LEVEL II HYDROGEOLOGIC CHARACTERIZATION REPORT: EDGEWOOD AND LARKINSBURG SITES

Near Edgewood, Illinois,
Effingham and Clay Counties
(Federal Aid Project 328
Sequence Numbers 391 and 10469)

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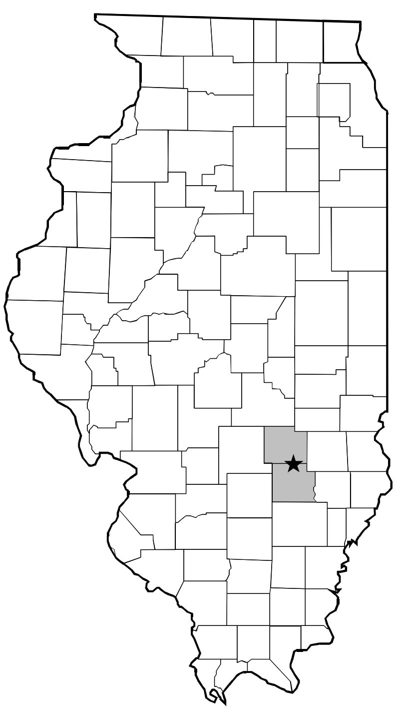

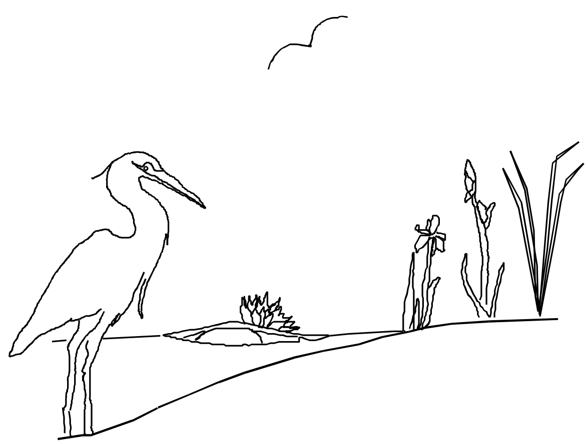

EXECUTIVE SUMMARY

In September 2002, the Illinois Department of Transportation (IDOT) tasked the Wetlands Geology Section of the Illinois State Geological Survey (ISGS) to conduct a hydrogeologic characterization of the Edgewood and Larkinsburg potential wetland compensation sites, located near Edgewood, Illinois in Effingham and Clay counties. Site monitoring began in April 2003.

Results of this investigation indicate that the potential for wetland compensation at these sites is low. No reversible hydrologic alterations were found, and direct precipitation is currently the primary source of water for these sites. Wetland hydrology criteria were satisfied at Edgewood and Larkinsburg in only limited areas due to the combination of unfavorable landscape positions and limited water sources. Excavation of wetland creation basins is the only option for potentially increasing the areas satisfying wetland hydrology criteria. Even with excavation, there may be insufficient water to support the additional wetland areas because both sites will still depend upon precipitation as the primary water source. It may be necessary to excavate catchment areas for each wetland creation basin, and nearby excavations suggest catchment areas may need to be twice the size of wetland areas needed.

The land surface at the Edgewood site slopes gently westward, and exhibits broad, flat areas along with a few isolated topographic lows. Water is held in the low areas for long periods of time, which is likely due to low permeability surface materials. If more extensive isolated low areas are created through shallow excavation, and retention of water is aided by building of berms, then additional areas may satisfy wetland hydrology criteria. In addition to excavation, redirecting runoff from adjacent farm fields onto the site using shallow ditches would increase the catchment area and may provide sufficient water for the wetland mitigation areas. Recommended excavation depths range up to 0.5 m (1.6 ft.), and up to 2.6 ha (6.5 ac.) of mitigation might be feasible at this site, although larger areas may be possible.

The land surface at the Larkinsburg site is domed, and exhibits broad, somewhat flat uplands in its central portion and steeper slopes including drainage-ways in the northern and southern parts. The site occupies a higher landscape position than the Edgewood site. The shape and landscape position promote rapid site drainage in the upland areas. Also, the landscape position of the site precludes the option of redirecting runoff onto the site from adjacent properties. Significantly greater excavation would be required at the Larkinsburg site to create areas that could collect water because of the land-surface shape. Recommended excavation depths range up to 1.2 m (3.9 ft.), and up to 6.3 ha (15.6 ac.) of mitigation might be feasible at this site.

These recommendations were prepared using limited monitoring data. Additional monitoring is recommended to further support the observations and recommendations presented here.

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INTRODUCTION

This report was prepared by the Illinois State Geological Survey (ISGS) to provide the Illinois Department of Transportation (IDOT) with conclusions regarding the hydrogeologic conditions of two potential wetland compensation sites located near Edgewood, Illinois (Figure 1). The Edgewood site (SE 1/4, NE 1/4, Sec 30, T6N, R5E, Effingham County) covers 5.2 ha (12.8 ac.) and is currently used as an agricultural field. The Larkinsburg site (SE 1/4, NW 1/4, Sec 8, T5N, R5E, Clay County) covers 18.5 ha (45.6 ac.) and is also currently used as an agricultural field.

The purpose of this report is to provide IDOT with data and interpretations regarding the hydrogeologic conditions of the study sites, and to make recommendations regarding restoration and/or creation of wetlands. Therefore, for convenience, the report presents conclusions and design recommendations first, followed by a discussion of the methods and supporting data. Supporting data include ground-water, surface-water, and precipitation data collected from April 2003 through October 2004, along with geologic data collected during the initial site evaluation in August 2002, and all available file information. Soils information included in this report is from published reports and maps, and is presented for hydrogeologic purposes.

Data collection at the sites is ongoing and will continue until terminated by IDOT. The data currently being collected will be used to compare the pre- and post-construction hydrology of the sites, and to determine the impact of mitigation activities on the extent and duration of wetland hydrology.

SUMMARY

The potential for wetland compensation at the Edgewood and Larkinsburg sites is **low**, though Edgewood has a slightly higher potential than Larkinsburg. These conclusions are based on the following:

- Limited areas at Edgewood and Larkinsburg have met wetland hydrology criteria during two years of site monitoring — only 1.3 ha (3.2 ac.) at Edgewood (Figure 2), and 4.8 ha (11.9 ac.) at Larkinsburg (Figure 3). Very limited areas met wetland hydrology criteria for greater than 12.5% of the growing season.

- No wetland areas have been delineated by the Illinois Natural History Survey (INHS) at Edgewood. Very small wetland areas have been delineated at Larkinsburg, and these are at lower site elevations near the site boundary. The INHS suggested that establishing hydrophytic vegetation at either site is not likely to succeed without significant hydrologic alterations (INHS 2002).

- There are no hydrologic alterations at either site that can be reversed to restore wetlands. Wetland creation, through excavation and runoff diversion, is the only option for wetland compensation. The amount of excavation required at Larkinsburg will be significantly greater than at Edgewood.

- The main source of water available for wetland compensation at the sites appears to be direct precipitation, which is often unreliable and may lead to failure of the compensation site(s). Additional water could be provided to the Edgewood site through diversion of runoff from off-site areas.

- The sites are located on or near drainage divides, and at relatively high landscape positions. Therefore, there is little catchment area for collection and storage of precipitation. As a result, catchment areas may need to be created.

- There are very few wetlands in similar landscape positions within several miles of the sites. Absence of natural models in similar geomorphic positions in the area suggests that the combination of landscape position and precipitation as the primary water source limits the ability of wetlands to occur.

- USDA soils maps show hydric soils over a majority of the Edgewood site (Cisne silt loam and Newberry silt loam), and approximately half of the Larkinsburg site (Wynoose silt loam). INHS investigations confirmed the hydric soils at Edgewood, and further determined that all the soils at Larkinsburg are hydric. The hydric soils at both sites likely formed under hydrologic conditions that no longer appear to exist.

WETLAND COMPENSATION OPTIONS

The factors presented above suggest that wetland restoration is not possible, and wetland creation may be difficult or require significant alterations. The following options for creating wetland on each site are based on the geologic and hydrologic data presented afterward. Although neither site is recommended, we consider Edgewood to be more promising than Larkinsburg because: 1) it has a more favorable landscape position that will require less excavation, and 2) has the potential for utilizing runoff diverted from off-site areas.

Edgewood

The geologic deposits present on the site have relatively low permeability, which is conducive to ponding water. The land surface slopes gently westward, and exhibits broad, flat areas along with a few isolated topographic lows (Figure 4). Ponded water has been repeatedly observed in the topographic low spots north of wells 2S and 12S.

Option 1

Field observations and site topography suggest that if larger isolated low areas were created, then these areas might collect precipitation and help retain runoff. Therefore, wetland creation basins could be excavated (Figure 4) over a total area of approximately 2.6 ha (6.5 ac.). Present site topography promotes runoff toward the west, so a basin could be excavated in the western part of the site by lowering the land surface to an elevation of 172.0 m (564.3 ft.) over an area of 2.1 ha (5.2 ac.). An additional basin could be excavated in the northeastern part of the site by lowering the land surface to an elevation of 172.1 m (564.6 ft.) over an area of 0.5 ha (1.3 ac.). The proposed excavation areas still leave the central portion of the site as an upland area that could function as a small catchment to provide some local runoff, or it too could be excavated if additional acreage is needed.

In addition, water-level data suggest that excavating to these depths may intersect the water table for a period of time greater than 12.5% of the growing season, thereby increasing the potential for meeting wetland hydrology criteria. The amount of water that might be provided to the excavations through intersection with the water table is not known, but we presume that so direct precipitation and runoff would be the primary water sources.

The amount of material to be excavated would vary according to location, but approximately 70% of the recommended area would involve excavation depths ranging from 0.3 to 0.5 m (0.9 to 1.6 ft.). However, the entire excavation may not become wetland because of limited water sources, and nearby sites suggest that the catchments may need to be as large as twice the areas of wetland compensation needed. Larger excavations may be possible, but may require greater depths of excavation and may not become wetland due to limited water sources.

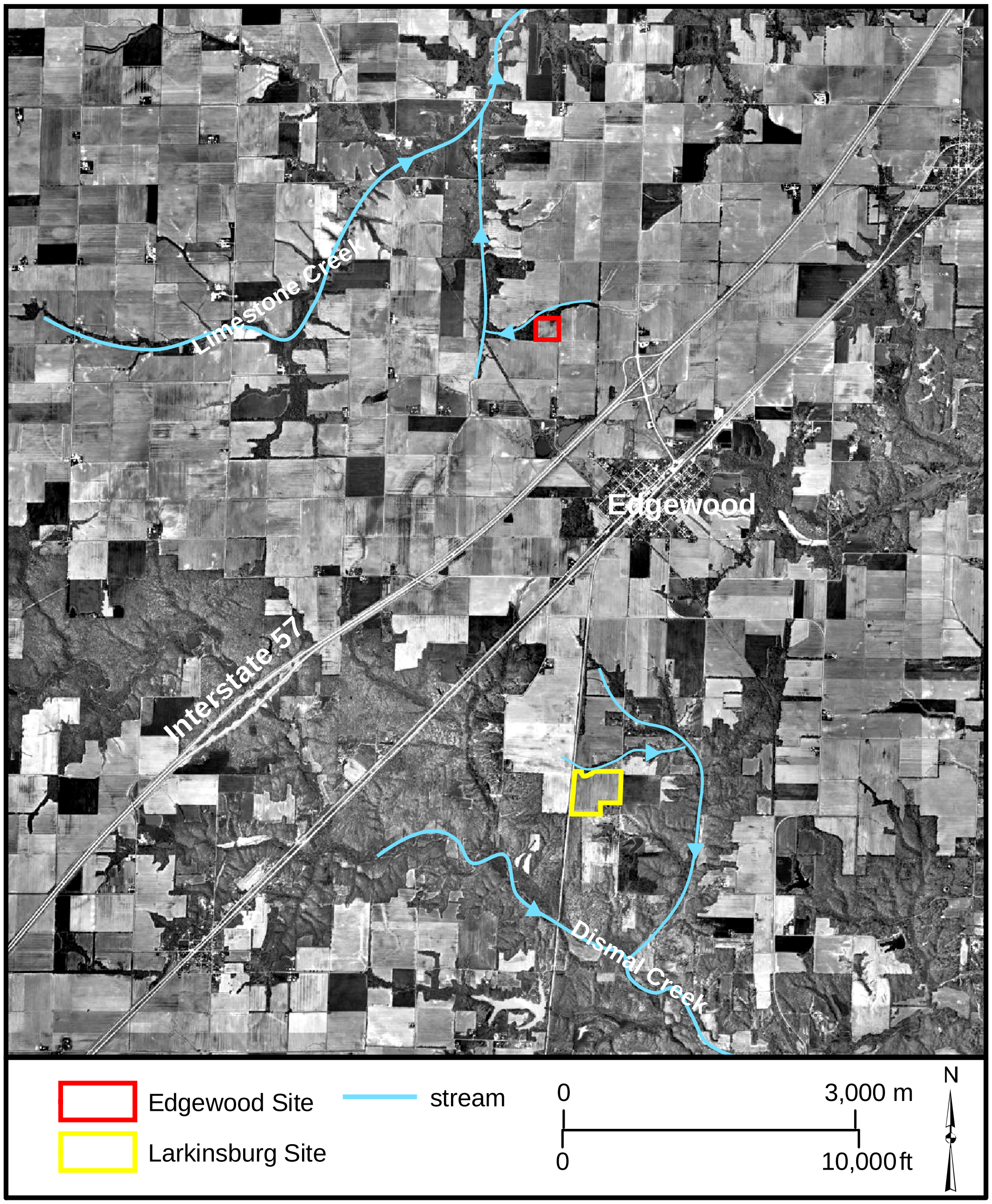

Figure 1 Location of the Edgewood and Larkinsburg sites. Map based on Edgewood quadrangle digital orthophoto (ISGS 2000).

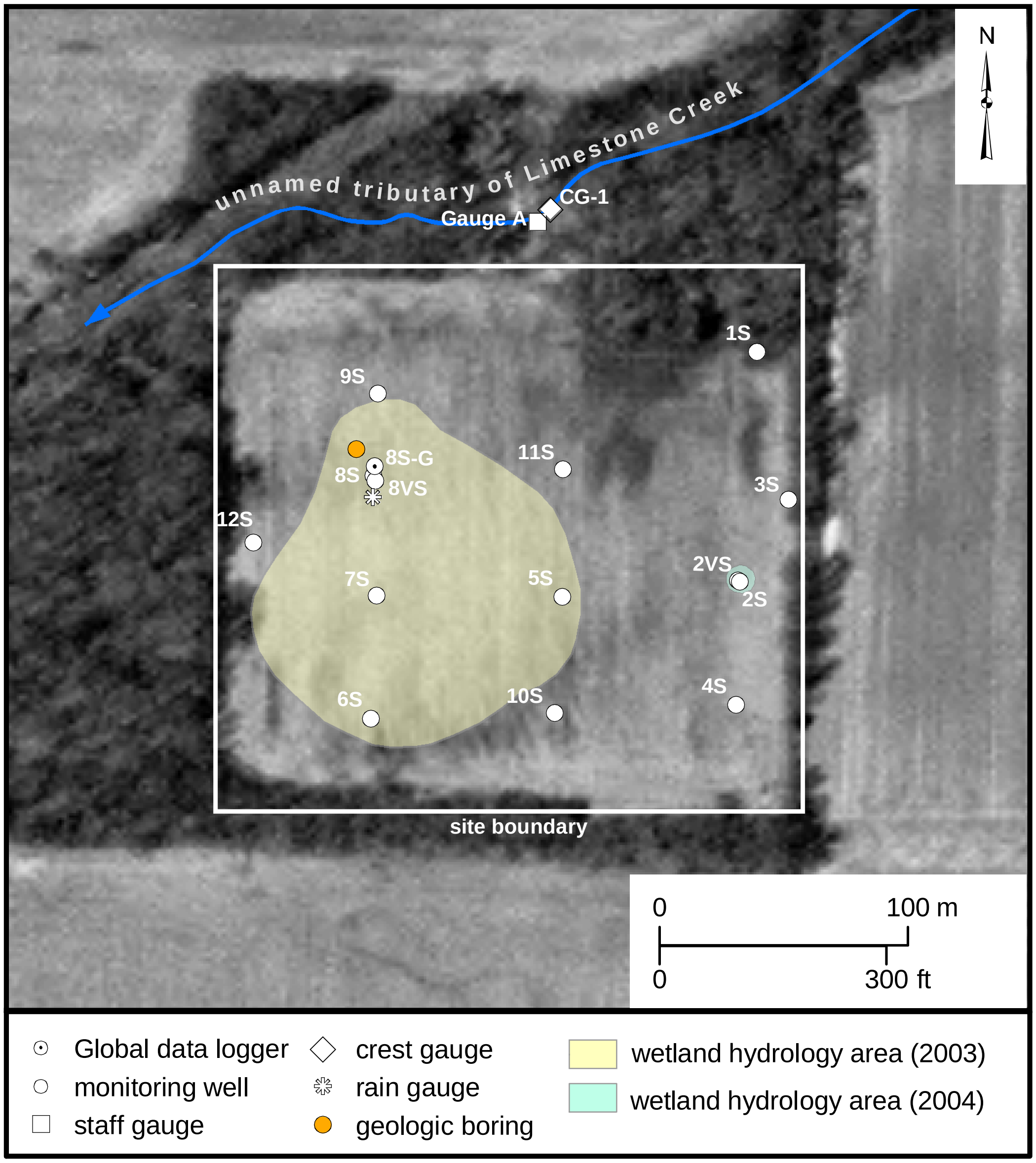

Figure 2 Estimated areal extent of wetland hydrology at the Edgewood site. Surface- and ground-water monitoring network is shown as configured in 2004. Map based on Edgewood SE quarter quadrangle digital orthophoto (ISGS 2000).

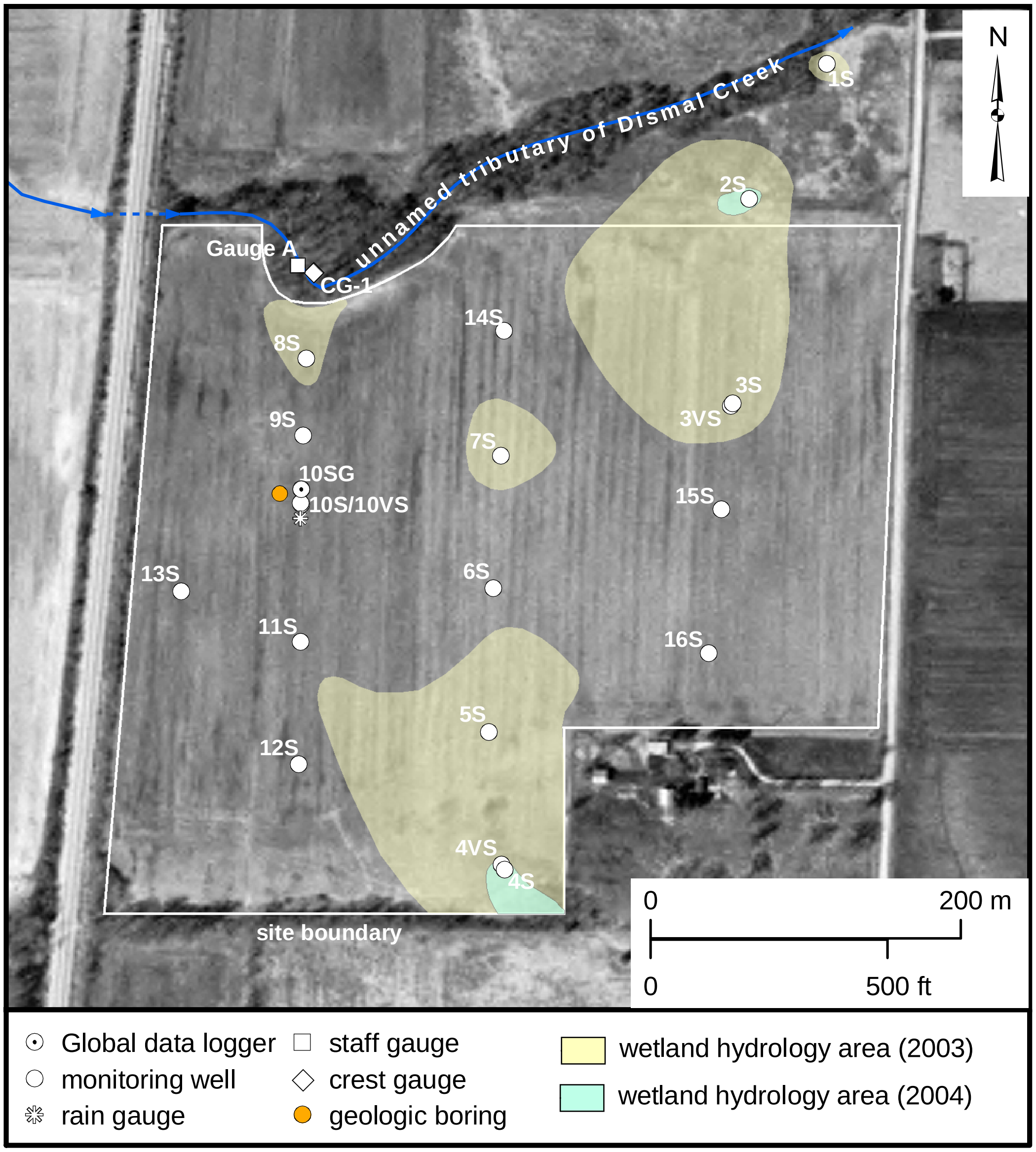

Figure 3 Estimated areal extent of wetland hydrology at the Larkinsburg site. Surface- and ground-water monitoring network shown as configured in 2004. Map based on Edgewood SE quarter quadrangle digital orthophoto (ISGS 2000).

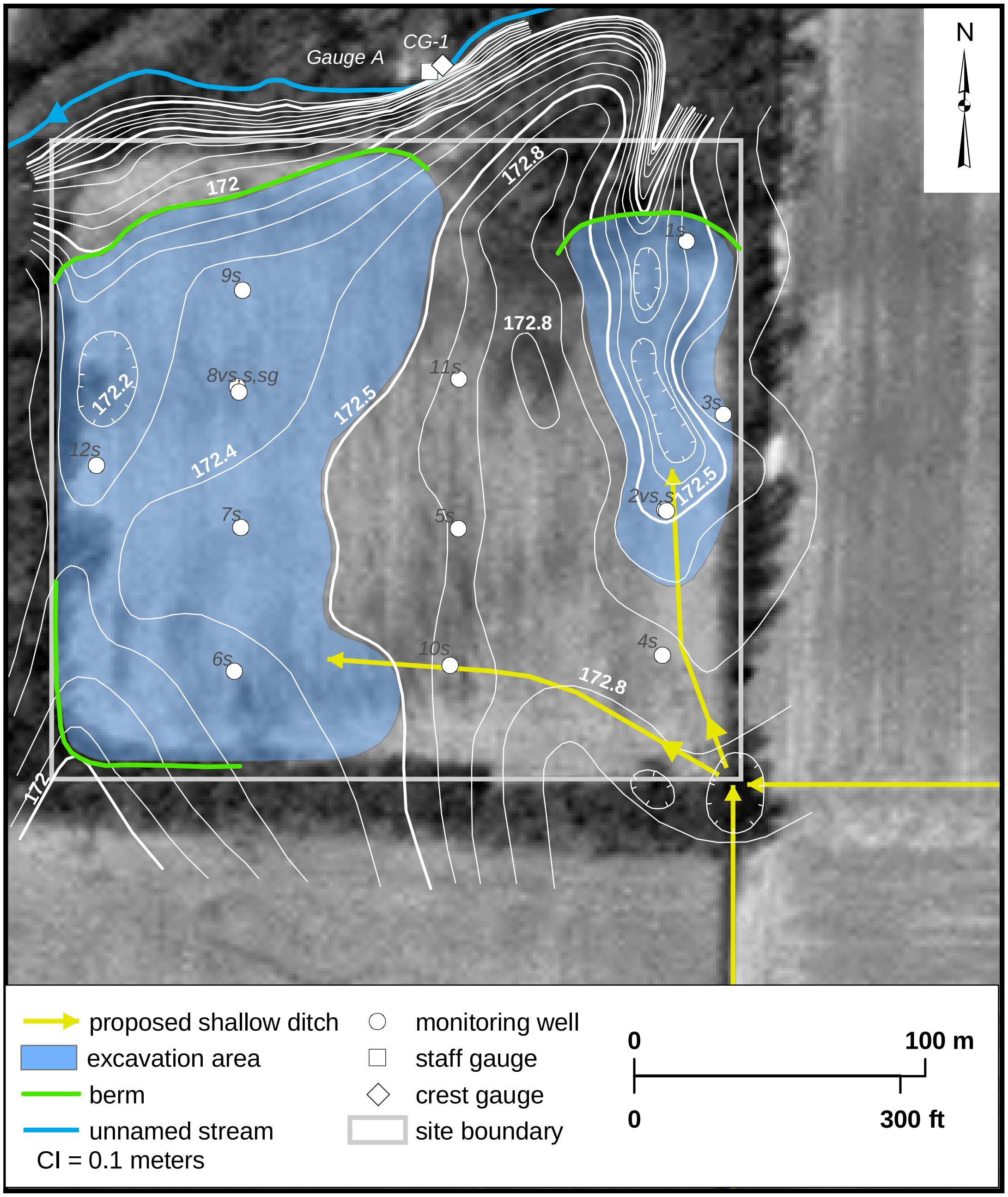

Figure 4 Topographic map and suggested alterations for the Edgewood site. Map based on Edgewood SE quarter quadrangle digital orthophoto (ISGS 2000).

The maximum elevation of flooding from the unnamed stream to the north of the site during the monitoring period was 170.9 m (560.7 ft.), which is below the recommended bottom elevation of the wetland creation basin. Therefore, the creek would not likely be a source of water to the excavated mitigation areas, and would drain the excavated areas if connected. To limit drainage, berms approximately 0.3 m (1 ft.) tall would need to be constructed between the stream and the excavated areas to ensure the mitigation areas are not drained. Another berm of the same height would need to be constructed in the southwest part of the site in order to block the natural drainage in that direction. The berms would also increase water storage, thus facilitating wetland hydrology.

Option 2

In addition to the excavation above, wetland hydrology could be aided by diverting surface water onto the site from neighboring fields located to the southeast (Figure 4). This would be accomplished using shallow ditches, which need only be a few centimeters deep (<15 cm) in order to bring runoff to the new excavations. If shallow ditches from neighboring fields are diverted onto the site into the new excavations, then the likelihood of the site achieving wetland hydrology would be increased. This option may not be feasible because it depends on the cooperation of surrounding landowners.

Larkinsburg

The geologic deposits present on the site have relatively low permeability, which is conducive to ponding water. However, observations indicate that the residence time of water is brief in the upland parts of the site. This is attributed to the domed shape of the land surface (Figure 5), in which steeper slopes at the northern and southern boundaries readily promote site drainage. Ponded water has been repeatedly observed in topographic low spots located near wells 2S and 8S, and between wells 3S and 14S, although the areas of the site that met wetland hydrology criteria for greater than 12.5% of the growing season are located along drainageways at elevations lower than the average site elevation.

Field observations and site topography suggest that if a larger isolated low area were created, then this area might collect precipitation and help retain runoff. Therefore, a wetland creation basin could be excavated in the northern part of the site (Figure 5). Hydrologic alterations are not recommended in the southern portion of the site because of possible impacts to the residence located near the southeastern site boundary. Present site topography promotes runoff toward the north, so a basin could be excavated in the northern part of the site by lowering the land surface to an elevation of 167.6 m (549.9 ft.) over an area of 6.3 ha (15.6 ac.). This excavation would create a large, continuous basin, lower than the surrounding land surface to the south, which would increase the catchment area for precipitation and help retain any runoff.

Water-level data suggest that excavating to this depth may intersect the water-table for a period of time greater than 12.5% of the growing season, thereby increasing the potential for meeting wetland hydrology criteria. The amount of water that might be provided to the excavations through intersection with the water table is not known, but direct precipitation and runoff are expected to be the primary water sources.

Most of the area in the north quarter of the site is above an elevation of 168 m. Therefore, excavation depths would range from 0.6 to 1.2 m (2.0 to 3.9 ft.) over approximately 70% of the recommended excavation area, and depths would range from 0 to 0.6 m (0 to 2.0 ft.) over the remainder of the excavation area. The entire excavation may not become wetland because of limited water sources, and nearby sites suggest that the catchment may need to be as large as twice the area of wetland compensation needed. Larger excavations may be possible, but may require greater depths of excavation and may not become wetland due to limited water sources.

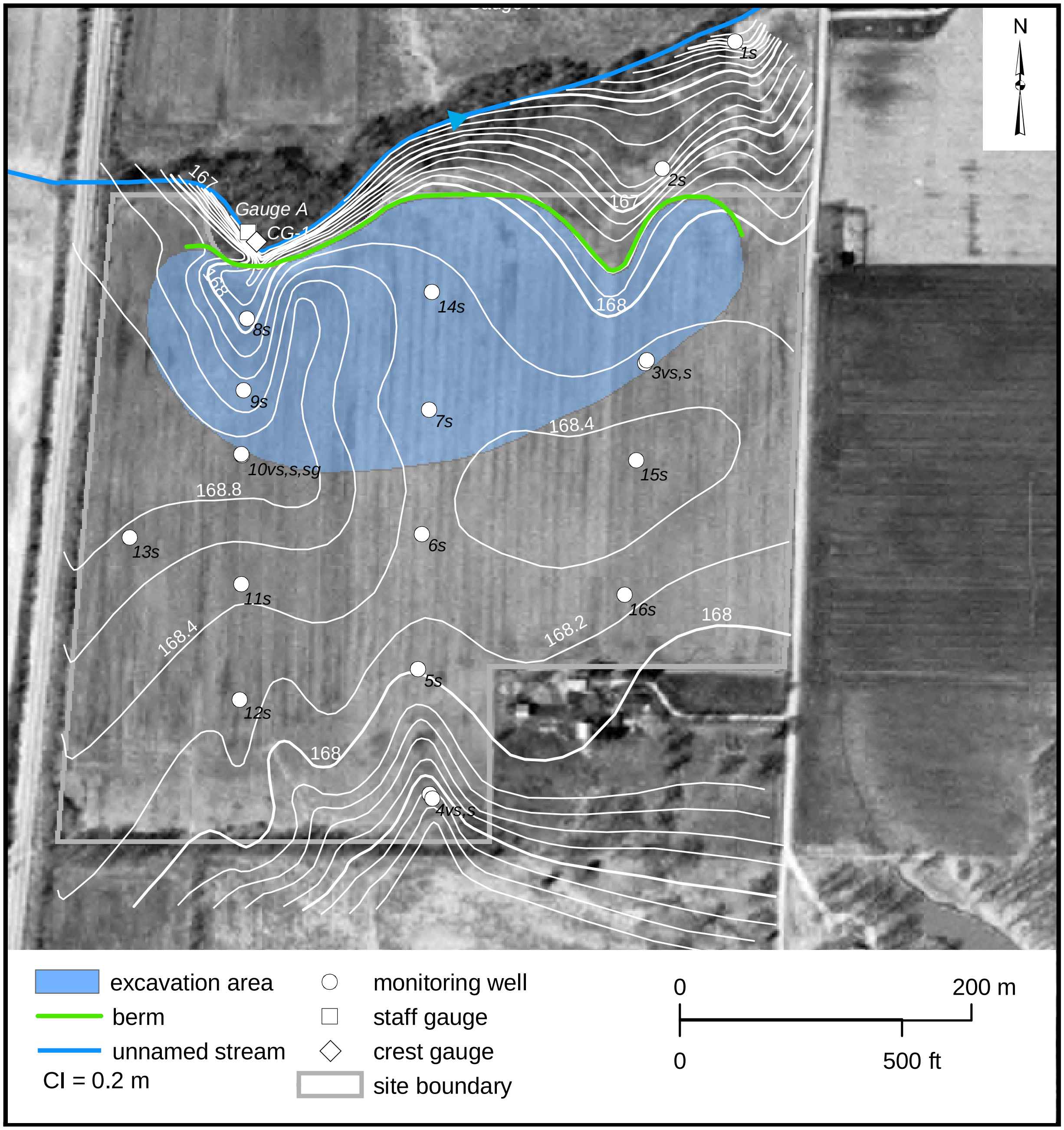

Figure 5 Topographic map and suggested alterations for the Larkinsburg site. Map based on Edgewood SE quarter quadrangle digital orthophoto (ISGS 2000).

The maximum elevation of flooding from the unnamed stream to the north of the site during the monitoring period was 167.4 m (549.2 ft.), which is still below the recommended bottom elevation of the wetland creation basin. Therefore, the creek would not likely be a source of water to the excavated mitigation area, and would cause drainage of the mitigation area if connected. To limit drainage, a low berm approximately 0.3 m (1 ft.) in height is needed to separate the excavated area from the stream. The berm would also increase water storage, thus facilitating wetland hydrology.

METHODS

Geology

A total of 39 geologic borings were made, 17 at Edgewood and 22 at Larkinsburg. The majority of the borings were made for installation of monitoring wells, though a few were made for geologic characterization purposes. All boreholes were drilled using a bucket-type hand auger. Most borings were to depths of 75 cm, though a few were made to depths as great as 2.4 m. As each boring progressed, the material removed from the hole for that interval was placed on the ground nearby in proper stratigraphic position. The characteristics of the geologic materials were described and noted, with detailed logs recorded for the deeper borings. The characteristics of interest included: texture, Munsell color, presence and type of redoximorphic features, soil and sedimentary structures, presence of joints or fractures, and the degree of water saturation. The geologic profile observed in the deeper borings provided the basis for the interpretations of the geology at both sites, and the shallow borings provided support for the interpretations.

Monitoring Wells

A total of 15 wells in 12 locations were installed at the Edgewood site (Figure 4), and a total of 20 wells in 16 locations were installed at the Larkinsburg site (Figure 5). Both very shallow (VS) and shallow (S) wells were designed to monitor near-surface saturation and were used to determine the extent of wetland hydrology at the sites. All of the VS-wells and most of the S-wells were constructed of 2.5-cm (1-in.) PVC casing and slotted screen. Two of the S-wells, designated as SG-wells, were constructed using 5.1-cm (2-in.) PVC casing and slotted screen. All screens were manufactured with 0.025-cm (0.01-in.) slots, and the installed lengths were approximately 15 cm (5.9 in.) and 30 cm (11.8 in.) for the VS- and S-wells, respectively. Sand pack was placed around each well casing from the borehole base to within depths of 15 cm (5.9 in.) and 30 cm (11.8 in.) of land surface for VS- and S-wells, respectively. The boreholes were then sealed from the top of the sand pack to land surface using bentonite granules. All wells that contained water at the time of well installation were developed using a hand-cranked peristaltic pump. Each well was pumped dry, then allowed to recharge. This was repeated until the water pumped from each well was visibly clear, and therefore mostly free of sediment. Further details of well construction can be found in Appendix D.

Water-Level Measurement

Depth to water in the wells was measured manually with a Solinst electronic water-level meter on a biweekly basis in April, May and June, and on a monthly basis during the remainder of the monitoring period (Appendix B). Ground-water elevations (Appendix C) were calculated by subtracting the depth to water in the well from the elevation of the top of the well. Wells designated as SG are larger-diameter S-wells instrumented with Global pressure transducers. The pressure transducers measured the water column heights in the wells, and were equipped with data loggers that recorded water levels at 1-hour intervals, thereby detecting water-level variations between manual readings. The Global units were installed during Spring 2003 in wells 8SG (at Edgewood) and 10SG (at Larkinsburg).

Surface-water data were collected using one staff gauge and one crest-type gauge at each site (Figures 4 and 5). The gauges were utilized to monitor surface-water fluctuations in the unnamed tributaries of Limestone Creek at Edgewood and Dismal Creek at Larkinsburg. Surface-water levels at the staff gauges were measured visually on the same days that the wells were read. The highest creek levels between measurements were recorded by the crest-type gauges, which were read on the same basis as the staff gauges.

Climate

Precipitation data recorded at Vandalia (Station # 118781) and Effingham (Station # 112687) were obtained from the Midwestern Regional Climate Center (MRCC 2004) at the Illinois State Water Survey (ISWS). The Vandalia and Effingham weather stations are located approximately 34 km (21 mi.) west and 24 km (15 mi.) northeast, respectively, of the village of Edgewood. The data were used to determine the effect of precipitation trends on surface- and ground-water levels. On-site precipitation data were also collected using tipping-bucket rain gauges equipped with data loggers. The on-site data were used both as a check against weather station data, and to analyze the relationship between site water-level changes and precipitation event timing.

The growing season for the region was determined using temperature data for the Vandalia weather station. The growing season is the period of time between the last occurrence of 28°F (-2.2°C) temperatures in the spring and the first occurrence in the fall (Environmental Laboratory 1987). According to the data, the median length of the growing season for the region is 211 days, with the median starting date on April 4th and the median ending date on November 1st (National Water and Climate Center 2003).

Surveying

The elevations of the monitoring wells and stage gauges were surveyed each spring with either a Sokkia B1 Automatic Level or a Leica TC702 total station. Instrument locations were surveyed in March 2004 using a Trimble Pathfinder ProXR GPS unit. A topographic survey was conducted by the ISGS using the Leica total station. Site elevations were surveyed relative to survey benchmarks set at the sites by the ISGS. These benchmarks consist of 2-m (6.6-ft.) long steel rods set in concrete. The heights of the benchmarks above mean sea level, referenced to the NAVD 1988 datum plane, were determined by GPS methods using a Trimble Pro XR GPS receiver.

SITE CHARACTERIZATION

Geographic Setting and Site Topography

Edgewood

The site is located near the southern boundary of the Springfield Plain of the Till Plains Section (Leighton et al. 1948). The site is situated south of an unnamed tributary of Limestone Creek (Figure 1) along the lower slope of a broad drainage divide, and is bordered by agricultural fields on the south and east sides, and by a wooded area on the west side. The surface topography at Edgewood consists of broad, flat areas containing a few, small isolated lows, imparting a subtle hummocky character to the site (Figure 4). The site ranges in elevation from 170.9 m to 172.9 m (560.7 to 567.2 ft.), with a mean elevation of 172.4 m (565.6 ft.) as determined using GIS methods on a grid-based land surface model of the site. The channel of the unnamed stream is deeply incised, and has an elevation of 169.7 m (556.6 ft.) near the northeastern part of the site, which is approximately 2.7 m (8.8 ft.) below the average site elevation. Elevations vary by approximately 0.7 m (2.3 ft.) across a majority of the site. The overall trend in site elevation is a gentle rise to the southeast, with the lowest measured elevation in the northwest corner and the highest measured near the southeast corner.

Larkinsburg

The site is located near the southern boundary of the Springfield Plain of the Till Plains Section (Leighton et al. 1948). The site is situated south of an unnamed tributary of Dismal Creek (Figure 1), and north of a shallow, ephemeral drainage, thus the central part of the site comprises a local drainage divide. The site is bordered by railroad tracks on the west side, by a road on the east side, and by untilled pastureland and a residence on the south side. The site is convex or dome shaped (Figure 5). Elevations range from 166.3 m to 169.0 m (545.6 to 554.5 ft.), with a mean elevation of 168.3 m (552.2 ft.) as determined using GIS methods on a grid-based land surface model of the site. The channel of the unnamed stream to the north is moderately incised, and has an elevation of 166.5 m (546.2 ft.) near the northwestern part of the site, which is approximately 1.8 m (5.9 ft.) lower than the mean site elevation. The lowest site elevation is located in the vicinity of well nest 4, and the highest site elevation is located in the west-central part of the site in the vicinity of well nest 10 (Figure 5). High elevations are generally found in the center of the site, and low elevations are found to the north and south. Elevations vary by approximately 0.9 m (3.0 ft.) across the central, upland portion of the site.

Geology

Bedrock of the Pennsylvanian Mattoon Formation (Willman et al. 1967), consisting of shales, sandstones, and coals, is present at approximately 6 to 15 m (approximately 20 to 50 ft.) below land surface (Berg and Kempton 1988, Lineback 1979) in the vicinity of both sites. Bedrock is overlain by sediments of the Glasford Formation, consisting of loamy and sandy diamictons (Berg and Kempton 1988, Lineback 1979). Geologic borings made at both sites confirm this mapping, and show that the surficial sediments exhibit primarily fine-grained textures, though minor amounts of sand were observed at Larkinsburg at depths greater than 50 cm (20 in.). The typical shallow geologic profile at both sites consists of approximately 50 cm (20 in.) of clayey silt material overlying silty clay material. Most of the geologic borings were 75 cm (30 in.) deep, and were made during S-well installation. Two additional borings were made to depths of 1.4 m (4.6 ft.) and 1.8 m (5.9 ft.) at Edgewood and Larkinsburg, respectively (Appendix A). Although no detailed logs were recorded for the 75-cm (30-in.) borings, similar conditions were observed at all of the borehole locations. The permeability of the surficial materials is low due to their fine-grained texture. However, the permeability in the soil zone in some locations appears to be somewhat higher, likely due to the presence of secondary permeability created by weathering and soils development, including fissures, fractures, and roots.

Soils

Edgewood

A majority of the site is mapped as the Cisne silt loam and Newberry silt loam soils (Figure 6), both of which are on the county and state lists of hydric soils (USDA 1995, USDA 2005). The Cisne silt loam is found in uplands, is poorly drained, has a seasonal high water table within 0.6 m (2 ft.) of the land surface from February through June in most years, and does not flood. The Newberry silt loam is found in shallow depressions on uplands, is poorly drained, and has a seasonal high water table within 0.6 m (2 ft.) of the land surface from March through June in most years (USDA 1991). There is a small strip of Hoyleton silt loam soil mapped in the northwest corner of the site that is not included on either the county or the state hydric soils lists. During its site investigation, the Illinois Natural History Survey confirmed the presence of the Cisne, Newberry, and Hoyleton soils, and also determined that a majority (> 95%) of the soils on the site are hydric soils (INHS 2002).

Larkinsburg

A majority of the site is mapped as the Wynoose silt loam and the Bluford silt loam soils (Figure 7), and the Wynoose is on the state and county lists of hydric soils (USDA 1995, USDA 2005). The

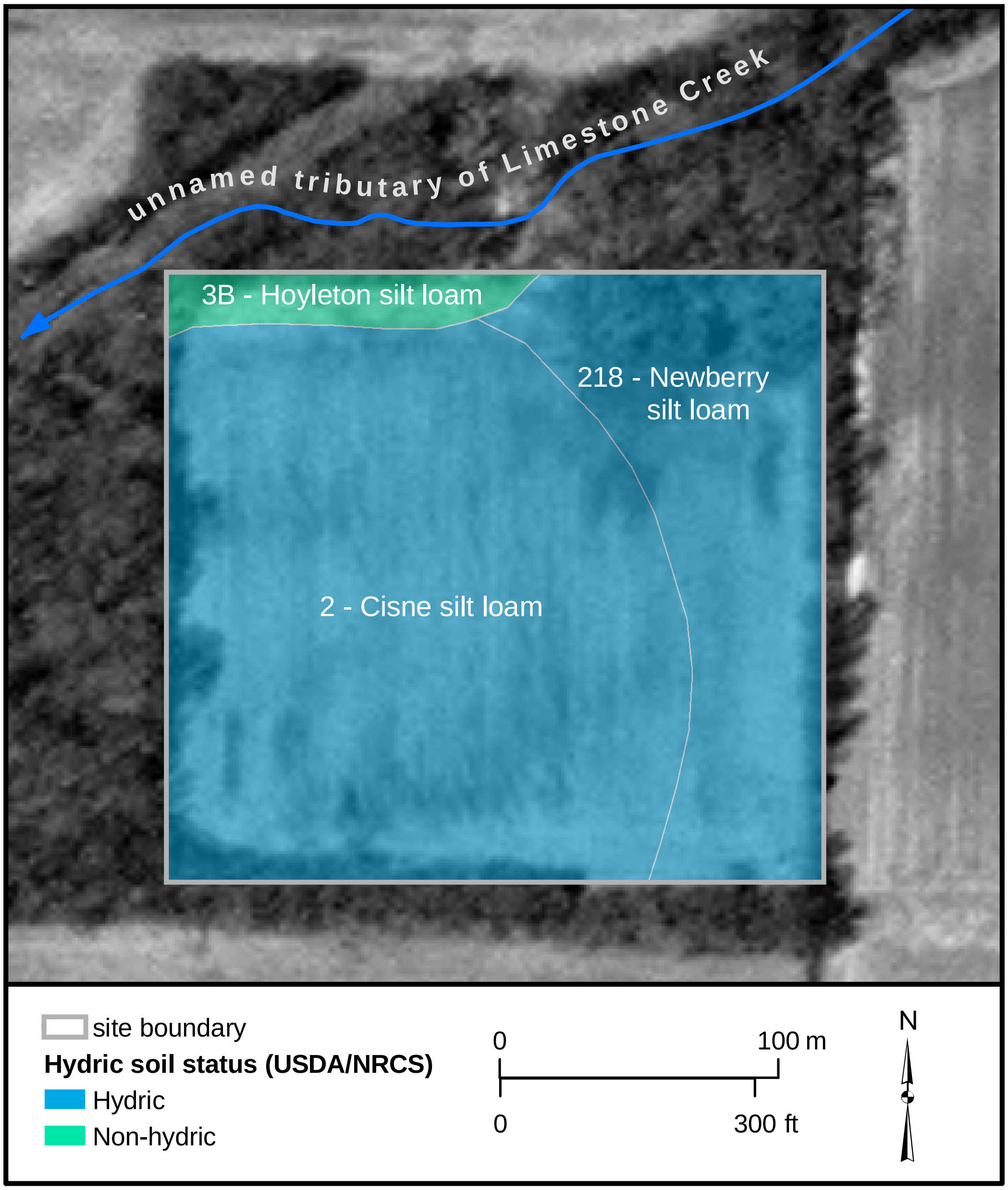

Figure 6 Soils mapped on the Edgewood site (USDA 1991). Map based on Edgewood SE quarter quadrangle digital orthophoto (ISGS 2000).

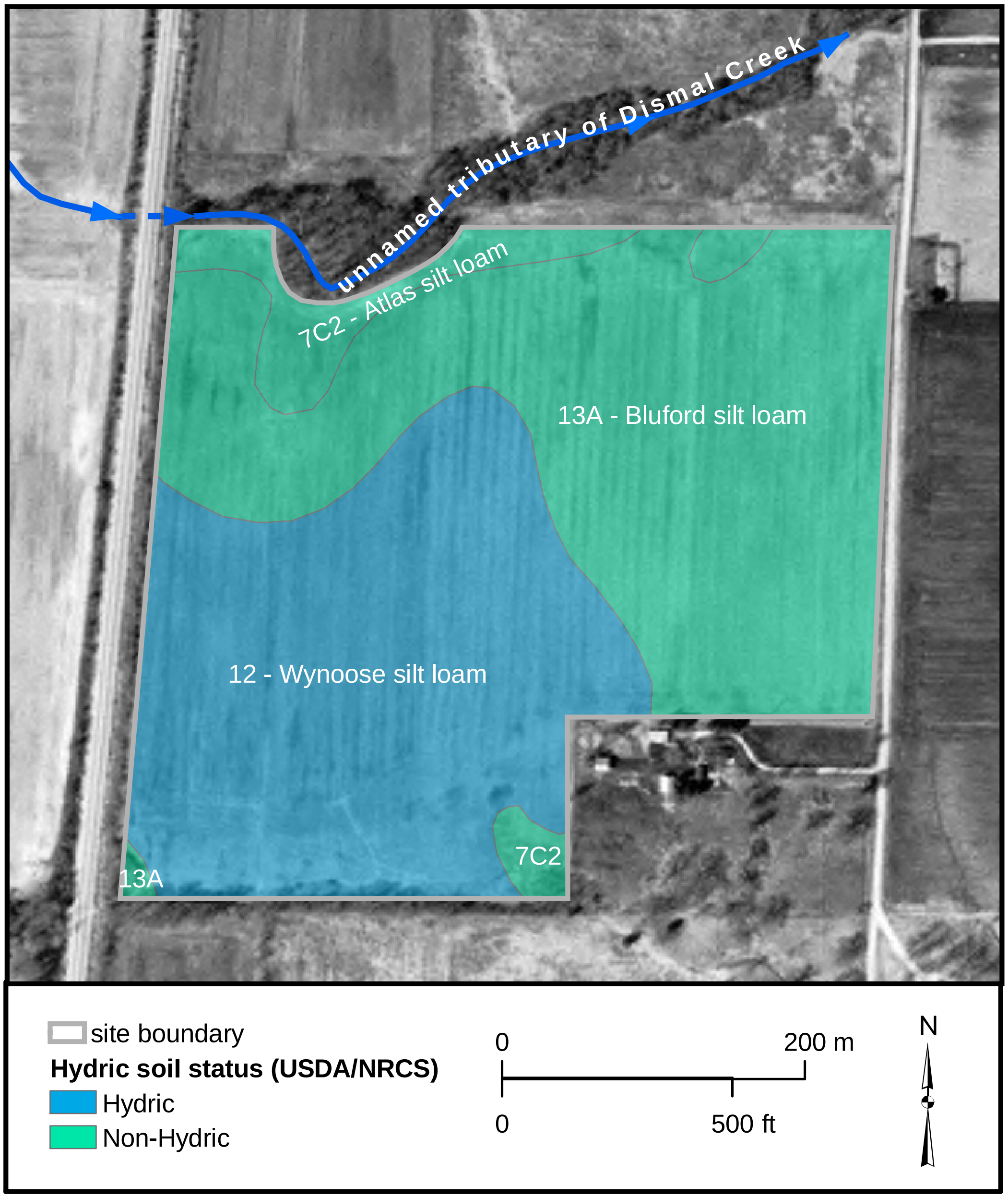

Figure 7 Soils mapped on the Larkinsburg site (USDA 1998). Map based on Edgewood SE quarter quadrangle digital orthophoto (ISGS 2000).

Wynoose silt loam is found on uplands, is poorly drained, and has a seasonal high water table at a depth of less than 0.3 m (1 ft.) (USDA 1998). During its site investigations, the Illinois Natural History Survey confirmed the presence of the Wynoose silt loam, and that the soils are hydric (INHS 2002). NRCS mapping indicates that the Bluford silt loam covers most of the remaining two-thirds of the site, except for a small area in the northwestern part of the site, where the Atlas silt loam is present. Both the Bluford and the Atlas are described as non-hydric soils (USDA 1998). However, the INHS observed that the soils in the areas mapped as Atlas and Bluford exhibited soil characteristics that are typical of the Wynoose soils, including widespread hydric-soil indicators, and not typical of either the Bluford or the Atlas soils. Therefore, INHS has determined that the areas mapped as Atlas and Bluford are also hydric soils (Scott Wiesbrook, INHS personal communication).

The hydric soils at both sites are likely relict because the hydrologic conditions that created them no longer appear to be present. Although no single obvious cause for drainage of these hydric soils was observed onsite, irreversible alteration of regional hydrology through construction of a composite, county-wide system of ditches is considered largely responsible for drainage of the soils (ISGS 2002). Longer-term geologic processes, such as development of the natural drainage system during post-glacial conditions, may also have contributed to regional hydrologic changes that led to drainage of the soils.

Wetlands

Edgewood

The Edgewood site is classified as prior converted wetland (PC) by the NRCS. There are no NWI-mapped wetlands on the site. The INHS did not delineate any wetlands on the site, and further indicated that the lack of hydrophytic vegetation in neighboring wooded areas suggests that hydrophytic vegetation could not likely be reestablished on the site without significant hydrologic alterations (INHS 2002).

Larkinsburg

The majority of the Larkinsburg site is classified as prior converted wetland (PC) by the NRCS. There are no NWI-mapped wetlands on the site. The INHS did delineate small wetland areas on the site, which roughly correspond to areas that maintained saturation or inundation for greater than 12.5% of the growing season. These wetland areas are located at the southern site boundary and at elevations much lower than the average site elevation. The INHS noted a lack of hydrophytic vegetation in the neighboring untilled field to the south, thus concluding that reestablishment of hydrophytic vegetation across a majority of the site is not likely to succeed because of unfavorable hydrologic conditions (INHS 2002).

Precipitation

Average annual precipitation at the nearby Vandalia station is 38.8 in. (98.6 cm) (National Weather and Climate Center 2003). Rainfall is typically highest from April through July, peaking in May (Appendix E). During 2003 and 2004, the total annual precipitation at Vandalia was above the 30-year average. Total precipitation was at or slightly above average for the period from March through May 2003, and was above average for March through May 2004 (Table 1). However, in 2004 there was minimal rainfall during April, and the bulk of the precipitation in March and May was concentrated over roughly 1-week periods toward the first and last parts of those months. This precipitation pattern provided longer periods of time for evaporation of the water that likely had collected at the sites, which may have adversely affected the extent of wetland hydrology.

	30-year average	*2003*	*2004*
March - May	11.4 in. (29.0 cm)	11.9 in. (30.2 cm)	15.7 in. (39.9 cm)
Annual	38.8 in. (98.6 cm)	42.5 in. (108.0 cm)	42.2 in. (107.2 cm)

Table 1 Precipitation at the Vandalia weather station.

Hydrology

Surface- and ground-water elevations were used to determine if wetland hydrology was present according to the Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987). According to the Manual (Environmental Laboratory 1987), inundation occurs when surface water is present at depths no greater than 2 m (6.6 ft.). Saturation occurs when the water table is no deeper than 30 cm (1 ft.) below land surface. Areas that were inundated or saturated for greater than 5% of the growing season satisfied wetland hydrology criteria. Areas that were inundated or saturated for greater than 12.5% of the growing season satisfied wetland hydrology criteria in a conclusive manner, which strongly indicates wetland conditions (Environmental Laboratory 1987), and assists ISGS in determining the likelihood of successful wetland mitigation. As suggested by informal Corps guidance, water levels within 30 cm (1 ft.) of land surface in S or VS wells are interpreted to show saturation to land surface due to the presence of a capillary fringe. Interpolation or extrapolation was performed to determine the duration of saturation for wells where manual water-level measurements were collected.

Surface Water

Edgewood

The maximum surface-water level attained in the unnamed tributary of Limestone Creek during the entire monitoring period was 170.9 m (560.7 ft.), but the average ground-surface elevation of the mitigation site is 172.4 m (565.6 ft.). Therefore, the stream was not a source of water for the majority of the site in either 2003 or 2004, and would likely not provide water to the wetland creation basins if the excavation option were to be chosen for this site. There are also no field indications that runoff from adjacent uplands currently provides water to the Edgewood site. Therefore, we conclude that precipitation is the primary water source for the site. The slope of the land surface and the deeply incised channel of the nearby stream appear to provide sufficient hydraulic gradient to readily promote runoff from the site. However, ponding has repeatedly been observed at the site in isolated topographic low areas, such as the surface depressions located north of wells 12S and 2S. Though this ponding has only been observed following precipitation, it does appear to persist for several days, which suggests that the surficial materials are capable of retaining water for long periods of time.

Larkinsburg

The maximum surface-water level attained in the unnamed tributary of Dismal Creek during the entire monitoring period was 167.4 m (549.2 ft.), while the average ground-surface elevation of the mitigation site is 168.3 m (552.2 ft.). Therefore, the stream was not a source of water for the majority of the site in either 2003 or 2004, and would likely not provide water to the wetland creation basin if the excavation option for this site were chosen. The Larkinsburg site is located on a local drainage divide, so that there are no neighboring uplands to provide runoff to the site. Therefore, we conclude that precipitation is the primary water source for the site. The sloping land surfaces in the northern and southern parts of the site appear to provide sufficient hydraulic gradient to readily promote runoff, and hence fairly quick drainage of upland areas. However, ponding has repeatedly been observed at the site in the lower elevations of drainageways, such as the area north of well 8S, areas between wells 3S and 14S, the area around well 2S, and the area north of well 4S. Though this ponding has only been observed following precipitation, it does appear to persist for several days, which suggests that the surficial materials are capable of retaining water for long periods of time.

Ground Water

Edgewood

In 2003, wells 5S, 6S, 7S, and 8S satisfied wetland hydrology criteria, but only well 8S satisfied wetland hydrology criteria for greater than 12.5% of the growing season. Based on these water-level data, and site topography, we determined that an area of 1.3 ha (3.2 ac.) satisfied wetland hydrology criteria in 2003 (Figure 2), and that only 0.2 ha (0.4 ac.) of this area satisfied wetland hydrology criteria for greater than 12.5% of the growing season. In 2004, only well 2VS satisfied wetland hydrology criteria. Therefore, we determined that a very restricted area of 0.01 ha (0.03 ac.) met wetland hydrology criteria in 2004 (Figure 2). The wetland hydrology areas of Figure 2 are primarily presented to show the extent of wetland hydrology with the existing site configuration, and are not useful for predicting post-construction wetland hydrology areas because of the alterations to site hydrology that would result from construction.

In 2003, ground-water levels were high from late April through mid-May, a time during which precipitation occurred roughly every 3 to 4 days (Figures 8 and 9). Water levels then dropped as precipitation became less frequent (Figure 8), until another period of sustained precipitation occurred in mid-June during which water levels were nearly at ground surface (Figures 8 and 9). In 2004, water levels were generally low, except for a period from late May to early June, which corresponded to a rainy period (Figures 8 and 9). From these data, we conclude that wetland hydrology at this site is tied closely to precipitation, and the timing and duration of precipitation events during the growing seasons are principally responsible for the difference between wetland hydrology areas during 2003 and 2004.

Ground-water levels were within 0.6 m (2.0 ft.) of the land surface in wells 1S, 2S, 3S, 6S, 7S, 8S, 9S,and 12S for periods greater than 12.5% of the growing season (Appendix C and Figure 9), corresponding to water-level elevations at or above 172 m, which is the recommended bottom elevation of the wetland creation basin. Therefore, if the excavation option were pursued, then the excavated areas may partly intersect the water table. However, the extent to which intersection with the water table might provide water to the excavated areas is not well-known, and any water that may be provided to the excavated areas through intersection with the water table would only supplement the primary water sources of precipitation and runoff. The proposed excavation depths are based primarily on site topography, requiring removal of material from upland areas to create basins that can capture and retain runoff and precipitation.

Larkinsburg

In 2003, wells 1S, 2S, 3S, 4S, and 5S satisfied wetland hydrology criteria, but only wells 2S and 4S satisfied wetland hydrology criteria for greater than 12.5% of the growing season. Based on these water-level data, site topography, and field observations, we determined that an area of 4.8 ha (11.9 ac.) satisfied wetland hydrology criteria (Figure 3) in 2003, and that only 0.3 ha (0.7 ac.) of this area satisfied wetland hydrology criteria for greater than 12.5% of the growing season. In 2004, only wells 2S and 4S satisfied wetland hydrology criteria. Therefore, we determined that an area of 0.1 ha (0.2 ac.) satisfied wetland hydrology criteria in 2004 (Figure 3). In both monitoring years, the areas that met wetland hydrology for greater than 12.5% of the growing season were at elevations approximately 1.6 m (5.3 ft.) below the average site elevation, and located in low spots along drainage-ways that retained precipitation and runoff. The wetland hydrology areas in Figure 3 are primarily presented to show the extent of wetland hydrology with the existing site configuration, and are not useful for predicting post-construction wetland hydrology areas because of the alterations to site hydrology that will result from construction.

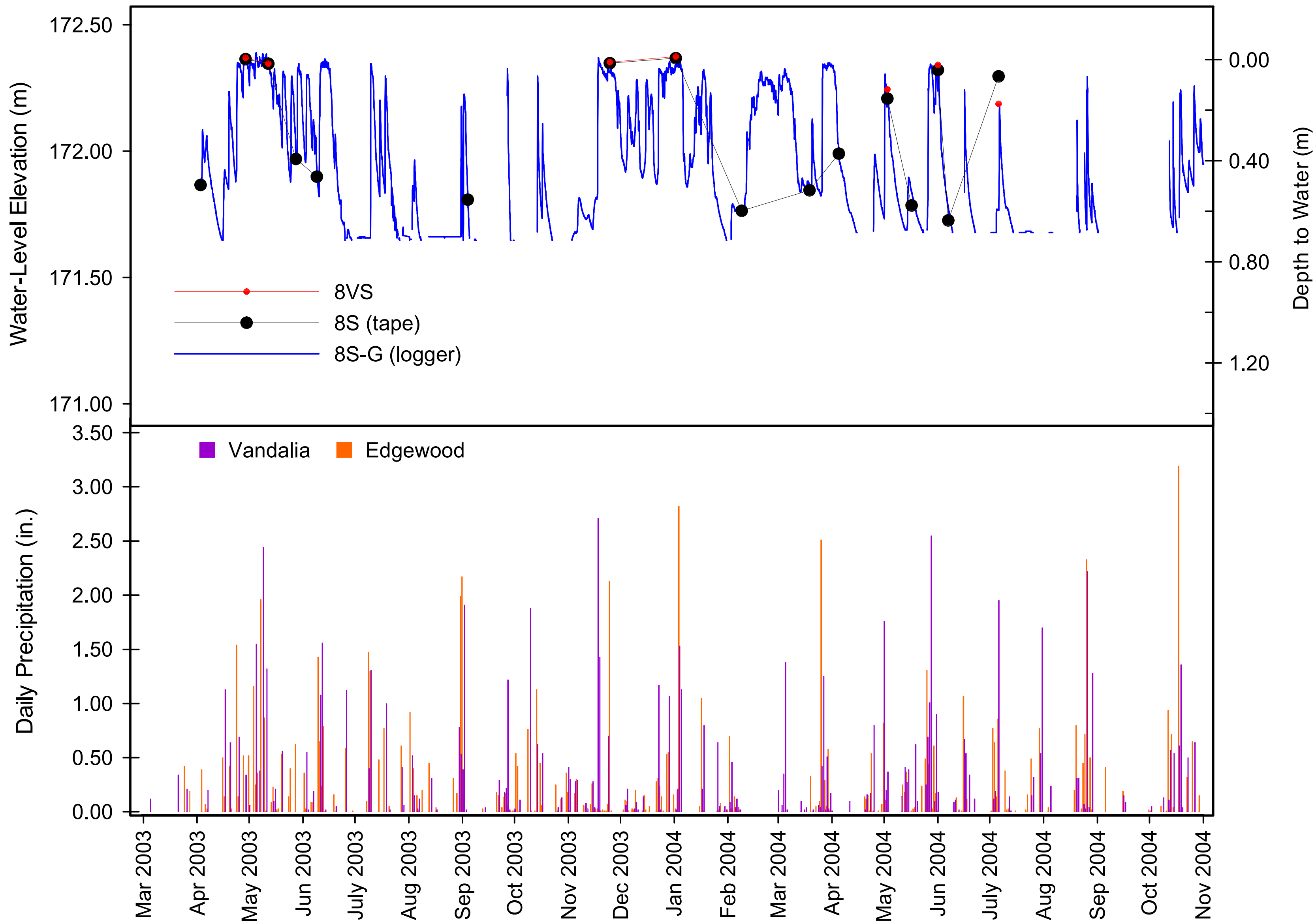

Figure 8 Water levels at well nest 8 versus precipitation at the Edgewood site and at Vandalia.

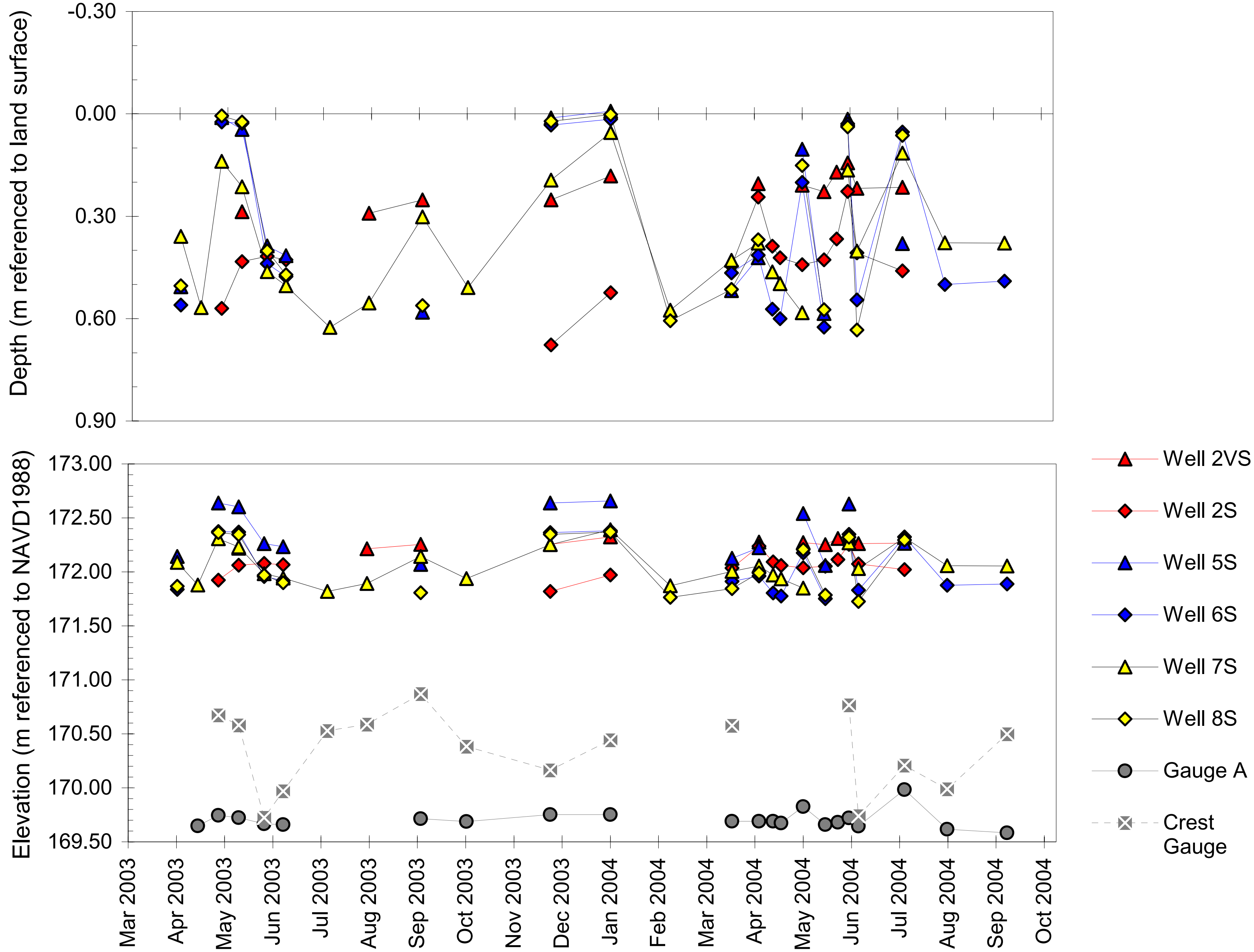

Figure 9 Depths to water and water-level elevations in selected wells, and water-level elevations at stage gauges at the Edgewood site.

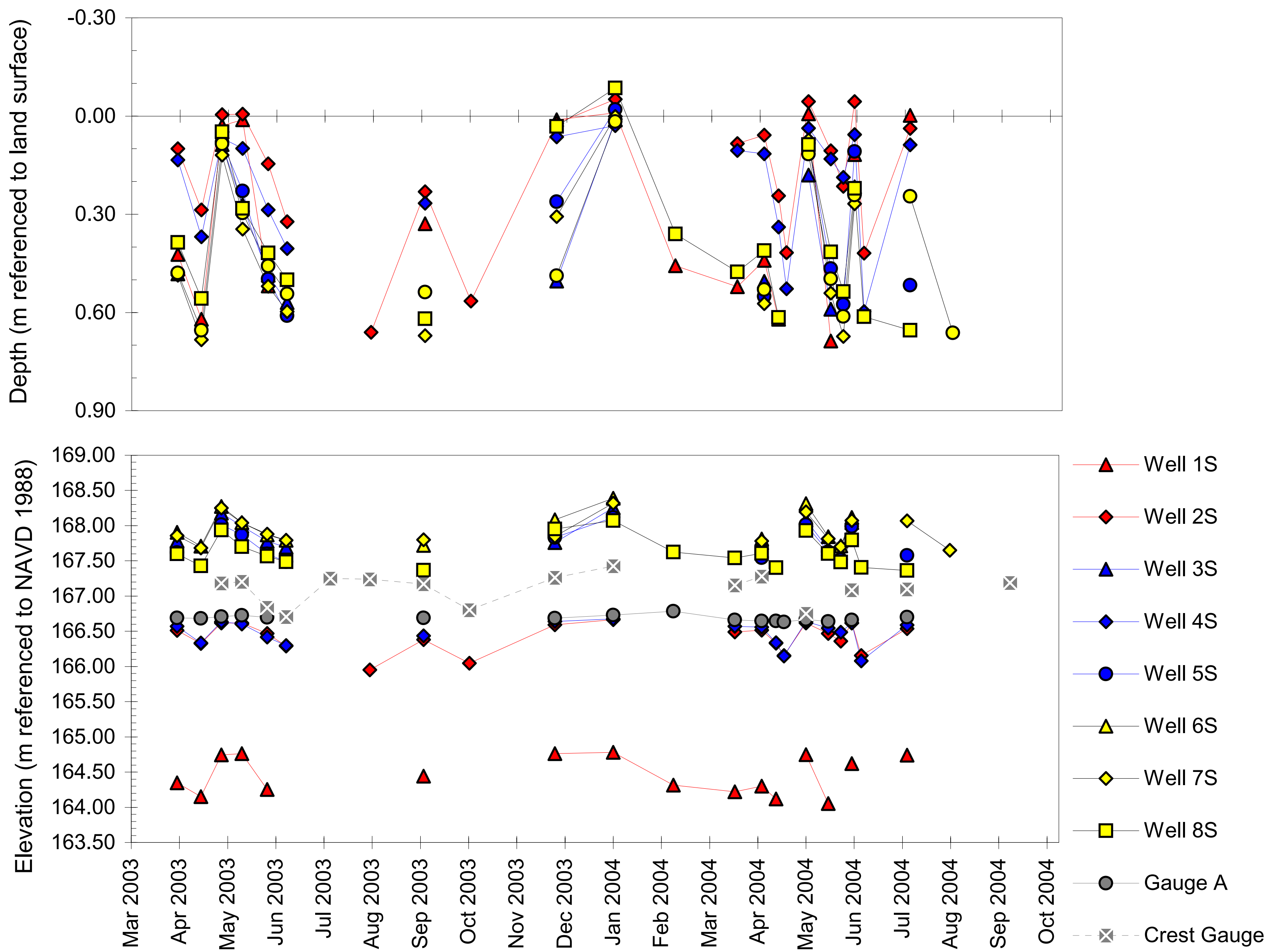

Figure 10 Depths to water and water-level elevations in selected wells, and water-level elevations at stage gauges at the Larkinsburg site.

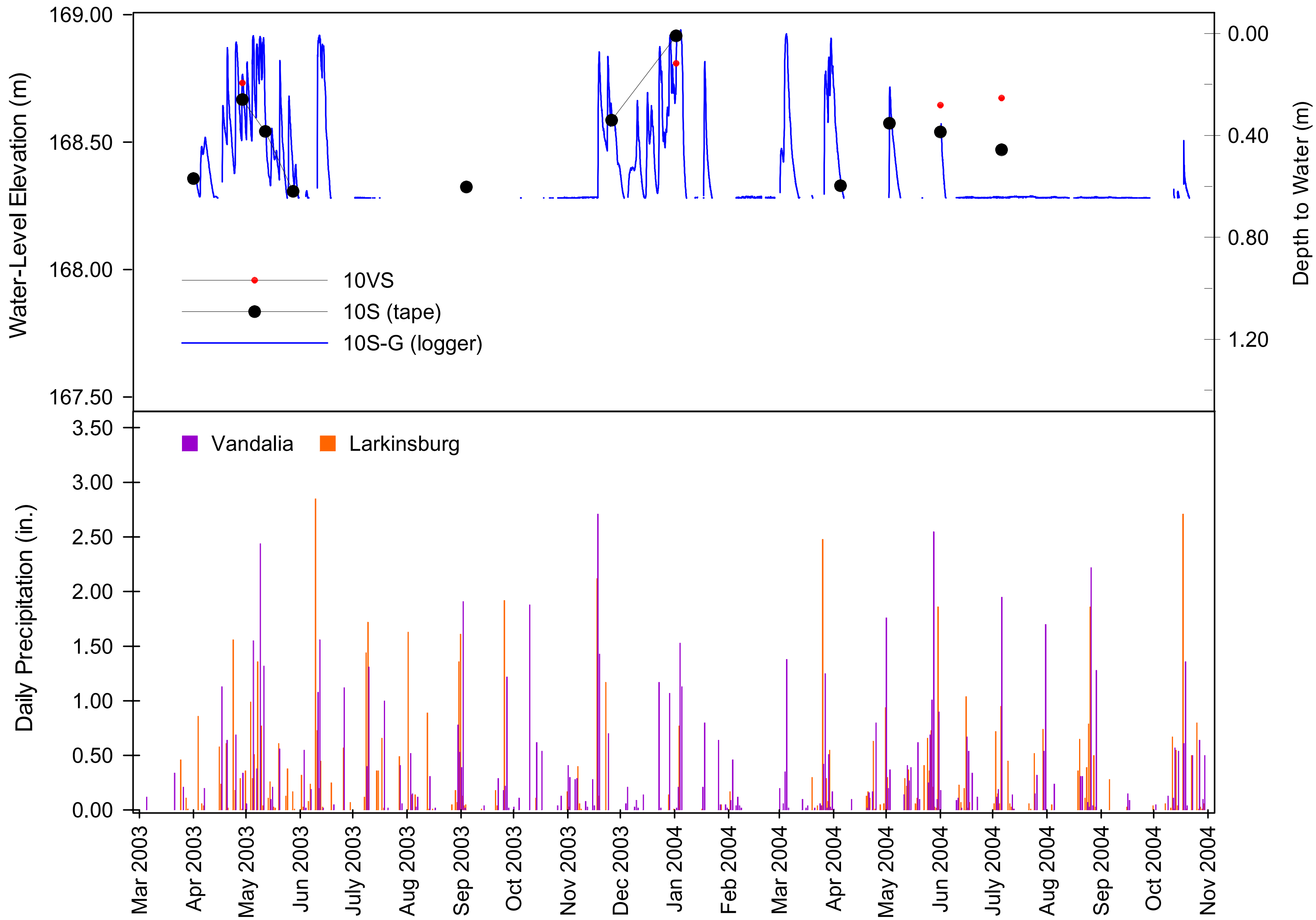

Figure 11 Water levels at well nest 10 versus precipitation at the Larkinsburg site and at Vandalia.

In 2003, ground-water levels were mostly high from late April through mid May, a time during which precipitation occurred roughly every 3 to 4 days (Figures 10 and 11). Water levels then dropped as precipitation became less frequent, until another period of sustained precipitation occurred in mid June during which water levels were nearly at ground surface (Figure 11). In 2004, water levels were at greater depths for most of the growing season (Figures 10 and 11), except for rises that persisted briefly following sustained precipitation events (Figure 11). From these data, we conclude that wetland hydrology at this site is tied closely to precipitation, and the timing and duration of precipitation events during the growing seasons are principally responsible for the difference between wetland hydrology areas during 2003 and 2004.

Ground-water levels were within approximately 0.6 m (2.0 ft.) of the land surface in wells 3S, 5S, 6S, 7S, 8S, 9S, and 10S for periods greater than 12.5% of the growing season (Appendix C and Figure 10), corresponding to water-level elevations above 167.6 m (549.9 ft.), which is the recommended bottom elevation of the wetland creation basin. Therefore, if the excavation option were pursued, then the excavated areas may partly intersect the water table. However, the extent to which intersection with the water table might provide water to the excavated areas is not well-known, and any water that may be provided to the excavated areas through intersection with the water table would only supplement the primary water sources of precipitation and runoff. The proposed excavation depths are based primarily on site topography, requiring removal of material from upland areas to create a basin that can capture and retain runoff and precipitation.

CONCLUSIONS

The results of this investigation indicate that both Edgewood and Larkinsburg have low potential for success as wetland compensation sites. We base this rating and our wetland compensation options on the following factors.

Both sites are located on or near drainage divides, therefore the catchment areas for the sites are minimal. Most runoff is directed toward drainage-ways bordering the sites, resulting in short residence time of water on the sites. However, the Edgewood site does have neighboring uplands that could supply additional water to the site as runoff, and its site topography results in slightly slower drainage than at Larkinsburg.

Streams border both sites at elevations much lower than the average site elevations, and do not flood at elevations that would regularly provide water to a majority of the site areas, nor is it likely that the streams would provide water to the proposed wetland creation basins.

The geologic materials at both sites have relatively low permeability, and so the potential for ponding water is good. Ponding that appears to persist for periods of several days has been observed in isolated low areas at both sites. Excavation to the depths suggested will create basins for trapping precipitation and runoff, thereby increasing the likelihood of meeting wetland hydrology criteria. Water levels collected during this investigation indicate that the water table was within 0.5 to 0.6 m (1.6 to 2.0 ft.) of the land surface over portions of both sites for periods exceeding 12.5% of the growing season. Therefore, the proposed excavations may intersect the water table at one or both sites, thus increasing the likelihood of meeting wetland hydrology criteria. However, the extent to which intersection with the water table may provide water to the excavated areas is not well-known, and so precipitation and runoff would be the primary water sources for both sites.

USDA soil mapping indicates that about 95% of the Edgewood site and 50% of the Larkinsburg site have hydric soils. INHS investigations confirmed the presence of hydric soils at Edgewood, and further determined that all the soils at Larkinsburg are hydric. The hydrologic conditions that formed the hydric soils no longer appear to exist. We presume that the drainage of these soils resulted from regional hydrologic changes caused by the creation of regional drainage systems, and/or longer-term geologic processes.

Fairly small percentages of the total site areas at Edgewood and Larkinsburg met wetland hydrology criteria during two years of site monitoring, with 1.3 ha (3.2 ac.) at Edgewood, and 4.8 ha (11.9 ac.) at Larkinsburg, and considerably smaller areas met wetland hydrology criteria for greater than 12.5% of the growing season. At Edgewood and Larkinsburg, the areas of the sites that produced wetland hydrology did so because they were located in low or nearly flat areas that retained precipitation and runoff. Additionally, all areas that produced wetland hydrology at Larkinsburg were at elevations greater than 1.5 m (4.9 ft.) below the average site elevation, and roughly correspond to areas already delineated as wetland by the INHS. The INHS also suggested that establishing hydrophytic vegetation at either site is not likely to succeed without significant hydrologic alterations (INHS 2002).

Precipitation appears to be the primary source of water for both sites. Precipitation as the primary water source is generally considered unreliable, because the timing and duration of precipitation events are crucial to successfully producing wetland hydrology. It is evident that the success of the sites would be tightly bound to precipitation in any given year. The disparities between areas that satisfied wetland hydrology criteria in 2003 versus 2004 at Edgewood and Larkinsburg are directly associated with the variation in precipitation patterns during the early growing seasons of those years.

There is no evidence of reversible hydrologic alterations on the sites, except for 6- to 10-cm (2- to 4-in.) deep field ditches observed at the Larkinsburg site. Drainage tile was not observed at either site. A lack of major alterations suggests that the sites are not supplied with enough water to sustain a wetland. Additionally, there are very few wetlands in similar landscape positions within several miles of the sites. Absence of natural models in similar geomorphic positions in the area suggests that the combination of landscape position and precipitation as the primary water source limits the ability of wetlands to occur.

Construction of wetland creation basins is the only viable option for satisfying wetland hydrology criteria over areas sufficient to meet IDOT requirements. These excavations would create basins that would increase the catchment area for precipitation and help retain any runoff. The entire excavation at either or both of the sites may not become wetland because of limited water sources, and nearby sites suggest that the catchment may need to be as large as twice the area of wetland compensation needed. At Edgewood, recommended excavation depths range up to a maximum of 0.5 m (1.6 ft.), and approximately 30% of the excavation would involve depths of 0.3 m (1.0 ft.) or less. A feasible excavation area could be as large as 2.6 ha (6.5 ac.). Additionally, runoff could be redirected onto the Edgewood site from neighboring properties using shallow ditches, although this option is dependent on cooperation from neighboring landowners. At Larkinsburg, the maximum recommended excavation depth is 1.2 m (5.3 ft.), with approximately 30% of the excavation involving depths up to 0.6 m (2.0 ft.), and the remaining 70% involving depths from 0.6 to 1.2 m (2.0 to 5.3 ft.). A feasible excavation area could be as large as 6.3 ha (15.6 ac.). The Larkinsburg site requires greater excavation depths because the land surface in the northwestern quarter is approximately 0.5 m (1.6 ft.) higher than the average site elevation. To prevent drainage of the created wetland basins and to aid in retention of water, construction of low berms, approximately 0.3 m (1.0 ft.) high, will be needed at both sites to isolate the excavated areas from the creeks that border both sites. Larger areas could be excavated at either site, although that would require greater excavation depths, and the areas may not become wetland due to limited water sources.

ACKNOWLEDGMENTS

Keith Carr and Kelli Weaver designed and installed the well networks. Geoff Pociask and Paula Sabatini assisted with field work. Christine Fucciolo managed data and assisted with figures. Funding for this study was provided by the Illinois Department of Transportation.

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APPENDIX A Geologic Descriptions of Borings

Site Name **Edgewood**
Location Boring made in NRCS-mapped Cisne silt loam during the Initial Site Evaluation
Date June 24, 2002
Field Crew Blaine Watson, Keith Carr, Marshall Lake, Geoff Pociask, Paula Sabatini, Kelli Weaver, Katy Werner

Depth	Description
0 – 34 cm	**Clayey silt**; very dark grayish brown (10YR 3/2); common, strong brown (7.5YR 4/6) redox concentrations.
34 – 50 cm	**Clayey silt**; dark grayish brown (10YR 4/2); many, distinct, yellowish brown (10YR 5/6) redox concentrations and brown (10YR 5/3) depletions; few, small manganese (Mn) nodules less than 1 mm in diameter.
50 – 120 cm	**Silty clay**; grayish brown (2.5Y 5/2); many, distinct, light olive brown (2.5Y 5/6) redox concentrations; few, small Mn nodules about 1 mm in diameter, possible organic material at 110 cm.
120 – 140 cm	**Silty clay**; dark gray (2.5Y 4/1); yellowish brown (10YR 5/8) redox concentrations and dark gray (2.5Y 4/1) depletions; Mn nodules up to 3 mm in diameter; saturated conditions and free water encountered at 140 cm.
140 cm	**End of boring**; standing depth of water at 140 cm upon completion.

Site Name **Larkinsburg**
Location Boring made in NRCS-mapped Wynoose silt loam during the Initial Site Evaluation
Date June 25, 2002
Field Crew Blaine Watson, Keith Carr, Marshall Lake, Geoff Pociask, Paula Sabatini, Kelli Weaver, Katy Werner

Depth	Description
0 – 22 cm	**Clayey silt**; olive brown (2.5Y 4/3); trace of sand and gravel; few quartz rock fragments; saturated; soft.
22 – 55 cm	**Clayey silt**; light brownish gray (2.5Y 6/2); many (25–30%) distinct yellowish brown (10YR 5/6) redox concentrations, 0.5 to 1 cm in diameter; dry; crumbly.
55 – 115 cm	**Silty clay**; light brownish gray (2.5Y 6/2) with trace of sand; many (20–30%) distinct yellowish brown (10YR 5/6) redox concentrations, 0.25–0.5 cm in diameter; damp; stiff.
115 – 181 cm	**Clayey silt**; gray (2.5Y 6/1) with trace of sand; many (30–60%) distinct yellowish brown (10YR 5/6) redox concentrations; large Mn nodules, 2–3 cm in diameter at 115 cm and deeper; moist at 115 cm; saturated below 130 cm; soft.
181 cm	**End of boring**; standing depth of water at 180 cm on completion.

APPENDIX B Water-Level Elevations

Table B1 Water-Level Elevations at the Edgewood Site

	Water-Level Elevations (in m referenced to NAVD 1988)								
Date	04/03/03	04/16/03	04/29/03	05/12/03	05/28/03	06/09/03	07/07/03	08/01/03	09/04/03
Well 1S	dry	dry	dry	171.92	dry	dry	dry	dry	dry
Well 2VS	dry	dry	dry	172.22	dry	dry	dry	172.22	172.25
Well 2S	dry	dry	171.93	172.06	172.08	172.07	dry	dry	dry
Well 3S	dry	dry	dry	dry	dry	dry	dry	dry	172.08
Well 4S	172.27	dry	172.30	172.42	172.32	172.27	dry	dry	dry
Well 5S	172.14	dry	172.64	172.60	172.26	172.23	dry	dry	172.07
Well 6S	171.84	dry	172.37	172.37	171.96	171.92	dry	dry	dry
Well 7S	172.09	171.88	172.31	172.23	171.98	171.94	171.82	171.89	172.14
Well 8VS	dry	dry	172.37	172.35	dry	dry	dry	dry	dry
Well 8S	171.87	dry	172.36	172.35	171.97	171.90	dry	dry	171.81
Well 9S	**	**	**	**	**	**	**	**	**
Well 10S	**	**	**	**	**	**	**	**	**
Well 11S	**	**	**	**	**	**	**	**	**
Well 12S	**	**	**	**	**	**	**	**	**
Gauge A	*	169.65	169.75	169.72	169.67	169.66	dry	dry	169.72
Crest Gauge	*	*	170.67	170.58	169.72	169.97	170.53	170.59	170.87

Table B1 Water-Level Elevations at the Edgewood Site *(continued)*

	Water-Level Elevations (in m referenced to NAVD 1988)								
Date	10/03/03	11/25/03	01/02/04	02/09/04	03/19/04	04/05/04	04/14/04	04/19/04	05/03/04
Well 1S	dry	dry	dry	dry	171.96	172.12	171.89	171.80	dry
Well 2VS	dry	172.25	172.32	dry	dry	172.28	dry	dry	172.27
Well 2S	dry	171.82	171.97	dry	172.04	172.24	172.09	172.06	172.04
Well 3S	171.99	172.43	172.44	172.08	172.13	172.12	172.13	172.11	172.41
Well 4S	dry	dry	dry	dry	172.27	172.36	172.31	172.27	172.16
Well 5S	dry	172.64	172.66	dry	172.13	172.22	dry	dry	172.54
Well 6S	dry	172.36	172.38	dry	171.91	171.96	171.81	171.78	172.18
Well 7S	171.94	172.25	172.39	171.87	172.01	172.06	171.97	171.94	171.85
Well 8VS	dry	172.35	172.37	dry	dry	dry	dry	dry	172.24
Well 8S	dry	172.35	172.37	171.76	171.85	171.99	dry	dry	172.21
Well 9S	**	**	172.36	171.69	171.82	171.90	dry	dry	172.23
Well 10S	**	**	172.66	dry	172.12	172.23	dry	dry	172.55
Well 11S	**	**	172.70	dry	172.15	172.22	dry	dry	172.49
Well 12S	**	**	172.35	dry	171.85	171.87	171.70	dry	172.24
Gauge A	169.69	169.75	169.75	frozen	169.69	169.69	169.69	169.67	169.83
Crest Gauge	170.38	170.16	170.44	frozen	170.58	*	*	*	*

* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well

APPENDIX B Water-Level Elevations *(continued)*

Table B1 Water-Level Elevations at the Edgewood Site *(continued)*

	Water-Level Elevations (in m referenced to NAVD 1988)							
Date	05/17/04	05/25/04	06/01/04	06/07/04	07/06/04	08/02/04	09/09/04	10/05/04
Well 1S	dry	dry	171.86	dry	dry	dry	dry	dry
Well 2VS	172.25	172.31	172.34	172.26	172.27	dry	dry	dry
Well 2S	172.05	172.11	172.25	172.07	172.02	dry	dry	dry
Well 3S	172.18	172.24	172.47	172.09	172.31	dry	dry	dry
Well 4S	172.12	dry	172.28	172.23	172.11	dry	172.21	dry
Well 5S	172.06	dry	172.63	dry	172.27	dry	dry	dry
Well 6S	171.75	dry	172.35	171.83	172.32	171.88	171.89	dry
Well 7S	dry	dry	172.27	172.03	172.32	172.06	172.06	dry
Well 8VS	dry	dry	172.34	dry	172.19	dry	dry	dry
Well 8S	171.79	dry	172.32	171.73	172.30	dry	dry	dry
Well 9S	171.70	dry	172.28	dry	dry	dry	dry	dry
Well 10S	172.13	dry	172.63	dry	172.56	dry	dry	dry
Well 11S	dry	dry	172.60	dry	172.17	dry	dry	dry
Well 12S	171.85	171.74	172.25	dry	171.96	dry	dry	dry
Gauge A	169.66	169.68	169.72	169.65	169.98	169.62	169.58	dry
Crest Gauge	*	*	170.77	169.74	170.21	169.99	170.50	*

* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well

APPENDIX B   Water-Level Elevations *(continued)*

Table B2   Water-Level Elevations at the Larkinsburg Site

	Water-Level Elevations (in m referenced to NAVD 1988)								
Date	04/01/03	04/16/03	04/29/03	05/12/03	05/28/03	06/09/03	07/07/03	08/01/03	09/04/03
Well 1S	164.35	164.15	164.74	164.76	164.25	dry	dry	dry	164.44
Well 2S	166.51	166.33	166.62	166.62	166.47	166.29	dry	165.95	166.38
Well 3VS	dry	dry	168.18	167.99	dry	dry	dry	dry	dry
Well 3S	167.78	dry	168.18	167.99	167.78	167.70	dry	dry	dry
Well 4VS	166.58	dry	166.63	166.60	166.42	dry	dry	dry	166.51
Well 4S	166.57	166.33	166.64	166.60	166.42	166.30	dry	dry	166.44
Well 5S	167.62	dry	168.02	167.87	167.60	167.49	dry	dry	dry
Well 6S	167.90	167.71	168.27	168.05	167.87	167.79	dry	dry	167.72
Well 7S	167.86	167.68	168.25	168.04	167.88	167.79	dry	dry	167.80
Well 8S	167.60	167.43	167.94	167.70	167.57	167.49	dry	dry	167.37
Well 9S	167.96	dry	168.31	168.10	167.96	167.94	dry	dry	dry
Well 10VS	dry	dry	168.73	dry	dry	dry	dry	dry	dry
Well 10S	168.36	dry	168.67	168.54	168.31	dry	dry	dry	168.32
Well 11S	*	dry	168.38	168.16	167.97	167.88	dry	dry	dry
Well 12S	**	**	**	**	**	**	**	**	**
Well 13S	**	**	**	**	**	**	**	**	**
Well 14S	**	**	**	**	**	**	**	**	**
Well 15S	**	**	**	**	**	**	**	**	**
Well 16S	**	**	**	**	**	**	**	**	**
Gauge A	166.69	166.68	166.71	166.73	166.70	dry	dry	dry	166.69
Crest Gauge	*	*	167.18	167.20	166.83	166.71	167.25	167.24	167.17

* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well

APPENDIX B Water-Level Elevations *(continued)*

Table B2 Water-Level Elevations at the Larkinsburg Site *(continued)*

	Water-Level Elevations (in m referenced to NAVD 1988)								
Date	10/03/03	11/26/03	01/02/04	02/09/04	03/19/04	04/05/04	04/14/04	04/19/04	05/03/04
Well 1S	dry	164.76	164.78	164.32	164.22	164.30	164.12	dry	164.75
Well 2S	166.05	166.59	166.66	frozen	166.49	166.52	166.33	166.16	166.62
Well 3VS	dry	dry	168.25	dry	dry	dry	dry	dry	168.20
Well 3S	dry	167.76	168.25	dry	dry	167.76	dry	dry	168.08
Well 4VS	dry	166.64	166.67	frozen	166.59	166.58	dry	dry	166.65
Well 4S	dry	166.64	166.67	frozen	166.57	166.56	166.34	166.15	166.64
Well 5S	dry	167.83	168.12	dry	dry	167.55	dry	dry	168.01
Well 6S	dry	168.08	168.39	dry	dry	167.81	dry	dry	168.31
Well 7S	dry	167.85	168.32	dry	dry	167.78	dry	dry	168.20
Well 8S	dry	167.95	168.07	167.63	167.54	167.61	167.40	dry	167.93
Well 9S	dry	168.18	168.48	dry	dry	167.86	dry	dry	168.36
Well 10VS	dry	dry	168.81	dry	dry	dry	dry	dry	dry
Well 10S	dry	168.59	168.92	dry	dry	168.33	dry	dry	168.57
Well 11S	dry	168.27	168.51	167.85	dry	167.86	dry	dry	168.40
Well 12S	**	**	168.29	dry	167.65	167.74	dry	dry	168.22
Well 13S	**	**	168.81	dry	168.17	168.29	dry	dry	168.74
Well 14S	**	**	168.30	dry	167.65	167.89	dry	dry	168.24
Well 15S	**	**	168.49	dry	dry	167.92	dry	dry	168.40
Well 16S	**	**	168.29	dry	dry	167.70	dry	dry	168.22
Gauge A	dry	166.69	166.73	166.78	166.66	166.64	166.64	166.63	166.67
Crest Gauge	166.80	167.26	167.43	frozen	167.15	167.28	*	*	166.75

* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well

APPENDIX B Water-Level Elevations *(continued)*

Table B2 Water-Level Elevations at the Larkinsburg Site *(continued)*

	Water-Level Elevations (in m referenced to NAVD 1988)							
Date	05/17/04	05/25/04	06/01/04	06/07/04	07/06/04	08/02/04	09/09/04	10/05/04
Well 1S	164.05	dry	164.62	dry	164.74	dry	dry	dry
Well 2S	166.47	166.36	166.62	166.16	166.54	dry	dry	dry
Well 3VS	dry	dry	168.03	dry	dry	dry	dry	dry
Well 3S	167.67	dry	168.04	dry	dry	dry	dry	dry
Well 4VS	166.56	166.50	166.64	dry	166.63	dry	dry	dry
Well 4S	166.54	166.49	166.62	166.08	166.59	dry	dry	dry
Well 5S	167.63	167.52	167.99	dry	167.58	dry	dry	dry
Well 6S	167.84	167.71	168.12	dry	dry	dry	dry	dry
Well 7S	167.82	167.70	168.07	dry	168.07	167.65	dry	dry
Well 8S	167.60	167.48	167.80	167.41	167.36	dry	dry	dry
Well 9S	167.98	167.89	168.15	dry	dry	dry	dry	dry
Well 10VS	dry	dry	168.65	dry	168.67	dry	dry	dry
Well 10S	dry	dry	168.54	dry	168.47	dry	dry	dry
Well 11S	168.00	167.87	168.21	dry	dry	dry	dry	dry
Well 12S	167.91	167.83	168.13	167.62	168.00	dry	dry	dry
Well 13S	168.36	168.22	168.61	dry	168.17	dry	dry	dry
Well 14S	167.77	dry	168.14	dry	167.84	dry	dry	dry
Well 15S	167.97	dry	168.21	dry	dry	dry	dry	dry
Well 16S	167.77	167.67	168.04	dry	dry	dry	dry	dry
Gauge A	166.64	dry	166.66	dry	166.70	dry	dry	dry
Crest Gauge	*	*	167.08	dry	167.10	*	167.19	*

* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well

APPENDIX C Depths to Water

Table C1 Depths to Water at the Edgewood Site

	Depths to Water (in m referenced to land surface)								
Date	04/03/03	04/16/03	04/29/03	05/12/03	05/28/03	06/09/03	07/07/03	08/01/03	09/04/03
Well 1S	dry	dry	dry	0.47	dry	dry	dry	dry	dry
Well 2VS	dry	dry	dry	**0.29**	dry	dry	dry	**0.29**	**0.25**
Well 2S	dry	dry	0.57	0.43	0.42	0.43	dry	dry	dry
Well 3S	dry	dry	dry	dry	dry	dry	dry	dry	0.54
Well 4S	0.47	dry	0.44	0.32	0.42	0.48	dry	dry	dry
Well 5S	0.51	dry	**0.01**	**0.05**	0.39	0.42	dry	dry	0.58
Well 6S	0.56	dry	**0.02**	**0.03**	0.44	0.48	dry	dry	dry
Well 7S	0.36	0.57	**0.14**	**0.21**	0.46	0.50	0.63	0.55	**0.30**
Well 8VS	dry	dry	**0.01**	**0.03**	dry	dry	dry	dry	dry
Well 8S	0.50	dry	**0.01**	**0.02**	0.40	0.47	dry	dry	0.56
Well 9S	**	**	**	**	**	**	**	**	**
Well 10S	**	**	**	**	**	**	**	**	**
Well 11S	**	**	**	**	**	**	**	**	**
Well 12S	**	**	**	**	**	**	**	**	**

Table C1 Depths to Water at the Edgewood Site *(continued)*

	Depths to Water (in m referenced to land surface)								
Date	10/03/03	11/25/03	01/02/04	02/09/04	03/19/04	04/05/04	04/14/04	04/19/04	05/03/04
Well 1S	dry	dry	dry	dry	0.46	**0.29**	0.52	0.61	dry
Well 2VS	dry	**0.25**	**0.18**	dry	dry	**0.20**	dry	dry	**0.21**
Well 2S	dry	0.68	0.52	dry	0.45	**0.24**	0.39	0.42	0.44
Well 3S	0.63	**0.20**	**0.18**	0.54	0.50	0.51	0.50	0.52	**0.21**
Well 4S	dry	dry	dry	dry	0.46	0.37	0.42	0.46	0.57
Well 5S	dry	**0.01**	**-0.01**	dry	0.52	0.42	dry	dry	**0.10**
Well 6S	dry	**0.03**	**0.02**	dry	0.47	0.41	0.57	0.60	**0.20**
Well 7S	0.51	**0.19**	**0.05**	0.57	0.43	0.38	0.46	0.50	0.58
Well 8VS	dry	**0.02**	**0.00**	dry	dry	dry	dry	dry	**0.12**
Well 8S	dry	**0.02**	**0.00**	0.61	0.51	0.37	dry	dry	**0.15**
Well 9S	**	**	**0.00**	0.66	0.54	0.45	dry	dry	**0.12**
Well 10S	**	**	**-0.01**	dry	0.52	0.42	dry	dry	**0.09**
Well 11S	**	**	**-0.01**	dry	0.54	0.46	dry	dry	**0.20**
Well 12S	**	**	**-0.06**	dry	0.44	0.42	0.59	dry	**0.05**

- indicates water above land surface
* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well
bold depth values less than or equal to 0.304 m

APPENDIX C Depths to Water *(continued)*

Table C1 Depths to Water at the Edgewood Site *(continued)*

	Depths to Water (in m referenced to land surface)							
Date	05/17/04	05/25/04	06/01/04	06/07/04	07/06/04	08/02/04	09/09/04	10/05/04
Well 1S	dry	dry	0.56	dry	dry	dry	dry	dry
Well 2VS	**0.23**	**0.17**	**0.14**	**0.22**	**0.21**	dry	dry	dry
Well 2S	0.43	0.37	**0.23**	0.41	0.46	dry	dry	dry
Well 3S	0.45	0.39	**0.16**	0.54	0.32	dry	dry	dry
Well 4S	0.61	dry	0.45	0.51	0.62	dry	0.52	dry
Well 5S	0.59	dry	**0.02**	dry	0.38	dry	dry	dry
Well 6S	0.62	dry	**0.03**	0.54	**0.05**	0.50	0.49	dry
Well 7S	dry	dry	**0.16**	0.40	**0.11**	0.38	0.38	dry
Well 8VS	dry	dry	**0.02**	dry	**0.17**	dry	dry	dry
Well 8S	0.57	dry	**0.04**	0.63	**0.06**	dry	dry	dry
Well 9S	0.65	dry	**0.08**	dry	dry	dry	dry	dry
Well 10S	0.51	dry	**0.02**	dry	**0.08**	dry	dry	dry
Well 11S	dry	dry	**0.08**	dry	0.51	dry	dry	dry
Well 12S	0.44	0.55	**0.04**	dry	0.33	dry	dry	dry

- indicates water above land surface
* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well
bold depth values less than or equal to 0.304 m

APPENDIX C Depths to Water *(continued)*

Table C2 Depths to Water at the Larkinsburg Site

	Depths to Water (in m referenced to land surface)								
Date	04/01/03	04/16/03	04/29/03	05/12/03	05/28/03	06/09/03	07/07/03	08/01/03	09/04/03
Well 1S	0.42	0.62	**0.03**	**0.01**	0.52	dry	dry	dry	0.33
Well 2S	**0.10**	**0.29**	**0.00**	**-0.01**	**0.15**	0.32	dry	0.66	**0.23**
Well 3VS	dry	dry	**0.09**	**0.28**	dry	dry	dry	dry	dry
Well 3S	0.48	dry	**0.09**	**0.27**	0.49	0.57	dry	dry	dry
Well 4VS	**0.11**	dry	**0.06**	**0.08**	**0.26**	dry	dry	dry	**0.18**
Well 4S	**0.13**	0.37	**0.07**	**0.10**	**0.29**	0.40	dry	dry	**0.27**
Well 5S	0.48	dry	**0.08**	**0.23**	0.50	0.61	dry	dry	dry
Well 6S	0.49	0.68	**0.12**	0.34	0.52	0.60	dry	dry	0.67
Well 7S	0.48	0.65	**0.08**	**0.30**	0.46	0.54	dry	dry	0.54
Well 8S	0.39	0.56	**0.05**	**0.28**	0.42	0.50	dry	dry	0.62
Well 9S	0.54	dry	**0.19**	0.39	0.54	0.56	dry	dry	dry
Well 10VS	dry	dry	**0.20**	dry	dry	dry	dry	dry	dry
Well 10S	0.56	dry	**0.25**	0.38	0.61	dry	dry	dry	0.60
Well 11S	*	dry	**0.12**	0.34	0.53	0.62	dry	dry	dry
Well 12S	**	**	**	**	**	**	**	**	**
Well 13S	**	**	**	**	**	**	**	**	**
Well 14S	**	**	**	**	**	**	**	**	**
Well 15S	**	**	**	**	**	**	**	**	**
Well 16S	**	**	**	**	**	**	**	**	**

- indicates water above land surface
* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well
bold depth values less than or equal to 0.304 m

APPENDIX C Depths to Water *(continued)*

Table C2 Depths to Water at the Larkinsburg Site *(continued)*

	Depths to Water (in m referenced to land surface)								
Date	10/03/03	11/26/03	01/02/04	02/09/04	03/19/04	04/05/04	04/14/04	04/19/04	05/03/04
Well 1S	dry	**0.01**	**-0.01**	0.46	0.52	0.44	0.62	dry	**-0.01**
Well 2S	0.57	**0.02**	**-0.05**	frozen	**0.08**	**0.06**	**0.24**	0.42	**-0.04**
Well 3VS	dry	dry	**0.02**	dry	dry	dry	dry	dry	**0.06**
Well 3S	dry	0.50	**0.01**	dry	dry	0.50	dry	dry	**0.18**
Well 4VS	dry	**0.05**	**0.02**	frozen	**0.09**	**0.09**	dry	dry	**0.03**
Well 4S	dry	**0.06**	**0.03**	frozen	**0.11**	**0.12**	0.34	0.53	**0.04**
Well 5S	dry	**0.26**	**-0.02**	dry	dry	0.55	dry	dry	**0.08**
Well 6S	dry	0.31	**0.00**	dry	dry	0.57	dry	dry	**0.07**
Well 7S	dry	0.49	**0.02**	dry	dry	0.53	dry	dry	**0.12**
Well 8S	dry	**0.03**	**-0.09**	0.36	0.48	0.41	0.62	dry	**0.09**
Well 9S	dry	0.32	**0.02**	dry	dry	0.61	dry	dry	**0.12**
Well 10VS	dry	dry	**0.12**	dry	dry	dry	dry	dry	dry
Well 10S	dry	0.33	**0.00**	dry	dry	0.58	dry	dry	0.33
Well 11S	dry	**0.23**	**-0.01**	0.65	dry	0.62	dry	dry	**0.08**
Well 12S	**	**	**-0.04**	dry	0.61	0.51	dry	dry	**0.04**
Well 13S	**	**	**-0.04**	dry	0.60	0.48	dry	dry	**0.03**
Well 14S	**	**	**-0.03**	dry	0.62	0.38	dry	dry	**0.03**
Well 15S	**	**	**0.00**	dry	dry	0.56	dry	dry	**0.09**
Well 16S	**	**	**-0.02**	dry	dry	0.57	dry	dry	**0.04**

- indicates water above land surface
* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well
bold depth values less than or equal to 0.304 m

APPENDIX C   Depths to Water *(continued)*

Table C2   Depths to Water at the Larkinsburg Site *(continued)*

	Depths to Water (in m referenced to land surface)							
Date	05/17/04	05/25/04	06/01/04	06/07/04	07/06/04	08/02/04	09/09/04	10/05/04
Well 1S	0.69	dry	**0.12**	dry	**0.00**	dry	dry	dry
Well 2S	**0.11**	**0.21**	**-0.04**	0.42	**0.04**	dry	dry	dry
Well 3VS	dry	dry	**0.23**	dry	dry	dry	dry	dry
Well 3S	0.59	dry	**0.22**	dry	dry	dry	dry	dry
Well 4VS	**0.11**	**0.18**	**0.04**	dry	**0.05**	dry	dry	dry
Well 4S	**0.13**	**0.19**	**0.06**	0.60	**0.09**	dry	dry	dry
Well 5S	0.47	0.57	**0.11**	dry	0.52	dry	dry	dry
Well 6S	0.54	0.67	**0.27**	dry	dry	dry	dry	dry
Well 7S	0.50	0.61	**0.24**	dry	**0.24**	0.66	dry	dry
Well 8S	0.42	0.54	**0.22**	0.61	0.65	dry	dry	dry
Well 9S	0.50	0.59	0.33	dry	dry	dry	dry	dry
Well 10VS	dry	dry	**0.26**	dry	**0.23**	dry	dry	dry
Well 10S	dry	dry	0.37	dry	0.44	dry	dry	dry
Well 11S	0.48	0.62	**0.27**	dry	dry	dry	dry	dry
Well 12S	0.35	0.43	**0.13**	0.64	**0.26**	dry	dry	dry
Well 13S	0.41	0.56	**0.16**	dry	0.60	dry	dry	dry
Well 14S	0.50	dry	**0.13**	dry	0.43	dry	dry	dry
Well 15S	0.52	dry	**0.27**	dry	dry	dry	dry	dry
Well 16S	0.50	0.60	**0.23**	dry	dry	dry	dry	dry

- indicates water above land surface
* no measurement
** not yet installed
S indicates soil-zone monitoring well
VS indicates very shallow monitoring well
bold depth values less than or equal to 0.304 m

APPENDIX D Well-Construction Information

Table D1 Well-Construction Information for the Edgewood Site

Well-Construction Information	**1S**	**2S**	**2VS**	**3S**	**4S**	**5S**	**6S**	**7S**
Total length of well (m)	1.89	1.89	0.96	1.89	1.89	1.88	1.89	1.88
Screen length (m)	0.27	0.27	0.15	0.28	0.27	0.28	0.27	0.27
Depth of borehole (m) *	0.75	0.76	0.39	0.75	0.75	0.75	0.75	0.75
Bentonite seal - top (m) *	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand pack - top (m) *	0.30	0.30	0.15	0.30	0.30	0.30	0.30	0.30
Sand pack - bottom (m) *	0.75	0.76	0.39	0.75	0.75	0.75	0.75	0.75
Top of screen (m) *	0.44	0.46	0.20	0.43	0.40	0.40	0.40	0.41
Bottom of screen (m) *	0.71	0.73	0.35	0.70	0.67	0.68	0.67	0.69

* as depth referenced to land surface

Table D1 Well-Construction Information for the Edgewood Site *(continued)*

Well-Construction Information	**8S**	**8VS**	**8SG**	**9S**	**10S**	**11S**	**12S**
Total length of well (m)	1.89	0.97	1.96	1.87	1.88	1.92	1.86
Screen length (m)	0.28	0.16	0.30	0.24	0.29	0.30	0.27
Depth of borehole (m) *	0.75	0.39	0.75	0.75	0.75	0.75	0.75
Bentonite seal - top (m) *	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand pack - top (m) *	0.30	0.15	0.30	0.30	0.30	0.30	0.30
Sand pack - bottom (m) *	0.75	0.39	0.75	0.75	0.75	0.75	0.75
Top of screen (m) *	0.39	0.20	0.39	0.47	0.40	0.40	0.44
Bottom of screen (m) *	0.66	0.36	0.69	0.71	0.69	0.70	0.71

* as depth referenced to land surface

Table D2 Well-Construction Information for the Larkinsburg Site

Well-Construction Information	**1S**	**2S**	**3S**	**3VS**	**4S**	**4VS**	**5S**	**6S**
Total length of well (m)	1.87	1.88	1.89	0.98	1.89	0.96	1.88	1.88
Screen length (m)	0.27	0.27	0.27	0.16	0.27	0.15	0.27	0.27
Depth of borehole (m) *	0.76	0.76	0.75	0.39	0.75	0.39	0.75	0.76
Bentonite seal - top (m) *	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand pack - top (m) *	0.30	0.30	0.30	0.15	0.30	0.15	0.30	0.30
Sand pack - bottom (m) *	0.76	0.76	0.75	0.39	0.75	0.39	0.75	0.76
Top of screen (m) *	0.47	0.42	0.42	0.17	0.43	0.18	0.41	0.43
Bottom of screen (m) *	0.74	0.69	0.69	0.33	0.70	0.33	0.68	0.70

* as depth referenced to land surface

Table D2 Well-Construction Information for the Larkinsburg Site *(continued)*

Well-Construction Information	**7S**	**8S**	**9S**	**10S**	**10VS**	**10SG**	**11S**	**12S**
Total length of well (m)	1.92	1.88	1.91	1.90	0.98	2.03	1.90	1.91
Screen length (m)	0.28	0.27	0.28	0.27	0.16	0.31	0.27	0.28
Depth of borehole (m) *	0.75	0.75	0.75	0.75	0.39	0.75	0.75	0.75
Bentonite seal - top (m) *	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand pack - top (m) *	0.30	0.30	0.30	0.30	0.15	0.30	0.30	0.30
Sand pack - bottom (m) *	0.75	0.75	0.75	0.75	0.39	0.75	0.75	0.75
Top of screen (m) *	0.41	0.42	0.42	0.41	0.18	0.36	0.41	0.41
Bottom of screen (m) *	0.69	0.69	0.70	0.69	0.34	0.66	0.68	0.69

* as depth referenced to land surface

APPENDIX D Well-Construction Information *(continued)*

Table D2 Well-Construction Information for the Larkinsburg Site *(continued)*

Well-Construction Information	**13S**	**14S**	**15S**	**16S**
Total length of well (m)	1.93	1.92	1.92	1.93
Screen length (m)	0.32	0.27	0.29	0.32
Depth of borehole (m) *	0.75	0.75	0.75	0.75
Bentonite seal - top (m) *	0.00	0.00	0.00	0.00
Sand pack - top (m) *	0.30	0.30	0.30	0.30
Sand pack - bottom (m) *	0.75	0.75	0.75	0.75
Top of screen (m) *	0.36	0.41	0.39	0.39
Bottom of screen (m) *	0.68	0.68	0.68	0.71

* as depth referenced to land surface

APPENDIX E Precipitation Trend at Vandalia, Illinois