Geol Survey

KLEIN CREEK POTENTIAL WETLAND MITIGATION SITE: FINAL HYDROGEOLOGIC CHARACTERIZATION REPORT

(Illinois Route 64 at Kuhn Road,
Carol Stream, Du Page County, Illinois)
(Federal Aid Project 307)

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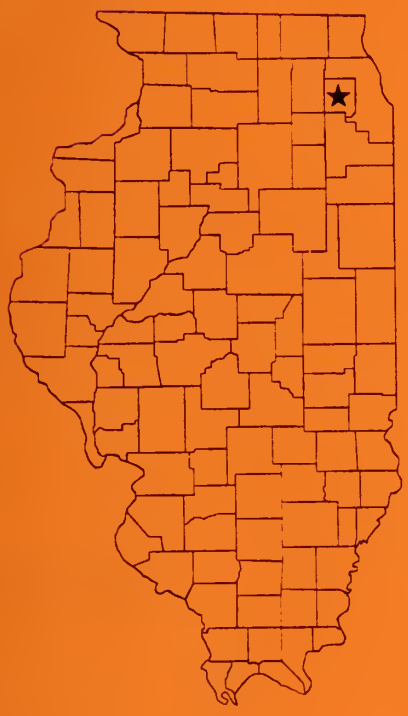
615 East Peabody Drive
Champaign, IL 61820-6964

Submitted Under Contract No. AE89005 to
Illinois Department of Transportation
Bureau of Design and Environment, Wetlands Unit
2300 South Dirksen Parkway
Springfield, IL 62764

December 4, 1994
Illinois State Geological Survey
Open File Series 1994-8



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INTRODUCTION

The Illinois State Geological Survey (ISGS) prepared this report to provide the Illinois Department of Transportation (IDOT) with information regarding the suitability of the Klein Creek site for wetland mitigation. Geologic, hydrologic, and geochemical data collected during short-term monitoring are provided for the study area. This report includes and supersedes all information provided in the Interim Report of December 1993. If long-term monitoring is required, a final monitoring report containing all characterization and monitoring results will be sent at the end of the monitoring period or as required by IDOT.

The Klein Creek site is located in W1/2 Sec. 31, T40N, R9E, in Carol Stream, Illinois (fig. 1), and is approximately 26 hectares (65 acres) in size. The site is bordered on the south primarily by St. Charles Road and on the east by Morton (Kuhn) Road, and extends approximately 400 meters (m) (1,300 feet [ft]) westward and 800 to 1,000 m (2,600–3,300 ft) northward. Illinois Route 64 divides the site into north and south portions; both are characterized in this report.

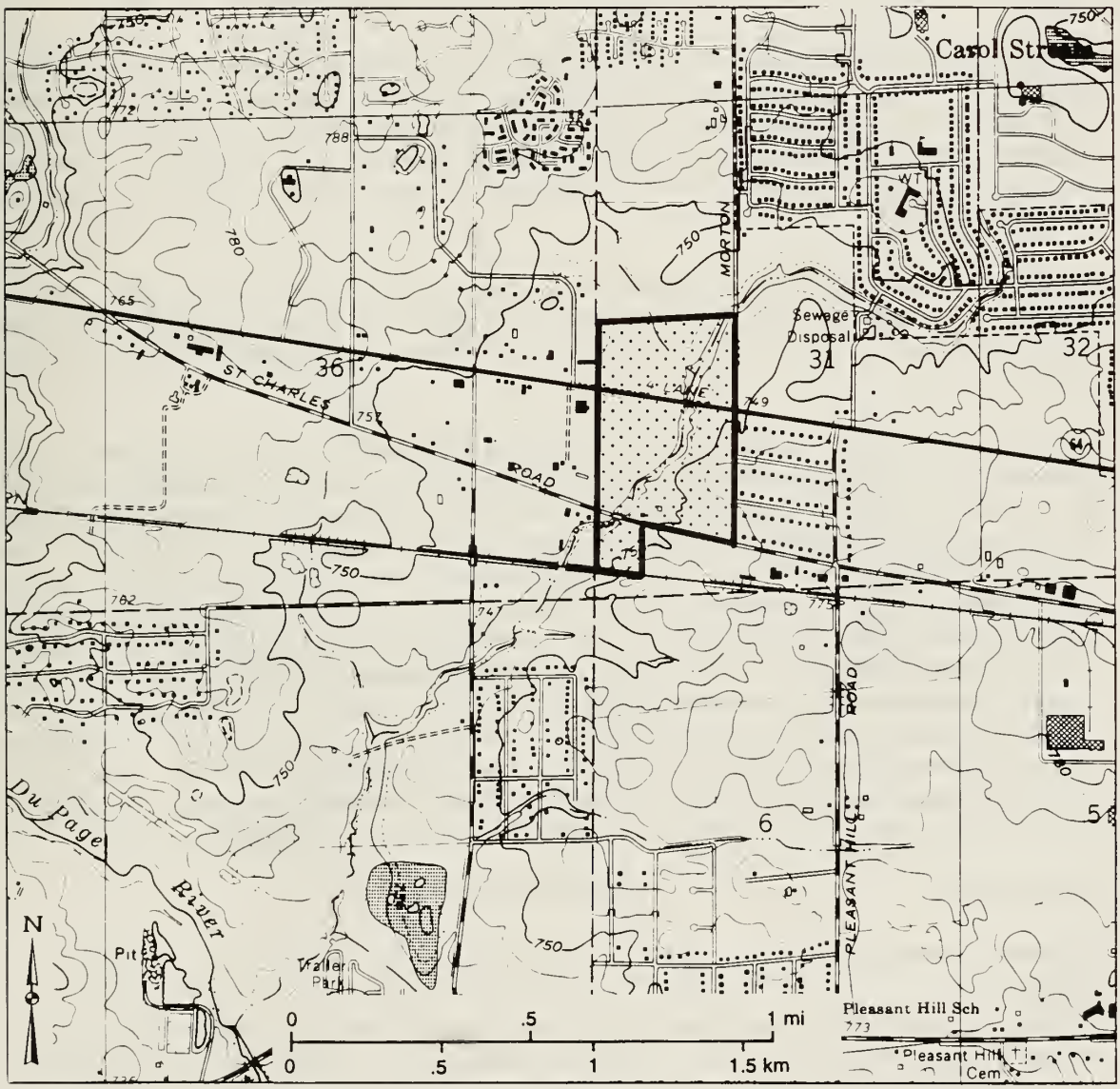

Figure 1 Study area (stippled) and vicinity as shown on the West Chicago 7.5-minute topographic map (USGS 1962). Contour interval is 10 ft (3 m).

METHODS

The surficial geology of the study area was characterized through a series of 10 borings (fig. 2). All borings were made using a Mobile B-30S drill rig that used a 1.5-m (5-ft) long split-spoon sampler to obtain a continuous core 75 millimeters (mm) (3 inches [in.]) in diameter. Geologic logs for each boring are shown in Appendix A.

Characterization of ground water in the study area required the installation of monitoring wells to measure ground-water levels and estimate ground-water flow directions in identified aquifers. Four monitoring wells were installed in selected borings through the hollow-stem auger of the Mobile drill rig. Well casing consisted of 2.54-cm (1-in.) diameter PVC pipe. Well screens were 0.69 m (2.25 ft) long and contained slots 0.25 mm (0.01 in.) in thickness. Well screens were packed with quartz sand 0.25–0.50 mm (0.01–0.20 in.) in diameter. Annular seals of bentonite were placed above the sand. Borings were then backfilled with varying amounts of bentonite pellets and cuttings. Appendix B lists all well construction measurements. Protective covers set in approximately 0.3 m (1 ft) of concrete were installed over each well. Water levels in wells were measured monthly and are reported in Appendix C. Wells were not developed because of the unavailability of equipment for wells of this depth and diameter.

Characterization of surface water in the study area was performed by installing stage gauges in Klein Creek. In July 1993, stage gauge A was installed on the Kuhn Road bridge and stage gauge B was installed on the Illinois Route 64 bridge (fig. 2). Stage gauge C was installed on the St. Charles Road bridge (fig. 2) in April 1994. Surface-water levels were measured monthly. Water-level elevations at all gauges are reported in Appendix C.

Elevations of wells and stage gauges were determined to third-order accuracy using a Sokkia B-1 automatic level and a fiberglass extending rod. The elevation of a Du Page County Highway Department survey monument located on site was used for a bench-mark.

Geochemical screening of Klein Creek was also performed. Quarterly collection of grab samples from Klein Creek began in June 1993 at stage gauge A, located just upstream from the site (fig. 2). Because the purpose of this sampling was to screen Klein Creek for chemical constituents, no measurements of flow rate or volume were made. Grab samples of surface water from the center of the creek were collected using a 2.2-liter (L) PVC Beta Plus bailer. Subsamples were then placed into labeled 125- and 250-milliliter (mL) Nalgene bottles and kept on ice for conventional water quality and inductively coupled plasma spectroscopy (ICP) analyses. The remainder of the sample was used for the field measurement of pH, redox potential (Eh), conductivity, and temperature. Dissolved oxygen was measured directly in the flowing water by using an Industrial Chemical Measurement (ICM) oxygen meter. The samples for ICP analysis were filtered in the laboratory within 36 hours of collection and prior to being acidified. The samples analyzed for conventional water quality parameters were not filtered or acidified.

GEOLOGY

Regional Setting

Bedrock

The uppermost bedrock unit at the Klein Creek site consists of silty and shaly dolomites of the Niagaran Series of the Silurian System (Willman et al. 1967). Bedrock units dip to

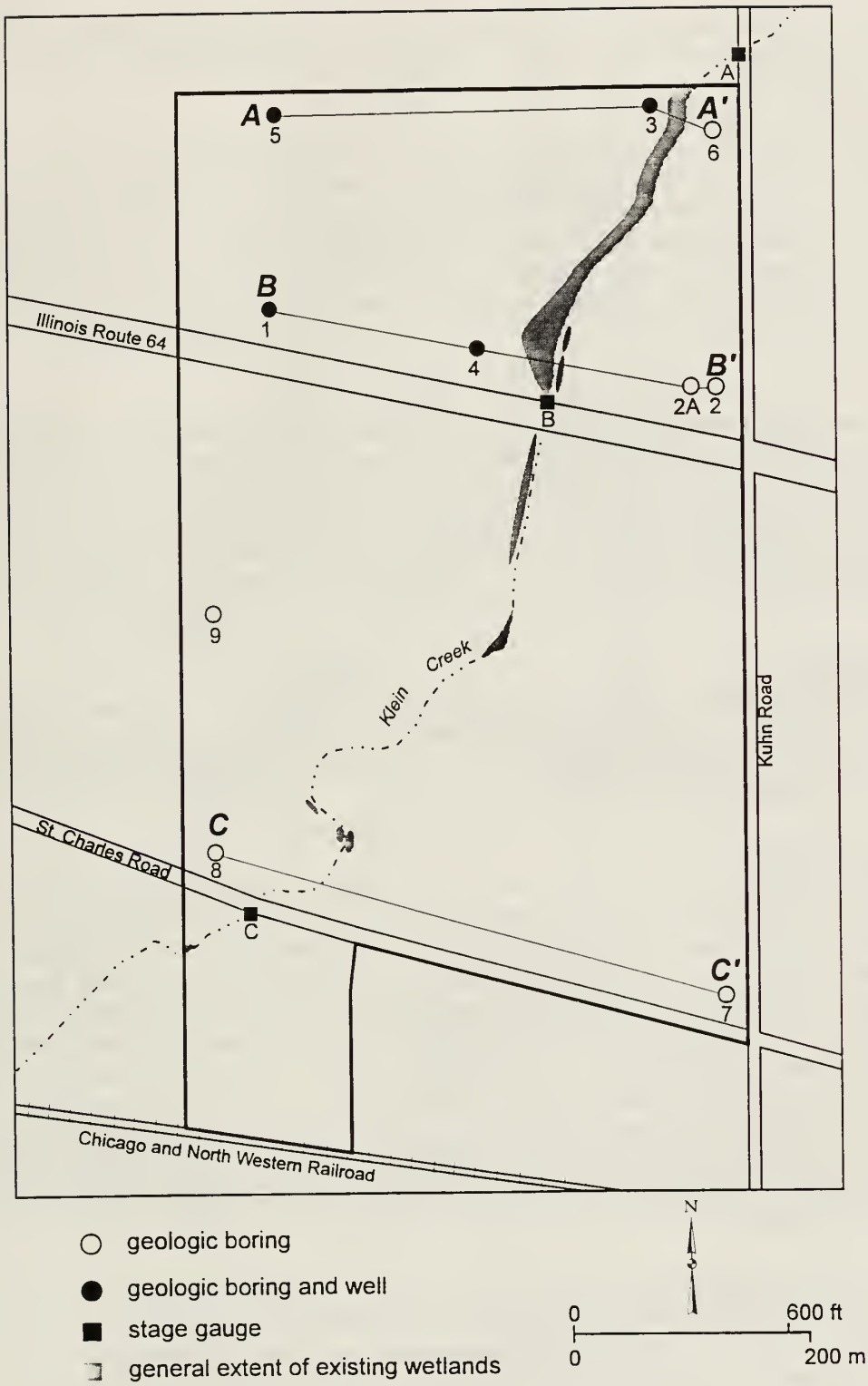

Figure 2 Site map showing locations of borings, wells, stage gauges, lines of cross section, and existing wetlands (from Nugteren et al. 1991).

the east approximately 2.6 meters per kilometer (m/km) (13 ft/mi) (Willman 1971). The bedrock surface dips to the east approximately 1.5 m/km (8 ft/mi) (Horberg 1957).

Quaternary Sediments

Bedrock is overlain by approximately 30 m (100 ft) of unlithified Quaternary sediments (Horberg 1957, Piskin and Bergstrom 1975, and ISGS well records on file). These sediments consist predominantly of glacially deposited diamictons interbedded with sand and gravel and are classified as part of the Wedron Formation of the Wisconsinan Stage (Berg and Kempton 1988). Diamicton is a term used to describe all very poorly sorted sediments such as glacial till and debris flows without implying an origin of the deposit (Eyles 1983, p. 13).

Soils

The most extensive soil in the parcel is Mundelein silt loam (fig. 3) (U.S. Department of Agriculture 1979). Mundelein silt loam is somewhat poorly drained but is not listed as a hydric soil. Poorly drained soils listed as hydric soils (USDA 1991, rev. January 31, 1992) include Drummer silt loam adjacent to Klein Creek and Ashkum silty clay loam. Better drained areas in the parcel are mapped as Barrington silt loam and Markham silt loam, both of which are classified as moderately well drained to well drained.

Topography

Total relief in the study area is approximately 8 m (25 ft) (fig. 1). The land surface slopes from the northwest and the southeast toward Klein Creek, which flows southwest toward the West Branch of the Du Page River. The banks of Klein Creek are incised 0 to 2 m (0–6 ft) below the adjacent floodplain.

Geomorphology

The Klein Creek site is located in a geomorphic region known as the Valparaiso Morainic System, which in the study area features a series of adjacent, north-south-trending, glacially formed ridges known as end moraines (Willman 1971). The Wheaton Moraine is located adjacent to and partially within the site on the east, whereas the West Chicago Moraine is located west of the site. These moraines consist predominantly of diamicton classified as the Wadsworth Till Member of the Wedron Formation. Modern streams such as Klein Creek, Spring Brook, and the West Branch of the Du Page River occupy valleys formed by glacial meltwaters. Sand and gravel deposits of the Henry Formation are found in the floors and as terraces in these valleys. The northern and western portions of the Klein Creek site are located in a former outwash channel that occupied the valley in which Klein Creek now flows. The area east of Klein Creek borders on the flanks of the Wheaton Moraine.

Site Characterization

Three cross sections were prepared from the geologic borings made during this study (Appendix A, part 2). Geologic units delineated on these cross sections are described below. Locations of borings and lines of cross section are shown in figure 2.

The uppermost unit of sediments in the study area is designated silty clay unit A. This stiff, fine-grained deposit is laminated in the lower parts, a condition suggesting a lacustrine origin. Unit A is up to 4.6 m (15 ft) thick but has been completely eroded in the bed of Klein Creek along the north and south borders of the site, as shown on cross sections A–A′ and C–C′. At the base of unit A in several borings were lenses of sand

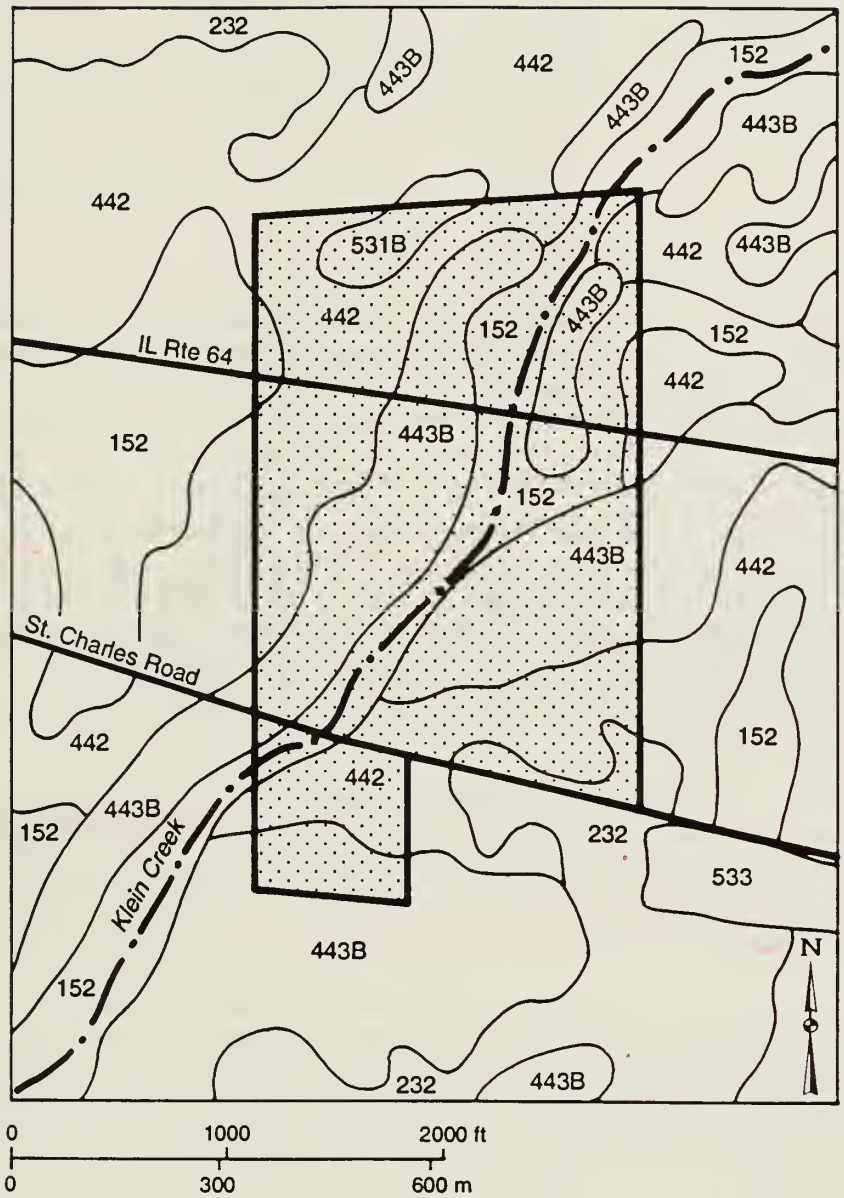

Figure 3 Part of a map from *Soil Survey of Du Page and Part of Cook Counties, Illinois,* showing soils in and around the study area (USDA 1979). Soil types: 152 = Drummer silt loam, 232 = Ashkum silty clay loam, 442 = Mundelein silt loam, 443B = Barrington silt loam, 531B = Markham silt loam, 533 = urban land.

and gravelly sand approximately 0.1 m (4 in.) thick and saturated where encountered. The remainder of the unit was unsaturated during drilling.

Below silty clay unit A, upper diamicton unit B is found. Upper diamicton unit B is 2.7 to 3.4 m (9–11 ft) thick, composed of gray to brown silt loam to silty clay loam diamicton, and variable in texture and stiffness. It contains stiff, dry, silty clay sections that alternate with softer, moist, sandy clay zones on a scale of approximately 50 cm (1.5 ft). Thin sand laminae occur within the diamicton. Lenses of gravel are present at the base of the unit.

Sand and gravel unit C underlies upper diamicton unit B beneath most of the parcel west of the present position of Klein Creek, as shown in borings 1, 3, 5, 6, and 9. Cross sections A–A′ and B–B′ show the extent of this body. This bedded sand and gravel deposit, which is up to 4.5 m (15 ft) thick in borings made for this study, is present along the axis of the regional valley in which Klein Creek flows. The beds within the body are approximately 0.25 m (10 in.) thick and have relatively high porosity. Clasts in the gravel units include cobbles up to 0.1 m (4 in.) in diameter and consist of various lithologies, including exotic igneous and metamorphic crystalline rocks and more locally derived sedimentary rocks such as dolomite and shale.

Below sand and gravel unit C and directly below upper diamicton unit B in the area generally east of Klein Creek, lower diamicton unit D is present. This unit is lithologically similar in description to upper diamicton unit B, but may vary in clast content. The unit was not fully penetrated in the drilling, but is at least 4.9 m (16 ft) thick in boring 2.

Conclusions

During the late Wisconsinan Age, Wadsworth Till, represented by lower diamicton unit D in this study, was deposited across this site. During glacial retreat, meltwaters were carried in the valley of Klein Creek toward the West Branch of the Du Page River, eroding into the till and depositing sand and gravel unit C as a body along the axis of the regional valley in which Klein Creek now flows. The area east of the present position of Klein Creek was on the flanks of the Wheaton Moraine and was not covered by this sand and gravel deposit.

After deposition of the sand and gravel body, upper diamicton unit B, a younger unit of the Wadsworth Till Member, was deposited across the entire parcel. The genesis of the upper diamicton is not known, but it may have been deposited as a till during a readvance of the glacier. Alternatively, unit B may represent debris flow deposits from the adjacent morainal uplands.

After deposition of upper diamicton unit B, a lake occupied the valley of Klein Creek and deposited silty clay unit A across the entire site. This lake may have been dammed by sediments aggrading in the West Branch of the Du Page River, along which lie sand and gravel terraces with elevations of approximately 230.1 m (755 ft) above sea level (Sec. 14, T40N, R9E, ISGS field notes file, M. M. Leighton 1919). A second possibility is that debris flows may have dammed the valley downstream of this site. The rhythmic nature of the laminae in this deposit show that the lake was receiving regular pulses of sediment, which suggest glacial meltwater input. This input may have been from a glacier located at the Keeneyville or younger moraines, or perhaps from backwater flooding into the Klein Creek valley from the West Branch of the Du Page River.

Finally, postglacial erosion by Klein Creek has completely removed silty clay unit A along the north and south borders of the parcel adjacent to Klein Creek; approximately 1 m (3 ft) of this deposit remains in the area alongside Illinois Route 64.

HYDROLOGY

Regional Setting

Water well records in ISGS files indicate that water in private wells is obtained from carbonate rocks approximately 30 to 45 m (100–150 ft) in depth; no water withdrawals from unlithified materials are recorded for the vicinity.

Effluent from the Carol Stream sewage treatment plant discharges into Klein Creek directly upstream from the parcel. Records from the Illinois Environmental Protection Agency (IEPA) indicate that discharge averages approximately 0.11 cubic meters per second (m^3/s) (29.0 gallons per second [gal/s)], and ranges from 0.010 to 0.13 m^3/s (26.0–34.3 gal/s).

Site Characterization

Ground Water

Four monitoring wells were installed in various geologic units to identify potential ground-water sources for the purpose of sustaining a wetland (fig. 2). Monitoring wells were installed in boreholes made for geological characterization.

Likely sources of ground water interacting with surface water in this project area include sand and gravel unit C and gravelly lenses at the base of silty clay unit A and within upper diamicton unit B. Therefore, attempts were made to install wells in these units to determine water levels, flow directions, and the relative connectivity of the lenses.

Wells 1, 3, and 5 were screened at various intervals in sand and gravel unit C. Hydrographs show the water levels, referenced to the National Geodetic Vertical Datum of 1929 (NGVD, 1929), (fig. 4) and depth to water (fig. 5) measured in these wells between March 1993 and June 1994. Water levels measured 7 m (23 ft) or more below land surface, indicating that unsaturated conditions persist in the upper part of sand and gravel unit C. Artesian conditions did not occur during the monitoring period. Water levels in wells 1, 3, and 5 indicate that ground water in sand and gravel unit C flows to the west, away from Klein Creek.

Borings 2, 2A, and 4 were made in an attempt to determine the extent of the gravelly lenses at the base of silty clay unit A. The lenses were noted in borings 2 and 4 but not in boring 2A. It was not possible to install wells in these lenses because they were discontinuous and extremely thin.

Well 4 was installed in a thin, discontinuous sand and gravel lens in upper diamicton unit B in boring 4. Since installation, this well has been dry, indicating that this lens does not transmit a significant amount of water. Water-level elevations and depths to water below land surface are reported in Appendix C.

Surface Water

Klein Creek represents a potential source of surface water to sustain a wetland in the study area. The watershed of Klein Creek headward of the study area is approximately 42 km^2 (16 mi^2) and much of it is mixed agricultural and residential. Rainfall in this area is approximately 86 cm (34 in.) per year; evaporative radiation on an open pond is approximately 81 cm (32 in.) per year, and the greatest evapotranspiration occurs in the summer (Neely and Heister 1987).

Much of the water in Klein Creek is discharged from the Carol Stream sewage treatment plant. IEPA records indicate discharge of approximately 0.11 m^3/s (29.0 gal/s) from the plant. The owner of the site informed ISGS personnel that prior to construction of the treatment station, the creek dried up during the summer; it now flows continuously and occasionally smells of sewage. ISGS personnel noted that the creek did not freeze during the winters of 1992–93 or 1993–94. Elevated levels of nutrients due to input from the treatment station may be expected in this water.

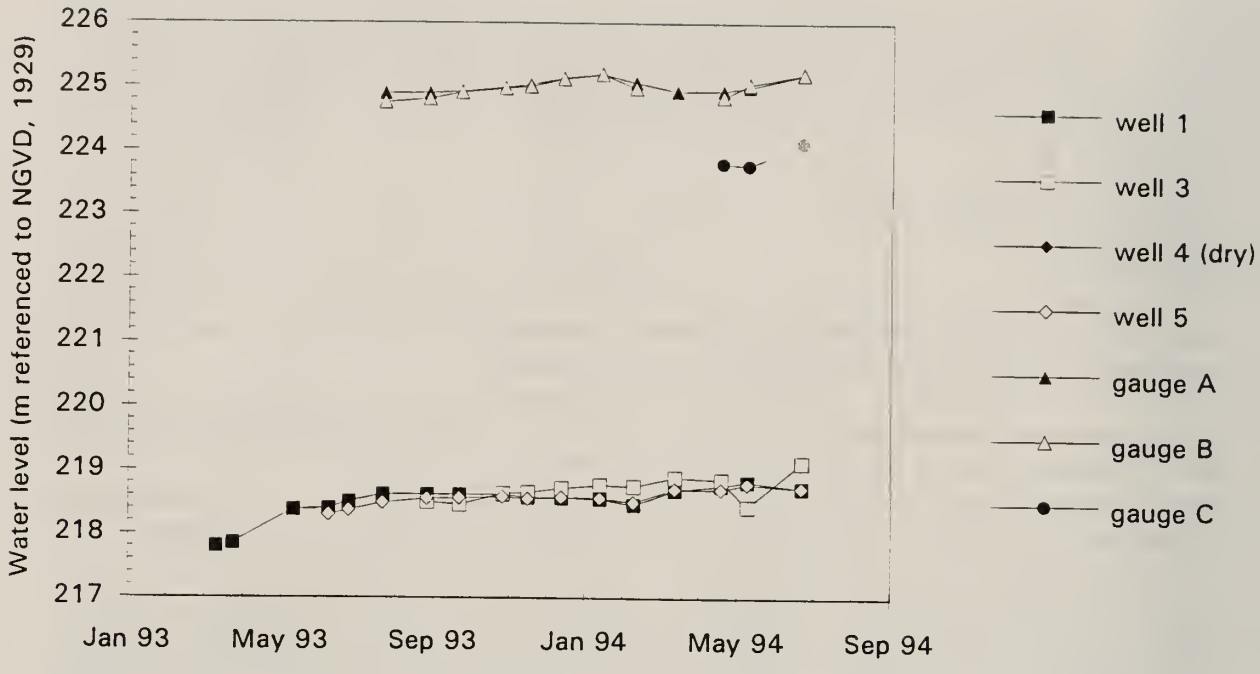

Figure 4 Hydrograph showing water-level elevations in wells and stage gauges in the study area during monitoring between March 1993 and June 1994.

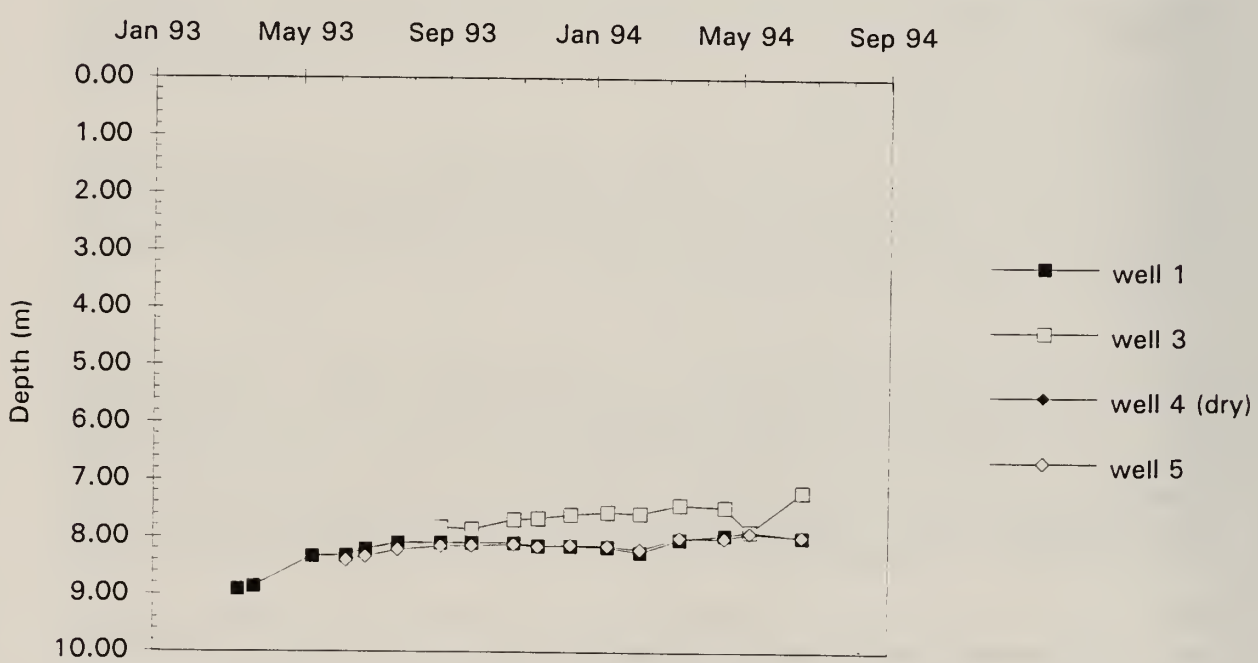

Figure 5 Chart showing depth to ground water, referenced to land surface, at each well site in the study area during monitoring between March 1993 and June 1994.

The bed of Klein Creek is incised approximately 1.5 m (5 ft) below the land surface in the study area north of Illinois Route 64 and increases to approximately 5 m (15 ft) near St. Charles Road on the south side of the parcel. During winter and after heavy rains, overbank flooding has been observed adjacent to Klein Creek in the present wetland area north of Illinois Route 64, but no adequate characterization of the elevation and duration of water levels has yet been made.

Present Wetlands

Present wetlands in the study area are located along the channel and floodplain of Klein Creek (fig. 2). The wetlands along Klein Creek appear to be supported by direct precipitation, overland flow, and overbank flooding from Klein Creek. Although no wells were installed in silty clay unit A, the stiff, laminated, clayey character of the deposit suggests that little water could be provided from this unit to sustain a wetland.

No wetlands were identified in isolated depressions elsewhere in the study area. Because of insufficient rainfall and the lack of catchment areas, it is unlikely that wetlands could be supported on this parcel, except where supplied by Klein Creek. No information regarding the presence of field tiles was available for this study.

Conclusions

Dense, low-permeability materials (silty clay unit A and upper diamicton unit B) are present to a depth of approximately 7 m in most of the study area. Klein Creek has partly eroded into these deposits, especially south of Illinois Route 64.

Sand and gravel unit C is unsaturated to a depth of approximately 8 to 9 m. Therefore, no upward gradient for ground-water flow was identified as evidence of ground-water/surface-water interaction. Additionally, ground-water levels indicate that flow in sand and gravel unit C is westward, indicating that no discharge occurs to Klein Creek.

The thin lenses of sand and gravel located within upper diamicton unit B and at the base of silty clay unit A were found to be discontinuous. The fact that there was no flow into well 4 from one of these lenses indicates that they do not appear to store or transmit significant amounts of water.

The primary surface-water source consists of Klein Creek, which is partially fed by a sewage treatment plant located on the east side of the parcel. This source is constant and did not freeze during the winters of 1992–93 or 1993–94. The creek bed is incised approximately 1.5 to 5 m (5–15 ft). Because the treatment plant provides a significant source of water to Klein Creek, uncertainties in future plant operation and capacity make it impossible to predict or guarantee water levels in perpetuity.

If the observed overbank flooding is sufficient to support the present wetlands along Klein Creek (fig. 2), then wetland creation at this site would require excavation to create additional low-lying areas that would receive flooding. It has not been determined, however, that overbank flooding from Klein Creek is the primary water source for the present wetlands. Continuous monitoring of water-level and flow volume of Klein Creek would be required to make this determination.

Monitoring

No sources of ground water that may be used to sustain a wetland have been identified in the study area. Therefore, measurement of ground-water levels will be discontinued

at this site as of June 1995, unless long-term monitoring is required by IDOT. Summaries of ground-water data will be submitted as required by IDOT.

Monthly measurement of the surface-water levels at this site will continue through June 1995, unless long-term monitoring is required by IDOT. Summaries of surface-water levels will be submitted as required by IDOT.

GEOCHEMISTRY

Collection Procedures

Because discharge from the Carol Stream sewage treatment plant most likely affects the water quality in Klein Creek, geochemical analysis was performed on grab samples collected quarterly from Klein Creek at stage gauge A (fig. 2). This discharge occurs less than 300 m (1,000 ft) upstream of stage gauge A.

Laboratory Procedures and Data

The water quality parameters measured in collected samples are listed in table 1. Details of analytical procedures are found in Cahill (1985). Results are reported in table 1.

Quality Control/Quality Assurance

Standard ISGS quality control/quality assurance (QA/QC) samples were included with samples submitted for analysis. The results were judged acceptable by ISGS QA/QC procedures.

Conclusions

Levels of nitrate and phosphate are elevated in the waters of Klein Creek. The presence of these nutrients is expected, given the proximity of discharge outlets from the Carol Stream sewage treatment plant. Results also indicate that a variety of metals and other constituents may be intermittently present; however, no constituent has been present at elevated levels in all screening samples. Loading rates of constituents cannot be calculated because no measurements were made of the flow rates and volume of Klein Creek. Therefore, it is not possible to discuss potential effects of these constituents on wetlands in the study area.

Monitoring

Sample collection will continue at quarterly intervals until the screening process is complete or no longer required by IDOT.

SUMMARY

A hydrogeologic characterization of the Klein Creek site has been completed, including a short-term program of monitoring ground- and surface-water levels and a geochemical screening of water from Klein Creek.

The geologic site characterization indicates that approximately 30 m (100 ft) of sediments cover bedrock in the parcel. Geologic borings indicate that the sediments are composed of two layers of diamictons (upper diamciton unit B and lower diamicton unit D) capped by a silty clay (silty clay unit A). West of Klein Creek, a large body of sand and gravel (sand and gravel unit C) occurs between the diamictons. A series of thin, discontinuous sand and gravel lenses occurs at the base of silty clay unit A.

Table 1 Results of water-chemistry analyses at Klein Creek. All values reported in mg/L (ppm) except temperature, specific conductivity, conductivity, pH, and Eh.

Laboratory Number	B-5583	W00020	W00025	Secondary Water Quality Standard
Sampling Date	06/25/93	01/25/94	04/25/94	
Water Quality Parameters				
Total dissolved carbon	28.70	36.80	39.70	
Inorganic dissolved carbon	57.10	55.90	91.60	
Dissolved organic carbon	85.80	92.70	131.30	
Total nitrogen	9.20	6.52	14.20	
Total Kjeldahl nitrogen	0.09	<0.01	12.79	
Ammonia nitrogen	0.20	0.12	5.46	
Nitrite nitrogen	<0.005	<0.005	<0.005	
Nitrate nitrogen	9.11	7.18	1.41	10
Ortho phosphorus	0.68	1.40	0.61	0.05
Total phosphorus	0.52	1.35	0.60	
Sulfate sulfur	50.45	55.27	54.50	250
Fluoride	0.46	<0.01	<0.01	
Chloride	107	342	172	500
Bromide	0.06	0.59	<0.01	
Total alkalinity	147	139	173	
Specific conductivity (in μS)	772	1,233	850	
Field Measured Parameters				
Conductivity (in μS)	710	1,580	830	
pH	7.7	7.4	7.9	6.5-9.0
Dissolved oxygen	6	X	9	5.0-6.0
Redox potential (Eh) (in ev)	122	217	205	
Temperature (in °C)	20.1	7.6	22.1	
ICP Analysis				
Aluminum	0.05	<0.02	0.06	
Arsenic	<0.1	0.10	<0.1	0.05
Boron	0.27	0.39	0.44	
Barium	0.02	0.02	0.02	1
Beryllium	<0.001	<0.001	<0.001	
Calcium	51.6	57.8	56.6	
Cadmium	<0.01	<0.01	<0.01	0.01
Cobalt	<0.01	<0.01	<0.01	
Chromium	<0.01	<0.01	<0.01	0.05
Copper	0.02	0.01	0.02	1
Iron	0.06	0.03	0.07	0.3

X Not determined

Table 1 *continued*

Laboratory Number	B-5583	W00020	W00025	Secondary Water Quality Standard
Sampling Date	06/25/93	01/25/94	04/25/94	
Potassium	9	9	9	
Lanthanum	<0.002	<0.002	<0.002	
Lithium	<0.01	0.01	0.01	
Magnesium	17.7	19.7	21.4	
Manganese	0.01	0.04	0.11	0.05
Molybdenum	<0.01	<0.02	<0.01	
Sodium	79.7	197.0	105.0	
Nickel	<0.03	<0.03	<0.03	1
Lead	<0.08	<0.08	<0.08	0.05
Antimony	<0.06	<0.01	<0.1	
Scandium	<0.003	<0.003	<0.003	
Selenium	<0.2	<0.1	0.30	0.01
Silicon	1.50	2.76	2.15	
Strontium	0.12	0.18	0.16	
Titanium	<0.01	<0.01	<0.01	
Thallium	<0.2	<0.01	<0.1	
Vanadium	<0.01	<0.01	<0.01	
Zinc	0.07	0.05	0.05	5
Zirconium	<0.01	<0.01	<0.01	

X Not determined

Wells were installed in sand and gravel unit C and in a lens within diamicton unit B to determine the character of the ground water at the site. The well in diamicton unit B has been dry since installation, indicating that no significant amounts of ground water are stored or transmitted by this lens. At the same time, the upper part of sand and gravel unit C was unsaturated and had water levels between 7.6 and 9.1 m (25 and 30 ft) below the land surface, indicating that artesian conditions were not present and no ground water was transmitted to the surface during this time. Because little ground-water/surface-water interaction was identified during this study, ground-water monitoring will be discontinued as of June 1995, unless long-term monitoring is required by IDOT.

Surface water was flowing in Klein Creek during all site visits from June 1992 through June 1994. Observations indicate that the water probably does not freeze in the winter. Overbank flooding into wetlands adjacent to Klein Creek has been noted in the study area. Discharge estimates and landowner statements indicate that the Carol Stream sewage treatment plant provides significant flow into Klein Creek. Elevated levels of nutrients and other constituents are found in Klein Creek. Unpredictable future changes in discharge may greatly affect the design criteria and success of the mitigation site. These factors indicate that it may not be appropriate to use Klein Creek as a water source for wetland

mitigation. Monitoring of the water levels in Klein Creek will continue through June 1995, unless long-term monitoring is required by IDOT.

Existing wetlands are likely supported by overland flow, direct precipitation, and overbank flooding along the banks of Klein Creek. Excavation of a low-lying area that would receive overbank flooding from Klein Creek may be necessary to support created wetlands in the study area.

If surface water is to be used in mitigation, then automated, continuous monitoring may be required for adequate characterization of flow levels in Klein Creek for design purposes. Estimates of overland flow and precipitation will have to be made to project amounts and seasonal patterns of water that might be available from other sources. The appropriate IDOT personnel will be consulted prior to the commencement of these activities.

Geochemical screening of Klein Creek waters collected quarterly will continue through June 1995, unless long-term screening is required by IDOT. Summaries of ground- and surface-water levels and geochemical data collected through June 1995 will be submitted as required by IDOT.

ACKNOWLEDGMENTS

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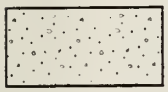
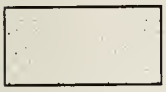
APPENDIX A Geologic Cross Sections and Logs of Borings at Klein Creek Site
Part 1 Index of Geologic Symbols


Gravel
(includes boulders, cobbles, pebbles, and granules)


Sandy gravel


Sand and gravel


Sand


Silty sand


Silty clay sand


Clayey sand


Sandy silt


Silt


Clayey silt

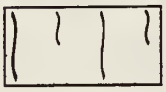

Silty clay


Clay


Diamicton


Peat

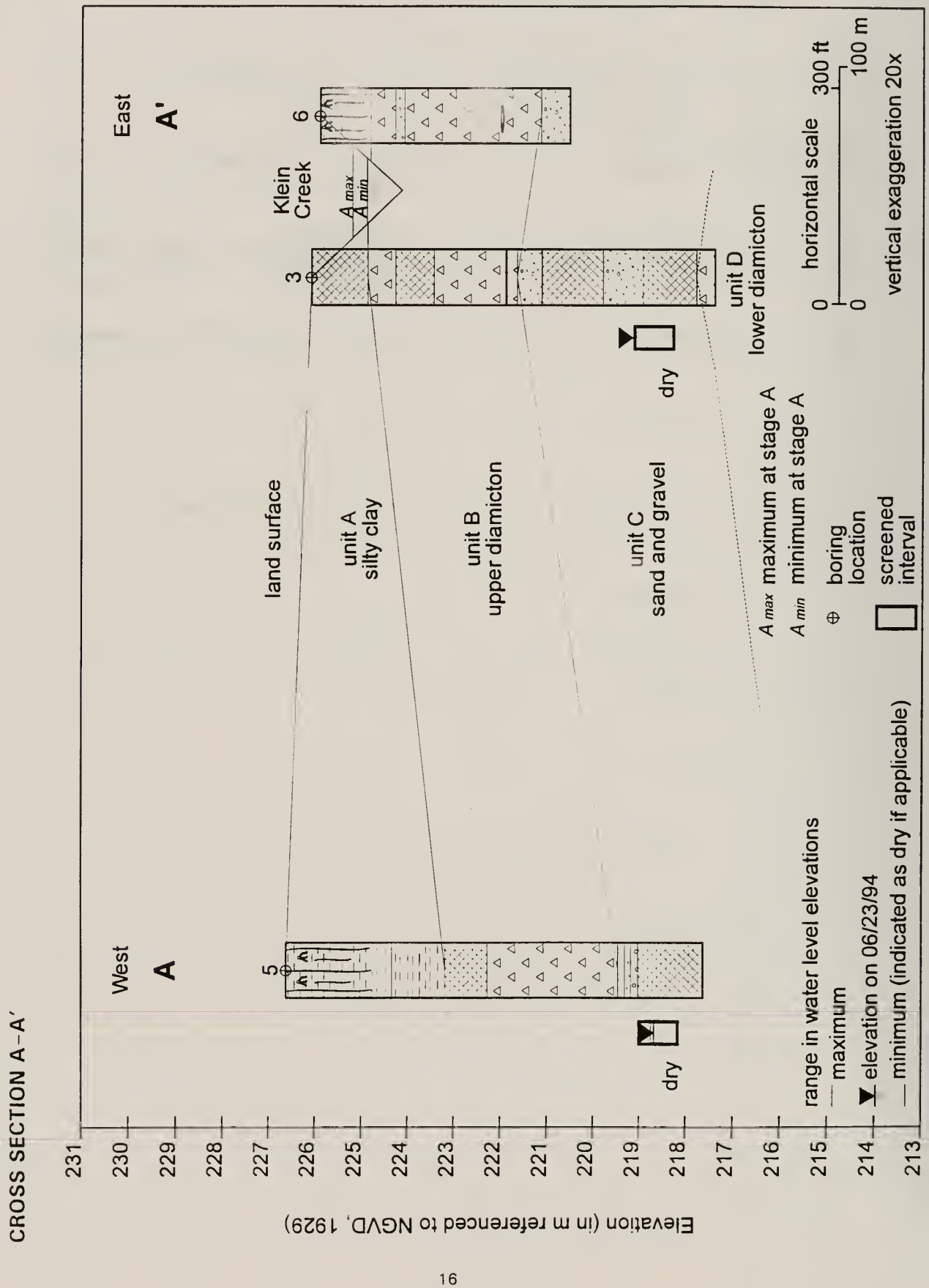

Black organic material


Depth of soil development


Roots

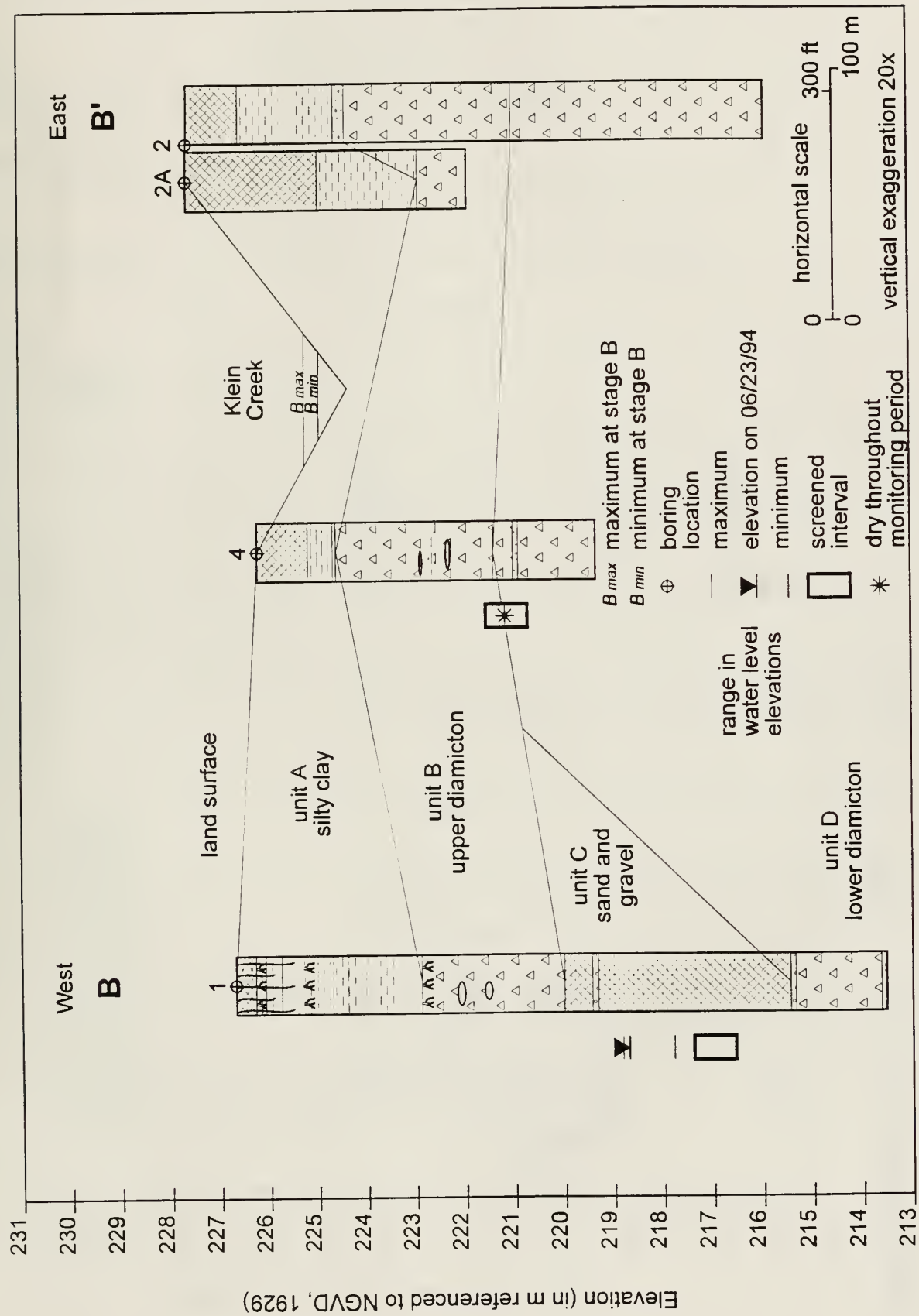

No recovery

Part 2 Geologic Cross Sections (lines of cross section shown in figure 2)

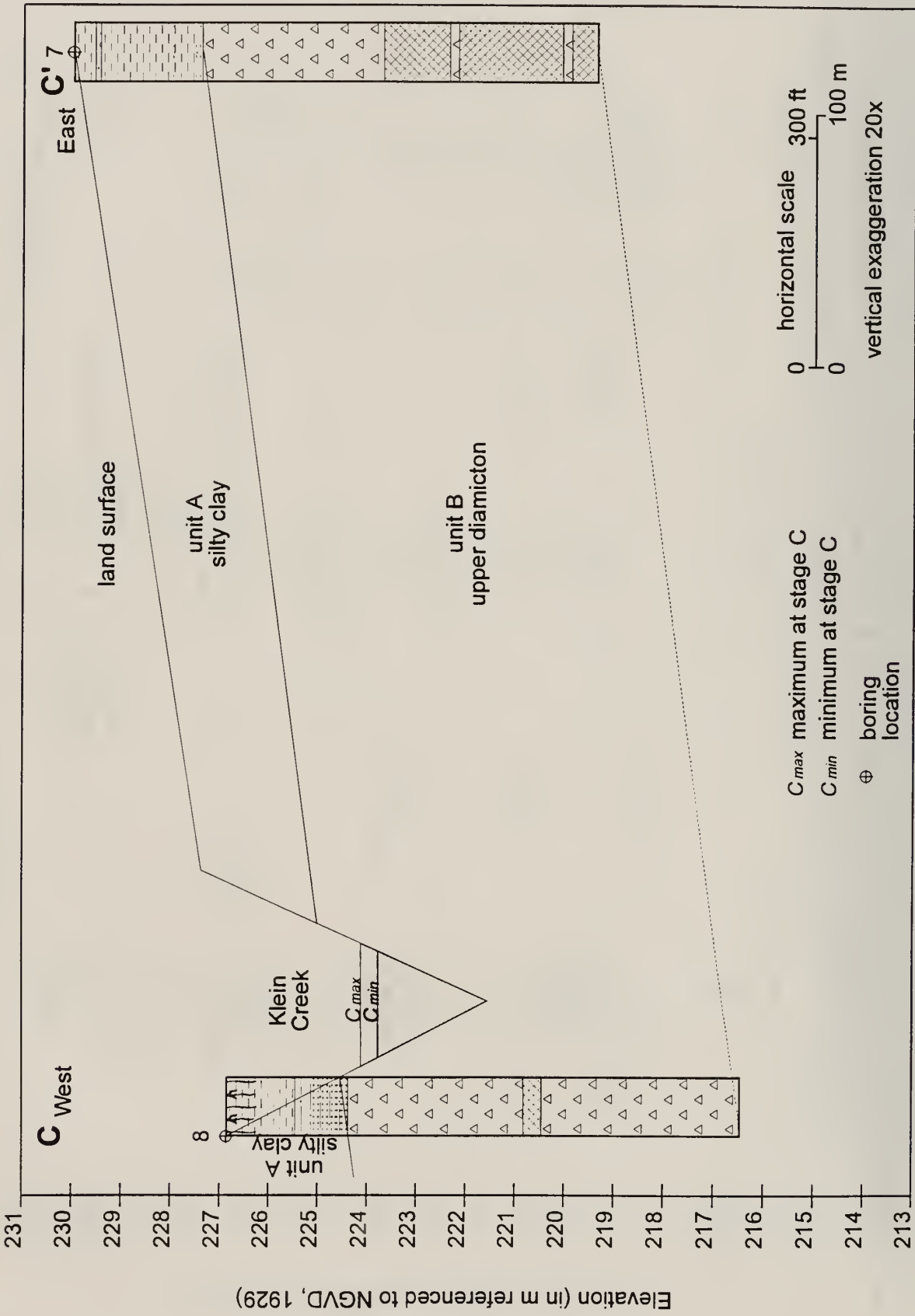


APPENDIX A *continued*

Part 2 **Geologic Cross Sections** (lines of cross section shown in figure 2)

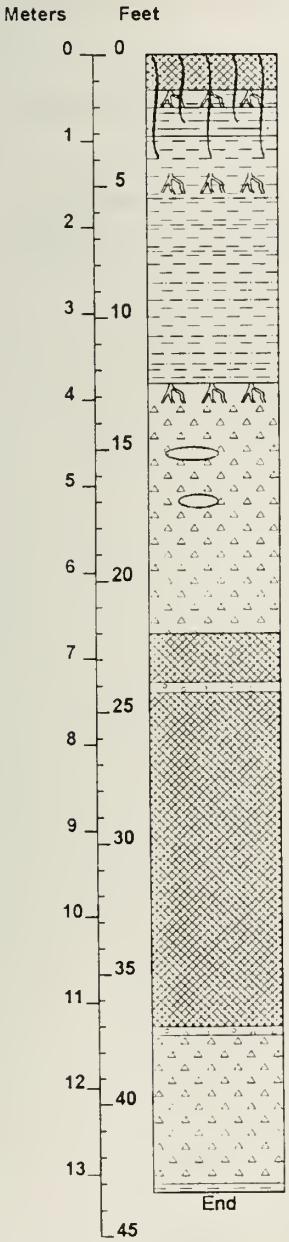


Part 2 Geologic Cross Sections (lines of cross section shown in figure 2)



KLEIN CREEK #1

Location NW NW SW Sec. 31, T40N, R10E, West Chicago, Illinois
Date 02/16/93 1:00 PM and 02/17/93 9:00 AM
Field Crew Tim Young, Mark Hart, Jim Miner
Weather Conditions Sunny, 15° F
Comments Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler 23 m (75 ft) north of the centerline of Illinois Route 64, 61 m (200 ft) east of motel
Well Information One well installed; construction information in Appendix B

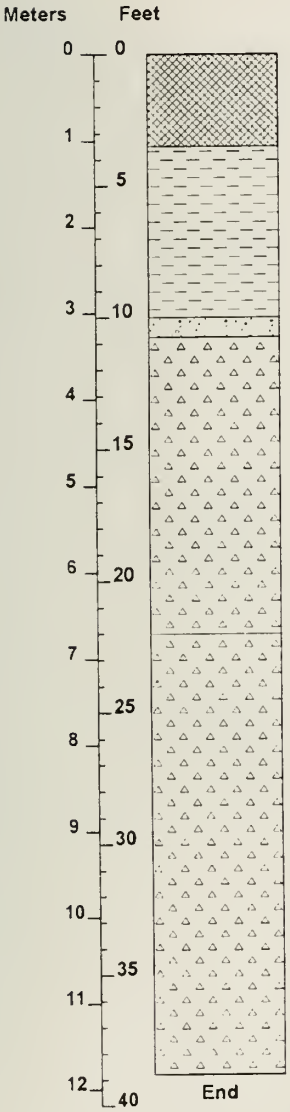


Depth	Unit Descriptions
0.00– 0.41 m (0.00– 1.33 ft)	**No recovery**; frozen ground.
0.41– 0.51 m (1.33– 1.67 ft)	**Silty clay**; very dark gray (10YR 3/1); organic; noncalcareous; structureless; many roots.
0.51– 0.61 m (1.67– 2.00 ft)	**Silty clay**; light olive gray (5Y 6/2), platy structure.
0.61– 0.94 m (2.00– 3.08 ft)	**Clayey silt**; light olive gray (5Y 6/2) with yellowish brown (10YR 5/8) mottles; crumb structure.
0.94– 1.47 m (3.08– 4.83 ft)	**Silty clay**; dark gray (5Y 4/1) with yellowish brown (10YR 5/8) mottles; blocky peds; noncalcareous; structureless; roots; rare pebbles 10 mm (0.39 in.) in diameter in last 0.41 m (16 in.); laminated. Gradual contact to:
1.47– 1.58 m (4.83– 5.17 ft)	**Silty clay**; black (5Y 2.5/1); organic; soft; roots; noncalcareous; layered with above deposit. Sharp contact to:
1.58– 2.67 m (5.17– 8.75 ft)	**Silty clay**; olive gray (5Y 5/2); calcareous; laminated; laminae are 1 mm (0.039 in.) thick, consist of brown (7.5YR 4/4) silt and are spaced 13–51 mm (0.5–2.0 in.) apart; upper 0.15 m (0.5 feet) mottled.
2.67– 3.81 m (8.75–12.50 ft)	**Silty clay**; same as above, but laminae are spaced 13 mm (0.5 in.) apart; no mottling; rare silt lens, 3 mm (0.12 in.) thick, at 3.48 m (11.42 feet); in last 25 mm, (1.0 in.), laminae grade to thicker, fine sand, silty clay, and diamicton. Gradual lower contact to:

Depth	Unit Descriptions
3.81– 6.71 m (12.50–22.00 ft)	**Diamicton;** silty loam to silty clay texture; gray (10YR 5/1); very dense; less than 5% is pebbles of dolomite, shale, granitics; pebble diameter less than 5 mm (0.20 in.); calcareous; upper 0.25 m (0.83 feet) has oxidized root zones; sand lenses at 4.62–4.67 and 5.16–5.18 m (15.17–15.33 and 16.92–17.00 feet).
6.71– 7.29 m (22.00–23.92 ft)	**No recovery;** refusal of sampler; center bit drilled.
7.29– 7.39 m (23.92–24.25 ft)	**Gravel;** 5–30 mm (0.20–1.18 in.) in diameter; clean; no sand; subangular; dolomite, shale, granitics.
7.39–11.28 m (24.25–37.00 ft)	**No recovery;** center bit drilled; driller reports sand and gravel.
11.28–11.38 m (37.00–37.33 ft)	**Granules;** slightly rounded; well sorted; noncalcareous; dolomite, shale, granitics.
11.38–13.11 m (37.33–43.00 ft)	**Diamicton;** silty clay texture; dark gray (5Y 4/1); calcareous; sheared appearance when cut; rare dolomite pebbles 10 mm (0.39 in.) in diameter; rare granule layers 1 mm (0.039 in.) thick.
13.11–13.21 m (43.00–43.33 ft)	**Silty clay;** laminated, 10 mm (0.39 in.) thick, by color and texture; weakly calcareous; soft; moist.

KLEIN CREEK #2

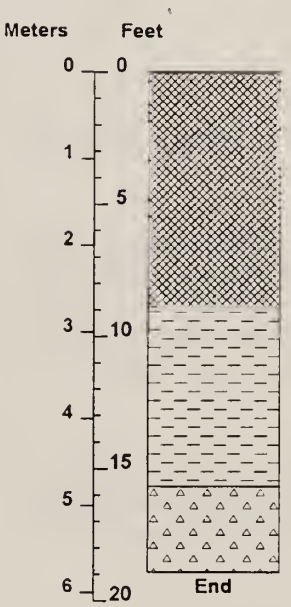
Location NE NW SW Sec. 31, T40N, R10E, West Chicago, Illinois
Date 02/18/93 12:00 PM
Field Crew Tim Young, Mark Hart, Jim Miner
Weather Conditions Sunny, very cold, high winds, 0° F
Comments Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler
30 m (100 ft) north of the centerline of Illinois Route 64,
30 m (100 ft) west of the centerline of Kuhn Road
Well Information No well installed



Depth	Unit Descriptions
0.00– 1.09 m (0.00– 3.58 ft)	**No recovery;** frozen ground; center bit drilled; cuttings consist of black silty clay.
1.09– 3.07 m (3.58–10.08 ft)	**Silty clay;** calcareous; dry; stiff; conchoidal fracture when split; upper 0.53 m (1.75 feet) strong brown (7.5YR 5/6) with light gray (7.5YR 7/1) mottles; slightly finer texture downward; lower portion laminated with 1-mm (0.039-in.) laminae of silt and fine sand. Gradual laminated lower contact to:
3.07– 3.28 m (10.08–10.75 ft)	**Sand and gravel;** laminated with 13 mm (0.5 in.) layers of fine sand alternating with coarse sand, granules and pebbles; weakly calcareous; rounded and subrounded clasts in each laminae. Sharp contact to:
3.28– 6.71 m (10.75–22.00 ft)	**Diamicton;** silty loam texture; gray (5Y 5/1); 3% consisting of 10 mm (0.39 in.) pebbles including shale, quartzite, granitics, and dolomite with glacial striae and fractures; variable stiffness in zones about 0.20 m (0.67 feet) in length, stiff, dry zones with less sand alternate with softer, moist zones with more sand; weakly calcareous; top 10 mm (0.39 in.) is oxidized reddish brown; 10 mm (0.39 in.) lens of gray, medium sand at 3.83 m (12.58 feet). Sharp lower contact to:
6.71–11.83 m (22.00–38.80 ft)	**Diamicton;** loam texture; gray (5Y 5/1); weakly calcareous; 10% consisting of pebbles including shale, dolomite and granitics; very dense; at 7.06–7.11 m (23.17–23.33 feet), a lens of laminated clayey sand is present, laminae are 3 mm (0.12 in.) thick and are poorly sorted; cobbles up to 70 mm (2.8 in.) noted; at 7.11–7.80 m (23.33–25.58 feet), color is grayish brown (10YR 5/2), less dense.

KLEIN CREEK #2A

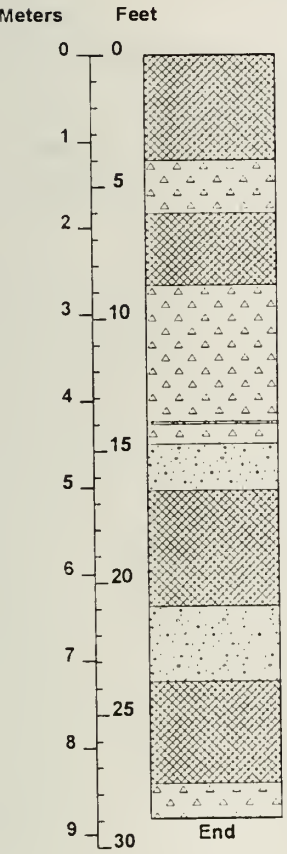
Location NE NW SW Sec. 31, T40N, R10E, West Chicago, Illinois
Date 02/19/93 11:00 AM
Field Crew Tim Young, Mark Hart, Jim Miner
Weather Conditions Windy, 15° F
Comments Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler
15 m (50 ft) west of Klein Creek #2
Well Information No well installed



Depth	Unit Descriptions
0.00– 2.72 m (0.00– 8.92 ft)	**No recovery;** center bit drilled.
2.72– 4.67 m (8.92–15.33 ft)	**Silty clay**; gray (5Y 5/1); calcareous; laminated in last inch. Sharp lower contact to:
4.67– 5.77 m (15.33–18.92 ft)	**Diamicton**; sandy loam texture; gray (5Y 5/1).

KLEIN CREEK #3

Location SE SW NW Sec. 31, T40N, R10E, West Chicago, Illinois
Date 02/24/93 10:00 AM
Field Crew Tim Young, Mark Hart, Jim Miner
Weather Conditions Sunny, high wind, 5° F
Comments Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler
244 m (800 ft) north of the centerline of Illinois Route 64,
61 m (200 ft) west of the centerline of Kuhn Road
Well Information One well installed; construction information in Appendix B



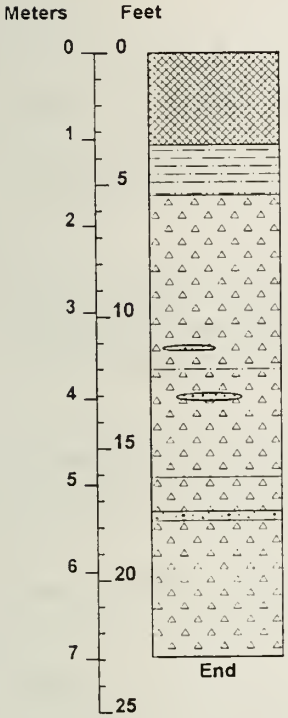
Depth	Unit Descriptions
0.00– 1.24 m (0.00– 4.08 ft)	**No recovery;** frozen ground; center bit drilled.
1.24– 1.85 m (4.08– 6.08 ft)	**Diamicton;** loam texture; gray (5Y 6/1) with yellowish brown (10YR 5/4) root zones; 1% is pebbles up to 50 mm (2.0 in.) in diameter; highly calcareous; very dry; very dense. Hit rock at 1.85 m (6.08 feet).
1.85– 2.67 m (6.08– 8.75 ft)	**No recovery;** using center bit drill to dislodge rock.
2.67– 3.79 m (8.75–12.42 ft)	**Diamicton;** same as above; platy structure when cut; colors as described above are reversed; last 0.46 m (1.50 feet) has vertically mixed zone, half above unit, half below.
3.79– 4.24 m (12.42–13.92 ft)	**Diamicton;** silty clay loam texture; gray (5Y 5/1); soft; moderately calcareous; platy structure; 1–3% is pebbles of shale, dolomite, chert, and granitics from 20–60 mm (0.78–2.4 in.) in diameter; slightly moist. Sharp lower contact to:
4.24– 4.27 m (13.92–14.00 ft)	**Sand and gravel;** 20–50 mm (0.78–2.0 in.) in diameter; olive gray (5Y 4/2); calcareous; dry; slightly rounded and subrounded; some clay. Sharp lower contact to:
4.27– 4.50 m (14.00–14.75 ft)	**Diamicton;** same as 3.79–4.24 m (12.42–13.92 ft); contains a sand and gravel lens 20 mm (0.78 in.) thick at 4.34 m (14.25 ft) which is similar to 4.24–4.27 m (13.92–14.00 ft).
4.50– 4.52 m (14.75–14.83 ft)	**Coarse sand and granules;** rounded and subrounded; high pore space; bedded; dry to slightly moist.
4.52– 4.75 m (14.83–15.58 ft)	**Laminated sand and gravel;** laminae consist of fine sand alternating with granules; clean; bedded; dry to slightly moist.

KLEIN CREEK #3 *continued*

Depth	Unit Descriptions
4.75– 5.03 m (15.58–16.50 ft)	**Sand and gravel;** pebbles and cobbles from 50–100 mm (2.0–3.9 in.) in diameter; mixed with silt and clay; bedded; dry to slightly moist.
5.03– 6.38 m (16.50–20.92 ft)	**No recovery;** using center bit drill to clear cobbles.
6.38– 7.24 m (20.92–23.75 ft)	**Sand and gravel;** similar to 4.75–5.03 m (15.58–16.50 ft); pebbles and cobbles from 10–100 mm (0.39–3.9 in.) in diameter consisting of dolomite, shale and granitics; dry. Sampler stopped; switching to center bit drill.
7.24– 8.41 m (23.75–27.58 ft)	**No recovery;** using center bit drill; driller reports gravel.
8.41– 8.81 m (27.58–28.92 ft)	**Diamicton;** silty clay texture; dark gray (5Y 4/1); weakly calcareous; 1% is pebbles of dolomite and shale; platy structure when split.

KLEIN CREEK #4

Location NE NW SW Sec. 31, T40N, R10E, West Chicago, Illinois
Date 02/24–25/93 3:00 PM
Field Crew Tim Young, Mark Hart, Jim Miner
Weather Conditions Overcast, snowy, windy, 20° F
Comments Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler
30 m (100 ft) north of the centerline of Illinois Route 64,
23 m (75 ft) west of Klein Creek
Well Information One well installed; construction information in Appendix B

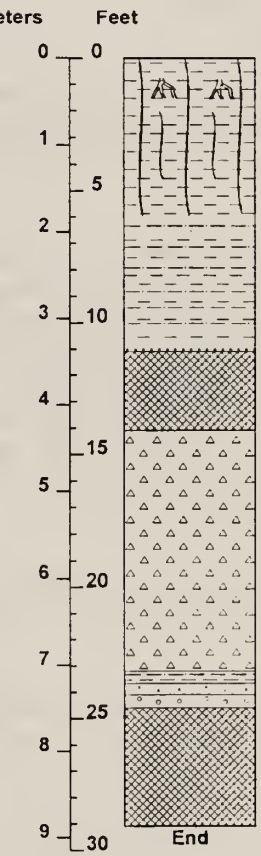


Depth	Unit Descriptions
0.00– 1.07 m (0.00– 3.50 ft)	**No recovery;** frozen ground; center bit drilled.
1.07– 1.65 m (3.50– 5.42 ft)	**Silt**; upper 0.46 m (1.50 ft) mottled reddish yellow (7.5YR 6/6) matrix with gray (5Y 5/1) root zones; fine sandy laminated silt in lower 0.05 m (0.17 ft) Sharp lower contact to:
1.65– 4.90 m (5.42–16.08 ft)	**Diamicton**; silty clay loam texture; dark gray (5Y 4/1), but brown (10YR 5/3) in upper 0.46 m (1.5 ft); calcareous; platy structure; 1–3% is pebbles of dolomite, shale and granitics; stiff texture; alternating zones with higher sand or silt content; oxidized zone at 2.26–2.31 m (7.42–7.58 ft); oxidized sandy pebble lens at 3.35–3.38 m (11.00–11.08 ft); silt layer at 3.61–3.68 m (11.83–12.08 ft); granule-rich lens at 3.91–3.96 m (12.83–13.00 ft). Sharp lower contact to:
4.90– 5.31 m (16.08–17.42 ft)	**Diamicton;** loam texture; dark gray (5Y 4/1); 10% is pebbles of dolomite 20–50 mm (0.78–2.0 in.) in diameter; moist with saturated zones; calcareous.
5.31– 5.41 m (17.42–17.75 ft)	**Sand and gravel;** dark gray (5Y 4/1); saturated; mostly granule-sized clasts; rounded and subrounded. Sharp lower contact to:
5.41– 6.99 m (17.75–22.92 ft)	**Diamicton**; silty clay loam texture; dark gray (5Y 4/1); calcareous; 1–3% is pebbles of primarily dolomite 20–50 mm (0.78–2.0 in.) in diameter; dry; platy structure; very stiff.

APPENDIX A *continued*
Part 3 **Geologic Logs of Borings**

KLEIN CREEK #5

Location SW SW NW Sec. 31, T40N, R10E, West Chicago, Illinois
Date 03/02/93 8:00 AM
Field Crew Tim Young, Mark Hart, Jim Miner
Weather Conditions Fog, calm winds, 35° F
Comments Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler 305 m (1000 ft) north of the centerline of Illinois Route 64, 15 m (50 ft) east of motel
Well Information One well installed; construction information in Appendix B



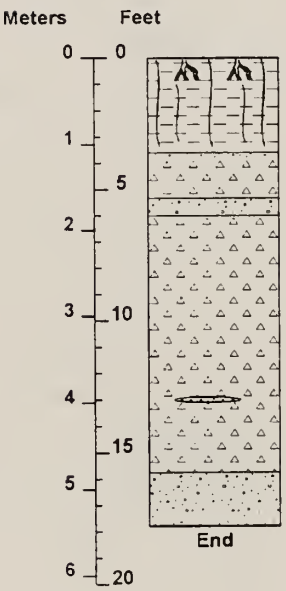
Depth	Unit Descriptions
0.00– 0.28 m (0.00– 0.92 ft)	**Silty clay;** black (5Y 2.5/1); organic; rooty O-horizon; noncalcareous; platy structure.
0.28– 0.46 m (0.92– 1.50 ft)	**Silty clay;** very dark gray (5Y 3/1); rooty; crumb structure.
0.46– 0.53 m (1.50– 1.75 ft)	**Silty clay;** greenish gray (5GY 6/1) with reddish yellow (5YR 6/8) mottles; increased sand and granule content; noncalcareous; rooty; crumb structure. Sharp lower contact to:
0.53– 1.91 m (1.75– 6.25 ft)	**Silty clay;** greenish gray (5GY 6/1) with reddish yellow (7.5YR 6/8) mottles; slightly calcareous in last 0.41 m (1.33 ft). Sharp lower contact to:
1.91– 1.96 m (6.25– 6.42 ft)	**Silty clay;** dark gray (5Y 4/1); noncalcareous. Sharp lower contact to:
1.96– 3.39 m (6.42–11.12 ft)	**Silty clay;** dark gray (5Y 4/1); laminated with 1–3 mm (0.039–0.12 in.) laminae of silt alternating with fine sand; laminae spaced 6–9 mm (0.25–0.75 in.) apart, possibly finer laminae between those; calcareous; dry; laminae are brown near top, gray at base, increasing in thickness to 6 mm (0.25 in.) of fine to medium sand with rounded and sub-rounded grains; small pebbles at base.
3.39– 4.29 m (11.12–14.08 ft)	**No recovery;** sample refusal in barrel.
4.29– 7.06 m (14.08–23.17 ft)	**Diamicton;** silty clay texture; dark gray (5Y 4/1); calcareous; 1–3% is pebbles of chert, dolomite and shale 10–20 mm (0.39–0.79 in.) in diameter, about 10% is sand. Sample ribboned due to rock blocking sampler aperture; top 0.05 m (0.17 ft) is clayey sand and gravel; poorly sub-rounded and rounded; moist; final 0.36 m (1.17 feet) contains 5–10% pebbles including green schist and micas. Sharp lower contact to:

KLEIN CREEK #5 *continued*

Depth	Unit Descriptions
7.06– 7.21 m (23.17–23.67 ft)	**Coarse silt**; dark gray (5Y 4/1); 5 mm (0.02 in.) thick laminae; poorly calcareous. Sharp lower contact to:
7.21– 7.34 m (23.67–24.08 ft)	**Very coarse sand**; gray; 0.23–2 mm (0.01–0.08 in.) in diameter; subrounded and subangular; noncalcareous; bedded 50 mm (2.0 in.) thick by grain size; wet, but not saturated; tightly packed.
7.34– 7.49 m (24.08–24.58 ft)	**Coarse gravel**; 30–50 mm (1.2–2.0 in.) in diameter; clean.
7.49– 8.86 m (24.58–29.08 ft)	**No recovery**; center bit drilled; driller reports gravel.

KLEIN CREEK #6

Location SE SW NW Sec. 31, T40N, R10E, West Chicago, Illinois
Date 03/03/93 9:00 AM
Field Crew Tim Young, Mark Hart, Jim Miner
Weather Conditions Cloudy, 30° F
Comments Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler
274 m (900 ft) north of the centerline of Illinois Route 64,
15 m (50 ft) west of the centerline of Kuhn Road
Well Information No well installed

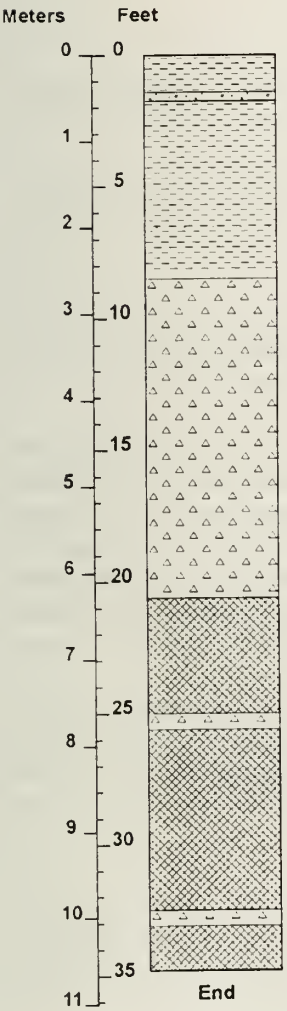


Depth	Unit Descriptions
0.00– 0.25 m (0.00– 0.83 ft)	**Silty clay;** black (2.5YR 2/0) O-horizon; noncalcareous; rooted; crumb structure. Gradual lower contact to:
0.25– 1.04 m (0.83– 3.42 ft)	**Silty clay;** olive gray (5Y 4/2) with yellowish brown (10YR 5/8) mottles; noncalcareous; rooted; fine crumb structure; increasing sand content in last 0.05 m (0.17 feet). Sharp contact to:
1.04– 1.62 m (3.42– 5.33 ft)	**Diamicton;** silt loam texture; yellowish brown (10YR 5/4) with olive gray (5Y 4/2) mottles; noncalcareous; 5% is pebbles of dolomite and shale 10 mm (0.39 in.) in diameter; top 0.02 m (0.08 feet) is sandy granule layer. Sharp contact to:
1.62– 1.83 m (5.33– 6.00 ft)	**Sand and gravel;** yellowish brown (10YR 5/4); noncalcareous; wet, but not saturated; slightly subrounded to rounded. Sharp contact to:
1.83– 4.80 m (6.00–15.75 ft)	**Diamicton;** silty loam to silty clay loam texture; yellowish brown (10YR 5/4) to 3.10 m (10.17 feet), then dark gray (5Y 4/1); calcareous; 3–5% is pebbles of dolomite, shale, quartzite and biotite; stiff; dry; structureless; 25 mm (1 in.) lens of fine, saturated gravel at 3.96 m (13.00 feet); last 0.18 m (0.58 feet) is sandy with 10% pebbles.
4.80– 5.43 m (15.75–17.83 ft)	**Sand and gravel;** nonsaturated; bedded with gravel 10–20 mm (0.39–0.79 in.) in diameter alternating with medium to coarse sand; subrounded and rounded; open pore spaces.

APPENDIX A *continued*
Part 3 Geologic Logs of Borings

KLEIN CREEK #7

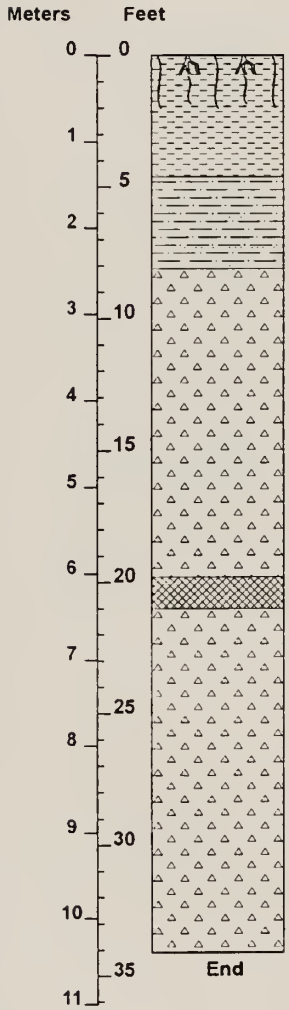
Location SE SW SW Sec. 31, T40N, R10E, West Chicago, Illinois
Date 03/03/93 9:00 AM
Field Crew Jim Neal, Christine Fucciolo
Weather Conditions Cloudy, 40° F
Comments Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler
Well Information No well installed



Depth	Unit Descriptions
0.00– 0.29 m (0.00– 0.96 ft)	**Silty clay**; black.
0.29– 0.42 m (0.96– 1.38 ft)	**Silty clay**; brownish.
0.42– 0.53 m (1.38– 1.75 ft)	**Sand and gravel.**
0.53– 1.97 m (1.75– 6.46 ft)	**Silty clay**; brownish
1.97– 2.01 m (6.46– 6.58 ft)	**Sand and gravel.**
2.01– 2.60 m (6.58– 8.54 ft)	**Silty clay**; brownish; sand and gravel lenses at 2.46 m (8.08 ft) and 2.57 m (8.42 ft).
2.60– 6.29 m (8.54–20.63 ft)	**Diamicton**; grayish; gravel layer at 5.22–5.30 m (17.13–17.38 ft).
6.29– 7.62 m (20.63–25.00 ft)	**No recovery.**
7.62– 7.80 m (25.00–25.58 ft)	**Diamicton**; grayish; wet.
7.80– 9.91 m (25.58–32.50 ft)	**No recovery.**
9.91–10.08 m (32.50–33.08 ft)	**Diamicton**; grayish; wet.
10.08–10.62 m (33.08–34.83 ft)	**No recovery.**

KLEIN CREEK #8

Location NW SE SW Sec. 31, T40N, R10E, West Chicago, Illinois
Date 11/17/93
Field Crew Jim Neal, Christine Fucciolo, Jim Miner
Weather Conditions Windy, 35° F, cloudy in the morning, sunny in the afternoon
Comments Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler
Well Information No well installed



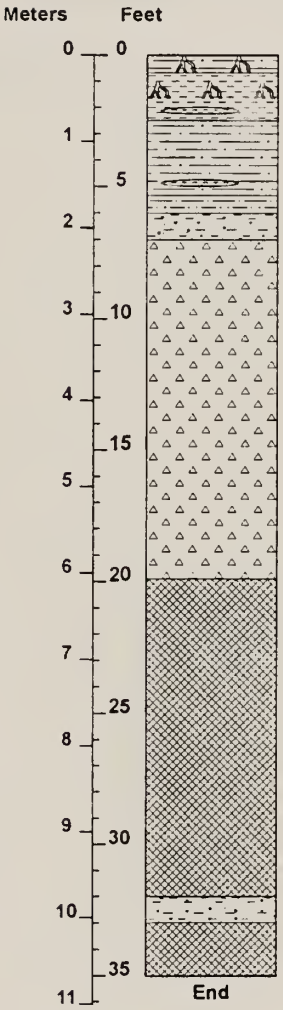
Depth	Unit Descriptions
0.00– 0.51 m (0.00– 1.67 ft)	**Silty clay;** black (10YR 2/1); noncalcareous; nonlaminated; rooty. Gradual color change at 0.51 m (1.67 ft) to:
0.51– 0.89 m (1.67– 2.92 ft)	**Silty clay;** brown (10YR 4/3); noncalcareous; nonlaminated; slightly mottled with dark yellowish brown (10YR 4/6) root zones.
0.89– 1.40 m (2.92– 4.58 ft)	**Silty clay;** yellowish brown (10YR 5/4) and brownish yellow (10YR 6/8); laminated at 1–2 mm (0.04–0.08 in.) intervals by color and texture; noncalcareous.
1.40– 2.46 m (4.58– 8.08 ft)	**Silt;** brownish yellow (10YR 6/8) and yellowish brown (10YR 5/4); laminated by color; calcareous; at 1.80 m (5.92 ft), grades into sandy silt; laminated at 3–5 mm (0.12–0.20 in.) intervals by color and texture; brownish yellow (10YR 6/8) sandy laminae alternate with yellowish brown (10YR 5/4) silty laminae; sand laminae thicken toward base with rare layers up to 50 mm (1.97 in.) thick.
2.46– 2.59 m (8.08– 8.50 ft)	**Diamicton;** silty clay loam texture; dark yellowish brown (10YR 4/4); weakly calcareous; sandy: wet; stiff; some brownish yellow (10YR 6/8) mottles; approximately 1–3% is pebbles of dolomite and shale up to 10 mm (0.39 in.) in diameter.
2.59– 3.25 m (8.50–10.67 ft)	**Diamicton;** silty clay loam texture; dark grayish brown (10YR 4/2); very stiff; weakly calcareous; slightly laminated by color from gray to brown; approximately 1–3% is pebbles of dolomite and shale up to 10 mm (0.39 in.) in diameter.
3.25– 6.05 m (10.67–19.83 ft)	**Diamicton;** silt loam to silty clay loam texture; gray (10YR 5/1); calcareous; structureless; approximately 1–5% is pebbles of dolomite up to 10 mm (0.39 in.) in diameter and very small pebbles of shale.

KLEIN CREEK #8 *continued*

Depth	Unit Descriptions
6.05– 6.40 m (19.83–21.00 ft)	**No recovery**; center bit drilling to remove rock.
6.40– 7.42 m (21.00–24.33 ft)	**Diamicton**; silty clay loam texture; dark gray (10YR 4/1); less stiff than above diamicton unit; very calcareous; no visible pebbles greater than 5 mm (0.20 in.) in diameter; structureless.
7.42–10.39 m (24.33–34.08 ft)	**Diamicton**; same as 6.40–7.42 m (21.00–24.33 ft), but some platyness when cut.

KLEIN CREEK #9

Location	SW NW SW Sec. 31, T40N, R10E, West Chicago, Illinois
Date	11/18/93
Field Crew	Jim Neal, Christine Fucciolo, Jim Miner
Weather Conditions	Foggy, 30° F
Comments	Mobile rig, hollow-stem auger, continuous 1.5-m (5-ft) sampler
Well Information	No well installed



Depth	Unit Descriptions
0.00– 0.20 m (0.00– 0.67 ft)	**Clayey silt;** black (10YR 2/1); noncalcareous; organic with roots; no soil structure. Gradual contact to:
0.20– 0.48 m (0.67– 1.58 ft)	**Silty clay;** dark gray (10YR 4/1); noncalcareous; rooty; fine crumb structure. Gradual contact to:
0.48– 0.76 m (1.58– 2.50 ft)	**Silty clay;** grayish brown (2.5Y 5/2); noncalcareous; coarse crumb structure; has burrows filled with black soil; at 0.64–0.66 m (2.08–2.17 ft) sandy silty clay lens with gravel up to 3 mm (0.12 in.) in diameter is present; gravel is rounded and nonsorted; some very slight tiny orange mottles are present, perhaps representing oxidized rootlets. Gradual lower contact to:
0.76– 1.02 m (2.50– 3.33 ft)	**Clayey silt;** grayish brown (2.5Y 5/2) mottled with yellowish brown (10YR 5/6) oxidized rooty zones; noncalcareous; subangular fine blocky structure. Gradual contact to:
1.02– 1.63 m (3.33– 5.33 ft)	**Clayey silt;** grayish brown (2.5Y 5/2) with yellowish brown (10YR 5/6) mottles; possibly laminated by texture (silt alternating with clay); at 1.47–1.50 m (4.83–4.92 ft) sandy clayey silt lens which is grayish brown (2.5Y 5/2) and structureless; definitely laminated at 1.57–1.63 m (5.17–5.33 ft); laminae are 3–5 mm (0.12–0.20 in.) thick. Gradual lower contact to:
1.63– 1.80 m (5.33– 5.92 ft)	**Silt;** slightly sandy; sand is fine; gray (2.5Y 6/1) matrix with yellowish brown (10YR 5/8) mottles; calcareous; coarse crumb structure; slight lamination in the manner deposit breaks; coarsens gradually downward to sandy silt at 1.75 m (5.75 ft). Grades into:
1.80– 2.13 m (5.92– 7.00 ft)	**Silty sand and gravel;** yellowish brown (10YR 5/6); slightly silty; gravel up to 30 mm (1.18 in.) in diameter; gravel is subrounded to well rounded, sorted, and consists of chert, shale and degraded green sandstone.

KLEIN CREEK #9 *continued*

Depth	Unit Descriptions
2.13– 2.64 m (7.00– 8.67 ft)	**Diamicton**; silty loam to silty clay loam texture; approximately 1–3% is pebbles of dolomite up to 20 mm (0.79 in.) in diameter and small shale pebbles; structureless; 2.13–2.18 m (7.00–7.17 ft), weathered brownish yellow (10YR 5/6), noncalcareous; 2.18–2.64 m (7.17–8.67 ft), gray (10YR 5/1); weakly calcareous; stiff.
2.64– 4.24 m (8.67–13.92 ft)	**Diamicton**; similar to 2.18–2.64 m (7.17–8.67 ft), but calcareous.
4.24– 5.84 m (13.92–19.17 ft)	**Diamicton**; gray (10YR 5/1); calcareous; approximately 1–5% is pebbles of dolomite shale and crystalline rocks up to 50 mm (1.97 in.) in diameter; character alternates between dry, stiff, silty clay loam texture and wet, sandier, less, stiff silty clay loam texture; structureless; sand may be in lenses; larger pebbles are bullet-shaped.
5.84– 9.75 m (19.17–32.00 ft)	**No recovery.**
9.75–10.06 m (32.00–33.00 ft)	**Silty sand and gravel**; gray (10YR 6/1), silty sand with gravel up to 50 mm (1.97 in.) in diameter; pebbles are mostly dolomite; some pebbles are bullet shaped and striated.
10.06–10.67 m (33.00–35.00 ft)	**No recovery.**

APPENDIX B Well Construction Information

Table B1 Construction information for monitoring wells.

	Well 1	Well 3	Well 4	Well 5
Elevation of top of well (m, NGVD, 1929)	227.53	226.99	226.98	227.37
Land surface elevation (m, NGVD, 1929)	226.72	226.33	226.32	226.71
Total length of well (m)	10.87	8.61	6.38	9.25
Stick up (m)	0.81	0.66	0.66	0.66
Screen length (m)	0.69	0.69	0.69	0.69
Depth of borehole**	13.21	8.81	6.93	8.86
Depth of well**	10.06	8.05	5.89	8.56
Concrete seal—top**	0.00	0.00	0.00	0.00
Concrete seal—bottom**	0.61	0.61	0.61	0.61
Bentonite seal—top**	0.61	0.61	0.61	0.61
Bentonite seal—bottom**	8.53	2.13	4.37	*
Cuttings—top**	NA	2.13	NA	*
Cuttings—bottom**	NA	7.11	NA	*
Bentonite seal—top**	NA	NA	NA	*
Bentonite seal —bottom**	NA	NA	NA	*
Sand pack—top**	8.53	7.11	4.37	7.62
Sand pack—bottom**	10.67	8.20	5.89	8.56
Bentonite seal—top**	NA	8.20	NA	NA
Bentonite seal—bottom**	NA	8.81	NA	NA
Depth to top of screen**	9.32	7.21	4.98	7.82
Depth to bottom of screen**	10.01	7.90	5.67	8.51
Depth to bottom of well point**	10.06	7.95	5.72	8.59
Screened unit(s)	unit C sand and gravel	unit C sand and gravel	unit B and D upper and lower diamictons	unit C sand and gravel

NA Not applicable
* Data not available
** Reported in m below land surface

APPENDIX C Water-Level Elevations and Depths to Water Below Land Surface

Table C1 Water-level elevations referenced to NGVD, 1929 (in m).

	Well 1	Well 3	Well 4	Well 5	Gauge A	Gauge B	Gauge C
03/12/93	217.80	dry	dry	dry	*	*	*
03/25/93	217.86	dry	dry	dry	*	*	*
05/12/93	218.38	dry	dry	dry	*	*	*
06/09/93	218.40	dry	dry	218.30	*	*	*
06/25/93	218.51	dry	dry	218.37	*	*	*
07/22/93	218.62	dry	dry	218.49	224.90	224.75	*
08/27/93	218.62	218.50	dry	218.55	224.90	224.81	*
09/22/93	218.62	218.47	dry	218.56	224.92	224.91	*
10/27/93	218.62	218.64	dry	218.58	224.99	224.98	*
11/16/93	218.57	218.66	dry	218.55	225.03	225.01	*
12/13/93	218.57	218.72	dry	218.57	225.14	225.13	*
01/13/94	218.55	218.77	dry	218.56	225.20	225.20	*
02/09/94	218.46	218.75	dry	218.50	225.07	224.99	*
03/14/94	218.69	218.90	dry	218.71	224.94	**	*
04/20/94	218.77	218.86	dry	218.70	224.95	224.85	223.81
05/11/94	218.83	218.44	dry	218.79	225.01	225.05	223.78
06/23/94	218.72	219.13	dry	218.73	225.21	225.21	224.13

* Not yet installed

** No measurement

APPENDIX C *continued*

Table C2 Depth to water in monitoring wells referenced to land surface (in m).

	Well 1	Well 3	Well 4	Well 5
03/12/93	8.92	dry	dry	dry
03/25/93	8.86	dry	dry	dry
05/12/93	8.34	dry	dry	dry
06/09/93	8.32	dry	dry	8.41
06/25/93	8.21	dry	dry	8.34
07/22/93	8.10	dry	dry	8.22
08/27/93	8.10	7.83	dry	8.16
09/22/93	8.10	7.86	dry	8.15
10/27/93	8.10	7.69	dry	8.13
11/16/93	8.15	7.67	dry	8.16
12/13/93	8.15	7.61	dry	8.14
01/13/94	8.17	7.56	dry	8.15
02/09/94	8.26	7.58	dry	8.21
03/14/94	8.03	7.43	dry	8.00
04/20/94	7.95	7.47	dry	8.01
05/11/94	7.89	7.89	dry	7.92
06/23/94	8.00	7.20	dry	7.98