THE VAN PATTEN WOODS POTENTIAL WETLAND MITIGATION SITE:
INTERIM HYDROGEOLOGIC CHARACTERIZATION REPORT

Illinois Route 173, Rosecrans
Lake County, Illinois
(Federal Aid Project 303)

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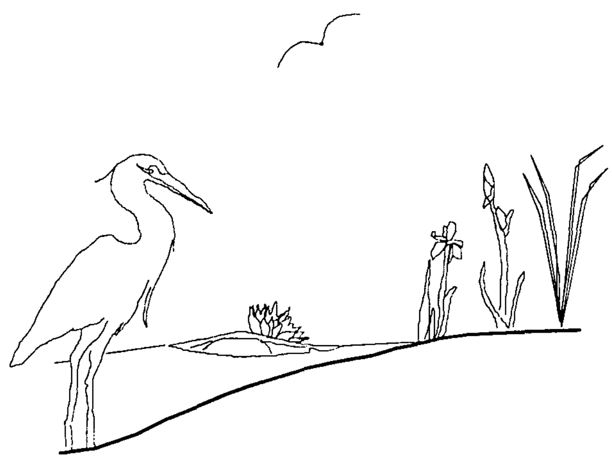

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INTRODUCTION

This interim report was prepared by the Illinois State Geological Survey (ISGS) to provide the Illinois Department of Transportation (IDOT) with preliminary information regarding the hydrogeologic characterization of the proposed wetland mitigation site described below. The report provides geologic and hydrologic data for the project area, and describes planned monitoring.

IDOT has requested that the ISGS determine the suitability of the study area for wetland mitigation. Surface- and ground-water levels will be monitored through May 1996 or until no longer required by IDOT. A final hydrogeologic characterization report containing all of the characterization and monitoring results will be sent at the end of the monitoring period.

The study area (fig. 1) is located in S1/2, Sec. 10 and NW 1/4, Sec. 15, T46N, R11E,

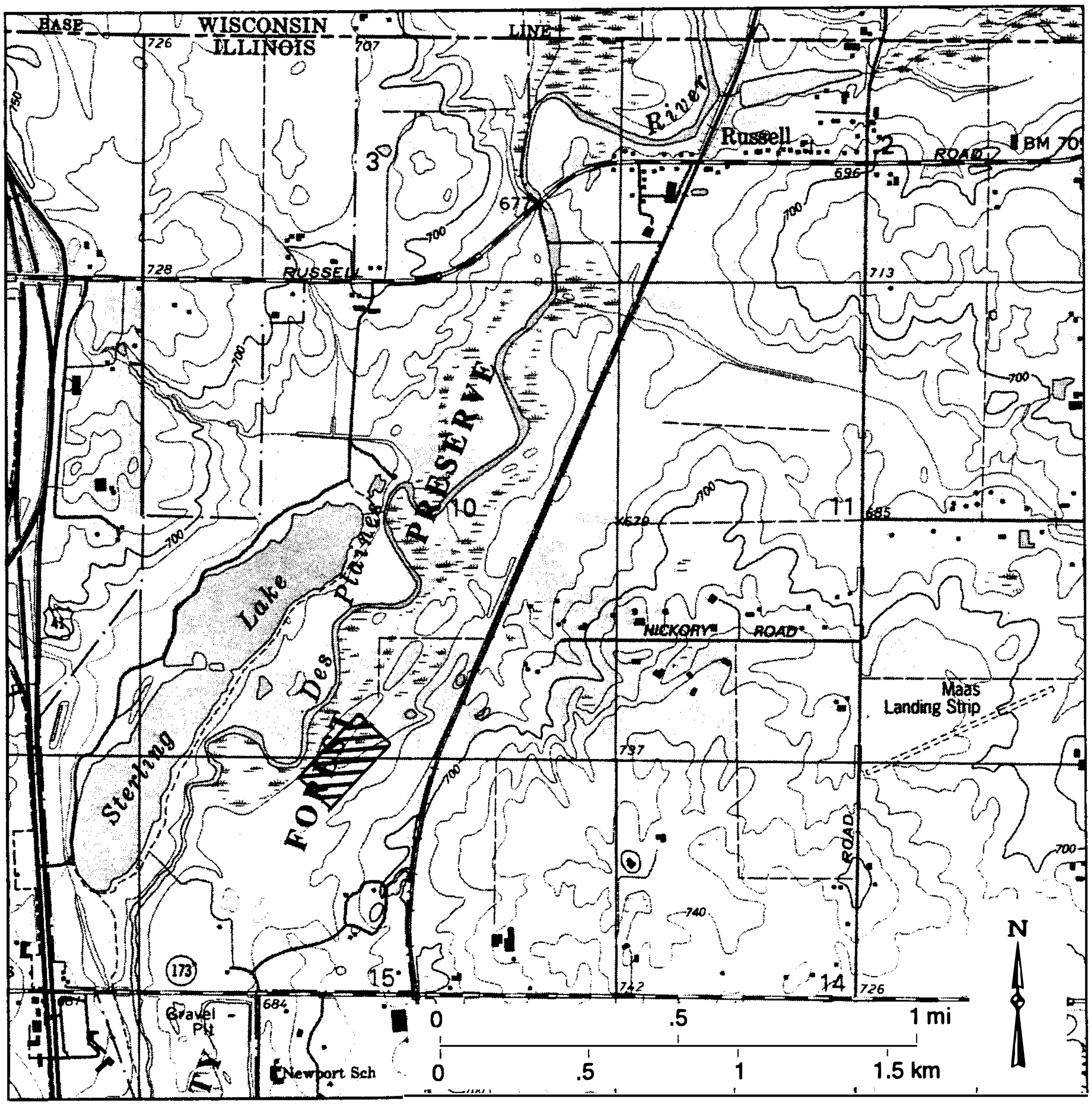
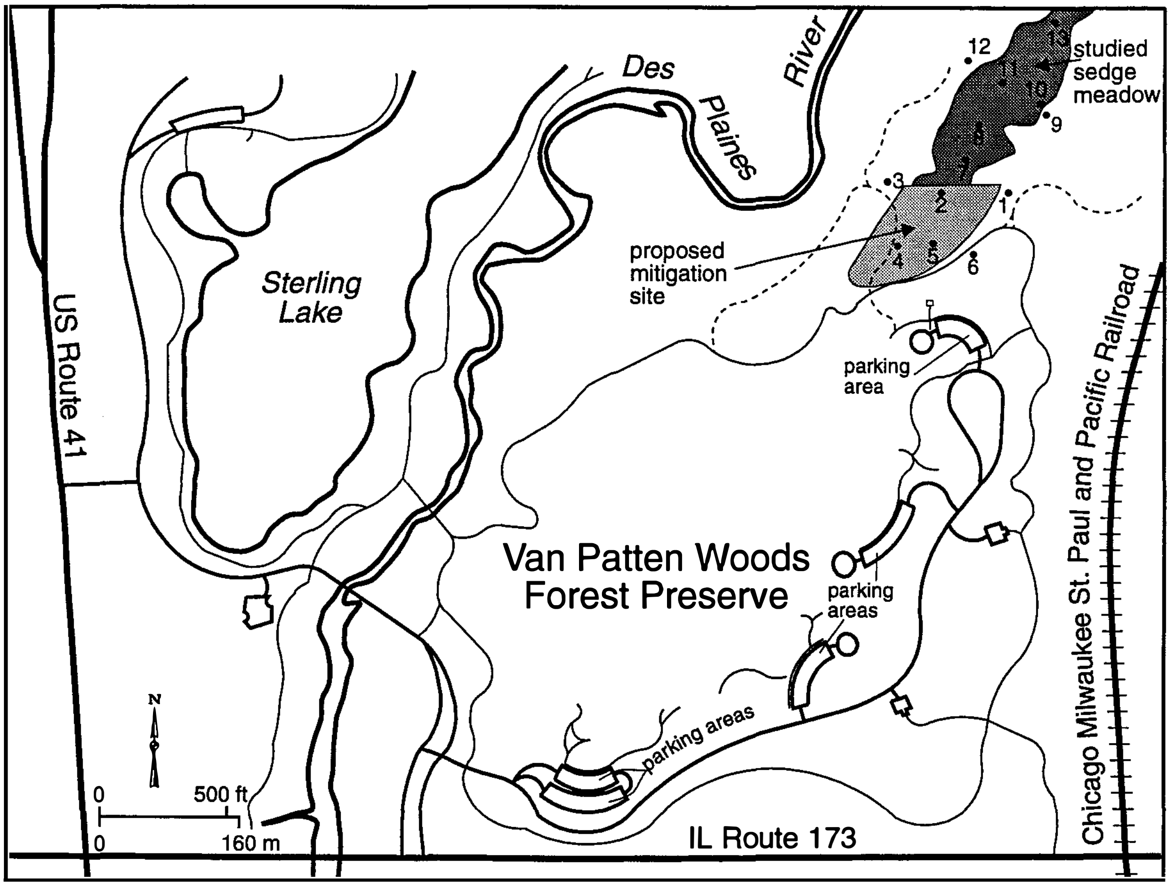


Figure 1 Location map showing the study area (outlined) on the Wadsworth, IL–WI, 7.5-minute topographic map (U.S. Geological Survey 1993). Contour interval is 10 ft (3 m).



• geologic boring — gravel trail

asphalt road ------- grass trail

Figure 2 Site map showing the proposed mitigation site, the studied sedge meadow, and the locations of geologic borings made in this study. Map based on USGS (1993) and a Lake County Forest Preserve map of Van Patten Woods (date unknown).

approximately 1 kilometer (km) (0.6 mile) (mi) northeast of the intersection of U.S. Route 41 and Illinois Route 173 near Rosecrans, Illinois. The site is located within the Des Plaines River valley in the Van Patten Woods Forest Preserve, and is managed by the Lake County Forest Preserve District.

The Van Patten Woods site contains the proposed mitigation site and an adjacent natural wetland (sedge meadow) to the north (fig. 2). The purpose of this report is to identify the hydrogeologic conditions present in the mitigation site and the sedge meadow, and to compare any differences in order to evaluate the potential for successful wetland creation in the mitigation area. The sources of water that support the sedge meadow will be evaluated to assist in the design of the mitigation site.

METHODS

The geology of the study area was characterized by drilling 13 borings (fig. 2) using various methods as required by site conditions. Six borings (1–6) were made in and adjacent to the mitigation site using a Mobile B-30S drilling rig, which collected a continuous, 100-millimeter (mm) (4-inch) (in.) diameter core using a 1.5-meter (m) (5-foot) (ft) long split-spoon sampler. Within and adjacent to the sedge meadow to the north, seven borings (7–13) were made using a hand auger 75 mm (3 in.) in diameter. Geologic logs for each boring were prepared, and are shown in Appendix A. Cross sections are also included in Appendix A, showing each unit of sediment encountered. Locations of lines of cross-section are shown in figure 3.

The hydrology of the site is being characterized by measuring ground-water levels in monitoring wells (fig. 3) installed at various depths in selected geologic borings. The ISGS is monitoring the wells monthly, and Rebecca Reid, a graduate student from Northern Illinois University (NIU) is monitoring the wells weekly. Monitoring wells 1 through 6 (U and L) (upper and lower screened intervals) were installed through the hollow-stem auger of the Mobile drill rig. Monitoring wells 1 through 12 (S) (soil-zone screened interval) and 7 through 13 (S and L) were installed in open boreholes made using a hand auger. Surface-water levels are being measured at a stage gauge located within the sedge meadow (fig. 3). Water-level elevations and depths to water in wells and on the stage gauge are reported in Appendix B. A standard, manual rain gauge is located in the sedge meadow to measure input from rainfall.

Well casing and screen for wells 1 through 6 (U and L), 12 (L), and 13 (L) consisted of 5.1-cm (2-in.) diameter PVC pipe; all other wells were constructed of 2.54-cm (1-in.) diameter PVC pipe. Well screens were between 0.30 and 0.75 m (1.0–2.5 ft) in length, and contained slots 0.25 mm (0.01 in.) thick. Well screens were packed with quartz sand 0.25 to 0.50 mm (0.01–0.20 in.) in diameter. Borings were then backfilled to the surface with bentonite. Wells were developed by surging the wells with a surge block then pumping the wells with a peristaltic pump until clear water was obtained. Cross sections showing the screened intervals of each well are shown in Appendix A. Appendix C lists all well construction measurements. The relative elevations of the stage gauge and wells were determined by leveling to third-order accuracy using a Sokkia B-1 automatic level and a fiberglass extending rod. A benchmark was established on site at an arbitrary elevation of 100.00 m (328.1 ft). The benchmark is a chiseled square located on the southeast corner of the concrete pad supporting an outhouse approximately 50 m (160 ft) south of the site.

GEOLOGY

Regional Setting

Bedrock

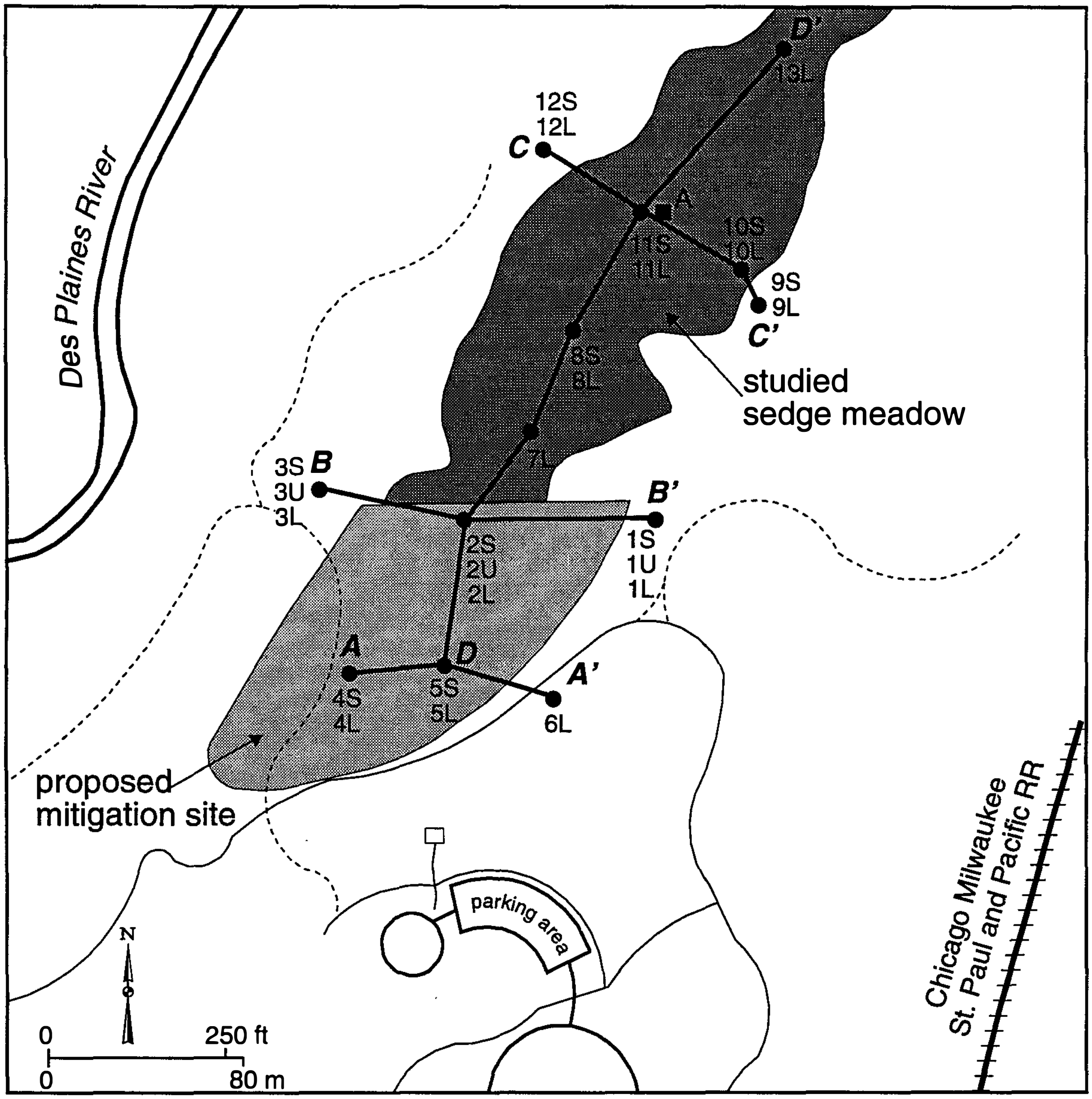
The uppermost bedrock unit in the study area consists of silty and shaly dolomites of the Silurian System (Willman et al. 1967). Bedrock units dip to the east approximately 4.0 m/km (21.5 ft/mi) (Willman 1971). The bedrock surface slopes to the east-southeast toward a bedrock valley that slopes eastward toward Lake Michigan (Herzog et al. 1994).

Topography

Total relief of the site (fig. 1) is approximately 3 m (10 ft) (U.S. Geological Survey 1993). The general land surface of the site slopes from the uplands on the east toward the Des Plaines River on the west. However, the mitigation site and the sedge meadow are located in a small trough that trends northeast-southwest and slopes to the northeast.

Sediments

Bedrock in the study area is overlain by unlithified Quaternary sediments approximately 45 to 60 m (150–200 ft) thick (Piskin and Bergstrom 1975, and ISGS well records on file).



● geologic boring and monitoring well(s)
■ stage gauge
—— asphalt road
—— gravel trail
------- grass trail

Figure 3 Site map showing the locations of monitoring wells, lines of cross section, and the stage gauge.

On the east side of the study area, sediments are mapped (Berg and Kempton 1988) as silty and clayey diamictons of the Wedron Formation of the Wisconsinan Stage. Diamicton is a term used to describe all very poorly sorted sediments, such as glacial tills and debris flows, without implying the origin of the deposit. On the west side of the study area, multiple sedimentary units have been mapped. From the surface downward, they consist of: less than 6 m (20 ft) of clay, silt, and sand of the Cahokia Alluvium, greater than 6 m (20 ft) of silt and clay of the Carmi Member of the Equality Formation, and less than 6 m (20 ft) each of sand and gravel of the Henry Formation and silty and clayey diamictons of the Wedron Formation. Other sediments may be present below these units as well.

Soils

Soils in the mitigation area are mapped as Nappannee silt loam (228B), Morley silt loam (194B), Zurich silt loam (696C2), and Hennepin loam (25F) (U.S. Department of Agriculture 1970); these soils are not listed as hydric by the Natural Resources Conservation Service (NRCS) (U. S. Department of Agriculture 1991). Soils in the sedge meadow are mapped as Sawmill silty clay loam (107), which is listed as hydric.

Regional Geologic History

The sediments at this site reflect the effects of several late Wisconsinan glaciers that advanced across the site. In places, each glacier partially eroded the deposits of earlier glaciers and deposited glacial till and outwash on top of the remaining sediment.

Sediments to the east of the study area are glacial tills of the Wedron Formation that were deposited in narrow, closely-spaced moraines that trend north-south in this area (Willman 1971). To the west of the site, glacial meltwaters were carried in the Des Plaines River valley and deposited sand and gravel outwash. In addition, lakes formed in proglacial positions and in outwash valleys dammed by glacial ice or sediments, leading to the deposition of lacustrine sediments that are also found in the area (Willman 1971).

Site Characterization

Cross sections showing site geology are presented in Appendix A. The lowermost layer of sediments encountered during drilling comprises silty clay, clayey silt, and sandy silt (unit A), and is up to approximately 7 m (23 ft) thick. This unit, which likely underlies the entire site, has a variable character. In boring 3, the unit contains two sequences of bedded, varve-like sandy silts separated by a structureless clayey silt. This may indicate glaciers approaching the site and depositing coarser sediment in a proglacial lake. Unit A is partially or completely overlain by unit B in the central and eastern parts of the site.

Unit B is a diamicton that in general has the characteristics of Wadsworth Till (Willman and Frye 1970). Unit B occurs at the surface in the eastern part of the site adjacent to well 1, but intertongues with and is buried by sediments of unit A in the central part of the site; it does not occur in the western part of the site. Unit B is stratified in places, indicating that some of the sediment may have been transported as mudflows after deposition. The glacier that deposited this diamicton was likely the source of the sand and varve-like sediments in unit A. Unit B is up to approximately 6.5 m (21.3 ft) thick.

Unit C is a sand and gravel body that overlies unit A in the western part of the site and unit B in the central part of the site; the unit does not occur in the eastern part of the site. Unit A is up to approximately 4.5 m (14.8 ft) thick. In the sedge meadow area, pyrite crystals occur in this unit and may be postdepositional in origin, formed in the reducing conditions of the wetland. The stratigraphic relationships shown on the cross sections suggest that unit C was deposited in a former river channel that eroded downward into the sediments of units A and B. This channel may have at one time been part of a river system that carried meltwaters in the Des Plaines River valley and then was abandoned during later river downcutting.

Unit D is a clayey silt that overlies unit C. It is absent in the eastern part of the site. The unit is approximately 0.5 m (1.6 ft) thick. The color of this unit changes according to the landscape position, from brown in upland areas to olive and black in sedge meadow areas. The genesis of the deposit is not known, but it may have formed through deposition in an occasionally flooded backwater or cutoff channel.

Overlying unit D is unit E, a variably textured unit exposed at the surface in the western and central parts of the site. This unit is sandy silt in upland areas, and grades into muck in the sedge meadow. This unit also includes an organic mat comprising lake sedge (*Carex lacustris*) and other wetland plants at the surface in the central parts of the sedge meadow that are more regularly inundated; this mat contains little clastic material. This unit is up to approximately 0.5 m (1.6 ft) thick.

Conclusions

The sediments at this site record a series of events of Late Wisconsinan age. Unit A is a sandy to clayey silt lacustrine deposit that is likely classified as part of the Carmi Member of the Equality Formation (Woodfordian substage). This lake was likely in a proglacial position as shown by the rhythmic, varvelike bedding indicating an adjacent, fluctuating source of coarse clastic material such as that produced by a glacier.

Unit B is a diamicton, likely deposited as a glacial till, that shows some stratification that may indicate reworking of the glacial deposits by other processes. This deposit represents a glacial advance into the study area from the east. This glacier advanced into the proglacial lake, producing the rhythmic deposits in unit A and likely forming mudflows that produced the stratification in unit B. The glacial advance extended to the center of the site, where the diamicton ends and intertongues with unit A. Unit A continued to be deposited during and after the glacial advance. Unit B is likely classified as part of the Wadsworth Till Member of the Wedron Formation (Woodfordian substage).

Meltwaters produced by the retreating glacier and by other glacial advances east and north of the site deposited sand and gravel outwash materials in the valley of the present Des Plaines River. Unit C was deposited at this time over the western and central parts of the site in a side channel or meander bend that eroded into the preexisting sediments of units A and B. Unit C probably extends both north and south of the study area (Willman 1971). During the evolution of the Des Plaines River valley, subsequent erosion and downcutting likely caused abandonment of the side channel. Unit C is likely part of the Mackinaw Member of the Henry Formation (Woodfordian substage).

After meltwater was no longer carried regularly in the river channel that deposited unit C, a backwater lake or marsh may have existed in the former channel. A certain amount of floodwater may have flowed irregularly into this channel, depositing a clayey silt (unit D) over the western and central parts of the site. The uncertain genesis of unit D does not permit stratigraphic classification of this deposit.

Unit E reflects the present depositional environment. It includes the organic mat and muck deposited in the sedge meadow, and the sandy silt deposited in the uplands in the western and central parts of the site. Little clastic material is being deposited at present in the regularly inundated parts of the sedge meadow. The wetland deposits would likely be classified as part of the Grayslake Peat, and are likely Holocene in age.

HYDROLOGY

Regional Setting

Water-well records for this area indicate that water for some private homes is withdrawn from various sand and gravel layers interbedded in glacial tills and other glacial sediments at depths of approximately 12 to 43 m (40–140 ft). Other wells in the region withdraw water from carbonate bedrock at depths of approximately 45 to 60 m (150–200 ft).

Regional slope and surface-water flow is from the uplands east of the site toward the Des Plaines River to the west. The Des Plaines River flows to the south. Total topographic relief between the crest of the slope 1.5 km to the east and the Des Plaines River directly adjacent to the site on the west is approximately 25 m (80 ft). Local surface-water flow is toward the mitigation site and the sedge meadow from the east, south, and west and then northward. A small, ephemeral stream channel drains into the wetland from the southeast, and may supply sufficient clastic material to affect the plant assemblage at the discharge point (S. Simon, Illinois Natural History Survey, pers. comm.). In general, local and regional ground-water flow is expected to mimic surface-water flow patterns.

Climate

Total annual precipitation in the region is approximately 83 cm (32.5 in.), and is highest in the spring and summer months (U.S. Department of Agriculture 1970). Most ground-water recharge is estimated to occur during spring, fall and winter when precipitation is moderate or high and when evapotranspiration is low (Hensel 1992).

The growing season is defined as the period of time when soil temperatures exceed 5°C (41°F) at a depth of 0.5 m (20 in.) (U.S. Army Corps of Engineers 1987). The growing season can also be defined as the period between the last killing frost of the spring and the first killing frost of the fall. A killing frost occurs at an air temperature of -2.2°C (28°F). However, these two measures often give different results, so calculations using each method will be made.

Air temperature data from the Soil Survey, Lake County, Illinois (U.S. Department of Agriculture 1970) indicate that the average last occurrence of air temperatures of -2.2°C (28°F) in the spring is April 23, and the average first occurrence in the fall is October 10. This gives an average growing season of 170 days. These weather data are an average of conditions recorded at Antioch, approximately 13 km (8 mi) to the west, and Waukegan, approximately 9 km (5 mi) to the southeast.

Soil temperature data are not widely available for Illinois, and can vary greatly depending on the orientation or aspect, amount of shading, and landscape position of the recording site. Data indicate that the growing season begins at the Morton Arboretum on approximately March 24 (P. Kelsey, Morton Arboretum, pers. comm.). The Arboretum is approximately 80 km (50 mi.) south of the mitigation site. Therefore an estimated correction factor of 7 days is needed. Based on soil temperature data, the approximate the start of the growing season at Van Patten Woods is April 1. Given that this is 23 days earlier than calculated using air temperature data, 23 days are also added to extend the end of the growing season to November 2. This makes a growing season of 213 days based on soil temperature data.

Observations at this site in 1995, indicated that wetland vegetation was growing by April 1. Therefore, the longer growing season calculated from soil temperature data is likely more accurate and will be used in this report.

Site Characterization

Ground Water

The hydrologic characterization of this site is not yet complete. Measurements of hydraulic conductivity and evapotranspiration are pending. A calculation of runoff from the catchment area, a search for field tiles, and a calculation of a water budget are planned. A study in progress by Rebecca Reid of NIU will measure the components of the water budget for this site. Therefore, any conclusions in this report on ground water are preliminary and subject to change as more data become available.

The purpose of the hydrogeologic investigation is to identify aquifers, aquitards, and flow paths in the proposed mitigation site and the adjacent sedge meadow. Hydrogeologic differences between the mitigation site and the sedge meadow are to be identified. Water sources of the sedge meadow are to be investigated in order to act as a model for design of the mitigation site.

Monitoring wells were installed in various geologic units throughout the site to 1) identify water levels within each unit, 2) determine ground-water gradients, 3) estimate ground-water flow directions, 4) estimate source areas for ground-water input, and 5) determine the extent of wetlands hydrology at the site. Water levels measured during the monitoring period are shown in Appendix B. The screened intervals of each monitoring well in relation to the geologic units on site are shown on cross sections in Appendix A.

Ground-water conditions in the soil zone

As stated in the 1987 Wetlands Delineation Manual (U.S. Army Corps of Engineers 1987), wetlands hydrology is a function of the period of time water levels are within 0.3 m (1 ft) of the land surface. If that water level is exceeded for 12.5% of the growing season, then wetlands hydrology exists. If that water level is present between 5 and 12.5% of the growing season, then wetlands hydrology may exist. If that water level is exceeded less than 5% of the growing season, then wetlands hydrology does not exist. Given that this site has a growing season calculated at 213 days, 5% and 12.5% of that growing season equals 11 and 27 days, respectively.

In order to determine the extent of wetlands hydrology on site, monitoring wells 1S through 5S and 8S through 12S were installed in the soil zone. These wells are all labeled "S" to indicate a similar construction. These wells normally were 0.75 m (2.5 ft) deep, had screened intervals in the range of 0.45 to 0.75 m (1.5–2.5 ft) in depth, were packed with sand to 0.3 m (1 ft) in depth, and were sealed to the land surface with bentonite. Slight variations occurred in this design, but all well construction measurements are shown in Appendix C. The geology of each boring was generally not considered when installing these wells because of their extremely shallow nature and because the wells are primarily designed to determine jurisdictional wetland status.

Water levels recorded in all soil-zone (S) wells located in the mitigation area and the sedge meadow are shown in figures 4 and 5, respectively. During spring 1995, water levels indicate that wetlands hydrology is present in the vicinity of wells 2S, 5S, and 8S through 12S. Wetlands hydrology is not present adjacent to wells 1S and 4S.

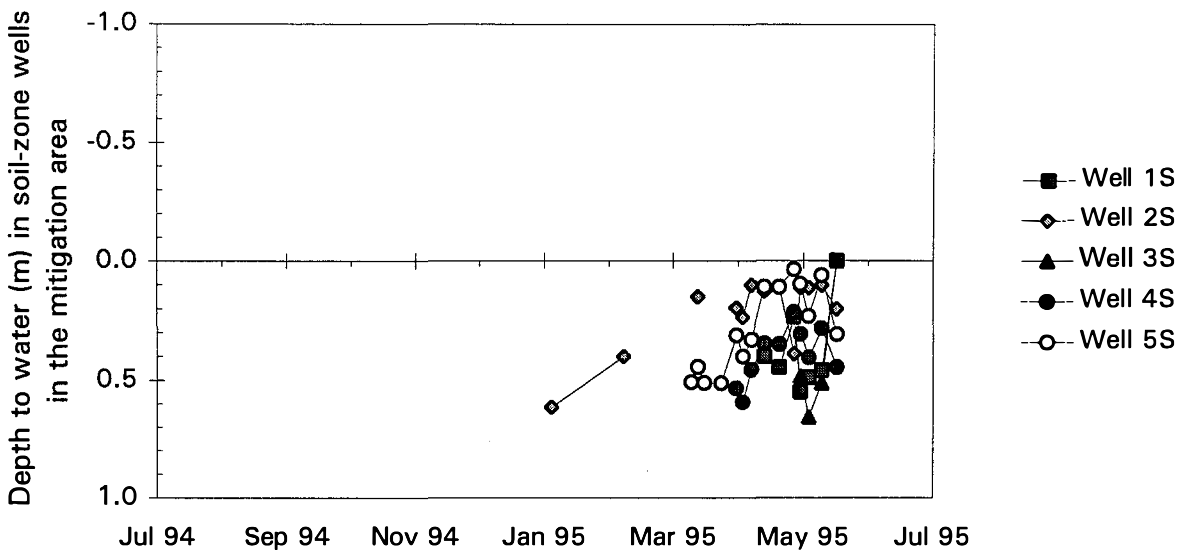


Figure 4 Depth to water below land surface in soil-zone (S) monitoring wells in the proposed mitigation site recorded between November 1994 and May 1995. Negative values indicate water levels above land surface.

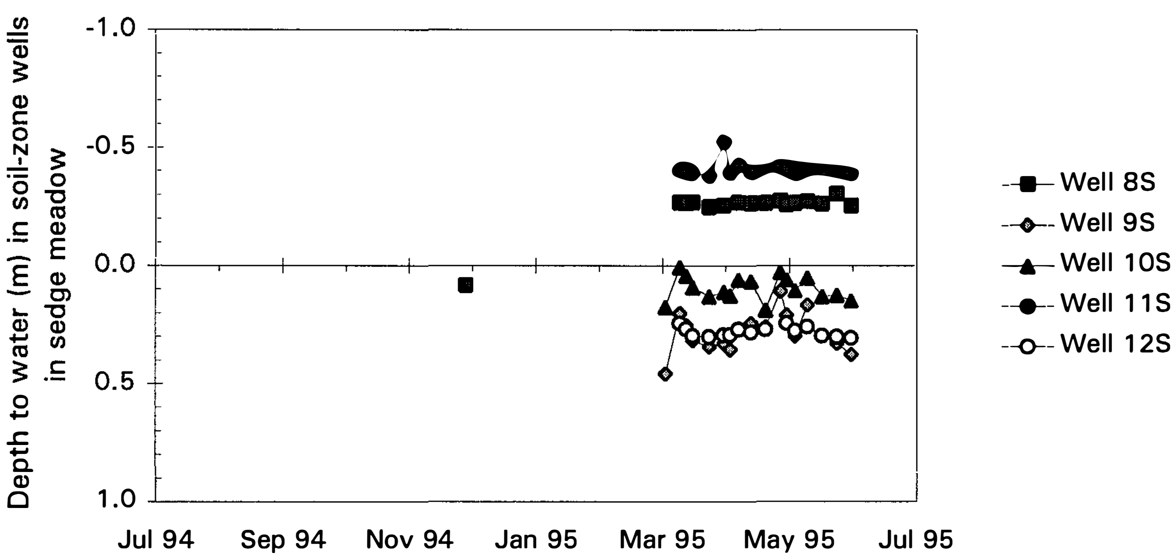


Figure 5 Depth to water below land surface in soil-zone (S) monitoring wells in the sedge meadow recorded between November 1994 and May 1995. Negative values indicate water levels above land surface.

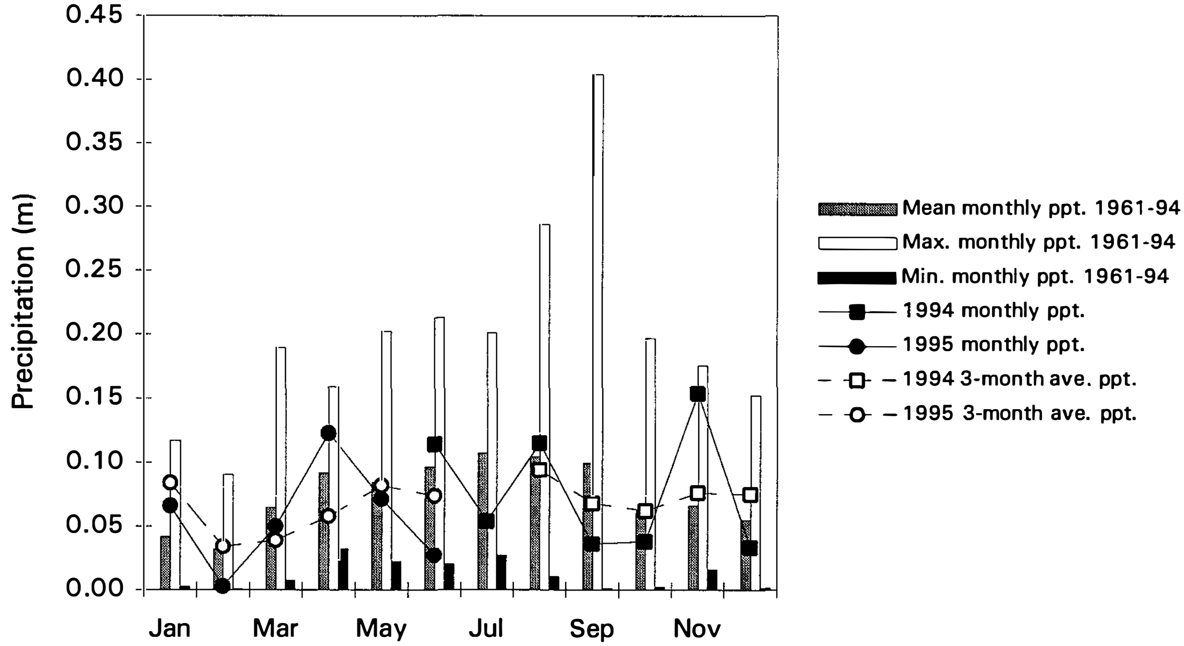


Figure 6 Precipitation data for the region, including summarized minimum, mean, and maximum monthly precipitation (ppt.) between 1961 and 1994 and monthly precipitation during January 1994 through March 1995 recorded at Antioch, Illinois (from the Illinois State Water Survey Midwestern Climate Center archive of NOAA climate station data), and monthly precipitation recorded on site from April 1995 through June 1995.

To properly interpret the wetlands hydrology information presented above, it is necessary to determine if the climatic conditions of the sampled year are average. Monthly precipitation data are shown in figure 6. Mean, maximum, and minimum monthly rainfall recorded at Antioch for the period 1961 through 1994 are shown (archived National Oceanic and Atmospheric Administration (NOAA) data, Midwestern Climate Center, Illinois State Water Survey). Monthly rainfall and a running 3-month average for available 1994 and 1995 data are also shown (National Oceanic and Atmospheric Administration 1994); data beginning in April 1995 are from a rain gauge located on site. The data show that periods of less than average rainfall occurred in Fall 1994 and February and March 1995. Higher than average precipitation occurred during November 1994 and January 1995 and in April 1995.

Precipitation in April 1995 was much higher than average, and corresponds with rises in water levels in many wells. Levels began to drop in most wells by early May 1995. In many wetland sites monitored by ISGS in northern Illinois, high water levels occur in March and early April, followed by a drop in level in mid to late April. The usual period of higher water levels in spring may have been extended at this site by higher than average rainfall in April 1995, causing certain upland areas to exhibit wetland hydrology during 1995. The mitigation site and adjacent upland areas (adjacent to wells 1–6) lack a dominance of hydrophytic vegetation (Keene and Nugteren 1993), and therefore will not exhibit wetlands hydrology in an average year.

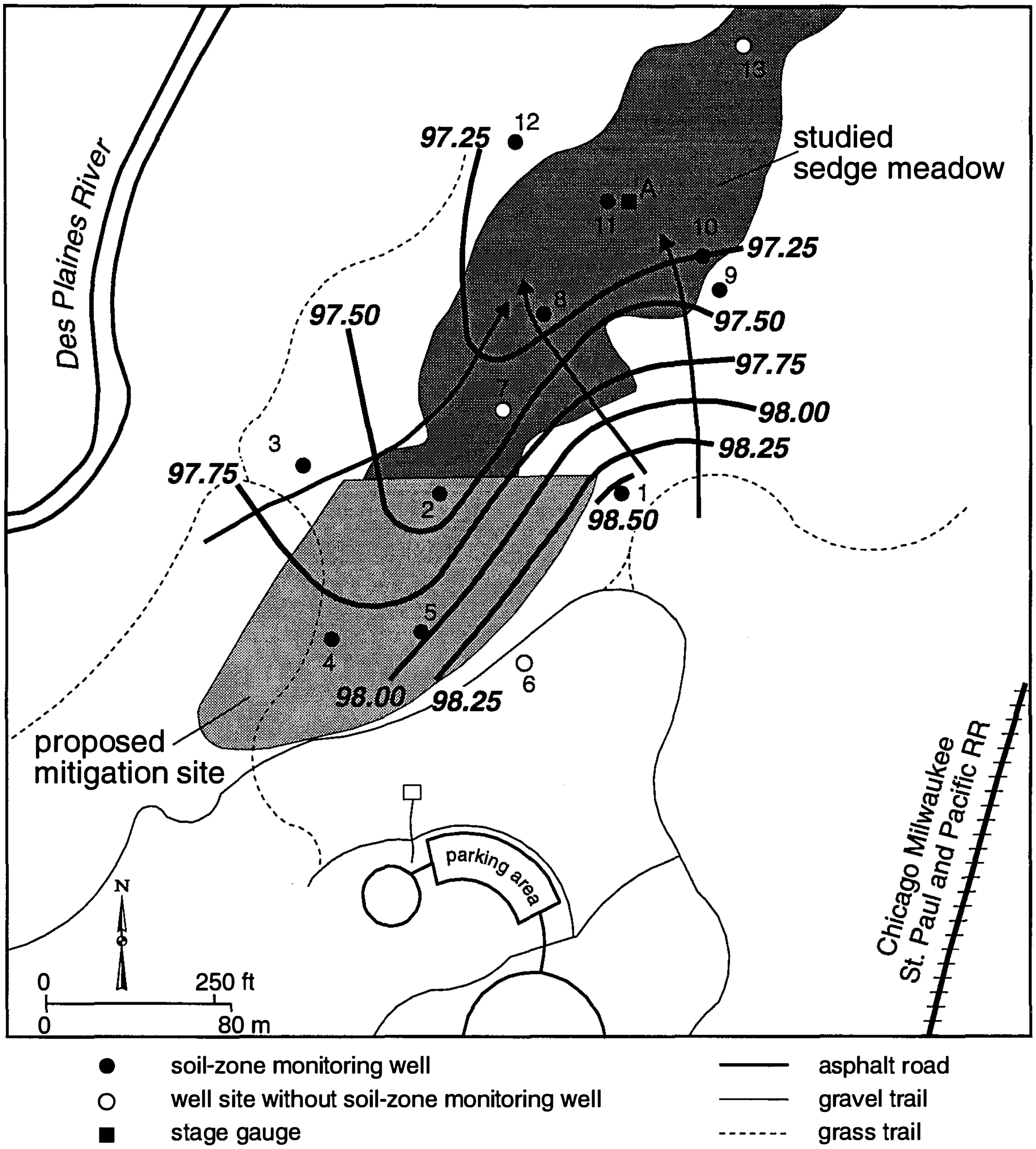


Figure 7 Contours of the potentiometric surface measured on May 2, 1995, in soil-zone (S) wells, and estimated ground-water flow directions (arrows). Contour interval is 0.25 m. Elevations are relative to an arbitrary benchmark set on site at 100.00 m in elevation.

Figure 7 shows the elevation of ground water in soil-zone (S) wells on May 2, 1995, during a period of above average precipitation. The contours of the potentiometric surface suggest that water flows into the mitigation site and sedge meadow from the east, south, and west, then northward. Figure 8 shows water levels measured in S wells on April 2, 1995, and shows that during periods with less precipitation, the eastward component of flow does not occur and flow into and through the wetland is in general to the northwest. The difference in flow behavior may indicate that the upland between the study area and the Des Plaines River to the west is only a source of ground water for the wetland during periods of heavy infiltration.

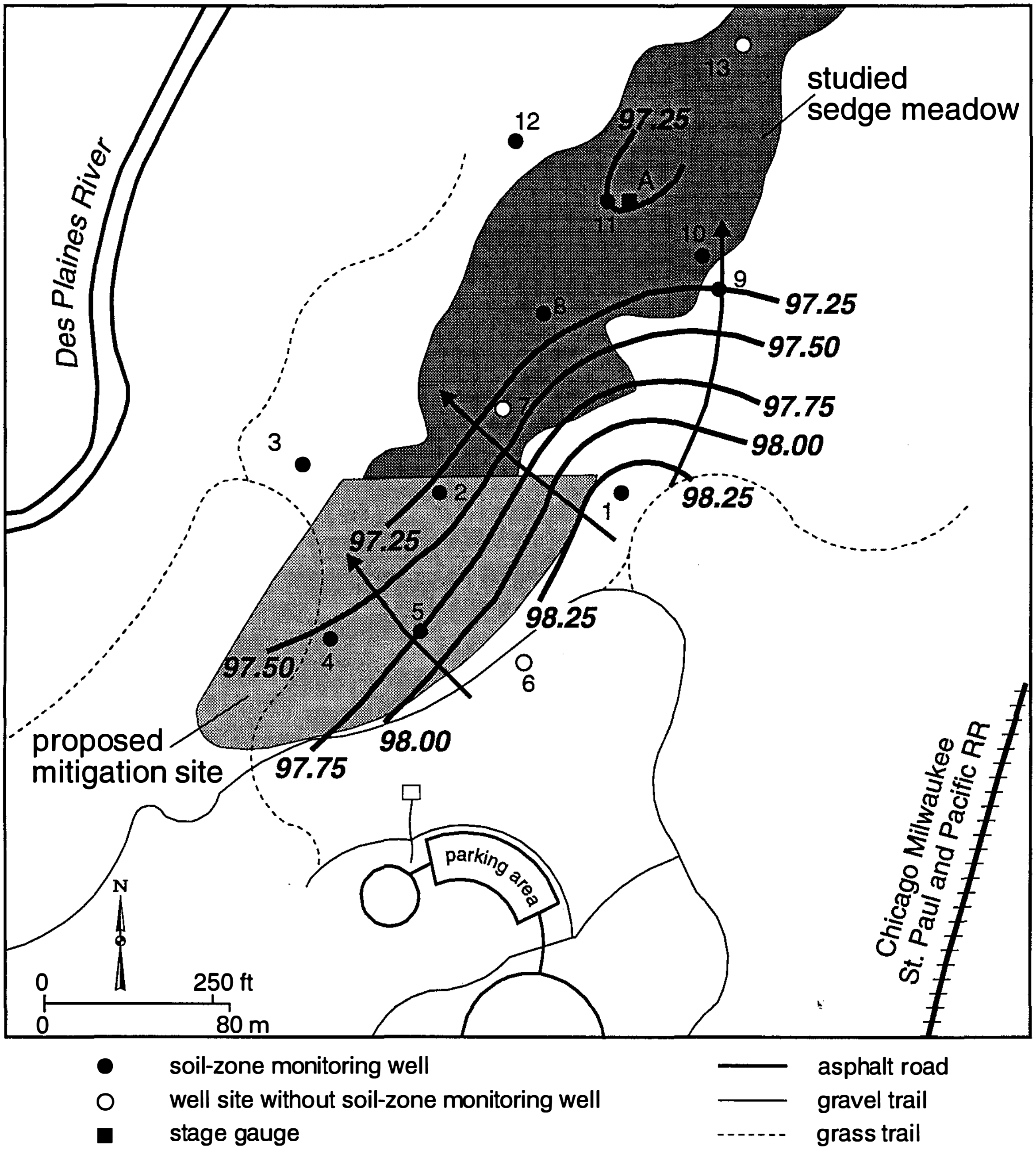


Figure 8 Contours of the potentiometric surface measured on April 2, 1995, in soil-zone (S) wells, and estimated ground-water flow directions (arrows). Contour interval is 0.25 m. Elevations are relative to an arbitrary benchmark set on site at 100.00 m in elevation.

<u>Ground-water conditions in unit C</u>

Unit C underlies the majority of the mitigation site and the sedge meadow at a depth of approximately 0.25 to 1.5 m (0.8–4.9 ft), so that ground-water flow in this unit is important to mitigation design. Water levels in unit C may help determine if the sedge meadow is a perched system or if there is a connection to the ground-water system. Although other units may contain some dispersed or thin beds of sand and gravel, silt and clay contained in those units likely reduces their average hydraulic conductivities.

Water levels and flow directions in unit C help define the role that it plays in the maintenance of the sedge meadow and its potential for use as a water source for the mitigation area. A number of wells are installed in unit C throughout the site as shown in the cross sections in Appendix A. Well site 2 has nested well screens to determine vertical flow-gradients in the unit. Water levels in wells screened in unit C in the mitigation area and the sedge meadow are shown in figures 9 and 10.

Figure 11 shows water levels in unit C on May 2, 1995; this date was during a period of significant precipitation. Water flows into the mitigation area from the southwest, south, and southeast, then northward toward the sedge meadow. Southward ground water flow into unit C from the Des Plaines River does not occur. Measurements in wells 4 and 5 possibly indicate that water levels also decrease to the south, suggesting that the upland to the south may act as a local ground-water divide.

Figure 12 shows water levels in unit C on April 2, 1995. The flow pattern is similar to that described above, but shows no eastward component of flow. This may indicate that during periods of heavy precipitation resulting in ground-water recharge, the upland west of the study area and east of the Des Plaines River becomes saturated and drives a component of flow northeastward, helping to cause saturation of unit C and ponding on the surface in the sedge meadow. It is expected that as recharge lessens, westward ground-water flow through unit C returns. Figure 9 shows that flow toward well 2 from well 3 did not occur throughout much of the monitoring period.

<u>Ground-water conditions in other units</u>
Figure 13 shows the water levels measured in selected wells 1 through 3 (U and L) to compare levels in unit C to those in units A and B. Well 1U is screened in unit B, well 2U is screened in unit C, and well 3L is screened in unit A. These levels are compared to determine if ground water is capable of flowing into unit C from the surrounding units.

Water levels in unit B are higher than those in unit C, indicating that the potential exists for ground water to discharge into unit C. Unit B is a silty clay diamicton, so that the hydraulic conductivity of the matrix is likely very small. However, fractures noted in the unit likely increase the secondary porosity, thereby increasing the bulk hydraulic conductivity of the unit. A measurement of the hydraulic conductivity of unit B is pending, and it will allow a calculation of the volume of water available for discharge into unit C.

Water levels in unit A are normally lower than those in unit C, indicating that ground water discharges westward from unit C into unit A toward the Des Plaines River. During periods of high precipitation, this trend reverses, as discussed above. Sand beds within unit A may have significant hydraulic conductivity. A measurement of the hydraulic conductivity of unit A is pending.

<u>Ground-water gradients</u>
Water-level gradients in all nested wells are shown in figure 14. Most gradients are less than $\pm$0.05 m (0.2 ft), and generally vary both upward and downward. All sustained gradients (2 or more consecutive readings) larger than approximately 0.1 m (0.3 ft) are downward, and no sustained gradients are larger than about 0.3 m (1 ft). These data indicate that no upward ground-water flow regularly occurs at the site. Because there is no significant upward gradient, unit C is most likely a water-table aquifer.

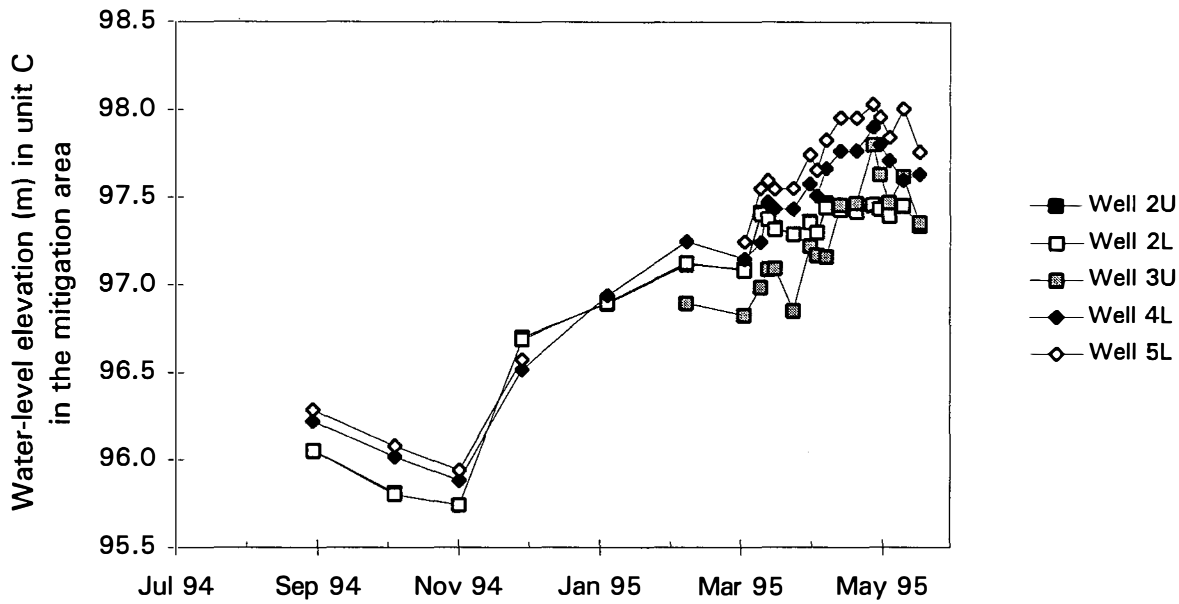


Figure 9 Water levels in wells screened in unit C in the proposed mitigation area recorded between August 1994 and May 1995. Levels are referenced to a benchmark set on site at 100.00 m in elevation.

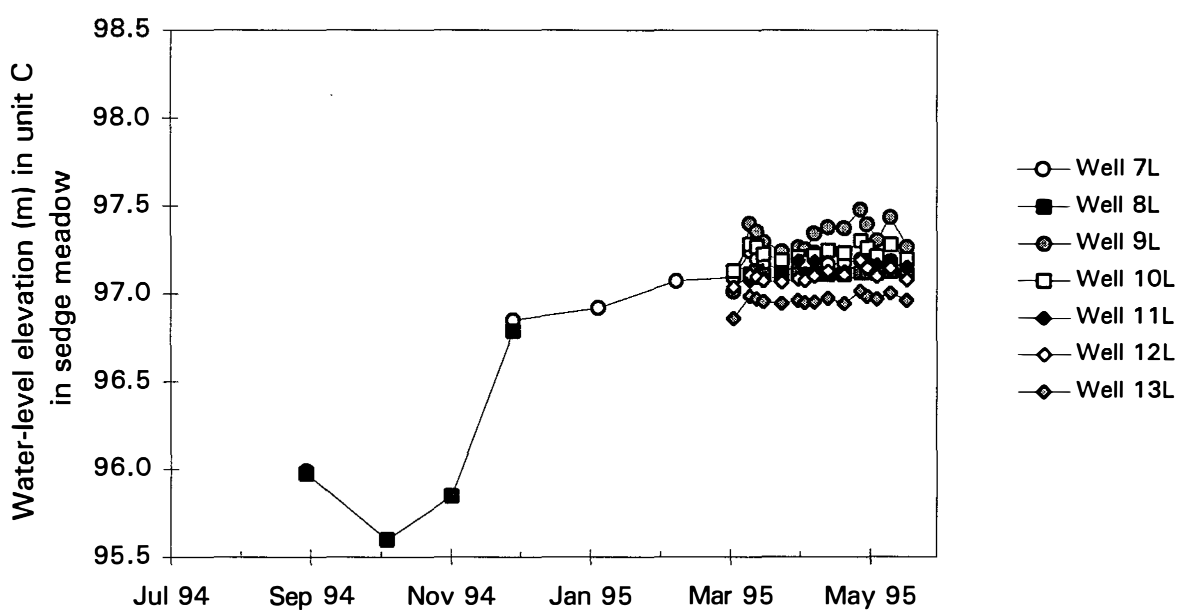


Figure 10 Water levels in wells screened in unit C in the sedge meadow recorded between August 1994 and May 1995. Levels are referenced to a benchmark set on site at 100.00 m in elevation.

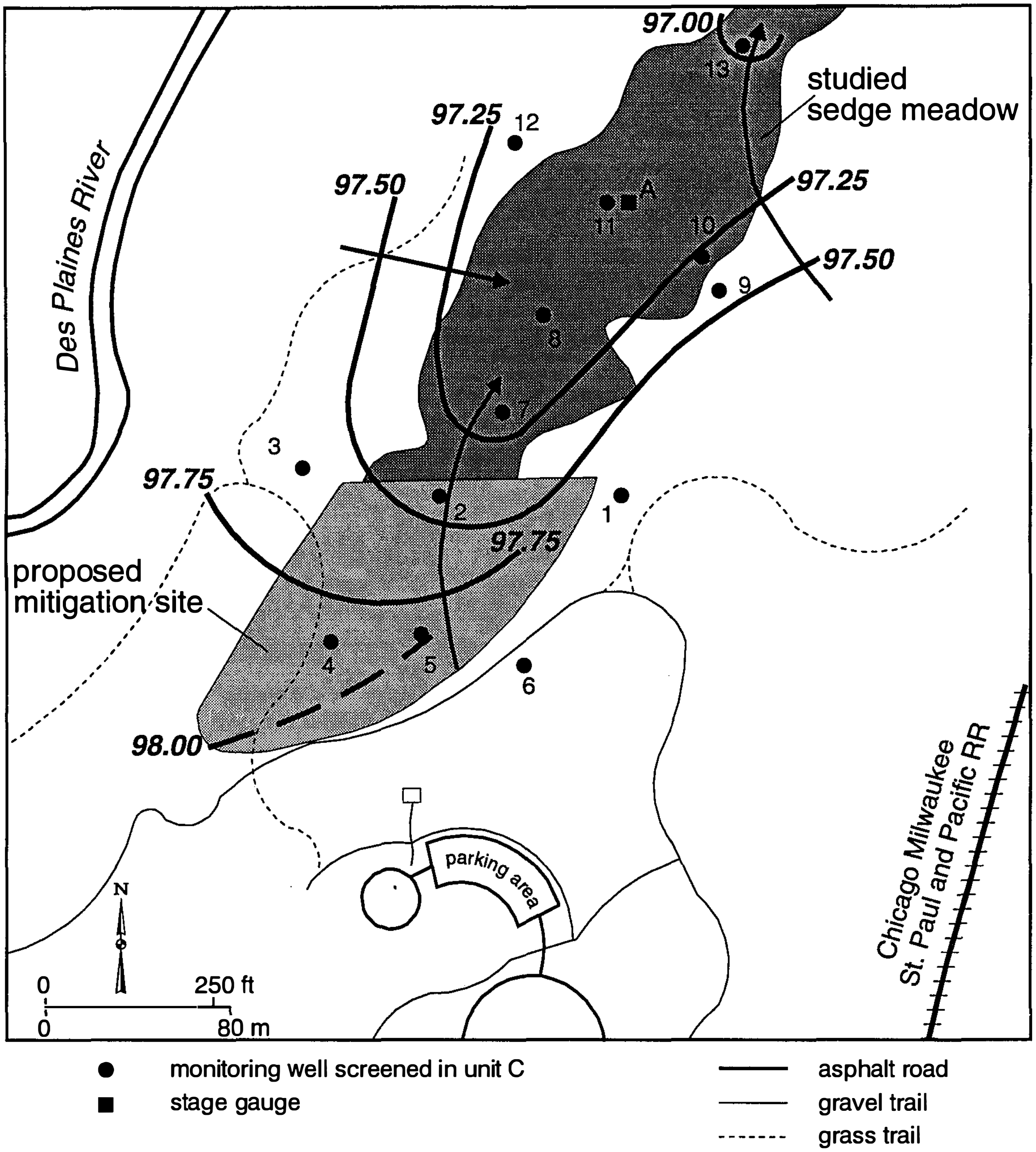


Figure 11 Contours of the potentiometric surface measured on May 2, 1995, in wells screened in unit C, and estimated ground-water flow directions (arrows). Contour interval is 0.25 m. Elevations are relative to an arbitrary benchmark set on site at 100.00 m in elevation.

Surface Water

Surface waters in the study area include the Des Plaines River, ponded water in the sedge meadow, and two intermittent streams (not mapped) that flow into the sedge meadow. A stage gauge (gauge A) was installed in the sedge meadow adjacent to well 11. No other stage gauges were installed at the site because the Des Plaines River is an estimated 5 m (16 ft) below the level of the sedge meadow, and because flow was never observed in the intermittent streams. Data regarding the stage of the Des Plaines River will be presented in the final report.

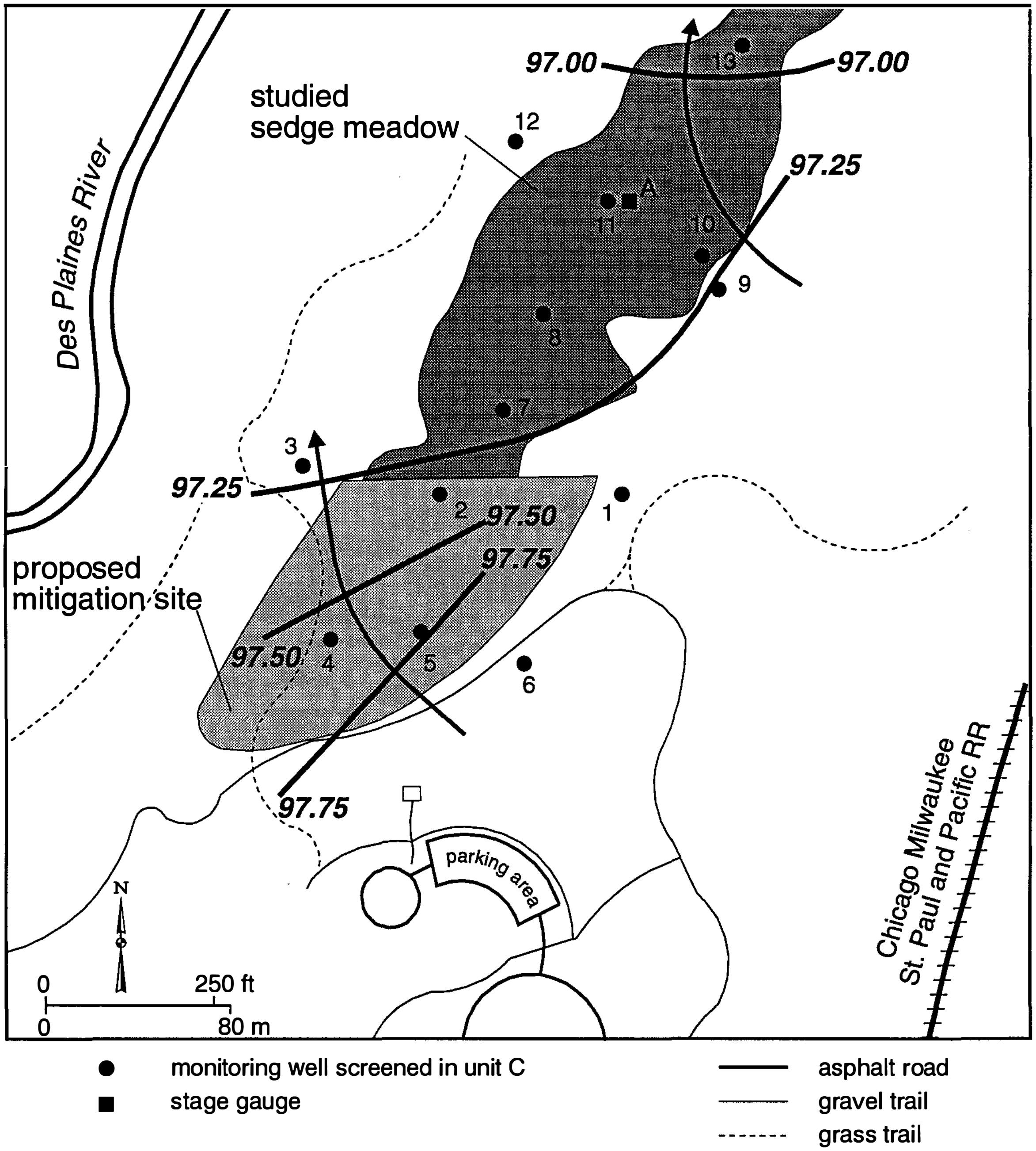


Figure 12 Contours of the potentiometric surface measured on April 2, 1995, in wells screened in unit C, and estimated ground-water flow directions (arrows). Contour interval is 0.25 m. Elevations are relative to a benchmark set on site at 100.00 m in elevation.

Figure 15 shows water levels at stage gauge A and wells 8L, 11L, and 12L during the monitoring period, and indicates that water levels in the sedge meadow are relatively stable and closely match levels seen in the wells. This indicates that the surface water in the sedge meadow is hydrologically connected to ground water in units C through E. The stability of water levels in the sedge meadow may indicate that there is some sort of control of water levels. The source of this control is not known, but it may function so as to maintain a certain saturation level in unit C during recharge; higher water levels would spill over the outlet and drain from unit C. As recharge lessens, water levels may decrease. Continued monitoring of the site will be necessary to determine the behavior of water levels in an entire hydrologic year.

The catchment area of the site is approximately 26 hectares (65 acres). A calculation of the amount of runoff expected from this area has not yet been performed.

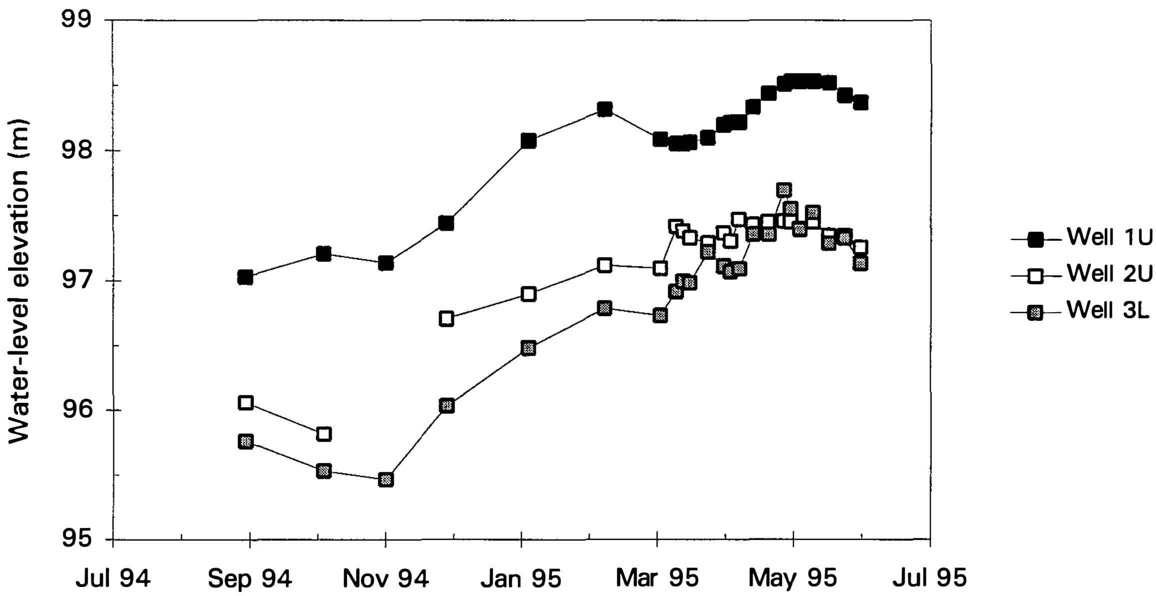


Figure 13 Water levels in wells located in unit A (well 3L), unit B (well 2U), and unit C (well 1U). Elevations are relative to an arbitrary benchmark set on site at 100.00 m in elevation.

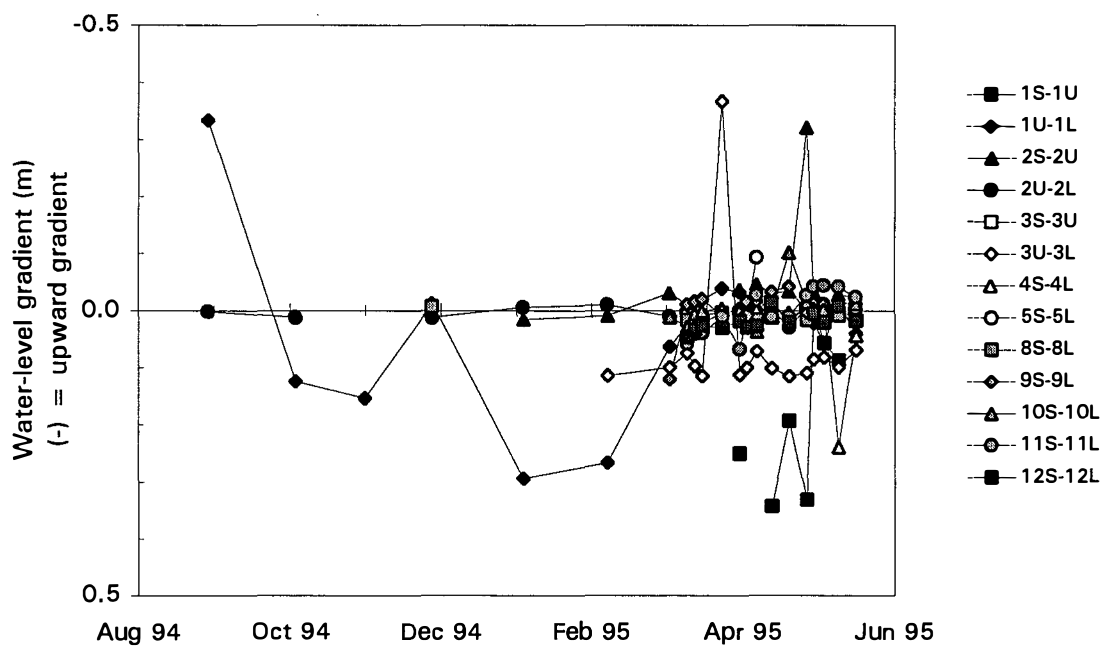


Figure 14 Water-level gradients between selected, nested monitoring wells between August 1994 and May 1995. Negative values indicate an upward gradient.

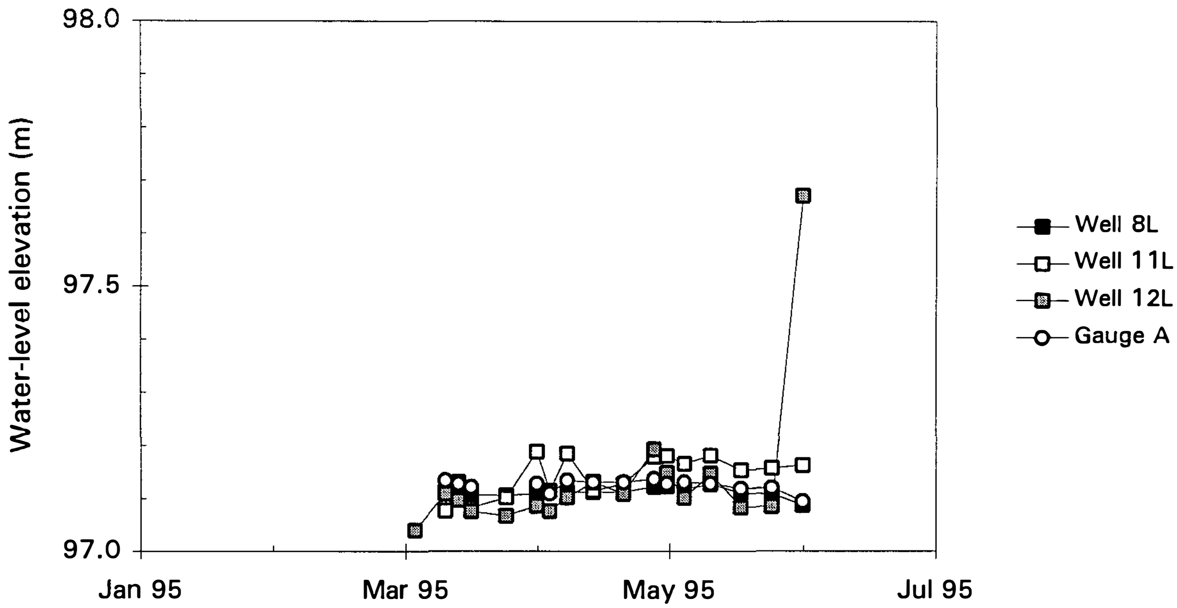


Figure 15 Water levels recorded from wells 8L, 11L, and 12L and stage gauge A between March 1995 and May 1995. Elevations are relative to an arbitrary benchmark set on site at 100.00 m in elevation.

Conclusions

All conclusions regarding the hydrology of this site are preliminary and subject to change as additional data are received. Preparation of a water budget for this site will greatly increase the understanding of the relative importance of water sources that support the sedge meadow and will help identify design targets that may be appropriate for the mitigation site.

Wetlands hydrology was present during spring 1995 adjacent to wells 2S, 5S, and 8S through 12S. Wells 2S and 5S are located in areas determined by the Illinois Natural History Survey (INHS) to be nonwetland due to a lack of dominant hydrophytic vegetation (Keene and Nugteren 1993); and wells 9S and 12S are near the wetlands boundary as located by vegetation patterns. Wetlands hydrology was likely present in these areas due to higher than average precipitation during April 1995. Monitoring will continue to determine wetland hydrology status during normal precipitation patterns.

Water levels indicate that ground water in the study area flows from unit B on the east and southeast into unit C in the mitigation area and the sedge meadow, then northwestward within unit C toward unit A and the Des Plaines River. However, there is also flow from the southwest into the mitigation area and the sedge meadow during periods of heavy precipitation and ground-water recharge.

Water levels in the soil zone indicate that ground water flows into the mitigation site and the sedge meadow from the southeast similar to the pattern observed in unit C, and has similar southwesterly flow during periods of ground-water recharge.

Ground-water gradients at each nested well site indicate that no significant, sustained, upward gradients occur in the mitigation site or the sedge meadow. This indicates that unit C is a water-table aquifer.

Surface-water levels in the sedge meadow are equal to ground-water levels in unit C underlying the wetland, indicating that the surface water is in hydrologic contact with the ground water. Relatively constant water levels in the sedge meadow during spring 1995 may indicate that the levels are controlled by an outlet. The source of this control is not known, but it may act to maintain water levels at a certain elevation during periods of recharge, then would not function during periods of drawdown.

Monitoring

Until hydrologic characterization is completed, short-term ground- and surface-water level monitoring will be continued through May 1996 or until no longer required by IDOT. A final hydrogeologic characterization report will be prepared at the end of the short-term monitoring. Long-term monitoring may be necessary in the event that the proposed mitigation site is utilized for wetland creation.

MITIGATION POTENTIAL OF THE STUDY AREA

The mitigation area occurs in an upland area along a slope that grades northward into the sedge meadow; the boundary between the mitigation area and the sedge meadow to the north is diffuse. Historic air photos show that the northward extent of plowing in the mitigation area varied, presumably according to the amount of precipitation during the spring. The extent of wetlands hydrology will change in response to the amount of precipitation during the year, so that only average precipitation conditions will accurately determine the wetland/nonwetland boundary.

The mitigation area southward of and uphill from the sedge meadow is not former wetland (Keene and Nugteren 1993). No evidence of altered hydrology exists, although a search for drainage tiles is pending. Therefore, the establishment of wetlands in the mitigation area is not restoration, but creation. Normally creation is not a preferable mitigation alternative, but the sedge meadow has similar geology and is available to act as a model for design.

To create wetland in upland positions, it is necessary to either increase the available water or to decrease the surface topography so that the water table would more closely approach the land surface for longer periods during the growing season. Given that the surface water in the sedge meadow is hydrologically connected to the water levels in underlying units, and similar geology exists beneath the sedge meadow and the mitigation site, it is not likely that water can be made to pond on the surface using dikes or other control structures without a liner; water would infiltrate and flow downward to the water table. Therefore, the other option would involve excavation of the land surface.

Given that 1995 had higher than average precipitation in April, it is not possible to directly examine water levels in the monitoring wells to determine the amount of necessary excavation. Monitoring during an average precipitation year would be required. However, it may be possible to predict the average behavior of water levels if the effects of the precipitation in April 1995 can be removed.

As seen in other sites monitored by the ISGS, water levels in many types of wetlands in northern Illinois are high during March and early April, then fall below 0.3 m (1 ft) in depth by mid to late April. During 1995, heavy precipitation in late April may have extended the period of high water levels into mid to late May. If that effect can be ignored, then the water-level decrease in late May can be considered the usual, although belated, behavior during spring.

If levels in the first week of April can be considered indicative of average conditions, and if water-level increases caused by heavy rains in late April are deleted from the record, then a "normal" spring profile can be inferred from the record. From this artificial record, the following wells would show wetlands hydrology: 8S, 10S, 11S; possible wetlands hydrology by wells 2S, 9S, and 12S; and no wetlands hydrology by wells 1S, and 3S through 5S. This distribution resembles the vegetation patterns at the site, suggesting that these data may reflect more closely the average precipitation conditions.

The sedge meadow is located in an area underlain by sand and gravel of unit C, which apparently is a water-table aquifer. Preliminary data have shown that standing water in the wetland is hydrologically connected to water levels in unit C. Therefore, the standing water expresses the level to which unit C is saturated. Water will inundate the area where the land surface intersects the water level in unit C. Therefore, it is likely that if the land surface is lowered, water can be made to pond or to approach the land surface. This will only be effective in areas that are underlain by similar geologic units. The mitigation site has geology similar to that of the sedge meadow, except that unit C does not underlie the area adjacent to well 1.

A determination of the volume of water available from each source is pending, and may be desired prior to final design of the site. This determination may help indicate if excavation in the mitigation area will significantly alter the water balance of the sedge meadow. Because water levels in the sedge meadow appear to be controlled by an outlet during periods of recharge, it seems likely that excess water will be available to compensate for increased evapotranspiration in the excavated mitigation area. If so, water levels in the sedge meadow may be unaffected by the mitigation project.

RECOMMENDATIONS

Given the above scenario, the minimum depth of excavation required to achieve wetlands hydrology near each well site ranges from 10 to 40 cm (0.3–1.3 ft). This figure does not include an estimation of increased evapotranspiration (ET), which would add to the amount of excavation required. Minimum excavation depths for each well site can be calculated based on the amount that the land surface needs to be lowered to achieve wetlands hydrology. However, ET will likely increase after excavation, and will likely decrease water levels, so that a calculation of excavation based solely on present conditions likely will not be accurate for post-construction conditions. A comparison of present ET in the mitigation area to present ET in the sedge meadow is necessary to estimate ET in the mitigation area after construction; any differences would affect future water levels. These components will be addressed in the water budget in preparation.

Additionally, excavation to a depth that assured a minimum amount of surface-water inundation each year may be prudent, and may more closely approximate the wetter conditions in the sedge meadow where *Carex lacustris* occurs, rather than the transition area between the sedge meadow and the mitigation area where *Carex stricta* occurs. Therefore, it may be necessary to excavate in places to depths similar to but not below those in the sedge meadow, or approximately 97.00 to 97.25 m (318.2–319.1 ft) after the topsoil has been replaced. This elevation could be reached in the deeper parts of the mitigation area. The extent of excavation to this elevation would depend on the acreage necessary and the required angle of the side slopes. This elevation and all elevations in this study are relative to a benchmark set on site at an arbitrary elevation of 100.00 m (328.1 ft).

Features that should be included in the design of the mitigation area are a buffer strip approximately 10 m (32.8 ft) wide between the excavation in the mitigation area and the southern extent of the sedge meadow, and the final grading in the mitigation area should not be deeper than the deepest part of the sedge meadow, or to an elevation of approximately 97 m (318.2 ft). The usual design criteria regarding gentle side slopes, silt fencing, and topsoil stockpiling and replacement should also be included. Excavation should only be performed in dry or frozen conditions to minimize compaction and siltation, and should be done with excavators equipped with tread specifically designed to minimize compaction.

The design of this site will rely on ground water in unit C to sustain the mitigation area. Therefore, the grading should only be done in areas where unit C exists. The created wetland area should not include the area of well 1, and may include but should not extend eastward of well 6; however, grading to attain suitable side-slopes may occur in these areas.

SUMMARY

The geology of the Van Patten Woods potential wetland mitigation site and adjacent sedge meadow has been characterized. A hydrologic characterization program is in progress. Conclusions presented here regarding the hydrology of the study area are considered preliminary and subject to change as additional data are collected.

The mitigation site and the adjacent sedge meadow to the north are largely underlain by thin clayey silt and muck deposits. Below these deposits, a sand and gravel body (unit C) is present beneath the wetland and the mitigation site, glacial till (unit B) is present on the east, and a bedded silt (unit A) is present on the west.

Ground water discharges from unit B into unit C from the east, then flows to the northwest, where it discharges into unit A and then the Des Plaines River valley. During heavy rains and ground-water recharge, water flows into unit C from the west as well, then northward through the abandoned channel sediments of unit C toward a small stream that drains into the Des Plaines River from the uplands to the east.

Wetlands hydrology was present during spring 1995 in the vicinity of the following wells: 2, 5, and 8 through 12. Heavy precipitation during April 1995 may have extended the usual, higher spring water levels enough to cause wetlands hydrology near wells that are not likely installed within wetlands, particularly wells 2, 3, and 5. Vegetation data indicate that the mitigation site is not wetland.

The sedge meadow is supported by ground-water discharge, direct precipitation, and surface runoff. Ground-water recharge saturates unit C and ponds on the land surface in areas that intersect the water table. Surface water appears in the wetland in the winter and spring, and is in hydrologic contact with ground water in unit C. An estimate of the volume of water supplied by each source is not yet available. However, because surface water is only seasonally present, and ground-water flow patterns change during periods of high precipitation, seasonally variable sources other than ground water may be dominant in this system. It is likely that water levels in unit C are controlled by an outlet that allows discharge of water above a certain elevation, thereby limiting water levels in

unit C. Therefore, evapotranspiration is likely the dominant output from the wetland during periods when water levels are lower, but may be less significant when water levels are higher and the outlet is operational.

Future work at this site will include continued monitoring of ground-water levels. In addition, detailed data regarding each component of the water budget of the site and hydrologic parameters of the sediments onsite (i.e. hydraulic conductivity) will be collected and used to clarify the present understanding of the site hydrology and the relative importance of the various water sources that supply the sedge meadow. A calculation of the volume of water for each input and output is planned, and will allow a determination of the effects that any excavation may have on the water balance of the sedge meadow.

Recommendations regarding the design of the mitigation site include excavation of the site to a depth similar to but not below that of the sedge meadow, leaving an intact barrier between the sedge meadow and the mitigation site, and removing and stockpiling the topsoil prior to grading for eventual replacement in the mitigation area. Geological constraints suggest that the created wetland area should not include the area near well 1, and should not extend east of well 6. Excavators equipped with treads that minimize compaction should be used.

ACKNOWLEDGMENTS

Funding for this study was provided primarily by the Illinois Department of Transportation. Additional funding was provided by the Illinois State Geological Survey (ISGS). David Larson and Nancy Rorick of the ISGS reviewed this report. Rebecca Reid of the Department of Geology at Northern Illinois University reviewed this report, provided water-level data, and assisted in monitoring the site.

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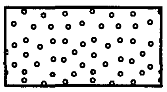
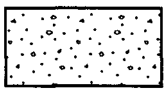
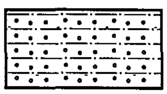
APPENDIX A Geologic Cross Sections and Logs of Borings at the Van Patten Woods Site
Part 1 Index of Geologic Symbols


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


Gravelly sand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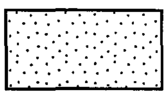
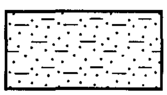
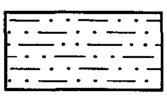
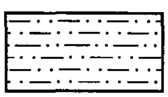

Sand


Silty sand


Clayey sand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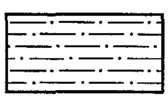
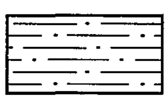

Silt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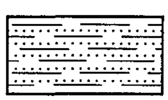
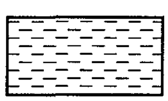
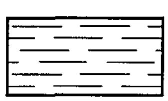

Sandy clay


Silty clay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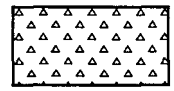
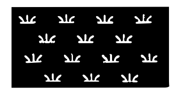
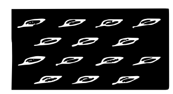
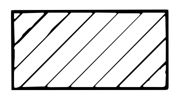

Diamicton


Peat


Muck


Organic mat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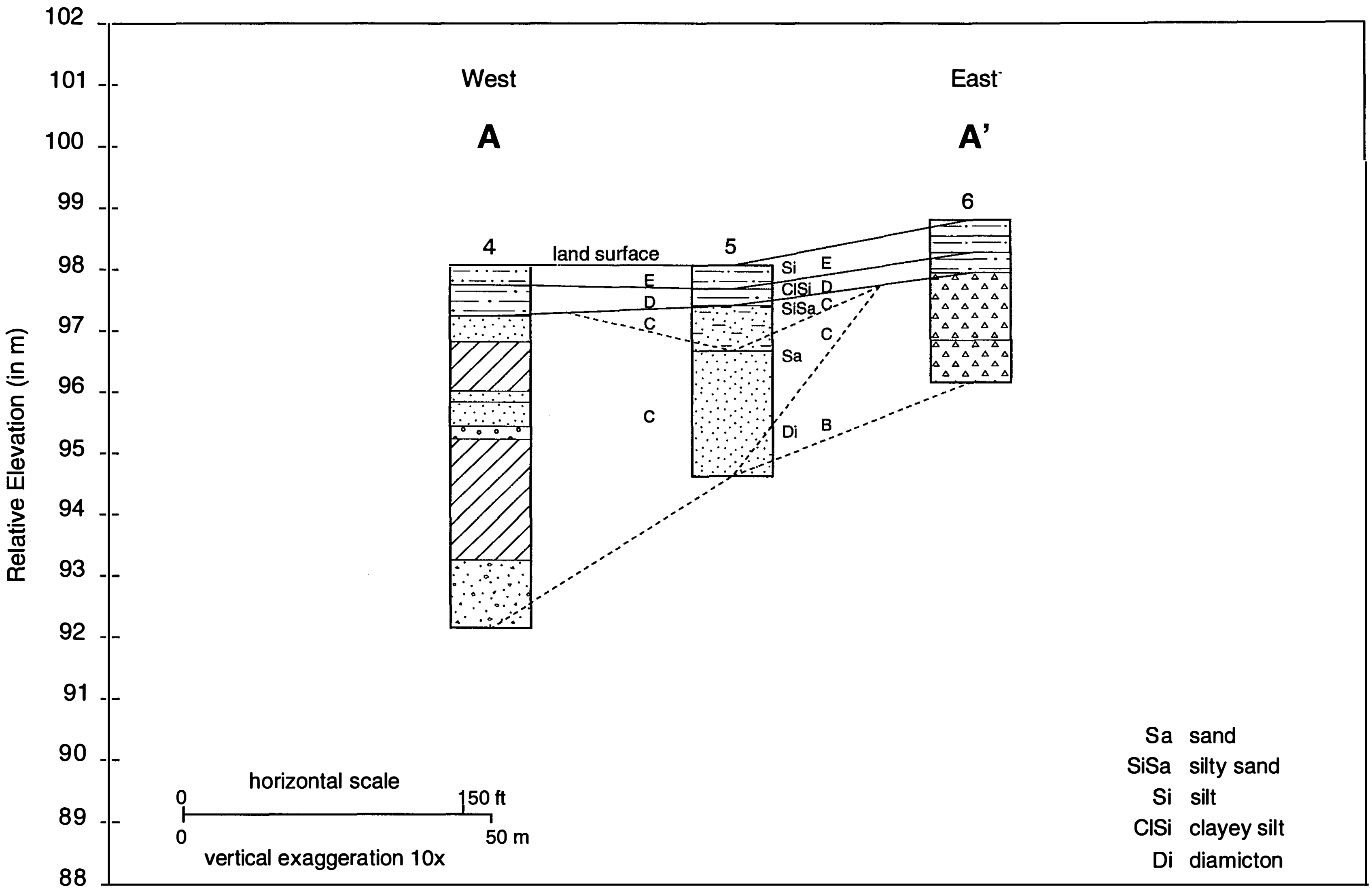
Part 2 Geologic Cross Sections (lines of cross section shown in figure 3)

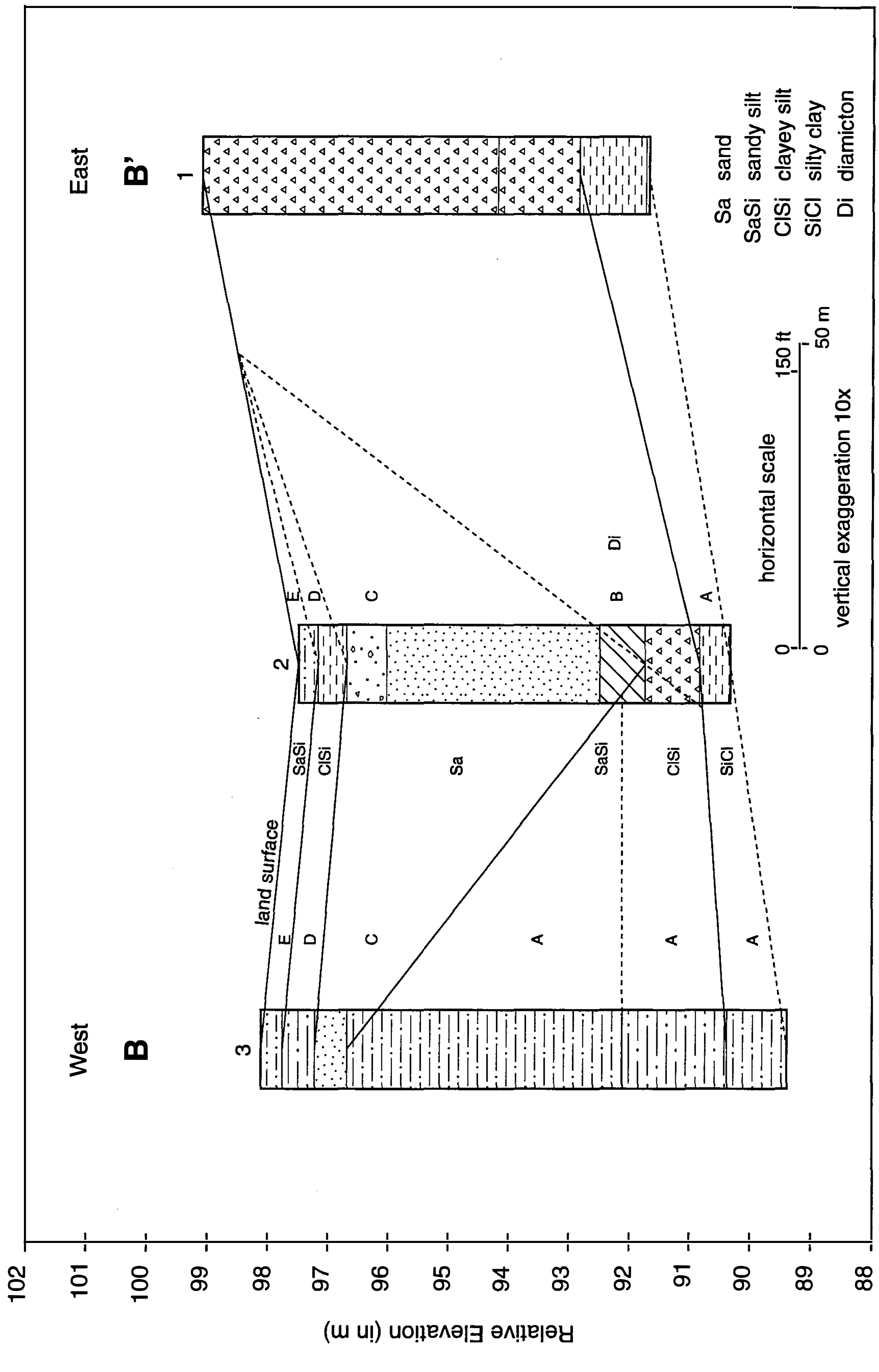
CROSS SECTION A–A′



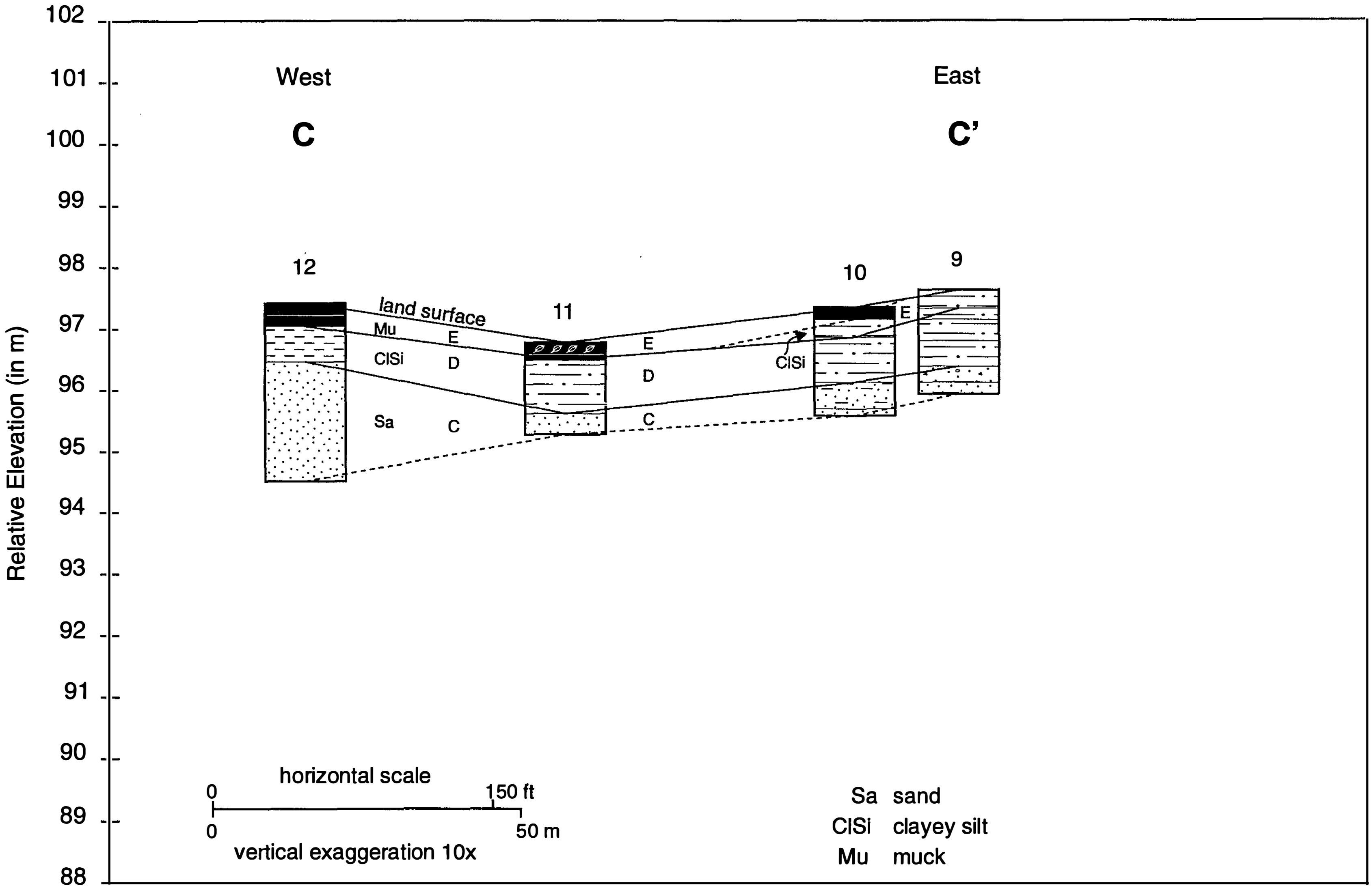
APPENDIX A *continued*

Part 2 Geologic Cross Sections (lines of cross section shown in figure 3)

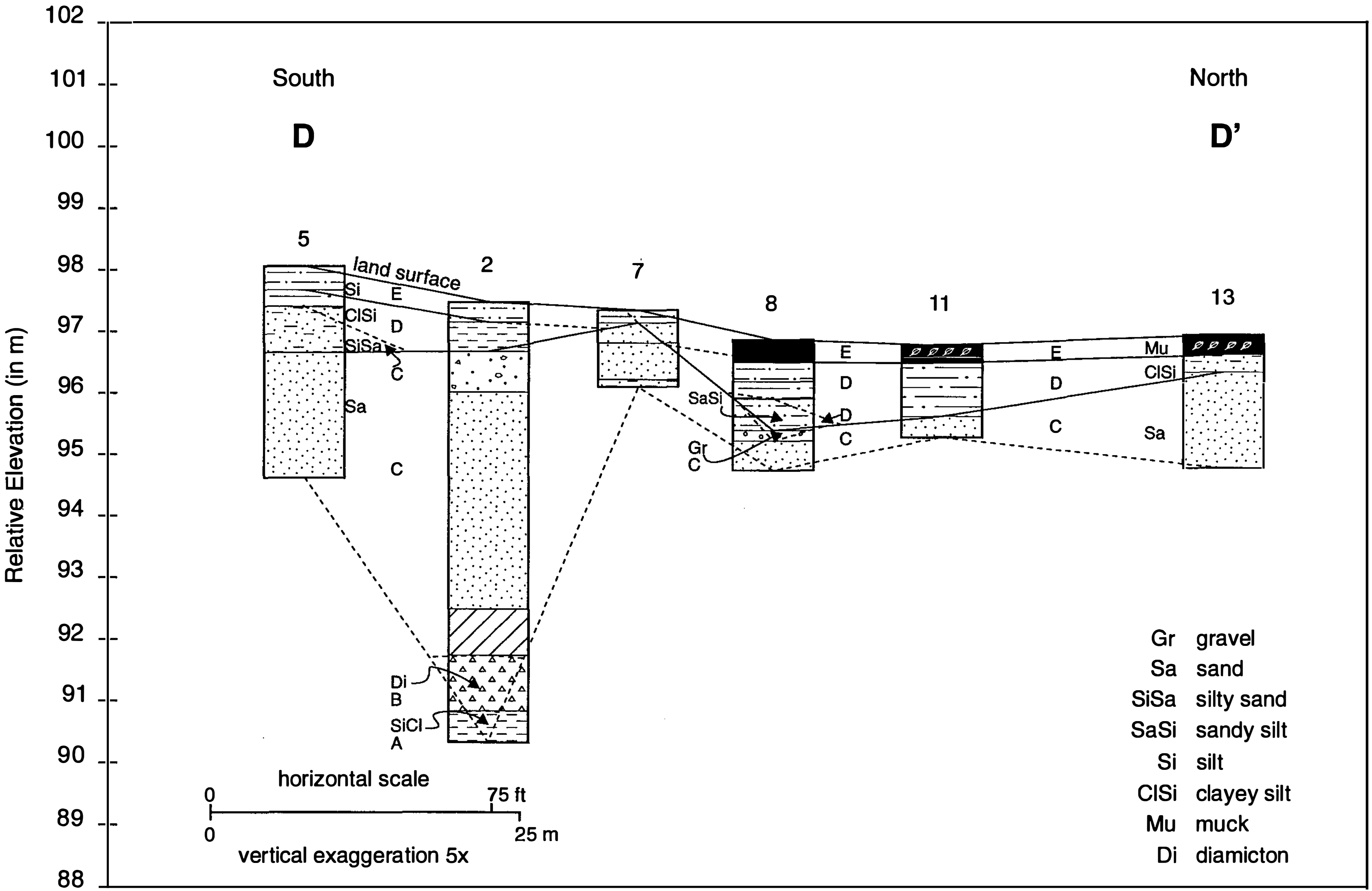
CROSS SECTION B–B′



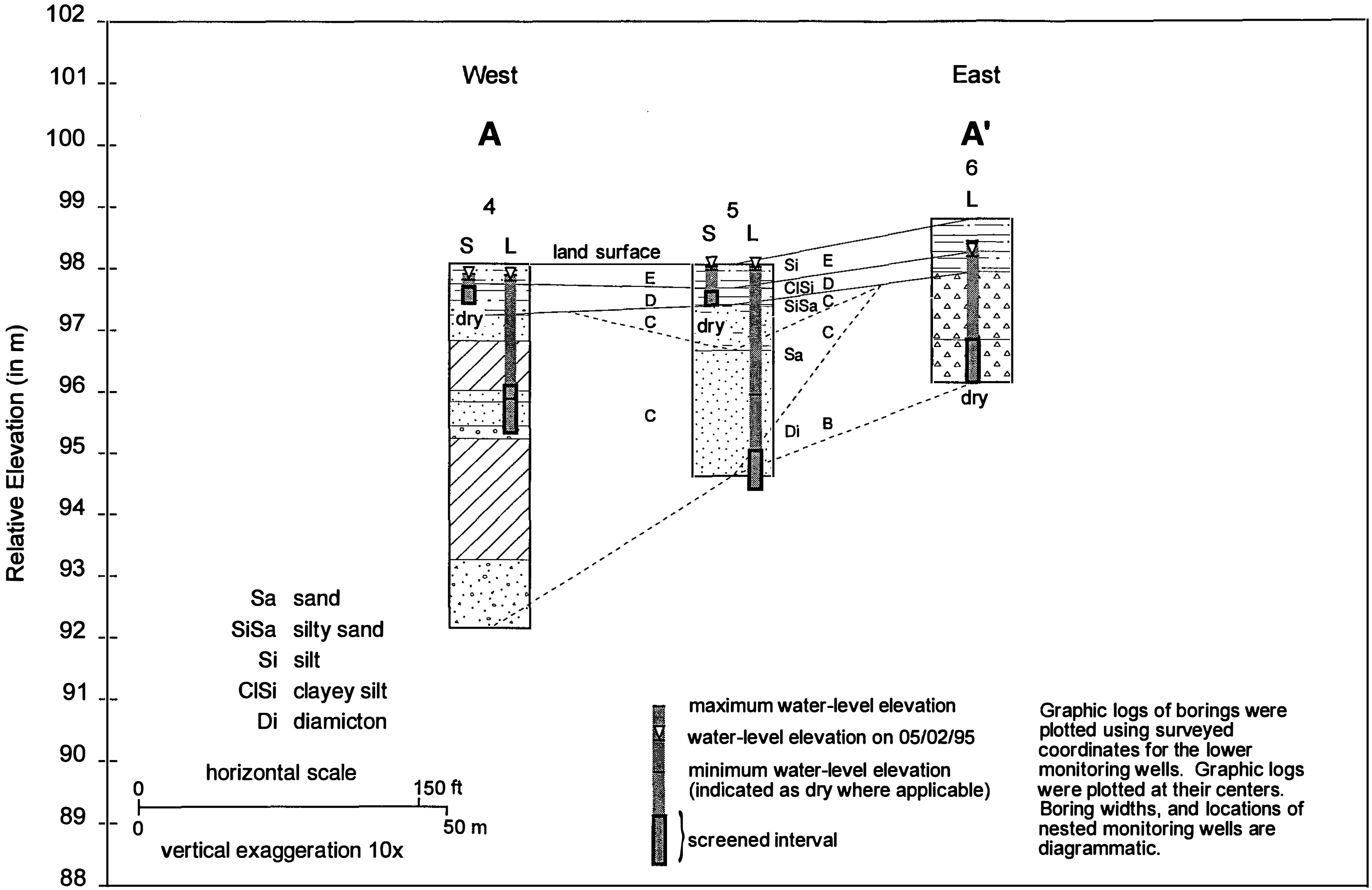
CROSS SECTION C–C′



CROSS SECTION D–D′



CROSS SECTION A–A′



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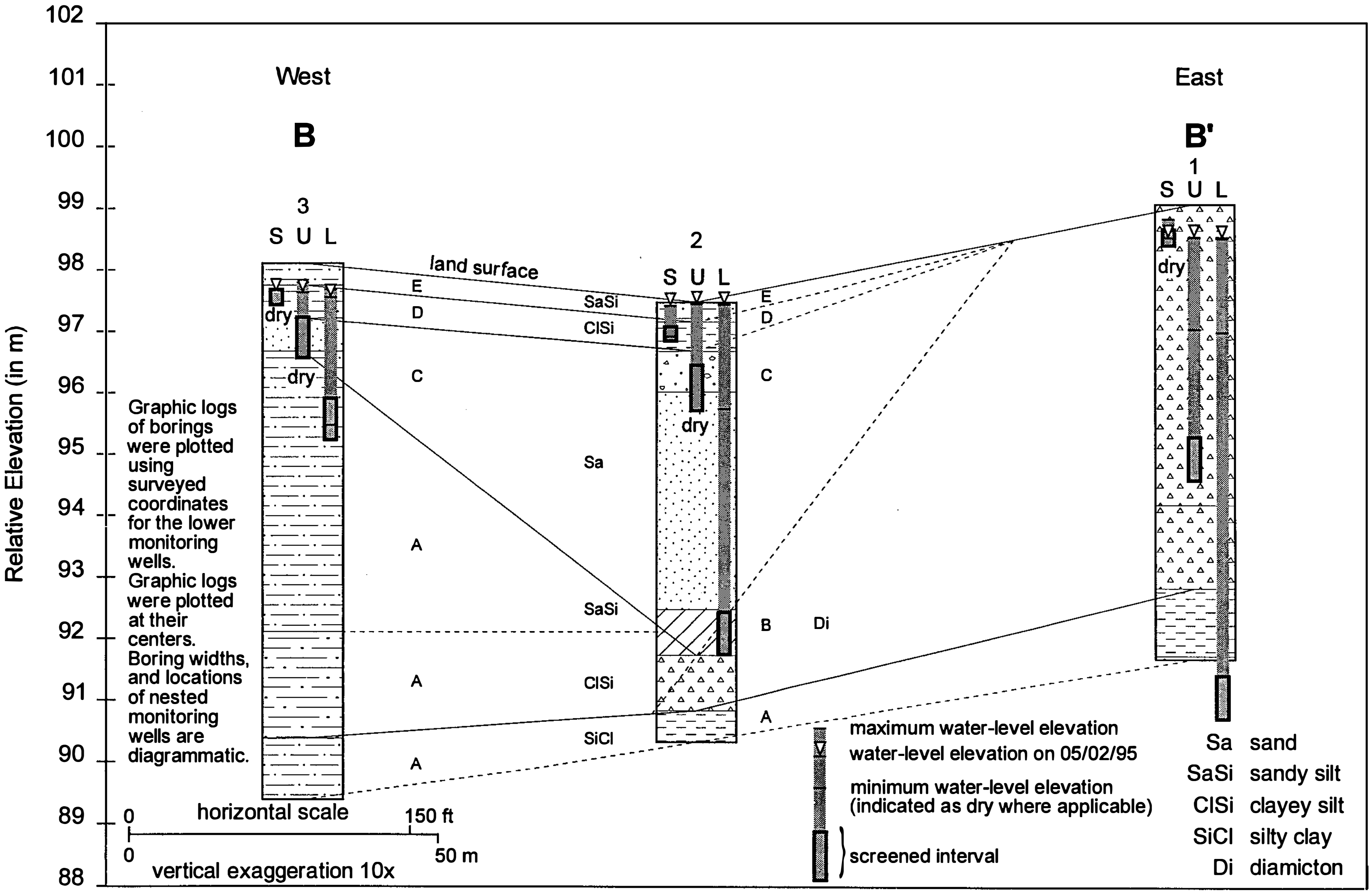
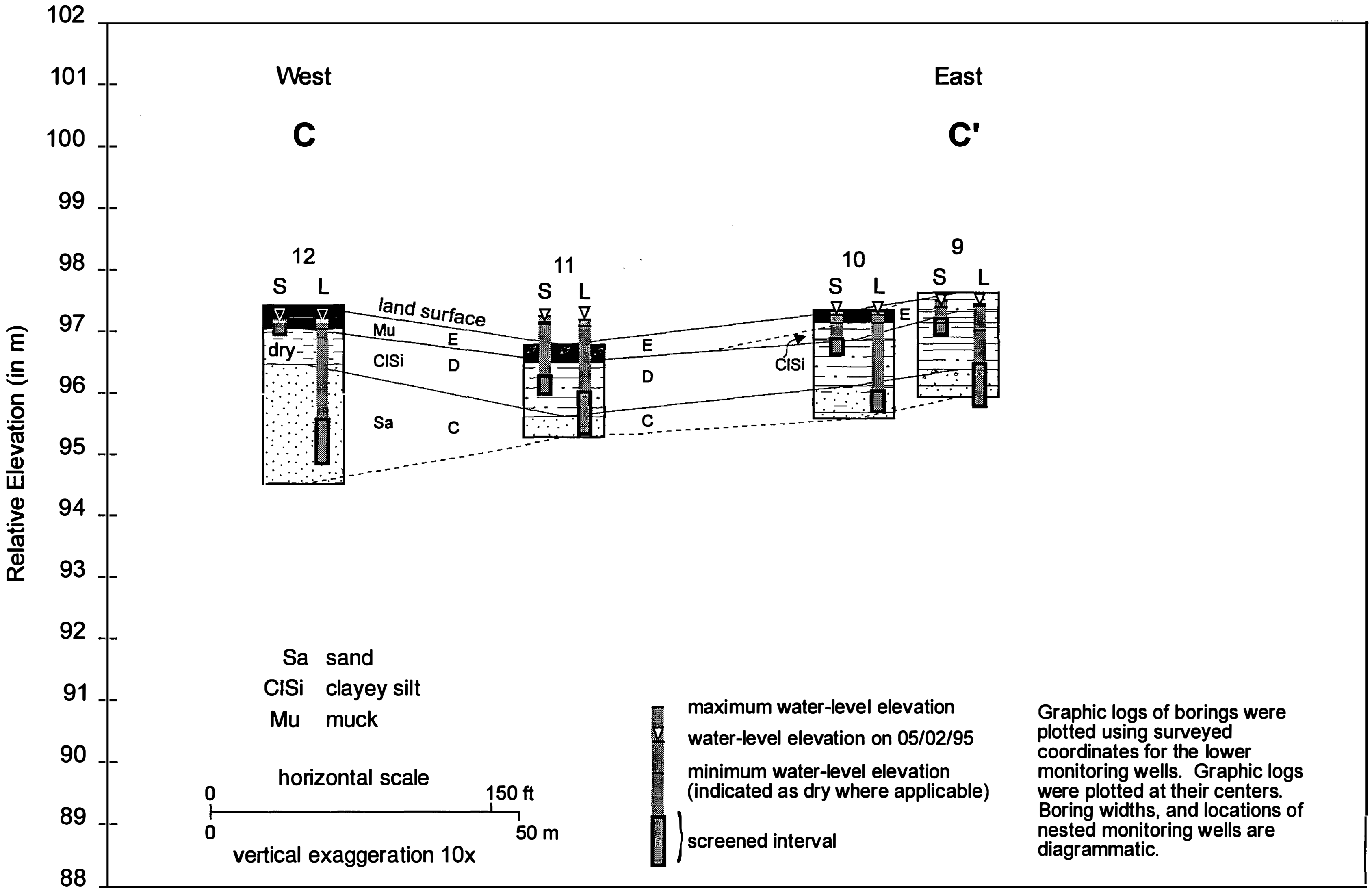


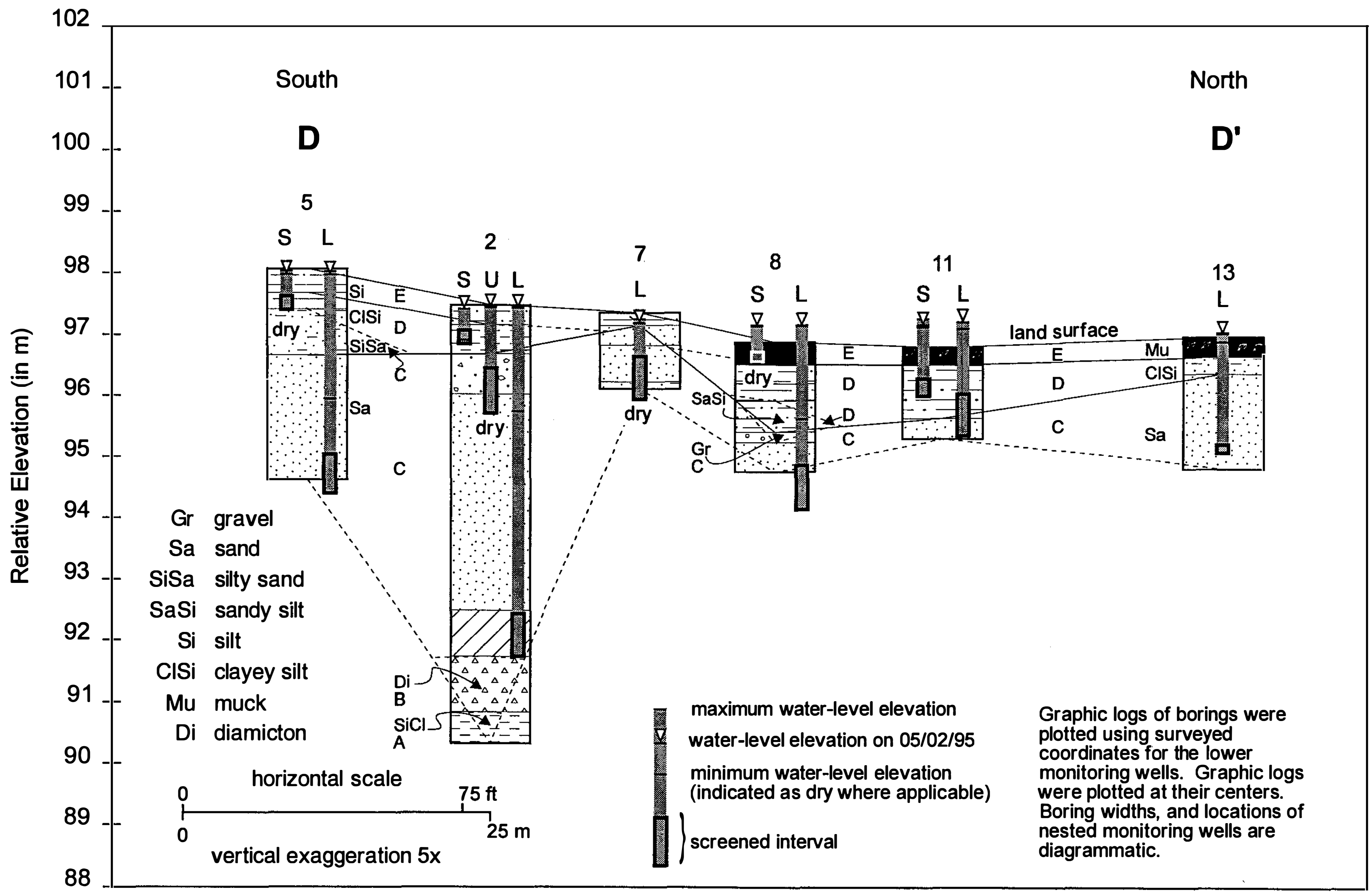
Part 3 Cross Sections with Well Diagrams (lines of cross section shown in figure 3)

CROSS SECTION C–C′



Part 3 Cross Sections with Well Diagrams (lines of cross section shown in figure 3)

CROSS SECTION D–D′

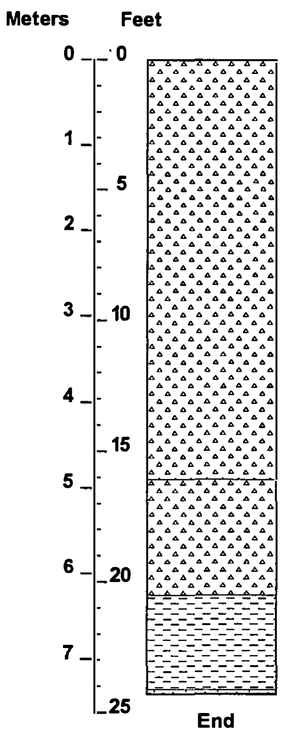


APPENDIX A *continued*

Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #1

Location	NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date	08/08/94
Field Crew	Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions	Not determined
Drilled With	Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments	Located on upland, east of the potential wetland mitigation area
Well Information	Three wells installed; construction information in Appendix C

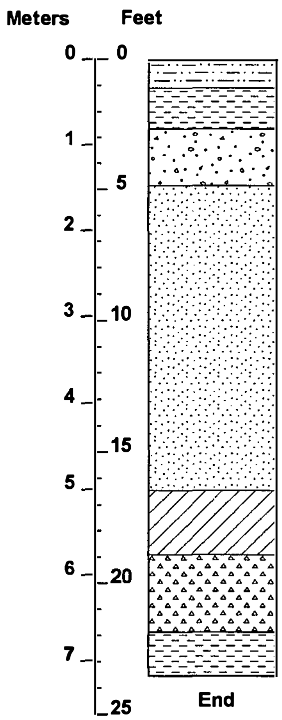


Depth		Unit Descriptions
0.00 –	4.89 m	**Diamicton;** silty clay loam texture; very stiff and dense; matrix supported; no visible sedimentary structures; less than 1% is pebbles of dolomite and red siltstone less than 10 mm in diameter; upper 0.35 m is brown (10YR 4/3), dry, noncalcareous, rooty, and has a very coarse crumb soil structure; between 0.35 and 1.52 m, grades to dark yellowish brown (10YR 4/4), is dry, weakly calcareous, and has root channels and a blocky soil structure; at 1.52 m, grades to brown (10YR 5/3) and becomes calcareous; at 2.36 m, grades to dark grayish brown (10YR 4/2) and becomes slightly softer, slightly moist, and more clay-rich; gray clay skins on fractures; at 3.45 m, grades to dark gray (10YR 4/1) and contains dark yellowish brown (10YR 4/6) fractures. Gradational lower contact to:
4.89 –	6.26 m	**Diamicton;** silty clay loam texture; moderately stiff and dense; moist; calcareous; matrix supported; contains less than 1% pebbles that are less than 10 mm in diameter of dolomite and red siltstone; slightly bedded containing softer, moister, clay-rich, grayish brown (10YR 5/2) zones in a dark gray (10YR 4/1), stiff, dry, silty clay matrix; no obvious boundaries between the beds are noted. Sharp lower contact to:
6.26 –	7.37 m	**Silty clay;** dark gray (10YR 4/1); moist; calcareous; finely laminated; Laminae are less than 1 mm thick; below 7.16 m, laminae coarsen and thicken downward; laminae consist of clay alternating with silt; clay laminae are grayish brown (10YR 5/2) and 2.5–5.0 mm thick; silt laminae are dark gray (10YR 4/1) and 1.0–2.5 mm thick. Sharp lower contact to:
7.37 –	7.41 m	**Sand;** dark gray (10YR 4/1); very coarse; sorted; clast supported; saturated; highly calcareous; bedded with sandy loam diamicton; diamicton is matrix supported, dark gray (10YR 4/1), highly calcareous, and saturated.

APPENDIX A *continued*
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #2

Location	NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date	08/08/94 3 P.M. and 08/09/94 A.M.
Field Crew	Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions	70°F, overcast
Drilled With	Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments	Located in potential wetland mitigation area, west of boring #1
Well Information	Three wells installed; construction information in Appendix C



Depth	Unit Descriptions
0.00 – 0.39 m	**Sandy silt;** black (N 2.5/); dry; noncalcareous; crumb to coarse crumb structure; approximately 5–10% is sand; about 50% is roots in the upper 0.12 m. Gradational lower contact to:
0.39 – 0.81 m	**Silty clay;** dark grayish brown (2.5Y 4/2) with approximately 10% small yellowish brown (10YR 5/8) mottles; mottles increasing with depth to greater than 50% at 0.65 m; root zones have reduced colors; increased sand content with depth; approximately 10% is manganese nodules, 1.0–2.5 mm in diameter, occur in a layer between 0.70 and 0.75 m. Sharp lower contact to:
0.81 – 1.49 m	**Gravelly sand;** mixed colors of gray, white and brown; approximately 5% is silty clay; moist to wet; clast supported in sorted beds; bedding is 1–2 mm thick; gravel is poorly sorted, subrounded, and composed of dolomite, granitics, quartzite, shale, and red siltstone up to 100 mm in diameter.
1.49 – 5.00 m	**Sand;** medium to very coarse; yellowish brown (10YR 5/6); sand is sorted, rounded, and composed of dolomite, quartz, basaltics, and siltstone; approximately 3% is gravel; wet; bedded; beds are 1–2 mm thick and vary in color and grain size with medium sand layers alternating with very coarse sand layers; very dark orange staining is present from 2.05–2.19 m; gravel up to 50 mm in diameter is present from 2.80–2.95 m; at 3.28 m, the unit changes to grayish brown (10YR 5/2); a silt layer, 10 mm in thickness, occurs at 3.40 m; granule layers 5 mm in thickness occur at 3.43, 3.60, and 4.52 m; grades into fine to medium sand at 4.60 m; a 100-mm diameter dolomite rock occurs at the base.
5.00 – 5.75 m	**No recovery.**

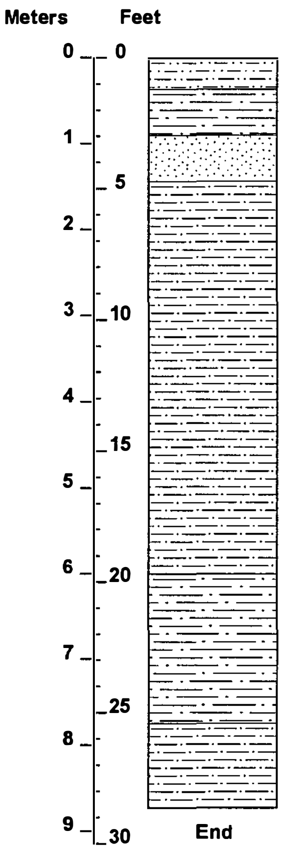
VAN PATTEN WOODS #2 *continued*

Depth	Unit Descriptions
5.75 – 6.67 m	**Diamicton;** silty clay loam texture; stratified with 10- to 20-mm thick beds of alternating dark gray (10YR 4/1) and grayish brown (2.5Y 5/2); matrix supported; rare gravel, 10–20 mm in diameter, of dolomite, shale, and basaltics; dense; dry; calcareous. Sharp lower contact to:
6.67 – 7.16 m	**Silty clay;** dark gray (10YR 4/1); calcareous; moist to dry; structureless; dense.

APPENDIX A *continued*
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #3

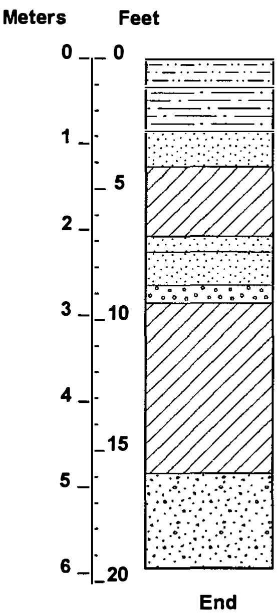
Location NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date 08/09/94 P.M.
Field Crew Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions Overcast, 75°F
Drilled With Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments Located on upland, west of boring #2. Wells were set in unsampled boring located 1.5 m west of this boring.
Well Information Three wells installed; construction information in Appendix C



Depth	Unit Descriptions
0.00 – 0.37 m	**Sandy silt;** brown (10YR 5/3); noncalcareous; rooty; stiff; dry; approximately 5–10% is sand; structureless. Gradational lower contact to:
0.37 – 0.91 m	**Clayey silt**; brown (10YR 4/3); rooty; dry; structureless; noncalcareous; approximately 10% is sand; color change at 0.75 m to yellowish brown (10YR 5/6). Sharp lower contact to:
0.91 – 1.44 m	**Sand;** medium; grayish brown (10YR 5/2) with yellowish brown (10YR 5/8) around roots; dry; bedded by grain size with beds between 1 and 5 mm in thickness. Sharp lower contact to:
1.44 – 6.00 m	**Sandy silt**; bedded; brown (10YR 5/3) but becomes saturated and grayish brown (2.5Y 5/2) below 2.38 m; beds are 1–100 mm thick; between 1.44 and 4.00 m, silt is bedded with medium to fine sand; between 4.00 and 6.00 m, silt has graded to clayey silt which is bedded with medium to fine sand; sand beds fine downward;
6.00 – 7.73 m	**Clayey silt;** bedded; dark gray (2.5Y 4/1); saturated; clayey silt is bedded with silt; silt beds are grayish brown (2.5Y 5/2); beds are 1–100 mm thick.
7.73 – 8.73 m	**Silt;** bedded; grayish brown (2.5Y 5/2); saturated; silt is bedded with clayey silt and very coarse sand; sand beds coarsen downward; beds are 1–100 mm thick; sand beds throughout unit are brown (10YR 5/3) to yellowish brown (10YR 5/8) with sorted and rounded grains; clayey silt beds are dark gray (2.5Y 4/1) and have a blocky structure.

VAN PATTEN WOODS #4

Location NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date 08/10/94
Field Crew Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions Rainy, overcast, 70°F
Drilled With Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments Well set in unsampled boring made 1.5 m southeast of this boring
Well Information Two wells installed; construction information in Appendix C

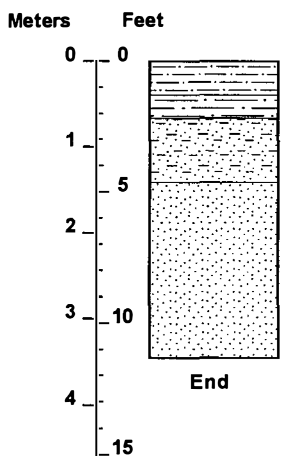


Depth		Unit Descriptions
0.00 –	0.34 m	**Sandy silt;** brown (10YR 4/3) grading to 10YR 5/3 at 0.30 m; soft; dry; noncalcareous; rooty.
0.34 –	0.83 m	**Clayey silt;** dark grayish brown (10YR 4/2); approximately 10% is sand; matrix supported; noncalcareous; porous; structureless; approximately 1–3% is gravel up to 20 mm in diameter consisting of basaltics and chert; rooty; manganese nodules noted; some mottling to yellowish brown (10YR 5/8); friable; worm burrows noted.
0.83 –	1.27 m	**Sand;** medium; laminated; laminae are 1–5 mm thick; sorted; subangular to rounded grains; noncalcareous; moist; rare 10-mm diameter gravel; clast supported.
1.27 –	2.06 m	**No recovery.**
2.06 –	2.25 m	**Sand;** medium to coarse; light yellowish brown (2.5Y 6/4); laminated by grain size with layers between 5 and 10 mm; approximately 5% is gravel up to 10 mm in diameter consisting of granitics, shale, and dolomite; noncalcareous; moist. Sharp lower contact to:
2.25 –	2.64 m	**Sand;** medium to coarse; well sorted; subangular; calcareous; structureless; moist. Sharp lower contact to:
2.64 –	2.84 m	**Sandy gravel;** saturated; sand is medium to coarse; subangular; poorly sorted; gravel is up to 100 mm in diameter and consists of dolomite, shale, and crystalline rocks; possible crude bedding.
2.84 –	4.84 m	**No recovery;** drilling behavior suggests gravel; sand in auger.
4.84 –	5.94 m	**Gravelly sand;** bedded with sandy to clayey silt; beds are 5–30 mm thick; dark gray (10YR 4/1); silts laminated; sands poorly sorted and subangular.

APPENDIX A *continued*
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #5

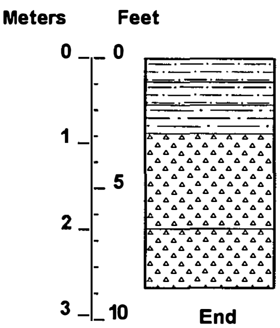
Location NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date 08/11/94
Field Crew Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions Overcast, 75°F
Drilled With Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments Located east of boring #4, in the potential wetland mitigation area. Wells installed in unsampled boring made 1.5 m west of this boring.
Well Information Two wells installed; construction information in Appendix C



Depth	Unit Descriptions
0.00 – 0.40 m	**Silt;** black (N 2.5/); organic; noncalcareous; dry to moist; rooty; no visible structure. Gradational lower contact to:
0.40 – 0.65 m	**Clayey silt;** olive brown (2.5Y 4/3) with yellowish brown (10YR 5/8) root rhizospheres; weakly calcareous; black burrow infillings; fine blocky peds; dry to moist. Gradational lower contact to:
0.65 – 1.40 m	**Silty sand;** moist; brown (10YR 5/3) with mottles of light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/8); at 0.92 m, grades to light olive brown (2.5Y 5/4) with mottles of brown (10YR 5/3) and yellowish brown (10YR 5/8); clast supported; rare 10-mm diameter gravel consisting of dolomite, shale, and sandstone; manganese nodules present between 0.95–1.05 m. Sharp lower contact to:
1.40 – 3.45 m	**Sand;** medium to very coarse; yellowish brown (10YR 5/4); wet to saturated; poorly bedded by grain size; subrounded to subangular; sorted grains; composed of quartz, dolomite, shale, heavy minerals; rare 1-mm thick brownish silt lenses.

VAN PATTEN WOODS #6

Location NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date 08/11/94, 3 P.M. start
Field Crew Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions Overcast, 70°F
Drilled With Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments Located in upland, east of boring #5
Well Information One well installed; construction information in Appendix C



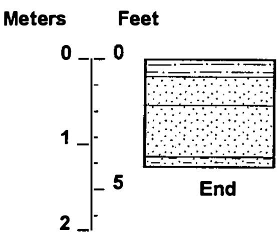
Depth		Unit Descriptions
0.00 –	0.26 m	**Silt;** very dark grey (10YR 3/1); organic; noncalcareous; rooty; dry to moist; crumb soil structure; rare 10-mm diameter dolomite gravel. Gradational lower contact to:
0.26 –	0.54 m	**Silt;** pale brown (10YR 6/3); dry; noncalcareous; coarse blocky soil structure. Gradational lower contact to:
0.54 –	0.86 m	**Clayey silt;** brown (10YR 4/3) with some root zones of strong brown (7.5YR 5/6); rooty; noncalcareous; dry; blocky soil structure; interbedded lower contact between 0.80 and 0.86 m with beds approximately 5 mm thick.
0.86 –	1.98 m	**Diamicton;** clay loam texture; dark yellowish brown (10YR 4/6); weakly calcareous; dry to moist; bedded with sand beds that are 100–200 mm thick; sand is strong brown (7.5YR 4/6), medium to very coarse, sorted, subangular, noncalcareous, dry to moist; becoming saturated, poorly sorted and poorly laminated below 1.56 m.
1.98 –	2.66 m	**Diamicton;** silty clay loam texture; dark gray (10YR 4/1) except brown (10YR 5/3) between 1.98 and 2.18 m; dense; dry to moist; large 50-mm diameter dolomite gravel at the upper contact; approximately 1% is gravel.

APPENDIX A *continued*

Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #7

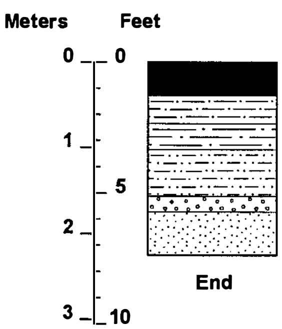
Location	SE SE SW Section 10, T46N, R11E, Rosecrans, IL
Date	08/22/94
Field Crew	Michael Miller, James Miner
Weather Conditions	Sunny 75°F, no wind
Drilled With	Hand auger
Comments	Located in wetland, north of the potential wetland mitigation area
Well Information	One well installed; construction information in Appendix C



Depth		**Unit Descriptions**
0.00 –	0.21 m	**Silt;** black (N 2.5/); peaty structure; organic; noncalcareous; rooty; moist to dry; slight increase in clay toward base. Gradational lower contact to:
0.21 –	0.55 m	**Sand;** light olive brown (2.5Y 5/3) grading to olive gray (5Y 5/2) below 0.40 m; medium to coarse; moderately sorted; subangular; contains approximately 10% silt; matrix supported; sand contains quartz and rock fragments; mottles of yellowish red (5YR 5/8) occur below 0.25 m; dispersed pyrite crystals, approximately 1 mm in diameter, occur in layers between 0.50 and 0.55 m; noncalcareous. Gradational lower contact to:
0.55 –	1.15 m	**Sand;** grayish brown (10YR 5/2); coarse grading to very coarse toward the base; clast supported; poorly sorted and subangular grains; poorly bedded; dispersed pyrite crystals, approximately 1 mm in diameter, occur in layers between 0.55 and 0.80 m; silt laminae, 1 mm thick, occur throughout and are whitish to tan to brown in color; below 0.80 m, unit becomes saturated; rare gravel 10 mm in diameter; near the base, sand becomes very coarse, pyritic, and brownish yellow (10YR 6/8). Gradational lower contact to:
1.15 –	1.25 m	**Silty sand;** light olive brown (2.5Y 5/4); very poorly sorted; approximately 10% is gravel that is 10 mm in diameter.

VAN PATTEN WOODS #8

Location	SE SE SW Section 10, T46N, R11E, Rosecrans, IL
Date	08/22/94
Field Crew	Michael Miller, James Miner
Weather Conditions	Sunny, 75°F
Drilled With	Hand auger
Comments	Located in wetland, north of the potential wetland mitigation area
Well Information	Two wells installed; construction information in Appendix C

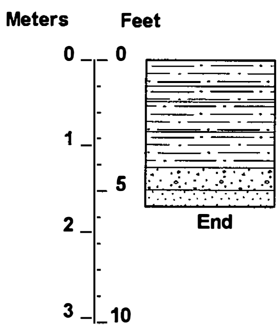


Depth		**Unit Descriptions**
0.00 –	0.40 m	**Muck;** root mat of partly decomposed cattails, very dark brown (10YR 2/2) becoming black (N 2.5/) at 0.09 m; slightly elastic; noncalcareous; slightly silty below 0.15 m. Sharp lower contact to:
0.40 –	0.70 m	**Silt;** black (N 2.5/) grading to dark grayish brown (2.5Y 4/2) with yellowish brown (10YR 5/8) root channels; organic; soft; roots present; slightly clayey; moist. Gradational lower contact to:
0.70 –	1.03 m	**Clayey silt;** dark grayish brown (2.5Y 4/2) with yellowish brown (10YR 5/8) root channels; soft; sticky; moist. Sharp lower contact to:
1.03 –	1.55 m	**Sandy silt;** very coarse silt and very fine sand; dark grayish brown (2.5Y 4/2); wet; clast supported. Gradational lower contact to:
1.55 –	1.75 m	**Gravel;** gray; granule-size; clean; clast supported; poorly sorted; sand composed of rock fragments and quartz; subangular; clasts up to 30 mm in diameter are present and consist of dolomite and chert; saturated.
1.75 –	2.13 m	**Sand;** gray; fine to coarse; bedded; sorted; subrounded to subangular; composed of rock fragments and quartz; saturated.

APPENDIX A *continued*
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #9

Location SW SW SE Section 10, T46N, R11E, Rosecrans, IL
Date 02/28/95
Field Crew James Miner, Rebecca Reid, Jeff Stillman, Martha Cardona
Weather Conditions Sunny, 25°F
Drilled With Hand auger
Comments Located north of the potential wetland mitigation site on the east side of the sedge meadow
Well Information Two wells installed; construction information in Appendix C

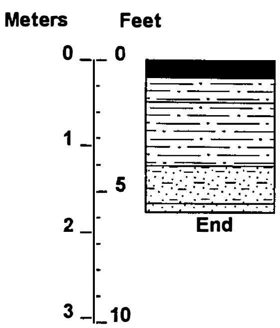


Depth	Unit Descriptions
0.00 – 0.30 m	**Clayey silt;** black (N 2.5/); moist; modern roots present; crumb soil structure; no mottling. Gradational lower contact to:
0.30 – 0.48 m	**Clayey silt;** very dark gray (10YR 3/1); moist; approximately 1–3% is sand and gravel; crumb soil structure; no apparent mottling. Gradational lower contact to:
0.48 – 0.83 m	**Clayey silt;** grayish brown (2.5Y 5/2) with yellowish brown mottles (10YR 5/8); mottles comprise about 20% and are 1–5 mm in diameter; moist; dense; approximately 1–3% is sand and gravel; rare modern roots present. Gradational lower contact to:
0.83 – 1.25 m	**Clayey silt;** olive gray (5Y 5/2) with yellowish brown (10YR 5/8) mottles; mottles comprise about 10% and are 5–10 mm in diameter. Sharp lower contact to:
1.25 – 1.51 m	**Gravelly sand;** multicolored by layers from yellowish brown to pinkish gray to orangish brown; very poorly sorted; poorly bedded; mixed matrix and clast supported; gravel is 10–30 mm in diameter, subangular and dolomitic. Gradual lower contact to:
1.51 – 1.70 m	**Sand;** grayish brown; fine to very coarse; poorly sorted; clast supported; subrounded to well rounded grains; very poorly bedded by grain size.

APPENDIX A *continued*
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #10

Location SW SW SE Section 10, T46N, R11E, Rosecrans, IL
Date 02/28/95
Field Crew James Miner, Rebecca Reid, Jeff Stillman, Martha Cardona
Weather Conditions Sunny, 25°F
Drilled With Hand auger
Comments Located north of the potential wetland mitigation site on the east side of the sedge meadow
Well Information Two wells installed; construction information in Appendix C

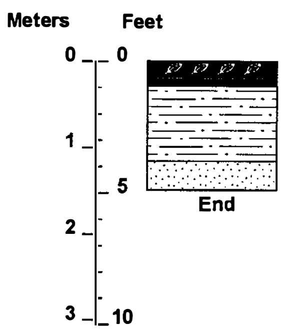


Depth	Unit Descriptions
0.00 – 0.20 m	**Muck;** black (N 2.5/); slightly elastic; rooty; approximately 30–50% is silt; very rare sand grains; massive structure. Gradual lower contact to:
0.20 – 0.49 m	**Clayey silt;** black (N 2.5/); organic-rich; rare sand grains; rooty; no mottling; very fine crumb structure. Gradual lower contact to:
0.49 – 1.23 m	**Clayey silt;** approximately 1–5% is sand; moist to saturated; between 0.49 and 0.62 m, unit is very dark gray (2.5Y 3/1), rooty, moderately stiff, and lacks mottling; between 0.62 and 1.23 m, unit contains woody fragments, and is gray (10YR 5/1) and mottled yellowish brown (10YR 5/8); mottles comprise about 25% and are approximately 1–5 mm in diameter; below 0.80 m, mottle diameter increases to 5–10 mm, and unit becomes soft and sticky.
1.23 – 1.66 m	**Silty sand;** grayish; layered; moist to saturated; matrix supported; sticky; very poorly sorted; rooty in places; multicolored pebbles of dolomite, shale, and red siltstone are present; dolomitic pebbles are up to 12 mm in diameter; subangular to angular grains. Sharp lower contact to:
1.66 – 1.77 m	**Sand;** brownish; very fine to very coarse; poorly sorted; clast supported; saturated; grains consist of quartz and rock fragments.

APPENDIX A *continued*
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #11

Location	SE SE SW Section 10, T46N, R11E, Rosecrans, IL
Date	03/01/95
Field Crew	Rebecca Reid, James Miner
Weather Conditions	Sunny, 25°F
Drilled With	Hand auger
Comments	Located north of the potential wetland mitigation site in the center of the sedge meadow
Well Information	Two wells installed; construction information in Appendix C

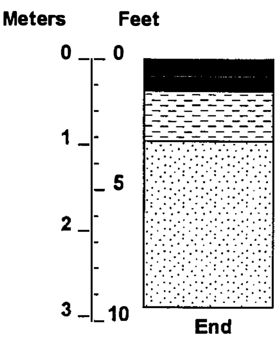


Depth		Unit Descriptions
0.00 –	0.20 m	**Organic mat** consisting of modern marsh-plant fragments; black (N 2.5/); very fibrous; no well developed peaty structure; no sand present; noncalcareous. Gradational lower contact to:
0.20 –	0.29 m	**Muck;** black (N 2.5/); clay-rich; organic; no apparent mottling or bedding; modern roots present; noncalcareous; moist. Gradational lower contact to:
0.29 –	1.16 m	**Clayey silt;** pale olive (5Y 6/4) matrix mottled with yellowish brown (10YR 5/8); mottles comprise about 30% and are 1–5 mm in diameter; noncalcareous; possibly laminated; below 0.89 m, matrix becomes pale olive (5Y 6/3) and mottles disappear. Laminated lower contact to:
1.16 –	1.50 m	**Sand;** dark gray (5Y 4/1); very poorly sorted; approximately 1–5% is gravel up to 30 mm in diameter; sand consists of quartz and rock fragments; grains are rounded to subangular and range in size from very fine to very coarse; noncalcareous; matrix supported; saturated; gravel is slightly rounded and consists of dolomite and igneous rock fragments.

APPENDIX A *continued*
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #12

Location SE SE SW Section 10, T46N, R11E, Rosecrans, IL
Date 03/01/95
Field Crew Rebecca Reid, James Miner
Weather Conditions Sunny, 25°F
Drilled With Hand auger
Comments Located north of the potential wetland mitigation site on the west border of the sedge meadow
Well Information Two wells installed; construction information in Appendix C

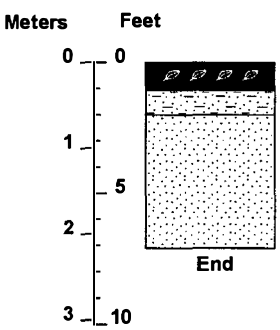


Depth	Unit Descriptions
0.00 – 0.20 m	**Muck;** black (N 2.5/); noncalcareous; modern roots present; mottling absent; coarse crumb soil structure. Gradational lower contact to:
0.20 – 0.38 m	**Muck;** black (N 2.5/); silty; noncalcareous; modern roots present; some preserved plant material present; slightly layered or streaked with light olive brown (2.5Y 5/3) silty material. Gradational lower contact to:
0.38 – 0.96 m	**Silty clay;** gray (5Y 6/1) matrix with yellowish brown (10YR 5/8) mottles; mottles comprise about 20% and are 1–5 mm in diameter; approximately 1–5% is sand. Gradational lower contact to:.
0.96 – 2.91 m	**Sand;** sorted; coarsely bedded by grain size; grains range in size between fine and coarse, and are rounded to subrounded; noncalcareous; saturated; some rooty material present between 0.96 and 1.26 m; olive yellow (2.5Y 6/8) between 0.96 and 1.30 m; light olive brown (2.5Y 5/4) between 1.30 and 2.15 m; gray (10YR 5/1) between 2.15 and 2.91 m; sand consists of quartz, and rock fragments of reddish siltstone, dolomite and shale; rare shale and dolomite gravel up to 20 mm in diameter.

APPENDIX A *continued*
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #13

Location	SW SW SE Section 10, T46N, R11E, Rosecrans, IL
Date	03/01/95
Field Crew	Rebecca Reid, James Miner
Weather Conditions	Sunny, 25°F
Drilled With	Hand auger
Comments	Located north of the potential wetland mitigation site on the north side of the sedge meadow
Well Information	One well installed; construction information in Appendix C



Depth	**Unit Descriptions**
0.00 – 0.33 m	**Organic mat** consisting of modern plant fragments; black (N 2.5/); rooty; no peaty structure; not elastic; no apparent clastics; noncalcareous; saturated. Gradational lower contact to:.
0.33 – 0.61 m	**Silty sand;** dark grayish brown (2.5Y 4/2) matrix with yellowish brown (10YR 5/8) mottles; mottles comprise about 5% and are approximately 5–10 mm in diameter; noncalcareous; saturated; sand is poorly sorted with subangular to rounded grains; sand consists of quartz and rock fragments of reddish siltstone, dolomite and shale; approximately 5–10% is clay. Gradational lower contact to:.
0.61 – 2.17 m	**Sand;** grayish brown (2.5Y 5/2); sorted, noncalcareous; saturated; subangular to rounded grains; grains consist of quartz, and rock fragments of reddish siltstone, dolomite and shale; between 0.61 and 1.01 m, unit is bedded with black rooty organic layers about 5 mm thick; becomes dark gray (2.5Y 4/1) near base; some crude bedding by grain size with fine layers alternating with medium to coarse layers; occasional 20-mm diameter pebbles present.

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

Table B1 Relative water-level elevations (in m).

Read by	ISGS	ISGS	ISGS	ISGS	ISGS	ISGS	NIU	NIU	ISGS	NIU	NIU	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	NIU
Date	08/31/94	10/05/94	11/02/94	11/29/94	01/05/95	02/08/95	03/05/95	03/12/95	03/15/95	03/18/95	03/26/95	04/02/95	04/05/95	04/09/95	04/15/95	04/22/95	04/29/95	05/02/95	05/06/95	05/12/95	05/19/95
Well 1S	*	*	*	*	dry	dry	dry	dry	dry	dry	dry	98.444	dry	dry	98.673	98.629	98.839	98.523	98.585	98.616	dry
Well 1U	97.029	97.203	97.133	97.437	98.073	98.313	98.083	98.051	98.049	98.061	98.095	98.194	98.213	98.216	98.330	98.435	98.508	98.529	98.528	98.528	98.516
Well 1L	97.363	97.079	96.979	97.449	97.779	98.047	98.020	98.026	98.065	98.079	98.134	98.226	98.225	98.217	98.350	98.413	98.519	98.507	98.473	98.542	98.476
Well 2S	*	*	*	*	96.907	97.121	97.058	97.401	97.371	frozen	frozen	97.325	97.285	97.420	97.395	97.411	97.132	97.410	97.409	97.419	97.320
Well 2U	96.054	95.814	dry	96.702	96.892	97.112	97.089	97.412	97.376	97.324	97.285	97.362	97.298	97.466	97.425	97.444	97.453	97.444	97.392	97.448	97.341
Well 2L	96.052	95.802	95.742	96.690	96.898	97.122	97.079	97.402	97.373	97.314	97.285	97.352	97.296	97.441	97.426	97.415	97.458	97.433	97.392	97.451	97.334
Well 3S	*	*	*	*	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	97.642	97.469	97.614	dry
Well 3U	dry	dry	dry	dry	dry	96.893	96.823	96.982	97.086	97.090	96.849	97.217	97.165	97.157	97.454	97.465	97.801	97.630	97.468	97.618	97.352
Well 3L	95.761	95.530	95.465	96.031	96.475	96.779	96.724	96.908	96.989	96.975	97.216	97.105	97.065	97.086	97.352	97.349	97.691	97.545	97.387	97.519	97.283
Well 4S	*	*	*	*	dry	dry	dry	dry	dry	dry	dry	97.586	97.526	97.663	97.774	97.771	97.905	97.813	97.715	97.837	97.674
Well 4L	96.220	96.018	95.884	96.518	96.938	97.245	97.144	97.239	97.472	97.432	97.430	97.576	97.508	97.663	97.763	97.766	97.900	97.802	97.709	97.598	97.631
Well 5S	*	*	*	*	dry	dry	dry	97.555	97.620	97.552	97.552	97.752	97.663	97.733	97.955	97.955	98.027	97.967	97.832	98.004	97.755
Well 5L	96.284	96.079	95.941	96.575	**	97.353	97.243	97.548	97.594	97.546	97.548	97.742	97.655	97.826	97.955	97.955	98.031	97.958	97.843	98.005	97.759
Well 6L	dry	dry	dry	dry	97.243	97.495	97.341	97.639	97.723	97.683	97.766	98.046	97.887	97.919	98.338	98.281	98.447	98.192	97.959	98.323	97.860
Well 7L	95.992	dry	dry	96.849	96.921	97.075	97.094	97.241	97.199	97.167	97.139	97.145	97.127	97.234	97.167	97.177	97.197	97.170	97.154	97.187	97.131
Well 8S	dry	dry	dry	96.782	frozen	frozen	frozen	97.128	97.126	97.128	97.109	97.116	frozen	97.128	97.125	97.128	97.138	97.122	97.128	97.136	97.126
Well 8L	95.976	95.598	95.847	96.789	frozen	frozen	frozen	97.112	97.131	97.107	97.106	97.109	frozen	97.112	97.112	97.112	97.122	97.123	97.117	97.127	97.110
Well 9S	*	*	*	*	*	*	97.134	97.390	97.340	97.275	97.250	97.263	97.237	97.326	97.348	97.333	97.485	97.384	97.294	97.426	97.256
Well 9L	*	*	*	*	*	*	97.014	97.400	97.355	97.296	97.241	97.267	97.253	97.343	97.381	97.375	97.481	97.397	97.306	97.438	97.268
Well 10S	*	*	*	*	*	*	97.141	97.311	97.274	97.225	97.187	97.206	97.191	97.257	97.251	97.130	97.289	97.259	97.212	97.266	97.187
Well 10L	*	*	*	*	*	*	97.131	97.283	97.269	97.225	97.191	97.207	97.181	97.219	97.248	97.232	97.303	97.263	97.214	97.280	97.199
Well 11S	*	*	*	*	*	*	frozen	97.134	97.139	97.121	97.112	97.254	97.123	97.157	97.126	97.137	97.152	97.138	97.121	97.139	97.129
Well 11L	*	*	*	*	*	*	frozen	97.076	97.099	97.083	97.102	97.188	97.114	97.184	97.115	97.127	97.178	97.180	97.165	97.181	97.153
Well 12S	*	*	*	*	*	*	frozen	97.155	97.130	97.101	97.097	97.104	97.105	97.129	97.117	97.129	dry	97.154	97.122	97.139	97.101
Well 12L	*	*	*	*	*	*	97.040	97.109	97.097	97.076	97.067	97.086	97.076	97.102	97.131	97.109	97.192	97.148	97.101	97.147	97.083
Well 13L	*	*	*	*	*	*	96.860	96.987	96.974	96.957	96.946	96.962	96.950	96.953	96.974	96.946	97.017	96.988	96.972	97.005	96.964
Gauge A	*	*	*	*	*	*	frozen	97.134	97.128	97.122	**	97.128	97.109	97.134	97.131	97.131	97.137	97.128	97.131	97.128	97.119

* Not yet installed

** No measurement

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

Table B2 Depth to water in monitoring wells referenced to land surface (in m).

Read by	ISGS	ISGS	ISGS	ISGS	ISGS	ISGS	NIU	NIU	ISGS	NIU	NIU	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	NIU
Date	08/31/94	10/05/94	11/02/94	11/29/94	01/05/95	02/08/95	03/05/95	03/12/95	03/15/95	03/18/95	03/26/95	04/02/95	04/05/95	04/09/95	04/15/95	04/22/95	04/29/95	05/02/95	05/06/95	05/12/95	05/19/95
Well 1S	*	*	*	*	dry	dry	dry	dry	dry	dry	dry	0.632	dry	dry	0.403	0.448	0.237	0.553	0.491	0.460	dry
Well 1U	2.042	1.868	1.938	1.634	0.998	0.758	0.988	1.020	1.022	1.010	0.976	0.877	0.858	0.855	0.741	0.636	0.563	0.542	0.543	0.543	0.555
Well 1L	1.714	1.998	2.098	1.628	1.298	1.030	1.057	1.051	1.012	0.998	0.943	0.851	0.852	0.861	0.727	0.664	0.558	0.570	0.604	0.535	0.601
Well 2S	*	*	*	*	0.616	0.402	0.465	0.122	0.152	frozen	frozen	0.198	0.238	0.103	0.128	0.112	0.391	0.113	0.114	0.104	0.203
Well 2U	1.428	1.668		0.780	0.590	0.370	0.393	0.070	0.106	0.159	0.197	0.120	0.184	0.016	0.057	0.038	0.029	0.038	0.090	0.034	0.141
Well 2L	1.428	1.678	1.738	0.790	0.582	0.358	0.401	0.078	0.107	0.167	0.195	0.128	0.184	0.039	0.054	0.065	0.022	0.047	0.088	0.029	0.146
Well 3S	*	*	*	*	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	0.485	0.658	0.513	dry
Well 3U	dry	dry	dry	dry	dry	1.215	1.285	1.126	1.022	1.018	1.259	0.891	0.943	0.951	0.654	0.643	0.307	0.478	0.640	0.490	0.756
Well 3L	2.326	2.557	2.622	2.056	1.612	1.308	1.363	1.179	1.098	1.112	0.871	0.982	1.022	1.001	0.735	0.738	0.396	0.542	0.700	0.568	0.805
Well 4S	*	*	*	*	dry	dry	dry	dry	dry	dry	dry	0.535	0.595	0.458	0.347	0.351	0.216	0.308	0.406	0.284	0.447
Well 4L	1.862	2.064	2.198	1.564	1.144	0.837	0.938	0.843	0.610	0.650	0.652	0.506	0.574	0.419	0.319	0.316	0.182	0.280	0.373	0.484	0.451
Well 5S	*	*	*	*	dry	dry	dry	0.510	0.445	0.513	0.513	0.313	0.402	0.332	0.110	0.110	0.038	0.098	0.233	0.061	0.310
Well 5L	1.777	1.982	2.120	1.486	**	0.708	0.818	0.513	0.467	0.515	0.513	0.319	0.406	0.235	0.107	0.107	0.030	0.103	0.218	0.056	0.302
Well 6L	dry	dry	dry	dry	1.555	1.303	1.457	1.159	1.075	1.116	1.032	0.752	0.911	0.879	0.460	0.517	0.351	0.606	0.839	0.475	0.938
Well 7L	1.351	dry	dry	0.494	0.422	0.268	0.249	0.103	0.144	0.176	0.204	0.198	0.216	0.109	0.176	0.166	0.146	0.173	0.189	0.156	0.212
Well 8S	dry	dry	dry	0.082	frozen	frozen	frozen	-0.264	-0.262	-0.264	-0.245	-0.252	frozen	-0.264	-0.261	-0.264	-0.274	-0.258	-0.264	-0.272	-0.262
Well 8L	0.859	1.237	0.988	0.046	frozen	frozen	frozen	-0.277	-0.296	-0.272	-0.271	-0.274	frozen	-0.277	-0.277	-0.277	-0.287	-0.288	-0.282	-0.292	-0.275
Well 9S	*	*	*	*	*	*	0.459	0.203	0.253	0.318	0.343	0.330	0.356	0.267	0.245	0.261	0.108	0.209	0.299	0.167	0.337
Well 9L	*	*	*	*	*	*	0.601	0.215	0.260	0.319	0.374	0.348	0.362	0.272	0.234	0.240	0.134	0.218	0.309	0.177	0.347
Well 10S	*	*	*	*	*	*	0.176	0.006	0.043	0.092	0.130	0.111	0.126	0.060	0.067	0.187	0.028	0.058	0.105	0.051	0.130
Well 10L	*	*	*	*	*	*	0.207	0.054	0.068	0.113	0.146	0.130	0.156	0.118	0.089	0.105	0.034	0.074	0.123	0.057	0.138
Well 11S	*	*	*	*	*	*	frozen	-0.399	-0.404	-0.386	-0.377	-0.519	-0.388	-0.422	-0.391	-0.402	-0.417	-0.403	-0.386	-0.404	-0.394
Well 11L	*	*	*	*	*	*	frozen	-0.310	-0.333	-0.317	-0.336	-0.422	-0.348	-0.418	-0.349	-0.361	-0.412	-0.414	-0.399	-0.415	-0.387
Well 12S	*	*	*	*	*	*	frozen	0.243	0.268	0.297	0.301	0.294	0.293	0.269	0.282	0.269	dry	0.244	0.276	0.259	0.297
Well 12L	*	*	*	*	*	*	0.379	0.311	0.322	0.344	0.352	0.333	0.343	0.317	0.288	0.311	0.227	0.271	0.318	0.272	0.336
Well 13L	*	*	*	*	*	*	0.087	-0.040	-0.027	-0.010	0.001	-0.015	-0.003	-0.006	-0.027	0.001	-0.070	-0.041	-0.025	-0.058	-0.017

* Not yet installed
** No measurement
\- Above land surface

APPENDIX C Well Construction Information

Table C1 Construction information for monitoring wells (all measurements reported in m)

Well	Total length of well	Total depth of well	Height of measuring point above land surface	Depth to base of screen	Depth to top of screen	Depth to top of sand pack	Depth to top of bentonite seal	Depth of concrete seal
1U	5.08	4.50	0.58	4.50	3.79	3.69	0.76	0.76–surface
1L	8.98	8.38	0.60	8.38	7.67	7.22	4.72	0.76–surface
1S	1.85	0.71	1.14	0.69	0.42	0.31	surface	none
2U	2.31	1.77	0.54	1.77	1.03	0.61	0.30	0.30–surface
2L	6.79	5.75	1.04	5.75	5.05	4.40	3.35	0.30–surface
2S	1.83	0.72	1.11	0.68	0.45	0.32	surface	none
3U	2.28	1.52	0.76	1.52	0.85	0.70	0.50	0.50–surface
3L	3.77	2.86	0.91	2.86	2.18	2.03	1.55	0.50–surface
3S	1.84	0.73	1.11	0.70	0.45	0.38	surface	none
4L	3.68	2.77	0.91	2.72	1.99	1.82	0.52	0.52–surface
4S	1.83	0.72	1.11	0.69	0.42	0.35	surface	none
5L	4.83	3.73	1.10	3.67	3.03	1.68	0.53	0.53–surface
5S	1.81	0.72	1.09	0.68	0.45	0.44	surface	none
6L	3.86	2.72	1.14	2.66	1.96	1.40	0.70	0.70–surface
7L	2.35	1.50	0.85	1.42	0.72	0.60	surface	none
8S	1.78	0.36	1.42	0.32	0.16	0.10	surface	none
8L	3.88	2.79	1.09	2.72	2.00	1.25	0.40	0.40–surface
9S	1.92	0.72	1.20	0.66	0.39	0.34	surface	none
9L	2.34	1.92	0.42	1.85	1.15	1.08	surface	none
10S	1.89	0.75	1.14	0.71	0.45	0.35	surface	none
10L	2.71	1.71	1.00	1.66	1.32	1.25	surface	none
11S	1.95	0.84	1.11	0.77	0.48	0.28	surface	none
11L	2.45	1.53	0.92	1.45	0.76	0.58	surface	none
12S	1.01	0.72	0.29	0.69	0.46	0.38	surface	none
12L	3.79	2.64	1.15	2.58	1.85	1.50	surface	none
13L	3.27	1.96	1.31	1.91	1.77	1.75	surface	none