove, Kansas

1 Introduction

The Commodity Credit Corporation of the U.S. Department of Agriculture (CCC/USDA) operated a grain storage facility from 1954 to 1966 at the northeastern edge of Sylvan Grove, Kansas (Figures 1.1 and 1.2). During this time, commercial grain fumigants containing carbon tetrachloride were in common use to preserve grain in storage. The CCC/USDA is in the process of preparing a Corrective Action Study (CAS) to address carbon tetrachloride contamination in groundwater on the portion of the site that it formerly leased and operated.

As stated in the Kansas Department of Health and Environment (KDHE) Bureau of Environmental Remediation (BER) policy BER-RS-045 (KDHE 2016), *Considerations for Groundwater Potability and Use Determinations* (hereafter referred to as "Potability Determination Guidance"), the KDHE considers all groundwater to be a potential source of potable water.[1] This report, however, substantiates that groundwater resources in the Cretaceous Dakota Formation—more specifically, that localized portions of water bearing strata affected by operations at the former CCC/USDA site—are non-potable. The purpose of this report, therefore, is to provide additional information to support the KDHE's decision-making process with regard to the disposition and closure of the Sylvan Grove site.

Per the Potability Determination Guidance the results of this potability evaluation will play a role in selecting the site remedial action objectives and the overall proposed path for long-term management. This report presents the data and analyses of the potability study and the results of the potability determination, which will be taken into consideration during the development of cleanup goals for the CAS or for any other future remedial or long-term management action agreed to by the CCC/USDA and KDHE.

The Potability Determination Guidance provides a framework to evaluate groundwater potability by outlining:

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1 In BER-RS-045 (KDHE 2016), potable water is defined as water suitable for drinking and cooking purposes in terms of both human health and aesthetic considerations.

- The set of threshold criteria under which KDHE will consider an aquifer to be non-potable;

- The data and information necessary to evaluate potability; and,

- Considerations for long-term management of aquifers that are deemed non-potable.

According to the guidance, the KDHE may determine that groundwater is non-potable due to natural conditions such as water quality or quantity characteristics. As suggested in the guidance, this report will discuss the initial potability threshold screening for entering the evaluation process (Section 2); justify the work plan that was covered by the site investigation planning (also in Section 2); and present the relevant data and evaluation results (Sections 3-6).

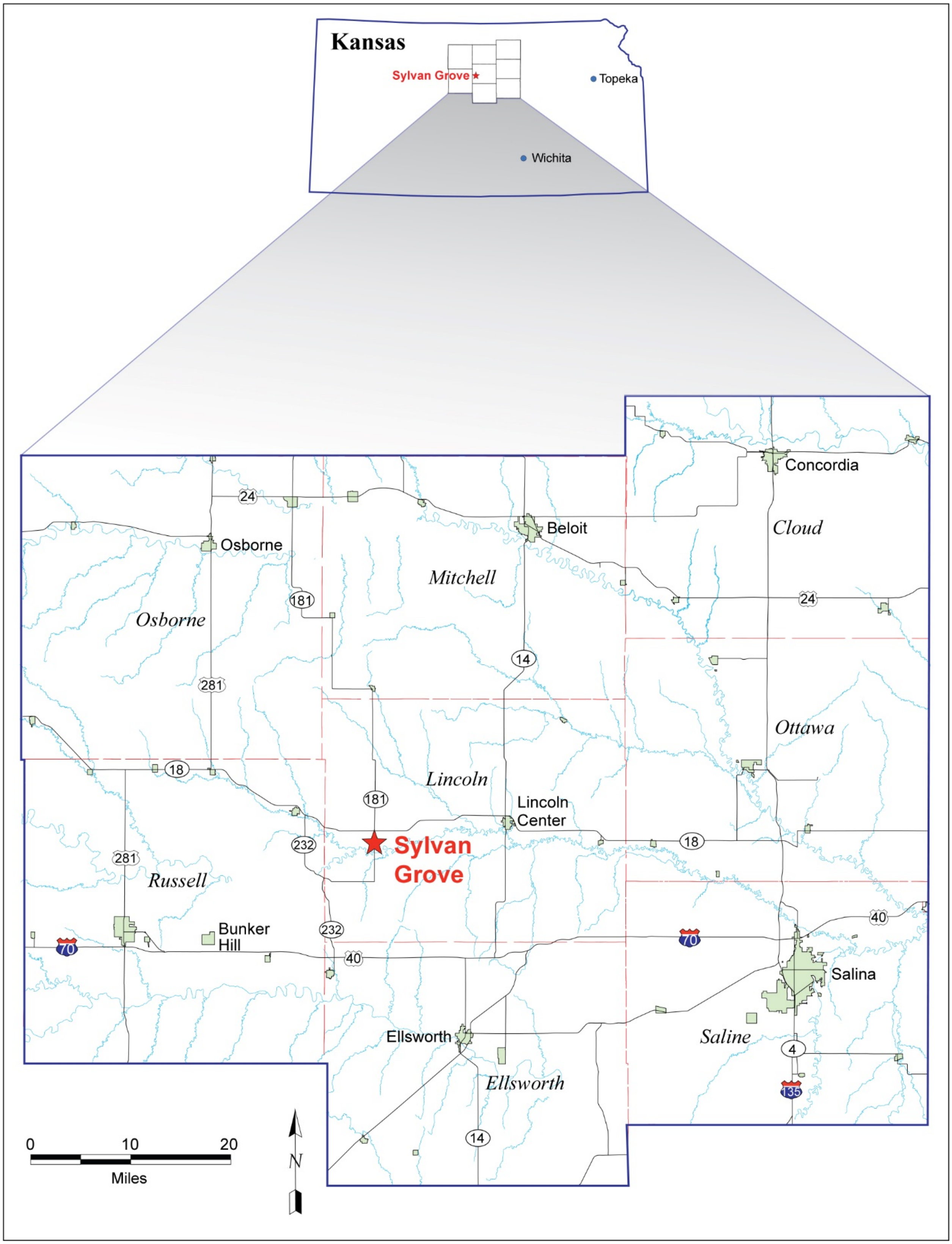

FIGURE 1.1 Location of Sylvan Grove, Kansas.

FIGURE 1.2 Locations of the former CCC/USDA facility, adjacent private wells, public water supply wells, and other contaminated sites. Source of photograph: USDA (2010).

2 Potability Threshold Criteria and Potability Evaluation Work Plan

2.1 Threshold Criteria

As specified in KDHE's Potability Determination Guidance, the following threshold criteria must be evaluated before proceeding to a potability evaluation:

- Identification of potential users;
- A general understanding of the nature, extent, and magnitude of contamination associated with a site/contaminated property;
- Underlying groundwater bearing zones;
- Exposure pathways; and
- Interactions between groundwater and surface waters.

The Potability Determination Guidance does not specify what the threshold is that must be exceeded for each criterion. However, as discussed briefly here in Section 2.1 and in greater detail in Sections 3-6, each threshold criterion has been evaluated as part of the work performed by Argonne on behalf of CCC/USDA, which includes main site investigation activities in 2012-2013 (Argonne 2014) and site monitoring from 2015-2017. Following the evaluation of threshold criteria, in Section 2.2, is the evaluation of potability.

2.1.1 Identification of Potential Users

The source of water for the Sylvan Grove public supply system is the saturated fluvial deposit overlying the bedrock formation underneath the Saline River and its floodplain, bordered by the upland at the elevation of about 1,460 ft AMSL, as shown in Figure 2.1. Two active city wells (PWS5 and PWS6) were built in 1936 and 1945 and are tapping water from the fluvial aquifer. The wells are located about 3,000 ft south/southwest of the former CCC/USDA facility (Figures 1.2 and 2.1). Argonne, on behalf of the CCC/USDA, has located 16 private wells within

0.5 mi of the former facility (Figure 1.2) based on information from previous investigations, state well registration forms, and city officials (Argonne 2012). Of these, eight are registered with the state of Kansas (Table 2.1). Two additional private wells for lawn and garden use were identified during Argonne's 2012 site investigation. All the wells registered with the state show depths ranging from 75 ft to 146 ft BGL, with one screen interval targeting the deep aquifer in the Dakota Formation (Argonne 2012 and 2014), except for one lawn and garden well (T.D. Meyer) with two screen intervals. Among those registered wells, two wells (Meitler and C. Meyer) that are withdrawing water only from the deep aquifer were confirmed for domestic use by Argonne during the site visit. All of the other private wells were used for lawn and garden purposes (Meitler 2012). On behalf of the CCC/USDA, Argonne representatives contacted the former Sylvan Grove utility superintendent in May of 2018. He indicated that all city residents (as well as residents of the Wolting and Kingery properties located outside city limits) are connected to the city public water supply (Meitler 2012 and Argonne 2018). Because of the good water quality and quantity of groundwater from the fluvial aquifer overlying the bedrock formation, the city public water supply system has provided water to the community for more than 100 years.

Based on information gathered to date, the perched aquifer, which is confined laterally within the former CCC/USDA facility property, and a portion of the shallow aquifer bounded by the former CCC/USDA facility, have been used as a lawn and garden irrigation source, such is the case with the Kingery hand-dug well, a well that is not registered with the state. There is no evidence indicating that groundwater from the perched aquifer and shallow aquifer has been used as a domestic water supply source. Details about the perched and shallow aquifers are discussed in Sections 3-6.

In summary, the fluvial aquifer overlying the bedrock formation below the Saline River and its floodplain has been the water resource for both the public water supply at Sylvan Grove and some domestic wells used by residents not connected to the public water supply system. The deep aquifer in the bedrock formation has been used for both domestic and lawn and garden purposes by residents not connected to the city public water supply system. The perched and shallow aquifers have only been used for non-domestic water supply purposes (e.g., the shallow wells at the Kingery and Wolting residences).

2.1.2 General Understanding of the Nature, Extent, and Magnitude of Contamination

Low concentrations of carbon tetrachloride and chloroform have been identified in groundwater at the northeastern edge of Sylvan Grove, Kansas, where the CCC/USDA operated a grain storage facility from 1954 to 1966. Carbon tetrachloride has been detected in groundwater at concentrations above the U.S. Environmental Protection Agency maximum contaminant level (MCL) for drinking water and the KDHE Tier 2 Risk Based Screening Level (RBSL) for drinking water (5.0 µg/L). Carbon tetrachloride was identified in one subsurface soil sample at a low concentration (34 µg/kg) and at trace levels (3.4-4.2 µg/kg) at two locations. Carbon tetrachloride was detected in a small area of a perched aquifer located in the central and southern parts of the former CCC/USDA facility. Carbon tetrachloride contamination above the MCL was also detected in the shallow aquifer. There has been limited migration of contaminants in the shallow aquifer over the 46 year period between termination of grain storage activities and current investigation activities. In addition, nitrate concentrations exceeding the MCL and RBSL for this contaminant in groundwater have also been detected in two private wells located on or near the former CCC/USDA facility. The source of nitrate contamination in the wells is unrelated to any activities performed on the former facility during the term of the CCC/USDA lease.

2.1.3 Underlying Groundwater Bearing Zones

Three groundwater-bearing zones within the bedrock formation were identified in the local geologic sequence based on the site investigation by Argonne on behalf of CCC/USDA: (1) the perched aquifer hosted by a few layers of sandy shale and sand confined within the upper shale (Unit 2), with a saturated thickness of 2-3 ft; (2) the shallow aquifer hosted by the shallow sand (Unit 3), with a varying thickness from 4 ft at the northern part of the former CCC/USDA facility to more than 19 ft at the southern part of the former facility; and (3) the deep aquifer hosted by the deep sand (Unit 5), which is the thickest (35 ft) of the aquifers identified in the investigation. The vertical relationship and locations of three groundwater-bearing zones are shown in Figure 2.2. Carbon tetrachloride contamination affects the perched aquifer and the upgradient portion of the shallow aquifer. There is no contamination pathway from the perched aquifer and the shallow aquifer to the deep aquifer (see Sections 3-6).

2.1.4 Exposure Pathways

The screening of the exposure pathways was performed for contaminated soil and groundwater. The soil screening was evaluated for two potential exposure pathways: (1) direct exposure, including ingestion of contaminated soil, direct inhalation of contaminated vapors or airborne contaminated soil particles, and direct dermal contact, and (2) indirect exposure via the soil-to-groundwater pathway. There are no current or future direct exposure routes to soil since no carbon tetrachloride or chloroform contamination was detected in near-surface or vadose zone soils. In addition, although carbon tetrachloride and chloroform were detected in soil within the perched aquifer, no carbon tetrachloride or chloroform concentrations exceeding the KDHE's RBSL guideline for protection of the soil-to-groundwater pathway were found.

Groundwater was also evaluated for two exposure pathways: (1) direct exposure, including ingestion of contaminated groundwater, direct inhalation of chemicals volatilized from contaminated groundwater, and dermal contact with contaminated groundwater, and (2) indirect exposure via the groundwater-to-indoor air pathway or the groundwater-to-surface water pathway. On the basis of the available Kansas well registration records and information obtained from the local community, all private and public wells for drinking water use are withdrawing water from the fluvial or deep aquifers. Water withdrawn from the contaminated perched and shallow aquifers is only used for non-domestic purposes. As a result, there are no complete exposure pathways between humans and contaminated groundwater in the perched and shallow aquifers.

The indoor air investigation was conducted for the Kingery and Wolting homes, which are both in close proximity to the groundwater contamination in the perched and shallow aquifers. The absence of carbon tetrachloride in indoor air samples collected from the basements of the two homes indicates that the exposure pathway for upward vapor migration of carbon tetrachloride from groundwater is incomplete.

The groundwater affected by carbon tetrachloride and chloroform is located in the upland area (Figure 2.1) and away from any existing surface water channels. The pathway for potential indirect exposure to contaminated groundwater via surface discharge from the perched and shallow aquifer is therefore also incomplete.

2.1.5 Interactions between Groundwater and Surface Waters

Field reconnaissance performed by Argonne on behalf of the CCC/USDA along the projected limits of the shallow and perched aquifers found no springs or seepage. Therefore, there is no interaction between groundwater and surface waters at the former CCC/USDA facility.

2.2 Potability Evaluation Work Plan

The Potability Determination Guidance refers to a Potability Evaluation Work Plan review and approval step. As suggested in the guidance, the potability evaluation process is intended to proceed concurrently with site investigation and/or remedial alternative evaluations. For the Sylvan Grove site, all the data collections, methodologies, and procedures required for a Potability Evaluation Work Plan are covered by the scope of the Site Investigation Work Plan (Argonne 2012). The work performed as part of the Site Investigation Work Plan has already been reviewed and approved by the KDHE (2012 and 2013). The required information, which includes:

- depth to groundwater,
- saturated aquifer thickness for the aquifer(s) being evaluated,
- seasonal trends (e.g., water elevation, concentration, etc.),
- groundwater flow direction, and
- well construction and development for wells to be evaluated (if applicable),

has been reported previously in the *Final Report: Results of the Environmental Site Investigation at Sylvan Grove, Kansas* (Argonne 2014). Information from the final site investigation report as well as information gathered during the monitoring phase since that report was prepared are summarized in Sections 3-6.

As required by the KDHE's Potability Determination Guidance, this potability determination report includes the following components:

- Site background (Section 3)
- Investigation summary (Section 4)
- Uncertainty analysis (Section 4.2.3)
- Remediation and/or risk management (Section 5)
- Current site data and justification/considerations for groundwater potability determination (Section 6)

This report is also supported with well logs, boring logs, and/or stratigraphic cross sections that comprehensively document geologic and hydrogeologic conditions, and maps that identify groundwater elevations, surface elevations, flow direction(s), saturated thickness, and surface water features, etc.

TABLE 2.1 Private wells registered with the State of Kansas.

Well Owner on the Registration Form	T12S R10W Sections (11-14)	Well Depth (ft)	Lithologic Description of Coarse-Grained Layer (depth range)	Depth of Screen Interval (ft)	Target Water Zone	Installation Date	Registered Water Use	Owner/Current Water Use
Private wells located within the 0.5 mile from the former CCC/USDA facility (Figure 1.2)								
Chris Meyer	SW/SW/SE Sec11	80	Sand rock (50-80 ft)	50-80	Deep aquifer	1995	Domestic	C. Meyer/domestic
Meyer Land & Cattle (Chris Meyer)	NW/SE/SE Sec11	93	Sandstone (63-90 ft)	70-90	Deep aquifer	1993	Domestic	Meitler/domestic
Lowell Fischer (1)	SW/SW/SW Sec12	100	Sand rock (95-100 ft)	80-100	Deep aquifer	2001	Domestic	Cannot be located in the field.
Lowell Fischer (2)	NE/SW/SW Sec12	120	Sandstone (115-118 ft)	100-120	Deep aquifer	2002	Domestic	Cannot be located in the field.
Bud Pistora	SE/SE/NW Sec13	95	Sand rock (45-95 ft)	75-95	Deep aquifer	1992	Domestic, lawn and garden	D. Hurlbut/lawn and garden
Toby Meyer	C/SE/NW Sec13	100	Sand rock (80-85 ft)	60-100	Deep aquifer	2000	Unknown	T.B. Meyer/lawn and garden
Glen Ringler	SW/SW/NW Sec13	136	Sandstone (11-27 ft) Sandstone (130-140 ft)	116-136	Deep aquifer	1992	Domestic, lawn and garden	Ringler/lawn and garden
Meyer Land & Cattle (Chris Meyer)	SW/SE/NE Sec 14	75	Sandstone (12-20 ft) Sandstone (25-51 ft) Sandstone (66-73 ft)	38-51 and 66-73	Shallow aquifer and deep aquifer	1991	Lawn and garden	T.D. Meyer/lawn and garden
Private wells outside of the Map (Figure 1.2) within T12S R10W Sections 11-14								
Chris Meyer	SE/SE/SE Sec13	33.5	Coarse sand (24-32 ft)	24-32	Fluvial aquifer	1998	Domestic, livestock	~1/4 mile southeast of map.
Erwin Thaemert	NW/NW Sec14	65	Sand (45-65 ft)	50-65	Fluvial aquifer	1975	Domestic	~1/4 mile west of map.
Clarence Wohler	SW/SW/NW Sec14	60	Sand and gravel (18-60 ft)	40-60	Fluvial aquifer	1982	Domestic	~1/4 mile west of map.

Source: Kansas Geological Survey Water Well Completion Records (WWC5) Database (http://www.kgs.ku.edu/Magellan/WaterWell/index.html).

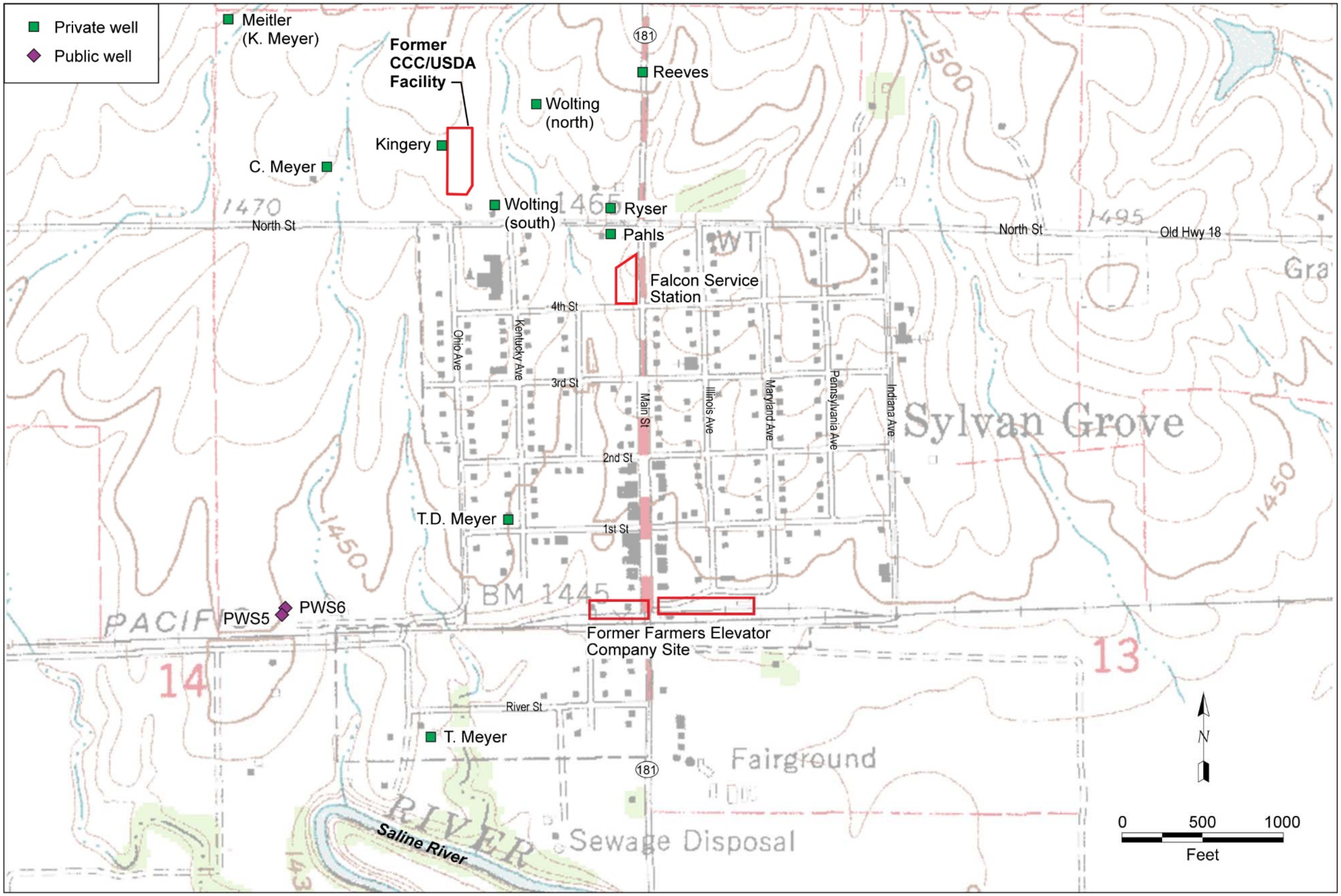

FIGURE 2.1 Local topography in the vicinity of the former CCC/USDA facility at Sylvan Grove and locations of private wells and public water supply wells that were sampled in the 2012 site investigation. Source of 1982 topographic map: USGS (1997).

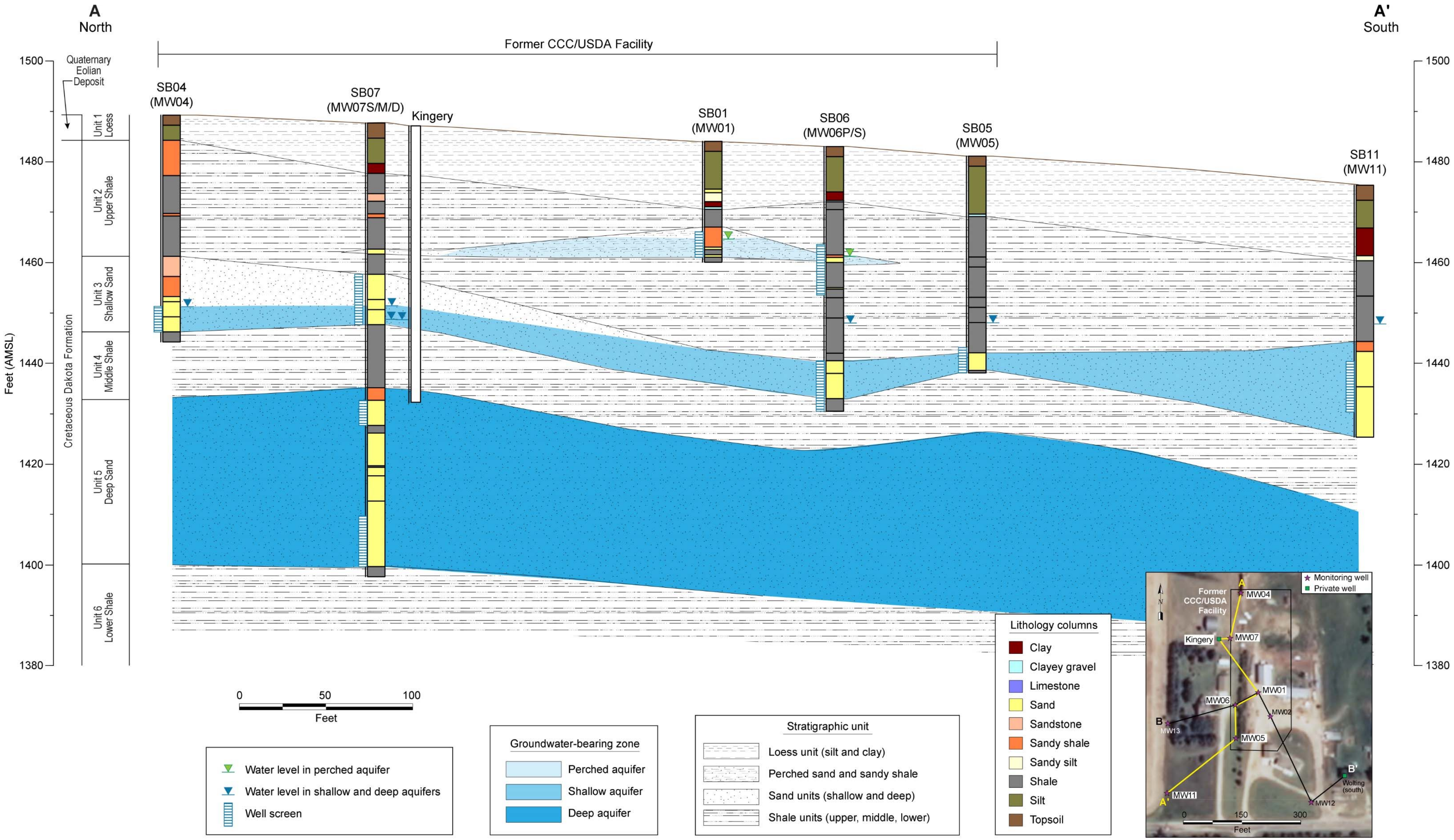

FIGURE 2.2 Interpretive north-to-south hydrogeologic cross section A-A' across the investigation area.

3 Site Background, Hydrogeologic Setting, and Known or Suspected Releases

3.1 Background

Sylvan Grove, Kansas, is a small rural city located in western Lincoln County, in Sections 11-14, Township 12 South, Range 10 West. The city has numerous small businesses and local agricultural services. The city also hosts the Sylvan-Lucas Unified High School, a medical clinic, a museum, a library, churches, and a historical society (Figure 1.1).

The 2015 Census recorded 258 residents in 200 households in the city of Sylvan Grove. The city is governed by a mayor and a city council. The residents of the city are served by a public water supply system that obtains its water from two groundwater wells (PWS5 and PWS6) located 2,800 ft southwest of the former CCC/USDA facility (Figure 1.2). No carbon tetrachloride has been found in the public wells (Argonne 2014).

The CCC/USDA operated a grain storage facility at the northwestern edge of Sylvan Grove from 1954 to 1966. During this time, commercial grain fumigants containing carbon tetrachloride were in common use to preserve grain in storage. The former grain storage facility had 30 circular bins on a two-acre property, which is currently owned by Ryan and Heather Wolting. No grain bins or other structures associated with the former CCC/USDA grain storage facility remain at the site.

3.2 Hydrogeologic Setting

The general local geologic sequence at the former CCC/USDA facility consists of six lithostratigraphic units to a depth of 90 ft BGL (Figure 3.1), consistent with those described by Berry (1952). The six units include a Quaternary loess unit (silt and clay; Unit 1), which unconformably overlies the Cretaceous Dakota Formation, consisting of five units: upper shale (Unit 2), shallow sand (Unit 3), middle shale (Unit 4), deep sand (Unit 5), and lower shale (Unit 6).

Three groundwater-bearing zones were identified in the local geologic sequence: (1) the perched aquifer hosted by a few layers of sandy shale and sand confined within the upper shale (Unit 2), with a saturated thickness of 2-3 ft; (2) the shallow aquifer hosted by the shallow sand (Unit 3), with a varying thickness from 4 ft at the northern part of the former CCC/USDA facility to more than 19 ft at the southern part of the former facility; and (3) the deep aquifer hosted by the deep sand (Unit 5), which is the thickest (35 ft) of the aquifers identified in the investigation. The vertical relationship and locations of three groundwater-bearing zones are shown in Figure 2.2.

The main characteristics of the perched aquifer within Unit 2 are as follows:

1. The perched aquifer occurs at a depth of approximately 20 ft BGL (elevation of 1,460-1,466 ft AMSL) and has a limited lateral extent within the former CCC/USDA property boundaries (Figure 2.2). The aquifer exists under unconfined conditions.

2. Groundwater movement in the perched aquifer is highly driven by local rainfall infiltration. However, the extremely low transmissivity of the unit results in significant water level fluctuations in response to rainfall events. The water table for the perched aquifer is more than 10 ft higher than the potentiometric surface of the underlying shallow aquifer.

3. The groundwater in the perched aquifer flows from east to west with a very high hydraulic gradient (0.5), which is consistent with the aquifer's poor transmissivity (Figure 3.2).

The main characteristics of the shallow aquifer (Unit 3) are as follows:

1. The shallow aquifer occurred at every investigation-related sampling location; its top is at a depth of 33-45 ft BGL. The aquifer exists under unconfined conditions in the northern part of the former CCC/USDA facility and under confined conditions in the southern part of the former facility (Figure 3.2).

2. The shallow aquifer is intercepted by the contaminated, hand-dug Kingery lawn and garden irrigation water supply well, although this well withdraws less water from the shallow aquifer than from the deep aquifer (Unit 5). The Wolting (south) lawn and garden well near the former facility withdraws groundwater solely from the shallow aquifer.

3. The apparent groundwater flow direction in the shallow aquifer is toward the south-southwest under ambient conditions (Figure 3.3) and shifts toward the south during pumping episodes lasting 10 hr or longer at the Wolting (south) well. The hydraulic gradient under ambient conditions varies from 0.01 on the former CCC/USDA facility to 0.001 in the area downgradient from the former facility. During pumping at the Kingery well, the groundwater flow direction remains the same, but the hydraulic gradient is reduced on the former CCC/USDA property.

The main characteristics of the deep aquifer (Unit 5) are as follows:

1. The deep aquifer is present below a depth of 53 ft BGL (elevation of 1,435 ft AMSL) and is one of the major aquifers for the local area. It is expected to extend across the entire upland area at Sylvan Grove. The deep aquifer exists under confined conditions (Figure 2.2).

2. The Kingery lawn and garden irrigation water supply well, located at the western edge of the former CCC/USDA facility, withdraws more water from the deep aquifer than the shallow aquifer.

3. The groundwater flow in the deep aquifer is expected to mimic the topographic change from the upland to the Saline River floodplain (south of the former CCC/USDA facility, Figure 2.1). Within the aquifer, an upward hydraulic gradient was observed at the former CCC/USDA facility, as illustrated in Figure 3.1. The potentiometric surface in the lower part of the deep aquifer is higher than that in the upper part of the aquifer.

3.3 Known or Suspected Releases

In 1998 and 2006, as a part of the statewide USDA private well sampling program, the KDHE sampled several private wells surrounding the former CCC/USDA facility and found carbon tetrachloride above the MCL in groundwater from one lawn and garden irrigation water supply well on the Kingery property. The well is located near the western edge of the former CCC/USDA facility. The Kingery well is a hand dug well operated by a hand pump or wind mill.

Carbon tetrachloride was identified at the well at concentrations of 18.2-33.6 5 µg/L in 1998 and 18.2 5 µg/L in 2006 (Figure 3.4). Elevated nitrate levels were also detected at the Kingery well (81.5 mg/L) and the Chris Meyer well (24.08 mg/L).

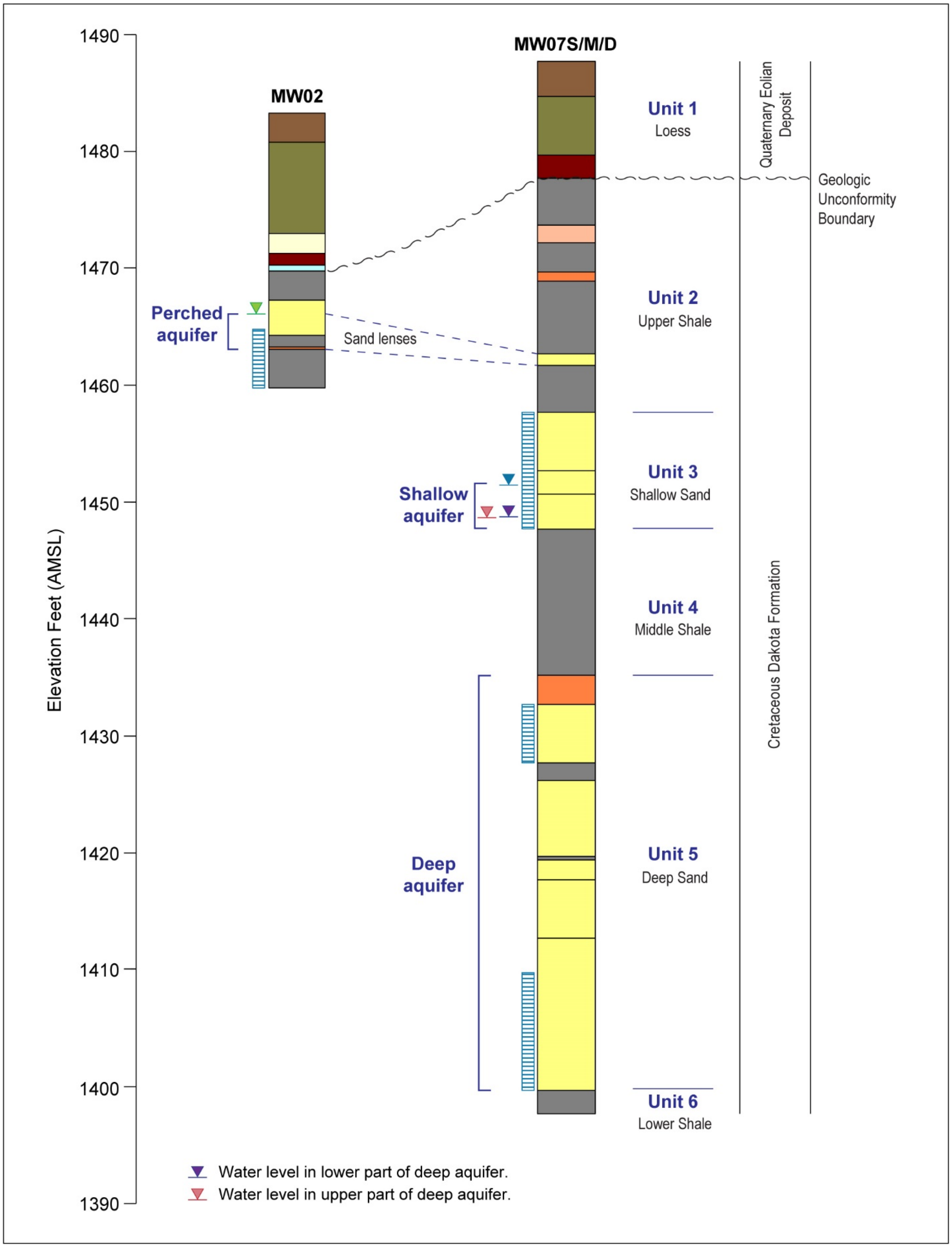

FIGURE 3.1 General sequence of local lithostratigraphic units at the former CCC/USDA facility.

FIGURE 3.2 Potentiometric surface for the perched aquifer at the former CCC/USDA facility, based on water levels measured on July 25, 2012, and aerial distribution of carbon tetrachloride and chloroform within the aquifer. Source of photograph: USDA (2010).

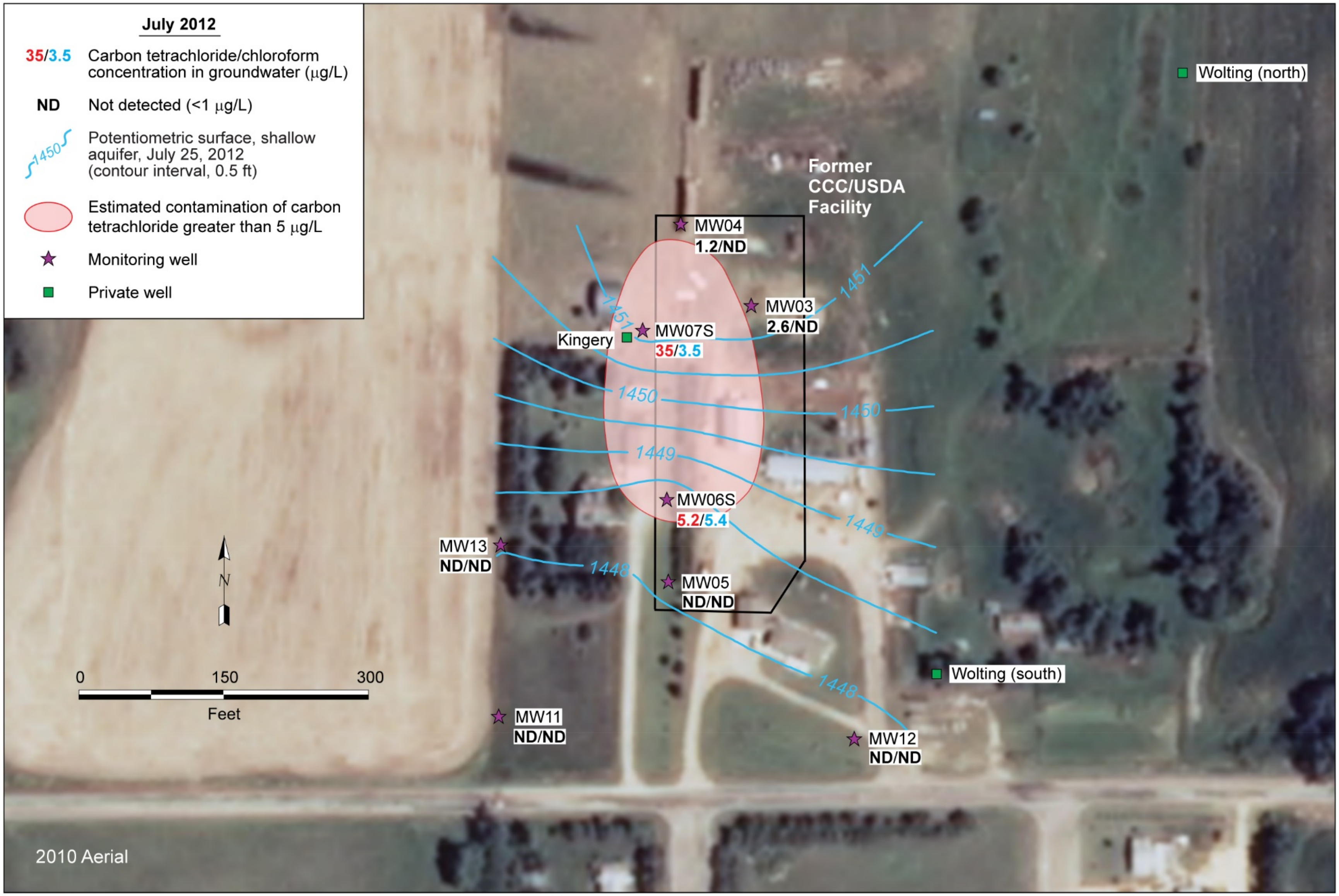

FIGURE 3.3 Potentiometric surface for the shallow aquifer at the former CCC/USDA facility, based on water levels measured on July 25, 2012, and areal distribution of carbon tetrachloride and chloroform within the aquifer. Source of photograph: USDA (2010).

FIGURE 3.4 Historical analytical results for carbon tetrachloride in groundwater samples collected by the KDHE in 1998 and 2006 from four private wells near the former CCC/USDA facility. Source of photograph: USDA (2010).

4 Investigation Summary

This section summarizes past KDHE and CCC/USDA investigation activities and results, including the nature and extent of contamination, migration pathways, and known or potential human health or ecological risks.

4.1 KDHE Investigations

After initial detection of carbon tetrachloride in the Kingery well in 1998, six subsurface soil samples were collected at depths ranging from 8.5 to 18.5 ft BGL at six locations on the grounds of the former CCC/USDA facility. A low level of carbon tetrachloride (28 µg/kg) was detected in one soil sample at a depth of 18.5 ft BGL during field screening of the samples. Field screening methods also identified carbon tetrachloride at concentrations just slightly in excess of the detection limit (0.2 µg/kg) in three of the other five samples. Two of the soil samples with positive detections of carbon tetrachloride, including the sample with 28 µg/kg as determined by the field screening methods, were analyzed by an off-site laboratory. The off-site laboratory was not able to verify the field screening result (KDHE 1998). In 2006, results of groundwater sampling for the private wells indicated continuous presence of carbon tetrachloride as well as elevated nitrate at the Kingery well.

4.2 CCC/USDA Investigations

The Sylvan Grove environmental site investigation was conducted in 2012-2013 by Argonne, on behalf of the CCC/USDA. The investigation was designed to address the specific technical objectives as defined in the work plan (Argonne 2012) approved by the KDHE (2012 and 2013). The circa 2012-2013 activities have been followed up with ongoing groundwater monitoring and hydraulic testing activities.

4.2.1 Results of the Main Field Investigation

The main field investigation was performed in July 2012 and a sampling event for the assessment of indoor air and ambient air was conducted during February 2013 in accordance with the site-specific environmental investigation work plan (Argonne 2012) approved by the KDHE

(2012) and the plan for indoor air and ambient air, also approved by the KDHE (2013). Monitoring of the water level fluctuations in the perched groundwater-bearing zone and in the shallow and deep groundwater zones identified during the investigation was continued in 2013 to evaluate seasonal variations, and analyses were based on the data up to April 2013. The activities during the 2012-2013 investigation and results of integrated analyses have been documented in detail (Argonne 2014) and are summarized here.

Subsurface soil samples were collected for volatile organic compounds (VOCs) analysis to identify soil contamination above the groundwater-bearing zones underlying the former CCC/USDA facility. Soil sampling was conducted in vertical profiles through the vadose zone to the depth of the first groundwater bearing zone, in accordance with the procedures outlined in the site-specific work plan (Argonne 2012) and the Master Work Plan (Argonne 2002). Over 75 soil samples were collected from seven different locations at 4-ft intervals starting at 2 ft BGL using a sonic drilling rig. In some cases, the intervals for sample collection were altered to account for changes in core lithology or recovery conditions. All soil samples were analyzed by a purge-and-trap sample preparation method with analysis on a gas chromatograph-mass spectrometer (GC-MS) system (EPA Methods 5030B and 8260B). Carbon tetrachloride was detected only in association with soil intervals at or near the perched groundwater zone.

Carbon tetrachloride was identified in subsurface soil at a low concentration (34 μg/kg) at only one location (SB02) and at trace levels (3.4-4.2 μg/kg) at two locations (SB01 and SB06/SB10) (Figure 4.1). All the soil intervals with detectable carbon tetrachloride are at or near the perched aquifer. Neither chloroform nor methylene chloride was detected in surface soil or in soil at any sampling point throughout the vadose zone. The results confirm the previous findings of the KDHE 1998 investigation and indicate that the contamination in soil does not provide a source of contamination for groundwater via the soil-to-groundwater pathway.

Groundwater sampling to delineate the groundwater contamination at the Sylvan Grove site was guided by the interpretation of multiple aquifers and groundwater flow patterns in conjunction with the contaminant source characteristics. Groundwater samples were collected from three monitoring wells for the perched aquifer, eight monitoring wells for the shallow aquifer, and two monitoring wells for the deep aquifer. In addition, groundwater samples were also collected from all accessible private wells and public water supply wells.

Carbon tetrachloride and chloroform detections in the perched aquifer were limited to a small area in the central and southern parts of the former CCC/USDA facility, with a maximum carbon tetrachloride concentration of 131 μg/L at MW06P (Figure 3.2). The perched aquifer is confined within the low-permeability upper shale (Unit 2); however, rainfall infiltration can provide a driving force, by raising the water table as much as 4 ft, for slow downward contaminant migration to the shallow aquifer through the confining shale unit (Figure 4.2).

The extent of carbon tetrachloride with concentrations above the MCL in the shallow aquifer is estimated to encompass an area 160 ft wide and 290 ft long, approximately within the footprint of the former CCC/USDA facility (Figure 3.3). The highest concentration of carbon tetrachloride identified, 35 μg/L, was detected at MW07S. The limited migration of contaminants in the shallow aquifer over the 46 yr period between termination of grain storage activities and the 2012 investigation indicates a degree of hydraulic containment possibly associated with controlling factors such as a slow leakage rate from the overlying perched aquifer through the confining layer of the low-permeability shale unit, the low lateral hydraulic conductivity of the shallow aquifer, the effects of intermittent pumping at the Kingery well, and/or a combination of these factors.

The results of all groundwater sampling events for the Kingery well suggest consistent carbon tetrachloride concentrations, 26.2-33.6 μg/L in 1998, 18.2 μg/L in 2006, and 14 μg/L in 2012. Groundwater collected from the hand-dug Kingery lawn and garden well is probably a mixture of groundwater from both the shallow and deep aquifers; although the deep aquifer is not affected by carbon tetrachloride.

No contamination was found in the deep aquifer at the former CCC/USDA facility (Figure 4.2), indicating that no vertical migration pathway is present from the shallow aquifer to the deep aquifer.

Other than the Kingery well, no carbon tetrachloride contamination was found in groundwater collected from the accessible private wells and the two public water supply wells sampled in the vicinity of Sylvan Grove. Nitrate contamination was found in private wells and investigation-related monitoring wells. The public water supply wells and private wells located within the Saline River floodplain at Sylvan Grove are using groundwater from the fluvial deposits overlying the bedrock (Figure 1.2). The fluvial deposits are separate from the perched, shallow and deep aquifers within the underlying bedrock units located beneath the former CCC/USDA facility.

The indoor air sampling for VOCs analysis found no carbon tetrachloride was in the indoor air in the Kingery and Wolting homes, which are both in close proximity to the groundwater contamination in the perched and shallow aquifers. This finding indicates an incomplete pathway for upward vapor migration of carbon tetrachloride from contaminated groundwater to the residential structures.

4.2.2 Results of the 2015-2017 Monitoring Activities and Hydraulic Testing

At the end of 2012-2013 environmental site investigation, 13 monitoring wells were installed at 10 locations to facilitate monitoring groundwater flow pattern and contamination level. Three of the 13 wells are screened exclusively in the perched aquifer (MW01, MW02, and MW06P), eight are screened in the shallow aquifer (MW03-MW05, MW06S, MW07S, and MW11-MW13) and two are screened in the deep aquifer (MW07M and MW07D). The monitoring activities included (1) groundwater sampling for VOCs and major ions in February 2015, April 2016, and February 2017; and (2) groundwater level measurements from 2013-2017. A summary of the quality control analysis for data collected during the 2015-2017 field monitoring activities is in Appendix A.

4.2.2.1 Monitoring Results of Groundwater Contamination

To confirm the 2012-2013 investigation results and monitor any changes since then, groundwater samples were collected in 2015 and 2016 for VOCs analysis from the perched aquifer at locations MW01, MW02, and MW06P, as well as from the underlying shallow and deep aquifer at locations MW03-MW05, MW07S, MW06S, MW11-MW13, MW07M and MW07D. The private wells at and near the former CCC/USDA facility (Kingery, Wolting [north], Wolting [south], and Wolting [east], formerly owned by Mark Ryser) were also sampled for VOCs analysis. The locations of the private wells are shown in Figure 1.2. In February 2017, confirmation sampling was performed again at the three locations with elevated contamination levels: MW06P (perched aquifer), MW07S (shallow aquifer), and the Kingery well. The sampling was conducted in accordance with the procedures outlined in the site-specific work plan (Argonne 2012) and the Master Work Plan (Argonne 2002). All groundwater samples were analyzed for VOCs at the

Applied Geosciences and Environmental Management (AGEM) Laboratory according to a modification of EPA Method 524.2 (EPA 1995).

Analytical results for groundwater samples collected from the perched aquifer are shown in Figure 4.3 and summarized in Table 4.1. Carbon tetrachloride concentrations increased slightly in the inferred upgradient perched aquifer well (MW02), but decreased significantly in the two downgradient perched aquifer wells (MW06P and MW01). From 2012 to 2016, carbon tetrachloride concentrations in MW02 increased from 7 to 15 μg/L. At two downgradient locations, the carbon tetrachloride concentrations decreased significantly in 2015-2016 from 131 to 44 μg/L in well MW06P and from 50 μg/L to 19 μg/L in well MW01. This decreasing trend was confirmed at one selected perched aquifer well (MW06P) from the 2017 sampling event. The concentrations of carbon tetrachloride at MW06P further decreased to 36 μg/L (Figure 4.3 and Table 4.1). In the 2015 and 2016 sample results, chloroform concentrations in the perched aquifer were confirmed to be low (less than 5 μg/L). Chloroform results showed a decreasing trend at MW01 and MW06P and remained the same at MW02 (Table 4.1 use 2.1). The results from 2015-2017 also confirmed that there is no contamination of methylene chloride in the perched aquifer.

The contamination in the shallow aquifer was also confirmed based on the analytical results for groundwater samples collected in 2015 and 2016. However, the carbon tetrachloride concentration increased from 35 μg/L in 2012 to 105 μg/L in 2016 at MW07S and from 14 μg/L in 2012 to 98 μg/L in August 2016 at the Kingery well (located 17 ft west of MW07S). In contrast, carbon tetrachloride was not detected at the downgradient location of MW06S (Figure 4.4). Carbon tetrachloride remained below 5 μg/L in 2015-2016 at the upgradient locations (MW03 and MW04). To confirm the increase in carbon tetrachloride at the Kingery well and MW07S, additional samples were collected in February 2017. The 2017 results indicate that carbon tetrachloride had dropped back to the previous level (10 μg/L) at the Kingery well and decreased to 69 μg/L from 105 μg/L at MW07S. The overall spatial distributions of carbon tetrachloride in the shallow aquifer over the 2012-2017 period suggest that the contamination level remained the same at the upgradient locations (below 5 μg/L) and reduced to non-detect at the downgradient location, but fluctuated at locations within the central part of the plume.

The absence of contamination in groundwater in the shallow aquifer at all the downgradient locations located off the former CCC/USDA facility (MW05, MW11-MW13, and Wolting [south] well) was confirmed by the results of the 2012-2013 investigation and the 2015-2016 sampling events. The extent of carbon tetrachloride in the shallow aquifer at levels greater than 5 μg/L is limited to a very small area encompassing only the Kingery well and MW07S (Figure 4.4). Chloroform was found at levels below 10 µg/L and no methylene chloride was detected in the shallow aquifer in 2015-2017 sampling events.

Groundwater samples were also collected in the 2015 and 2016 sampling events from the upper and lower parts of the deep aquifer at MW07M and MW07D, respectively. No contamination was found in these samples (Table 4.1).

4.2.2.2 Groundwater Geochemistry and Nitrate Contamination

During the sampling event in February 2015, additional groundwater sampling was performed for major ion analyses, in order to understand the existing groundwater geochemistry and water quality. Groundwater samples for major cation analysis were collected from wells representing the perched aquifer (MW06P), shallow aquifer (MW06S and MW07S), deep aquifer (MW07M and MW07D), and private wells (Kingery and Wolting [south]). The Kingery well intercepts both the shallow and deep aquifer; the Wolting (south) well intercepts the shallow aquifer only. Groundwater samples for major anion analysis, including nitrate analysis, were collected from all monitoring wells installed during 2012-2013 investigation and three private wells (Kingery, Wolting [south], and Wolting [north]). Major cations (metals) were analyzed by EPA Method 6010B. Bicarbonate alkalinity and carbonate alkalinity were analyzed as $CaCO_3$ by EPA Method 2320B. Other major anions were analyzed by EPA Method 300. The analytical results are summarized in Tables 4.2 and 4.3.

Ion balance is one of the key criteria used to evaluate the quality of analytical data and to aid in the interpretation of analytical results. In subsurface water-bearing units, the groundwater is electrically neutral (neither positively nor negatively charged). The ion balance between the sum of positive charges and the sum of negative charges, in milliequivalents per liter (meq/L), was estimated for groundwater samples collected from MW06P (perched aquifer), MW06S and MW07S (shallow aquifer), MW07M and MW7D (deep aquifer), and the contaminated private well (Kingery), as shown in Table 4.4 (use 2.4). Ideally, to reflect the electrically neutral condition in the subsurface, the sum of positive charges should equal the sum of negative charges, and the balance (the difference between the two) should be calculated as 0%. The results in Table 4.4 indicate a good ion balance for groundwater samples (within a range of between -3% and 3%).

To illustrate the characteristics of water chemistry of groundwater samples, a piper diagram was constructed for the major cations (Na^+, Ca^{2+}, and Mg^{2+}) and anions (Cl^-, SO_4^{2-}, and HCO_3^-), as shown in Figure 4.5. The piper diagram indicates that groundwater is mainly of the Ca-HCO_3-SO4 or Ca-Mg-HCO_3-SO_4 type (except for groundwater samples from MW06P and the Kingery well), containing predominately the dissolved minerals calcite ($CaCO_3$), anhydrite ($CaSO_4$), and dolomite [$CaMg(CO_3)_2$] (Table 4.4). This interpretation is consistent with the natural lithology composition of the bedrock units that host multiple aquifers. However, groundwater was altered by the high concentration of NaCl to form a water type of Ca-Na-HCO_3-Cl at MW06P (perched aquifer) and at the hand-dug Kingery well, as shown in Figure 4.5. The minor alteration also occurred at MW07S (in the shallow aquifer near the Kingery well), as indicated in Table 4.4, although it could not be differentiated in Figure 4.5. The potential major sources of high chloride concentration in the rural area are fertilizer, sewage, and livestock waste, none of which are associated with grain operations at the former CCC/USDA facility.

Total hardness of the groundwater was estimated as the sum of Ca^{2+} and Mg^{2+}, which can be precipitated from water as solid particles, expressed as $CaCO_3$ in mg/L (Table 4.4). Water from the perched aquifer (MW06P) and upgradient portion of the shallow aquifer (MW07S and the Kingery well) falls in the "very hard" category (Water Quality Association 2011), with a hardness (as $CaCO_3$) of 1,637-1,923 mg/L. In contrast, groundwater from the downgradient part of the shallow (MW06S and Wolting [south]) and deep (MW07M and MW07D) aquifers has relatively low hardness (at 258-463 mg/L).

On the basis of major ion concentrations in water, total dissolved solids (TDS) values were calculated by (1) summing the concentrations (mg/L) of major ions including Na^+, Ca^{2+}, Mg^{2+}, Cl^-, and SO_4^{2-}, and (2) adding the quantity of HCO_3^- and CO_3^{2-} that would be precipitated as calcite and dolomite if the milliequivalents of Ca^{2+} plus Mg^{2+} exceeded the milliequivalents of SO_4^{2-}. The calculated TDS values for the water samples are in Table 4.4. The results indicate that groundwater in the perched aquifer (MW06P) and the upgradient portion of the shallow aquifer (MW07S and the Kingery well) has a very high concentration of TDS, ranging from 3,146 mg/L to 3,643 mg/L. These concentrations exceed the secondary MCL (SMCL) for drinking water (500 mg/L). Furthermore, KDHE Potability Determination Guidance (BER-RS-045) specifies that drinking water with TDS levels of 900 to 1,200 mg/L may be unpalatable, and that levels greater than 1,200 mg/L are unacceptable (KDHE 2016). The measured concentrations of TDS in the shallow groundwater at Sylvan Grove is double this cited KDHE threshold level. The major source of TDS in this area is the natural mineral anhydrite, which is dissolved in water as Ca^{2+}, Mg^{2+}, and SO_4^{2-}, and anthropogenic alteration from chloride and nitrate. The calculated TDS values for groundwater in the downgradient shallow (MW06S and Wolting [south]) and deep (MW07M and MW09D) aquifers are relatively low, in the range of 258-463 mg/L (Table 4.4).

The analytical results of major anions also indicate elevated nitrate concentrations (Table 4.2). The spatial distribution of nitrate is shown in Figure 4.6 and suggests two distinct areas: (1) a high nitrate contamination area, including the perched aquifer (MW01, MW02, and MW06P) with concentrations ranging from 99 mg/L to 130 mg/L, and the upgradient shallow aquifer (MW03, MW04, MW07S, and the Kingery well that intercepts the shallow aquifer), with concentrations ranging from 93 mg/L to 340 mg/L; and (2) no nitrate contamination area, with nitrate levels less than or near the detection limit, including the downgradient shallow and deep aquifers, with a maximum nitrate concentration of 1.5 mg/L.

The high nitrate contamination area coincides with locations of highly elevated TDS. Neither nitrate nor TDS constituents were associated with the operation of the former CCC/USDA facility. Because of the presence of extremely high levels of nitrate and TDS, groundwater in the perched aquifer and the upgradient shallow aquifer cannot be considered a drinking water source, based on the KDHE drinking water standards (10 mg/L for nitrate and 1,200 mg/L for TDS).

4.2.2.3 Results of Groundwater Level Monitoring

Groundwater levels in the perched and shallow aquifers have been measured semi-annually or annually since the 2012-2013 site investigation to evaluate any change in potentiometric surface (or water table) in both aquifers. The manual measurements are summarized in Table 4.5.

The potentiometric surfaces of the perched aquifer in 2013, 2014, 2015, and 2016 were estimated based on the measured water levels and are shown in Figures 4.7-4.10 (use 2.12-2.15,) respectively. The results confirm a consistent flow pattern from the east to the west over the monitoring period. However, the hydraulic gradient varied from 0.04 in 2016 to 0.06 in 2013. During high gradient conditions, the water level is high in the upgradient part of the perched aquifer, resulting in a change from an unconfined to confined condition. In low gradient conditions, the majority of the perched aquifer remains unconfined.

Figures 4.11-4.14 show the interpreted potentiometric surfaces of the shallow aquifer in 2013, 2014, 2015, and 2016, respectively. The flow pattern was consistently towards the south-southwest over the monitoring period with a slight change in water level elevation. The monitoring results confirm the potentiometric surface configuration and flow direction of the shallow aquifer, as previously determined in the 2012-2013 site investigation.

4.2.2.4 Results of Hydraulic Testing and Estimated Water Yield

Slug tests were performed to investigate the range and distribution of hydraulic conductivity values for the perched, shallow, and deep aquifers, in order to understand groundwater flow and yield, and to develop design parameters to control contaminant transport. The testing was conducted at three monitoring wells (MW01, MW02, and MW06P) for the perched aquifer, five monitoring wells (MW05, MW06S, MW11, MW12, and MW13) for the shallow aquifer, and one monitoring well (MW07M) for the deep aquifer. The static water level in monitoring wells MW03, MW04, and MW07S was below the top of the screened interval; therefore, a slug test using a physical slug could not be performed. The water addition method (described below) also would not work in these wells because of the relatively high hydraulic conductivity of the shallow aquifer as compared to the perched aquifer; water dissipation in those wells would be quicker than the process of adding water to the wells. The information for the wells used to perform the slug tests (e.g, well depth, screen interval, static water level, and water height in casing and above the top of screen) and the slug test results are summarized in Table 4.6.

The slug tests in all wells, except for MW01, MW02, and MW06P, were performed by quickly lowering or withdrawing a physical slug into the casing to perturb the static water column. The physical slug used consisted of a 5-ft-long, 1.0-in.-diameter, sealed, sand-filled polyvinyl chloride (PVC) pipe. At each well, four slug tests were conducted, representing two complete insertion-and-withdrawal cycles, to monitor water level responses. For monitoring wells MW01, MW02, and MW06P, the solid slug could not be used because of low water height within the screen. An alternative method involving the addition of a slug of distilled water was used to monitor the water level response in these wells. This method is appropriate for wells installed in an aquifer with very low permeability since the response of the aquifer to the addition of a slug of water will be slow enough that it can be measured after the water slug is added to the well. Slug tests were performed using a slug of 2/3 gal of water. Each well was tested three times. The water level in the well being tested was allowed to recover to the static, starting groundwater level between tests. The water level responses for all tests were recorded by using self-contained, downhole pressure sensor and data logging units (Instrumentation Northwest, Inc., Model PT2XTM). All the slug test data are presented in Appendix B.

The water response data obtained from each of the slug tests were interpreted by using the analysis methods of Bouwer and Rice (Bouwer and Rice 1976; Bouwer 1989) and Hvorslev (1951), as implemented in the commercial well test software analysis package AqteSolv for Windows (HydroSolve, Inc.). Numerous alternative slug test analysis methods have been developed, each with advantages and disadvantages. The methods used for this study were selected in light of their relatively wide applicability, their level of documentation and general acceptance by the scientific community, and their ease of implementation to achieve the objective of estimating hydraulic parameters for three aquifers.

Complete data (time versus residual drawdown) for the slug tests and analysis parameters, with representative interpretive curve fits for the test data sets, are in Appendix B. The resulting horizontal hydraulic conductivity (K_h) estimates are summarized in Table 4.7. For each data set, the estimated K_h values calculated with the Bouwer and Rice method are of the same magnitude as, but lower than, the values for the same data set calculated with the Hvorslev method. All K_h values estimated from three or four sets of data by two methods were averaged for each testing location. The estimated average K_h values are 0.11-0.26 ft/day for the perched aquifer, 2.57-10.30 ft/day for the shallow aquifer, and 10.12 ft/day for the deep aquifer.

Figures 4.15-4.16 show the areal distribution of the calculated average K_h values. The shallow aquifer has a relatively low K_h in the upgradient area (2.57-5.47 ft/day) and a higher K_h in the downgradient area (8.95-10.3 ft/day) (Figure 4.16). The K_h for the perched aquifer is extremely low, ranging from 0.11 to 0.23 ft/day (Figure 4.15). The low K_h for the perched aquifer and upgradient part of the shallow aquifer is consistent with the observation of limited lateral migration of carbon tetrachloride (less than 290 ft) over a migration period of at least 46 yr.

In the event that any future corrective action involves an active groundwater pumping component, the potential production rate of pumping wells in the perched and shallow aquifers was evaluated to determine maximum water yield using the Theis equation, assuming a confined condition. A water yield for the perched aquifer was estimated, as shown in Figure 4.17, based on an average K_h of 0.22 ft/day, an aquifer thickness of 3.1 ft over the monitoring period 2013-2017, and a continuous pumping duration of 60 days. For a 6-in production well, the maximum water yield is only 0.01 gpm for the perched aquifer. Figure 4.18 shows the computed water yield for the upgradient part of the shallow aquifer, considering an average K_h of 4.32 ft/day, an aquifer thickness of 4.27 ft over monitoring period 2013-2017, and a continuous pumping duration of 60 days. For a 6-in production well, the estimated water yield for the shallow aquifer is also low at 0.3 gpm.

4.2.3 Uncertainty Analysis

This report compensates for uncertainties by using a weight of evidence approach. Several monitoring wells are used to monitor each of aquifers that are the subject of the potability determination. Each of the monitoring wells and several of the private wells have been sampled on multiple occasions to determine trends in water quality changes over time. In addition, hydraulic testing was performed four times for each of the shallow aquifer wells tested (MW 05, MW 06S, MW11, MW 12, and MW 13) and three times for each of the perched aquifer wells tested (MW 01, MW 02, and MW 06P).

TABLE 4.1 Analytical results from the AGEM Laboratory for groundwater samples collected from private and monitoring wells at and near the former CCC/USDA facility in 2012-2017.

				Concentration (µg/L)		
Location	Sample	Sample Date	Depth (ft BGL)	Carbon Tetrachloride	Chloroform	Methylene Chloride
Samples from private wells at and near the former CCC/USDA facility						
C. MEYER	SYCMEYER-W-33776	6/7/2012	–	ND	ND	ND
KINGERY	SYKINGERY-W-33773	6/7/2012	–	14	0.8 J	ND
	SYKINGERY-W-34301	2/19/15	–	52	3.7	ND
	SYKINGERY-W-34326	4/13/16	–	44	3.8	ND
	SYKINGERY-W-34343	2/23/17	–	10	0.9 J	ND
MEITLER	SYMEITLER-W-33777	6/7/2012	–	ND	ND	ND
WOLTING (SOUTH)	SYWOLTING-W-33771	6/7/2012	–	ND	ND	ND
	SYWOLTINGSOUTH-W-34302	2/19/15	–	ND	ND	ND
	SYWOLTINGSOUTH-W-34327	4/14/16	–	ND	ND	ND
WOLTING (NORTH)	SYWNORTH-W-33953	7/26/2012	55-65	ND	ND	ND
	SYWOLTINGNORTH-W-34303	2/18/15	55-65	ND	ND	ND
	SYWOLTINGNORTH-W-34328	4/14/16	55-65	ND	ND	ND
WOLTING (EAST) (formerly owned by RYSER)	SYRYSER-W-33778	6/7/2012	–	ND	ND	ND
	SYWOLTINGEAST-W-34329	4/13/16	–	ND	ND	ND
Samples from monitoring wells						
MW01	SYMW1-W-33939	7/16/2012	18-23	50	6.5	ND
	SYMW01-W-34288	2/17/15	18-23	20	2.4	ND
	SYMW01-W-34313	4/12/16	18-23	19	2.5	ND
MW02	SYMW2-W-33940	7/15/2012	18.5-23.5	7	1.3	ND
	SYMW02-W-34289	2/17/15	18.5-23.5	10	ND	ND
	SYMW02-W-34314	4/12/16	18.5-23.5	15	1.3	ND
MW03	SYMW3-W-33941	7/16/2012	33-38	2.6	ND	ND
	SYMW03-W-34290	2/17/15	33-38	1.3	ND	ND
	SYMW03-W-34315	4/13/16	33-38	2.8	0.7 J	ND
MW04	SYMW4-W-33942	7/17/2012	38-43	1.2	ND	ND
	SYMW04-W-34291	2/17/15	38-43	ND[a]	ND	ND
	SYMW04-W-34316	4/12/16	38-43	0.9 J[b]	ND	ND
MW05	SYMW5-W-33943	7/17/2012	38-43	ND	ND	ND
	SYMW05-W-34292	2/17/15	38-43	ND	ND	ND
	SYMW05-W-34317	4/12/16	38-43	ND	ND	ND
MW06P	SYMW6P-W-33944	7/17/2012	19.5-29.5	131	8.4	ND
	SYMW06P-W-34293	2/19/15	19.5-29.5	62	4.3	ND
	SYMW06P-W-34318	4/13/16	19.5-29.5	44	4.5	ND
	SYMW06P-W-34341	2/23/17	19.5-29.5	36	2.9	ND
MW06S	SYMW6S-W-33945	7/17/2012	42.5-52.5	5.2	5.4	ND
	SYMW06S-W-34294	2/19/15	42.5-52.5	ND	ND	ND
	SYMW06S-W-34319	4/13/16	42.5-52.5	ND	ND	ND
MW07S	SYMW7S-W-33946	7/18/2012	30-40	35	3.5	ND
	SYMW07S-W-34295	2/19/15	30-40	19	1.4	ND
	SYMW07S-W-34320	4/13/16	30-40	105	9.0	ND
	SYMW07S-W-34342	2/23/17	30-40	69	4.2	ND
MW07M	SYMW7M-W-33947	7/17/2012	55-60	ND	ND	ND
	SYMW07M-W-34296	2/19/15	55-60	ND	ND	ND
	SYMW07M-W-34321	4/13/16	55-60	ND	ND	ND
MW07D	SYMW7D-W-33948	7/17/2012	78-88	ND	ND	ND
	SYMW07D-W-34297	2/19/15	78-88	ND	ND	ND
	SYMW07D-W-34322	4/14/16	78-88	ND	ND	ND

TABLE 4.1 (Cont.)

Location	Sample	Sample Date	Depth (ft BGL)	Concentration (µg/L)		
				Carbon Tetrachloride	Chloroform	Methylene Chloride
MW11	SYMW11-W-33949	7/18/2012	35-45	ND	ND	ND
	SYMW11-W-34298	2/18/15	35-45	ND	ND	ND
	SYMW11-W-34323	4/14/16	35-45	ND	ND	ND
MW12	SYMW12-W-33950	7/18/2012	45-55	ND	ND	ND
	SYMW12-W-34299	2/18/15	45-55	ND	ND	ND
	SYMW12-W-34324	4/14/16	45-55	ND	ND	ND
MW13	SYMW13-W-33951	7/18/2012	34.5-39.5	ND	ND	ND
	SYMW13-W-34300	2/18/15	34.5-39.5	ND	ND	ND
	SYMW13-W-34325	4/14/16	34.5-39.5	ND	ND	ND

[a] ND, compound analyzed for but not detected at a level greater than or equal to the method detection limit (< 1 µg/L).

[b] J, compound identified with an estimated concentration between the instrument detection limit and the method detection limit.

TABLE 4.2 Analytical results from TestAmerica, Inc., for anions in groundwater at Sylvan Grove, Kansas, February 2015.

Location	Sample	Sample Date	Depth (ft BGL)	Concentration (mg/L)					
				Bromide	Chloride	Nitrate	Nitrite	Phosphate	Sulfate
KINGERY	SYKINGERY-W-34301	2/19/15	–	2.1 J[a]	710	120	ND (7.5)	ND (8.2)	690
WOLTING-NORTH	SYWOLTINGNORTH-W-34303	2/18/15	55-65	ND[b] (0.11)	10	0.08 J	ND (0.075)	ND (0.082)	98
WOLTING-SOUTH	SYWOLTINGSOUTH-W-34302	2/19/15	–	ND (0.11)	12	0.2	ND (0.75)	ND (0.082)	82
MW01	SYMW01-W-34288	2/17/15	18-23	1.8	1,000	99	ND (7.5)	ND (0.82)	620
MW02	SYMW02-W-34289	2/17/15	18.5-23.5	1.0	220	130	ND (0.75)	ND (0.82)	370
MW03	SYMW03-W-34290	2/17/15	33-38	2.2	440	340	ND (7.5)	ND (0.82)	490
MW04	SYMW04-W-34291	2/17/15	38-43	0.9	240	93	ND (0.75)	ND (0.82)	220
MW05	SYMW05-W-34292	2/17/15	38-43	ND (0.11)	12	0.08 J	ND (0.075)	ND (0.082)	93
MW06P	SYMW06P-W-34293	2/19/15	19.5-29.5	1.9 J	1,000	130 H[c]	ND (7.5) H	ND (8.2) H	850
MW06S	SYMW06S-W-34294	2/19/15	42.5-52.5	ND (0.11)	9.8	0.08 J H	ND (0.75) H	ND (0.082) H	59
MW07S	SYMW07S-W-34295	2/19/15	30-40	1.1 J	310	140	ND (7.5)	ND (8.2)	360
MW07M	SYMW07M-W-34296	2/19/15	55-60	ND (0.11)	35	1.5 H	ND (0.75) H	ND (0.082) H	50
MW07D	SYMW07D-W-34297	2/19/15	78-88	ND (0.11)	16	ND (0.046)	ND (0.75)	ND (0.082)	98
MW11	SYMW11-W-34298	2/18/15	35-45	ND (0.11)	21	0.08 J	ND (0.75)	ND (0.082)	59
MW12	SYMW12-W-34299	2/18/15	45-55	ND (0.11)	7.8	0.08 J	ND (0.075)	ND (0.082)	49
MW13	SYMW13-W-34300	2/18/15	34.5-39.5	ND (0.11)	23	0.1 J	ND (0.75)	ND (0.082)	110

[a] J, compound identified with an estimated concentration between the instrument detection limit and the method detection limit.

[b] D, compound analyzed for but not detected at a level greater than or equal to the indicated method detection limit.

[c] H, sample prepped or analyzed beyond the specified holding time.

TABLE 4.3 Analytical results from TestAmerica, Inc., for cations in groundwater at Sylvan Grove, Kansas, February 2015.

				Concentration (µg/L)									
Location	Sample	Sample Date	Depth (ft BGL)	Aluminum	Calcium	Iron	Magnesium	Manganese	Phosphorous	Potassium	Silicon	Sodium	Zinc
KINGERY	SYKINGERY-W-34301	2/19/15	–	ND[a] (200)	592,000	ND (200)	63,800	16	ND (250)	7,180	10,500	390,000	53
WOLTING-SOUTH	SYWOLTINGSOUTH-W-34302	2/19/15	–	ND (200)	100,000	ND (200)	21,800	188	ND (250)	3,120	9,390	35,300	211
MW06P	SYMW06P-W-34293	2/19/15	19.5-29.5	ND (200)	650,000	ND (200)	73,200	2.0 J[b]	71 J	9,190	8,020	704,000	14 J
MW06S	SYMW06S-W-34294	2/19/15	42.5-52.5	ND (200)	66,100	ND (200)	9,740	228	ND (250)	2150 J	9,480	14,900	222
MW07S	SYMW07S-W-34295	2/19/15	30-40	ND (200)	559,000	ND (200)	59,000	ND (10)	12 J	6,900	12,800	189,000	25
MW07M	SYMW07M-W-34296	2/19/15	55-60	ND (200)	72,000	ND (200)	6,860	27	ND (250)	2450 J	8,810	21,300	57
MW07D	SYMW07D-W-34297	2/19/15	78-88	ND (200)	108,000	ND (200)	23,200	393	ND (250)	3,100	9,620	47,300	65

[a] ND, compound analyzed for but not detected at a level greater than or equal to the indicated method detection limit.

[b] J, compound identified with an estimated concentration between the instrument detection limit and the method detection limit.

TABLE 4.4 Estimated geochemical properties of groundwater samples collected from the perched, shallow, and deep aquifers at Sylvan Grove, Kansas.

Location	Aquifer	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Ion Balance (%)	Total Hardness (as $CaCO_3$, mg/L)	TDS (mg/L)	Water Type	Predominant Dissolved Minerals
MW06P	Perched	69.1	69.4	0.23	38.5	3,598.6	Ca-Na-HCO_3-Cl	Halite-NaCl Calcite-$CaCO_3$
KINGERY	Shallow/Deep	53.7	52.1	-1.5	34.8	3,642.8	Ca--Na-HCO_3-SO_4	Halite-NaCl Anhydrite-$CaSO_4$
WOLTING-SOUTH	Shallow	8.3	8.5	1.15	6.8	416.5	Ca--Mg-HCO_3-SO_4	Dolomite-$CaMg(CO_3)_2$ Anhydrite-$CaSO_4$
MW06S	Shallow	4.7	4.9	1.79	4.1	257.8	Ca-HCO_3-SO_4	Calcite-$CaCO_3$ Anhydrite-$CaSO_4$
MW07S	Shallow	43.2	41.3	-2.3	32.75	3,146.0	Ca-HCO_3-Cl	Halite-NaCl Calcite-$CaCO_3$
MW07M	Deep	5.1	5.2	1.3	4.16	384.3	Ca-HCO_3-SO_4	Calcite-$CaCO_3$ Anhydrite-$CaSO_4$
MW07D	Deep	9.4	9.6	1.1	7.3	463.4	Ca--Na-Mg-HCO_3-SO_4	Anhydrite-CaSO4 Dolomite-$CaMg(CO_3)_2$

TABLE 4.5 Summary of manual measurements of groundwater level in monitoring wells at Sylvan Grove, Kansas.

Well	Ground Surface Elevation (ft, AMSL)	Measured Groundwater Level (ft, AMSL)						
		10/8/2013	4/10/2014	2/13/2015	10/29/2015	4/12/2016	8/16/2016	2/23/2017
MW01	1484.08	1467.03	1463.51	1463.46	1464.20	1464.98	1469.50	1467.68
MW02	1483.28	1467.67	1464.49	1464.90	–	1465.55	1470.00	1467.17
MW03	1487.22	1451.27	1450.99	1450.81	1450.60	1450.60	1450.84	1451.12
MW04	1489.27	1451.14	1450.72	1450.64	1450.31	1450.29	1450.61	1450.97
MW05	1481.13	1448.50	1448.50	1447.48	1447.24	1446.74	1448.26	1447.82
MW06P	1483.04	1462.14	1460.33	1460.17	1460.60	1462.02	1463.18	1463.26
MW06S	1483.15	1448.53	1447.94	1447.51	1447.36	1446.92	1448.34	1447.88
MW07D	1487.70	1448.32	1448.67	1448.27	1448.03	1447.65	1448.36	1447.60
MW07M	1487.47	1448.03	1448.60	1448.19	1447.96	1447.53	1447.33	1447.51
MW07S	1487.40	1451.03	1450.62	1450.51	1450.26	1450.25	1450.80	1451.11
MW11	1475.38	1448.37	1447.41	1447.13	1446.87	1446.37	1448.67	1447.83
MW12	1481.84	1448.45	–	1447.47	–	1446.72	1448.23	1447.58
MW13	1478.14	1448.48	1447.63	1447.33	1447.10	1446.59	1448.29	1447.90

TABLE 4.6 Summary of slug tests and testing wells.

Well	Reported Well Depth[a] (ft, BGL)	Screened Interval[a] (ft, BGL)	Gravel Pack Interval[a] (ft, BGL)	Static Water Level[b] (ft, TOC)	Static Water Level[b] (ft, BGL)	Height of Water Column in Casing[b] (ft)	Height of Water above Screen[b,c] (ft)	Slug Used for Testing	Number of Data Sets Collected
Perched Aquifer									
MW01	23	18-23	16-24	20.50	20.83	2.17	-2.83	Water slug[d]	3
MW02	23.5	18.5-23.5	16-23.5	18.76	19.04	4.46	-0.54	Water slug	3
MW06P	29.5	19.5-29.5	17-29.5	22.49	22.75	6.75	-3.25	Water slug	3
Shallow Aquifer									
MW05	43	38-43	36-43	33.97	34.26	8.74	3.74	Solid slug[e]	4
MW06S	52.5	42.5-52.5	40-52.5	35.95	36.23	16.27	6.27	Solid slug	4
MW11	45	35-45	33-46	28.56	28.77	16.23	6.23	Solid slug	4
MW12	55	45-55	42-56	34.73	35.01	19.99	9.99	Solid slug	4
MW13	39.5	34.5-39.5	32-40	31.10	31.35	8.15	3.15	Solid slug	4
Deep Aquifer (upper and lower parts)									
MW07M	60	55-60	52-60	39.34	39.58	20.42	15.42	Solid slug	4

[a] Well construction parameters as reported in KDHE WWC-5 Water Well Records.

[b] Water levels determined from measurements on April 13-14, 2015.

[c] Water above the top of the screen is postive; water below the top of the screen is negative.

[d] Physical slugs were constructed by adding 2/3 gallon of water.

[e] Physical slugs were constructed from a 5-ft long, 1-in.-diameter, sealed, sand-filled PVC tubing.

TABLE 4.7 Summary of interpreted results for slug tests in monitoring wells in April 2015.

	Calculated Hydraulic Conductivity (ft/day)								
Well	Bouwer and Rice Method Result for Each Test				Hvorslev Method Result for Each Test				Average[a]
Perched Aquifer[b]									
MW01	0.075	0.088	0.088	–	0.119	0.139	0.139	–	0.11
MW02	0.162	0.155	0.149	–	0.310	0.296	0.286	–	0.23
MW06P	0.129	0.145	0.154	–	0.334	0.375	0.399	–	0.26
Shallow Aquifer[c]									
MW05	3.848	4.346	3.947	4.196	5.422	6.123	5.561	5.913	4.92
MW06S	4.397	4.716	4.739	4.608	6.012	6.449	6.479	6.303	5.47
MW11	9.525	9.539	9.440	9.957	10.88	10.90	10.78	11.37	10.30
MW12	9.256	9.416	7.557	6.630	10.92	11.11	8.912	7.809	8.95
MW13	2.185	2.226	–	–	2.913	2.968	–	–	2.57
Deep Aquifer[c]									
MW07M	7.493	10.03	8.918	10.07	9.146	12.20	10.87	12.27	10.12

[a] Averaged for all tests and both calculation methods.

[b] Identified unconfined condition was applied for calculation, the thickness of the aquifer is based on the difference between the water level measured prior to the test and the bottom of the aquifer.

[c] Identified confined condition was used for calculation.

FIGURE 4.1 Maximum concentrations of carbon tetrachloride and chloroform in soil samples collected through the vadose zone at and near the former CCC/USDA facility and analyzed by the purge-and-trap method. Source of photograph: USDA (2010).

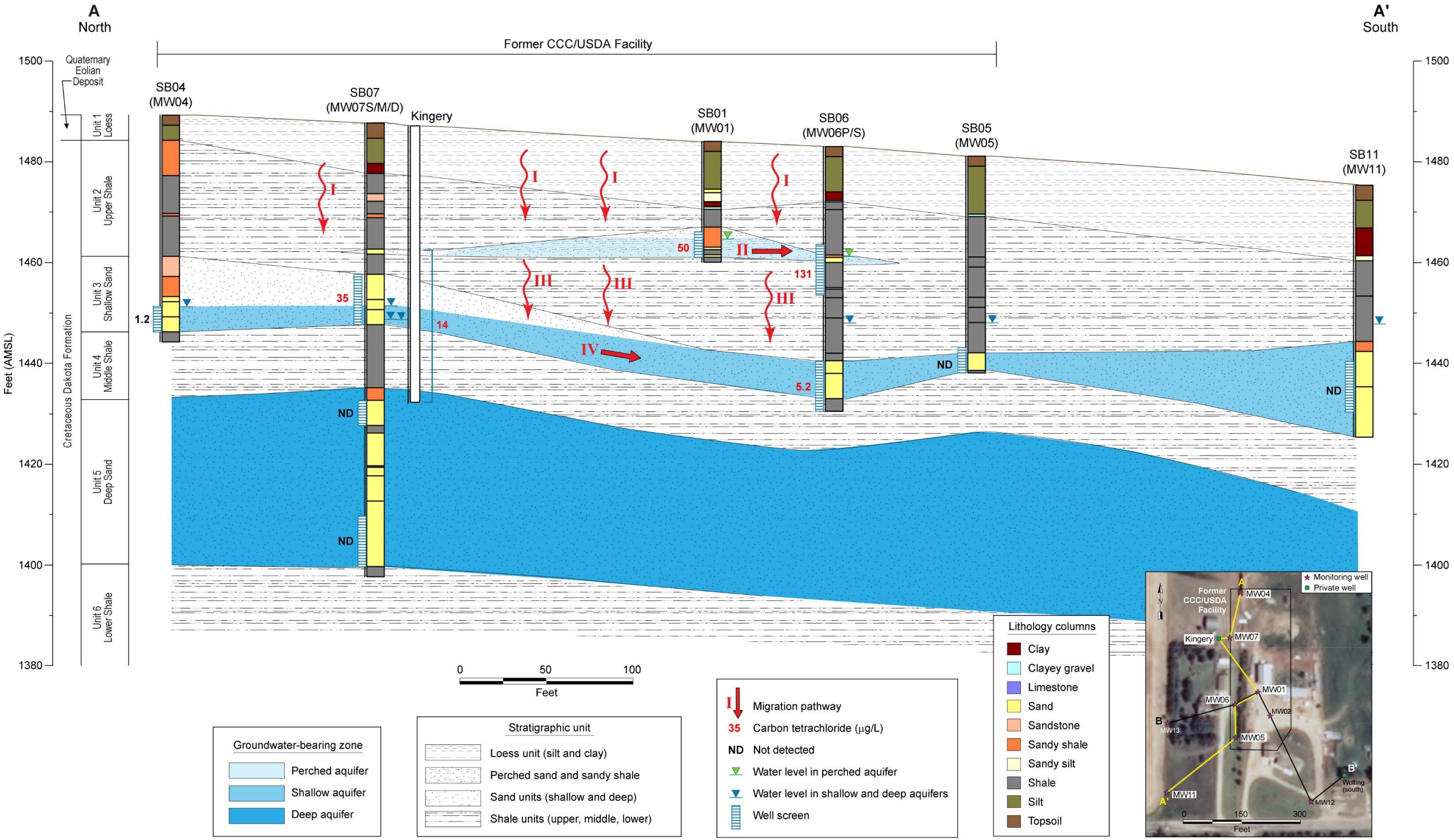

FIGURE 4.2 Vertical and lateral distribution of carbon tetrachloride in groundwater along north-to-south hydrogeologic cross section A-A', at and near the former CCC/USDA property.

FIGURE 4.3 Carbon tetrachloride concentrations in the perched aquifer based on groundwater sampling in 2012, 2015, 2016, and 2017. Source of photograph: USDA (2010).

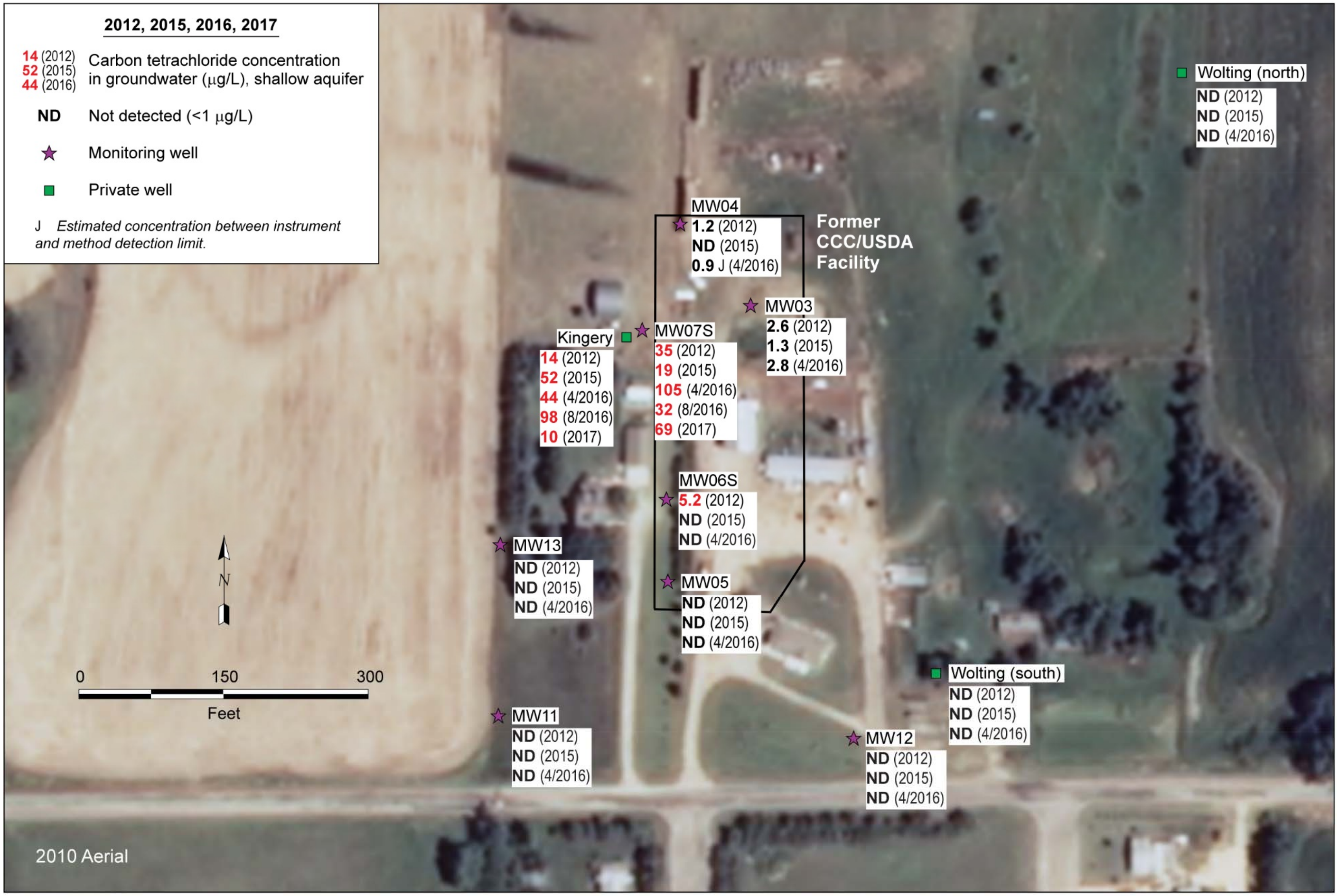

FIGURE 4.4 Carbon tetrachloride concentrations in the shallow aquifer based on groundwater sampling in 2012, 2015, 2016, and 2017. Source of photograph: USDA (2010).

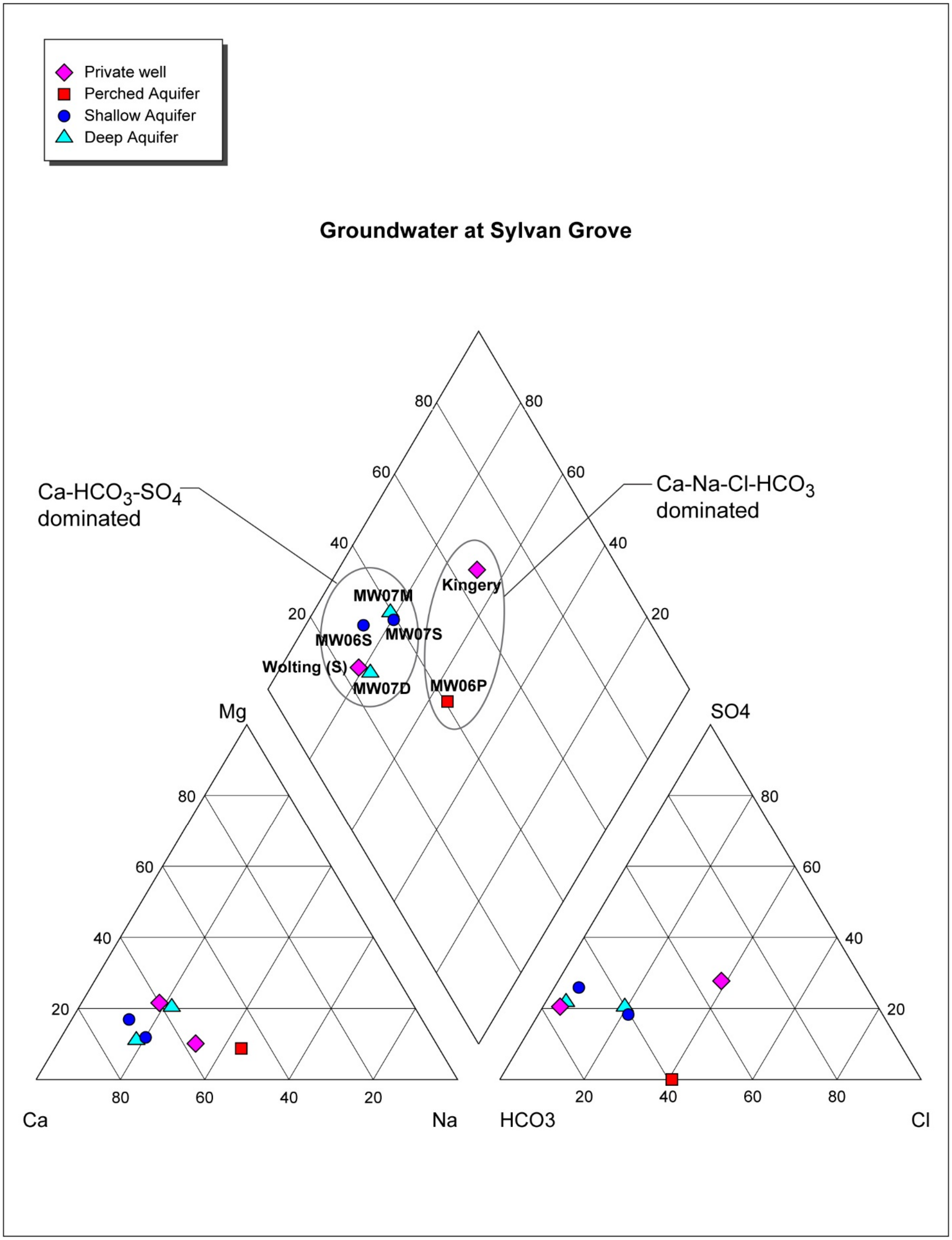

FIGURE 4.5 Composition of major cation and anion in groundwater samples collected from perched aquifer, shallow aquifer, deep aquifer, and lawn and garden wells (Kingery and Wolting [south]).

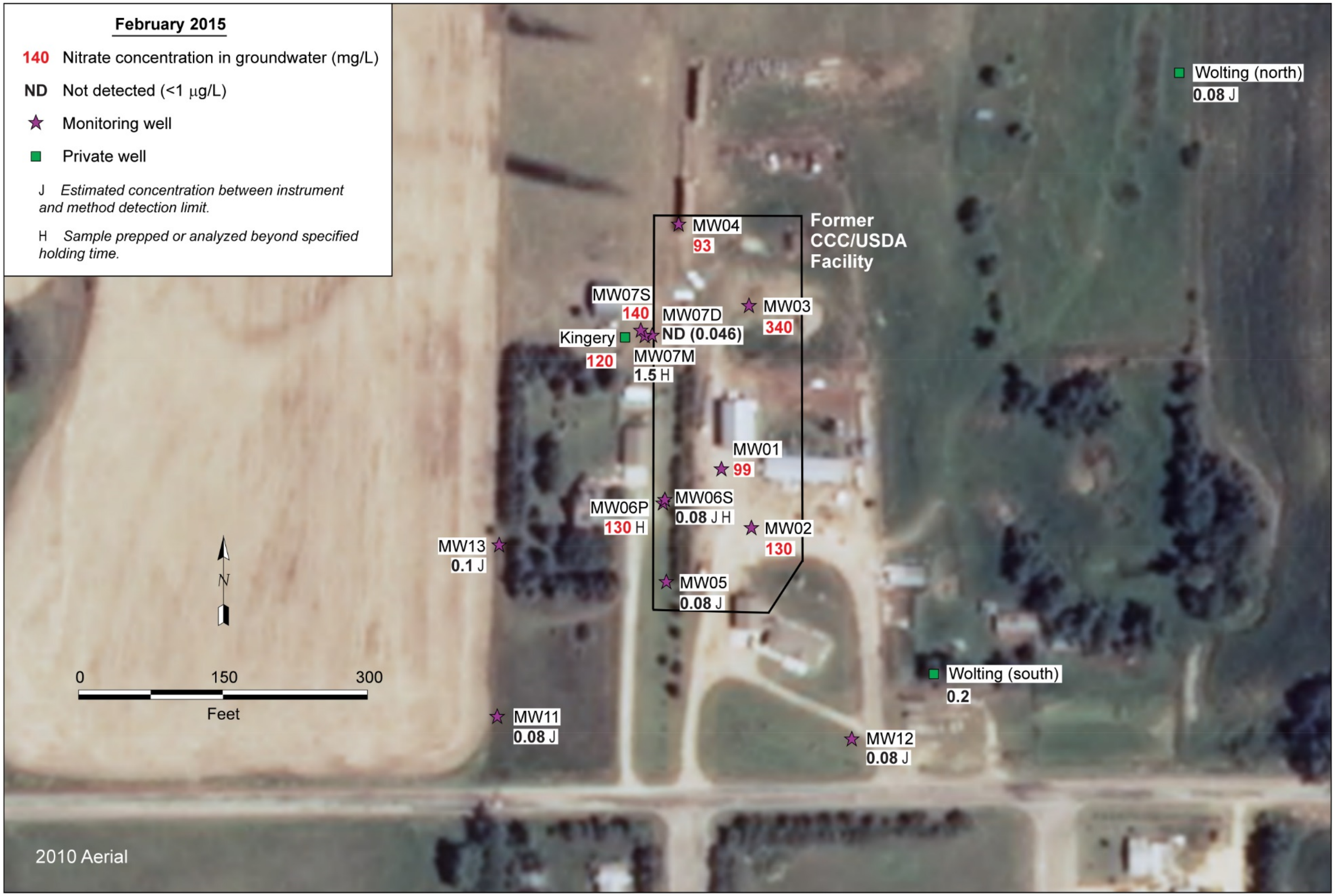

FIGURE 4.6 Areal distribution of nitrate in groundwater at and near the former CCC/USDA facility. Source of photograph: USDA (2010).

FIGURE 4.7 Potentiometric surface for the perched aquifer at the former CCC/USDA facility, based on water levels measured on October 8, 2013.

FIGURE 4.8 Potentiometric surface for the perched aquifer at the former CCC/USDA facility, based on water levels measured on April 10, 2014. Source of photograph: USDA (2010).

FIGURE 4.9 Potentiometric surface for the perched aquifer at the former CCC/USDA facility, based on water levels measured on February 13, 2015. Source of photograph: USDA (2010).

FIGURE 4.10 Potentiometric surface for the perched aquifer at the former CCC/USDA facility, based on water levels measured on April 12, 2016. Source of photograph: USDA (2010).

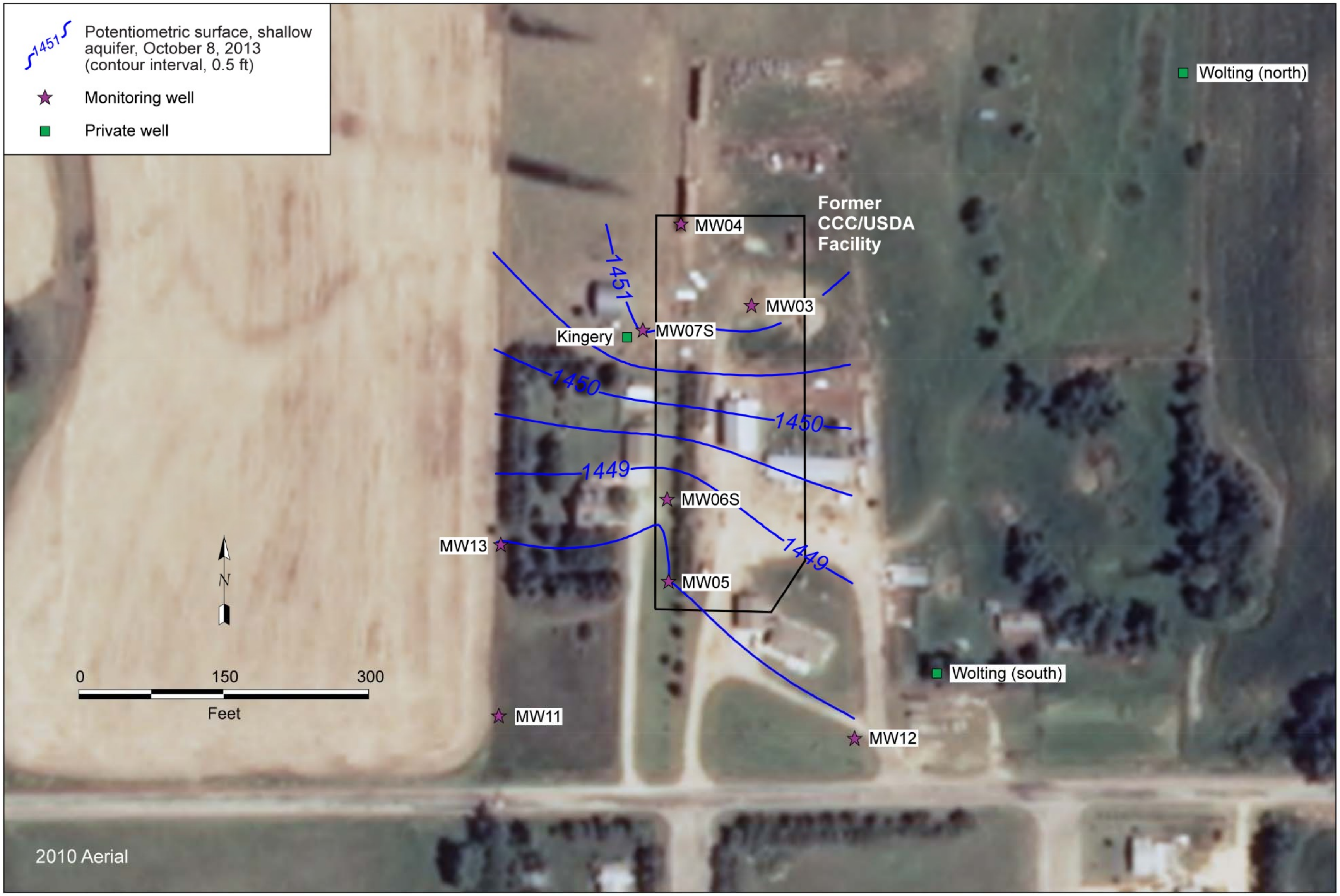

FIGURE 4.11 Potentiometric surface for the shallow aquifer at the former CCC/USDA facility, based on water levels measured on October 8, 2013. Source of photograph: USDA (2010).

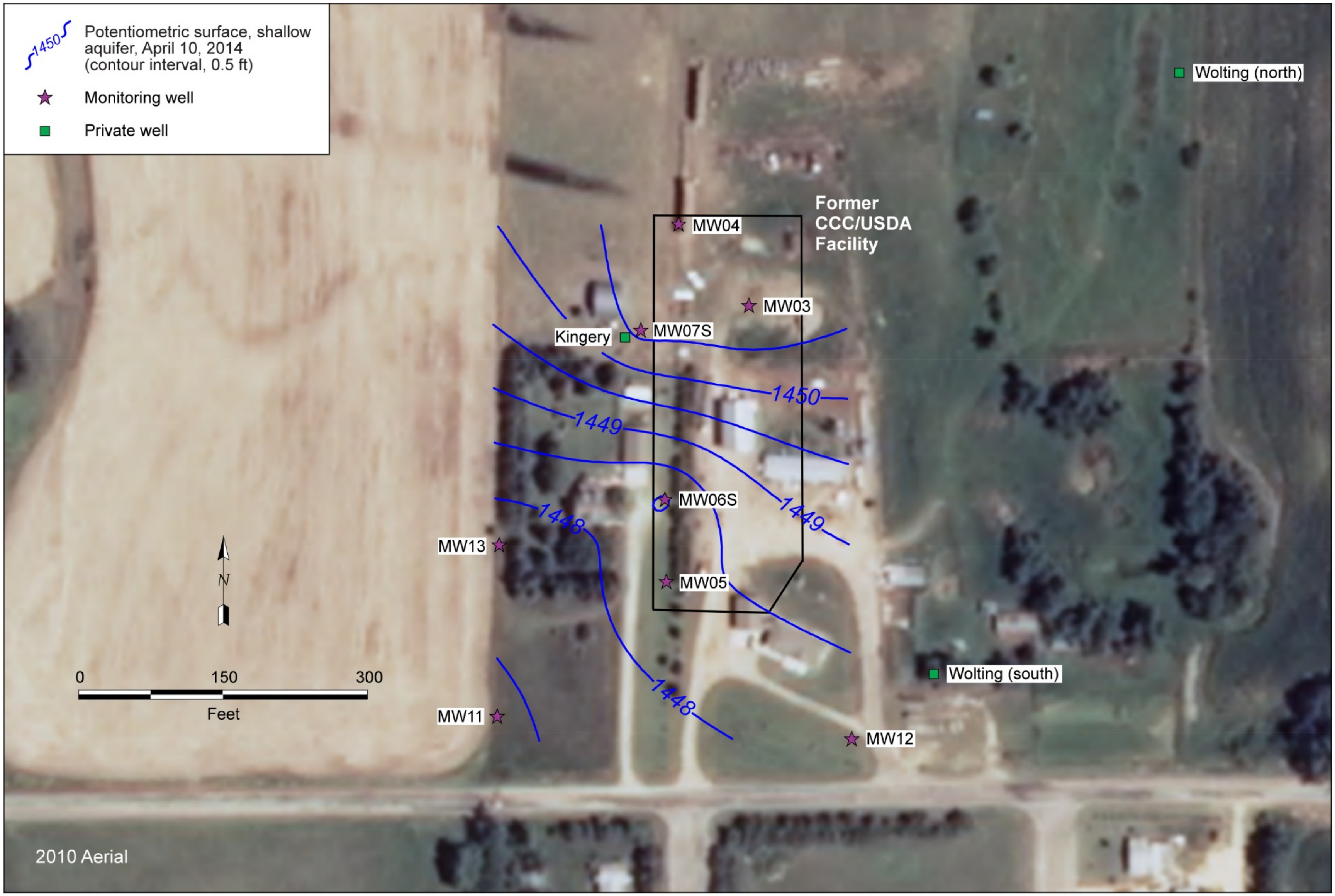

FIGURE 4.12 Potentiometric surface for the shallow aquifer at the former CCC/USDA facility, based on water levels measured on April 10, 2014. Source of photograph: USDA (2010).

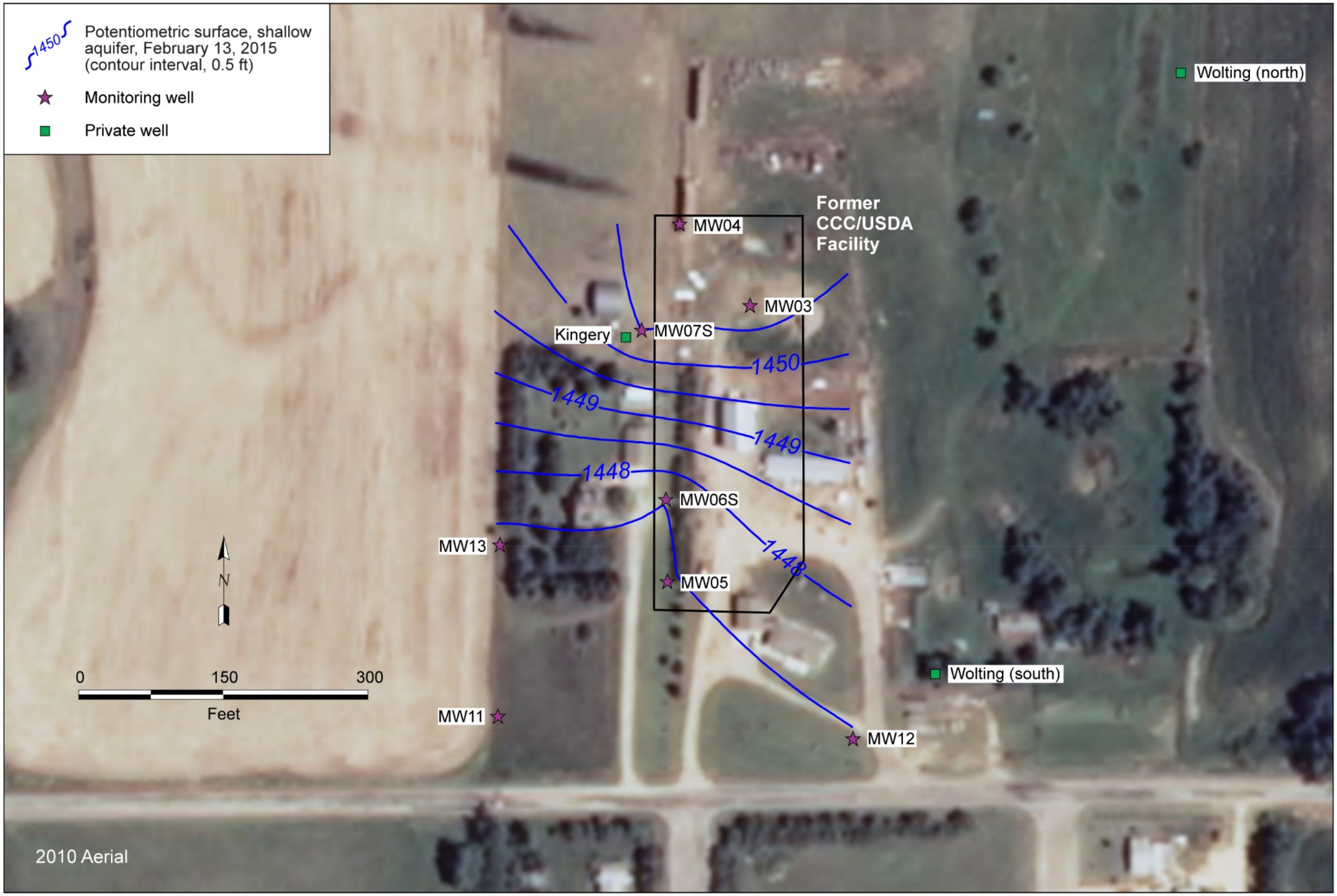

FIGURE 4.13 Potentiometric surface for the shallow aquifer at the former CCC/USDA facility, based on water levels measured on February 13, 2015. Source of photograph: USDA (2010).

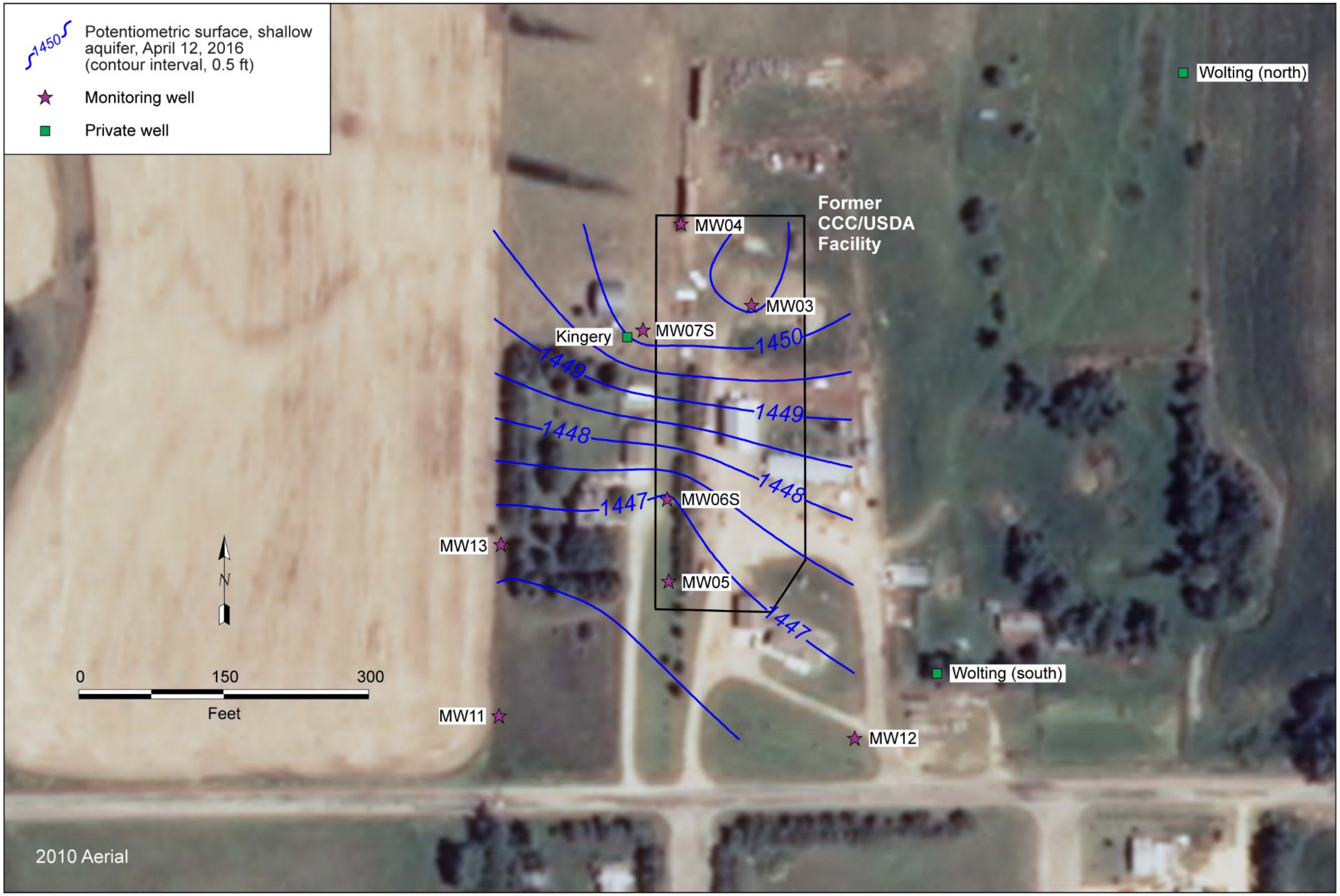

FIGURE 4.14 Potentiometric surface for the shallow aquifer at the former CCC/USDA facility, based on water levels measured on April 12, 2016. Source of photograph: USDA (2010).

FIGURE 4.15 Hydraulic conductivities for perched aquifer at the former CCC/USDA facility based on slug test results.
Source of photograph: USDA (2010).

FIGURE 4.16 Hydraulic conductivities for shallow aquifer at the former CCC/USDA facility based on slug test results.
Source of photograph: USDA (2010).

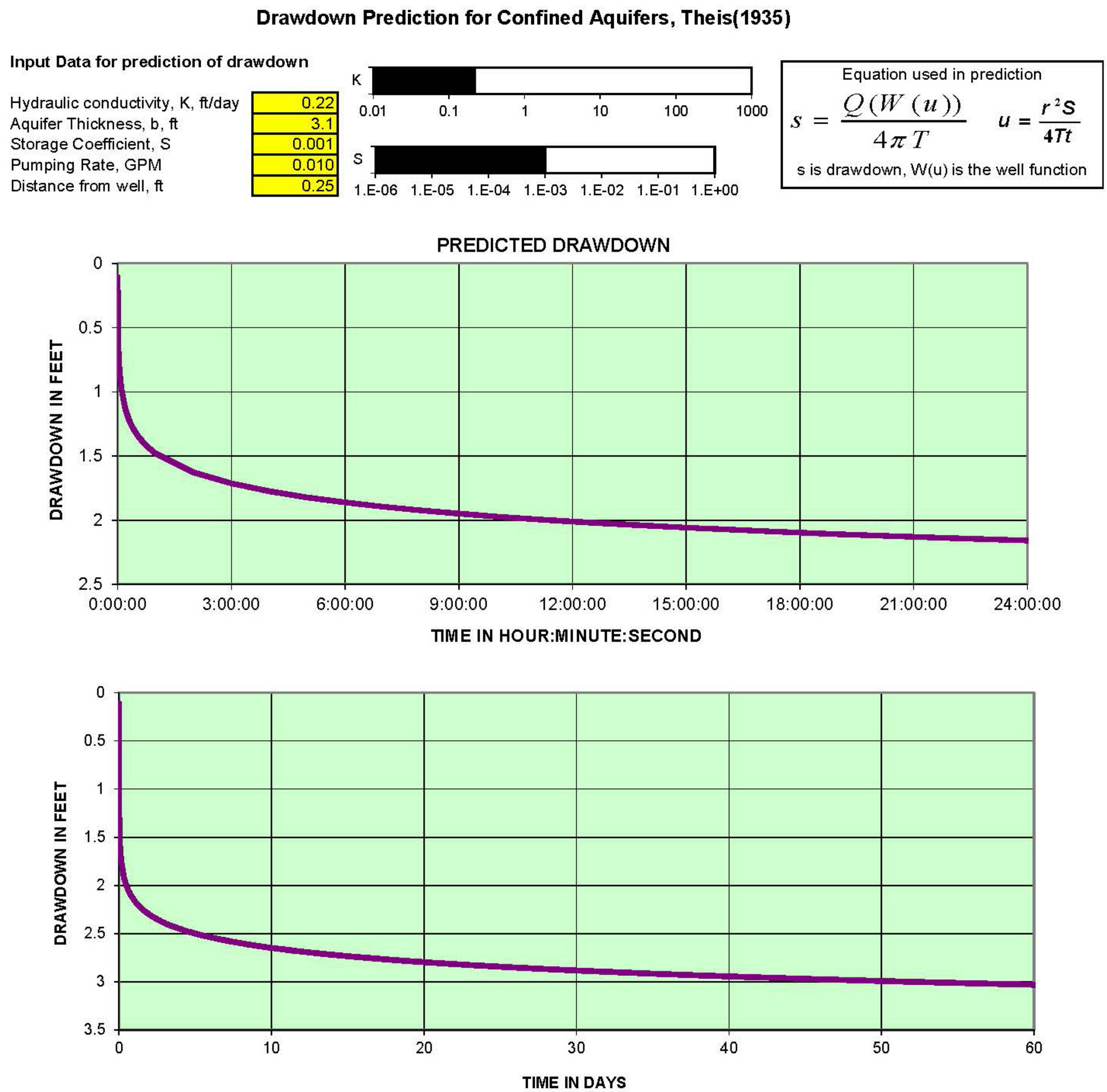

FIGURE 4.17 Estimated water yield and predicted drawdown for the perched aquifer.

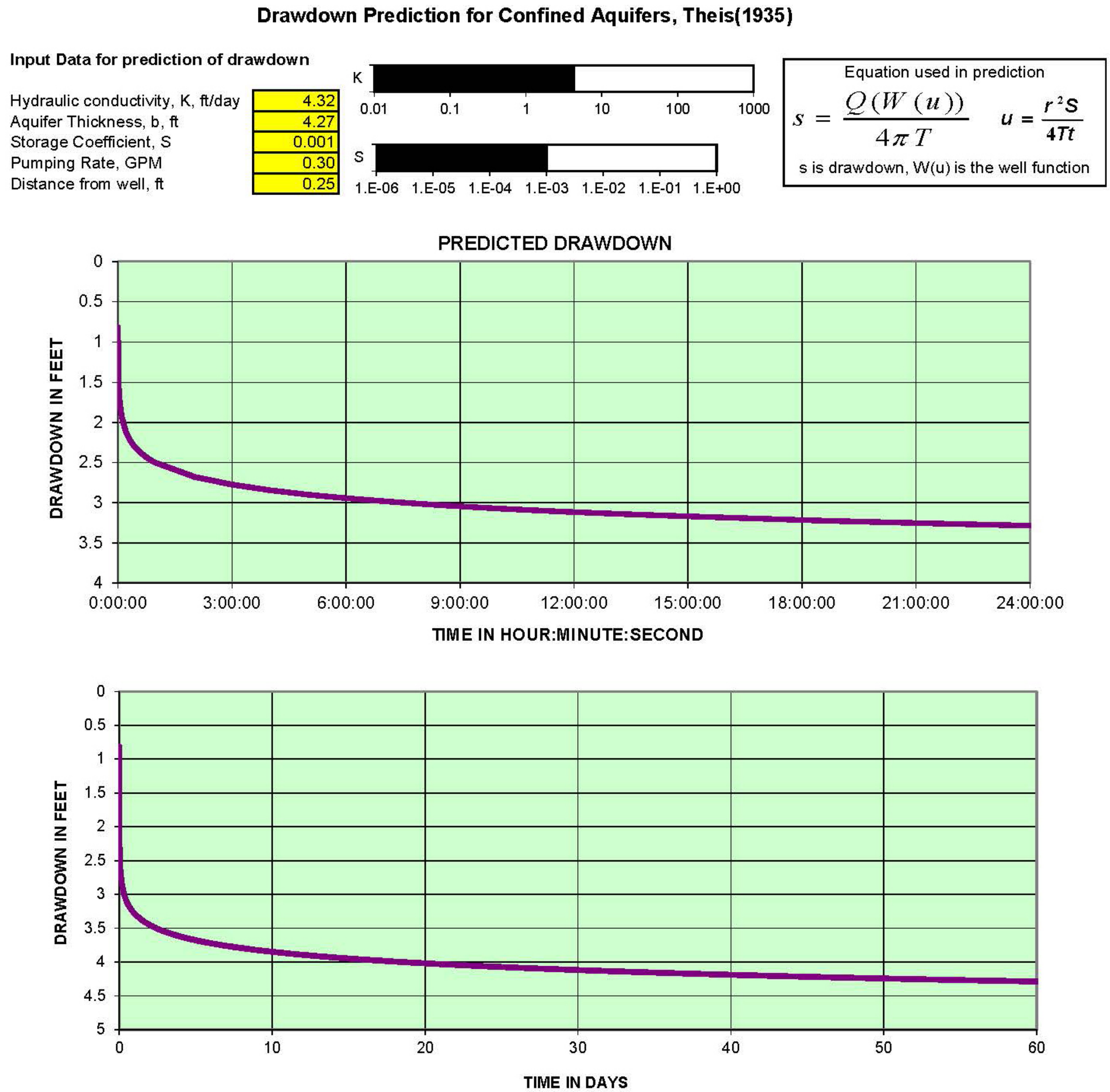

FIGURE 4.18 Estimated water yield and predicted drawdown for the upgradient portion of the shallow aquifer.

5 Remediation and/or Risk Management

The Potability Determination Guidance refers to the need for a discussion of any controls, remedial measures, and/or remedial actions taken to address environmental impacts or eliminate exposure pathways. The CCC/USDA will perform a CAS study to evaluate what controls, remedial measures, and/or remedial actions are needed, considering potability as well as contaminant migration potential and the risk to human health.

As discussed in Section 2.1.4, all the direct and indirect exposure pathways to the contaminated soil and groundwater are incomplete. Therefore, there are no unacceptable health risks associated with any potential human exposure to the contaminated soil and groundwater in the perched and shallow aquifers.

6 Current Site Data and Justification/Considerations for Groundwater Potability Determination

Both the perched aquifer and the portion of the shallow aquifer affected by operations at the former CCC/USDA facility are non-potable. These groundwater resources are non-potable for two reasons: 1) water quality-related considerations, including elevated TDS, hardness, and nitrate concentrations; and 2) there is insufficient groundwater quantity for potable use.

The measured concentrations of TDS in the shallow groundwater at Sylvan Grove is double the cited KDHE threshold level. Groundwater in the perched aquifer (MW06P) and upgradient portion of the shallow aquifer (MW07S and the Kingery well) has a very high concentration of TDS, ranging from 3,146 mg/L to 3,643 mg/L. These concentrations exceed the SMCL for drinking water (500 mg/L) and KDHE guidance which specifies that drinking water with TDS levels of 900 to 1,200 mg/L may be unpalatable and that levels greater than 1,200 mg/L are unacceptable.

Water from the perched aquifer (MW06P) and upgradient portion of the shallow aquifer (MW07S and the Kingery well) falls in the "extremely hard" category with a hardness of 1,637-1,923 mg/L ($CaCO_3$). Extremely hard water causes mineral deposits on dishes and glassware, results in high energy costs due to scale build-up in pipes and on appliances and causes scale build up in sink, tubs, faucets and appliances (Water Quality Association 2018). Extremely hard water is considered non-potable since the water source would not be acceptable for household purposes.

Water from the perched aquifer (MW01, MW02, and MW06P) has high concentrations of nitrate, ranging from 99 mg/L to 130 mg/L. Water from upgradient portions of the shallow aquifer (and the Kingery well that intercepts the shallow aquifer) has high concentrations of nitrate, with concentrations ranging from 93 mg/L to 340 mg/L. These concentrations exceed the MCL and the KDHE drinking water standard of 10 mg/L.

The estimated average K_h values for the perched aquifer are 0.11-0.26 ft/day. Based on an average K_h of 0.22 ft/day, an aquifer thickness of 3.1 ft over monitoring period of 2013-2017, and a continuous pumping duration of 60 days, the maximum water yield for the perched aquifer is only 0.01 gpm or 14.4 gal/day for a 6-in. production well. A water yield of 14.4 gal/day is far below the Kansas estimates for domestic well use of 99 gal per person per day as referenced in KDHE's Potability Determination Guidance.

The estimated average K_h values are 2.57-10.30 ft/day for the shallow aquifer. A water yield for the upgradient part of the shallow aquifer, the portion of the aquifer affected by the former CCC/USDA facility, was estimated based on an average K_h of 4.32 ft/day, an aquifer thickness of 4.27 ft, and a continuous pumping duration of 60 days. For a 6-in. production well, the estimated water yield for the shallow aquifer is low at 0.3 gpm or 432 gal/day. A water yield of 432 gal/day is above the Kansas estimates for domestic well use of 99 gal per person per day as referenced in the Potability Determination guidance.

7 Summary

As noted in KDHE's Potability Determination Guidance, whether an aquifer is potable or not is based strictly on the groundwater quality and/or the ability to extract groundwater for potable purposes. The focus of this potability determination report is on groundwater resources in a perched and shallow aquifer that have been affected by operations at the former CCC/USDA facility. Three groundwater-bearing zones in the bedrock formation were identified in the local geologic sequence: (1) the perched aquifer hosted by a few layers of sandy shale and sand confined within the upper shale (Unit 2), with a saturated thickness of 2-3 ft; (2) the shallow aquifer hosted by the shallow sand (Unit 3), with a varying thickness from 4 ft at the northern part of the former CCC/USDA facility to more than 19 ft at the southern part of the former facility; and (3) the deep aquifer hosted by the deep sand (Unit 5), which is the thickest (35 ft) of the aquifers identified in the investigation.

The deep aquifer, which has not been affected by operations at the former CCC/USDA facility is under confined conditions. The perched aquifer and shallow aquifer are non-potable because of TDS concentrations in excess of what is considered acceptable by the KDHE, hardness levels rated as "extremely hard" by the American Water Quality Association (2018), and considered to be antithetical to domestic water uses and nitrate concentrations in excess of threshold drinking water standards. The perched aquifer has also been determined to be non-potable based on poor yield: 14 gal per day per well.

The public water supply wells and private wells that are located in and near the Saline River floodplain bordered by the upland at the elevation of about 1,460 ft AMSL are withdrawing groundwater from the fluvial aquifer overlying the bedrock formation. The city public water supply system has provided a good quantity and quality of water for the community more than 100 years. All city residents (and residents of the Wolting and Kingery properties located outside city limits) are connected to the city public water supply system (Argonne 2018).

Based on the evaluation of exposure pathways, there are no unacceptable health risks associated with (1) direct human exposure to the contaminated soil and groundwater in the perched and shallow aquifers, or (2) indirect exposure through the soil-to-groundwater pathway, upward vapor migration into the residential structure, or discharge to surface water.

The results of this potability determination will be taken into consideration during the development of cleanup goals for the CAS or for any other future remedial or long-term management action agreed to by the CCC/USDA and KDHE.

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Appendix A:

Quality Control Data Summary

Appendix A:

Quality Control Data Summary

The QA/QC procedures for sample collection, handling, and analysis during the four monitoring events that occurred in 2015- 2017 are described in detail in the *Master Work Plan* (Argonne 2002). The sequence of activities for each monitoring event is listed in Table A.1.

The results of the QA/QC activities are summarized as follows:

- Sample integrity was maintained successfully during sample collection, shipping, and analysis through documentation of samples as they were collected and the use of custody seals and chain-of-custody (COC) records. All samples were received with custody seals intact and at the appropriate preservation conditions.

- Carbon tetrachloride and chloroform, the primary contaminants of concern, were not detected in laboratory method blanks at the AGEM Laboratory.

- Quality control samples (field blanks, equipment rinsates, and trip blanks) were collected to monitor sample-handling activities. Neither carbon tetrachloride nor chloroform was detected in any quality control sample (Table A.2).

- Groundwater samples were analyzed for VOCs, including carbon tetrachloride, chloroform, and methylene chloride, at the AGEM Laboratory by using the purge-and-trap method (a GC-MS method) for quantitative determination of contaminant distribution. Dual analyses were accomplished through either analysis of replicate samples submitted to the laboratory or duplicate analysis of samples selected by the laboratory. The average relative percent difference values for each monitoring event are shown in Table A.3 for carbon tetrachloride and chloroform in dual analyses by the AGEM Laboratory with the contaminants present above the respective method detection limits. The quality control range for relative percent difference between dual analyses is ±20%. Dual analyses of samples at AGEM Laboratory and TestAmerica, therefore, demonstrated consistency in the sampling and analytical methodologies. The results for chloroform in SYMW06P-W-34318 and its lab duplicate showed a difference of 25% due to the relatively small concentrations detected, but still compare favorably despite the relative percent difference value exceeding ±20%.

- The analyses of groundwater samples by the AGEM Laboratory were verified by TestAmerica. Agreement in the results from the two laboratories is good over the range of contaminant concentrations detected. The average relative percent difference values for each monitoring event are shown in Table A.4 for carbon tetrachloride and chloroform in verification analyses with the contaminants present above the respective method detection limits. The quality control range for relative percent difference between verification analyses is ±20%. The results for carbon tetrachloride and chloroform in the samples from the February 17-19, 2015, sampling event showed average relative percent differences of 26% and 35%, respectively, due to the relatively small concentrations detected, but still compare favorably despite exceeding ±20%. The concentrations detected in groundwater in analyses at the AGEM Laboratory are therefore supported by the verification analyses at TestAmerica.

TABLE A.1 Sequence of activities during multiple groundwater monitoring events at Sylvan Grove, Kansas, in 2015-2017.

Sample Date:Time	Location	Sample	Sample Type[a]	Depth from (ft BGL)	Depth to (ft BGL)	Sample Matrix[b]	Chain of Custody	Shipment Date	Sample Description
February 17-19, 2015, Sampling Event									
2/17/15 12:40	MW05	SYMW05-W-34292	N	38	43	WG	SY217151630	2/17/2015	Depth to water = 33.28 ft TOC. Depth of well = 43 ft. Sample collected with bailer after purging 18 L (3 well volumes).
2/17/15 13:20	MW02	SYMW02-W-34289	N	18.5	23.5	WG	SY217151630	2/17/2015	Depth to water = 18.06 ft TOC. Depth of well = 23.5 ft. Sample collected with bailer after purging 10 L (3 well volumes).
2/17/15 13:20	MW02	SYMW02-W-34289VER	VER	18.5	23.5	WG	SY219151652	2/19/2015	Verification sample sent to TestAmerica, Inc., South Burlington, VT.
2/17/15 13:50	QC	SYQCIR-W-34306	RI	–	–	WQC	SY217151630	2/17/2015	Rinsate of decontaminated sampling line after collection of sample SYMW02-W-34289.
2/17/15 14:00	QC	SYQCTB-W-34310	TB	–	–	WQC	SY217151630	2/17/2015	Trip blank with water samples shipped to AGEM Laboratory for organic analysis.
2/17/15 14:45	MW03	SYMW03-W-34290	N	33	38	WG	SY217151630	2/17/2015	Depth to water = 36.18 ft TOC. Depth of well = 38 ft. Sample collected with bailer after purging 3.25 L (3 well volumes).
2/17/15 15:45	MW04	SYMW04-W-34291	N	38	43	WG	SY217151630	2/17/2015	Depth to water = 38.40 ft TOC. Depth of well = 43 ft. Sample collected with bailer after purging 8.25 L (3 well volumes).
2/17/15 15:45	MW04	SYMW04-W-34291DUP	DUP-L	38	43	WG	SY217151630	2/17/2015	Duplicate laboratory analysis.
2/17/15 16:00	MW01	SYMW01-W-34288	N	18	23	WG	SY217151630	2/17/2015	Depth to water = 20.18 ft TOC. Depth of well = 23 ft. Sample collected with bailer after purging 5 L (3 well volumes).
2/18/15 10:00	QC	SYQCTB-W-34311	TB	–	–	WQC	SY218151625	2/18/2015	Trip blank with water samples shipped to AGEM Laboratory for organic analysis.
2/18/15 10:00	QC	SYQCTB-W-34311VER	VER	–	–	WQC	SY219151652	2/19/2015	Verification sample sent to TestAmerica, Inc., South Burlington, VT.
2/18/15 12:15	WOLTING-NORTH	SYWOLTINGNORTH-W-34303	N	55	65	WG	SY218151625	2/18/2015	Wolting well to the northeast of the house in the pasture. Depth to water = 37.13 ft TOC. Depth of well = 70 ft. Sample collected with redi-flow pump after purging 70 gal (3 well volumes).
2/18/15 12:15	WOLTING-NORTH	SYWOLTINGNORTH-W-34303VER	VER	55	65	WG	SY219151652	2/19/2015	Verification sample sent to TestAmerica, Inc., South Burlington, VT.
2/18/15 13:42	MW12	SYMW12-W-34299	N	45	55	WG	SY218151625	2/18/2015	Depth to water = 34.08 ft TOC. Depth of well = 55 ft. Sample collected with bailer after purging 39 L (3 well volumes).
2/18/15 13:42	MW12	SYMW12-W-34299DUP	DUP-L	45	55	WG	SY218151625	2/18/2015	Duplicate lab analysis.
2/18/15 15:25	MW13	SYMW13-W-34300	N	34.5	39.5	WG	SY218151625	2/18/2015	Depth to water = 27.99 ft TOC. Depth of well = 39.5 ft. Sample collected with bailer after purging 21 L (3 well volumes).
2/18/15 15:30	QC	SYQCIR-W-34307	RI	–	–	WQC	SY218151625	2/18/2015	Rinsate of decontaminated sampling line after collection of sample SYMW13-W-34300.
2/18/15 16:15	MW11	SYMW11-W-34298	N	35	45	WG	SY218151625	2/18/2015	Depth to water = 27.94 ft TOC. Depth of well = 45 ft. Sample collected with bailer after purging 31.2 L (3 well volumes).
2/19/15 9:30	QC	SYQCTB -W-34312	TB	–	–	WQC	SY219151650	2/19/2015	Trip blank with water samples to AGEM Laboratory for organic analysis listed on COC 6737.

TABLE A.1 (Cont.)

Sample Date:Time	Location	Sample	Sample Type[a]	Depth from (ft BGL)	Depth to (ft BGL)	Sample Matrix[b]	Chain of Custody	Shipment Date	Sample Description
2/19/15 10:00	MW06S	SYMW06S-W-34294	N	42.5	52.5	WG	SY219151650	2/19/2015	Depth to water = 35.45 ft TOC. Depth of well = 52.5 ft. Sample collected with bailer after purging 33 L (3 well volumes).
2/19/15 10:50	MW07M	SYMW07M-W-34296	N	55	60	WG	SY219151650	2/19/2015	Depth to water = 39.00 ft TOC. Depth of well = 60 ft. Sample collected with bailer after purging 40 L (3 well volumes). Tan in color and silty.
2/19/15 11:15	QC	SYQCIR-W-34308	RI	–	–	WQC	SY219151650	2/19/2015	Rinsate of decontaminated sampling line after collection of sample SYMW07M-W-34296.
2/19/15 12:15	MW06P	SYMW06P-W-34293	N	19.5	29.5	WG	SY219151650	2/19/2015	Depth to water = 22.54 ft TOC. Depth of well = 29.5 ft. Sample collected with bailer after purging 13 liter (3 well volumes).
2/19/15 14:00	MW07S	SYMW07S-W-34295	N	30	40	WG	SY219151650	2/19/2015	Depth to water = 36.60 ft TOC. Depth of well = 40 ft. Sample collected with bailer after purging 6 L (3 well volumes).
2/19/15 14:00	MW07S	SYMW07S-W-34295VER	VER	30	40	WG	SY219151652	2/19/2015	Verification sample sent to TestAmerica, Inc., South Burlington, VT.
2/19/15 15:42	MW07D	SYMW07DDUP-W-34305	DUP-F	78	88	WG	SY219151650	2/19/2015	Field replicate.
2/19/15 15:42	MW07D	SYMW07D-W-34297	N	78	88	WG	SY219151650	2/19/2015	Depth to water = 39.06 ft TOC. Depth of well = 88 ft. Sample collected with bailer after purging 93 L (3 well volumes). Gray in color.
2/19/15 15:42	MW07D	SYMW07D-W-34297DUP	DUP-L	78	88	WG	SY219151650	2/19/2015	Duplicate lab analysis.
2/19/15 16:15	WOLTING-SOUTH	SYWOLTINGSOUTH-W-34302	N	–	–	WG	SY219151650	2/19/2015	Identified on map Figure 3.2 as Ryan Wolting (Winckler). Well is located east of the home and the sample was collected from the hydrant on east side of the home. 308 West Old Hwy 18. Cell 785-658-7297.
2/19/15 16:30	KINGERY	SYKINGERYDUP-W-34304	DUP-F	–	–	WG	SY219151650	2/19/2015	Field replicate.
2/19/15 16:30	KINGERY	SYKINGERY-W-34301	N	–	–	WG	SY219151650	2/19/2015	Identified on map Figure 3.2 as Otis Kingery. Well is located north of the home under the windmill. The sample was collected from the active windmill jack pump. 400 West Old Hwy 18. Phone 785-658-7297.
April 12-14, 2016, Sampling Event									
4/12/16 9:00	QC	SYQCTB-W-34336	TB	–	–	WQC	SY413161640	4/13/2016	Trip blank with water samples shipped to AGEM Laboratory for organic analysis.
4/12/16 9:00	QC	SYQCTB-W-34336VER	VER	–	–	WQC	SY413161631	4/13/2016	Verification sample sent to TestAmerica, Inc., South Burlington, VT.
4/12/16 15:15	MW01	SYMW01-W-34313	N	18	23	WG	SY413161640	4/13/2016	Depth to water = 18.76 ft TOC. Depth of well = 23 ft. Well went dry after purging 4 L; field parameters not measured.
4/12/16 16:00	MW04	SYMW04-W-34316	N	38	43	WG	SY413161640	4/13/2016	Depth to water = 38.70 ft TOC. Depth of well = 43 ft. Sample collected with bailer after purging 8 L (3 well volumes).
4/12/16 16:00	MW04	SYMW04-W-34316VER	VER	38	43	WG	SY413161631	4/13/2016	Verification sample sent to TestAmerica, Inc., South Burlington, VT.
4/12/16 16:45	MW05	SYMW05-W-34317	N	38	43	WG	SY413161640	4/13/2016	Depth to water = 34.11 ft TOC. Depth of well = 43 ft. Sample collected with bailer after purging 16.5 L (3 well volumes).

TABLE A.1 (Cont.)

Sample Date:Time	Location	Sample	Sample Type[a]	Depth from (ft BGL)	Depth to (ft BGL)	Sample Matrix[b]	Chain of Custody	Shipment Date	Sample Description
4/12/16 17:15	QC	SYQCIR-W-34332	RI	–	–	WQC	SY413161640	4/13/2016	Rinsate of decontaminated sampling line after collection of sample SYMW05-W-34317.
4/12/16 18:00	MW02	SYMW02-W-34314	N	18.5	23.5	WG	SY413161640	4/13/2016	Depth to water = 17.45 ft TOC. Depth of well = 23.5 ft. Sample collected with bailer after purging 11.3 L (3 well volumes).
4/13/16 10:30	WOLTING-EAST	SYWOLTINGEAST-W-34329	N	–	–	WG	SY413161640	4/13/2016	Ryan Wolting (formerly Mark Ryser) well located east of the north house in a pit. Sample collected from a livestock water tank hydrant north of the well.
4/13/16 10:30	WOLTING-EAST	SYWOLTINGEAST-W-34329VER	VER	–	–	WG	SY413161631	4/13/2016	Verification sample sent to TestAmerica, Inc., South Burlington, VT.
4/13/16 11:15	MW06P	SYMW06P-W-34318	N	19.5	29.5	WG	SY413161640	4/13/2016	Depth to water = 20.76 ft TOC. Depth of well = 29.5 ft. Sample collected with bailer after purging 16.2 liter (3 well volumes).
4/13/16 11:15	MW06P	SYMW06P-W-34318DUP	DUP-L	19.5	29.5	WG	SY413161640	4/13/2016	Duplicate laboratory analysis.
4/13/16 12:05	MW06S	SYMW06S-W-34319	N	42.5	52.5	WG	SY413161640	4/13/2016	Depth to water = 35.95 ft TOC. Depth of well = 52.5 ft. Sample collected with bailer after purging 30.7 L (3 well volumes).
4/13/16 13:30	MW03	SYMW03-W-34315	N	33	38	WG	SY413161640	4/13/2016	Depth to water = 36.35 ft TOC. Depth of well = 38 ft. Sample collected with bailer after purging 3 L (3 well volumes).
4/13/16 13:55	MW07S	SYMW07S-W-34320	N	30	40	WG	SY413161640	4/13/2016	Depth to water = 36.85 ft TOC. Depth of well = 40 ft. Sample collected with bailer after purging 5.9 L (3 well volumes).
4/13/16 13:55	MW07S	SYMW07S-W-34320VER	VER	30	40	WG	SY413161631	4/13/2016	Verification sample sent to TestAmerica, Inc., South Burlington, VT.
4/13/16 14:15	QC	SYQCIR-W-34333	RI	–	–	WQC	SY413161640	4/13/2016	Rinsate of decontaminated sampling line after collection of sample SYMW07S-W-34320.
4/13/16 15:40	MW07M	SYMW07M-W-34321	N	55	60	WG	SY413161640	4/13/2016	Depth to water = 39.70 ft TOC. Depth of well = 60 ft. Sample collected with bailer after purging 37.7 L (3 well volumes).
4/13/16 16:15	KINGERY	SYKINGERY-W-34326	N	–	–	WG	SY413161640	4/13/2016	Barb Kingery well located north of the home under the windmill. The sample was collected from the active windmill jack pump.
4/13/16 16:45	MW05	SYMW05DUP-W-34330	DUP-F	38	43	WG	SY413161640	4/13/2016	Field replicate.
4/14/16 9:00	QC	SYQCTB-W-34337	TB	-	-	WQC	SY414161700	4/14/2016	Trip blank with water samples shipped to AGEM Laboratory for organic analysis.
4/14/16 10:30	MW12	SYMW12DUP-W-34331	DUP-F	45	55	WG	SY414161700	4/14/2016	Field replicate.
4/14/16 10:30	MW12	SYMW12-W-34324	N	45	55	WG	SY414161700	4/14/2016	Depth to water = 34.85 ft TOC. Depth of well = 55 ft. Sample collected with bailer after purging 37.4 L (3 well volumes).
4/14/16 11:45	MW11	SYMW11-W-34323	N	35	45	WG	SY414161700	4/14/2016	Depth to water = 28.80 ft TOC. Depth of well = 45 ft. Sample collected with bailer after purging 30 L (3 well volumes).
4/14/16 12:25	MW13	SYMW13-W-34325	N	34.5	39.5	WG	SY414161700	4/14/2016	Depth to water = 31.30 ft TOC. Depth of well = 39.5 ft. Sample collected with bailer after purging 15.5 L (3 well volumes).
4/14/16 12:25	MW13	SYMW13-W-34325DUP	DUP-L	34.5	39.5	WG	SY414161700	4/14/2016	Duplicate laboratory analysis.
4/14/16 13:25	MW07D	SYMW07D-W-34322	N	78	88	WG	SY414161700	4/14/2016	Depth to water = 39.78 ft TOC. Depth of well = 88 ft. Sample collected with bailer after purging 90 L (3 well volumes).

TABLE A.1 (Cont.)

Sample Date:Time	Location	Sample	Sample Type[a]	Depth from (ft BGL)	Depth to (ft BGL)	Sample Matrix[b]	Chain of Custody	Shipment Date	Sample Description
4/14/16 14:50	WOLTING-NORTH	SYWOLTINGNORTH-W-34328	N	55	65	WG	SY414161700	4/14/2016	Ryan Wolting well to the northeast of the house in the pasture. Depth to water = 37.75 ft TOC. Depth of well = 70 ft. Sample collected with redi-flow pump after purging 65 gal (3 well volumes).
4/14/16 15:30	WOLTING-SOUTH	SYWOLTINGSOUTH-W-34327	N	–	–	WG	SY414161700	4/14/2016	Ryan Wolting well located east of the home and the sample was collected from the hydrant on east side of the home.
4/14/16 16:00	QC	SYDIH2O-W-34334	FB	–	–	WQC	SY414161700	4/14/2016	Field blank of water used for equipment decontamination during April 2016 sampling event.
August 16, 2016, Sampling Event									
8/16/16 9:00	QC	SYQCTB-W-34340	TB	-	-	WQC	SY817161200	8/16/2016	Trip blank with water samples shipped to AGEM Laboratory for organic analysis.
8/16/16 11:05	MW07S	SYMW07S-W-34338	N	30	40	WG	SY817161200	8/16/2016	Depth to water = 36.35 ft TOC. Depth of well = 40 ft. Sample collected with bailer after purging 6.5 L (3 well volumes).
8/16/16 11:05	MW07S	SYMW07S-W-34338DUP	DUP-L	30	40	WG	SY817161200	8/16/2016	Duplicate laboratory analysis.
8/16/16 17:15	KINGERY	SYKINGERY-W-34339	N	–	–	WG	SY817161200	8/16/2016	Barb Kingery well located north of the home under the windmill. Sample is normally collected from the active windmill jack pump when the wind is blowing. Windmill was not active during this visit, but 8-10 gal were pumped manually before sampling.
8/16/16 17:15	KINGERY	SYKINGERY-W-34339DUP	DUP-L	–	–	WG	SY817161200	8/16/2016	Duplicate laboratory analysis.
February 23, 2017, Sampling Event									
2/23/17 9:00	QC	SYQCTB-W-34345	TB	–	–	WQC	SY223171710	2/23/2017	Trip blank with water samples shipped to AGEM Laboratory for organic analysis.
2/23/17 14:32	KINGERY	SYKINGERY-W-34343	N	–	–	WG	SY223171710	2/23/2017	Barb Kingery well located north of the home under the windmill. The sample was collected from the active windmill jack pump.
2/23/17 14:32	KINGERY	SYKINGERY-W-34343DUP	DUP-L	–	–	WG	SY223171710	2/23/2017	Duplicate laboratory analysis.
2/23/17 15:00	MW07S	SYMW07S-W-34342	N	30	40	WG	SY223171710	2/23/2017	Depth to water = 35.99 ft TOC. Depth of well = 40 ft. Sample collected with bailer after purging 7.5 L (3 well volumes).
2/23/17 16:16	MW06P	SYMW06P-W-34341	N	19.5	29.5	WG	SY223171710	2/23/2017	Depth to water = 19.52 ft TOC. Depth of well = 29.5 ft. Sample collected with bailer after purging 18.5 liter (3 well volumes).

[a] Sample types: DUP-F, field replicate; DUP-L, duplicate lab analysis; FB, field blank; N, primary sample; RI, rinsate; TB, trip blank; VER, verification sample.

[b] Matrix codes: WG, groundwater; WQC, QA/QC water sample, e.g., trip blank.

TABLE A.2 Results from the AGEM Laboratory for quality control samples collected during multiple groundwater monitoring events at Sylvan Grove, Kansas, in 2015-2017.

			Concentration (µg/L)		
Sample	Sample Date	Sample Type[a]	Carbon Tetrachloride	Chloroform	Methylene Chloride
February 17-19, 2015, Sampling Event					
SYQCIR-W-34306	2/17/2015	RI	ND[b]	ND	ND
SYQCIR-W-34307	2/18/2015	RI	ND	ND	ND
SYQCIR-W-34308	2/19/2015	RI	ND	ND	ND
SYQCTB-W-34310	2/17/2015	TB	ND	ND	ND
SYQCTB-W-34311	2/18/2015	TB	ND	ND	ND
SYQCTB -W-34312	2/19/2015	TB	ND	ND	ND
April 12-14, 2016, Sampling Event					
SYDIH2O-W-34334	4/14/2016	FB	ND	ND	ND
SYQCIR-W-34332	4/12/2016	RI	ND	ND	ND
SYQCIR-W-34333	4/13/2016	RI	ND	ND	ND
SYQCTB-W-34336	4/12/2016	TB	ND	ND	ND
SYQCTB-W-34337	4/14/2016	TB	ND	ND	ND
August 16, 2016, Sampling Event					
SYQCTB-W-34340	8/16/2016	TB	ND	ND	ND
February 23, 2017, Sampling Event					
SYQCTB-W-34345	2/23/2017	TB	ND	ND	ND
SYQCTB-W-34346	2/23/2017	TB	ND	ND	ND

[a] Sample types: DUP-F, field replicate; FB, field blank; N, primary sample; TB, trip blank.

[b] ND, compound analyzed for but not detected at a level greater than or equal to the method detection limit (< 1 µg/L).

TABLE A.3 Results from the AGEM Laboratory for quality control samples collected during multiple groundwater monitoring events at Sylvan Grove, Kansas, in 2015-2017.

						Concentration (µg/L)			Average Relative Percent Difference	
Location	Sample	Sample Date	Sample Type[a]	Start Depth (ft BGL)	End Depth (ft BGL)	Carbon Tetrachloride	Chloroform	Methylene Chloride	Carbon Tetrachloride	Chloroform
February 17-19, 2015, Sampling Event									0%	3%
KINGERY	SYKINGERY-W-34301	2/19/15	N	-	-	52	3.7	ND[b]		
KINGERY	SYKINGERYDUP-W-34304	2/19/15	DUP-F	-	-	52	3.6	ND		
MW04	SYMW04-W-34291	2/17/15	N	38	43	ND	ND	ND		
MW04	SYMW04-W-34291DUP	2/17/15	DUP-L	38	43	ND	ND	ND		
MW07D	SYMW07D-W-34297	2/19/15	N	78	88	ND	ND	ND		
MW07D	SYMW07D-W-34297DUP	2/19/15	DUP-L	78	88	ND	ND	ND		
MW07D	SYMW07DDUP-W-34305	2/19/15	DUP-F	78	88	ND	ND	ND		
MW12	SYMW12-W-34299	2/18/15	N	45	55	ND	ND	ND		
MW12	SYMW12-W-34299DUP	2/18/15	DUP-L	45	55	ND	ND	ND		
April 12-14, 2016, Sampling Event									2%	25%
MW05	SYMW05-W-34317	4/12/16	N	38	43	ND	ND	ND		
MW05	SYMW05DUP-W-34330	4/13/16	DUP-F	38	43	ND	ND	ND		
MW06P	SYMW06P-W-34318	4/13/16	N	19.5	29.5	44	4.5	ND		
MW06P	SYMW06P-W-34318DUP	4/13/16	DUP-L	19.5	29.5	45	3.5	ND		
MW12	SYMW12-W-34324	4/14/16	N	45	55	ND	ND	ND		
MW12	SYMW12DUP-W-34331	4/14/16	DUP-F	45	55	ND	ND	ND		
MW13	SYMW13-W-34325	4/14/16	N	34.5	39.5	ND	ND	ND		
MW13	SYMW13-W-34325DUP	4/14/16	DUP-L	34.5	39.5	ND	ND	ND		
August 16, 2016, Sampling Event									4%	6%
MW07S	SYMW07S-W-34338	8/16/16	N	30	40	32	2.0	ND		
MW07S	SYMW07S-W-34338DUP	8/16/16	DUP-L	30	40	33	2.2	ND		
KINGERY	SYKINGERY-W-34339	8/16/16	N	–	–	98	6.0	ND		
KINGERY	SYKINGERY-W-34339DUP	8/16/16	DUP-L	–	–	103	6.2	ND		

TABLE A.3 (Cont.)

Location	Sample	Sample Date	Sample Type[a]	Start Depth (ft BGL)	End Depth (ft BGL)	Concentration (µg/L) Carbon Tetrachloride	Chloroform	Methylene Chloride	Average Relative Percent Difference Carbon Tetrachloride	Chloroform
February 23, 2017, Sampling Event									0%	-
KINGERY	SYKINGERY-W-34343	2/23/17	N	–	–	10	0.9 J[c]	ND		
KINGERY	SYKINGERY-W-34343DUP	2/23/17	DUP-L	–	–	10	ND	ND		

[a] Sample types: DUP-F, field replicate; DUP-L, duplicate lab analysis; N, primary sample.

[b] ND, compound analyzed for but not detected at a level greater than or equal to the method detection limit (<1 µg/L).

[c] J, compound identified with an estimated concentration between the instrument detection limit and the method detection limit.

TABLE A.4 Results for quarterly groundwater samples collected during multiple sampling events and submitted for verification organic analysis.[a]

						Concentration (µg/L)			Average Relative Percent Difference	
Location	Sample	Sample Date	Analytical Laboratory	Start Depth (ft BGL)	End Depth (ft BGL)	Carbon Tetrachloride	Chloroform	Methylene Chloride	Carbon Tetrachloride	Chloroform
February 17-19, 2015, Sampling Event									26%	35%
MW02	SYMW02-W-34289	2/17/15	AGEM	18.5	23.5	10	ND	ND		
MW02	SYMW02-W-34289VER	2/17/15	TestAmerica	18.5	23.5	14	1.1	ND		
MW07S	SYMW07S-W-34295	2/19/15	AGEM	30	40	19	1.4	ND		
MW07S	SYMW07S-W-34295VER	2/19/15	TestAmerica	30	40	23 D[b]	2.0	ND		
WOLTING-NORTH	SYWOLTINGNORTH-W-34303	2/18/15	AGEM	55	65	ND[c]	ND	ND		
WOLTING-NORTH	SYWOLTINGNORTH-W-34303VER	2/18/15	TestAmerica	55	65	ND	ND	ND		
QC	SYQCTB-W-34311	2/18/15	AGEM	-	-	ND	ND	ND		
QC	SYQCTB-W-34311VER	2/18/15	TestAmerica	-	-	ND	ND	ND		
April 12-14, 2016, Sampling Event									5%	17%
MW04	SYMW04-W-34316	4/12/16	AGEM	38	43	0.9 J[d]	ND	ND		
MW04	SYMW04-W-34316VER	4/12/16	TestAmerica	38	43	1.0	ND	ND		
MW07S	SYMW07S-W-34320	4/13/16	AGEM	30	40	105	9.0	ND		
MW07S	SYMW07S-W-34320VER	4/13/16	TestAmerica	30	40	100 D	7.6	ND		
WOLTING-EAST	SYWOLTINGEAST-W-34329	4/13/16	AGEM	-	-	ND	ND	ND		
WOLTING-EAST	SYWOLTINGEAST-W-34329VER	4/13/16	TestAmerica	-	-	ND	ND	ND		
QC	SYQCTB-W-34336	4/12/16	AGEM	-	-	ND	ND	ND		
QC	SYQCTB-W-34336VER	4/12/16	TestAmerica	-	-	ND	ND	ND		

[a] TestAmerica verification data are in sample delivery groups 200-26783 and 200-33019 in Supplement _ (on CD).

[b] D, result from analysis at secondary dilution factor.

[c] ND, compound analyzed for but not detected at a level greater than or equal to the indicated method detection limit.

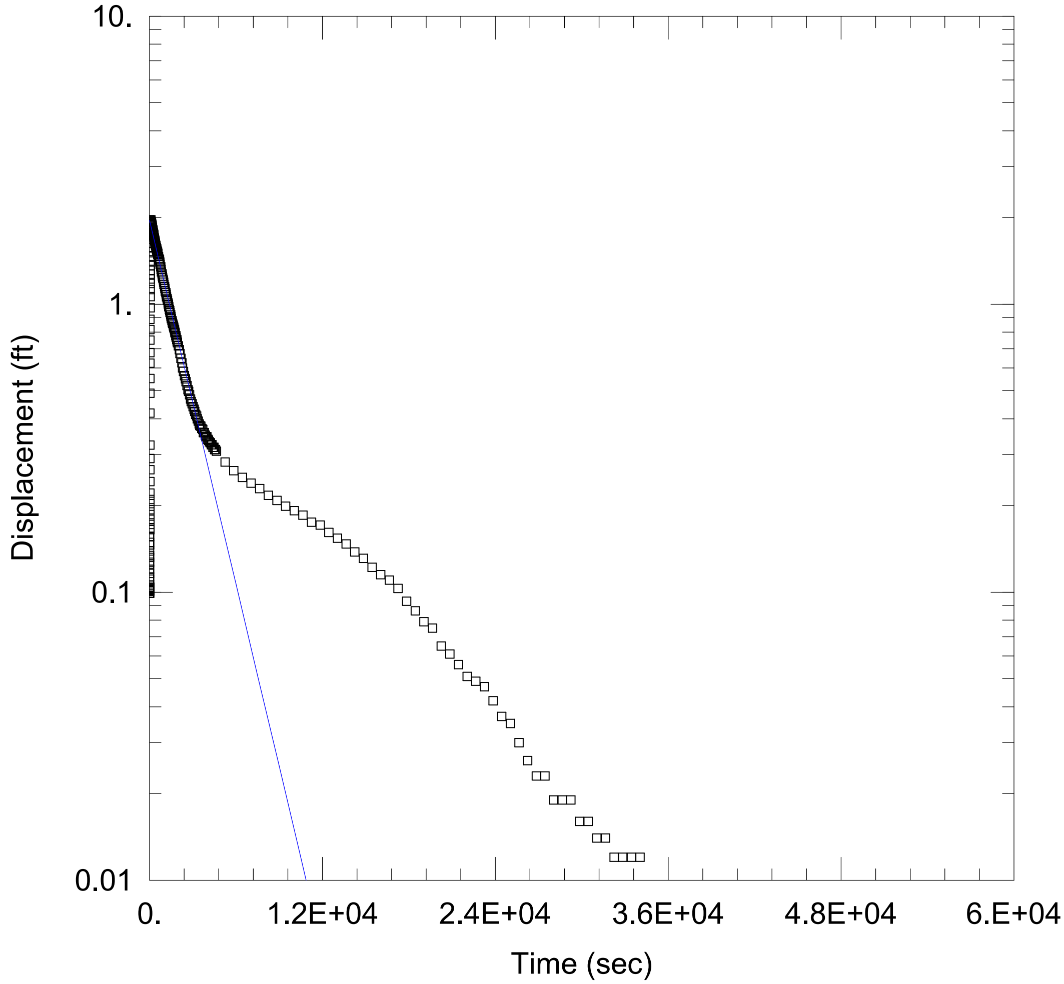
[d] J, compound identified with an estimated concentration between the instrument detection limit and the method detection limit.

Appendix B:

Slug Tests Data and Analysis

The List of Slug Tests and Interpretative Curves using Bouwer-Rice and Hvorslev Methods

	Well	Test
Perched Aquifer		
	MW01	SLUG_in_1
		SLUG_in_2
		SLUG_in_3
	MW02	SLUG_in_1
		SLUG_in_2
		SLUG_in_3
	MW06P	SLUG_in_1
		SLUG_in_2
		SLUG_in_3
Shallow Aquifer		
	MW05	SLUG_in_1
		SLUG_in_2
		SLUG_out_1
		SLUG_out_2
	MW06S	SLUG_in_1
		SLUG_in_2
		SLUG_out_1
		SLUG_out_2
	MW11	SLUG_in_1
		SLUG_in_2
		SLUG_out_1
		SLUG_out_2
	MW12	SLUG_in_1
		SLUG_in_2
		SLUG_out_1
		SLUG_out_2
	MW13	SLUG_in_1
		SLUG_in_2
Deep Aquifer		
	MW07M	SLUG_in_1
		SLUG_in_2
		SLUG_out_1
		SLUG_out_2



SLUG TEST ANALYSIS FOR MW01 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW01
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 2.17 ft
Anisotropy Ratio (Kz/Kr): 0.1

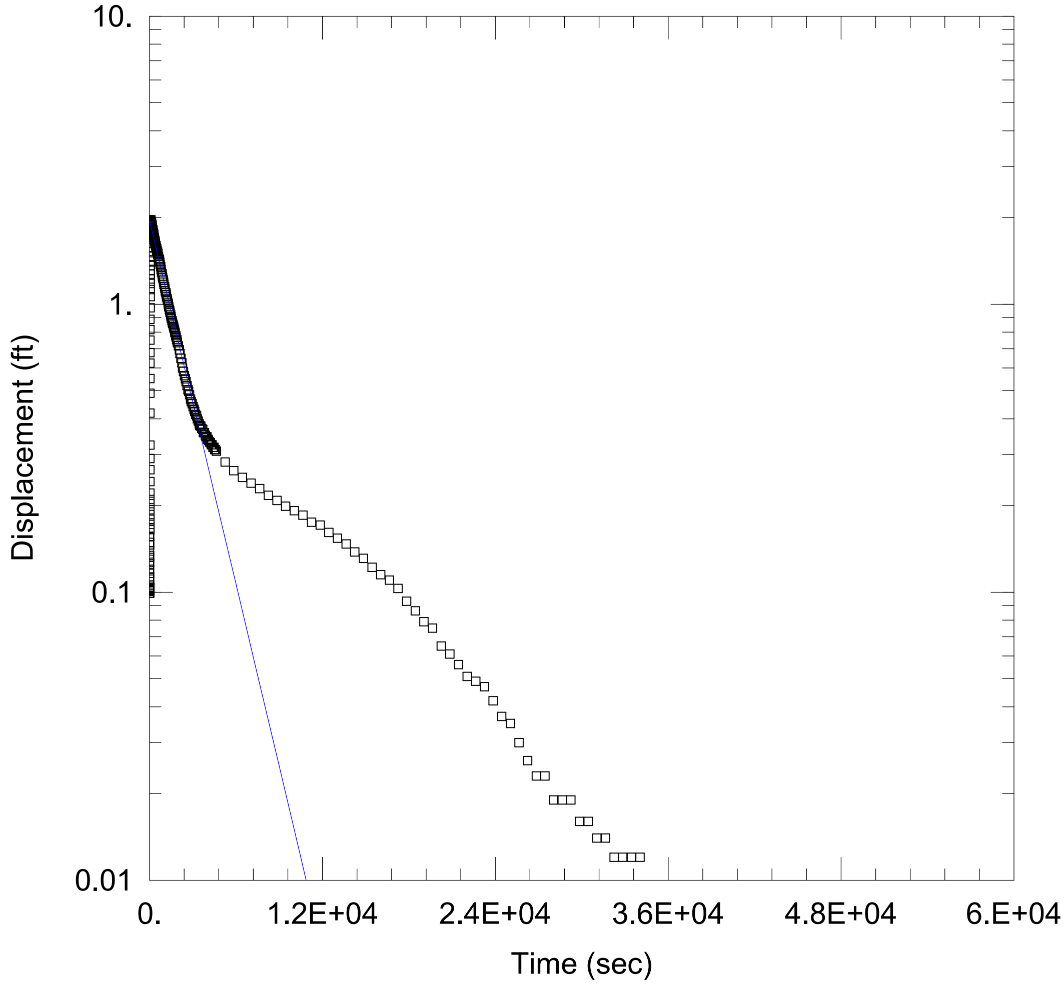
WELL DATA (MW01)

Initial Displacement: 1.961 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 2.17 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0751 ft/day
y0 = 1.955 ft



SLUG TEST ANALYSIS FOR MW01 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW01
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 2.17 ft
Anisotropy Ratio (Kz/Kr): 0.1

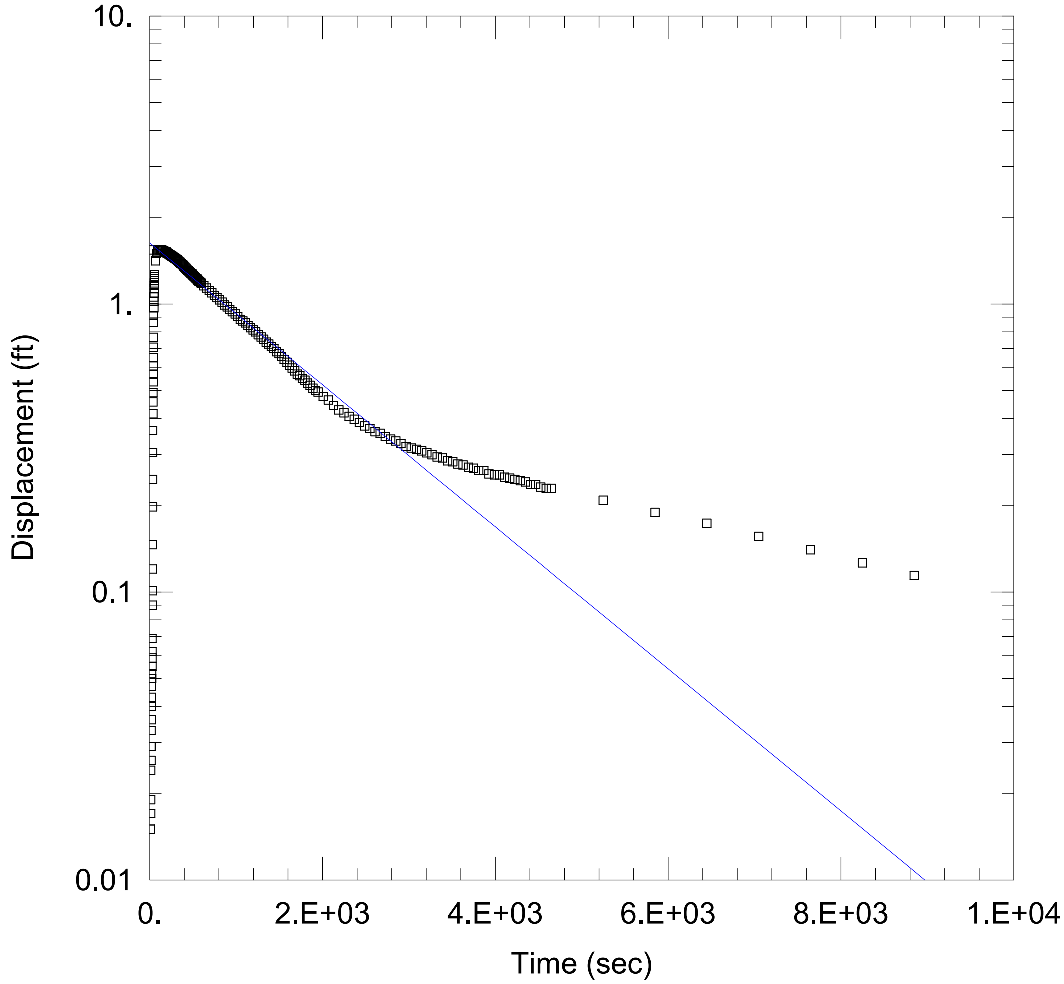
WELL DATA (MW01)

Initial Displacement: 1.961 ft
Casing Radius: 0.08333 ft
Wellbore Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Screen Length: 5. ft
Total Well Penetration Depth: 2.17 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.1191 ft/day
y0 = 1.955 ft



SLUG TEST ANALYSIS FOR MW01 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW01
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 2.17 ft
Anisotropy Ratio (Kz/Kr): 0.1

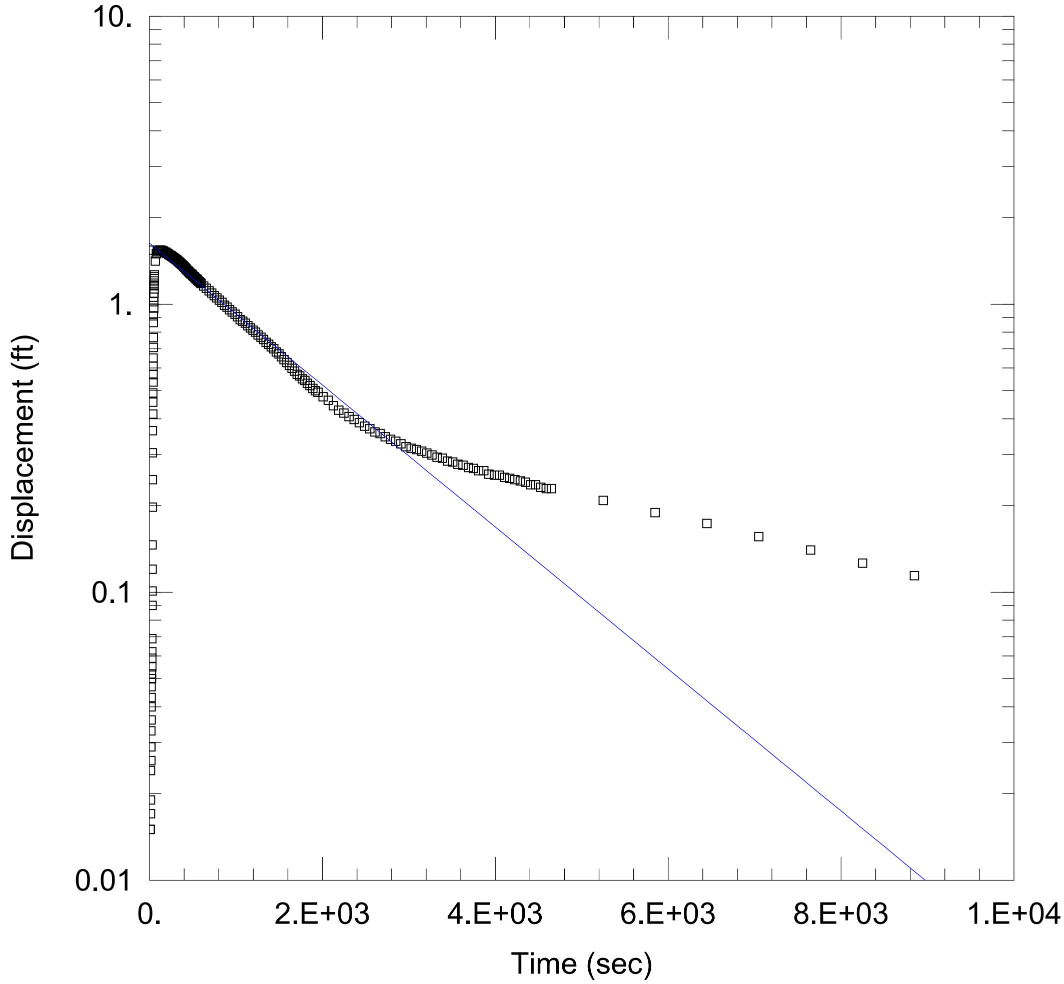
WELL DATA (MW01)

Initial Displacement: 1.54 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 2.17 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.08795 ft/day
y0 = 1.63 ft



SLUG TEST ANALYSIS FOR MW01 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW01
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 2.17 ft
Anisotropy Ratio (Kz/Kr): 0.1

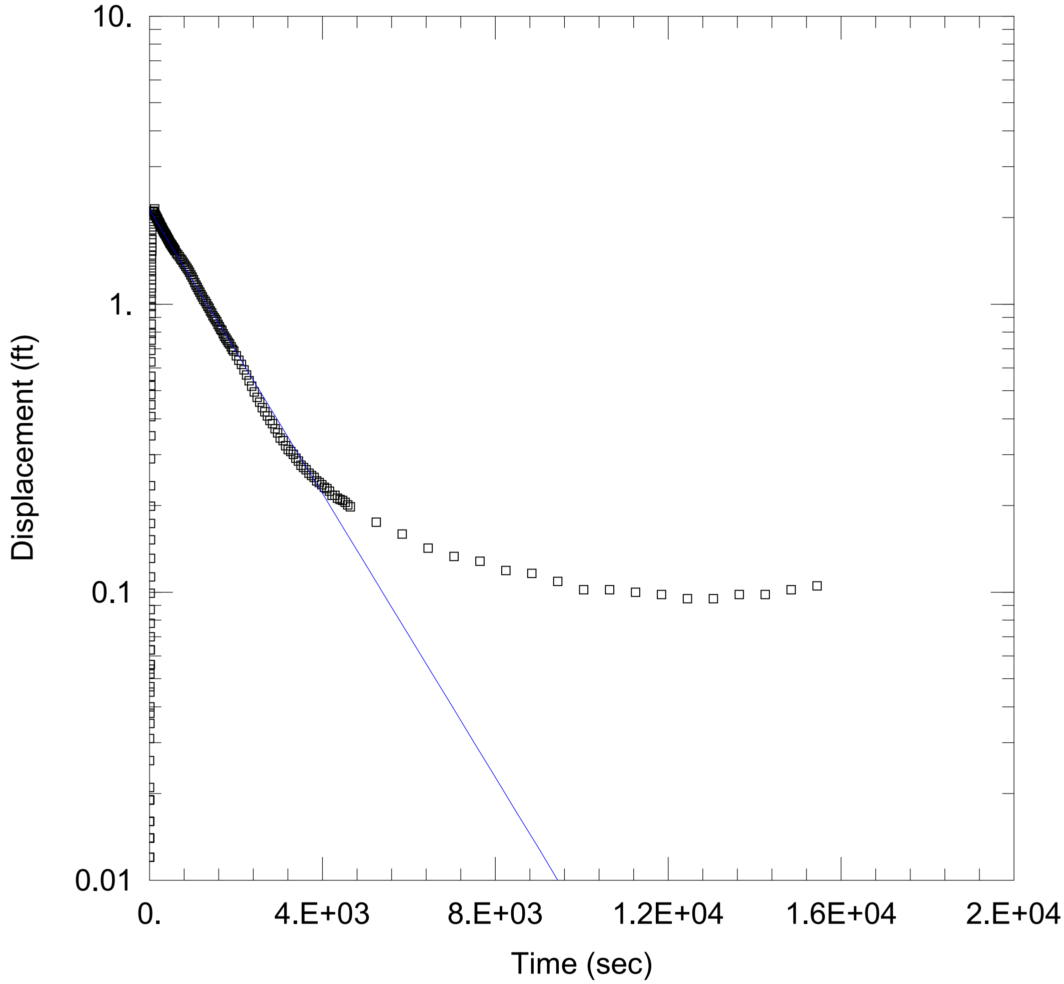
WELL DATA (MW01)

Initial Displacement: 1.54 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 2.17 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.1394 ft/day
y0 = 1.63 ft



SLUG TEST ANALYSIS FOR MW01 SLUG_IN_3

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW01
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 2.17 ft
Anisotropy Ratio (Kz/Kr): 0.1

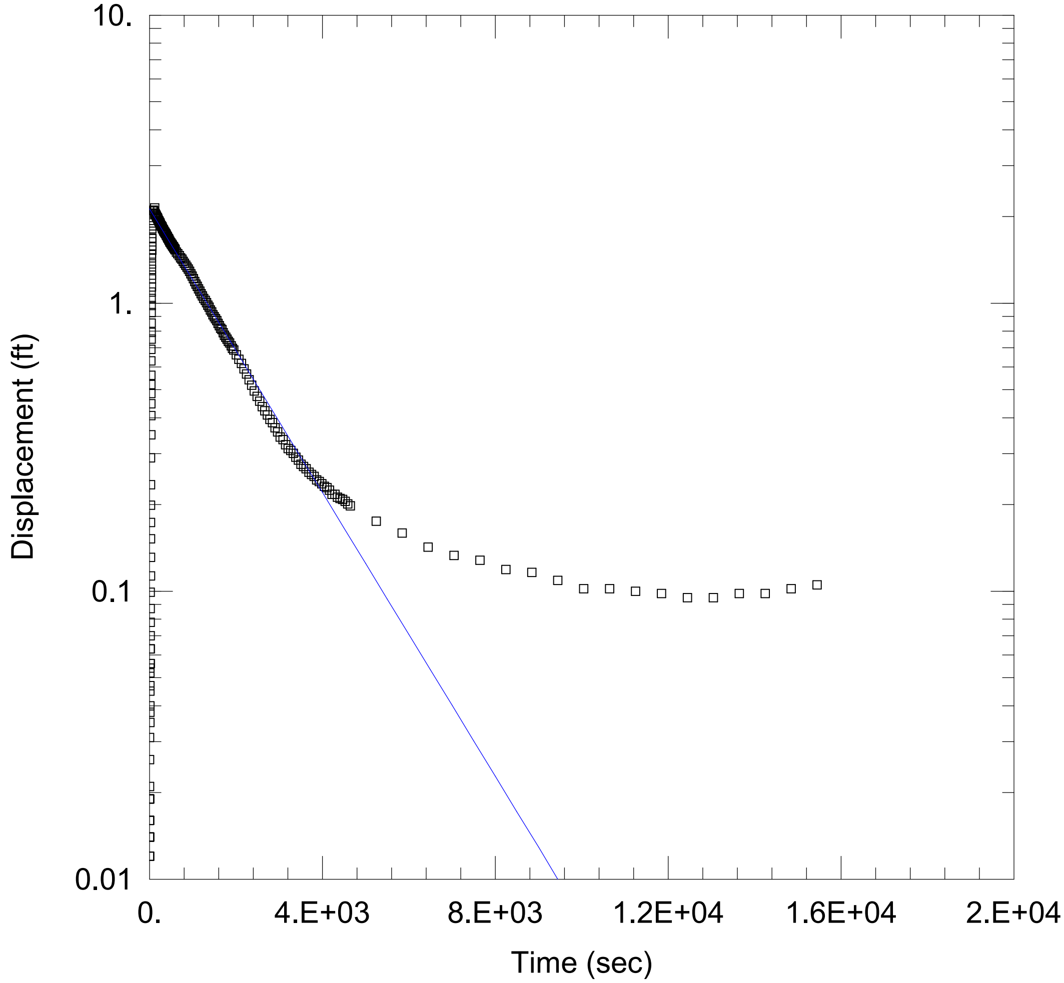
WELL DATA (MW01)

Initial Displacement: 2.1 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 2.17 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.08783 ft/day
y0 = 2.124 ft



SLUG TEST ANALYSIS FOR MW01 SLUG_IN_3

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW01
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 2.17 ft
Anisotropy Ratio (Kz/Kr): 0.1

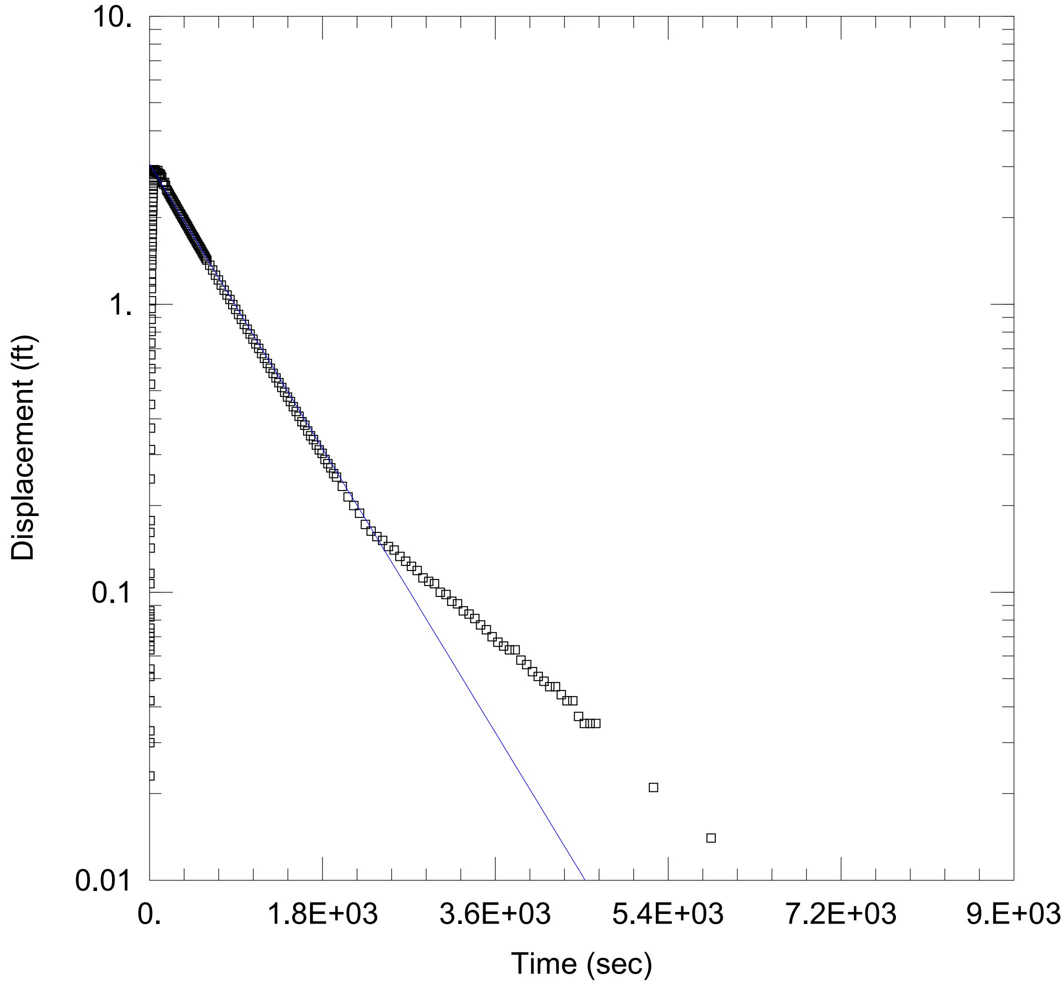
WELL DATA (MW01)

Initial Displacement: 2.1 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 2.17 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.1393 ft/day
y0 = 2.124 ft



SLUG TEST ANALYSIS FOR MW02 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW02
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 1.16 ft
Anisotropy Ratio (Kz/Kr): 0.1

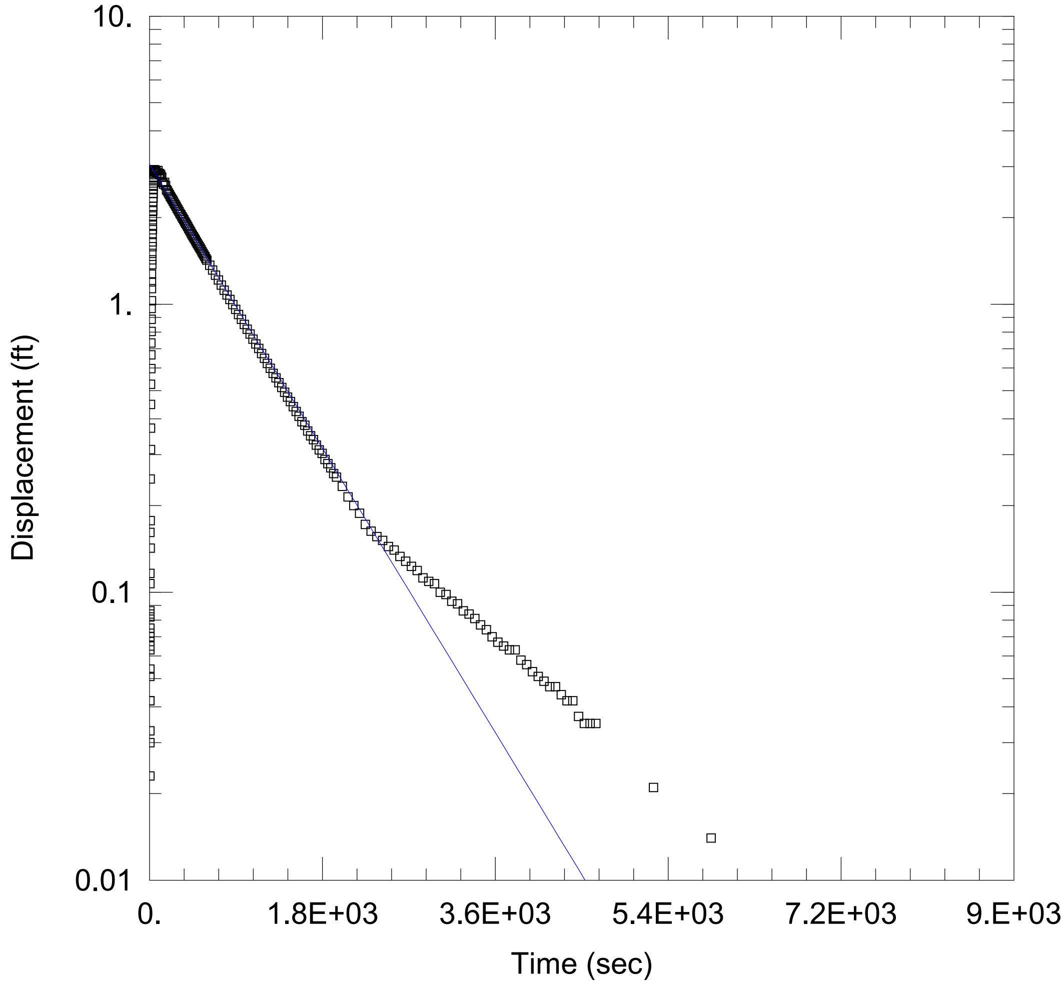
WELL DATA (MW02)

Initial Displacement: 2.924 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 1.16 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.162 ft/day
y0 = 3.061 ft



SLUG TEST ANALYSIS FOR MW02 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW02
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 1.16 ft
Anisotropy Ratio (Kz/Kr): 0.1

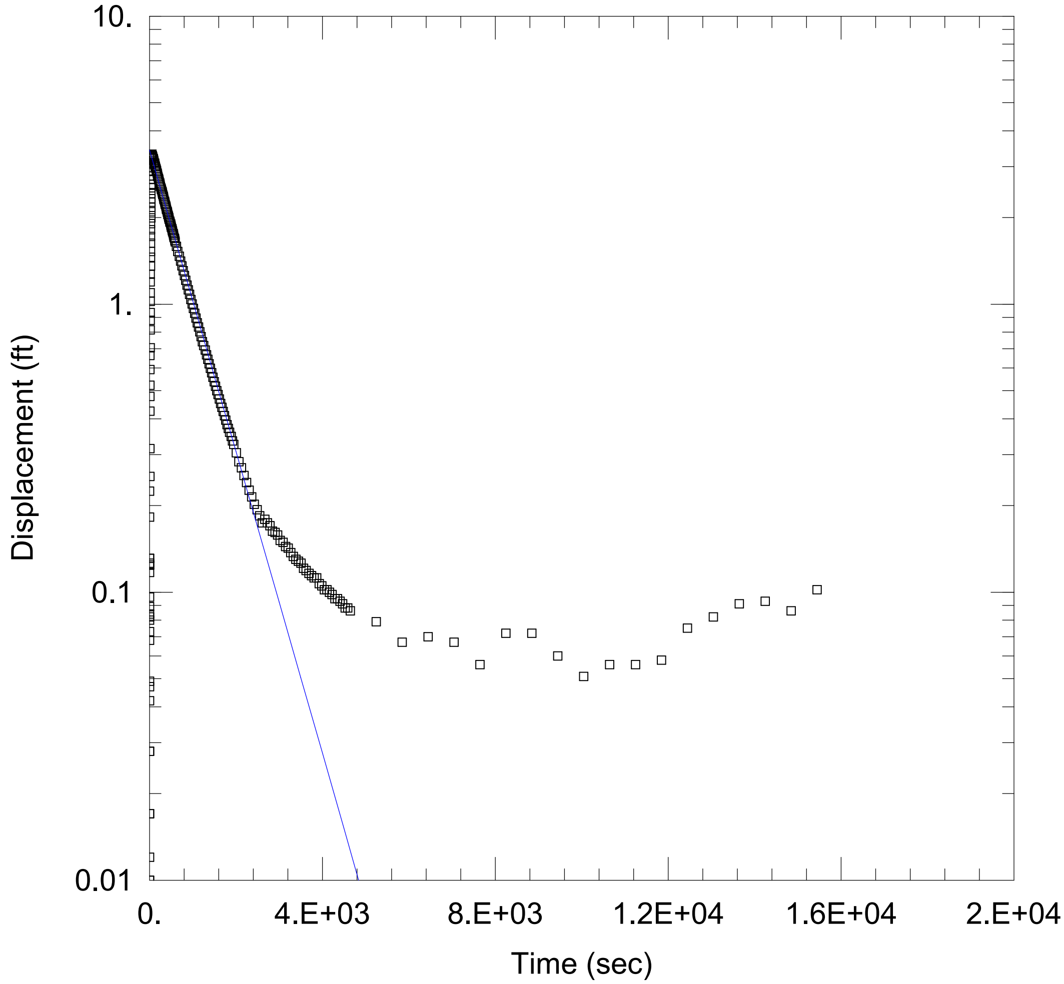
WELL DATA (MW02)

Initial Displacement: 2.924 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 1.16 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.3101 ft/day
y0 = 3.061 ft



SLUG TEST ANALYSIS FOR MW02 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW02
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 1.16 ft
Anisotropy Ratio (Kz/Kr): 0.1

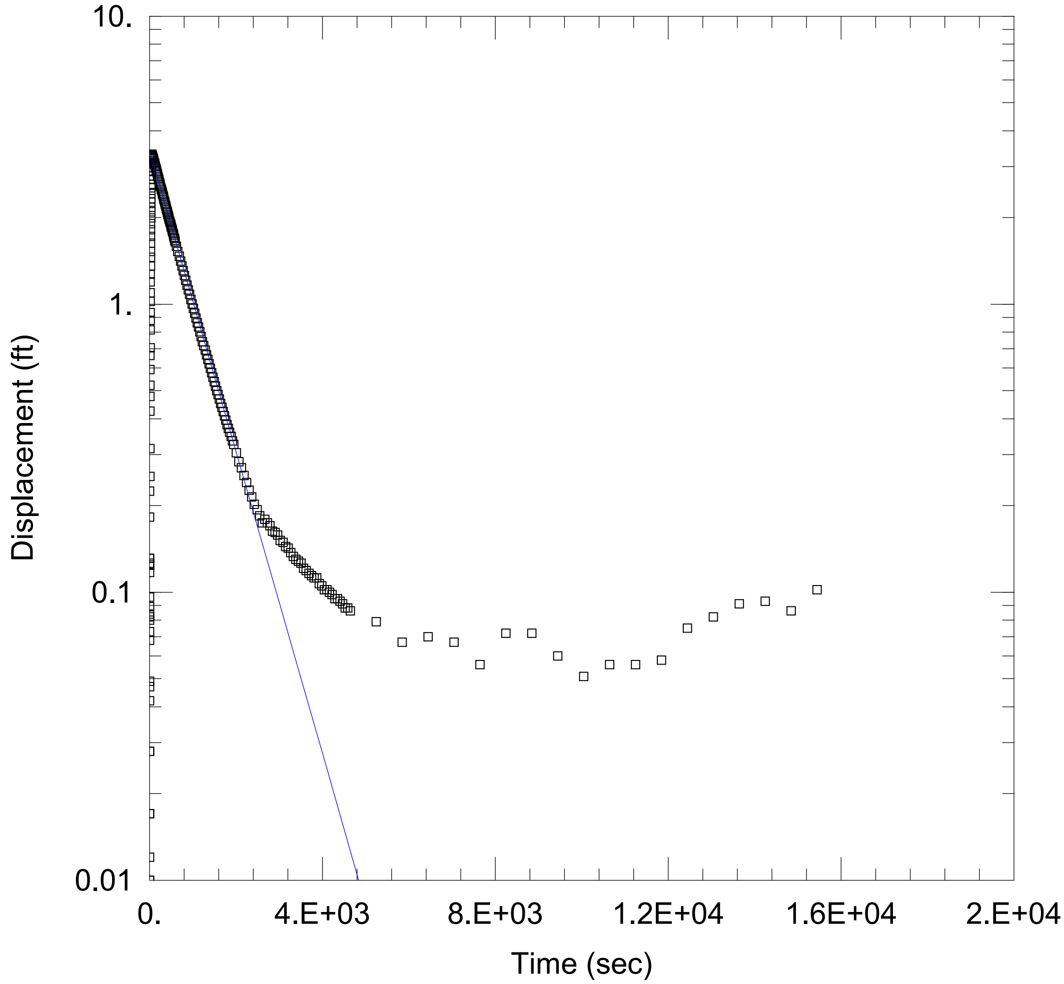
WELL DATA (MW02)

Initial Displacement: 3.316 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 1.16 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.1547 ft/day
y0 = 3.431 ft



SLUG TEST ANALYSIS FOR MW02 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW02
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 1.16 ft
Anisotropy Ratio (Kz/Kr): 0.1

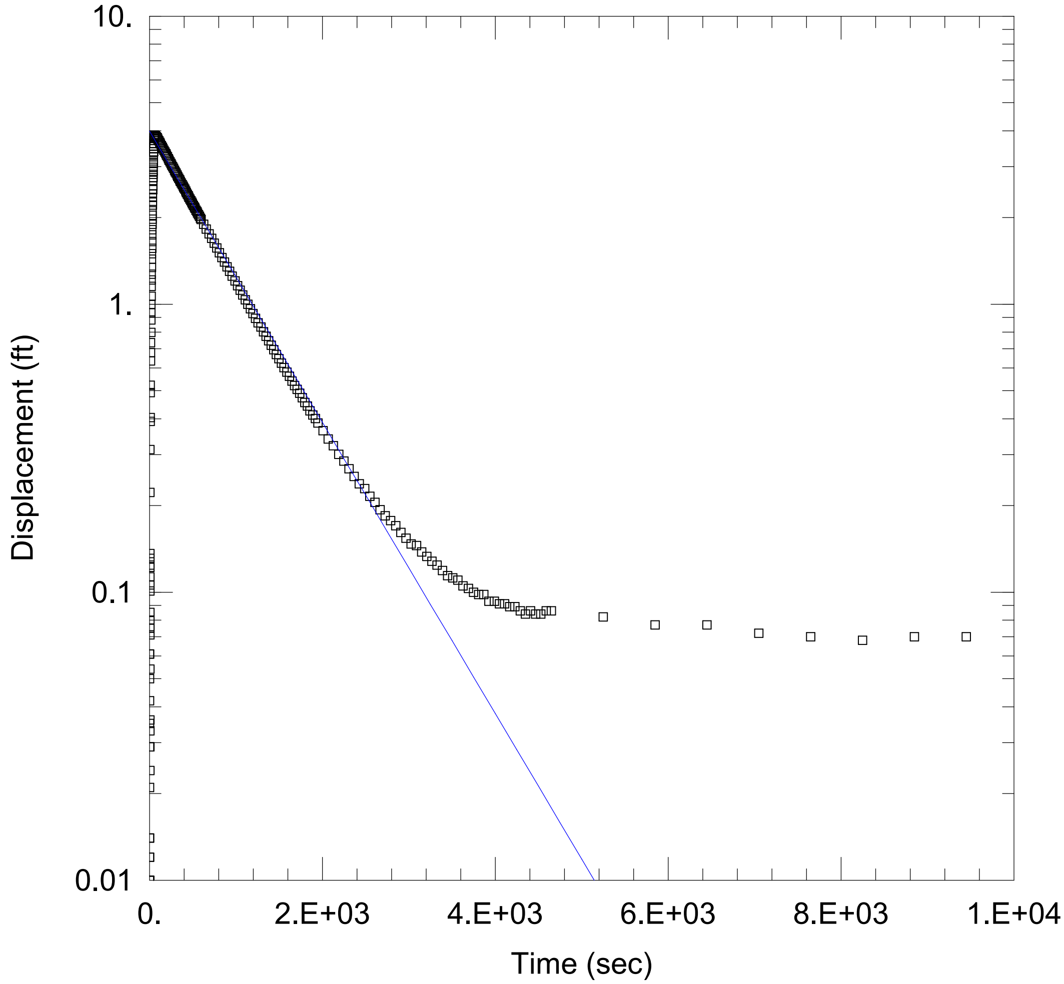
WELL DATA (MW02)

Initial Displacement: 3.316 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 1.16 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.2961 ft/day
y0 = 3.431 ft



SLUG TEST ANALYSIS FOR MW02 SLUG_IN_3

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW02
Test Date: April 14, 2015

AQUIFER DATA

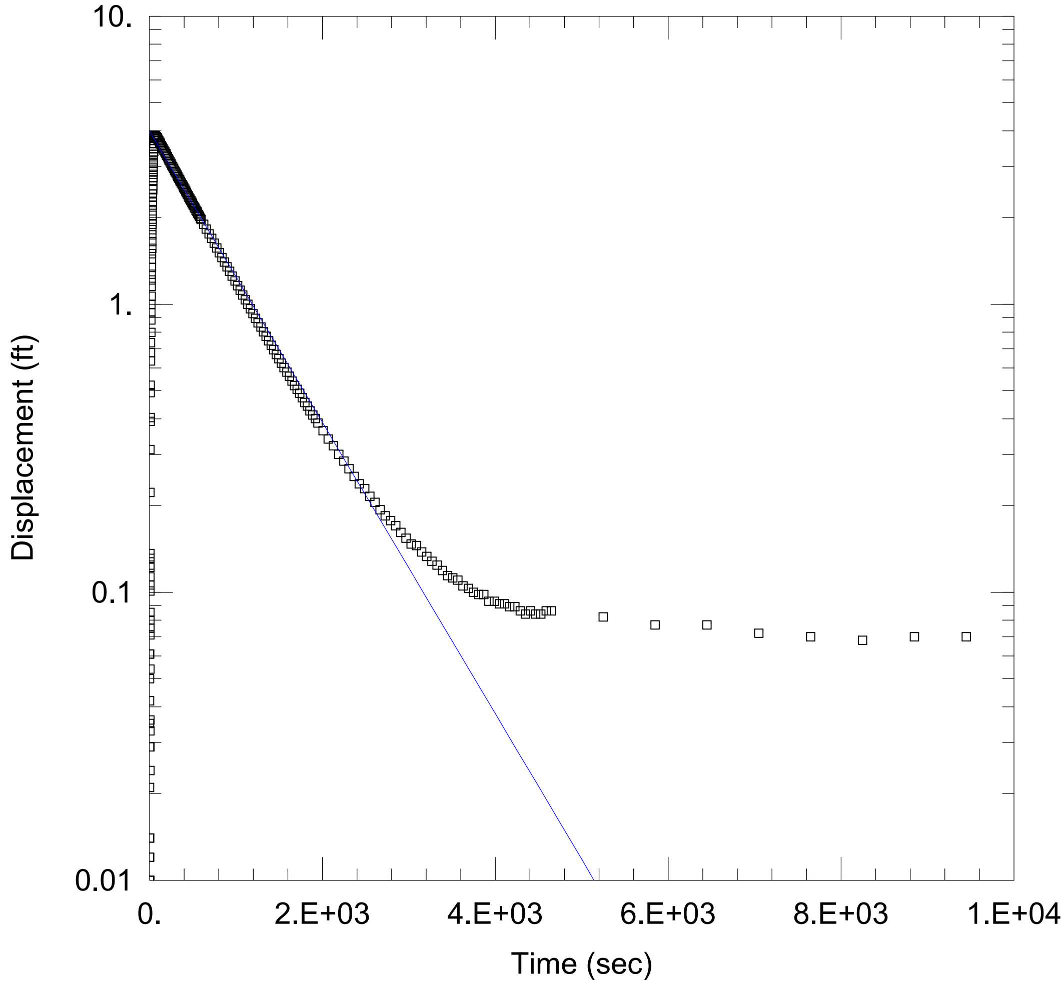
Saturated Thickness: 1.16 ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW02)

Initial Displacement: 3.855 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 1.16 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.1493 ft/day
y0 = 3.984 ft



SLUG TEST ANALYSIS FOR MW02 SLUG_IN_3

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW02
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 1.16 ft
Anisotropy Ratio (Kz/Kr): 0.1

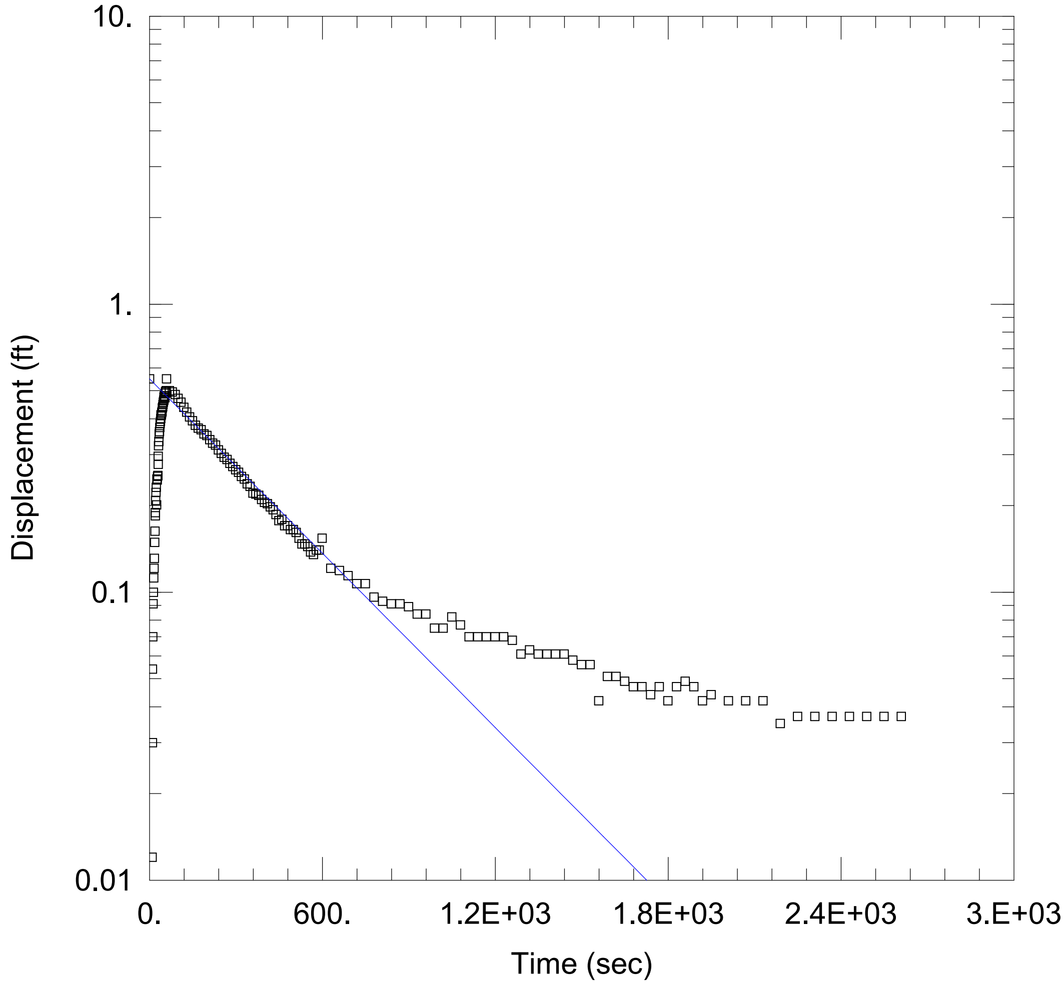
WELL DATA (MW02)

Initial Displacement: 3.855 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 1.16 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.286 ft/day
y0 = 3.984 ft



SLUG TEST ANALYSIS FOR MW06P SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06P
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 0.75 ft
Anisotropy Ratio (Kz/Kr): 0.1

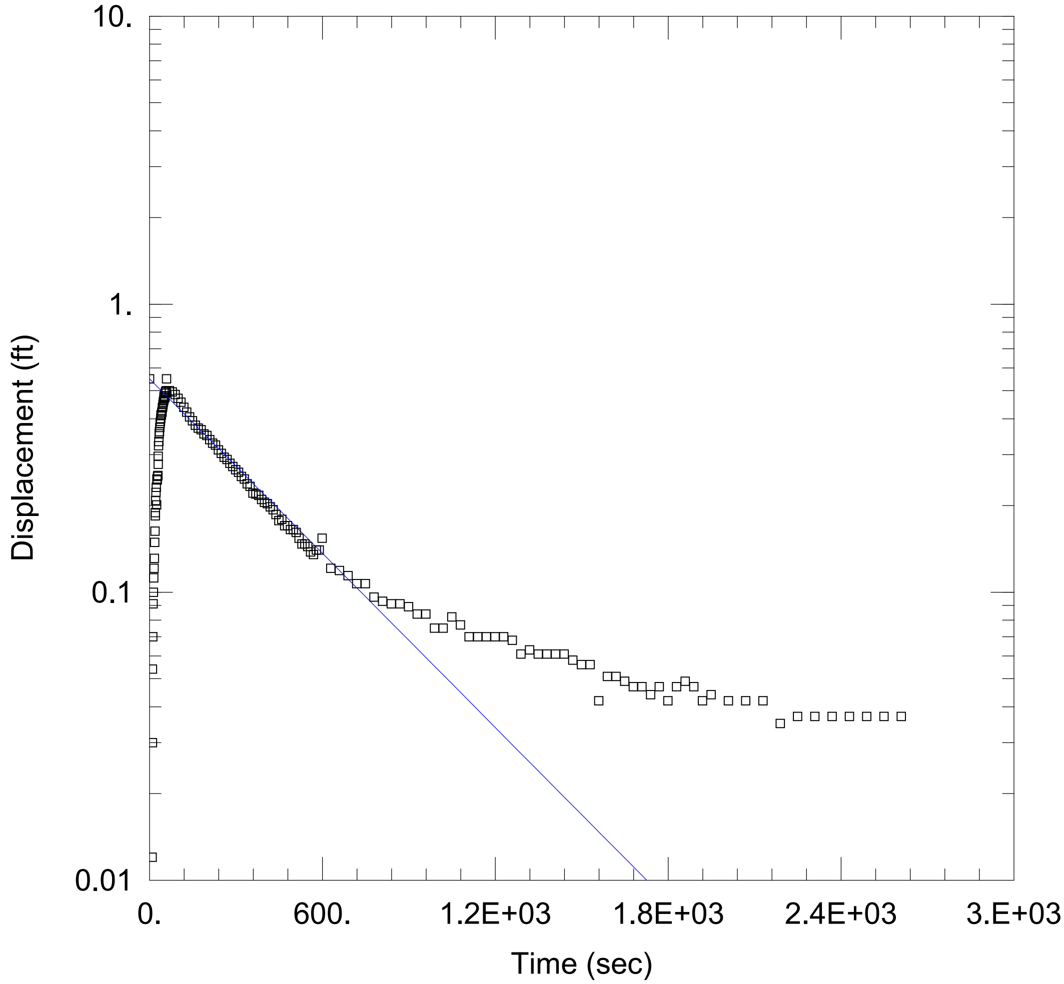
WELL DATA (MW06P)

Initial Displacement: 0.55 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 0.75 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.1286 ft/day
y0 = 0.55 ft



SLUG TEST ANALYSIS FOR MW06P SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06P
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 0.75 ft
Anisotropy Ratio (Kz/Kr): 0.1

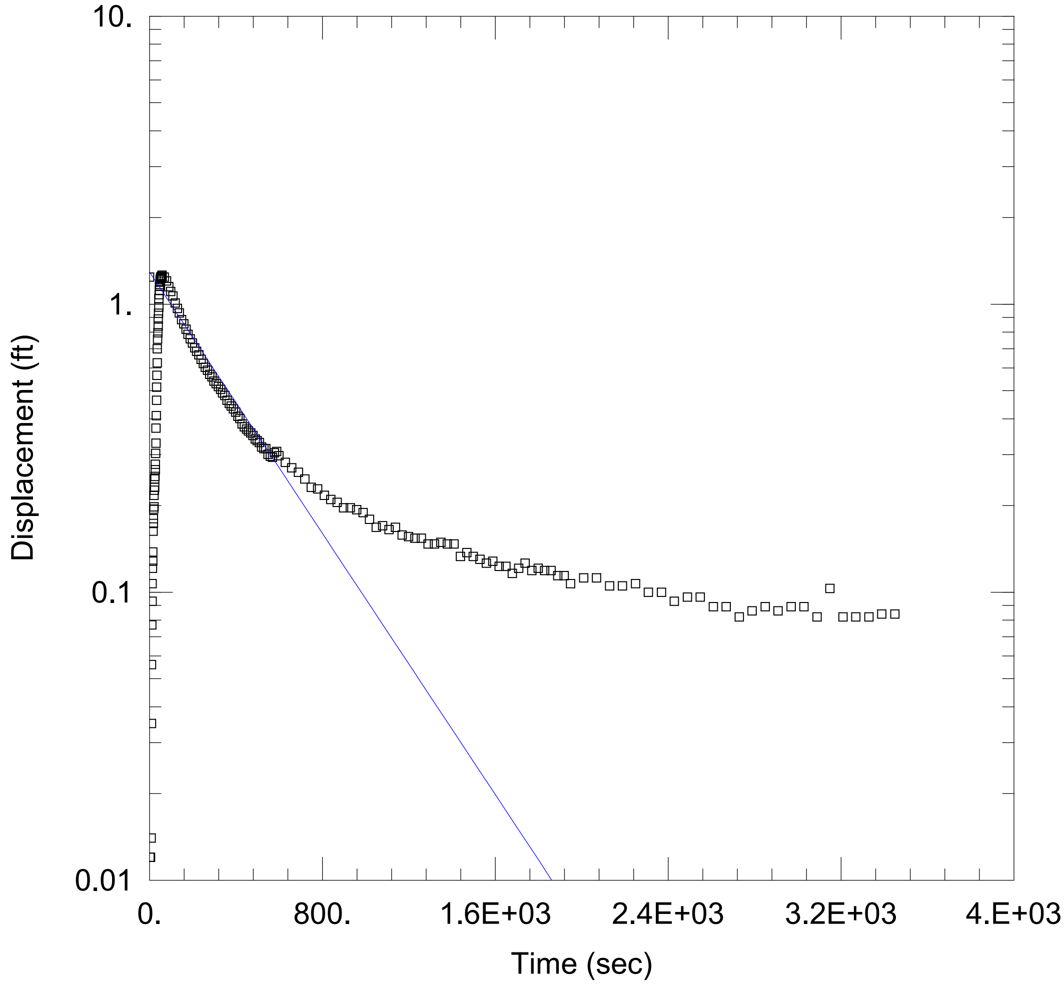
WELL DATA (MW06P)

Initial Displacement: 0.55 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 0.75 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.3336 ft/day
y0 = 0.55 ft



SLUG TEST ANALYSIS FOR MW06P SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06P
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 0.75 ft
Anisotropy Ratio (Kz/Kr): 0.1

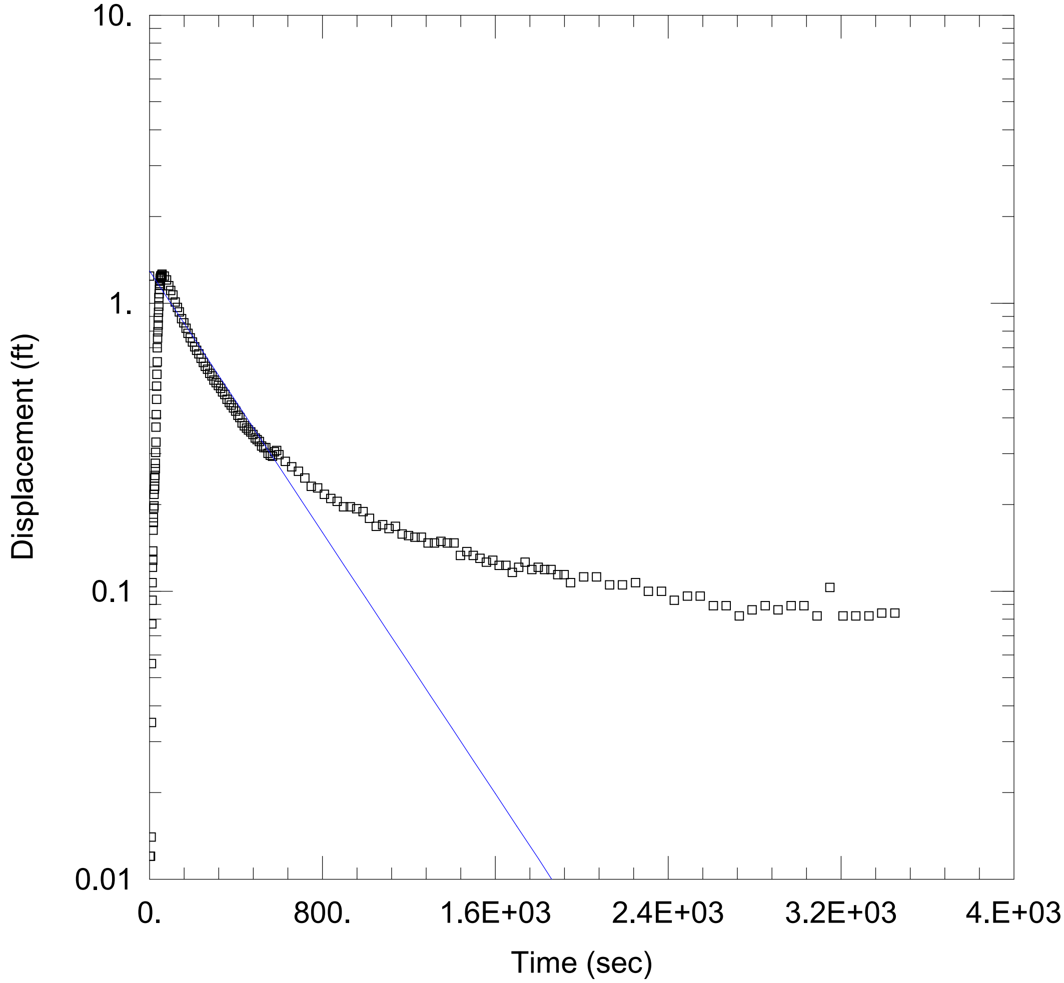
WELL DATA (MW06P)

Initial Displacement: 1.242 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 0.75 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.1446 ft/day
y0 = 1.293 ft



SLUG TEST ANALYSIS FOR MW06P SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06P
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 0.75 ft
Anisotropy Ratio (Kz/Kr): 0.1

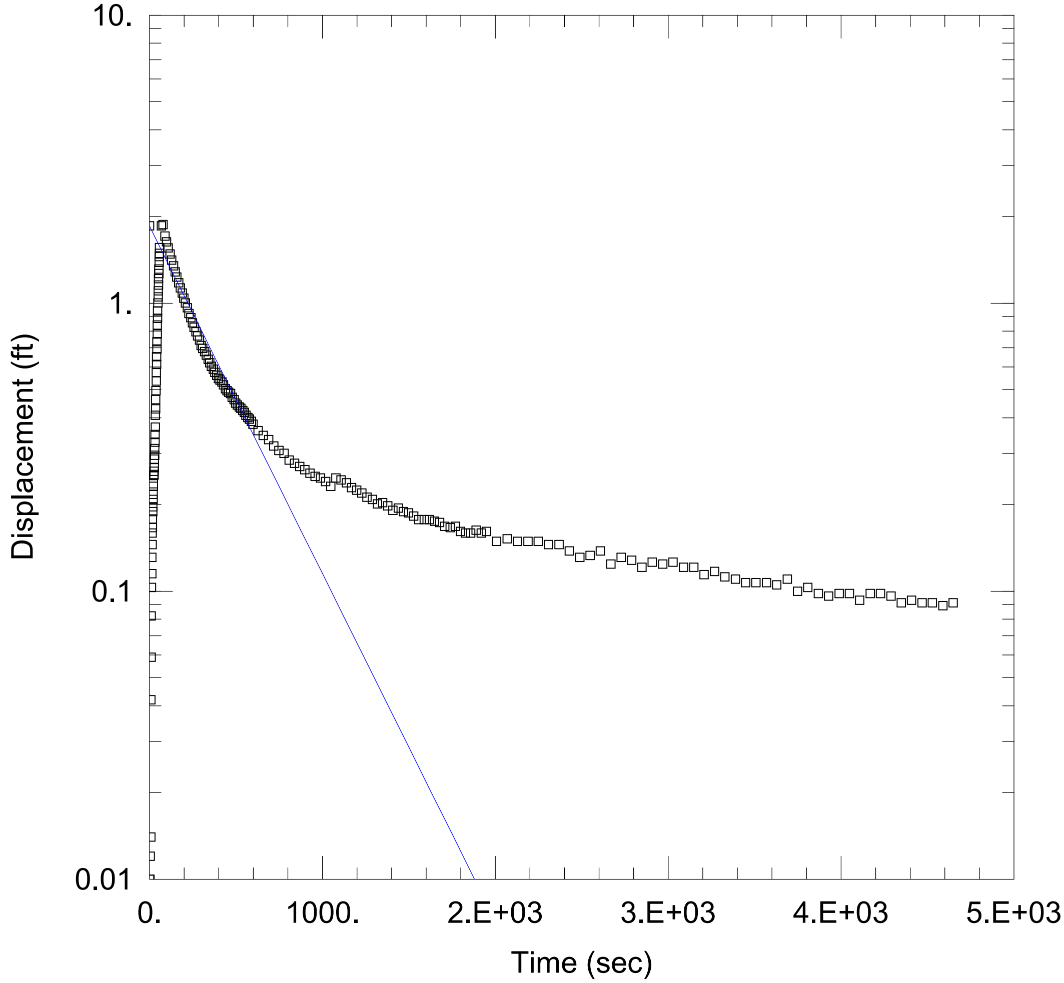
WELL DATA (MW06P)

Initial Displacement: 1.242 ft
Casing Radius: 0.08333 ft
Wellbore Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Screen Length: 10. ft
Total Well Penetration Depth: 0.75 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.3751 ft/day
y0 = 1.293 ft



SLUG TEST ANALYSIS FOR MW06P SLUG_IN_3

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06P
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 0.75 ft
Anisotropy Ratio (Kz/Kr): 0.1

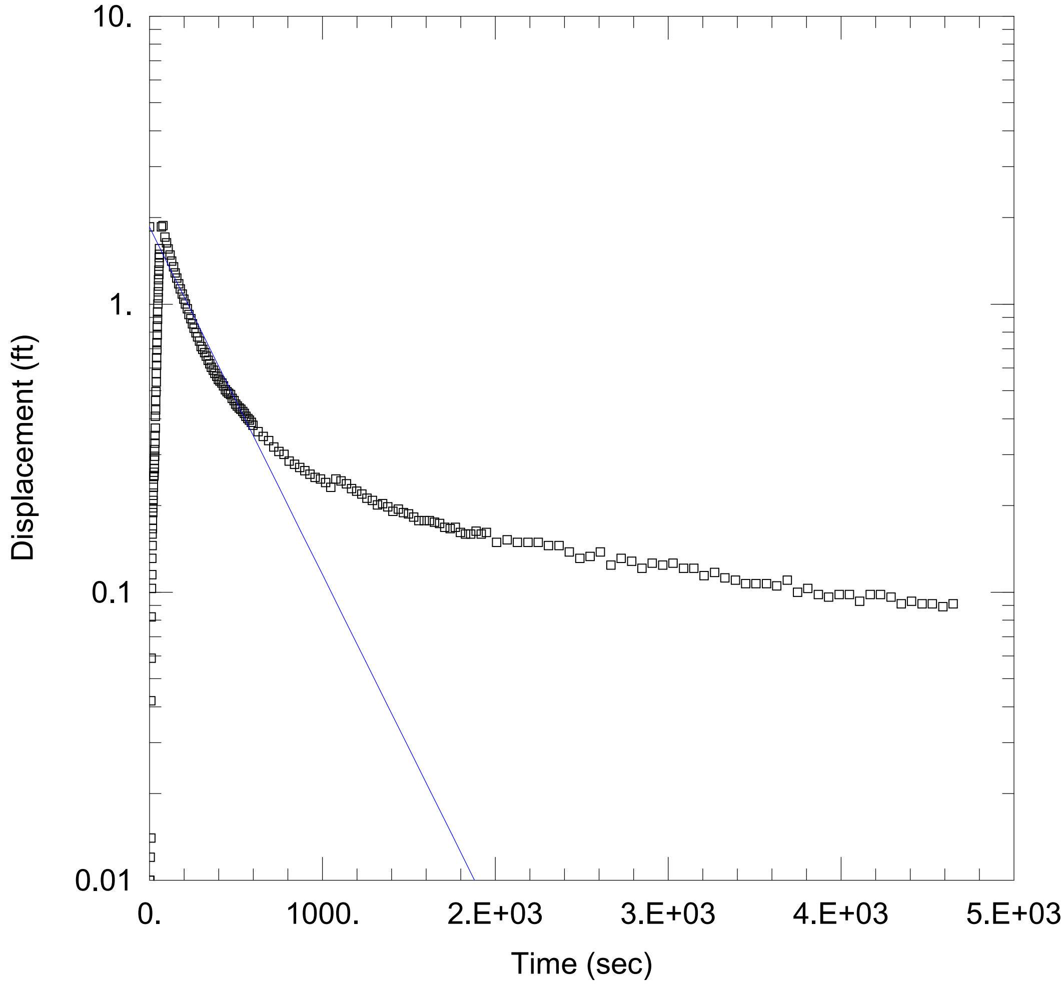
WELL DATA (MW06P)

Initial Displacement: 1.855 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 0.75 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.1538 ft/day
y0 = 1.85 ft



SLUG TEST ANALYSIS FOR MW06P SLUG_IN_3

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06P
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 0.75 ft
Anisotropy Ratio (Kz/Kr): 0.1

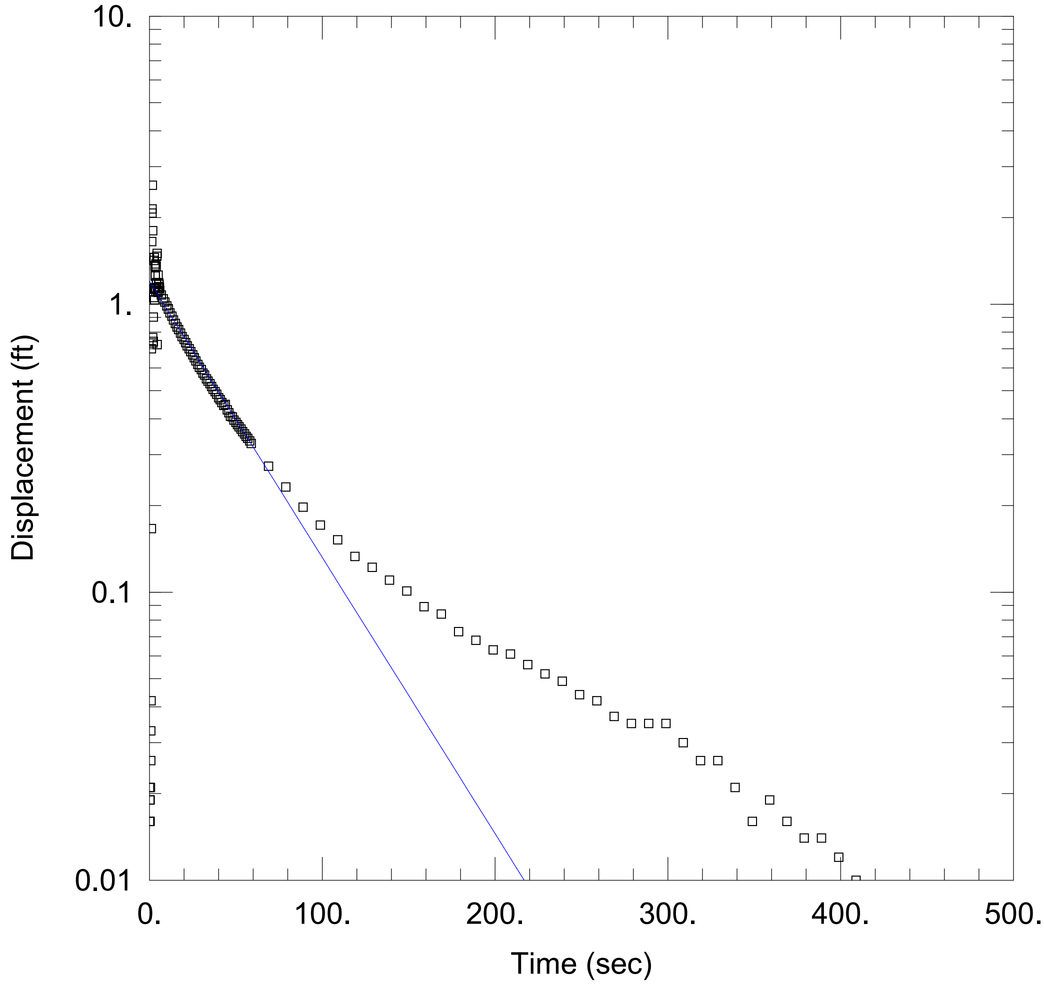
WELL DATA (MW06P)

Initial Displacement: 1.855 ft
Casing Radius: 0.08333 ft
Wellbore Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Screen Length: 10. ft
Total Well Penetration Depth: 0.75 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.3988 ft/day
y0 = 1.85 ft



SLUG TEST ANALYSIS FOR MW05 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW05
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 3.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

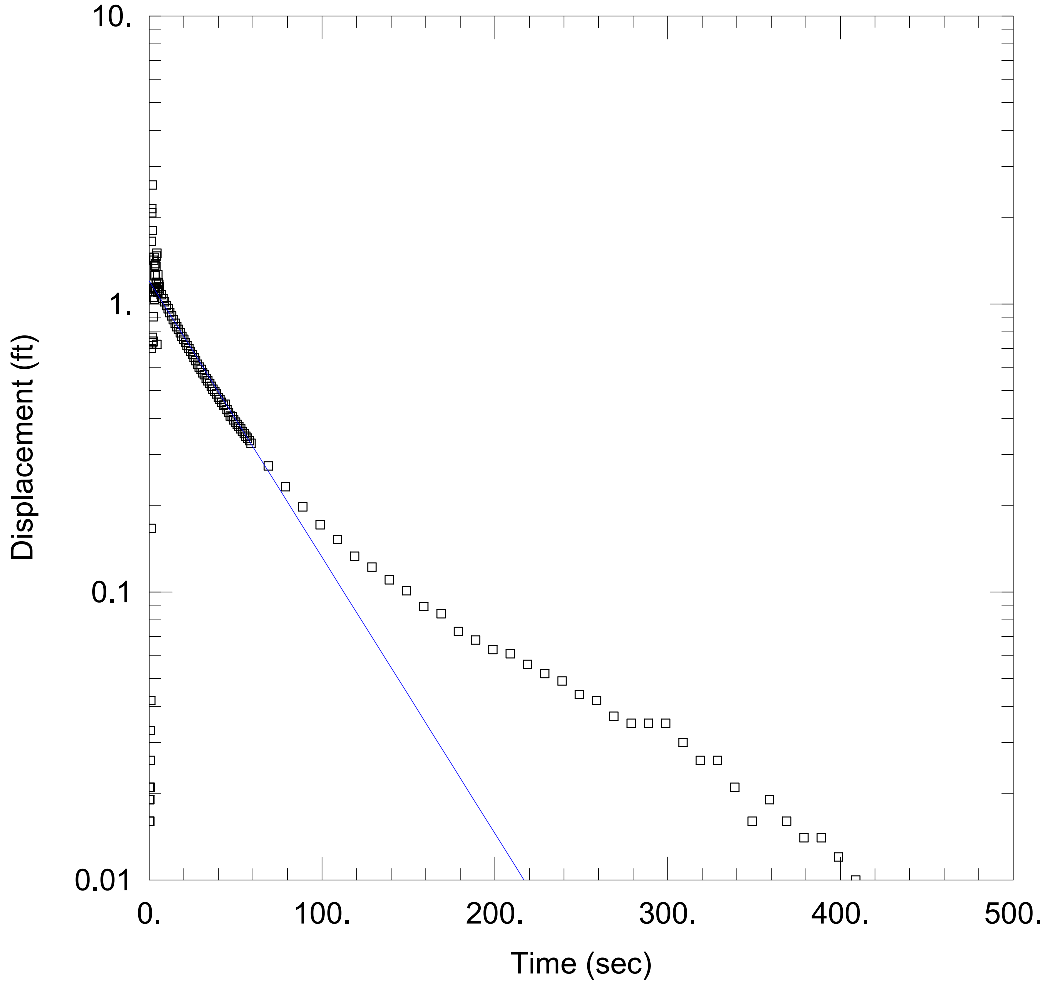
WELL DATA (MW05)

Initial Displacement: 1.451 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 3.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.848 ft/day
y0 = 1.2 ft



SLUG TEST ANALYSIS FOR MW05 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW05
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 3.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

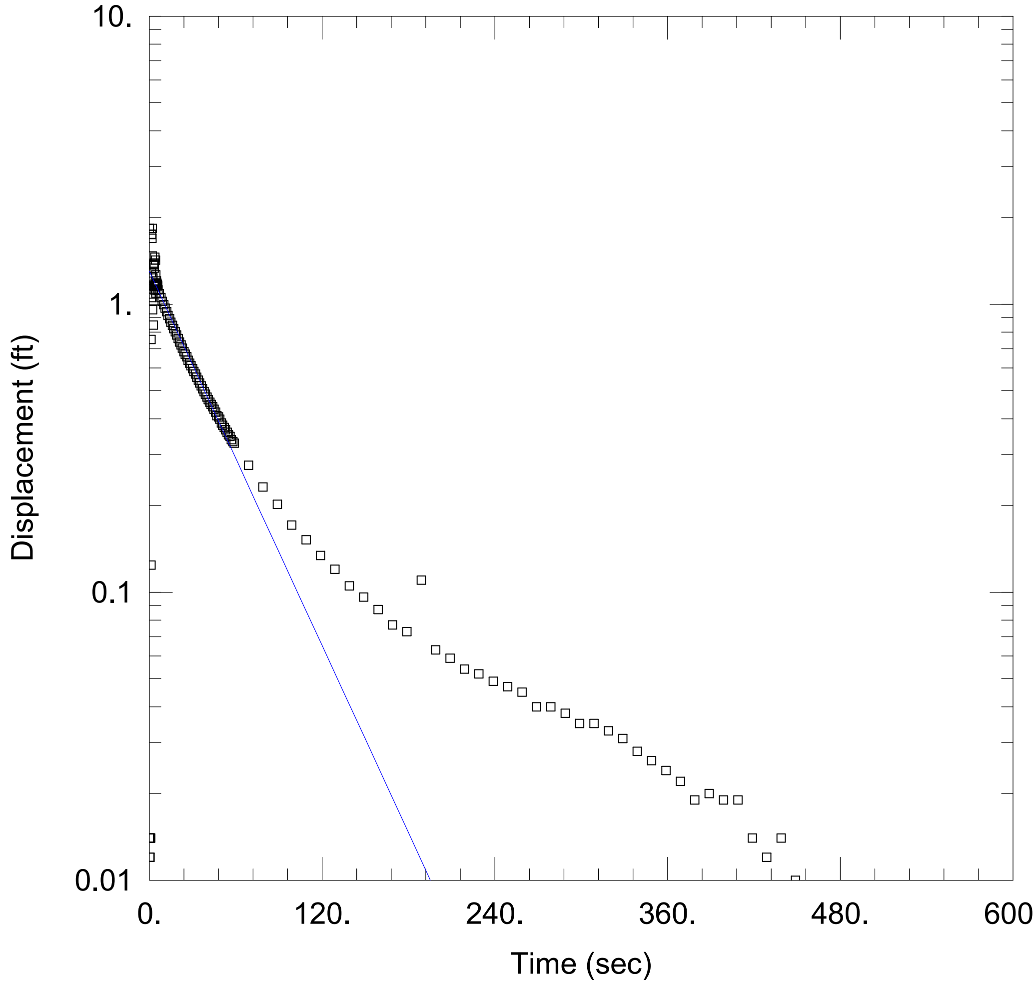
WELL DATA (MW05)

Initial Displacement: 1.451 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 3.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 5.422 ft/day
y0 = 1.2 ft



SLUG TEST ANALYSIS FOR MW05 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW05
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 3.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

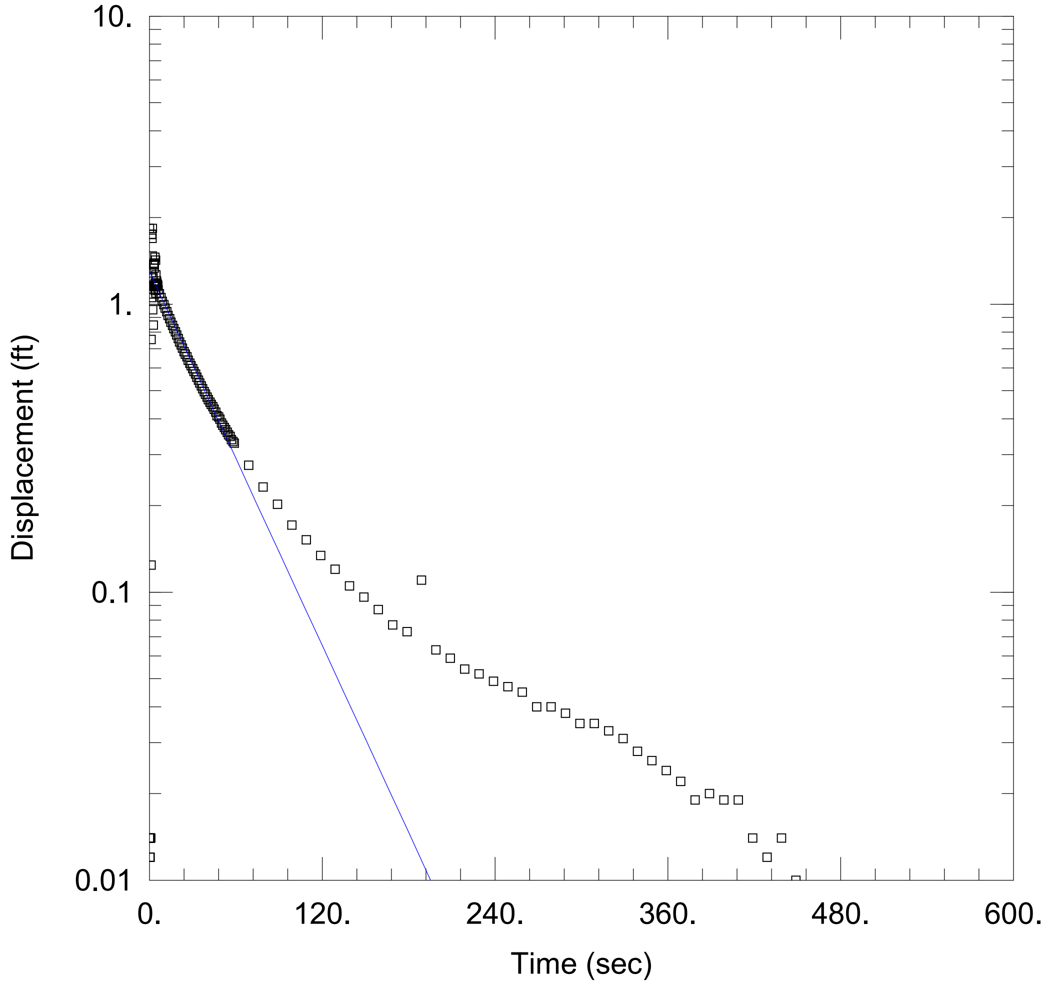
WELL DATA (MW05)

Initial Displacement: 1.83 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 3.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.346 ft/day
y0 = 1.3 ft



SLUG TEST ANALYSIS FOR MW05 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW05
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 3.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

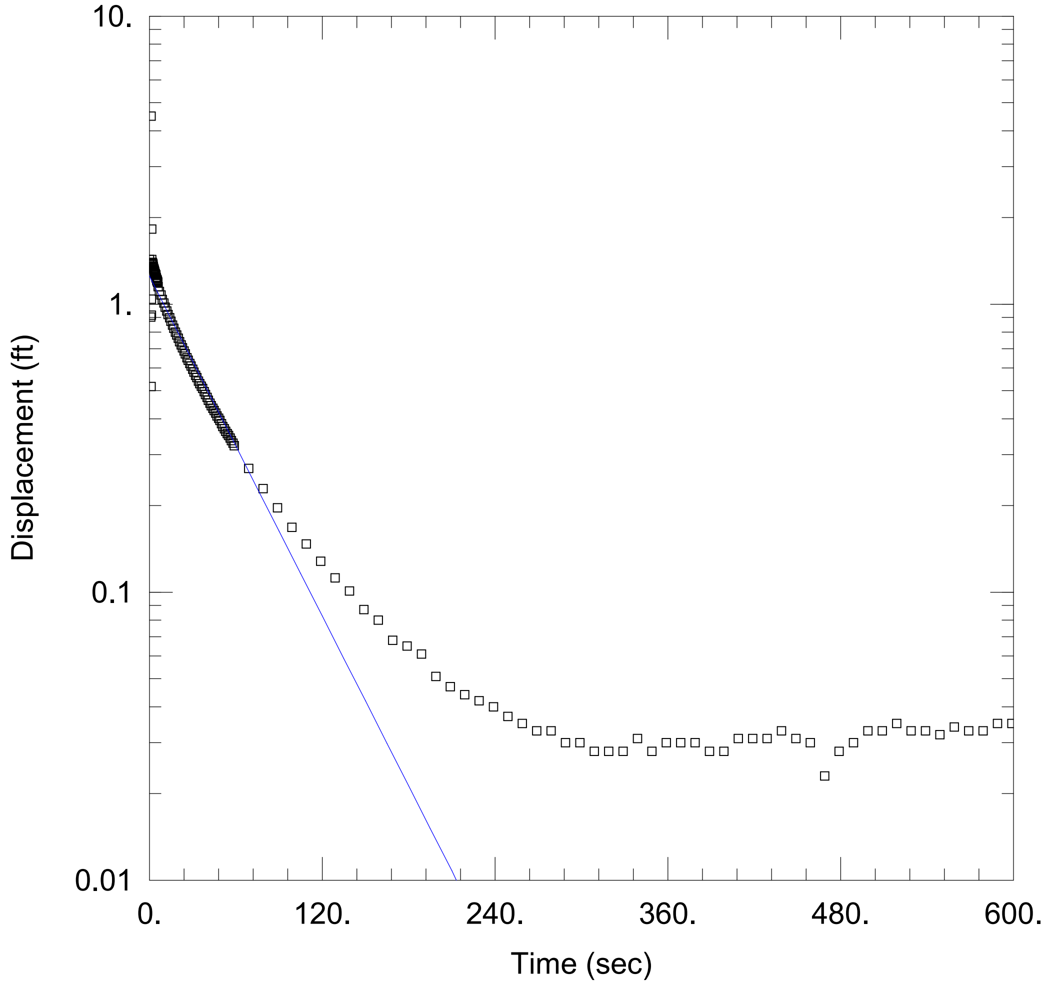
WELL DATA (MW05)

Initial Displacement: 1.83 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 3.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 6.123 ft/day
y0 = 1.3 ft



SLUG TEST ANALYSIS FOR MW05 SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW05
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 3.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

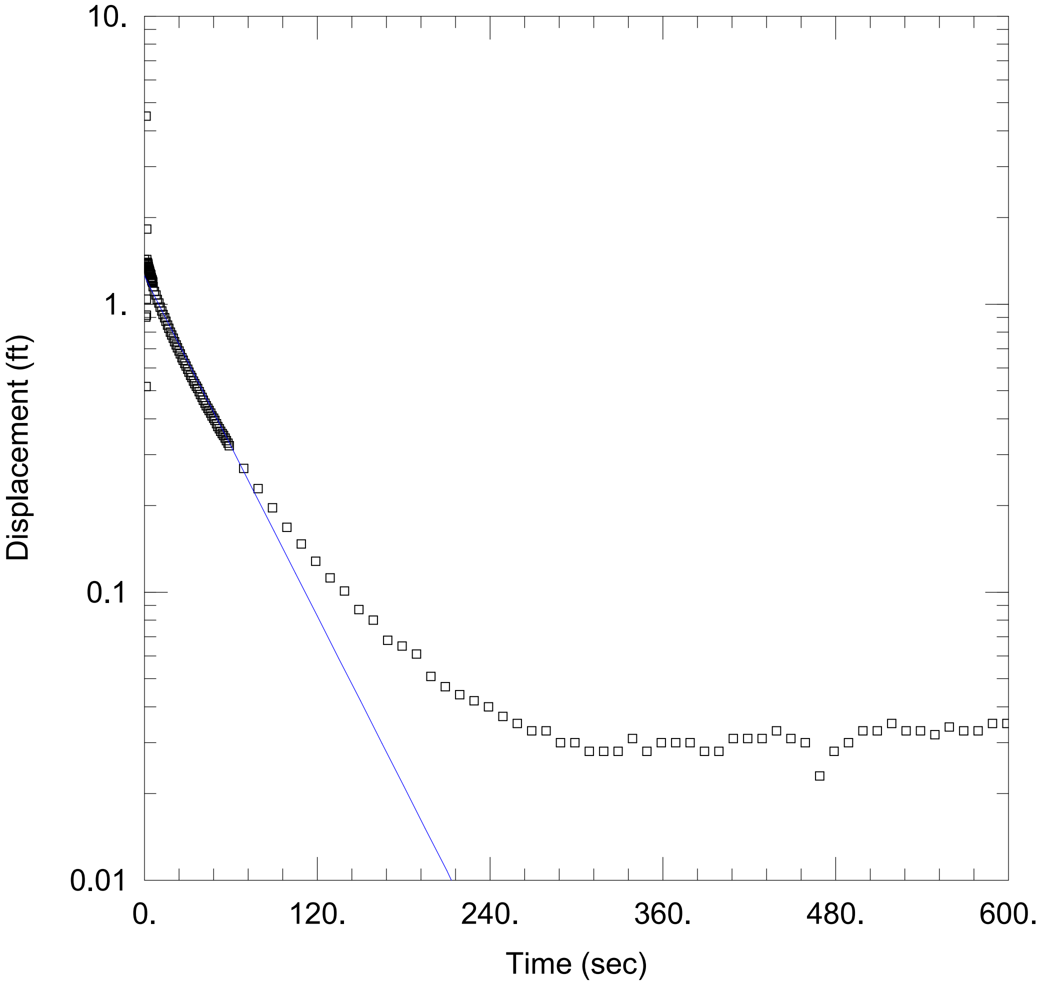
WELL DATA (MW05)

Initial Displacement: 1.429 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 3.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.947 ft/day
y0 = 1.25 ft



SLUG TEST ANALYSIS FOR MW05 SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW05
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 3.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

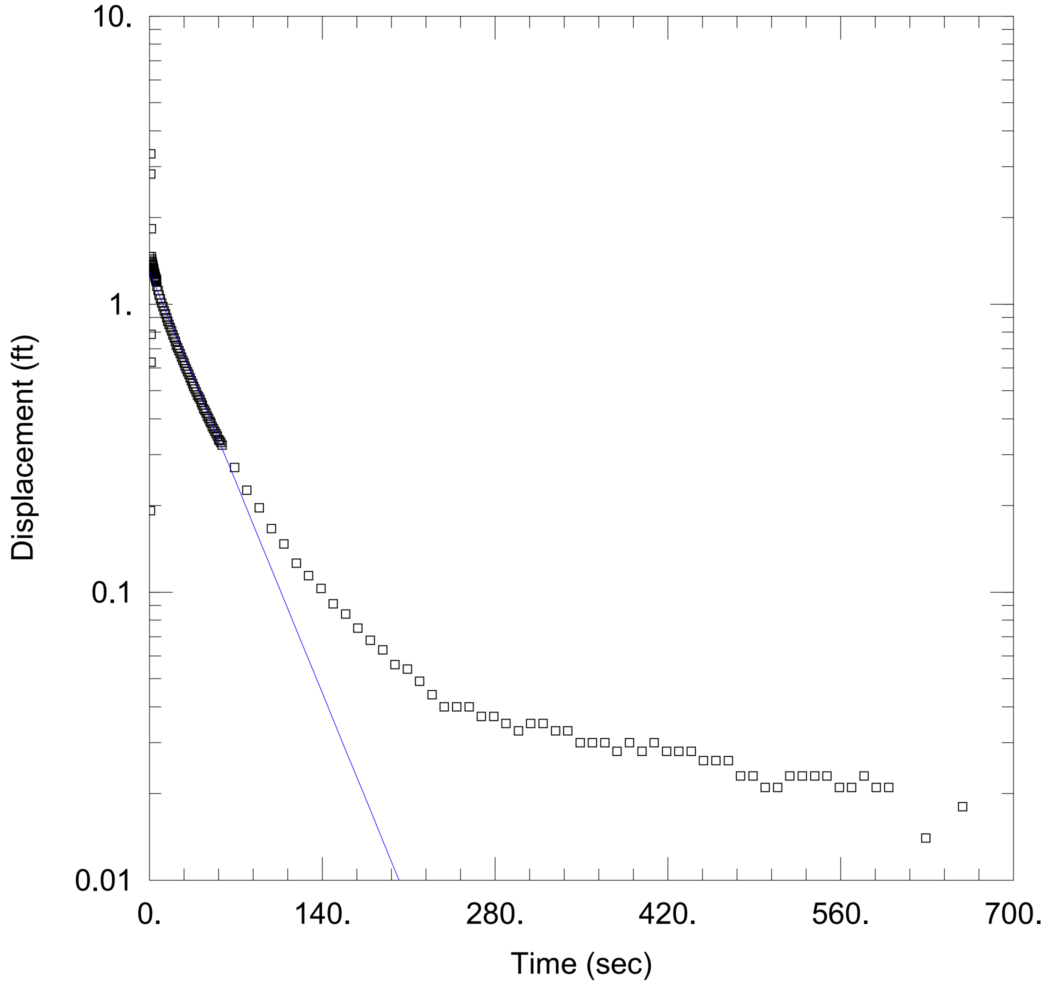
WELL DATA (MW05)

Initial Displacement: 1.429 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 3.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 5.561 ft/day
y0 = 1.25 ft



SLUG TEST ANALYSIS FOR MW05 SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW05
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 3.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

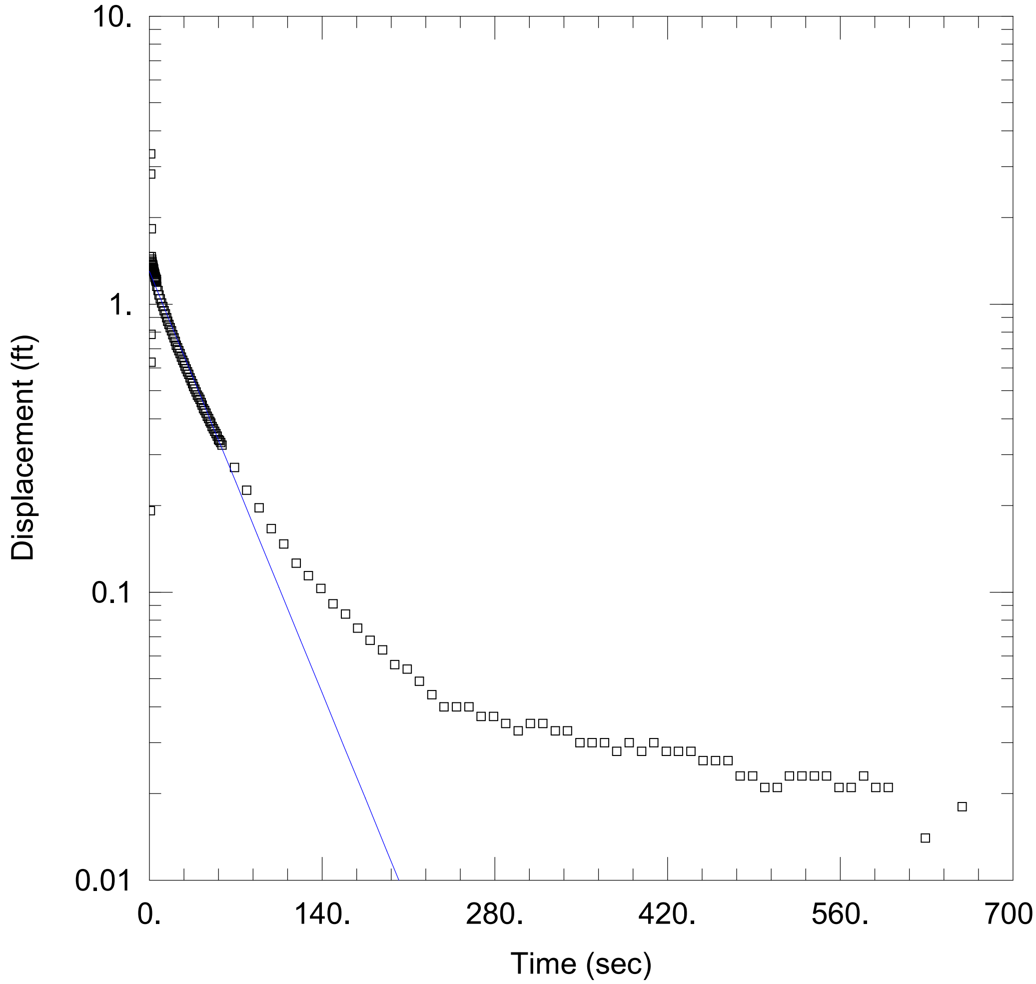
WELL DATA (MW05)

Initial Displacement: 1.464 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 3.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.196 ft/day
y0 = 1.3 ft



SLUG TEST ANALYSIS FOR MW05 SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW05
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 3.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

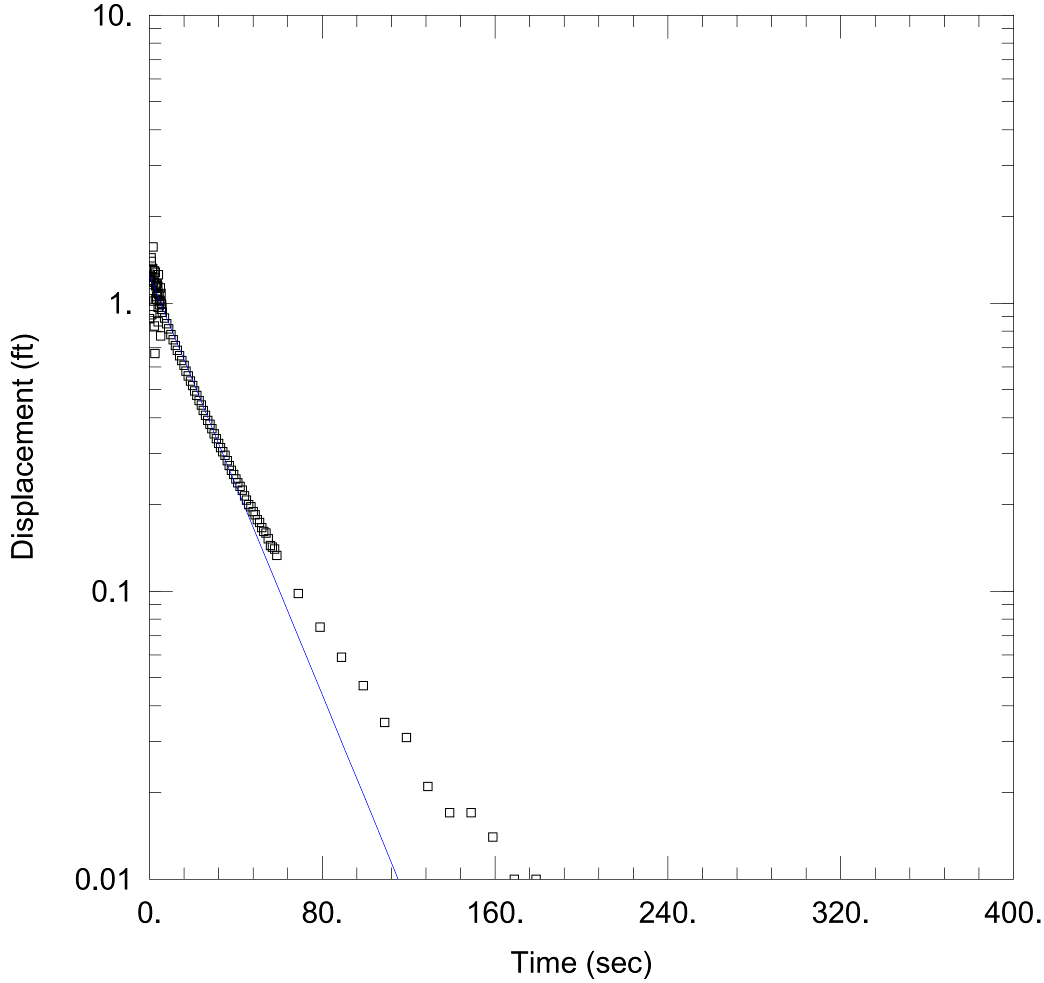
WELL DATA (MW05)

Initial Displacement: 1.464 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 3.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 5.913 ft/day
y0 = 1.3 ft



SLUG TEST ANALYSIS FOR MW06S SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06S
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

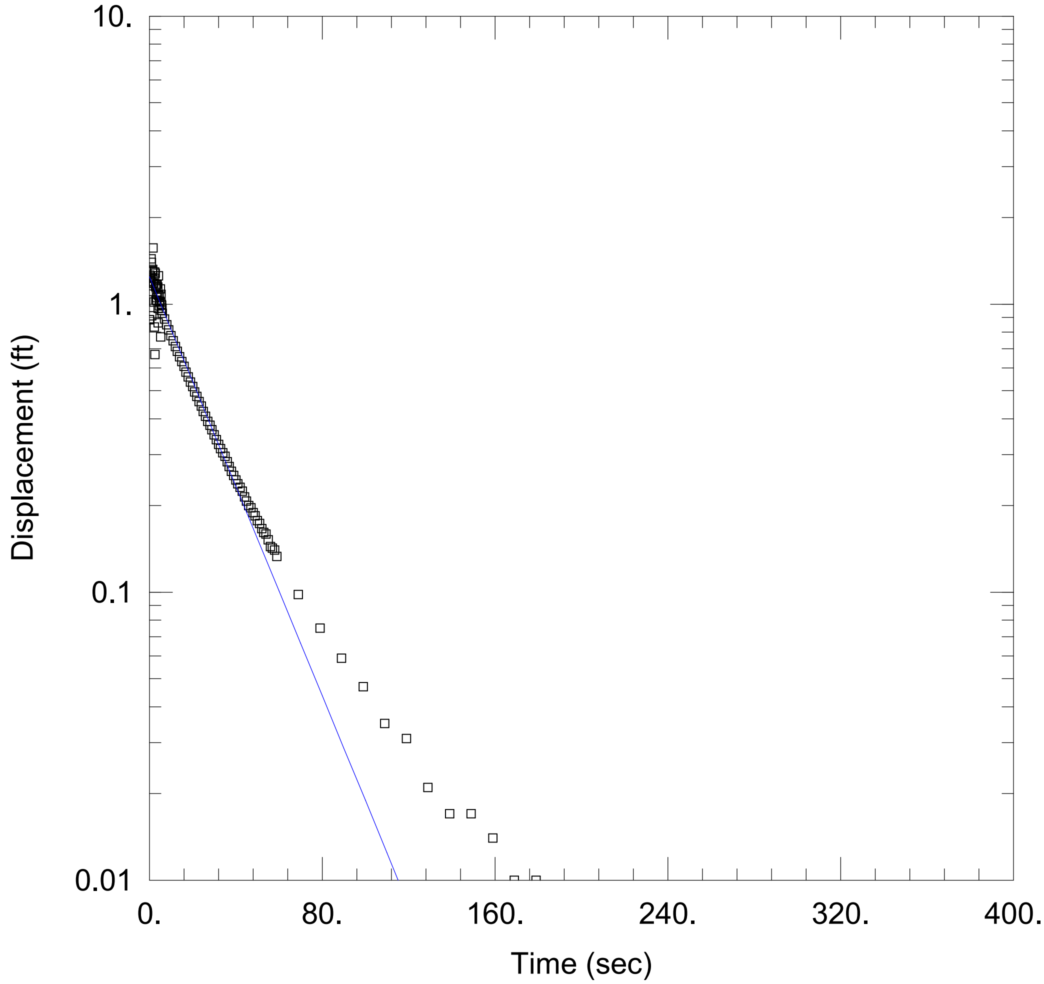
WELL DATA (MW06S)

Initial Displacement: 0.883 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.397 ft/day
y0 = 1.244 ft



SLUG TEST ANALYSIS FOR MW06S SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06S
Test Date: April. 13, 2015

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

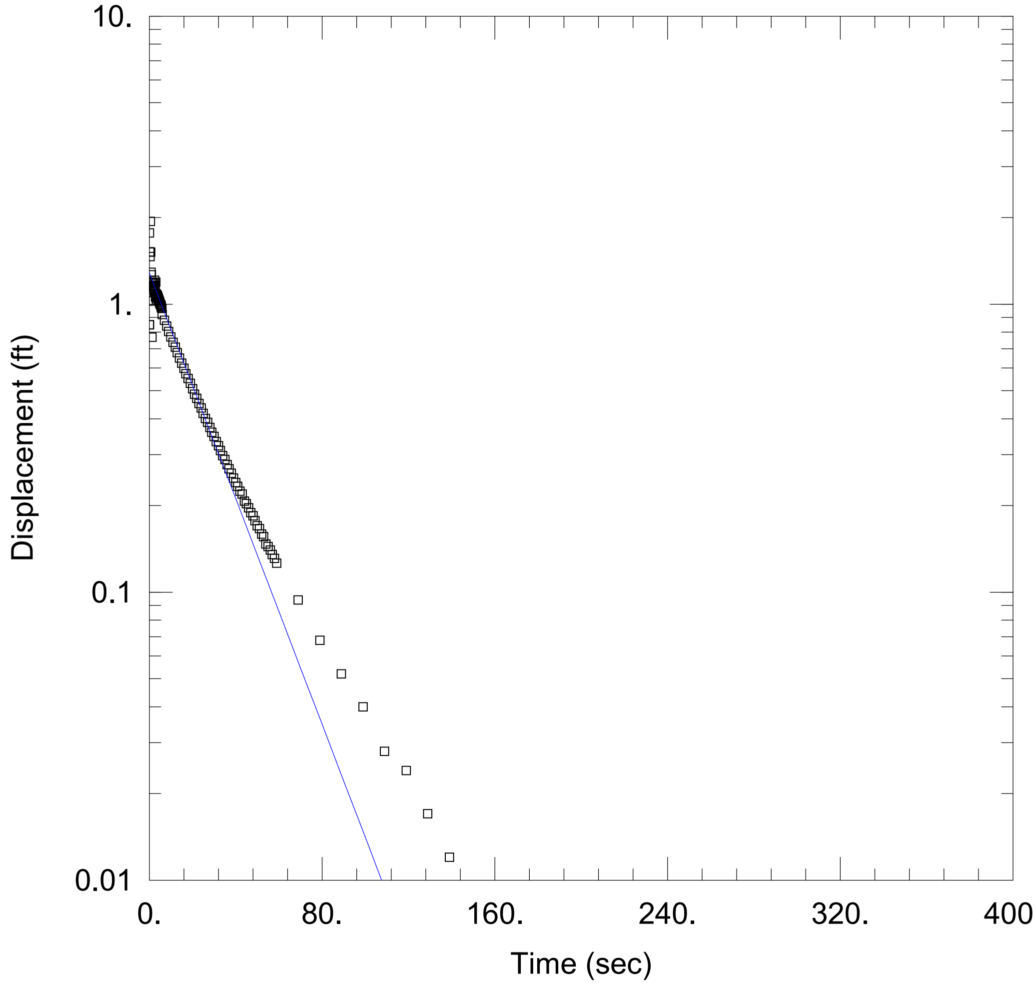
WELL DATA (MW06S)

Initial Displacement: 0.883 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 6.012 ft/day
y0 = 1.244 ft



SLUG TEST ANALYSIS FOR MW06S SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06S
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

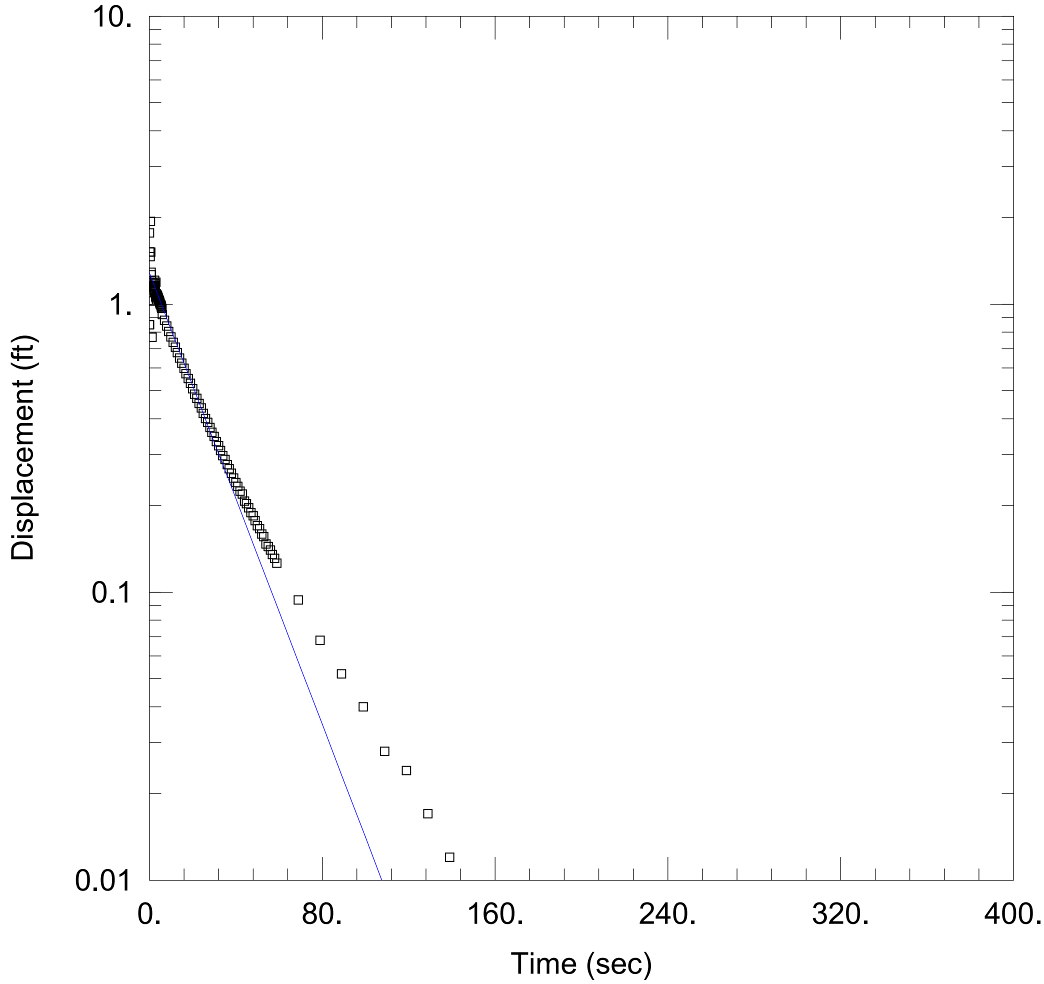
WELL DATA (MW06S)

Initial Displacement: 0.848 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.739 ft/day
y0 = 1.284 ft



SLUG TEST ANALYSIS FOR MW06S SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06S
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

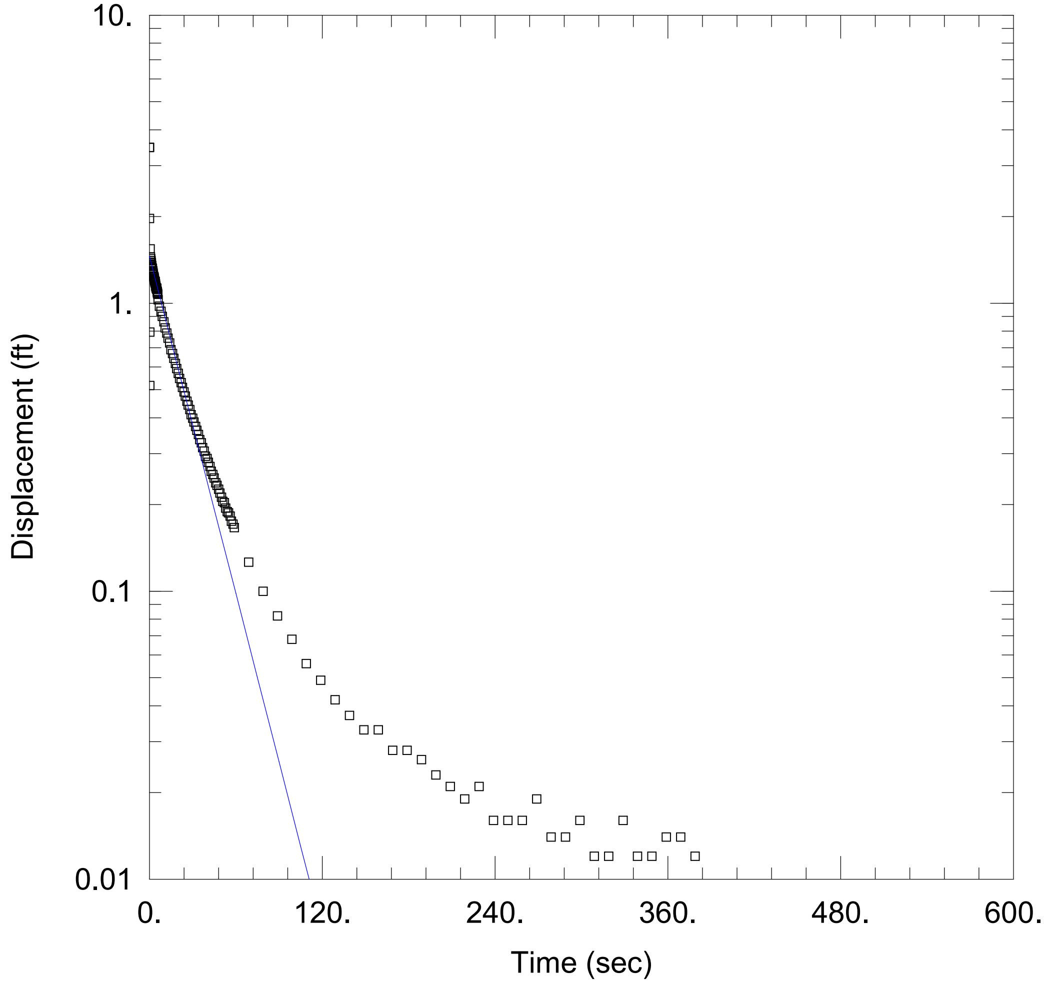
WELL DATA (MW06S)

Initial Displacement: 0.848 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 6.479 ft/day
y0 = 1.284 ft



SLUG TEST ANALYSIS FOR MW06S SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06S
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

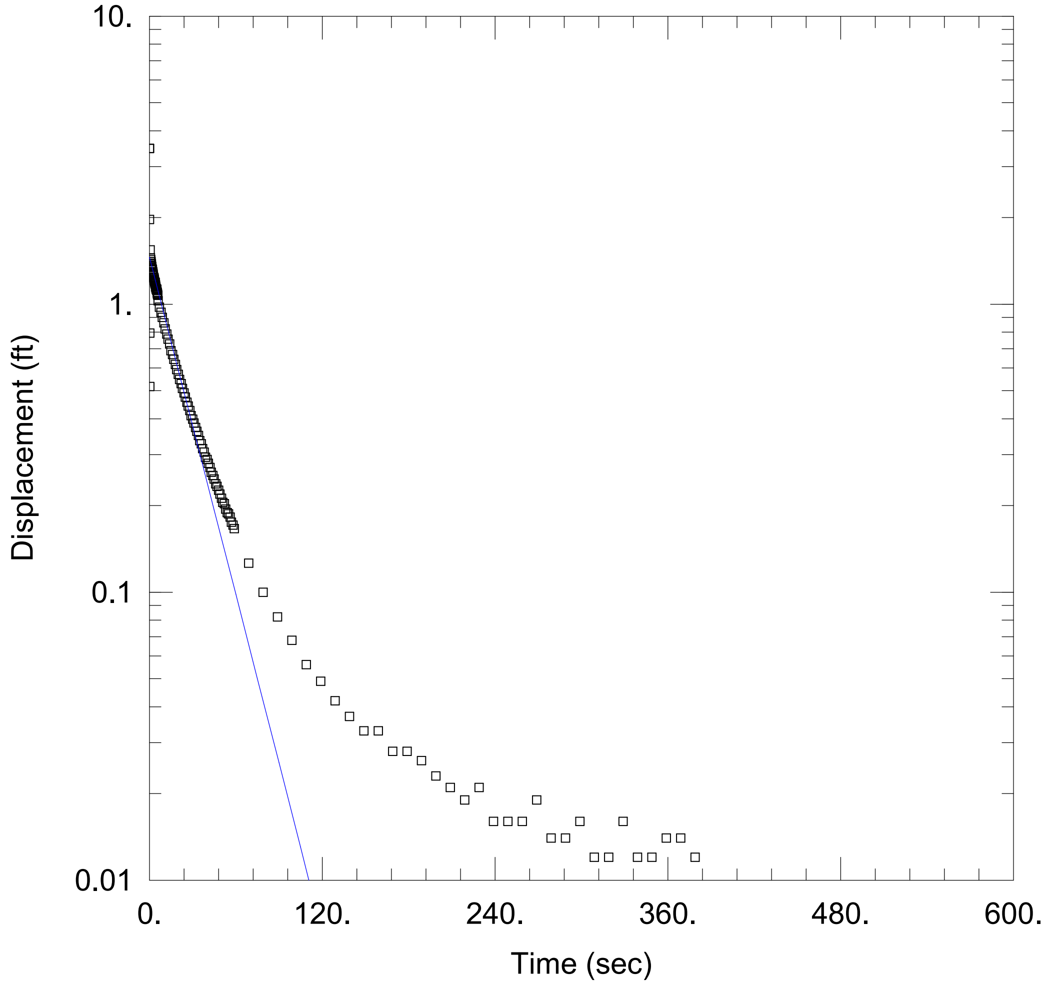
WELL DATA (MW06S)

Initial Displacement: 3.475 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.716 ft/day
y0 = 1.453 ft



SLUG TEST ANALYSIS FOR MW06S SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06S
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

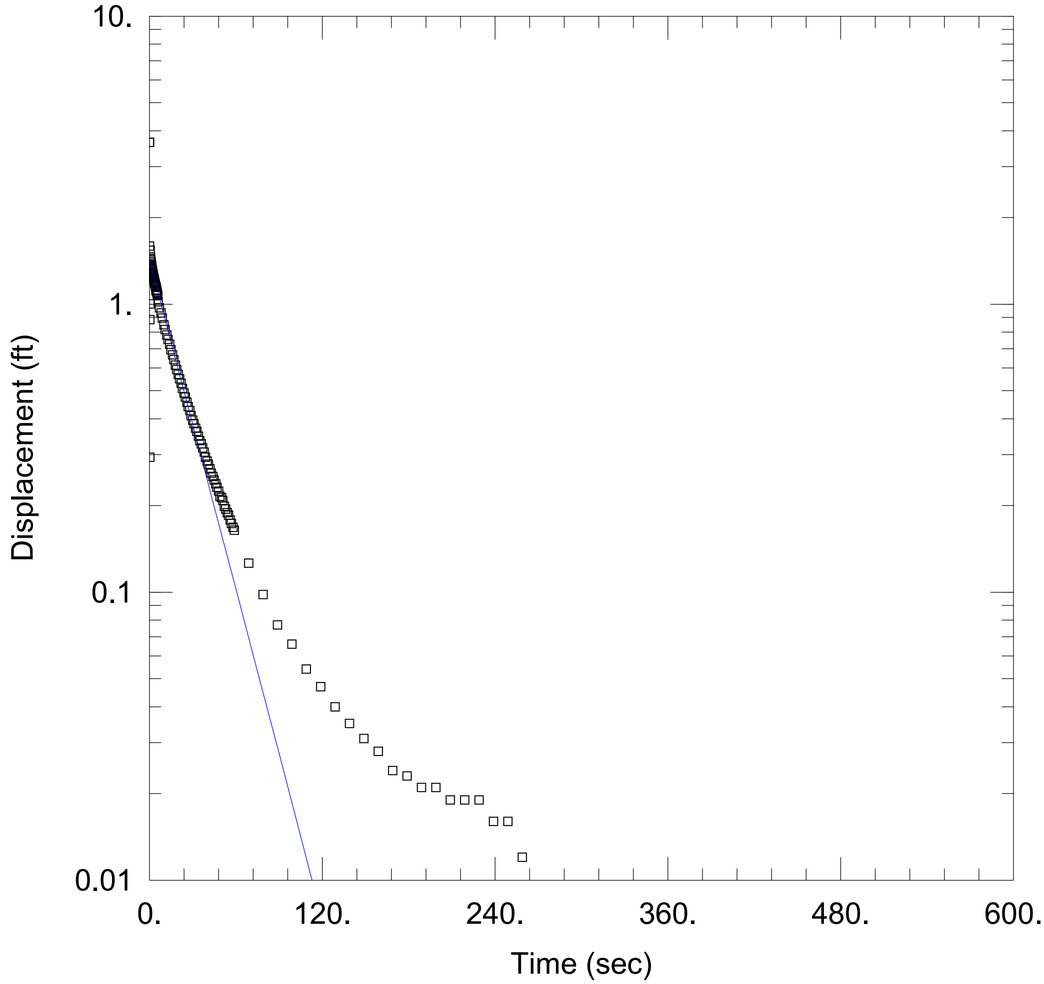
WELL DATA (MW06S)

Initial Displacement: 3.475 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 6.449 ft/day
y0 = 1.453 ft



SLUG TEST ANALYSIS FOR MW06S SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06S
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

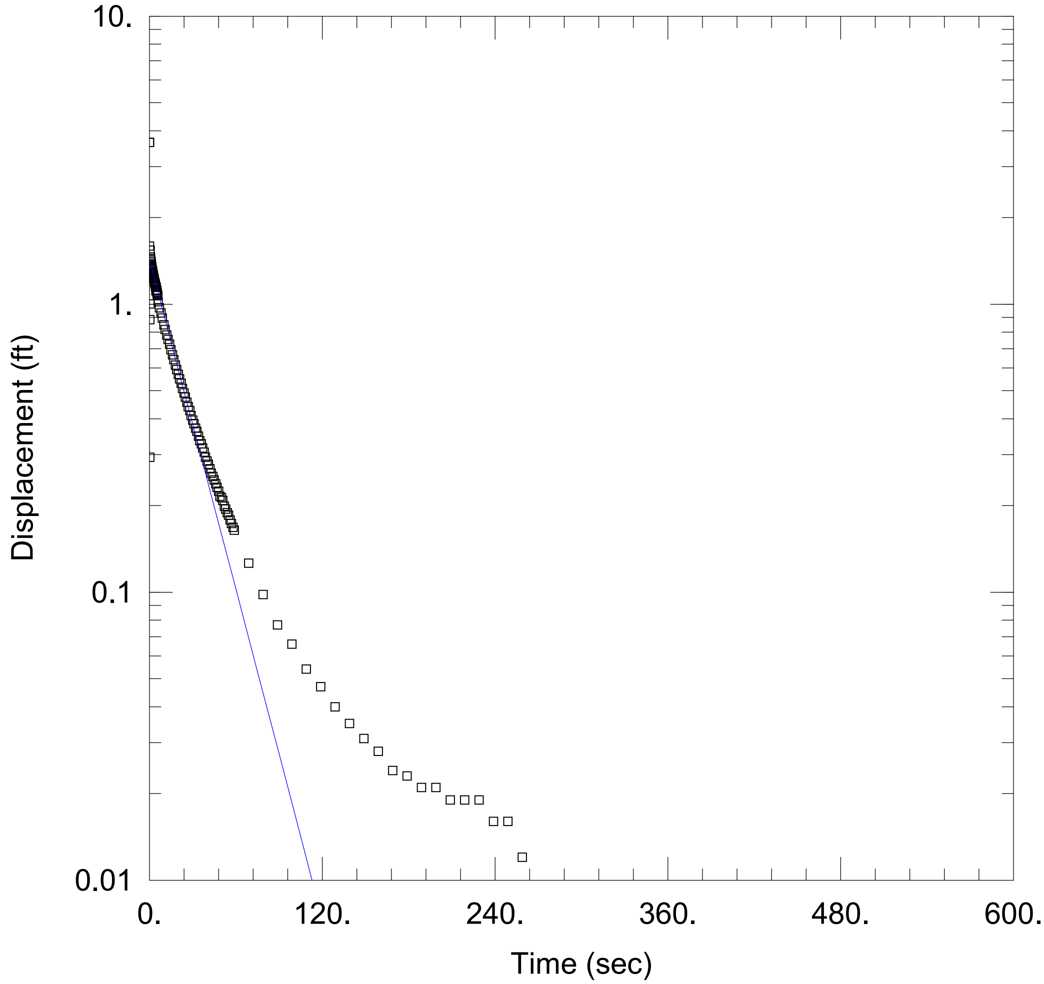
WELL DATA (MW06S)

Initial Displacement: 3.643 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.608 ft/day
y0 = 1.427 ft



SLUG TEST ANALYSIS FOR MW06S SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW06S
Test Date: April 13, 2015

AQUIFER DATA

Saturated Thickness: 7.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

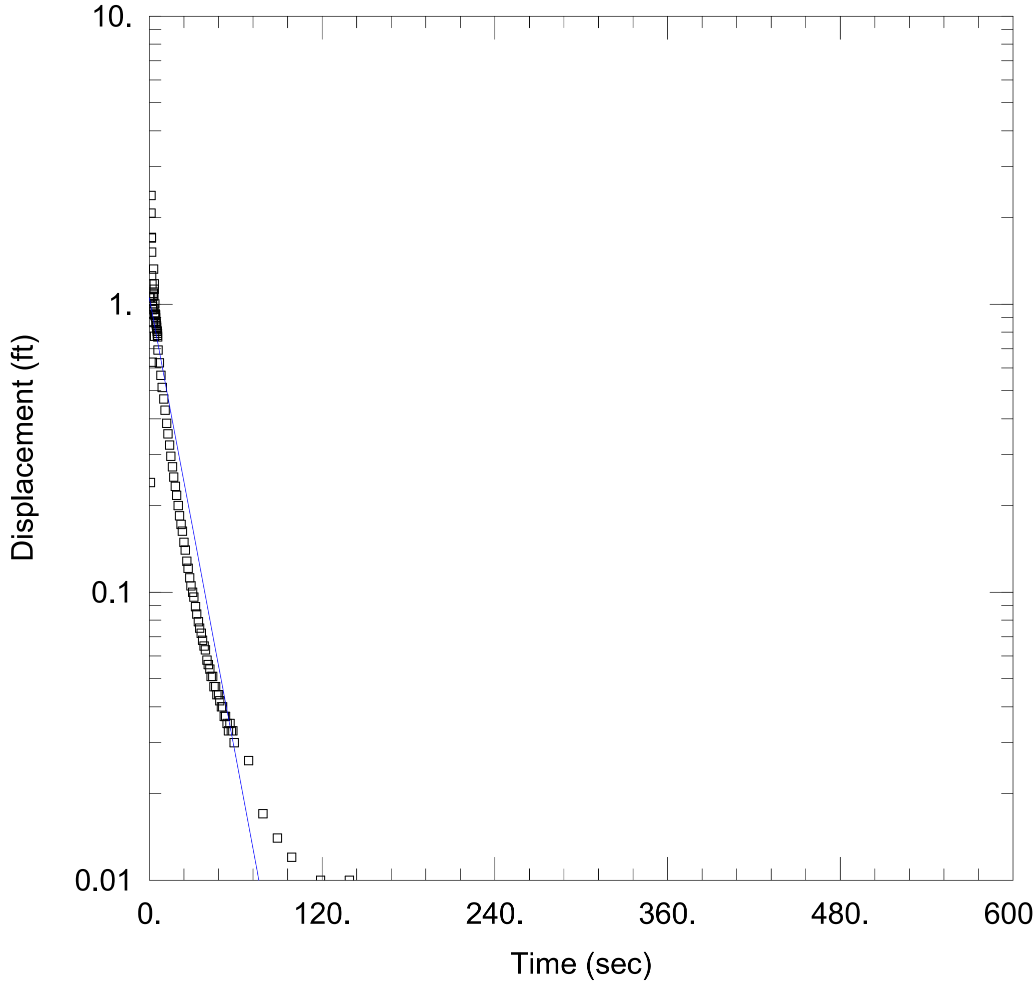
WELL DATA (MW06S)

Initial Displacement: 3.643 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 6.303 ft/day
y0 = 1.428 ft



SLUG TEST ANALYSIS FOR MW11 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW11
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 19. ft
Anisotropy Ratio (Kz/Kr): 0.1

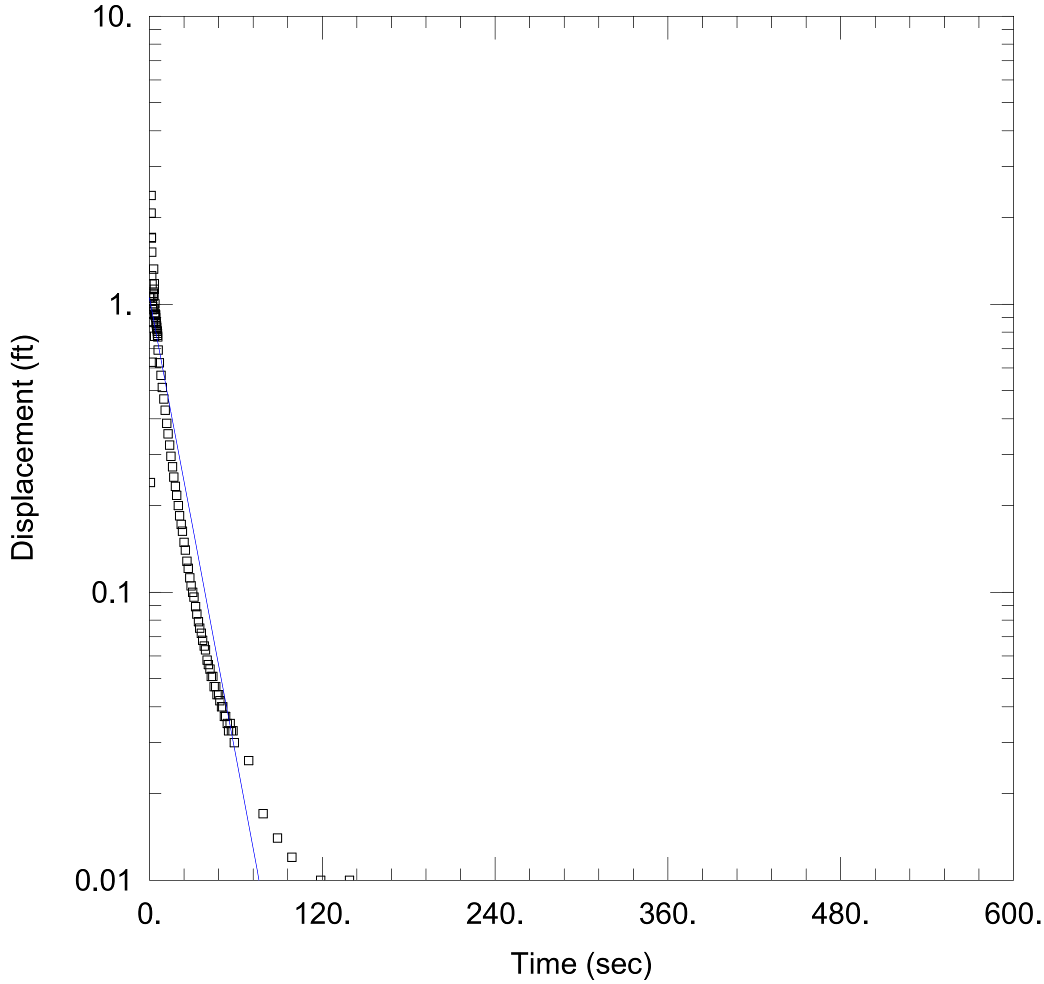
WELL DATA (MW11)

Initial Displacement: 1.05 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 19. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 9.525 ft/day
y0 = 1.05 ft



SLUG TEST ANALYSIS FOR MW11 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW11
Test Date: April. 14, 2015

AQUIFER DATA

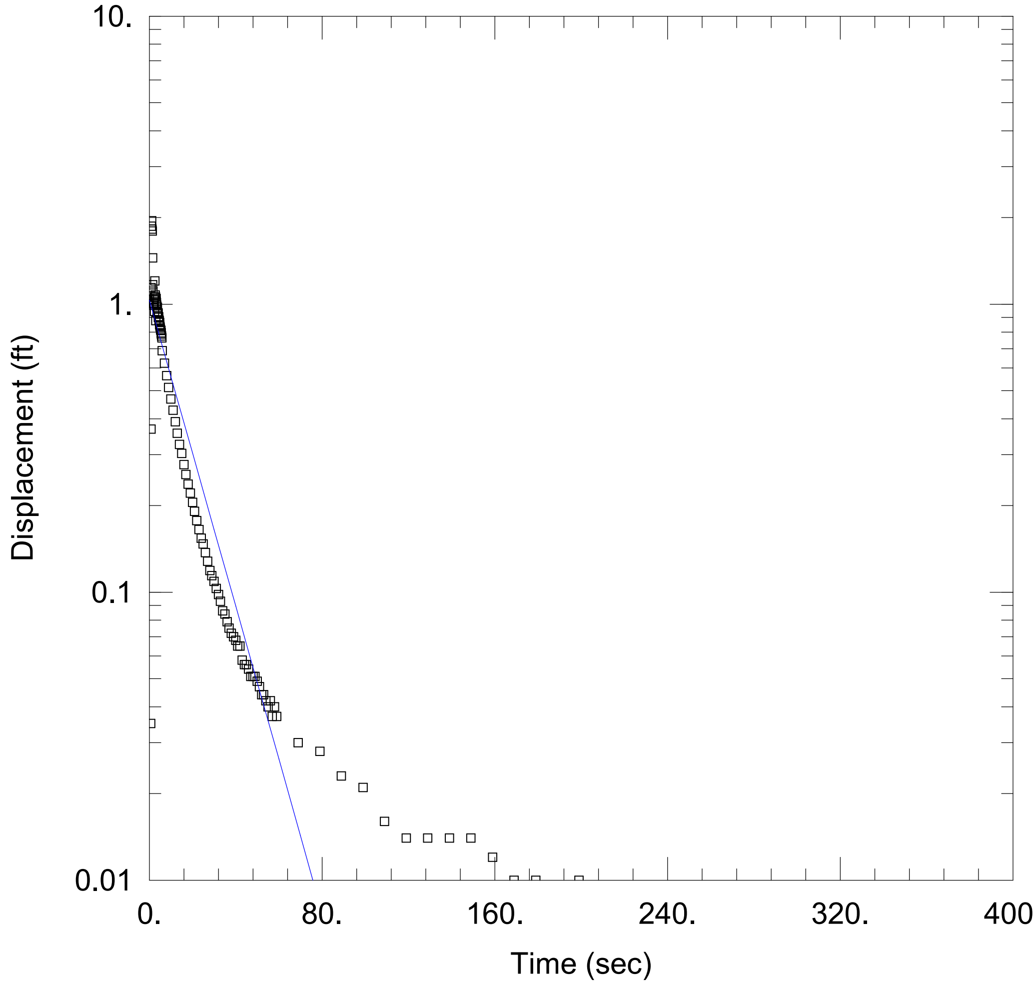
Saturated Thickness: 19. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW11)

Initial Displacement: 1.05 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 19. ft

SOLUTION

Aquifer Model: Confined
K = 10.88 ft/day
Solution Method:
y0 = 1.05 ft



SLUG TEST ANALYSIS FOR MW11 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW11
Test Date: April. 14, 2015

AQUIFER DATA

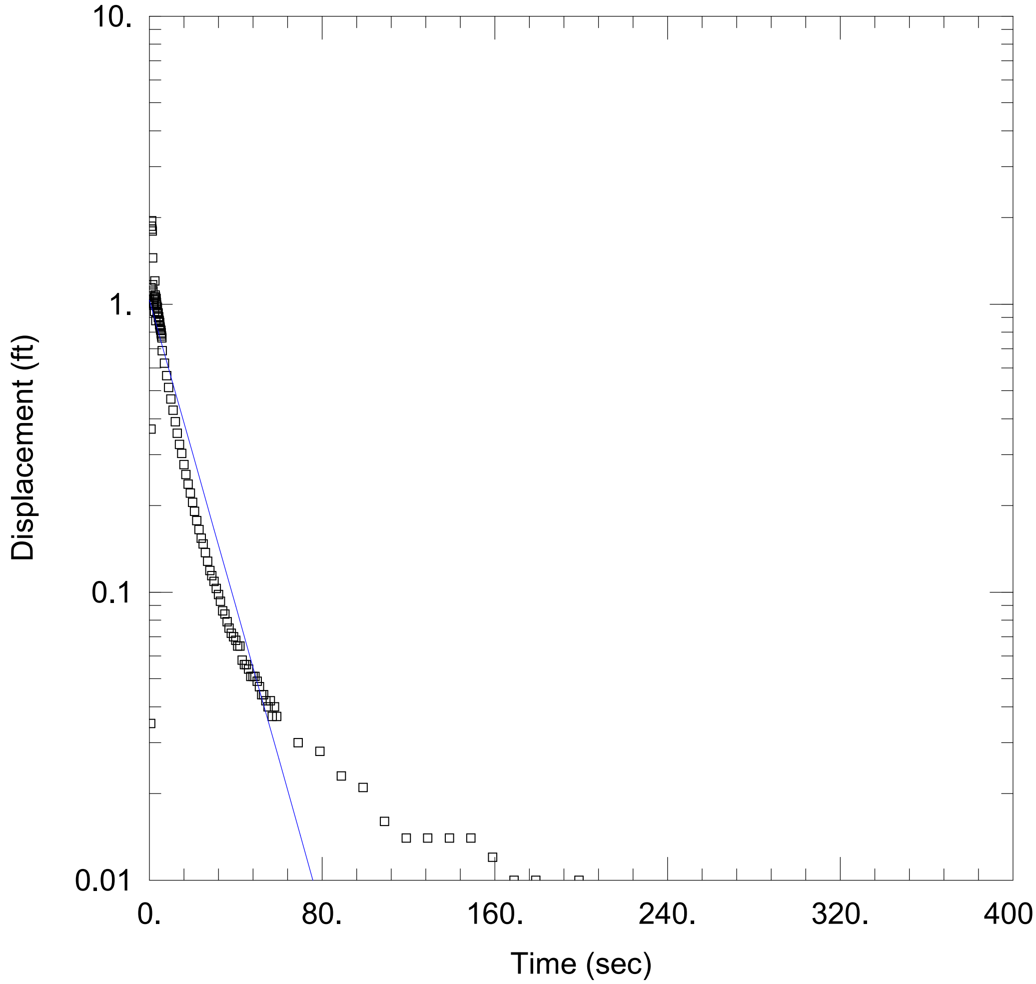
Saturated Thickness: 19. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW11)

Initial Displacement: 1.04 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 19. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 9.539 ft/day
y0 = 1.033 ft



SLUG TEST ANALYSIS FOR MW11 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW11
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 19. ft
Anisotropy Ratio (Kz/Kr): 0.1

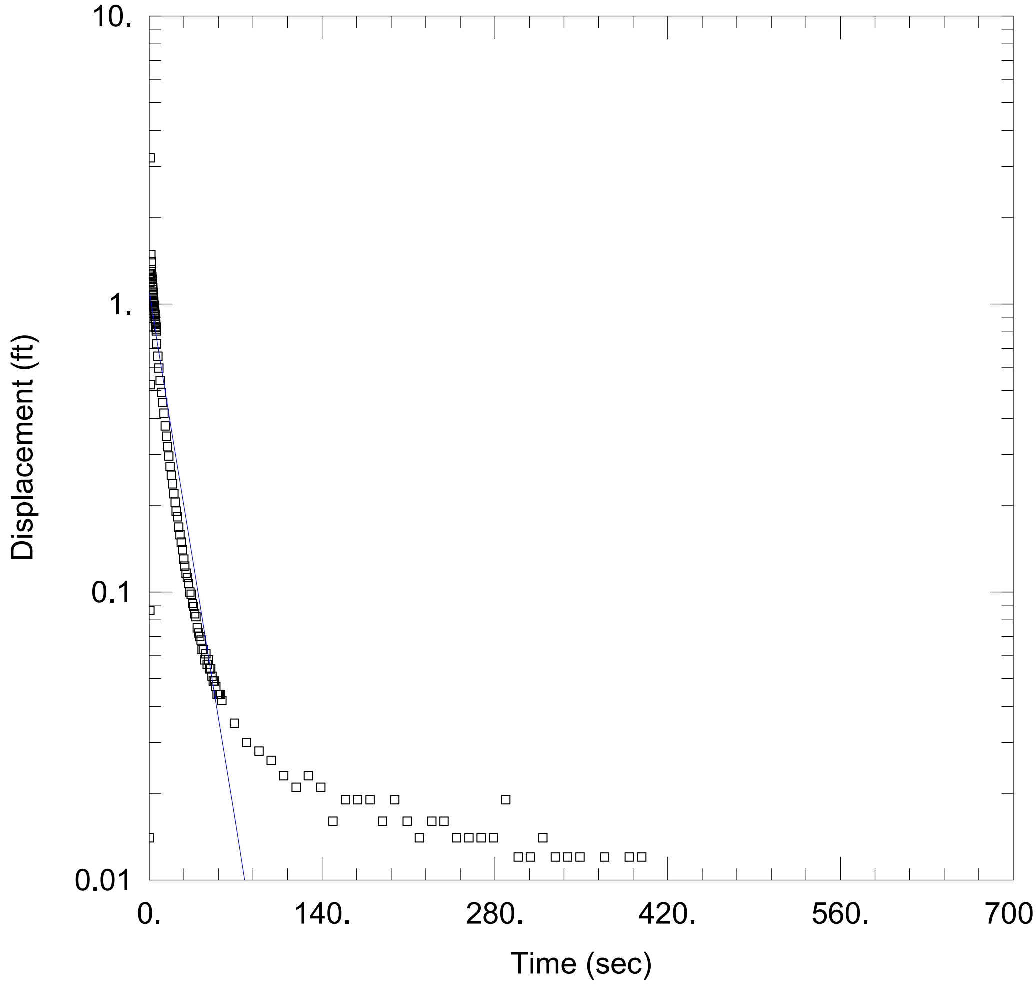
WELL DATA (MW11)

Initial Displacement: 1.04 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 19. ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 10.9 ft/day
y0 = 1.033 ft



SLUG TEST ANALYSIS FOR MW11 SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW11
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 19. ft
Anisotropy Ratio (Kz/Kr): 0.1

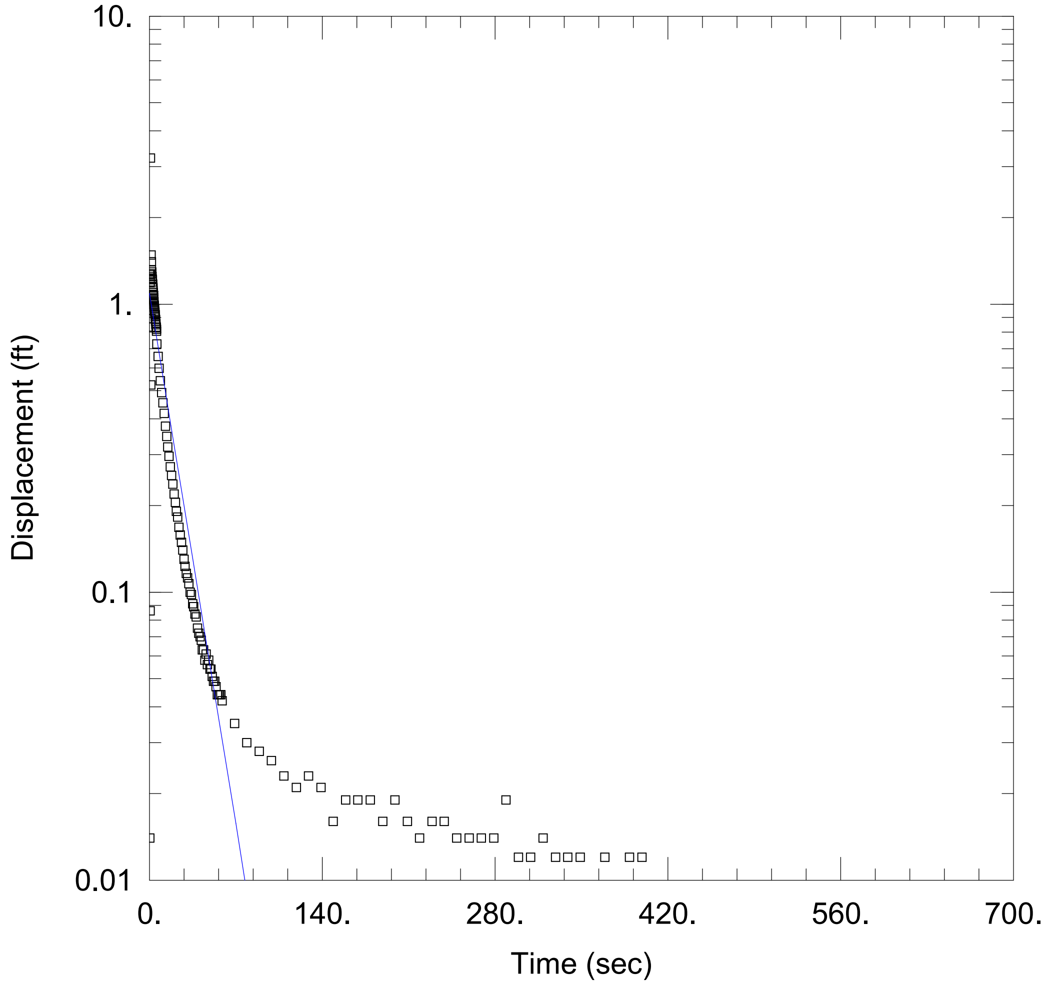
WELL DATA (MW11)

Initial Displacement: 1.27 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 19. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 9.44 ft/day
y0 = 1.091 ft



SLUG TEST ANALYSIS FOR MW11 SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW11
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 19. ft
Anisotropy Ratio (Kz/Kr): 0.1

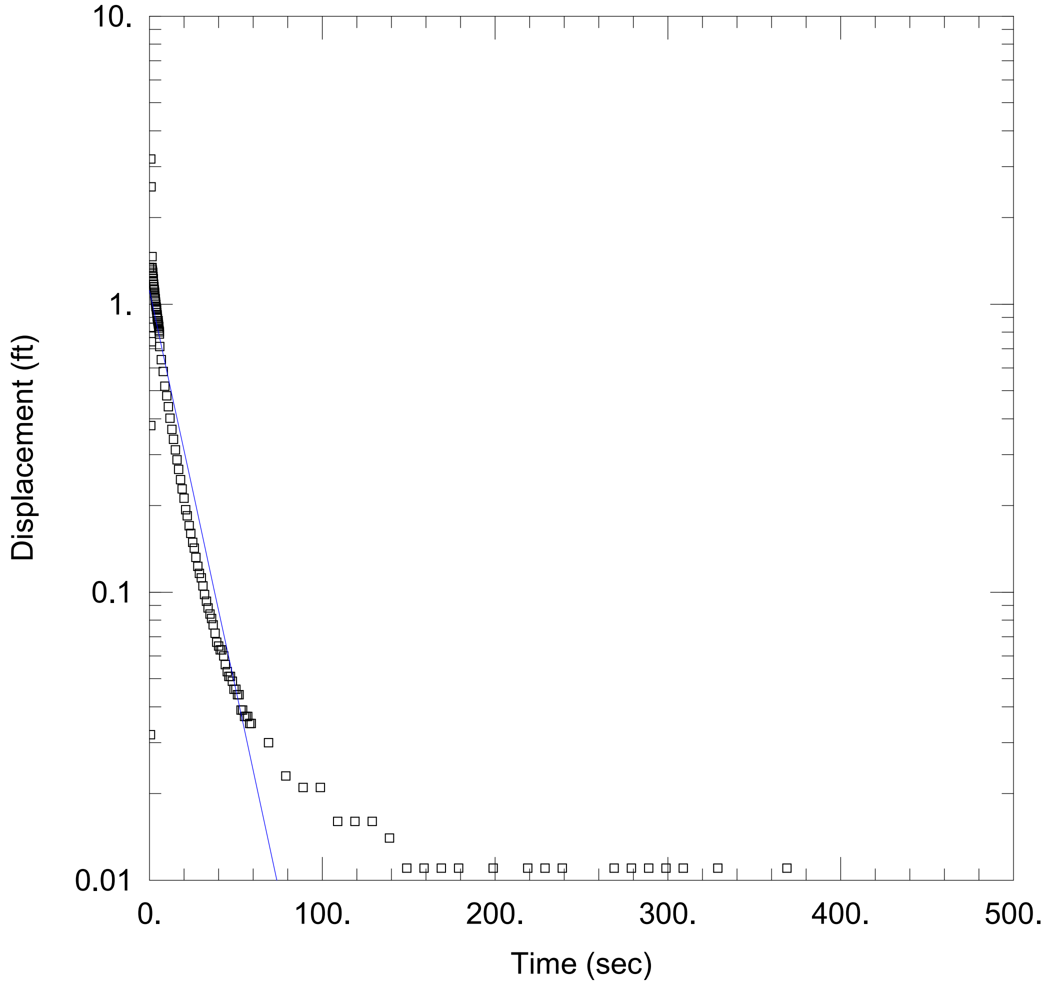
WELL DATA (MW11)

Initial Displacement: 1.27 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 19. ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 10.78 ft/day
y0 = 1.091 ft



SLUG TEST ANALYSIS FOR MW11 SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW11
Test Date: April. 14, 2015

AQUIFER DATA

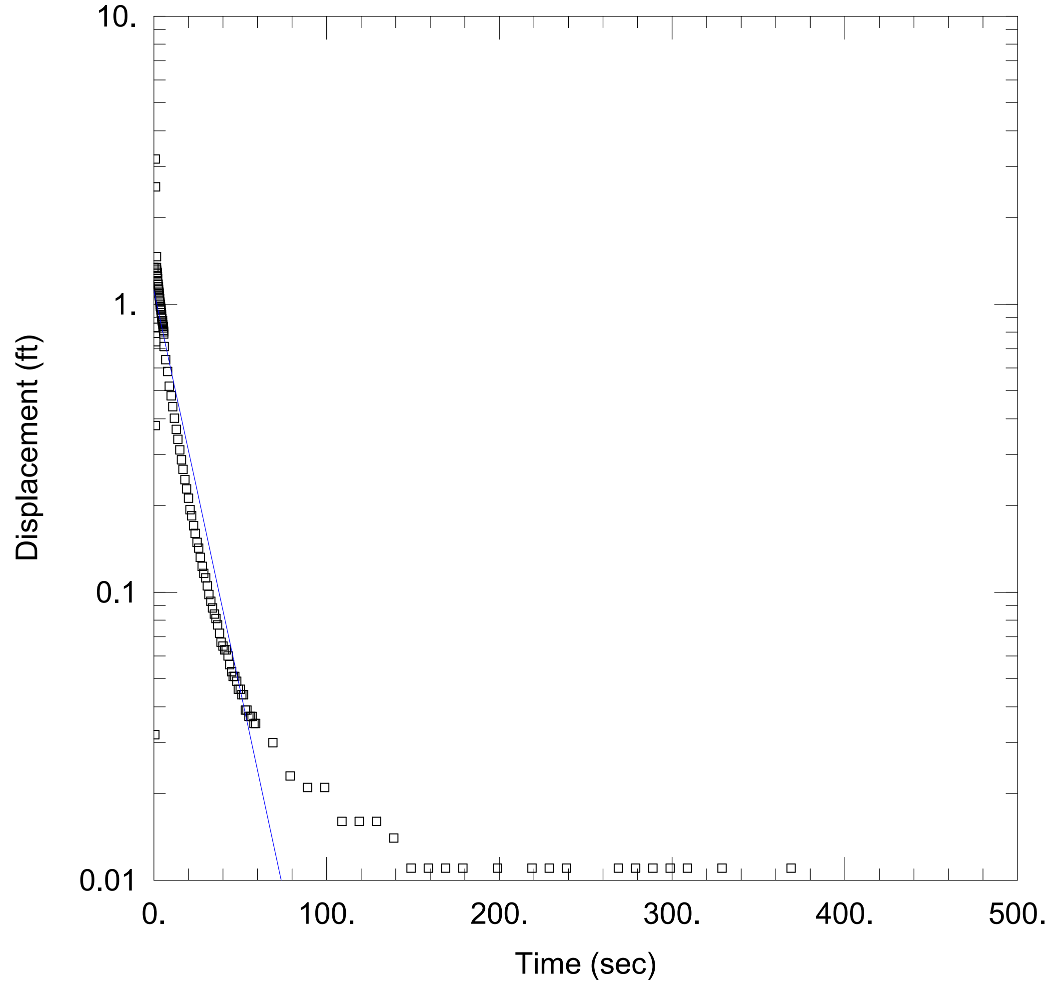
Saturated Thickness: 19. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW11)

Initial Displacement: 1.34 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 19. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 9.957 ft/day
y0 = 1.114 ft



SLUG TEST ANALYSIS FOR MW11 SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW11
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 19. ft
Anisotropy Ratio (Kz/Kr): 0.1

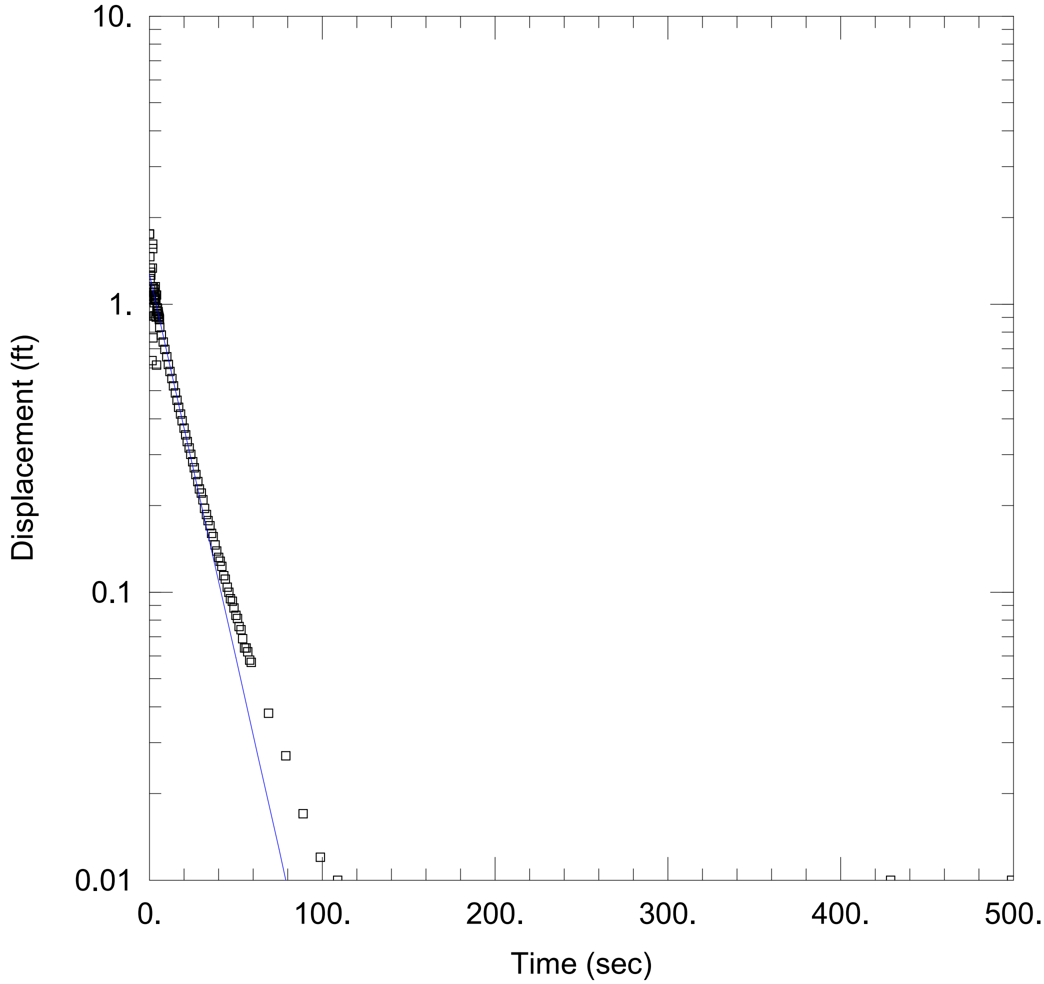
WELL DATA (MW11)

Initial Displacement: 1.34 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 19. ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 11.37 ft/day
y0 = 1.114 ft



SLUG TEST ANALYSIS FOR MW12 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW12
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 0.1

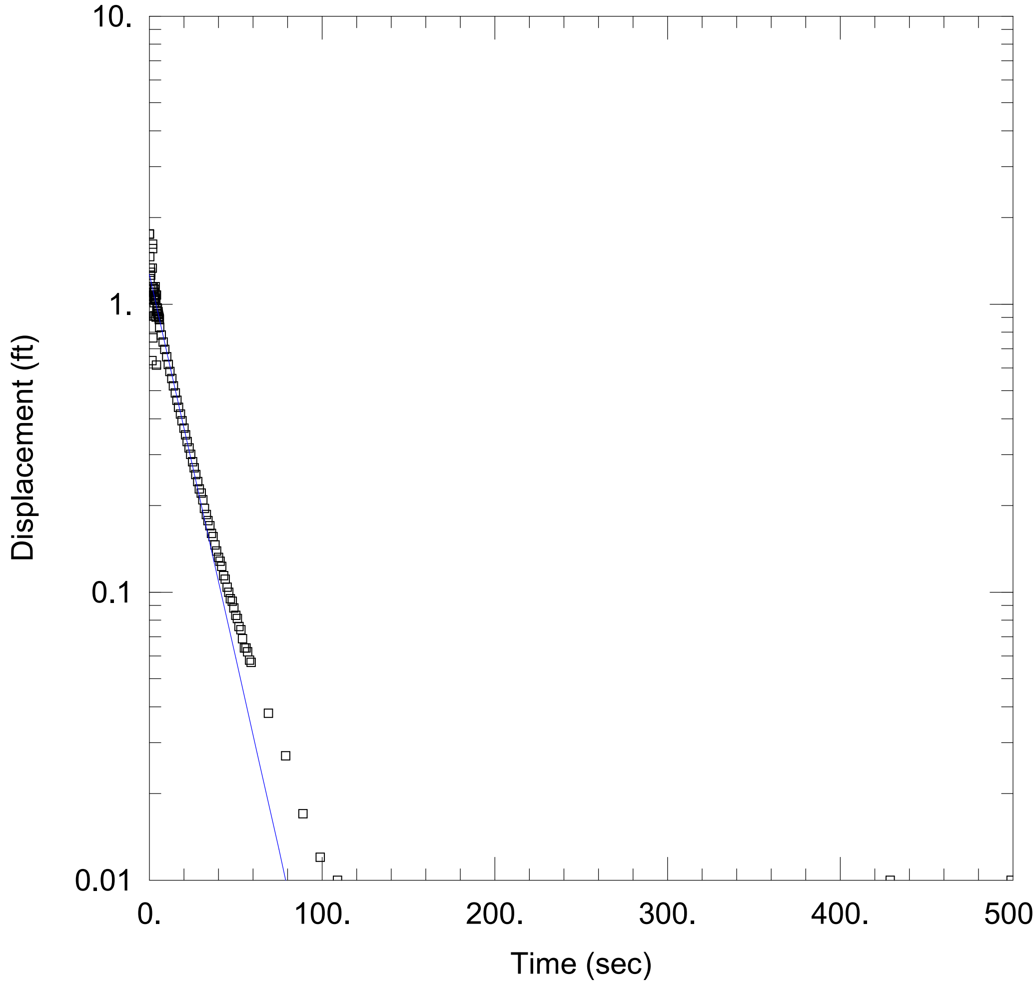
WELL DATA (MW12)

Initial Displacement: 1.75 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 15. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 9.256 ft/day
y0 = 1.268 ft



SLUG TEST ANALYSIS FOR MW12 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW12
Test Date: April. 14, 2015

AQUIFER DATA

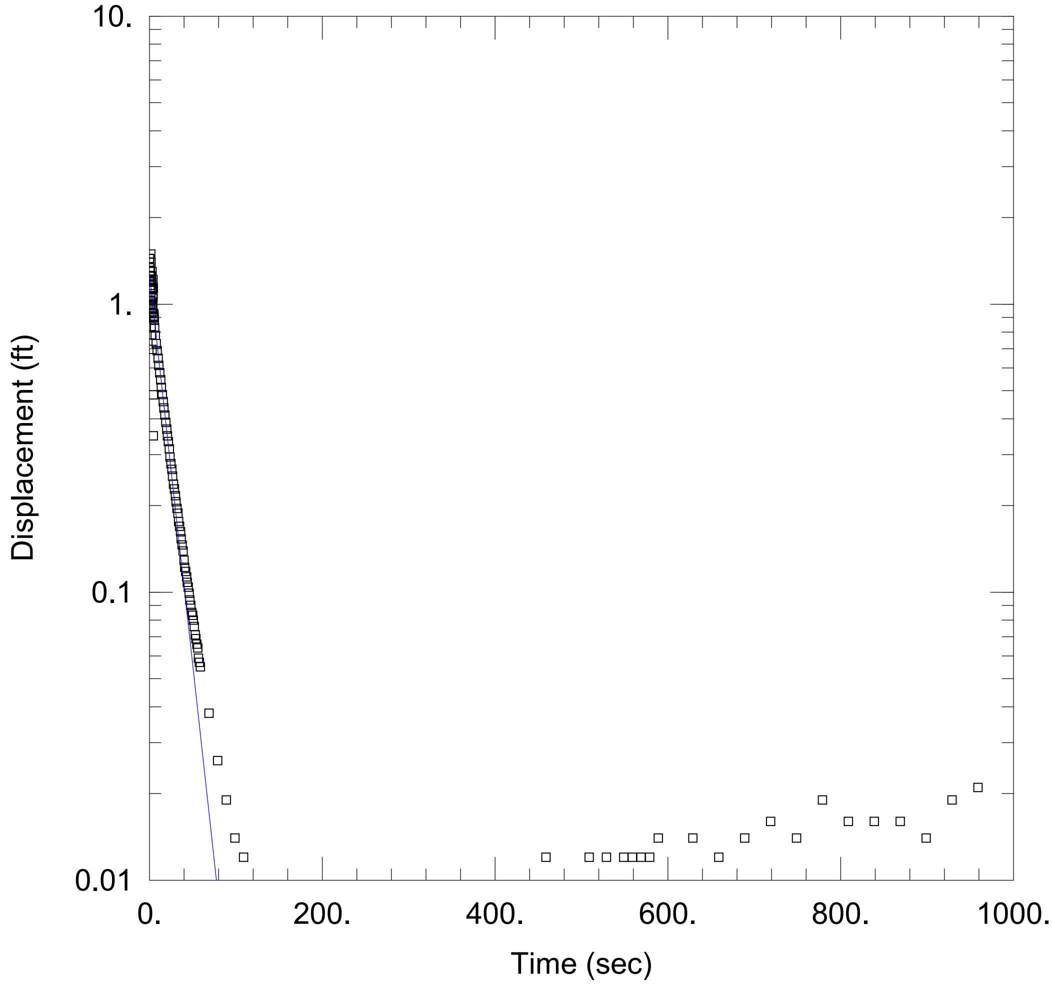
Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW12)

Initial Displacement: 1.75 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 15. ft

SOLUTION

Aquifer Model: Confined
K = 10.92 ft/day
Solution Method:
y0 = 1.268 ft



SLUG TEST ANALYSIS FOR MW12 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW12
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 0.1

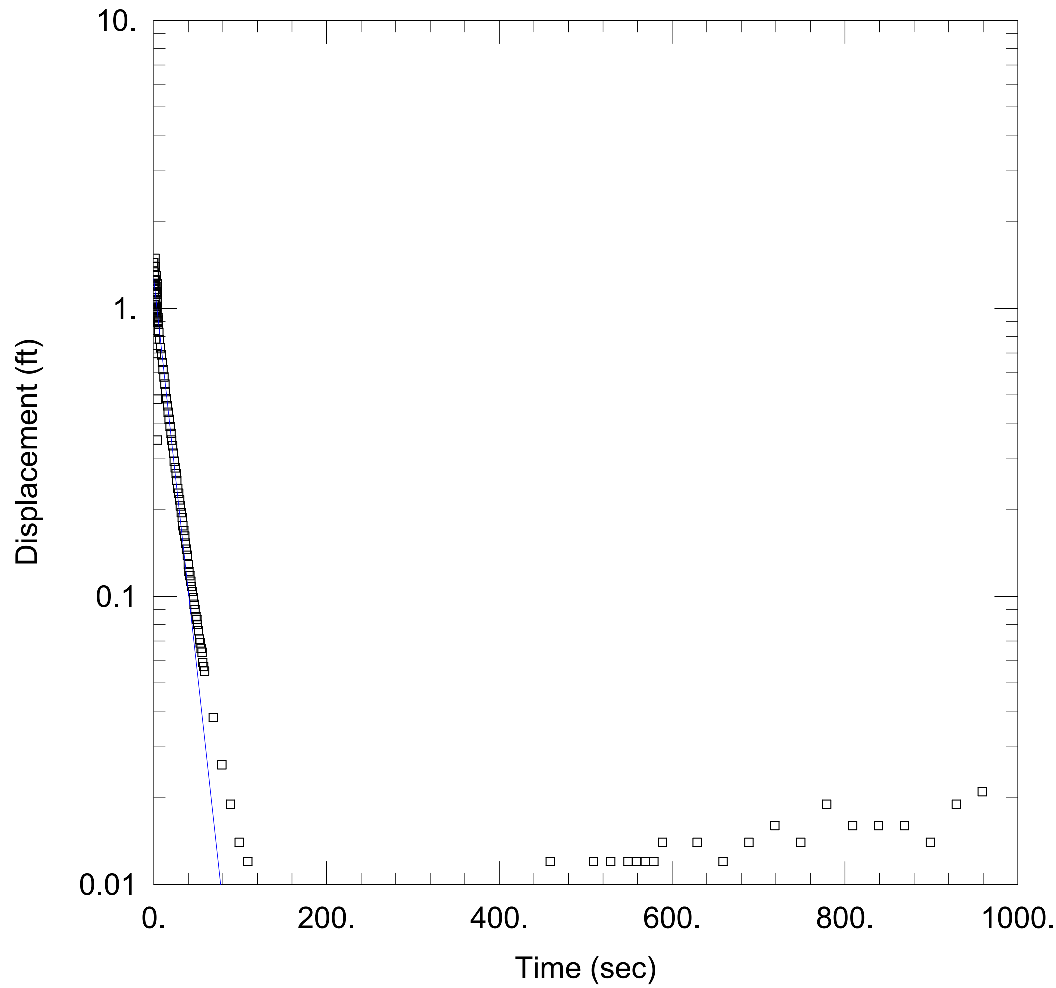
WELL DATA (MW12)

Initial Displacement: 1.44 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 15. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 9.416 ft/day
y0 = 1.266 ft



SLUG TEST ANALYSIS FOR MW12 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW12
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 0.1

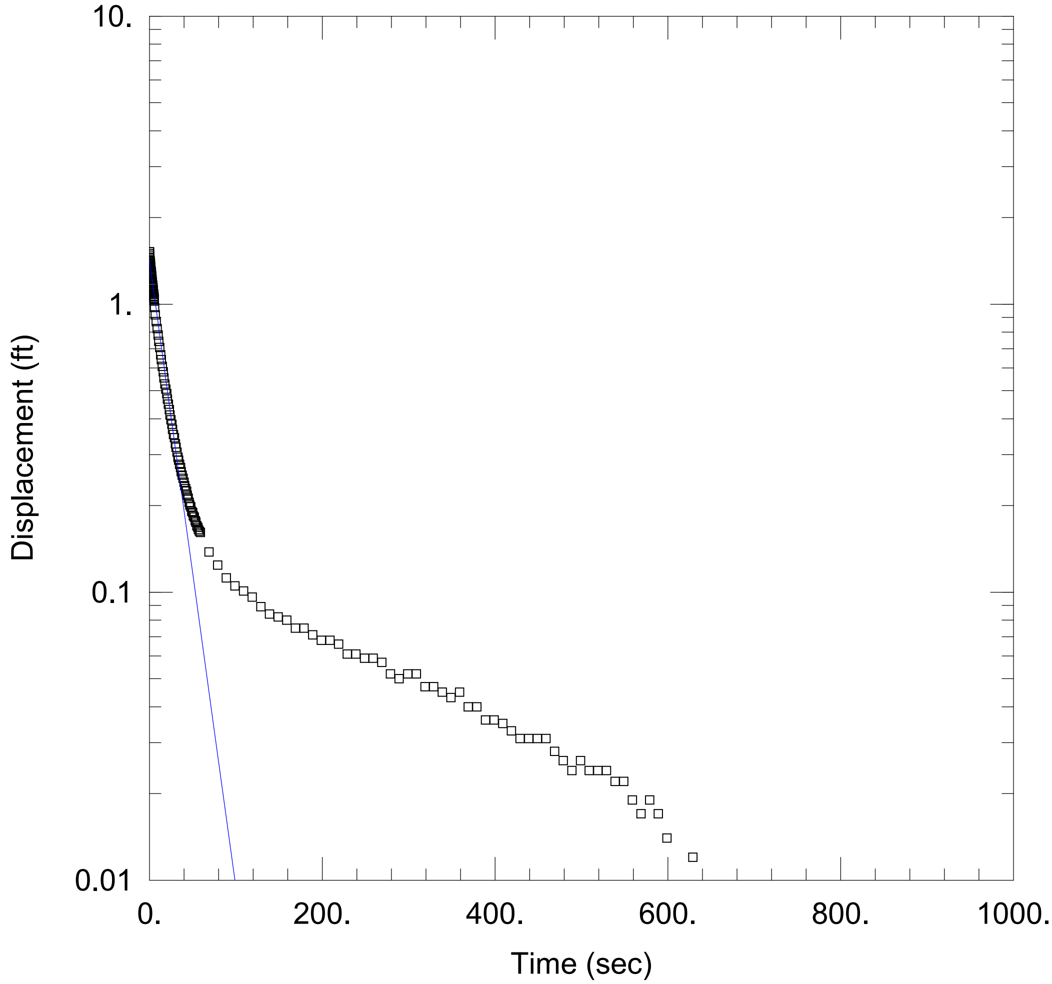
WELL DATA (MW12)

Initial Displacement: 1.44 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 15. ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 11.11 ft/day
y0 = 1.266 ft



SLUG TEST ANALYSIS FOR MW12 SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW12
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 0.1

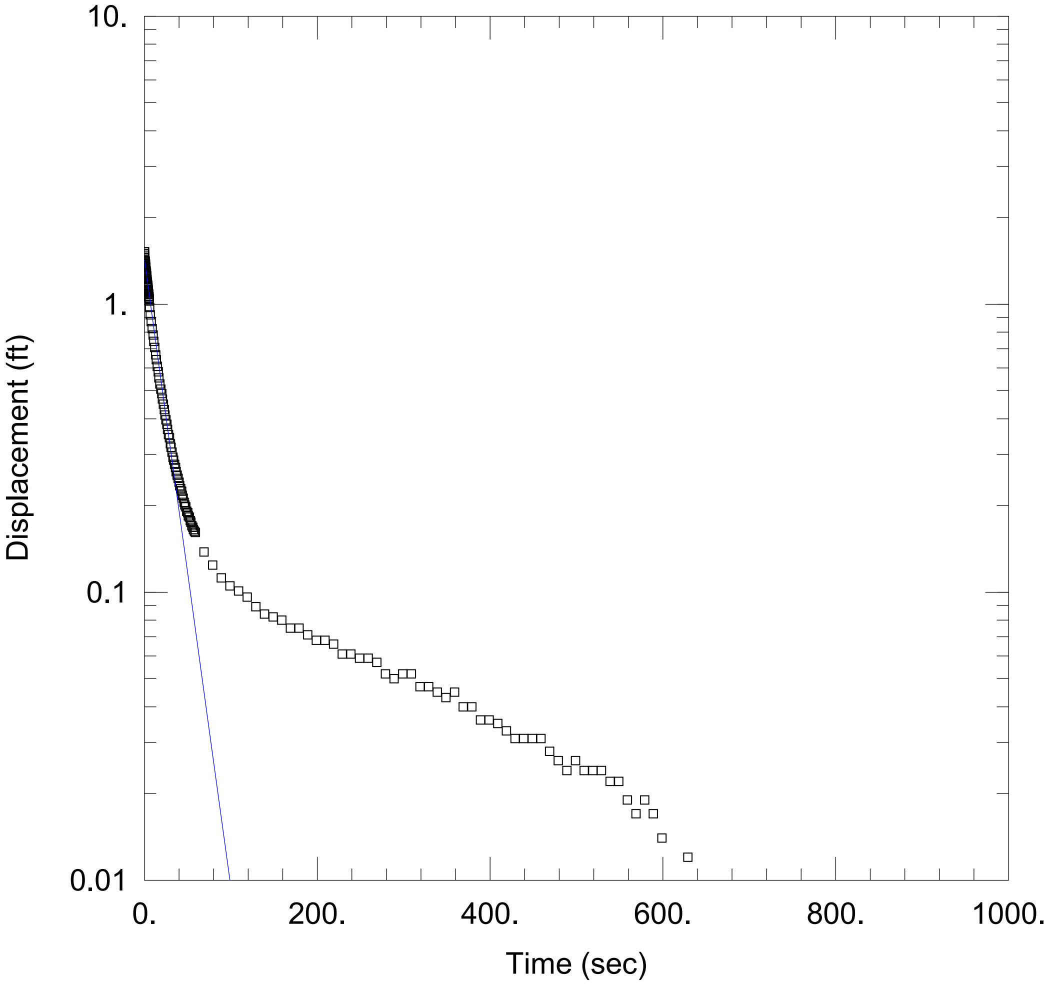
WELL DATA (MW12)

Initial Displacement: 1.52 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 15. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 7.557 ft/day
y0 = 1.42 ft



SLUG TEST ANALYSIS FOR MW12 SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW12
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 15. ft

Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW12)

Initial Displacement: 1.52 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3

Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 15. ft

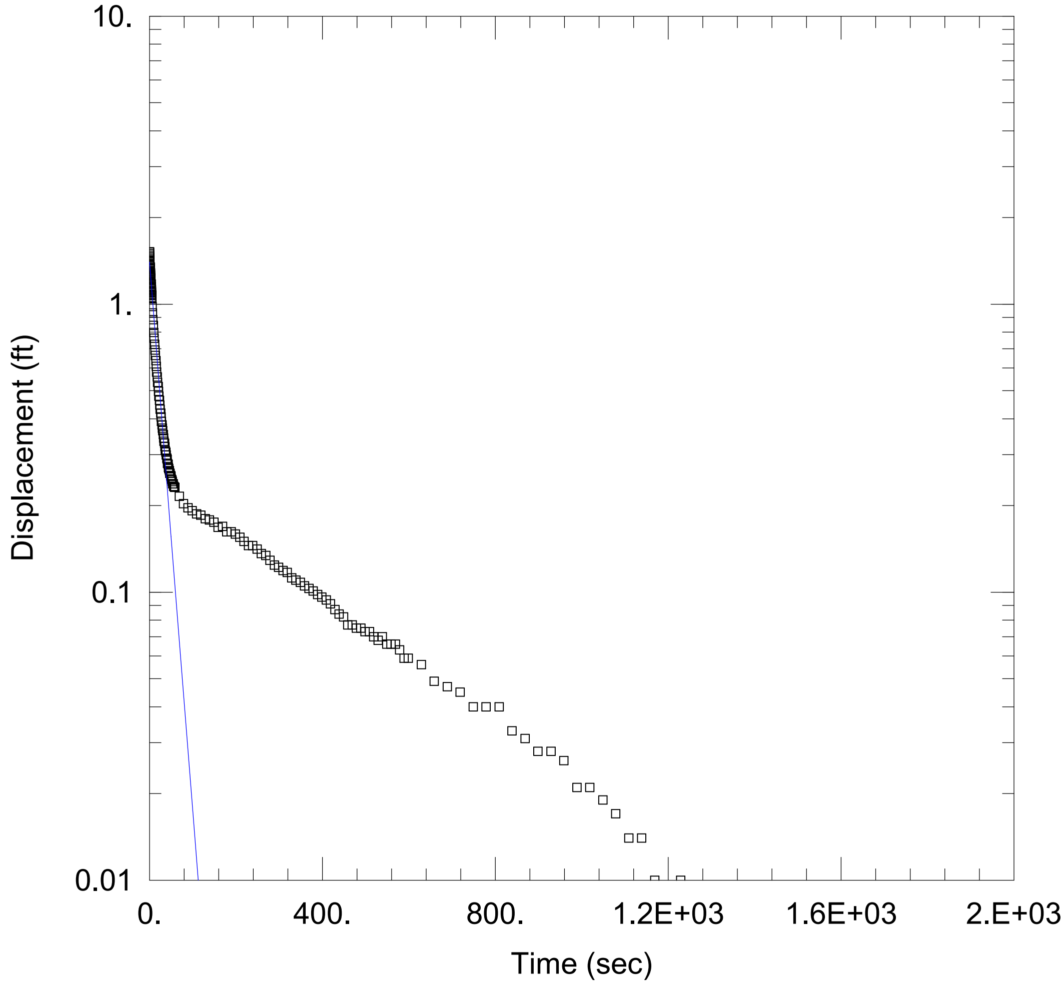
SOLUTION

Aquifer Model: Confined

Solution Method:

K = 8.912 ft/day

y0 = 1.42 ft



SLUG TEST ANALYSIS FOR MW12 SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW12
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 0.1

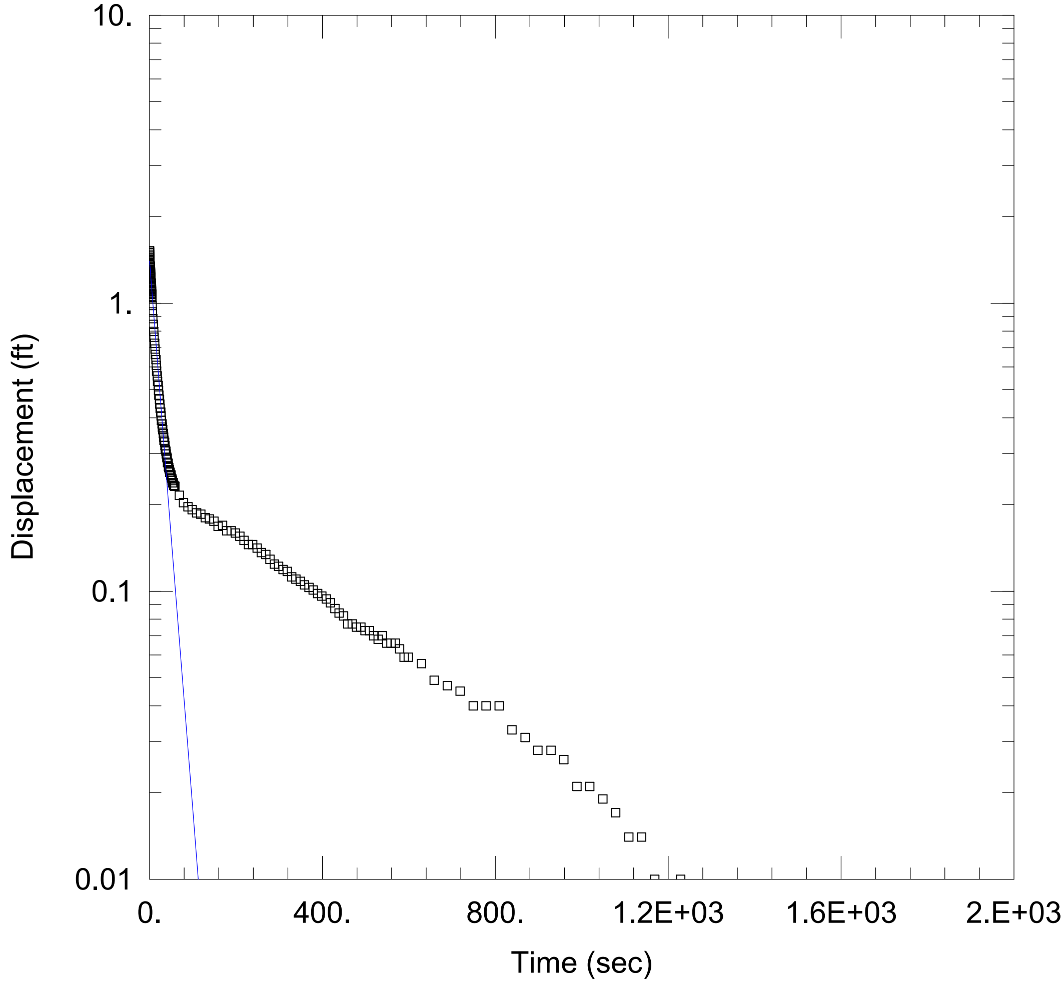
WELL DATA (MW12)

Initial Displacement: 1.52 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 15. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 6.63 ft/day
y0 = 1.4 ft



SLUG TEST ANALYSIS FOR MW12 SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW12
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 0.1

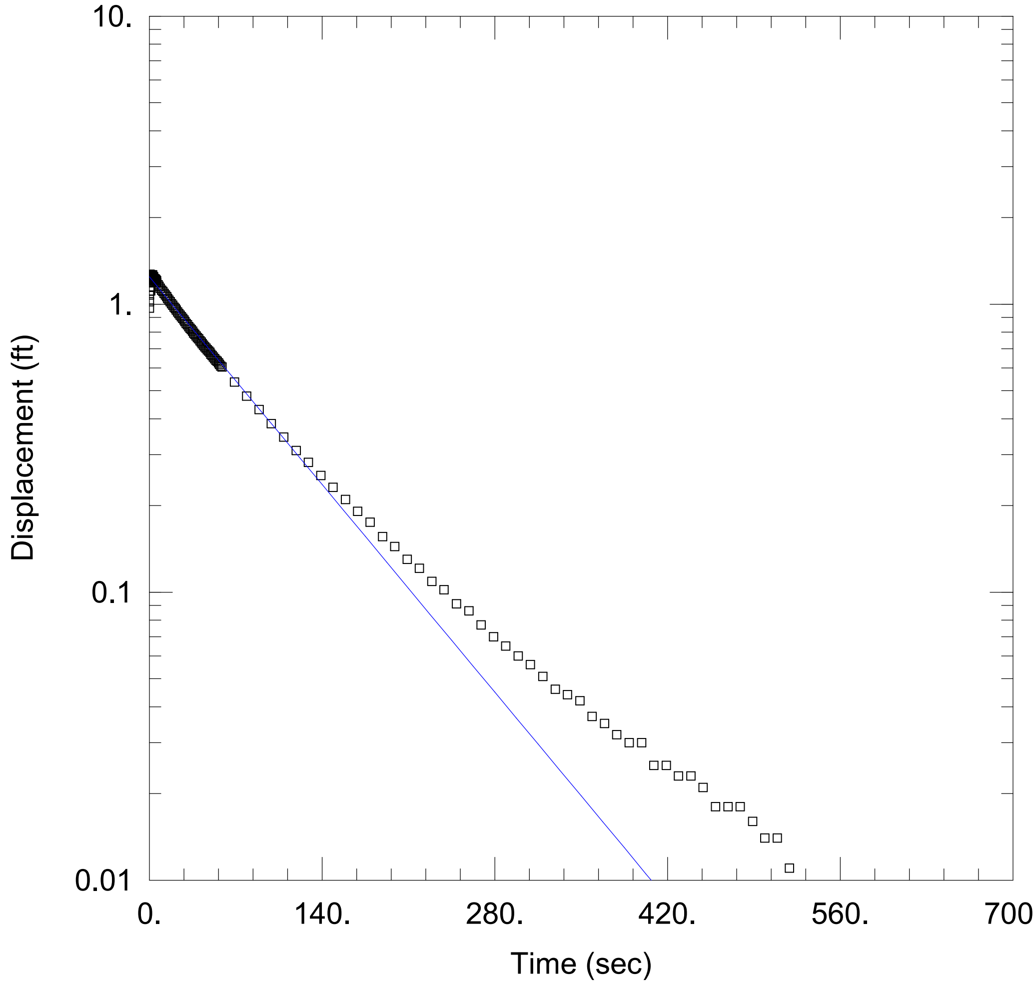
WELL DATA (MW12)

Initial Displacement: 1.52 ft
Wellbore Radius: 0.08333 ft
Screen Length: 10. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 15. ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 7.809 ft/day
y0 = 1.4 ft



SLUG TEST ANALYSIS FOR MW13 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW13
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 4.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

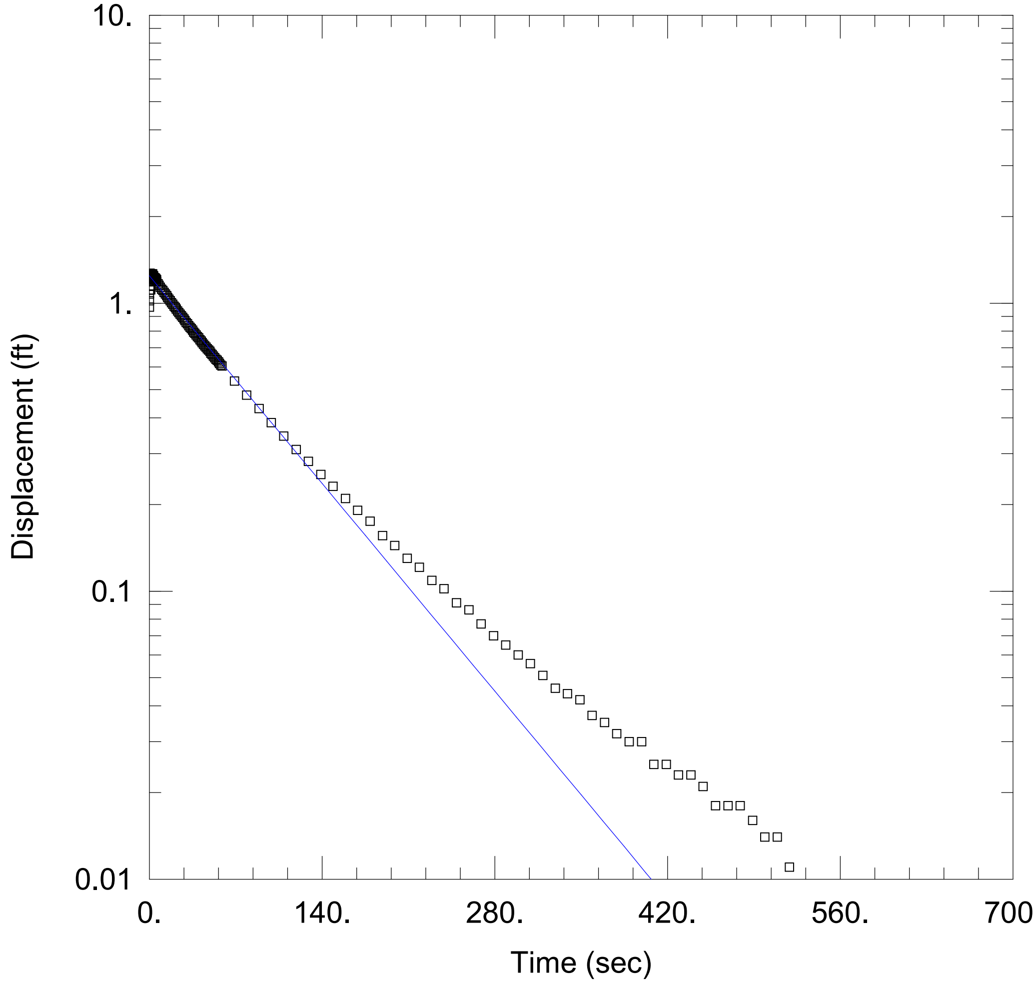
WELL DATA (MW13)

Initial Displacement: 1.24 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 4.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.185 ft/day
y0 = 1.243 ft



SLUG TEST ANALYSIS FOR MW13 SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW13
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 4.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

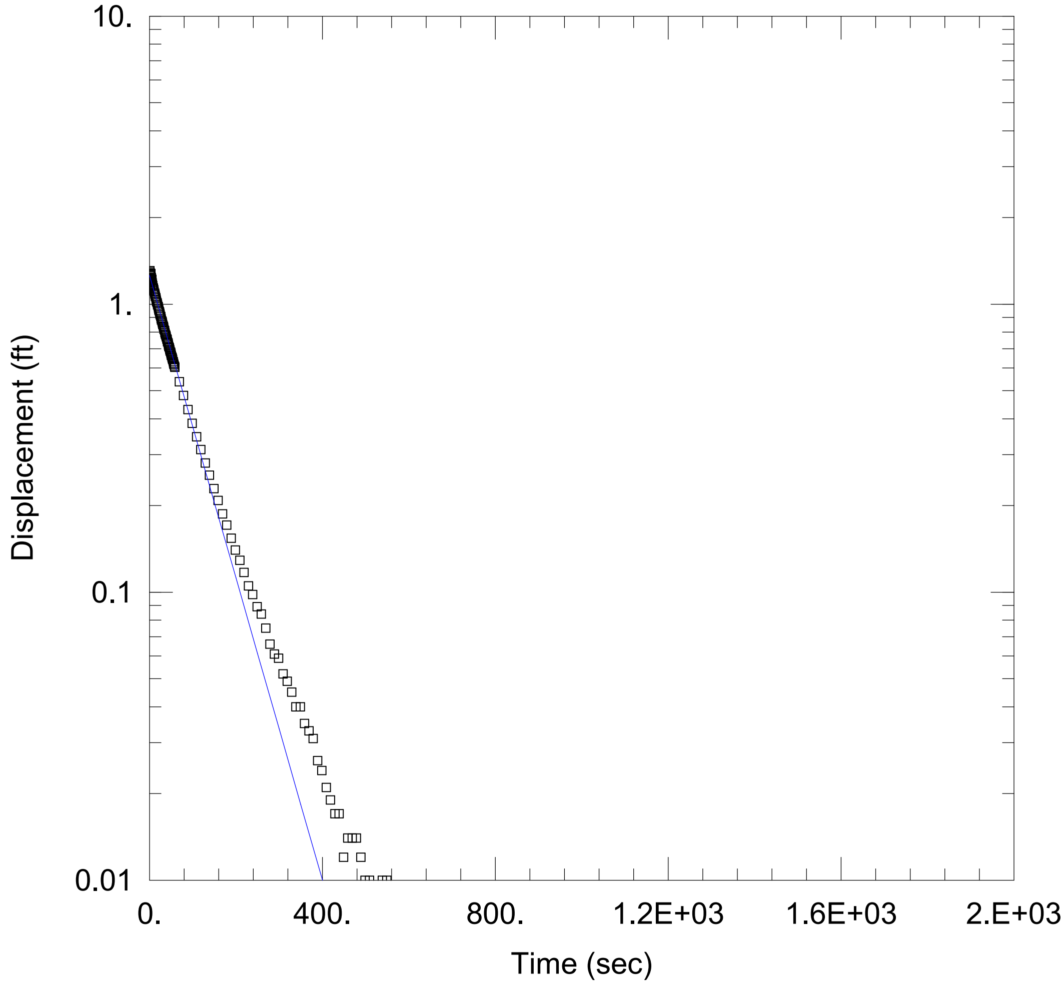
WELL DATA (MW13)

Initial Displacement: 1.24 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 4.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 2.913 ft/day
y0 = 1.243 ft



SLUG TEST ANALYSIS FOR MW13 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW13
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 4.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

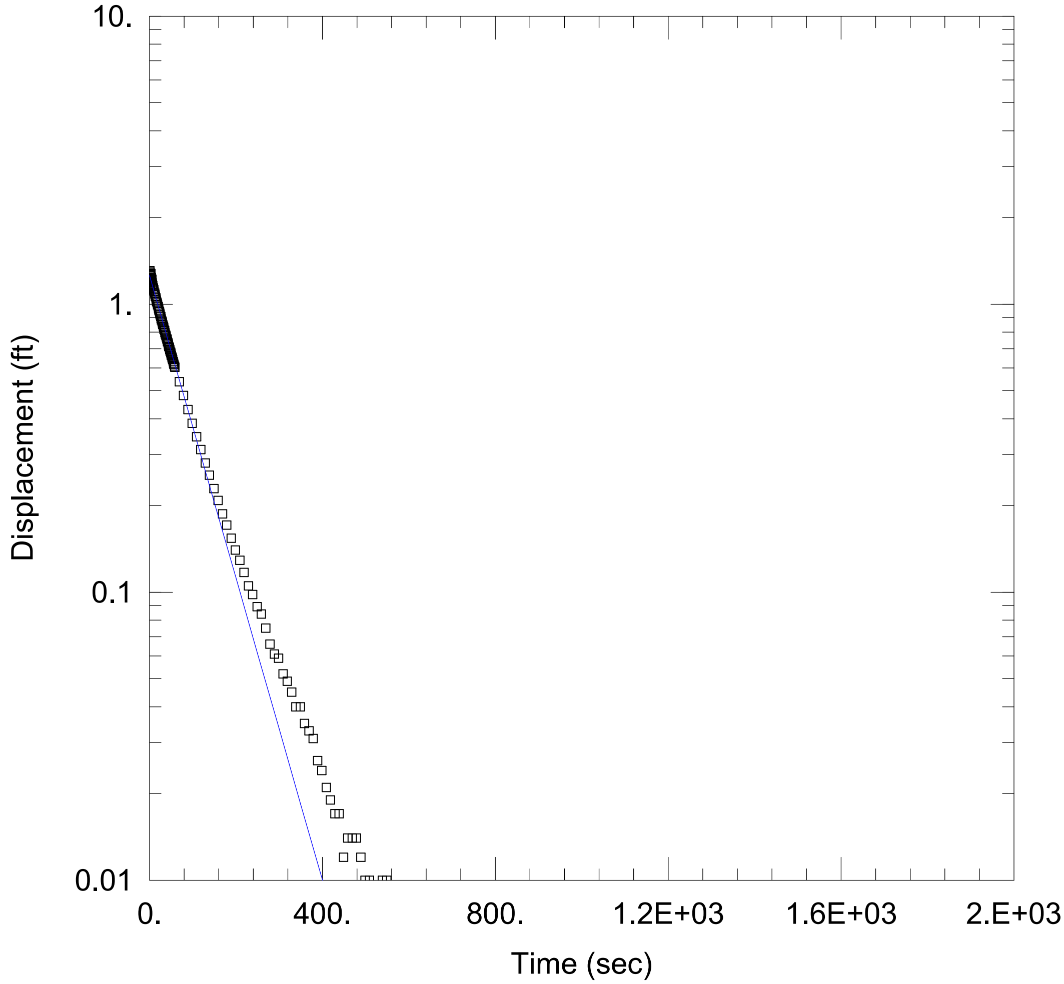
WELL DATA (MW13)

Initial Displacement: 1.185 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 4.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.226 ft/day
y0 = 1.256 ft



SLUG TEST ANALYSIS FOR MW13 SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW13
Test Date: April. 14, 2015

AQUIFER DATA

Saturated Thickness: 4.5 ft
Anisotropy Ratio (Kz/Kr): 0.1

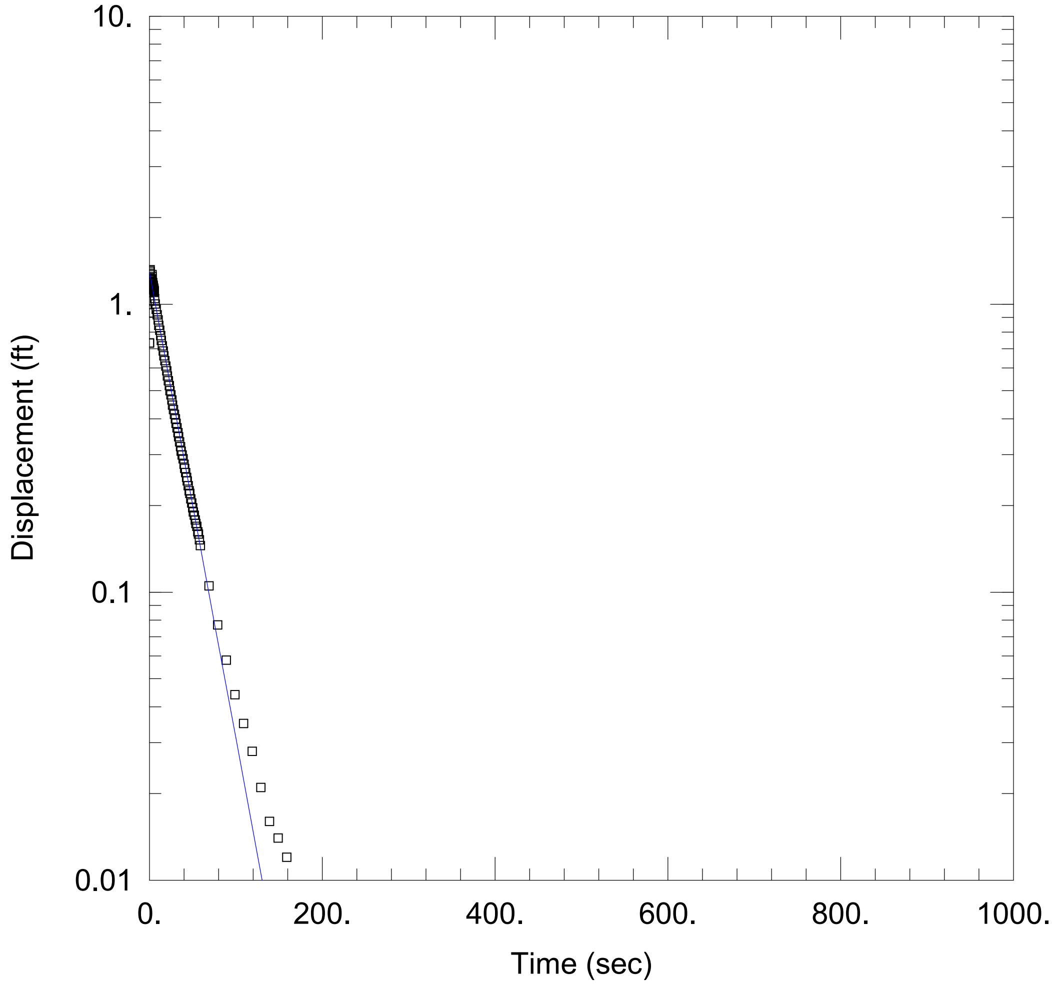
WELL DATA (MW13)

Initial Displacement: 1.185 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 4.5 ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 2.968 ft/day
y0 = 1.256 ft



SLUG TEST ANALYSIS FOR MW07M SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylva Grove
Test Well: MW07M
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 1.

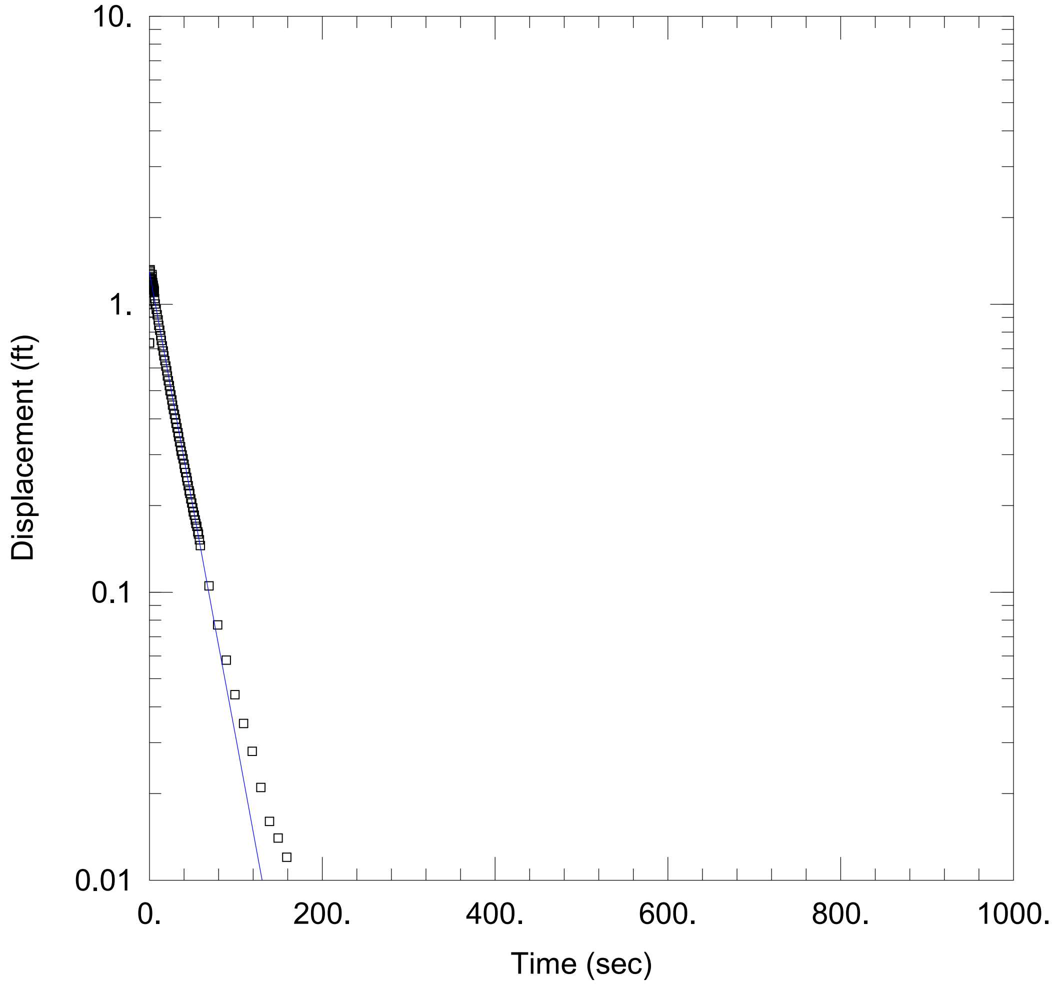
WELL DATA (MW07M)

Initial Displacement: 0.733 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 7.493 ft/day
y0 = 1.289 ft



SLUG TEST ANALYSIS FOR MW07M SLUG_IN_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW07M
Test Date: April 14 2015

AQUIFER DATA

Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 1.

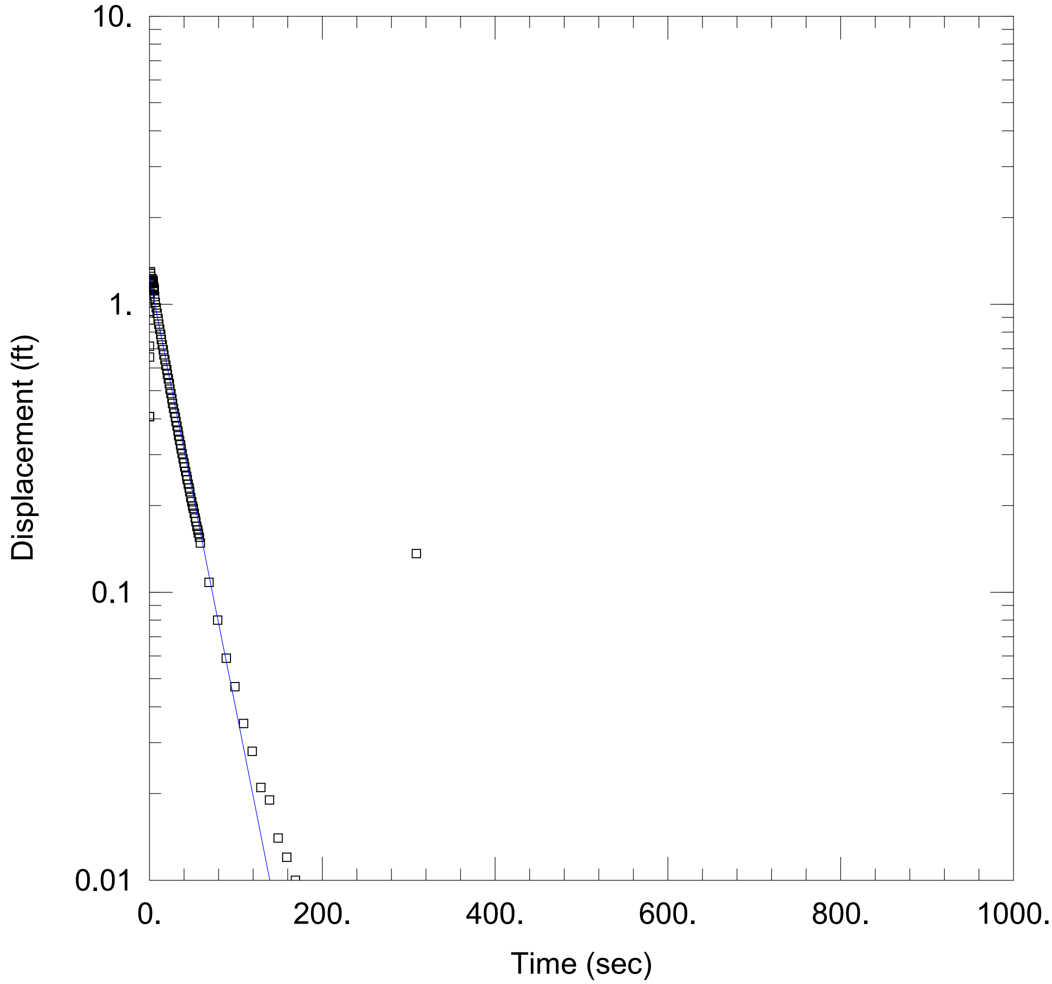
WELL DATA (MW07M)

Initial Displacement: 0.733 ft
Casing Radius: 0.08333 ft
Wellbore Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Screen Length: 5. ft
Total Well Penetration Depth: 7. ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 9.146 ft/day
y0 = 1.289 ft



SLUG TEST ANALYSIS FOR MW07M SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW07M
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 0.1

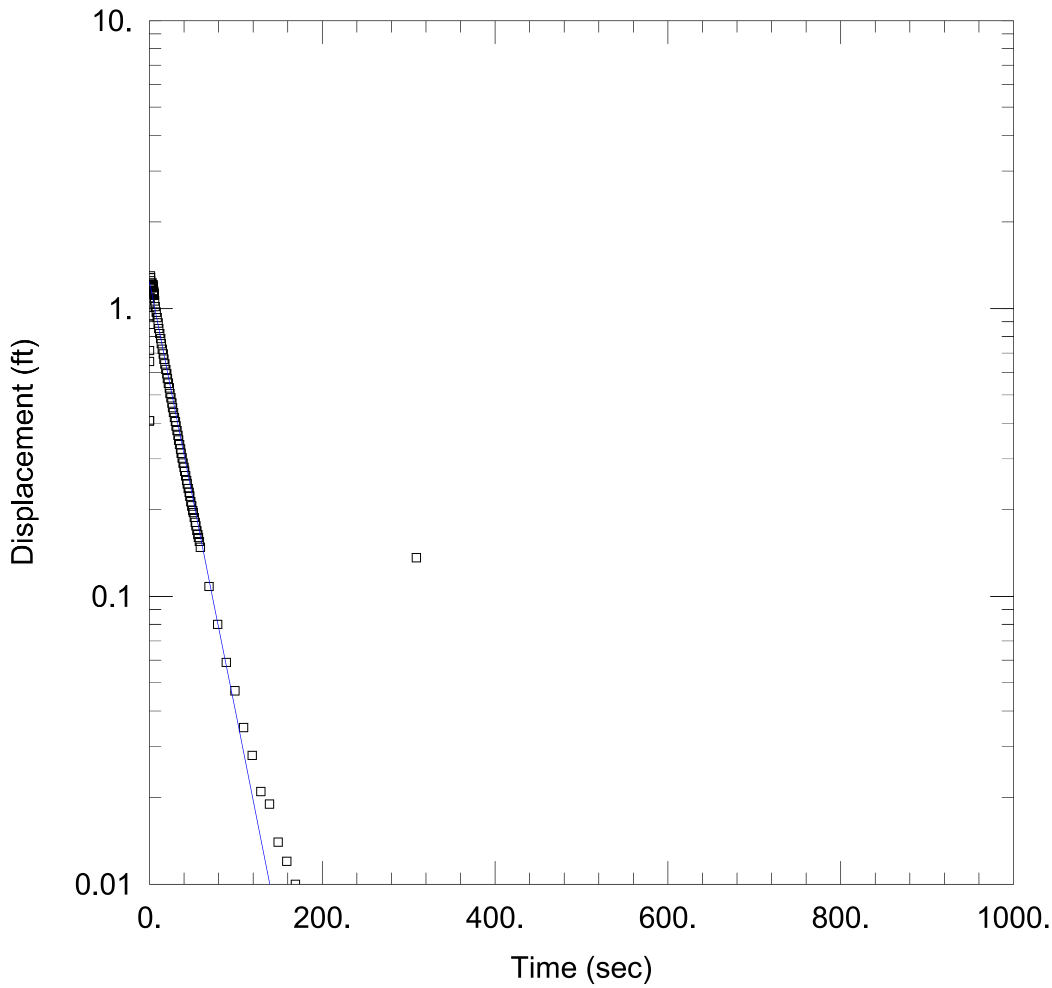
WELL DATA (MW07M)

Initial Displacement: 0.407 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 8.918 ft/day
y0 = 1.239 ft



SLUG TEST ANALYSIS FOR MW07M SLUG_IN_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW07M
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 0.1

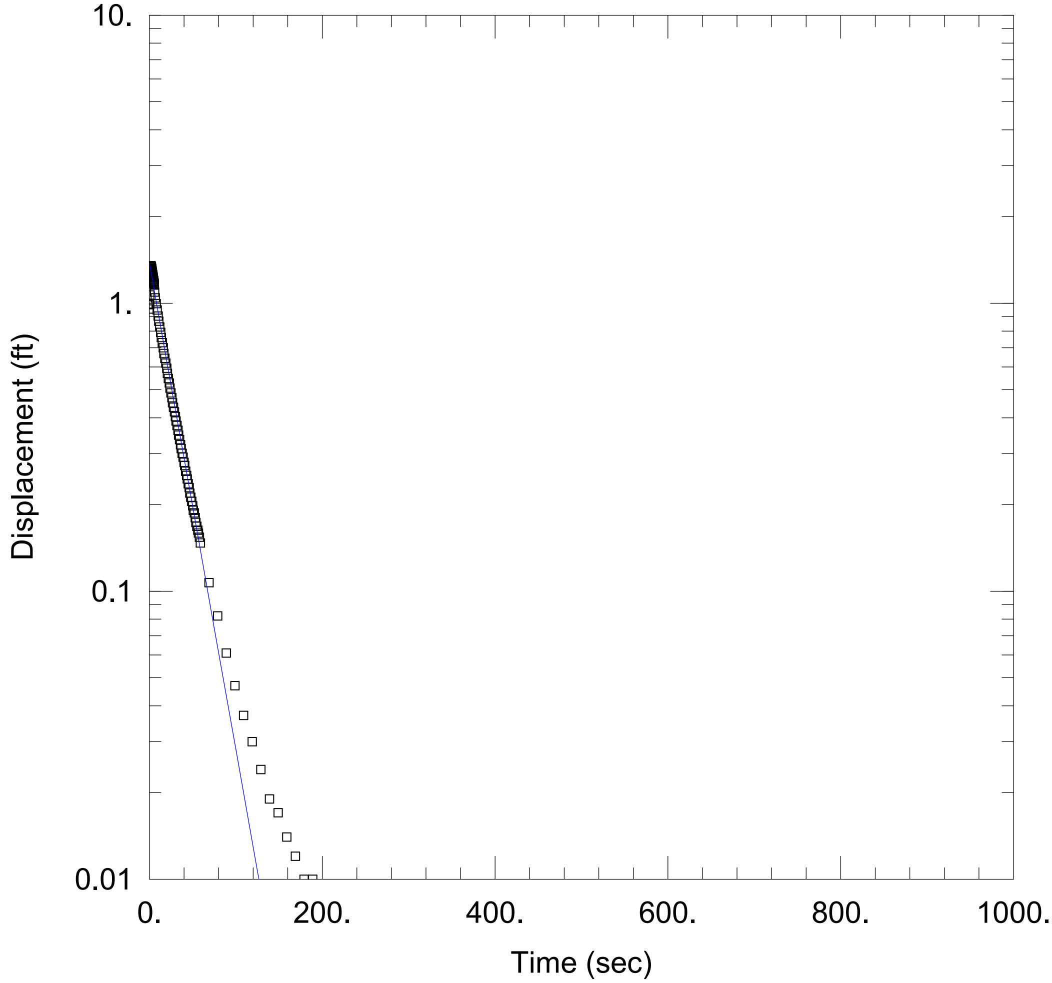
WELL DATA (MW07M)

Initial Displacement: 0.407 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7. ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 10.87 ft/day
y0 = 1.239 ft



SLUG TEST ANALYSIS FOR MW07M SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW07M
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 0.1

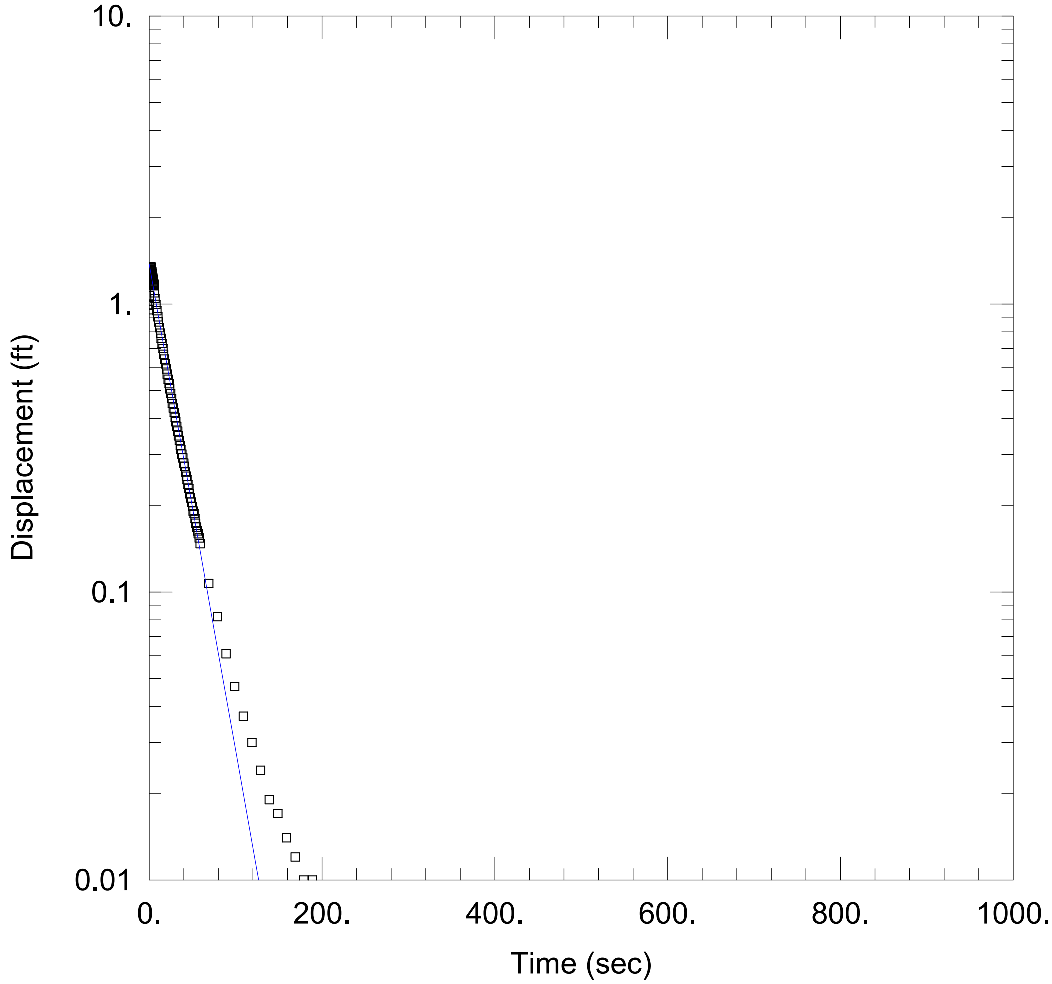
WELL DATA (MW07M)

Initial Displacement: 0.989 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 10.03 ft/day
y0 = 1.371 ft



SLUG TEST ANALYSIS FOR MW07M SLUG_OUT_1

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW07M
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 0.1

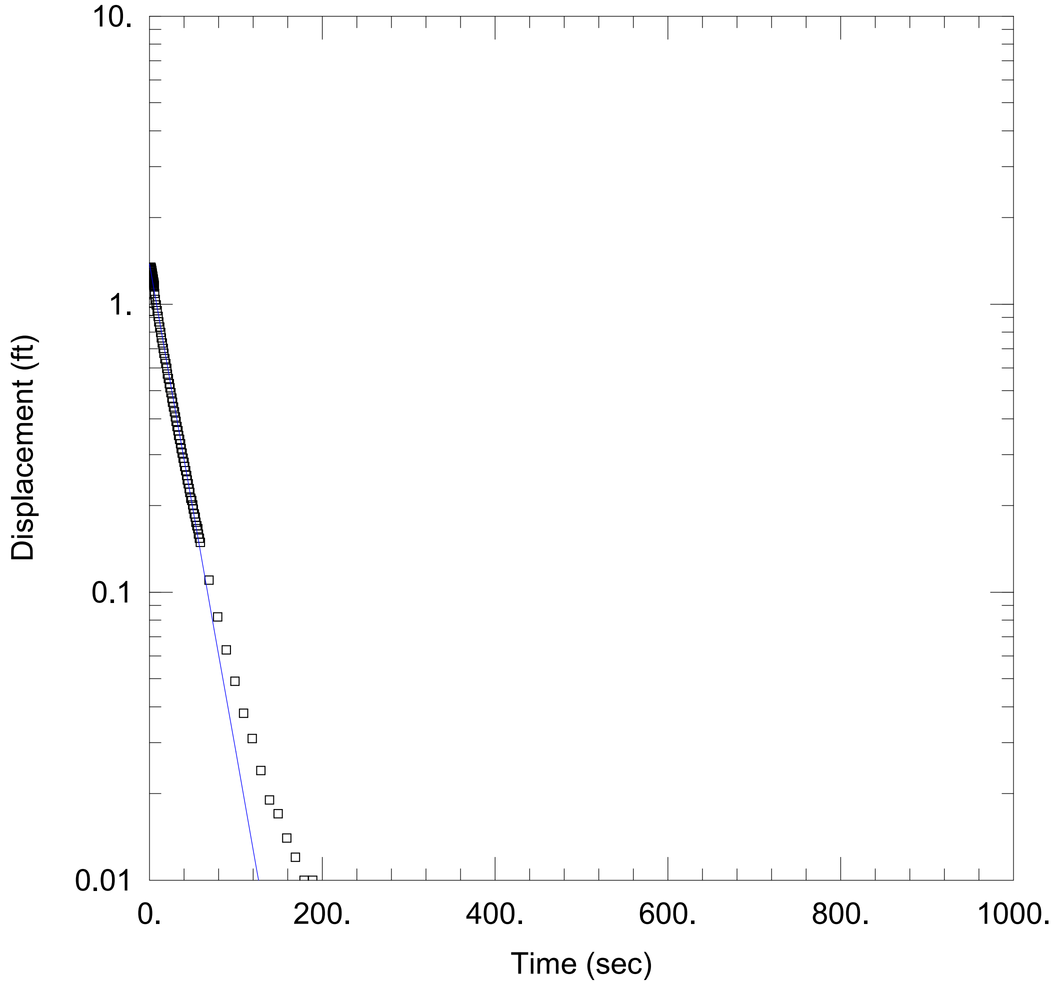
WELL DATA (MW07M)

Initial Displacement: 0.989 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7. ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 12.22 ft/day
y0 = 1.371 ft



SLUG TEST ANALYSIS FOR MW07M SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW07M
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 0.1

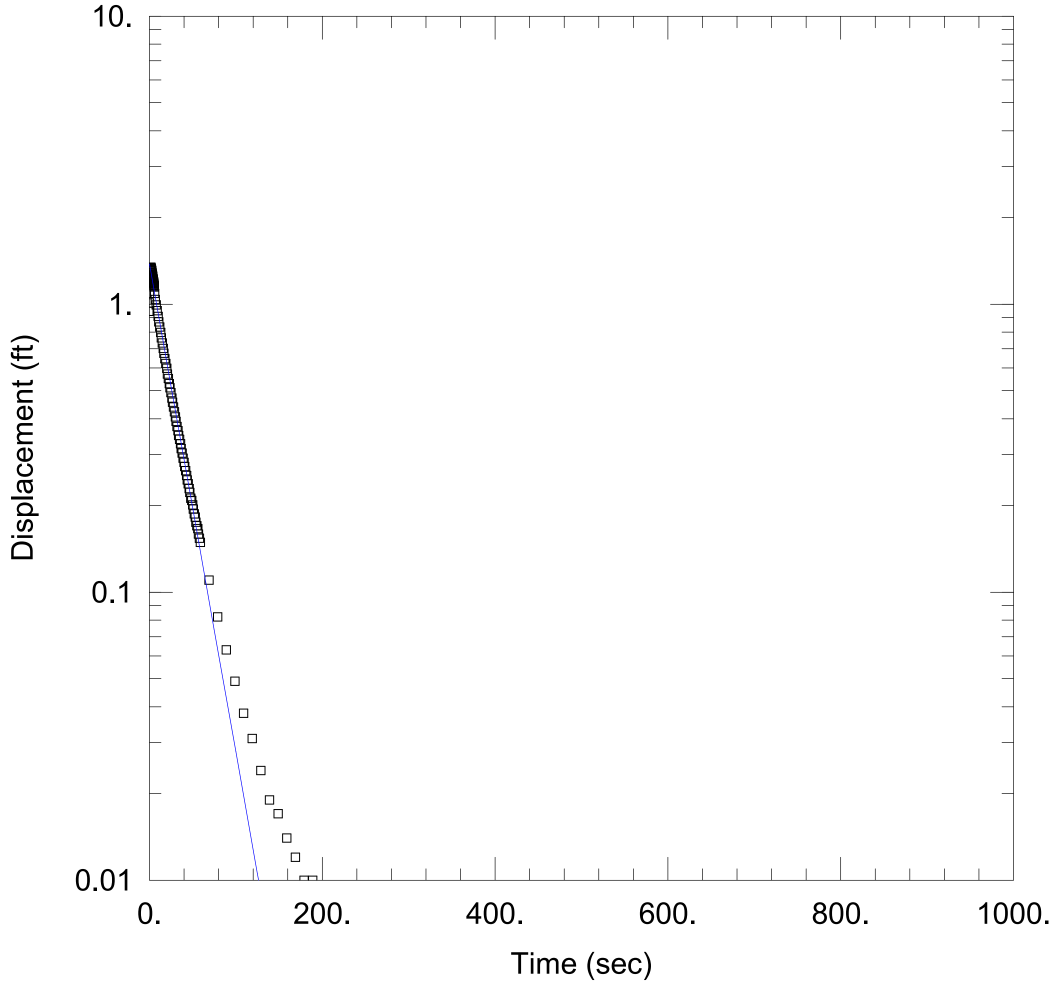
WELL DATA (MW07M)

Initial Displacement: 0.944 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 10.07 ft/day
y0 = 1.377 ft



SLUG TEST ANALYSIS FOR MW07M SLUG_OUT_2

PROJECT INFORMATION

Company: Argonne
Test Location: Sylvan Grove
Test Well: MW07M
Test Date: April 14, 2015

AQUIFER DATA

Saturated Thickness: 7. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW07M)

Initial Displacement: 0.944 ft
Wellbore Radius: 0.08333 ft
Screen Length: 5. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08333 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 7. ft

SOLUTION

Aquifer Model: Confined
Solution Method:

K = 12.27 ft/day
y0 = 1.377 ft

AGEM Team at Argonne

AGEM Staff Member	AGEM Role
Lorraine M. LaFreniere, Ph.D. Principal Geological Engineer	Program Manager
Jorge S. Alvarado, Ph.D. Chemist	Laboratory Manager and Analyst
Esther E. Bowen, M.S. Data Management Specialist	Quality Assurance/Quality Control and Records Manager
Laurel A. Culbert, B.A. Graphic Artist/Designer	Report Graphics and Maps (including GIS)
James Hansen, B.A. Program Coordinator/Manager	Site Reconnaissance and Community Relations
Louis E. Martino, M.S. Environmental Systems Engineer/Program Manager	Technical Lead/Remediation Specialist (Cost Engineering)
Terri Patton, M.S. Principal Geologist	Technical Editor
Robert A. Sedivy, M.S. Hydrogeologist	Technical Lead/Hydrogeologist
Eugene Y. Yan, Ph.D. Earth Scientist	Technical Lead/Hydrogeologist

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