Groundwater Conditions in the Glasford Formation beneath the Healey Street Basin, Champaign, IL

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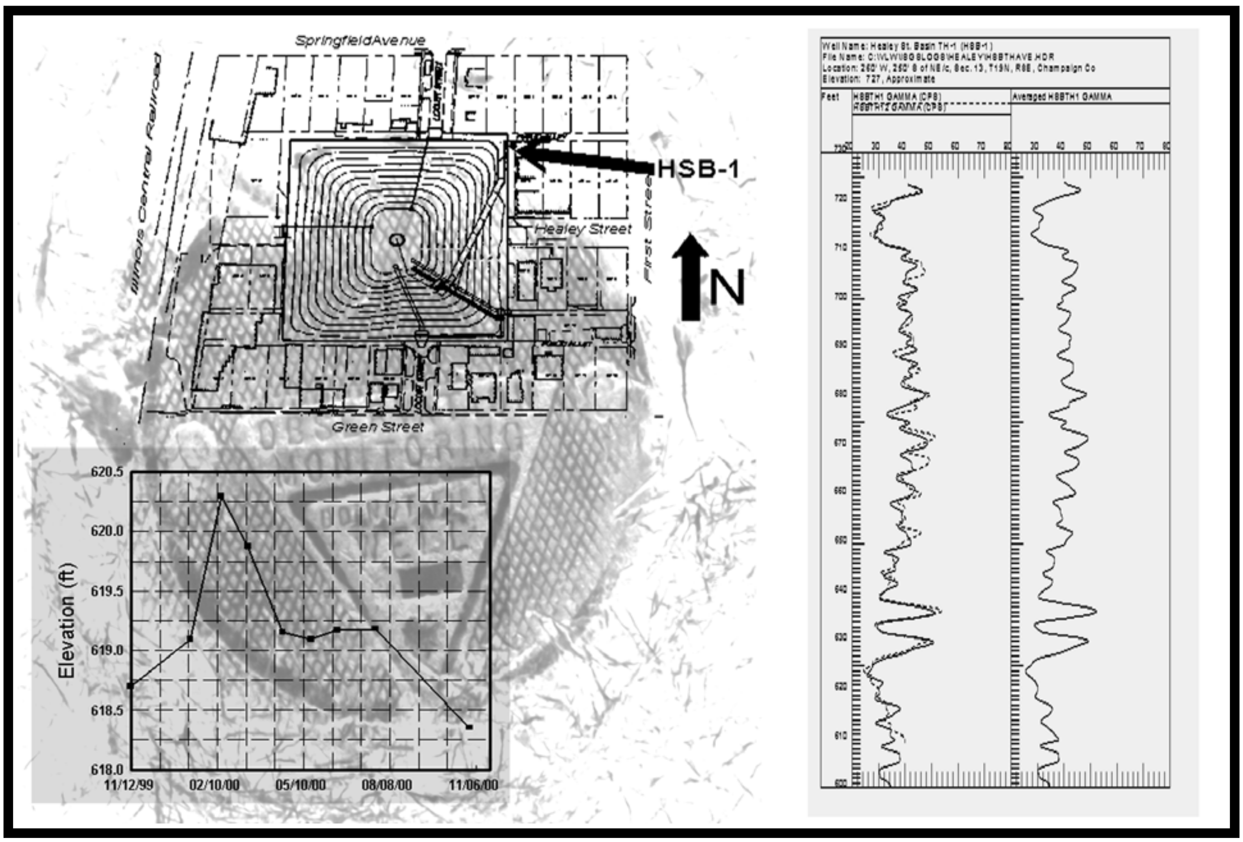

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INTRODUCTION

As part of its stormwater management plan, the City of Champaign excavated a stormwater detention basin, which is commonly known as the Healey Street Basin. This basin (figure 1) is located within a city block bounded on the north by Springfield Ave., on the east by First St., on the south by Green St., and on the west by the Illinois Central railroad tracks. The basin is located in the watershed of the Boneyard Creek and is approximately 70 feet deep. The bottom of the basin has an approximate elevation of 655 feet above mean sea level.

The Healey Street Basin has a volume of 117 acre-feet or 38 million gallons and was designed to alleviate flooding in Campustown and areas downstream from Campustown by reducing peak flows for storms up to and including the 100-year recurrence interval storm (Blackmon, personal communication, March 13, 2000). Along with the related construction of the Campustown Channel Improvements immediately downstream from the Healey Street Basin, the Campustown section of the Boneyard Creek currently is designed to handle flow for up to the 10-year storm. Completion of improvements downstream on the University of Illinois campus will help prevent flooding from a 25-year storm.

The City Council of the City of Champaign passed a resolution, Council Bill 99-97, approving the installation of a monitoring well at the Healey Street Basin by the Illinois State Geological Survey (ISGS). Steven Carter, City Manager, noted in a report to the City Council dated April 2, 1999 that the boring would provide geologic data to supplement data that the ISGS collected from the excavation of the basin. In addition, Mr. Carter reported that the monitoring well will allow long-term monitoring of the water quality in the Glasford Formation aquifer. The water quality within the Glasford Formation aquifer is a concern because this aquifer is used for water supply in Champaign and Urbana (Woller, 1975) and may be hydraulically connected to the underlying Mahomet aquifer. The Mahomet aquifer is the main source of drinking water for Champaign, Urbana, and surrounding communities.

Under the agreement with the City of Champaign, the ISGS is required to maintain the monitoring well in good condition, to seal the well upon abandonment, and to share the geologic, hydrologic, and water quality results with the City staff. This report fulfills that latter obligation.

GEOLOGIC SETTING

Approximately 300 feet of glacial drift overlies the bedrock beneath the drilling site (Piskin and Bergstrom, 1975). The geology of Champaign County, with an emphasis on the hydrogeology of glacial deposits, was described by Kempton et al. (1982 and 1991). They described the potential of glacial and related materials as aquifers and noted that aquifers are found in the sand and gravel deposits of the Henry, Glasford, and Banner Formations. Soller et al. (1999) compiled three-dimensional maps of the glacial drift or Quaternary materials for an area that includes Champaign County. The sand and gravel deposits that are considered aquifers are shown on the stratigraphic column (figure 2). For example, sand and gravel is found at the base of the Mason Group (Ashmore Tongue), within the Radnor Till Member of the Glasford Formation and between the Radnor Till and Vandalia Till Members of the Glasford Formation. These sand and gravel deposits, as well as the Henry Formation and the Mahomet Sand Member of the Banner Formation (i.e., the Mahomet aquifer), are considered aquifers in Champaign County. As depicted in Figure 2, these sand and gravel deposits are not uniformly distributed across Champaign County.

The Glasford Formation is of interest at this site. The top of the Glasford Formation is approximately 75 feet below ground or at an elevation of approximately 650 feet (Kempton et al., 1991). The top of the Banner Formation is found approximately 175 feet below the ground surface, or at an elevation of 550 feet (Kempton et al., 1991). Although the Banner Formation underlies the site, the Mahomet aquifer does not (Kempton et al., 1991). Because the bedrock beneath Champaign County is not considered a source of potable water and is more than 100 feet below the bottom of the borehole, the bedrock is not discussed in this report.

The primary source of recharge to the aquifers of the Glasford Formation and the deeper Mahomet aquifer is precipitation. Some precipitation infiltrates the soil and percolates slowly downward. Panno et al. (1994) estimated that it takes 3,000 to 5,000 years for recharge to move from the ground surface to the Mahomet aquifer in Champaign County. In addition, recharge to the central portion of the Mahomet aquifer was predominantly focused in western Champaign County, specifically in the area of the Sangamon River (Panno et al.,1994).

MONITORING WELL INSTALLATION

The installation of a monitoring well typically includes drilling, geological logging of core or cuttings, geophysical logging of the borehole, and construction of the monitoring well. The location for the monitoring well by the northeast corner of the detention basin was selected in August 1999 at a field conference attended by the ISGS and the City of Champaign and was finalized in November 1999 (figure 1). Buried utilities were located prior to drilling by calling J.U.L.I.E. The monitoring well is located 260 feet west and 250 feet south from the northeast corner of section 13, T19N, R8E.

The elevation of the top of the monitoring well was determined to be 726.30 feet by level surveying. Elevation data for the benchmark (top of pentagon nut of the fire hydrant at the northwest corner of Healey & First Streets, 726.265 ft) was supplied by the City of Champaign.

DRILLING

Drilling started on November 8 and was completed on November 10, 1999. The ISGS CME-75 drill rig was used to drill this borehole. Hollow-stem auger was used because limited space at the drilling site did not permit the use of mud tanks needed for the wireline coring system. Geologic samples were collected continuously using a 5-foot core barrel. Because of the knowledge obtained about the geologic materials during excavation of the detention basin, collecting samples from shallow depths was deemed unnecessary. Thus, sample collection was started at 26 feet. At a depth of 51 feet, sample collection had to be abandoned because the materials were too hard for the drill rig to penetrate without the use of a center bit. Geologic samples can not be collected when the center bit is used.

Drilling at this location with hollow-stem auger proved to be difficult. As discussed above, the center bit had to be used to penetrate the geologic materials deeper than 51 feet. In addition, at a depth of approximately 120 feet, the rod (1.25-inch diameter steel rod) for the center bit snapped. The broken rod was retrieved from the borehole, and drilling continued until a second rod snapped. The borehole was drilled to a depth of 129.8 feet, which was approximately 5 feet shallower than the planned total depth of the borehole.

LOGGING

Geologic materials recovered from 26 to 51 feet were described in the field using standard techniques. The geologic log (figure 3) includes descriptions of texture, color, mineralogy, structure, and other geologic features.

Because geologic samples were not collected from the entire length of the borehole, geophysical logs were run in the borehole. A natural gamma log was run twice (figure 4). This log was first run on November 9 to determine if the borehole had been advanced into sands of the Glasford Formation. By comparing the gamma logs in Burch et al. (1999) and our gamma log, we determined that the borehole should be advanced another 5 to 10 feet. The gamma log was rerun when the borehole was completed.

A natural gamma log provides data on the natural radioactivity of the geologic materials and is useful for determining the clay and silt content of the geologic materials. Because clays and silts contain more naturally occurring radioactive isotopes than sands, clays and silts have higher gamma counts on the log. Higher gamma counts or greater clay/silt content plot to the right in figure 4. Sands typically have gamma counts of 25 cps, whereas sands with some silt and/or clay have gamma counts of 28 cps or higher.

The gamma log was plotted with the stratigraphic and lithologic data (figure 5). Based on the gamma log, thin silty sand deposits are present within the tills of the Wedron Group and Glasford Formation. The bottom of the Healey Street basin, which has an approximate elevation of 655 feet, was estimated to be approximately 5 feet above the top of the Glasford formation. The elevation of the top of the Glasford formation was estimated from data in Kempton et al. (1991).

WELL INSTALLATION

The monitoring well was constructed using stainless steel casing and screen (figure 6). The screen was set at a depth of 124 to 129 feet and was sandpacked at a depth of 122 to 129 feet. The well was completed in a silty sand seam in the middle of the Glasford Formation. During well construction, the borehole collapsed from a depth of 95 to 122 feet, probably due to the presence of silty sand lenses in this depth interval (as shown on figure 5). Bentonite chips were used to hydraulically seal the borehole at depths of 87 to 95 feet and from 4 to 16 feet. The remainder of the borehole was backfilled with cuttings or concrete as shown on figure 6.

The monitoring well was developed in January 2000 by pumping water from the well using a centrifugal pump. Prior to development, the well had 22.4 feet of water or contained approximately 3.8 gallons of water. During development, the well was pumped dry in less than 5 minutes. The pump was shut off and the water level in the well was allowed to recover for 30 to 70 minutes before pumping again. The well was pumped dry five times. The water was initially thick and very muddy, but was light tannish grey in color during the final pumping event. During the final pumping event, the water contained some clay size particles, but no coarse particles.

MONITORING

The water level in well HSB-1 was monitored over time. In addition, a water sample was collected and analyzed.

WATER LEVEL

The water level in HSB-1 was measured (figure 7) using an electronic water level meter. This meter measures the depth to water below a reference point and has a precision of 0.01 feet. The reference point, the top of the casing, has a known elevation, thus the elevation of the water level can be calculated. The water level in the well is approximately 36 feet below the bottom of the basin, which means that the vertical hydraulic gradient between the basin and the Glasford aquifer is downward. In other words, any leakage from the basin would be expected to move down toward the Glasford aquifer. The rate which this leakage moves downward is not known, but it is expected to be slow based on the available geologic information.

The water level data for HSB-1 are consistent with other data reported for the Glasford Formation (Burch et al., 1999), which shows lower water levels in Champaign and Urbana than in areas outside of these cities. Water levels in Champaign and Urbana are 30 to 40 feet lower than the levels in outlying areas, which may reflect pumpage from this Glasford Formation in Urbana.

WATER QUALITY

A water sample was collected from this well on March 13, 2000 using a bailer, and analyzed for anions and cations (table 1). The anions and cations were determined by ISGS geochemists using three methods. Anions were determined using a Dionex model 211i ion chromatograph. Cations were determined using a Model 1100 Thermo-Jarrell Ash inductively coupled argon plasma spectrometer (ICAP). Total alkalinity was determined by titration. Dissolved oxygen, temperature, pH, Eh and specific conductivity were measured in the field using a Hydrolab Minisonde. These parameters are also reported in table 1. After sample collection, it was determined that the pH probe was not functioning properly. Thus, a pH value from a subsequent sampling event is reported in table 1.

The field parameters reveal that the groundwater has fairly low dissolved oxygen content, has a neutral pH, is oxidizing, and has moderate specific conductivity. The dominant anions in our sample are chloride and sulfate. The dominant cations are calcium, magnesium, and potassium. Total alkalinity is a measure of the capacity of water to neutralize strong acid (Snoeyink and Jenkins, 1980). In natural waters, this capacity is due to the presence of bases, bicarbonate, carbonate, and hydroxide. Thus, the alkalinity values and a neutral pH indicate that our sample may be rich in bicarbonate.

Panno et al. (1994) noted that groundwater from wells completed in the Glasford Formation in Champaign and surrounding counties was calcium-bicarbonate type water, which indicates that the dominant cation and anion are calcium and bicarbonate, respectively. Panno et al. (1994) also noted that the groundwater from the Glasford Formation was reducing as determined by lower and even negative Eh values and the presence of methane. Burch et al. (1999) reported water quality data for several samples collected from wells that were completed in the Glasford Formation on the University of Illinois campus (east of the Beckman Institute and west of the Abbott Power Plant). Compared to samples from Burch et al. (1999), our sample had higher concentrations of chloride, sulfate, sulfur and potassium and lower concentrations of calcium and silicon. The concentration of fluoride in our sample was greater than the published concentrations for a few Glasford samples (Woller, 1975; Panno et al.,1994). In Champaign, fluoride is added to the water supply under Illinois Department of Public Health guidelines, which call for fluoride concentrations of 0.9 to 1.2 mg/L. Thus, fluoride may be present in shallow groundwater if water from the municipal supply has been used for landscape irrigation or if water mains or sewers have leaked.

Because shallow groundwater in an urban setting could have elevated chloride and fluoride concentrations, we suspect that the deeper groundwater that we sampled may have been mixed with shallow groundwater (possibly from a sandy zone at elevations 710 to 720 feet) during drilling. In addition, the observed differences in water chemistry may be due to differences in the thoroughness of well development (our well may not have been fully developed), sampling technique, or natural variability in groundwater quality. Additional sampling over time will provide more data to understand these observed differences between the chemistry of the water in the monitoring well and of those reported in the literature.

SUMMARY and RECOMMENDATIONS

In this report, the geology beneath the Healey St. basin was described. The installation and construction of a stainless steel monitoring well also were described. The water level in the well was found to be consistent with other published data. The hydraulic data show that water from the Healey Street basin will flow downward to the Glasford formation. The rate at which this water will move is not known, but would be expected to be slow based on available information about the geologic materials. The water quality in the Glasford formation beneath the Healey St. basin varied from published data and appears to indicate that water sampled from HSB-1 was a mixture of water from shallow deposits and the Glasford formation.

The water level in this well should be monitored monthly for a period of 2 years to establish a baseline and understand seasonal fluctuations. In addition, the water quality should be monitored quarterly for at least a year to understand seasonal fluctuations in groundwater chemistry and to determine any effects of the detention basin on water in the Glasford Formation. This chemical analysis should include the parameters listed in table 1 and possibly some isotopic parameters such as tritium to estimate the age of the groundwater.

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Table 1. Chemistry of a water sample from HSB-1 compared with reported values from Burch et al. (1999).

Parameter	Units	Value	Reported Values
Field Parameters			
dissolved oxygen	% saturation	16.1	
temperature	EC	14.4	
pH	pH units	7.31*	7.38 - 7.77
Eh	mV	265	
specific conductivity	mS/cm	0.468	0.465 - 0.500
Anions			
bromide	mg/L	<0.02	
chloride	mg/L	30.5	1.58 - 4.52
fluoride	mg/L	0.80	
nitrate-nitrogen	mg/L	0.02	<0.04 - <0.08
phosphate	mg/L	<0.1	
sulfate	mg/L	12.9	<0.07 - 0.67
Other/ total alkalinity	mg/L	297	326 - 332
Cations			
aluminum	mg/L	0.03	
antimony	mg/L	<0.05	
arsenic	mg/L	<0.2	
barium	mg/L	0.205	0.070 - 0.72
beryllium	mg/L	<0.001	
boron	mg/L	0.69	
cadmium	mg/L	<0.01	
calcium	mg/L	46.7	55.3 - 63.0
chromium	mg/L	<0.01	
cobalt	mg/L	<0.01	
copper	mg/L	<0.01	
iron	mg/L	<0.01	
lanthanium	mg/L	<0.002	
lead	mg/L	<0.02	
lithium	mg/L	0.02	
magnesium	mg/L	26.3	22.3 - 29.9
manganese	mg/L	0.250	0.048 - 0.073
molybdenum	mg/L	<0.02	
nickel	mg/L	0.06	
potassium	mg/L	11	3.25 - 5.28
scandium	mg/L	<0.003	
selenium	mg/L	<0.05	
silicon	mg/L	4.76	8.53 - 9.33
sodium	mg/L	56.9	
strontium	mg/L	0.637	0.25 - 0.40
sulfur	mg/L	5.5	<0.26
thallium	mg/L	<0.1	
titanium	mg/L	<0.01	
vanadium	mg/L	<0.01	
zinc	mg/L	0.028	

*= determined from a sample collected on October 30, 2000.

Figure 1. Location map showing the Healey Street basin and the installed monitoring well, HSB-1.

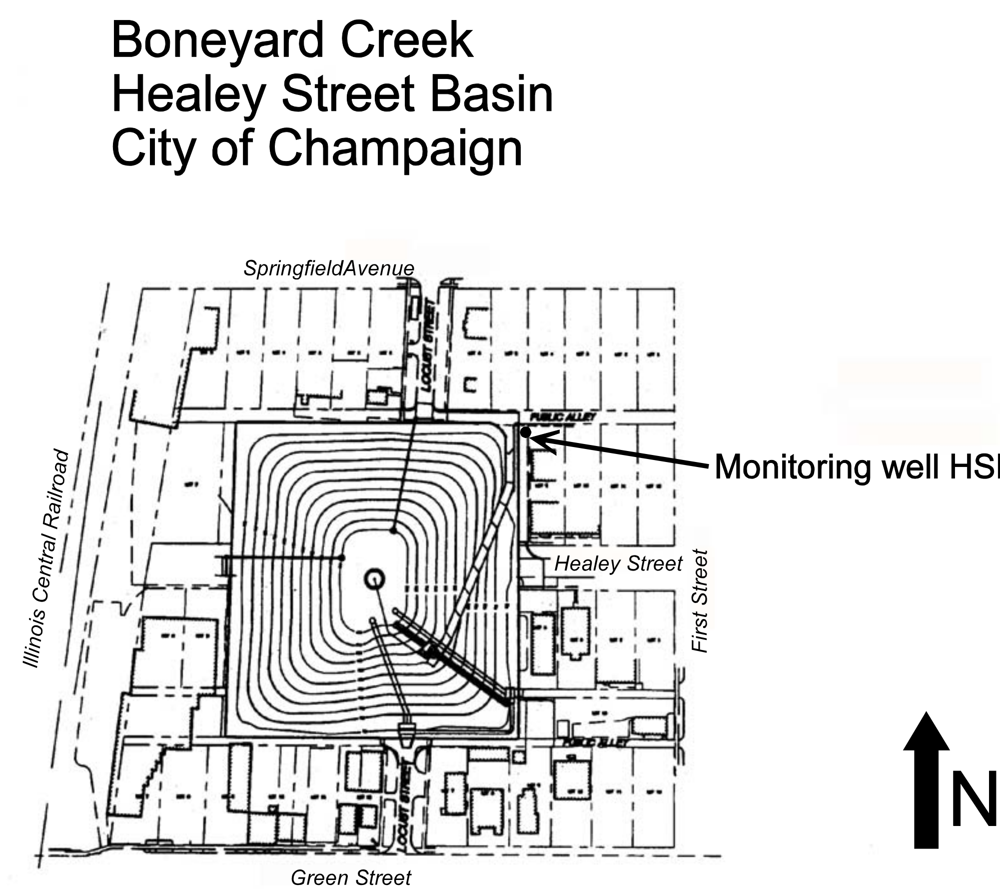

Figure 2. Stratigraphic column of the glacial and related deposits beneath east-central Illinois (from Soller et al.,1999)

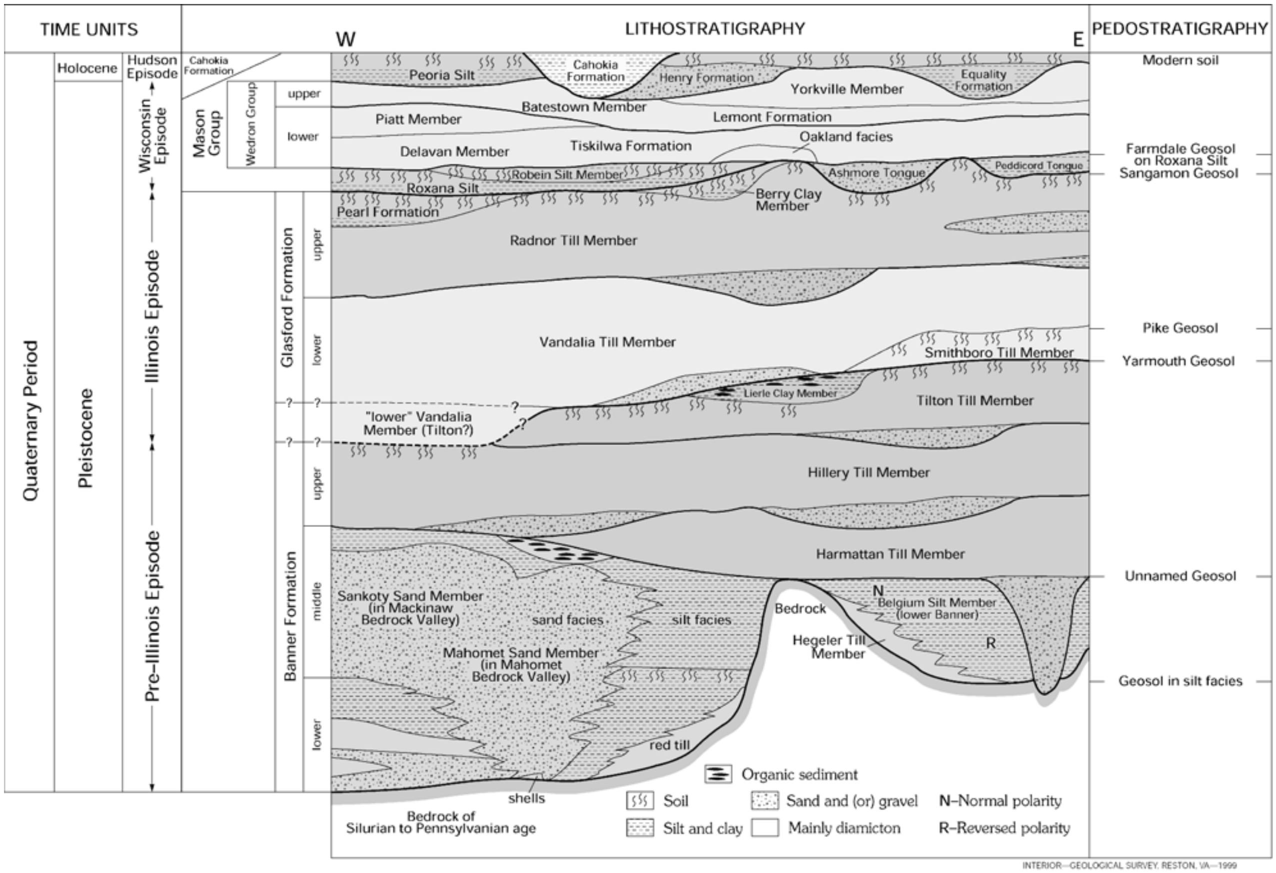

Figure 7.—Diagrammatic stratigraphic column of glaciogenic sediments in east-central Illinois. The Cahokia Formation was deposited mostly during the Hudson Episode. Geologic and stratigraphic names and intervals used in this figure are those accepted by the ISGS.

Figure 3. Geologic log for the Healey Street Basin Testhole

Location: Champaign County, NE ¼, NE ¼, NE ¼, Section 13, T19N, R08E
or 260' W and 250' S of NE corner of Section 13, T19N, R08E

Elevation: 726.3' (msl) **Total Depth**: 129.8' **Date started**: 11/8/99

Drilling method: hollow-stem auger with 5' core barrel
Core descriptions: David R. Larson and Edward Mehnert
Geophysical logs: two natural gamma: first to depth 118'; second to depth 128.6'
Depth to water (below land surface): 128.6' @ 12:10 PM and 128.5' @12:50 PM on 11/10/99; 107.56' on 11/12/99

Depth (ft)	Thickness (ft)	Description
0.0- 26.1	26.1	Drilled with center bit to depth 26' 1" (26.1')
26.1- 27.1	1.0	Sand and Gravel, gray, very fine sand to fine gravel with some medium gravel, poorly sorted; fines mostly subrounded to rounded quartz, carbonate, and shale grains, rest mostly subangular to subrounded carbonates, quartz, and shale grains; slightly calcareous
27.1- 27.9	0.8	Silt, olive (5Y 4/4), moderately clayey; slightly sandy, very slightly pebbly with sparse fine to medium gravel that is mostly subangular to subrounded carbonate and shale grains; slightly cohesive; slightly to moderately calcareous
27.9- 31.1	3.2	Clay, dark gray (5Y 4/1) with olive mottles at contact, very silty to clayey silt; slightly to moderately sandy with fine to very coarse sand, very slightly to slightly pebbly with sparse fine to medium gravel that is mostly subangular to subrounded carbonates and shale; dense, cohesive; slightly calcareous
31.1- 41.1	10.0	Clay, dark gray (5Y 4/1), moderately to very silty, in part clayey silt; moderately to very sandy with very sandy inclusions of very fine to very coarse sand, slightly pebbly with fine to medium gravel that is mostly subangular to subrounded carbonates and shale with sparse quartz pebbles; moderately cohesive; slightly to moderately calcareous with some increase with depth
41.1- 49.5	8.4	Silt, dark grayish brown (2.5Y 4/2), moderately clayey, slightly to moderately sandy with very fine to very coarse sand, slightly pebbly with fine to medium gravel that is mostly subangular to subrounded carbonates and shale, slightly cohesive to friable; slightly calcareous
49.5- 49.7	0.2	Silt, gray (2.5Y 5/1), soft, noncohesive; slightly to moderately calcareous
49.7- 50.1	0.4	Silt, gray (2.5Y 5/1), slightly clayey; soft; slightly cohesive; slightly calcareous
50.1- 50.2	0.1	Sand, dark gray (2.5Y 4/1), very fine to very coarse, mostly fine to medium, moderately well sorted; very silty, moderately clayey; very slightly cohesive; slightly to moderately calcareous
50.2- 51.1	0.9	Silt, gray (2.5Y 5/1), moderately clayey, moderately pebbly with fine to medium gravel and sparse coarse gravel that is mostly subangular to subrounded carbonates and shale; moderately cohesive , stiff, and dense; slightly to moderately calcareous; 1" carbonate pebble at 51.1'
51.1-129.8	78.7	Chased rock with core barrel to depth of 60', drilled with center bit to depth 129.8' and constructed observation well;

Figure 4. Natural gamma log run in HSB-1. Higher gamma counts plot to the right and indicate geologic materials with a greater percentage of clay and silt (i.e., less sand).

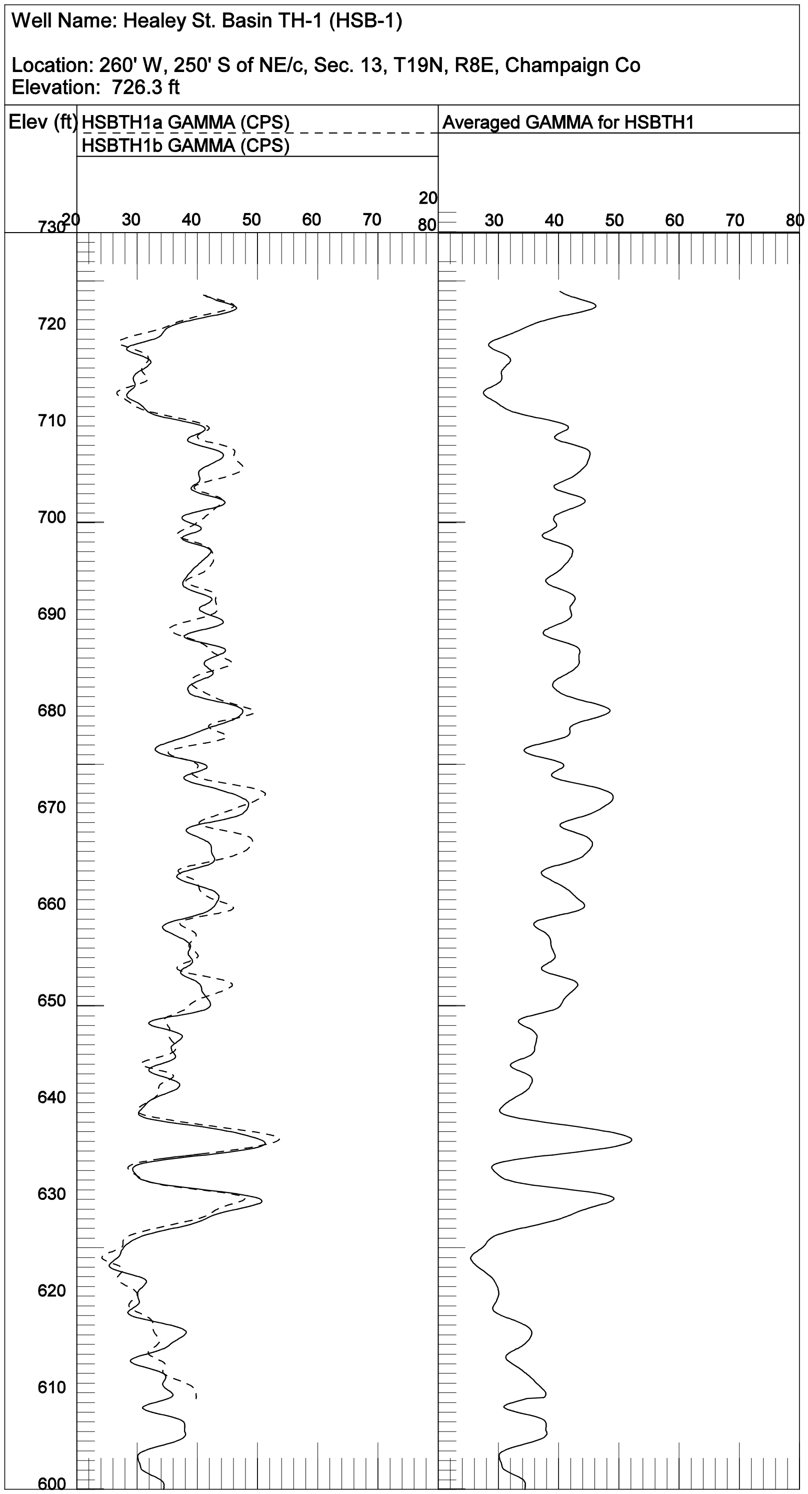

Figure 5. Composite figure that relates the stratigraphic, lithologic and geophysical data with the Healey St. basin

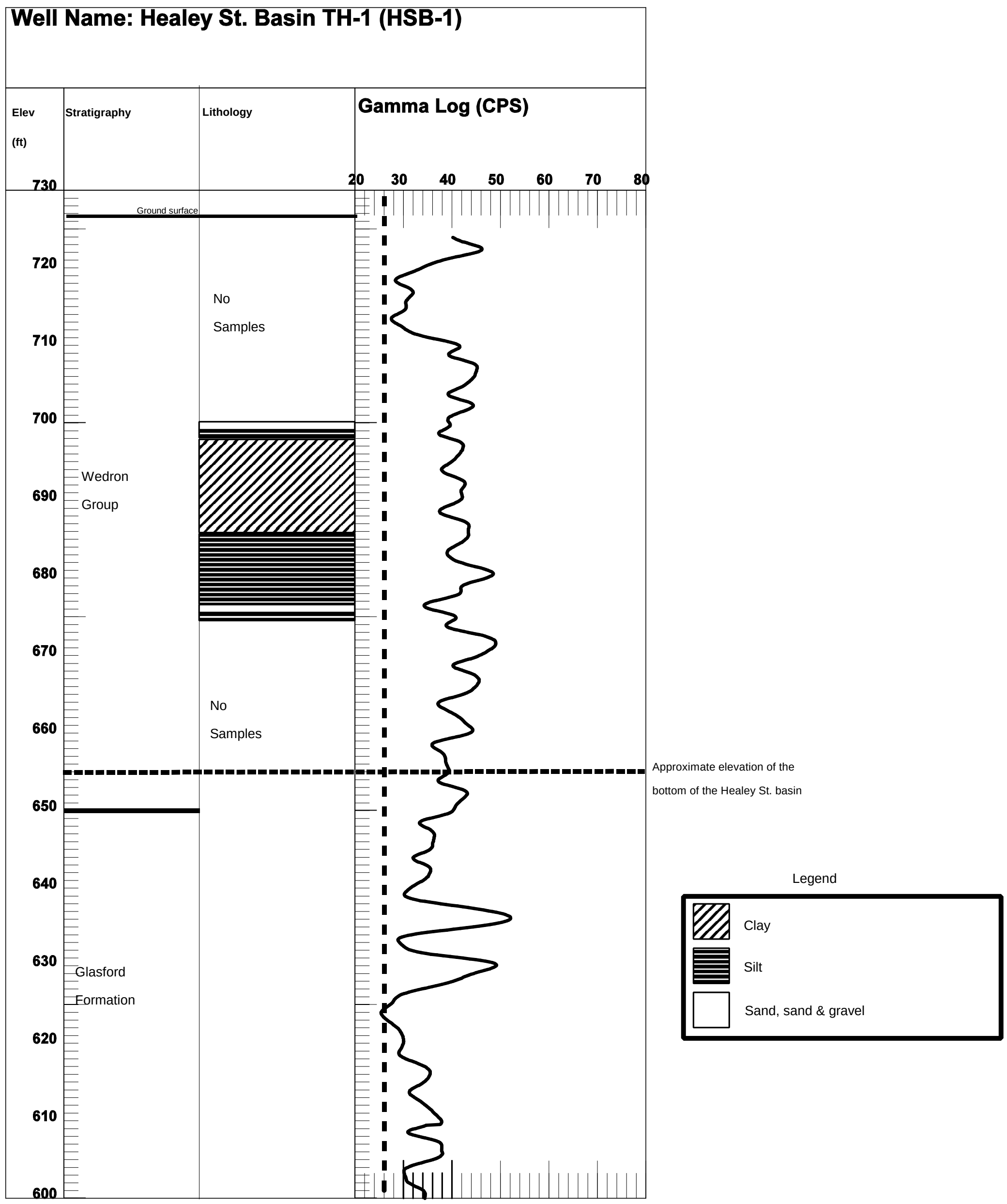

Figure 6. Well construction diagram for HSB-1.

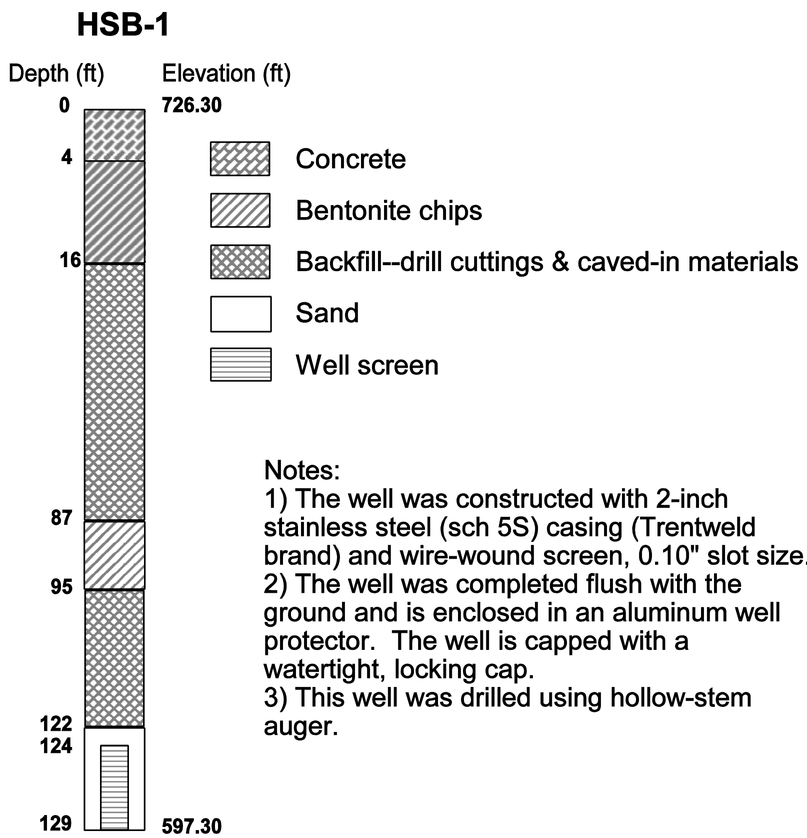

Figure 7. Hydrograph for HSB-1, which shows the elevation of the water level in HSB-1 over time.