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KARST SPRINGS IN THE SINKHOLE PLAIN OF ILLINOIS: THEIR COMMUNITY DIVERSITY AND HYDROGEOLOGY

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Abstract

The hydrogeology, water quality, and community structure and biodiversity of the fauna and flora of ten karst springs in the Sinkhole Plain Region, Monroe and St. Clair counties, Illinois were studied from November, 1994, through August, 1995. Of particular concern was the potential effects of nitrate nitrogren and the herbicides Atrazin, Alachlor, Cyanazine, and Metolachlor on the community structure of the biota in comparison with that of seven springs in the Shawnee Hills of Illinois.

Nitrate nitrogen concentrations ranged from 0.26-7.64 mg/L, mean 3.83 mg/L, and was detected in all 40 water samples. All concentrations were below the EPA MCL of 10 mg/L. Atrazine concentrations ranged from <DL-5.83 µg/L, mean 0.67 µg/L, and detected in 29 of the 40 water samples (73%). Three samples (7.5%) were at levels above the EPA MCL of 3 µg/L. Alachlor concentrations ranged from <DL-2.89 µg/L, mean 0.11 µg/L, and was detected in 11 of the 40 water samples (27.5%). One sample (2.5%) was at a level above the EPA MCL of 2 µg/L. Cyanazine concentrations ranged from <DL-1.74 µg/L, mean 0.13 µg/L, and was detected in 9 of the 40 water samples (22.5%) Two samples (5%) were at levels above the EPA HAL of 1 µg/L. Metolachlor concentrations ranged from <DL-3.28 µg/L, mean 0.29 µg/L, and was detected in 19 of the 40 water samples (47.5%). No samples were at levels above the EPA HAL of 100 µg/L.

One hundred and forty one taxa of aquatic macroinvertebrates were collected. Species richness ranged from 18-82 and averaged 42 taxa per spring. Amphipods, isopods, and Turbellaria dominated in terms of abundance. Aquatic insects (80 taxa) composed the most diverse group of macroinvertebrate, but generally in low abundance. Oligochaete worms (30 taxa) were the most diverse group of non-insectan aquatic macroinvertebrates. *Varichaetadrilus angustipenis*, a rare species in Illinois, was recorded from Dual Springs, Camp Vandeventer springbrook and Walsh springbrook. *Allonais paraguayensis*, a rare species in the United States was collected in Camp Vandeventer, Sparrow, and Walsh Springs. The amphipods *Gammarus troglophilus* and *Crangonyx forbesi* were collected in several springs. These species are typically cave stream inhabiting species, and reflect the subterranean cave origin of many of these springs. The cave inhabiting isopods *Caecidotea packardi* and *C. intermedia* were also collected in several springs.

In comparison, the species richness recorded for seven springs in the Shawnee Hills ranged from 11-46, average 27 taxa per spring. The dominant taxa in terms of abundance were the amphipods *Gammarus minus* and *G. pseudolimnaeus*, although the oligochaete worms (24 taxa) were the most diverse group of macroinvertebrates. *Varichaetadrilus angustipenis* and *Allonais paraguayensis* were also recorded from several springs. Only scattered representative of various aquatic insects were collected, and seldom in abundance.

No State or Federally threatened or endangered species of aquatic macroinvertebrates were collected in any of the 10 karst springs.

No aquatic macrophytes were collected from any of the ten karst springs in the Sinkhole Plain.

Springs in Monroe and St. Clair counties were actively discharging 10,840 ± 170 years BP. The 83-year record monthly rainfall in 1995 gave valuable insight on the ubiquitous nature of herbicides in the groundwater system associated with these 10 springs. Five distinctive patterns of residence and non residence of herbicides were recognized.

Chloride concentrations correlated linearly with discharge at nine springs in November, 1994, and in February, 1995, when discharge was <200 gpm. Specific conductance correlated linearly with alkalinity (as $CaCO_3$), dissolved Ca, hardness (EDTA), and total dissolved solids.

KARST SPRINGS IN THE SINKHOLE PLAIN OF ILLINOIS: THEIR COMMUNITY DIVERSITY AND HYDROGEOLOGY

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Introduction

Springs are a natural source of groundwater discharge at a rate high enough to form a channel on the earth's surface. They can be further described as the end point of a groundwater continuum and the initiation point for the base flow of many streams. Water quality data are not available for most springs in Illinois, although springs provide a point source for evaluating present and potential ground and surface water contamination. Systematic water quality sampling at springs provides information affecting the life cycle of aquatic organisms, including the loss or gain of species diversity. Although springs are an interface between groundwater (subsurface) and contribute to the base flow of streams (surface), they have not been a focal point of research by aquatic biologists or hydrogeologists interested in the elements or properties of lotic (flowing water) communities. The physical and chemical composition of springwater reflects not only the mineral composition of the various rock strata with which the water has been in contact, but also the various chemicals bound up in the surface waters which often move downward into the earth materials becoming groundwater.

Springs, along with their associated seeps and outflow brooks, provide a unique habitat for endemic and rare species of aquatic animals and plants because they usually exhibit a nearly constant physical and chemical environment (Butler 1984; Colbo 1991; Davidson and Wilding 1943; Elton 1966; Erman and Erman 1990; Forester 1991; Glazier 1991; Glazier and Gooch 1987; Gooch and Glazier, 1991; Meffe and Marsh 1983; Minshall 1968; Pritchard 1991; Ring 1991; Roughley and Larson 1991; Williams N. E. 1991; Williams and Danks 1991). In the United States and Canada, little emphasis has been given to the study of springs, particularly from the holistic standpoint of examining the entire biota and then relating the diversity and endemism found in their hydrogeologic and water quality setting. Williams, N. E. (1991) studied the Trichoptera of cold freshwater springs in Canada; Ring (1991) examined the insect fauna of natural salt springs on Saltspring Island, British Columbia; Barnby and Resh (1988) examined factors affecting the

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distribution of an endemic and a widespread species of brine fly in a northern California thermal saline spring; Brues (1924) observed the animal life in the thermal waters of Yellowstone National Park, Wyoming; Roughley and Larson (1991) reviewed the aquatic Coleoptera of springs in Canada; Forester (1991) examined the assemblages of ostracods from springs in the western United States; and Smith (1991) reported on the water mites in springs in Canada. All of these studies focused on a selected group of species, but provided little water quality information beyond water temperature, dissolve oxygen, *p*H and alkalinity. Glazier (1991) hypothesized that the aquatic macroinvertebrates of temperate, cold-water areas are dominated by either a non-insectan community (Turbellaria, Annelida, Amphipoda, Isopoda, Gastropoda) or an aquatic insect community (Odonata, Ephemeroptera, Plecoptera, aquatic Diptera, Trichoptera, and aquatic Coleoptera). The faunal dominance of non-insectan taxa appears in hard-water limestone springs with a *p*H >7.0 and alkalinity above 25 mg/L (as $CaCO_3$). Aquatic insects appear to dominate in acidic soft-water springs, with a *p*H <7.0 and alkalinity below 25 mg/L. Both types of springs occur in Illinois and offer an opportunity to evaluate species diversity and endemism of aquatic organisms in relation to the hydrogeology of cultural and non cultural drainage basins.

Due to the lack of baseline information on the fauna, water quality, and hydrogeology of Illinois springs, a cooperative program between the Illinois Natural History Survey and the Illinois State Geological Survey was initiated in 1991 to evaluate the current status of Illinois springs. The locations of Illinois springs were determined from historical data. Subsequently, a computerized database was developed to bring together all available information on a springs location, hydrogeology, water quality, fauna, and flora, as well as any historical information available. At the turn of the century, 88 springs (Bartow *et al.* 1909) were reported in Illinois. These springs were utilized as domestic drinking and bathing water sources or for the perceived health benefits derived from the minerals contained in the water. To date, over 300 springs have been entered into our database from historical, topographic, and personal data sources. Our focus now is to verify the precise location, and to determine the hydrogeology, biota, and water quality of each spring listed in the database.

Springs in Illinois (Figure 1) are principally found in the Mississippian and Devonian limestones of the four karst regions of Illinois: the Shawnee Hills, the Sinkhole Plain, the Lincoln Hills, and the Driftless Area.

Initially, six springs in the Shawnee Hills of southern Illinois were studied (Webb, Reed, and Wetzel 1992; Webb *et al.* 1995). Four of these springs were examined bimonthly for a year. These springs were selected because they lay outside areas of intensive agriculture where serious groundwater contamination by agricultural fertilizers and pesticides may occur. Nitrate nitrogen levels in these six springs were extremely low over the entire year, ranging from 0-0.005 mg/L to 0.66 mg/L for 56 samples.

In 1993, a study of "The Biological Resources of Illinois Caves and Other Subterranean Environments" examined the diversity, distribution, and status of the subterranean faunas of Illinois caves and how the aquatic faunas were related to groundwater quality (Webb, Taylor, and Krejca 1993). This study examined 99 caves, cave streams, and springs in the karst regions of Illinois. Nitrate levels measured in 35 samples from 33 cave streams or springs ranged from 0.80-11.45 mg/L. Two samples from Shivery Slithery Cave, Monroe County (11.17 mg/L) and an unnamed spring, Monroe County (11.45 mg/L), exceeded EPA Maximum Contaminant Level (EPA MCL) for Illinois. Nitrate nitrogen levels for the Sinkhole Plain area of Monroe, Randolph, and St. Clair counties were found to be higher than for the previously studied karst regions of Illinois. Pesticides (Dieldrin, DDE, and DDD) were found in four of 14 water samples analyzed, although at extremely low levels. Atrazine was not detected in any of the samples. One interesting fact to come out of this study was the presence of mercury in five amphipod and isopods samples (9.13-658.0 ppb) although no mercury was detected in 35 water samples analyzed during this study. It must be pointed out that 33 of the 35 water samples collected were simply one time collections and no temporal variation in nitrate nitrogen or mercury levels were determined.

The objectives of this study were to 1) characterize the hydrogeology of ten karst springs in the Sinkhole Plain Region of Illinois, including the structural setting, stream gradient, and estimated springhead elevation, along with the physical characteristics of the springhead and springbrook earth materials; 2) analyze the water quality of each spring with particular reference to nitrate nitrogen and herbicide levels; 3) determine the species diversity of the biota with particular reference to endemic and rare species; 4) determine the existence of State or Federally threatened or endangered species; and 5) to compare the fauna, water quality, and hydrogeology of these 10 springs with seven springs previously studied in the Shawnee Hills of Illinois.

Materials and Methods

Site Location

Auctioneer Spring (AS), 5.6 km NE Valmeyer postoffice (PO), Monroe County. 3rd Principal Meridian: Township 2 South, Range 11 West, Section 36, NE/SW/NW/NW/NE. Elevation: 590' MSL.

Camp Vandeventer Spring (CVDVS), 5.1 km WNW Waterloo (PO), Monroe County. 3rd Principal Meridian: Township 2 South, Range 10 West, Section 21, NW/NE/SW/SE/SE. Elevation: 450' MSL.

Dual Springs (DS), 5.4 km WNW Waterloo (PO), Monroe County. 3rd Principal Meridian: Township 2 South, Range 10 West, Section 21, NW/NW/SW/NW/SE. Elevation: 440' MSL.

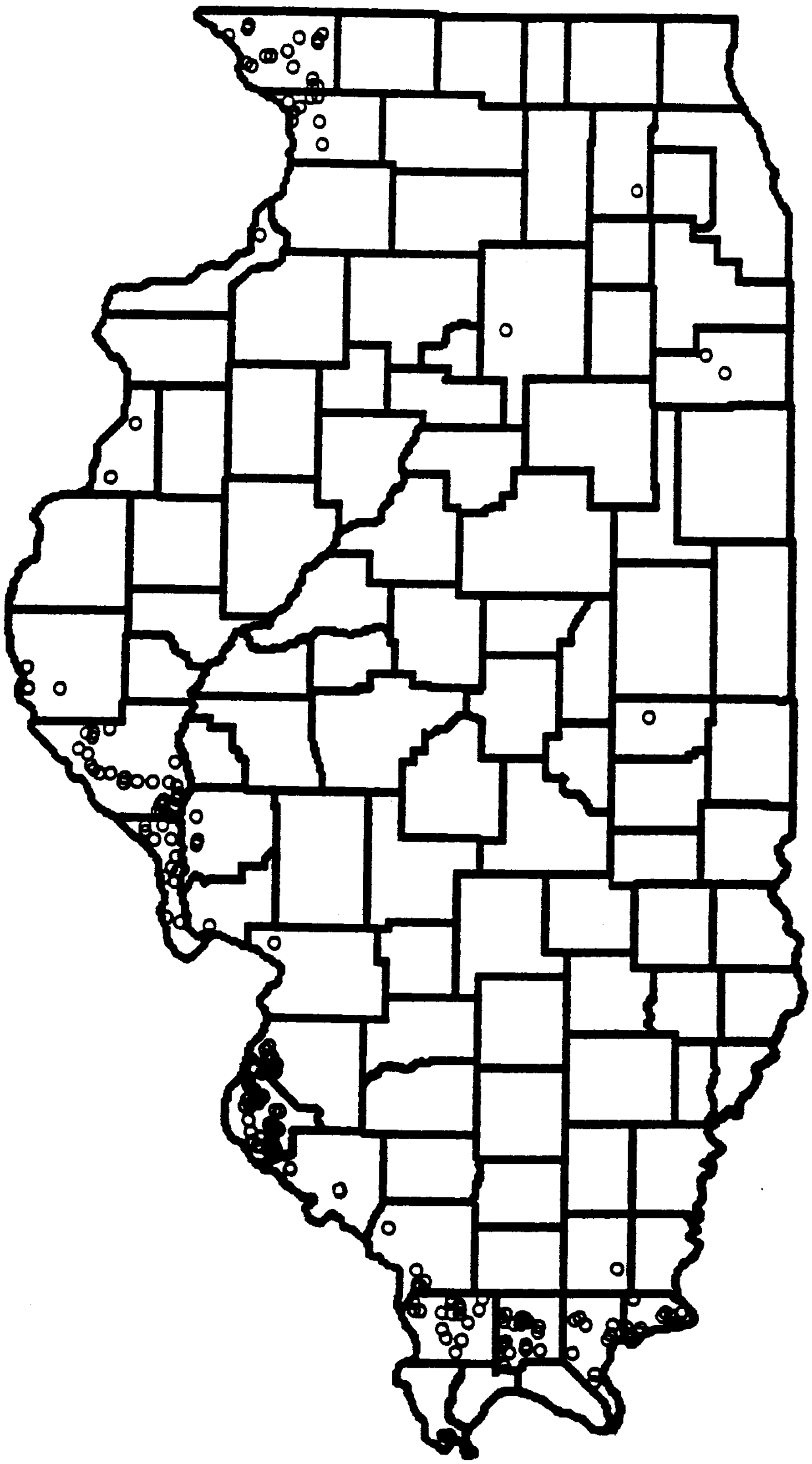

Figure 1. The general distribution of springs in Illinois.

Kelly Spring (KS), 10.3 km SSE Waterloo (PO), Monroe County. 3rd Principal Meridian: Township 3 South, Range 9 West, Section 29, S2/NE/SE/SE/NE. Elevation: 510' MSL.

Little Carr Spring (LCS), 3.8 km SW Columbia (PO), Monroe County. 3rd Principal Meridian: Township 1 South, Range 10 West, Section 29, SE/NE/SE/SW/NW. Elevation: 430' MSL.

Madonnaville Spring (MS), 0.5 km SE Madonnaville, Monroe County. 3rd Principal Meridian: Township 3 South, Range 10 West, Section 19, SW/NE/NE/NE/SE. Elevation: 645' MSL.

Ritter Spring (RS), 1.05 km NNE Columbia (PO), Monroe County. 3rd Principal Meridian: Township 1 South, Range 10 West, Section 15, SW/NW/NW/SE/NW. Elevation: 485' MSL.

Sparrow Spring (SS), 4.2 km E Dupo, St. Clair County. 3rd Principal Meridian: Township 1 North, Range 10 West, Section 36, NW/NW/NW/SW/NW. Elevation: 490' MSL.

Terry Spring, 3.25 km NW New Hanover, Monroe County. 3rd Principal Meridian: Township 1 South, Range 10 West, Section 31, NE/NE/SE/NE/NW. Elevation: 415' MSL.

Walsh Spring (WS), 13.4 km SSE Waterloo (PO), Monroe County. 3rd Principal Meridian: Township 4 South, Range 9 West, Section 4, NW/NE/NW/SW/NE. Elevation: 520' MSL.

Physical and Chemical Analyses

Water samples were collected and the following parameters measured from the springhead: ambient and water temperature, dissolved oxygen, hydrogen ion concentration (*p*H), field conductivity, and total alkalinity. Metals and other elements, including total phosphorus, were analyzed by inductively coupled argon plasma spectroscopy. Chlorides, bromides, fluorides, sulfates, orthophosphate, nitrate nitrogen, and nitrite nitrogen were analyzed by ion chromatography. Ammonia nitrogen was analyzed by a Technicon chemical analysis system.

Springwater samples were analyzed for herbicides following U.S. Environmental Protection Agency National Pesticide Survey Method 508 (U.S. EPA, 1988), with the exception that 1,3dimethyl-2-nitrobenzene was used as a surrogate standard. The 1,3dimethyl-2-nitrobenzene is a more versatile standard because it can be detected and quantified using either an electron capture detector (ECD) or nitrogen-phosphorus detector (NPD). Each sample was spiked with 50 µl of the surrogate solution (250 mg/L) before extraction. Water samples were buffered to *p*H 7 then extracted with 300 ml of methylene chloride. Trace amounts of water were removed from the methylene chloride phase with anhydrous sodium sulfate, and the solvent volume was decreased to about 2 ml by distillation. The remaining methylene chloride was exchanged with methyl tert-butyl ether. The internal standard, 4,6-dichloro-2-methylpyrimidine, was added to the sample prior to gas chromatography analysis. The sample extracts were analyzed and quantitated as described in Chou and Roy (1993).

Hardness (EDTA) was calcuated following standard methods outlined in American Public Health Association *et al.* (1985). Turbidity was measured using a Cole Parmer turbidimeter.

Biological Studies

Specimens of aquatic vertebrates and macroinvertebrates were collected utilizing dip and kick nets, Surber samplers, sieves, and core samplers, and hand picked from rocks, submerged logs, and leaf packs. All specimens are deposited in the INHS collections in Champaign.

Descriptions of the vegetation at the springhead and springbrook were made for a distance of about 40 meters downstream of the springhead. In a few instances, a lesser distance was described because the springbrook sometimes entered another stream, pond, or went beneath a roadbed. The vegetation was described within one meter of the normally well-defined bank of the springbrook. Species of plants growing on gravel bars within the springbrook were also included, as well as any that were growing in the water itself [for example, *Ludwigia peploides* (H.B.K.) Raven] Each site was visited twice during the growing season. During the first visit (16 May or 21 June 1995) a species list was generated for each site and voucher specimens were taken. An attempt was made to voucher at least one of each taxon found during this study. Vouchers are deposited at the Illinois Natural History Survey Herbarium (ILLS). During the second visit (19 to 21 July 1995) any additional species seen were added to the list generated from the first visit, and a vegetation analysis was conducted for the purpose of determining dominance of the trees, shrubs, woody vines, and herbs along the springs and springbrooks.

One meter square plots were positioned along the springbrook, and alternating down the springbrook at every other meter beginning at 0 meters, then 2, 4, 6, to 38 meters. In two instances, Terry Spring and Ritter Spring, only 8 one meter square plots were used because the characteristics of their springbrooks changed dramatically about 15 meters downstream of their springheads. Terry Spring brook flowed through a corrugated culvert beneath a blacktop road and Ritter Spring springbrook entered a small impoundment. Likewise, Little Carr Spring and springbrook was sampled for only a distance of 20 meters before it flowed beneath a road and Camp Vandeventer Spring Run entered a much larger drainage, Fountain Creek. All other springs were surveyed by 20 one-meter square plots. The area actually sampled at each site was 25% of the area along the springbrooks beginning at the springhead. Sparrow Creek Spring was surveyed at the springhead itself; a second survey was conducted 120 meters downstream where Sparrow Creek turns east from north. The first one-meter square plot was always positioned at the left side of the spring source when facing away from the spring. Vascular herbaceous plant species (including non-woody vines) rooted within the plot and their percent cover for each species were recorded for each plot using the Daubenmire cover scale (Daubenmire 1959, 1968) with modifications following Bailey and Poulton (1968). For woody species, all taxa were recorded that covered the plot as well as their modified cover scale. The modified Daubenmire cover scale is as follows: class 1, 0-1%; class 2, 1-5%; class 3, 5-25%; class 4, 25-50%; class 5, 50-75%; class 6, 75-95%; and class 7, 95-100%. Frames representing 1% and 5% of the plot area were used as guides in cover estimation. With this data, percent frequency, percent relative frequency, average mean cover, and percent relative average mean cover were determined. Cover class midpoints were used to calculate average canopy cover. An importance value (IV) was determined for each species recorded within the plots. The IV is the average of the percent relative frequency and the percent relative average mean cover. The species were then grouped according to their IV. When two or more species had equal IV's then they were listed alphabetically by species. Those species with the greatest IV's were considered the dominant species.

Species names primarily follow Mohlenbrock (1986).

Stream Measurements

Open channel flow measurement techniques used for this study utilized 1) timed gravimetric, 2) velocity-area, and 3) hydraulic structure devices. Where practical, two measurement methods were used for comparison (Appendix 6).

The timed gravimetric method is the simple "bucket and stopwatch" technique. During this study a 4.5 gallon plastic bucke was used.

Velocity-area method was used where flow rate is determined by mean flow velocity (utilizing a Swofford flowmeter) across a cross-section and multiplying this by the flow rate and area at that point. Discharge computations were made using the midsection method (Gupta 1989).

The hydraulic structures utilized in this study were 1) an aluminum Parshall Measuring Flume with a 3-inch throat, 2) an aluminum cutthroat flume with a 0.333 foot throat, and 3) a 60 and a 90 degree triangular V-notch weir. The flumes used in the study were equipped with outward extending wings with visqueen plastic "skirts" to direct the incoming flow into the structure. The 60 degree V-notch weir was constructed with a one foot notch in the center of a 1.5 foot by 7.0 foot, three-quarter inch thick plywood board.

The Parshall Measuring Flume, although requiring excavation, was considered very desirable for spring flow measurements because of self cleaning ability, relatively low head loss, and wide operating range of 2-250 gpm.

The cutthroat flume is a flat bottom device with a level floor, permitting emplacement on an existing channel bed and measuring flows from 10-650 gpm.

X-Ray Fluorescence Spectrometry (XRF)

Major Elements. Samples, as received, are dried overnight at 110 ^{o}C. The dry samples are ignited in platinum crucibles at 1000 ^{o}C for one hour to determine loss on ignition (LOI). An ignited sample (0.6 g) is mixed with dry (heated at 350 ^{o}C overnight) 50% lithium tetraborate -50% lithium metaborate flux (5.4 g) in a 955 Pt-5% Au crucible and fused in a furnace at 1000 ^{o}C for 15 minutes. This is followed by a short-cycle fusion in a Claisse Fluxer-Bis using a propane burner. After fusion, the fluxer pours the molten mixture into a 30-mm diameter 95% Pt-5% Au mold to make a glass disk (specimen) upon cooling. The specimen is analyzed by a Rigaku 3371 wavelength dispersive X-ray fluorescence spectrometer with an end-window rhodium X-ray tube. Analytical concentrations (on an ignited-sample basis) are calculated by the spectrometer's computer, using calibration curves based on natural and artificial standards plus matrix correction coefficients.

Trace Elements. Two different methods are used for trace element analysis. In method I, a low-dilution fusion method, samples are dried at 110 ^{o}C (4 to 6 hours), ashed overnight at 500 ^{o}C and cooled for 2 hours in air. An ashed sample (2.5 g) is mixed with dry 50-50 flux (5.2 g), transferred to a 95% Pt- 55 Au crucible and fused in a furnace at 1000 ^{o}C for 20 minutes. The fused product is ground in a SPEX Mixer Mill, mixed with 5% by weight bakelite plastic resin and pressed into a 32-mm diameter pellet that has been heated in an oven at 100 ^{o}C for 20 minutes. The specimen is analyzed by the Rigaku fundamental parameter calibration method. Method II is suitable for use when very volatile elements such as chlorine are to be determined. As-received samples are ground in a small tungsten carbide grinding container using a SPEX 8500 Shatterbox. A 6.3 g portion of the ground sample is mixed with 0.7 g of CHEMLEX X-Ray Mix in a plastic beaker and "ground" as per the as-received sample. The ground mixture is pressed into a 32-mm diameter pellet with a cellulose or X-ray Mix backing and analyzed using the Rigaku fundamental parameter calibration method.

The quality assurance protocol for XRF is based upon the use of reference specimens to obtain instrumental drift correction factors for X-ray intensities and analysis of standard samples. The practical determination limits for major elements are: SiO_2 (0.1 %), Al_2O_3 (0.1 %), Fe_2O_3 (0.01 %), CaO (0.02 %), MgO (0.1 %), K_2O (0-0.01 %), Na_2O (0.05 %), TiO_2 (0.01 %), P_2O_5 (0.02 %), MnO (0.01 %), SrO (0.01 %), and SO_3 (0.05 %). The practical determination limits for trace elements are: Cd (5 ppm), Cl (20 ppm), Cr (5 ppm), Cu (5 ppm), Pb (10 ppm), Mo (2 ppm), Nb (2 ppm), Rb (10 ppm), Sn (5 ppm), V (5 ppm), Zn (10 ppm), and Zr (10 ppm).

Spring Mapping

Sketch maps were constructed using a Brunton compass and a 300-foot nylon engineering tape extending between vertical steel rebar posts. After the alignments were made parallel to the springbrook, an azimuth was ascertained; springbrook and floodplain width measurements were then made at right angles to the azimuthal alignment on 10x10 cross section paper. Waterfalls, pools, large gravel and and boulder concentrations were also measured and included on the maps.

Final maps were drafted with three line widths. String discharge elevations were determined from U.S. Geological Survey 7.5 minute topographic quadrangle maps with contour intervals at 5, 10, or 20 feet.

COMMUNITY STRUCTURE AND DIVERSITY OF FAUNA AND FLORA

Ten springs were selected from the karst region of Monroe and St. Clair counties (Fig. 2). Five of these springs were selected from areas that were heavily disturbed by human activity (farmland, pasture or rural development). Five of these springs were selected from areas that retained a predominance of native woodland. A list of the aquatic macroinvertebrates collected from these springs in given in Appendix 7.

Auctioneer Spring

Auctioneer Spring (Fig. 3) is located in the uppermost part of Trout Hollow south of Trout Road about 671 m (2200 ft) east of the floodplain of the Mississippi River. Water at the springhead emerges from a hardpan substrate cave opening formed on a vertical rock face 2.4-4.6 m (8-15 ft) above the springbrook, then falls and cascades downward from a 0.9-1.9 m (3.5-4.0 ft) high and 4.6 m (15 ft) wide cave opening in a plume at five locations. A part of the water flows over a Holocene calcite deposit (Appendix 1). The calcite deposit contains overgrowths and inter growths of *Amblystegium tena* (Hedw.) C. Jens. The bedding plane and joint controlled cave and conduit system is formed mainly in limestone, chert, and dolomite of the Salem Limestone of Mississippian age. The gradient from the cave waterfall to Trout road, a distance of 134 m (440 ft.), is 3.9 m:30.5 m (12.7 ft:l00 ft). The discharge rate for November, 1994, and February, May, and August, 1995, ranged from 17-156 gallons/meter (gpm) [1.1-9.8 liters/second (L/sec)](Fig. 3).

Water Quality: Table 1. Nitrate nitrogen ranged from 2.34-4.64 mg/L, and were detected in all four water samples but never at levels above the EPA MCL. Atrazine ranged from 0.07-0.42 µg/L, and was detected in all four water samples but never at levels above the EPA MCL. Cyanazine ranged from <DL-1.48 µg/L, and was detected in the November and May water samples. The November samples was at a level above the EPA Health Advisory Level (EPA HAL). Alachlor, Metolachlor, and Mercury were undetected.

Fauna (springhead): Turbellaria: Planariidae: *Phagocata velata.* Annelida: Oligochaeta: Enchytraeidae (unidentifiable). Naididae: *Nais communis.* Crustacea: Amphipoda: Gammaridae: *Gammarus troglophilus.* Isopoda: Asellidae: *Caecidotea brevicauda.* Mollusca: Gastropoda: Physidae: *Physella* sp.

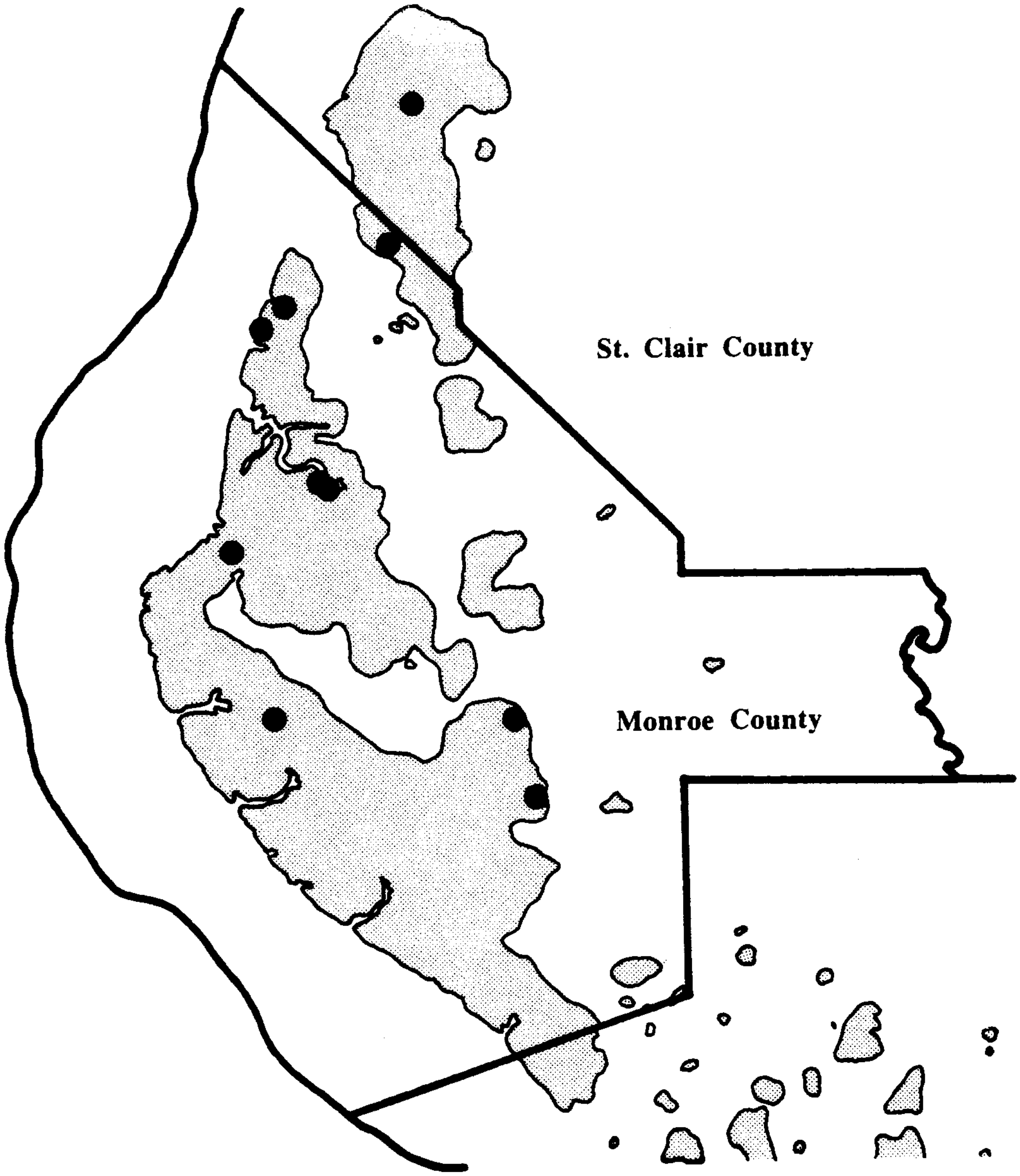

Figure 2. The location of study sites in the karst region of Monroe and St. Clair counties, Illinois. (modified from Panno *et al.* 1994)

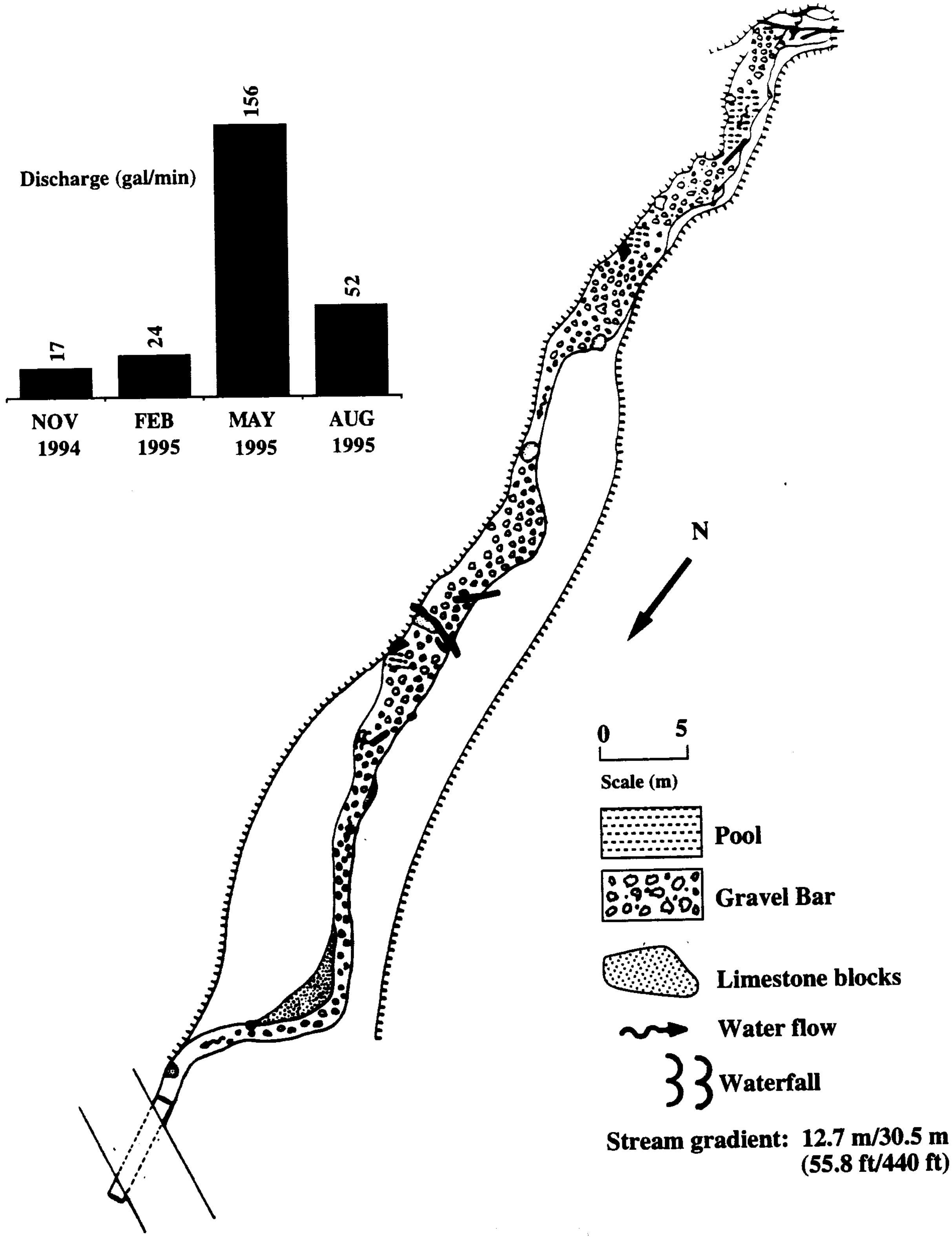

Figure 3. Auctioneer Spring, Monroe County, Illinois.

TABLE 1	County	Monroe	Monroe	Monroe	Monroe	
Auctioneer Spring: Water Quality	**Location**	Head	Head	Head	Head	
Analysis 1994 - 1995.	**Sample Date**	11/17/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					
Field Measurements						**Range**
Air Temperature (° C)	-	9.5	16	24	27	
Water Temperature (° C)	-	12.8	12.0	15.0	13.5	12.8-15.0
Dissolved Oxygen	never < 5.0	10.3	10.3	10.3	9.2	9.2-10.3
Hydrogen Ion Concentration (pH)	6.5 to 9.0		8.1	8.1	8.1	8.1
Alkalinity, as CaCO3 [<1]	-	269	245	213	265	213-269
Specific Conductivity (µmhos/cm)	-	622	573	466	566	466-622
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		66.1	61.7	52.5	57.8	52.5-66.1
Dissolved Organic Carbon [<0.1]		8.0	0.2	46.8	24.7	0.2-46.8
Total Dissolved Carbon [<0.1]		74.1	61.9	99.3	82.4	61.9-99.3
Sulfur as Sulfate [<0.01]	500.0	23.3	24.3	20.3	22.4	20.3-24.3
Ammonia Nitrogen [<0.01]	1.5 **	0.02	<DL	0.11	<DL	<DL-0.11
Nitrite Nitrogen [<0.01]	-	<DL	<DL	0.08	<DL	<DL-0.08
Nitrate Nitrogen [<0.01]	-	4.51	4.64	2.34	4.39	2.34-4.64
Total Phosphate [<0.01]		0.13	0.06	0.20	0.12	0.06-0.20
Hardness (EDTA)	*	263	283	229	310	229-310
Chlorides [<0.1]	500.	8.76	8.62	6.01	7.09	6.01-8.76
Total Dissolved Solids [<4]	1000.	428	380	344	392	344-428
Turbidity (NTU)	-	-	2	11	9	2-11
Dissolved Aluminum [<0.02]	-	0.03	<DL	<DL	0.07	<DL-0.07
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	<0.02	<0.02	<0.02	<0.02	<0.02
Dissolved Barium [0.005]	5.00	0.08	0.08	0.08	0.08	0.08
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolved Calcium [0.005]	-	86.0	91.7	74.2	102.0	86-102
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	<DL	<DL	0.02	0.47	<DL-0.47
Dissolved Potassium [1.0]	-	1	3	2	<DL	<DL-3
Dissolved Lanthanum		<0.002	<0.005	<0.003	<0.005	<0.002-<0.005
Dissolved Lithium [0.01	-	<DL	<DL	<DL	<DL	<DL

TABLE 1 (concluded).	County	Monroe	Monroe	Monroe	Monroe	
Auctioneer Spring: Water Quality	Location	Head	Head	Head	Head	
Analysis 1994 - 1995.	Sample Date	11/17/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					**Range**
Dissolved Magnesium [<0.01]	-	11.6	13.0	10.2	13.0	10.2-13.0
Dissolved Manganese [<0.01]	1.00	0.02	0.03	0.25	0.10	0.02-0.25
Dissolved Molybdenum [0.016]	-	<0.02	<0.02	<0.02	<DL	<DL-<0.02
Dissolved Sodium [<2]	-	13.2	14.2	10.4	13.9	10.4-14.2
Dissolved Nickel [0.03]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Lead [0.004]	0.1	<0.06	<0.04	<0.08	<0.04	0.04-0.08
Dissolved Antimony [0.06]	-	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Scandium		<0.003	<0.005	<0.003	<0.003	<0.003-<0.005
Dissolved Selenium [0.015]	1.0	<0.2	<DL	<DL	<DL	<DL-<0.2
Dissolved Silicon [0.010]	-	12.7	14.3	11.2	15.6	11.2-15.6
Dissolved Strontium [0.0015]	-	0.16	0.17	0.15	0.18	0.15-0.18
Dissolved Thallium [0.08]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	<0.01	0.19	0.73	0.01	<0.01-0.73
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	<DL	<DL	<DL	<DL	<DL
Atrazine	3 ppb	0.42	0.37	0.22	0.07	0.07-0.42
Alachlor	2 ppb	<DL	<DL	<DL	<DL	<DL
Metolachlor	100 ppb	<DL	<DL	<DL	<DL	<DL
Cyanazine	1 ppb	1.48	<DL	0.12	<DL	<DL-1.48

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

Fauna (springbrook): Turbellaria: Planariidae: *Phagocata velata.* Annelida: Oligochaeta: Enchytraeidae (unidentifiable). Lumbricidae (unidentifiable). Tubificidae: *Spirosperma* cf. *ferox.* Crustacea: Amphipoda: Gammaridae: *Gammarus troglophilus.* Isopoda: Asellidae: *Caecidotea brevicauda.* Insecta: Coleoptera: Dytiscidae: dytiscid sp. 1. Hydrophilidae: hydrophilid sp. 1. Diptera: Psychodidae: *Psychoda* sp. Tipulidae: *Tipula* sp. 1. Ephemeroptera: Heptageniidae: *Stenonema* sp. Hemiptera: Corixidae: *Trichocorixa* sp. 1. Gerridae: *Aquarius remigis.* Trichoptera: Hydropsychidae: *Cheumatopsyche analis.* Mollusca: Gastropoda: gastropodids sp. 1, sp. 2, sp. 4, sp. 6.

Flora: Auctioneer Spring forms a stream that flows northwest from a steep wooded slope through a forested ravine.

The dominant trees are *Tilia americana*, *Acer saccharum*, and *Ulmus americana*. Other trees included *Acer negundo*, *Asimina triloba*, *Carya ovata*, *Celtis occidentalis*, *Cornus florida*, *Fraxinus americana*, *Quercus prinoides* var. *acuminata*, *Quercus rubra*, and *Sassafras albidum.*

The dominant shrub is *Staphylea trifolia.* Other shrubs included *Hydrangea arborescens*, *Lindera benzoin*, and *Sambucus canadensis.*

The dominant woody vine is *Parthenocissus quinquefolia.* Other woody vines included *Smilax hispida*, *Toxicodendron radicans*, and *Vitis* sp.

The dominant herbs are *Impatiens capensis* and *Pilea pumila.* Other herbs include *Actaea pachypoda*, *Adiantum pedatum*, *Aralia racemosa*, *Arisaema triphyllum*, *Aster* sp., *Campanula americana*, *Carex albursina*, *Carex blanda*, *Carex radiata*, *Circaea lutetiana canadensis*, *Cryptotaenia canadensis*, *Cystopteris protrusa*, *Cystopteris tennesseensis*, *Dicentra cucullaria*, *Elymus virginicus*, *Festuca obtusa*, *Galium aparine*, *Galium triflorum*, *Geranium maculatum*, *Geum canadense*, *Hybanthus concolor*, *Laportea canadensis*, *Leersia virginica*, *Osmorhiza claytonii*, *Oxalis* sp., *Phlox divaricata laphamii*, *Phryma leptostachya*, *Poa pratensis*, *Polygonum virginianum*, *Polystichum acrostichoides*, *Ranunculus recurvatus*, *Sanicula canadensis*, *Sanicula odorata*, *Solidago flexicaulis*, *Uvularia grandiflora*, *Viola sororia*, and *Woodsia obtusa.*

The dominant moss is *Amblystegium tenax.*

Floral abundance and importance values are given in Appendix 2.

Current Status: Auctioneer Spring is set in a natural, wooded hillside with an extended springbrook. The springhead originates from a bedrock limestone opening to Auctioneer Cave. This hardpan clay substrate provides limited habitat for the seven taxa collected there. In contrast, the springbrook exhibits a diverse array of habitats from extended cobble riffles to pools and gravel riffles, with the occasional area of bedrock outcropping. In this diversity of habitat, a broad array of non-insect and aquatic insect taxa would be expected, comparable with the springbrooks of Camp Vandeventer, Kelly, and Sparrow Springs. Only 17 taxa of aquatic macroinvertebrates were collected from this springbrook, which is considerably below the expected diversity. Nitrate nitrogen and herbicide levels for this spring are in line with the levels found at other springs in this study. Currently, we have no explanation for the reduced fauna recorded for this spring, although the troglophilic cave amphipod *Gammarus troglophilus* was collected at the springhead and in the springbrook. No aquatic macrophytes were collected from this spring, although the moss *Ablystegium tenax* was abundant over the dripface of the springhead.

Camp Vandeventer Spring

Camp Vandeventer Spring (Fig. 4) is located at the base of a resistant vertical bluff 9.1-12.2 m (30-40 ft) high composed of St. Louis limestone of Mississippian age. Water from the spring moves outward in two prominent pathways from a 2.4 m (8 ft) partially submerged bedding plane opening into a leaky concrete retention basin, then through the basin spillway to a sand, gravel and cobble springbrook. The springbrook extends about 30.5 m (100 ft.) to Fountain Creek. A pump house near the retention basin and a cliffside lodge above the retention basin, along with several extremely large limestone blocks 3 m (10 ft) long axis near the confluence of the springbrook with Fountain Creek, are prominent features at the spring. The gradient from the springhead to Fountain Creek, a distance of 32 m (106 ft) is 1.1 m:30.5 m (3.5 ft:100 ft). The discharge rate taken in November, 1994, and February, May, and August, 1995, ranged from 81-9787 gpm (5.1-617 L/sec) (Fig. 4). Three substrate analyses (Fig. 5) at the springhead indicated a predominance of coarse sand and gravel, occasionally with large pieces of cobble

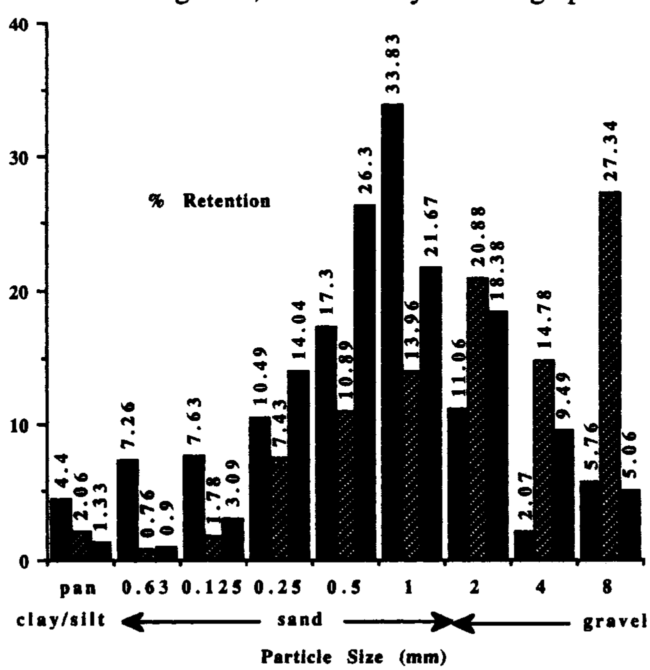

Figure 5. Substrate Analysis at springhead of Camp Vandeventer Spring, Monroe County, Illinois.

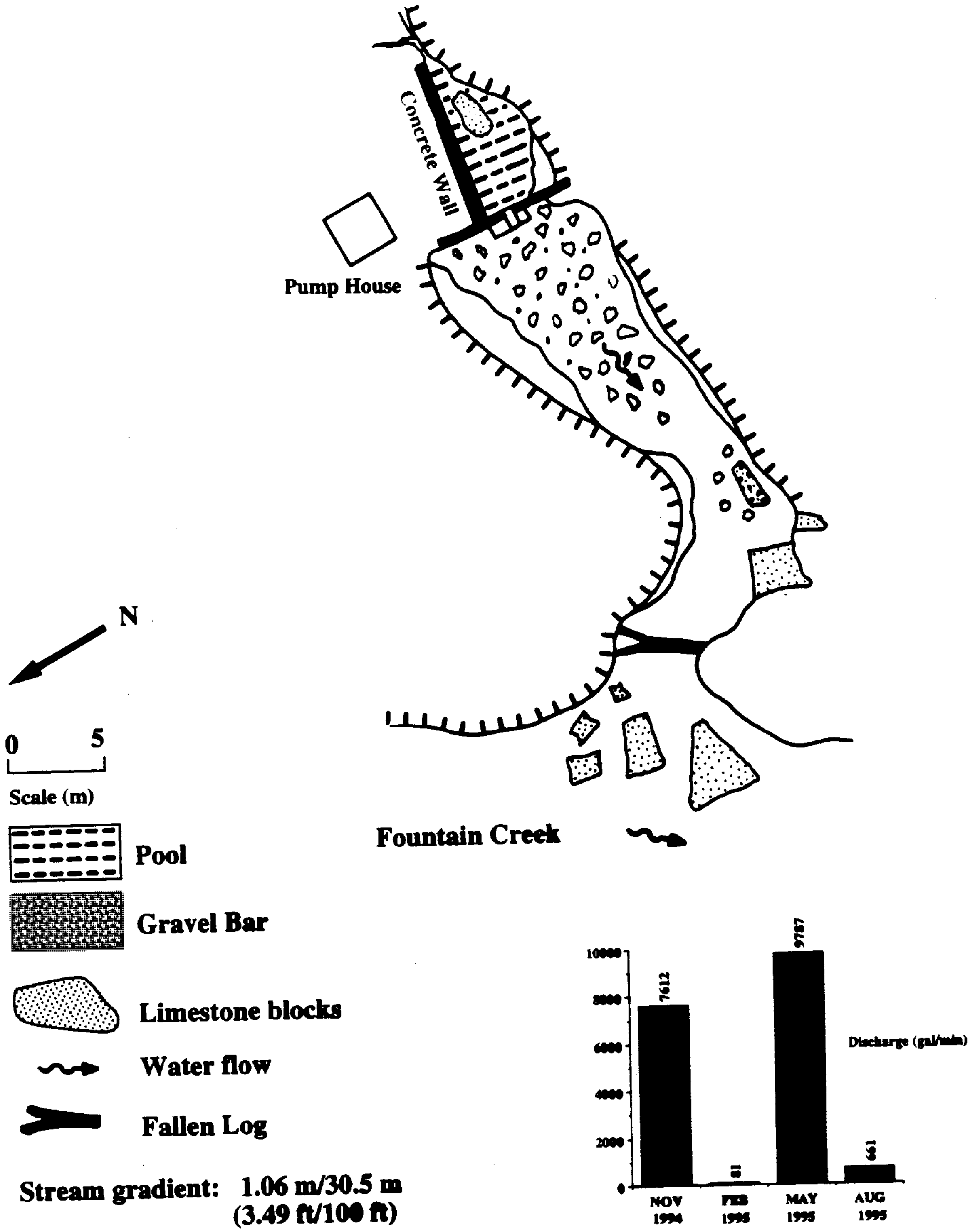

Figure 4. Camp Vandeventer Spring, Monroe County, Illinois.

Water Quality: Table 2. Nitrate nitrogen ranged from 1.42-3.79 mg/L, and was detected in all four water samples but not at levels above the EPA MCL. Alachlor ranged from <DL-0.36 µg/L, and was detected in two water samples but not at levels above the EPA MCL. Atrazine ranged from 0.18-3.56 µg/L, and was detected in all four water samples. The May sample was at a level above the EPA MCL. Cyanazine ranged <DL-0.41 µg/L, and was detected in the November and May water samples, but not at levels above the EPA HAL. Metolachlor ranged from <DL-3.28 µg/L, and was detected in the November and May water samples, but not at levels above the EPA HAL. Mercury ranged from <DL-0.08 ppb, and was detected in the May water sample but at levels below the EPA Maximum Level.

Fauna (springhead): Nematoda (unidentified). Annelida: Branchobdellida: Cambarincolidae: (unidentifiable). Oligochaeta: Enchytraeidae (unidentifiable). Lumbricidae: (unidentifiable). Lumbriculidae: (unidentifiable). Naididae: *Allonais paraguayensis, Nais bretscheri, N. pardalis, Ophidonais serpentina, Pristina leidyi.* Tubificidae: *Limnodrilus* sp. Crustacea: Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus troglophilus.* Decapoda: Cambaridae: *Orconectes virilis.* Isopoda: Asellidae: *Caecidotea brevicauda.* Ostracoda: *Cypria opthalmica.* Insecta: Ephemeroptera: Baetidae: *Baetis* sp. Heptageniidae: *Stenonema* sp. Hemiptera: Gerridae: *Aquarius remigis.* Mesoveliidae: *Mesovelia mulsanti.* Mollusca: Gastropoda: gastropods sp. 1, sp. 2, sp. 4. Pelecypoda: Sphaeriidae: *Pisidium* sp.

Fauna (springbrook): Platyhelminthes: Turbellaria: Planariidae: *Dugesia dorotocephala.* Annelida: Branchobdellida: Cambarincolidae: (unidentifiable). Oligochaeta: Enchytraeidae (unidentifiable). Haplotaxidae: *Haplotaxis gordioides.* Lumbriculidae (unidentifiable). Naididae: *Nais bretscheri, N. communis, N. pardalis, Nais* sp. LCC1 Tubificidae: *Limnodrilus hoffmeisteri, Varichaetadrilus angustipenis.* Arthropoda: Crustacea: Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus troglophilus.* Decapoda: Cambaridae: *Orconectes virilis.* Isopoda: Asellidae: *Caecidotea brevicauda.* Insecta: Coleoptera: Hydrophilidae: *Tropisternus lateralis,* hydrophilid sp. 1, sp. 2, sp. 3. Diptera: Ceratopogonidae: ceratopogonid sp. 1. Chaoboridae: *Chaoborus (Sayomyia) punctipennis.* Chironomidae: *Ablabesmyia illinoense, Clinotanypus scapularis, Cricotopus bicinctus, Cricotopus* sp. 1, *Harnischia curtilamellatus, Orthocladius* sp. 1, sp. 2, sp. 3, *Polypedilum scalaenum, Prolcdius bellus, P. sublettei, Tanytarus* sp. Psychodidae: *Psychoda* sp. Simuliidae: *Simulium tuberosum* complex (larvae containing Microsporidia: *Polydispyrenia simulii*). Tipulidae: *Tipula* sp. 1. Ephemeroptera: Baetidae: *Baetis* sp. Heptageniidae: *Stenonema* sp. Hemiptera: Corixidae: *Trichocorixa* sp. 1. Gerridae: *Aquarius remigis.* Mesoveliidae: *Mesovelia mulsanti.* Trichoptera: Helicopsychidae: *Helicopsyche borealis.* Hydropsychidae: *Cheumatopsyche analis, Hydropsyche betteni, Potomyia flava.* Hydroptilidae: *Hydroptila* cf. *scolops, C. waubiseana, Ochrotrichia*

TABLE 2 Camp Vandeventer Spring: Water Quality Analysis 1994 - 1995.	County	Monroe	Monroe	Monroe	Monroe	
	Location	Head	Head	Head	Head	
	Sample Date	11/16/95	2/22/95	5/16/95	8/22/95	
PARAMETERS *	**Standard****					
Field Measurements						**Range**
Air Temperature (° C)	-	9	19	23	26.5	
Water Temperature (° C)	-	13.1	12.5	17.0	12.5	12.5-17.0
Dissolved Oxygen	never < 5.0	8.6	15.0	10.9	11.0	8.6-15.0
Hydrogen Ion Concentration (pH)	6.5 to 9.0		8.0	7.5	7.7	7.5-8.0
Alkalinity, as CaCO3 [<1]	-	221	238	94	250	94-250
Specific Conductivity (µmhos/cm)	-	513	559	199	551	199-559
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		54.9	57.3	23.6	58.9	23.6-58.9
Dissolved Organic Carbon [<0.1]		12.0	0.1	45.9	33.5	0.1-45.9
Total Dissolved Carbon [<0.1]		66.9	57.4	69.5	92.4	57.4-92.4
Sulfur as Sulfate [<0.01]	500.0	31.2	36.9	13.2	126.0	13.2-126.0
Ammonia Nitrogen [<0.01]	1.5 **	0.03	<DL	0.02	0.01	<DL-0.03
Nitrite Nitrogen [<0.01]	-	<DL	<DL	<DL	<DL	<DL
Nitrate Nitrogen [<0.01]	-	3.06	3.79	1.42	3.13	1.42-3.79
Total Phosphate [<0.01]		0.25	0.1	0.64	0.09	0.09-0.64
Hardness (EDTA)	*	233	277	115	293	115-293
Chlorides [<0.1]	500.	11.70	13.40	4.33	11.10	4.33-11.70
Total Dissolved Solids [<4]	1000.	444	388	212	392	212-444
Turbidity (NTU)	-	-	2	196	13	2-196
Dissolved Aluminum [<0.02]	-	0.04	<DL	0.07	0.09	<DL-0.09
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	0.03	<0.02	<0.02	<0.02	<0.02-0.03
Total Barium [0.001]	5.0	0.08	0.07	0.06	0.10	0.06-0.10
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolve Calcium [0.005]	-	72.1	86.3	36.1	90.4	36.1-90.4
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	<DL	<DL	0.03	0.09	<DL-0.09
Dissolved Potassium [1.0]	-	3	1	4	2	1-4
Dissolved Lanthanum		<0.002	<0.005	0.003	<0.005	<0.002-0.003
Dissolved Lithium [0.01	-	<DL	<DL	<DL	<DL	<DL

TABLE 2 (concluded).	**County**	Monroe	Monroe	Monroe	Monroe	
Camp Vandeventer Spring: Water	**Location**	Head	Head	Head	Head	
Quality Analysis 1994 - 1995.	**Sample Date**	11/16/94	2/22/95	5/16/95	8/22/95	
PARAMETERS *	**Standard****					**Range**
Dissolved Magnesium [<0.01]	-	12.80	14.90	5.87	16.20	5.87-16.20
Dissolved Manganese [<0.01]	1.00	<DL	0.01	<DL	0.03	<DL-0.03
Dissolved Molybdenum [0.016]	-	<0.02	<0.02	<0.02	<DL	<DL-<0.02
Dissolved Sodium [<2]	-	18.1	21.6	6.4	21.9	6.4-21.9
Dissolved Nickel [0.03]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Lead [0.004]	0.1	<0.06	<0.04	<0.08	<0.04	<0.04-<0.08
Dissolved Antimony [0.06]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Scandium		<0.003	<0.005	<0.003	<0.003	<0.003-<0.005
Dissolved Selenium [0.015]	1.0	<0.2	<DL	<DL	<DL	<DL-<0.2
Dissolved Silicon [0.010]	-	8.60	9.31	6.05	10.00	6.05-10.00
Dissolved Strontium [0.0015]	-	0.18	0.19	0.10	0.20	0.10-0.20
Dissolved Thallium [0.08]	-	<0.3	0.40	<0.3	<0.3	<0.3-0.4
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	<0.01	0.12	0.16	0.05	<0.01-0.16
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	<DL	<DL	0.08	<DL	<DL-0.08
Atrazine	0.05	0.68	0.18	3.56	0.23	0.18-3.56
Alachlor	0.02	0.09	<DL	0.36	<DL	<DL-0.36
Metolachlor	0.02	0.22	<DL	3.28	<DL	<DL-3.28
Cyanazine	0.1	<DL	<DL	0.41	<DL	<DL-0.41

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

shawnee. Leptoceridae: *Athripsodes* cf. *transversus*. Philopotamidae: *Chimarra feria, C. obscura*. Polycentropodidae: *Nyctiophylax vestitus*. Rhyacophilidae: *Rhyacophila fenestra*. Mollusca: Gastropoda: gastropods sp. 2. Pelecypoda: Sphaeriidae: *Pisidium* sp. Osteichthyes: Cottidae: *Cottus carolinae*. Cyprinidae: *Pimephales promelas*.

Flora: Camp Vandeventer Spring is located at the base of a northwest-facing wooded cliff in the valley formed by Fountain Creek. The second growth woods in this mesic ravine appears little disturbed. The run from Camp Vandeventer Spring flows about 27 meters before it empties into Fountain Creek.

The dominant trees are *Carpinus caroliniana, Quercus rubra*, and *Acer negundo*. Other trees included *Acer negundo, Acer saccharum, Asimina triloba, Celtis occidentalis, Cercis canadensis, Cornus florida, Fraxinus americana, Ostrya virginiana, Pinus sylvestris, Prunus serotina, Quercus prinoides* var. *acuminata, Tilia americana*, and *Ulmus americana*.

The dominant shrub is *Hydrangea arborescens*. Other shrubs included *Cornus drummondii, Lonicera maackii, Ribes missouriense, Rosa multiflora, Staphylea trifoliata*, and *Symphoricarpos orbiculatus*.

The dominant woody vine is *Parthenocissus quinquefolia*. Other woody vines included *Smilax hispida* and *Toxicodendron radicans*.

The dominant herbs are *Cryptotaenia canadensis, Solidago flexicaulis, Leersia virginica, Polystichum acrostichoides*, and *Equisetum hyemale* var. *affine*. Other herbs included *Agrimonia pubescens, Agrostis perennans, Allium canadense, Amphicarpaea bracteata, Aquilegia canadensis, Arabis laevigata, Arisaema triphyllum, Asplenium rhizophyllum, Aster* sp., *Bidens sp., Carex blanda, Carex granularis, Carex grisea, Carex radiata, Carex* sp., *Cerastium nutans, Chaerophyllum procumbens, Circaea lutetiana canadensis, Cystopteris bulbifera, Cystopteris tennesseensis, Elymus virginicus, Equisetum arvense, Erigeron philadelphicus, Eupatorium rugosum, Festuca obtusa, Galium aparine, Geranium maculatum, Geum canadense, Heuchera americana* var. *hirsuticaulis, Juncus tenuis, Lactuca* sp., *Ornithogalum umbellatum, Osmorhiza longistylis, Oxalis* sp., *Panicum* sp., *Parietaria pensylvanica, Phlox divaricata laphamii, Pilea pumila, Plantago rugelii, Polygonatum biflorum, Polygonum amphibium, Prunella vulgaris, Ranunculus abortivus, Ranunculus recurvatus, Rudbeckia laciniata, Sanicula odorata, Scutellaria incana, Stellaria media, Sisyrinchium angustifolium, Taraxacum officinale, Viola sororia*, and *Viola striata*.

Floral abundance and importance values are given in Appendix 2.

Current Status: Camp Vandeventer Spring lies at the base of a vertical limestone bluff. The spring opening is the end point of a cave system. The springhead varies in its substrate composition from sand and gravel to several large limestone blocks, but in a pool setting. The fauna of the springhead is abundant (24 taxa) and diverse, highlighted by the occurrence of the rare oligochaete *Allonais paraguayensis* and the abundance of the cave amphipods *Crangonyx forbesi* and *Gammarus troglophilus*. The springbrook is relatively short, with a substrate ranging from sand and gravel to cobble and limestone blocks. This diversity of habitat is exemplified in the diversity of the fauna (56 taxa) collected. Here, the cave amphipods *Crangonyx forbesi* and *Gammarus troglophilus* remained the only amphipods present, along with the occurrence of a second rare oligochaete *Varichaetadrilus angustipenis*. The abundant non-insectan fauna was complimented with an diversity of aquatic insects, in particular the caddisflies (Trichoptera) and chironomids (Diptera: Chironomidae). The caddisfly *Ochrotrichia shawnee* was collected here, a species previously known only from the Shawnee Hills. Nitrate nitrogen and Atrazine were detected in each of the four water samples collected, with the May Atrazine sample reaching 3.56 ppb, which is above the EPA MCL.

Dual Springs

Dual Springs (Fig. 6) are located at the base of a 24.4 m (80 ft) Mississippian age St. Louis limestone bluff in the foodplain of Fountain Creek. Springwater discharges upward from several submerged cavernous rock ledges through two prominent cone-shaped silt and clay structures from the east part of a man-made retention pond. Water in the 12.2 x 54.9 m (40 x 180 ft.) retention pond is utilized to irrigate a nearby golf course. Water generally discharges continuously from a steel 20 inch diameter discharge pipe through an earthen dam at the west end of the retention pond forming a small tributary which flows into Fountain Creek, approximately 250 m downstream. The springbrook gradient from the west end of the retention pond dam to Fountain Creek, a distance of 97.5 m (320 ft.) is 0.32 m:30.5 m (1.05 ft:100ft). The discharge rate taken in November 1994, and February, May, and August, 1995, ranged from 17-156 gpm (Fig. 6). Substrate analysis at the springhead (Fig. 7) indicates a predominance of clay/silt.

Water Quality: Table 3. Nitrate nitrogen ranged from 0.26-2.37 mg/L, and was detected in all four water samples but not at levels above the EPA MCL. Alachlor ranged from 0.03-0.27 µg/L, and was detected in all four water samples but not at levels above the EPA MCL. Atrazine ranged from 0.22-2.45 µg/L, and was detected in all four water samples but not at levels above the EPA MCL. Cyanazine ranged from <DL-1.74 µg/L, and was detected in the November, February, and May samples. The November samples was at a level above the EPA HAL. Metolachlor ranged from 0.03-1.3 µg/L, and was detected in all four water samples but not at levels above the EPA HAL. Mercury was not detected in any of the four water samples.

Fauna (east springhead): Crustacea: Amphipoda: Gammaridae: *Gammarus pseudolimnaeus*. Isopoda: Asellidae: *Caecidotea brevicauda*, *C. packardi*. Ostracoda: *Candona* oligochaete *Allonais paraguayensis* and the abundance of the cave amphipods *Crangonyx forbesi* and *Gammarus troglophilus*. The springbrook is relatively short, with a substrate ranging from sand and gravel to cobble and limestone blocks. This diversity of habitat is exemplified in the diversity of the fauna (56 taxa) collected. Here, the cave amphipods *Crangonyx forbesi* and *Gammarus troglophilus* remained the only amphipods present, along with the occurrence of a second rare oligochaete *Varichaetadrilus angustipenis*. The abundant non-insectan fauna was complimented with a diversity of aquatic insects, in particular the caddisflies (Trichoptera) and chironomids (Diptera: Chironomidae). The caddisfly *Ochrotrichia shawnee* was collected here, a species previously known only from the Shawnee Hills. Nitrate nitrogen and Atrazine were detected in each of the four water samples collected, with the May Atrazine sample reaching 3.56 ppb, which is above the EPA MCL.

Dual Springs

Dual Springs (Fig. 6) are located at the base of a 24.4 m (80 ft) Mississippian age St. Louis limestone bluff in the foodplain of Fountain Creek. Springwater discharges upward from several submerged cavernous rock ledges through two prominent cone-shaped silt and clay structures from the east part of a man-made retention pond. Water in the 12.2 x 54.9 m (40 x 180 ft.) retention pond is utilized to irrigate a nearby golf course. Water generally discharges continuously from a steel 20 inch diameter discharge pipe buried in an earthen dam at the west end of the retention pond forming a small tributary which flows into Fountain Creek, approximately 250 m downstream. The springbrook gradient from the west end of the retention pond dam to Fountain Creek, a distance of 97.5 m (320 ft.) is 0.32 m:30.5 m (1.05 ft:100ft). The discharge rate taken in November 1994, and February, May, and August, 1995, ranged from 17-156 gpm (7.1-115.8 L/sec) (Fig. 6). Substrate analysis at the springhead (Fig. 7) indicates a predominance of clay/silt.

Water Quality: Table 3. Nitrate nitrogen ranged from 0.26-2.37 mg/L, and was detected in all four water samples but not at levels above the EPA MCL. Alachlor ranged from 0.03-0.27 μg/L, and was detected in all four water samples but not at levels above the EPA MCL. Atrazine ranged from 0.22-2.45 μg/L, and was detected in all four water samples but not at levels above the EPA MCL. Cyanazine ranged from <DL-1.74 μg/L, and was detected in the November, February, and May samples. The November samples was at a level above the EPA HAL. Metolachlor ranged from 0.03-1.3 μg/L, and was detected in all four water samples but not at levels above the EPA HAL. Mercury was not detected in any of the four water samples.

Fauna (east springhead): Crustacea: Amphipoda: Gammaridae: *Gammarus pseudolimnaeus*. Isopoda: Asellidae: *Caecidotea brevicauda*, *C. packardi*. Ostracoda: *Candona*

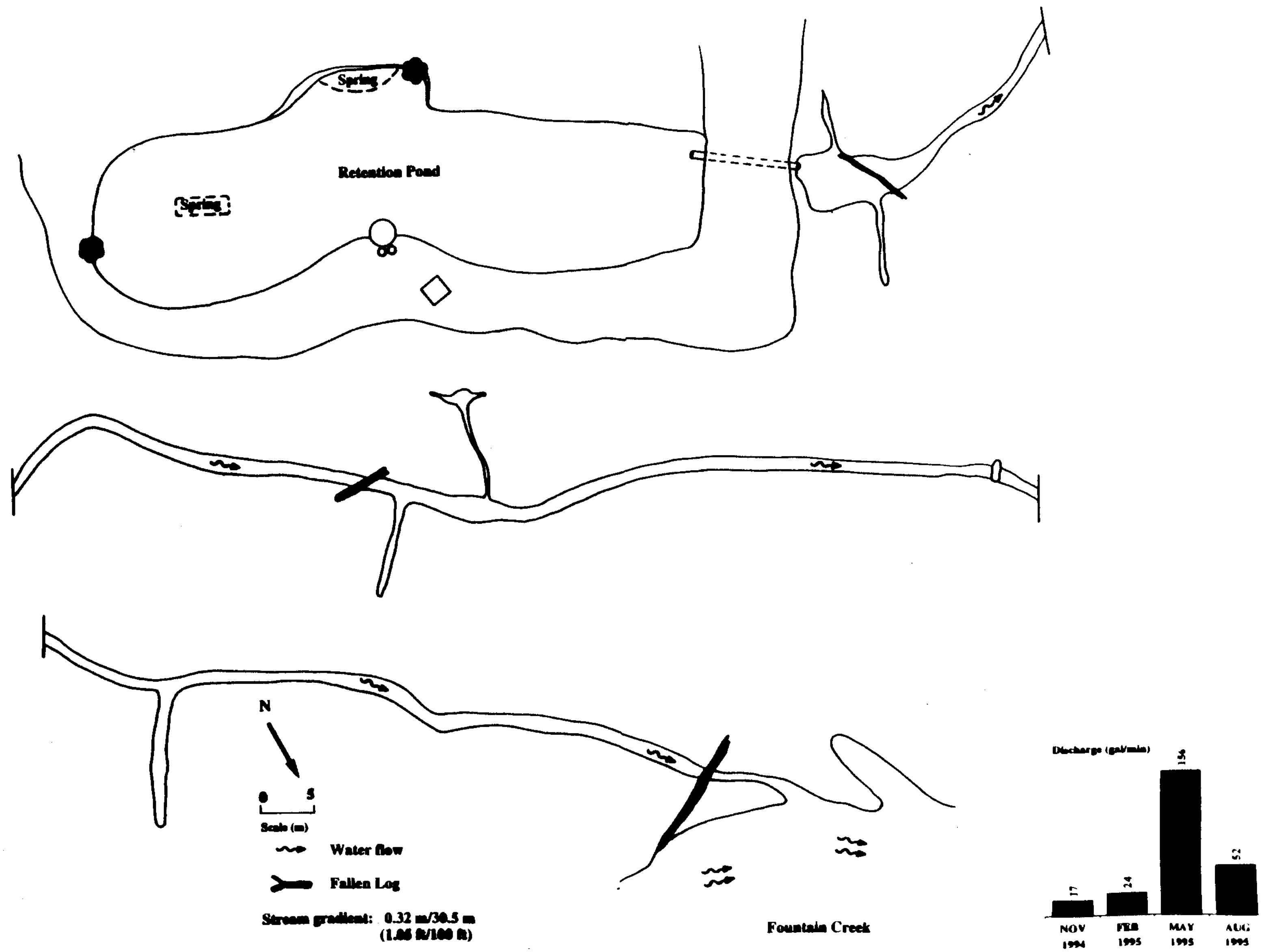

Figure 6. Dual Springs, Monroe County, Illinois.

TABLE 3	County	Monroe	Monroe	Monroe	Monroe	
Dual Spring: Water Quality	**Location**	Head	Head	Head	Head	
Analysis 1994-1995.	**Sample Date**	11/16/94	2/22/95	5/16/95	8/22/95	
PARAMETERS *	**Standard****					
Field Measurements						**Range**
Air Temperature (° C)	-	11	21	25	26	
Water Temperature (° C)	-	10.8	6.5	17.0	21.0	6.5-21.0
Dissolved Oxygen	never < 5.0	4.1	>15	4.6	3.2	3.2->15.0
Hydrogen Ion Concentration (pH)	6.5 to 9.0		8.1	7.6	8	7.6-8.1
Alkalinity, as CaCO3 [<1]	-	170	202	118	189	118-202
Specific Conductivity (µmhos/cm)	-	498	558	304	394	304-558
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		43.9	47.5	29.3	44.0	29.3-47.5
Dissolved Organic Carbon [<0.1]		15.3	0.3	43.6	28.9	0.3-43.6
Total Dissolved Carbon [<0.1]		59.2	47.8	72.9	72.9	47.8-72.9
Sulfur as Sulfate [<0.01]	500.0	30.7	48.4	18.1	18.6	18.1-48.4
Ammonia Nitrogen [<0.01]	1.5 **	0.29	0.06	<DL	0.2	<DL-0.29
Nitrite Nitrogen [<0.01]	-	<DL	<DL	DL	0.09	<DL-0.09
Nitrate Nitrogen [<0.01]	-	1.2	2.37	1.16	0.26	0.26-2.37
Total Phosphate [<0.01]		0.38	0.11	0.44	0.09	0.09-0.44
Hardness (EDTA)	*	178	232	124	209	124-232
Chlorides [<0.1]	500.	19.80	31.80	5.60	8.16	5.60-31.80
Total Dissolved Solids [<4]	1000.	388	360	200	189	189-388
Turbidity (NTU)	-		2	113	8	2-113
Dissolved Aluminum [<0.02]	-	0.05	<DL	0.08	0.06	<DL-0.08
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	0.06	0.02	<0.02	<0.02	<0.02-0.06
Dissolved Barium [0.005]	5.00	0.09	0.06	0.07	0.08	0.06-0.09
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolved Calcium [0.005]	-	54.3	68.0	38.5	64.9	54.3-68.0
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	<DL	<DL	0.03	0.11	<DL-0.11
Dissolved Potassium [1.0]	-	6	3	4	5	3-6
Dissolved Lanthanum		<0.002	<0.005	<0.003	<0.005	<0.002-<0.005
Dissolved Lithium [0.01	-	<DL	<DL	<DL	<DL	<DL

TABLE 3 (concluded).	County	Monroe	Monroe	Monroe	Monroe	
Dual Springs: Water Quality	Location	Head	Head	Head	Head	
Analysis 1994 - 1995.	Sample Date	11/16/94	2/22/95	5/16/95	8/22/95	
PARAMETERS *	**Standard****					**Range**
Dissolved Magnesium [<0.01]	-	10.10	15.00	6.73	10.90	6.73-15.00
Dissolved Manganese [<0.01]	1.00	0.55	0.16	<DL	0.91	<DL-0.91
Dissolved Molybdenum [0.016]	-	0.02	<0.02	<0.02	<DL	<DL-0.02
Dissolved Sodium [<2]	-	22.60	34.60	6.70	12.90	6.70-34.60
Dissolved Nickel [0.03]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Lead [0.004]	0.1	<0.06	<0.04	<0.08	<0.04	<0.04-<0.08
Dissolved Antimony [0.06]	-	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Scandium		<0.003	<0.005	<0.003	<0.003	<0.003-<0.005
Dissolved Selenium [0.015]	1.0	<0.2	<DL	<DL	<DL	<DL-0.2
Dissolved Silicon [0.010]	-	5.10	2.57	5.16	5.72	2.57-5.72
Dissolved Strontium [0.0015]	-	0.15	0.17	0.11	0.19	0.11-0.19
Dissolved Thallium [0.08]	-	<0.3	<0.2	<0.3	<0.3	<0.2-<0.3
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	0.01	0.05	0.02	0.01	0.01-0.05
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	<DL	<DL	<DL	<DL	<DL
Atrazine	0.05	0.3	0.22	2.45	0.67	0.22-2.45
Alachlor	0.02	0.27	0.03	0.23	0.05	0.03-0.27
Metolachlor	0.02	0.29	0.03	1.3	0.25	0.03-1.3
Cyanazine	0.1	1.74	0.18	0.76	<DL	<DL-1.74

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

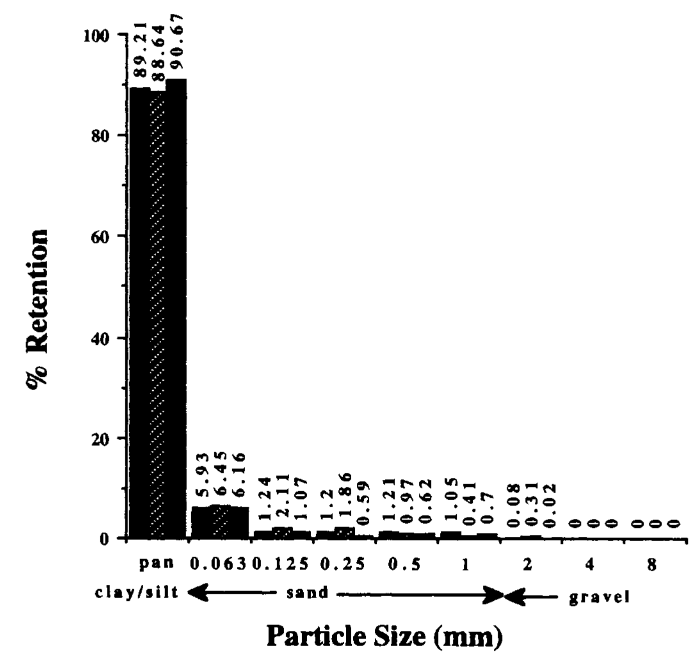

Figure 7. Substrate Analysis at east springhead of Dual Springs, Monroe County, Illinois.

caudata, Cypria opthalmica, Physocypria pustulosa. Insecta: Diptera: Simuliidae: *Simulium vittatum* complex.

Fauna (retaining pond): Annelida: Oligochaeta: Enchytraeidae (unidentifiable). Lumbricidae (unidentifiable). Lumbriculidae (unidentifiable). Naididae: *Dero digitata, D. nivea, Nais communis, N. variabilis, Nais* sp. *Ophidonais serpentina, Stylaria lacustris.* Tubificidae: *Branchiura sowerbyi, Ilyodrilus templetoni, Limnodrilus cervix, Limnodrilus claparedianus, Limnodrilus hoffmeisteri, Quistadrilus multisetosus, Varichaetadrilus angustipenis.* Hirudinea: Glossiphoniidae (unidentifiable). Crustacea: Amphipoda: Hyalellidae: *Hyalella azteca.* Isopoda: Asellidae: *Caecidotea brevicauda.* Crustacea: Decapoda: Cambaridae: *Orconectes* sp. (immature). Ostracoda: *Cypria opthalmica.* Insecta: Coleoptera: Dryopidae: *Helichus* sp. Dytiscidae: dytiscid sp. 1. Haliplidae: *Peltodytes* sp. Hydrophilidae: hydrophilid sp. 1. Diptera: Chaoboridae: *Chaoborus* (*Sayomyia*) *punctipennis.* Chironomidae: *Chironomus decorus, Cricotopus* sp. 1, *Glyptotendipes paripes, Tanytarsus* sp. Simuliidae: *Simulium vittatum* complex. Tipulidae: *Tipula* sp. Ephemeroptera: Baetidae: *Baetis* sp. Caenidae: *Caenis* sp. Heptageniidae: *Stenonema* sp. Hemiptera: Belostomatidae: *Belostoma fluminea.* Corixidae: *Trichocorixa* sp. 1. Gerridae: *Aquarius remigis.* Mesoveliidae: *Mesovelia mulsanti.* Nepidae: *Ranatra fusca.* Notonectidae: *Notonecta* sp. Megaloptera: Sialidae: *Sialis* sp. Trichoptera: Hydropsychidae: *Cheumatopsyche analis.* Mollusca: Gastropoda: Physidae: *Physa* sp. 1. Gastropodid sp. 2. Osteichthyes: Cottidae: *Cottus carolinae.*

Fauna (springbrook): Annelida: Oligochaeta: Lumbriculidae: (unidentifiable). Tubificidae: *Limnodrilus udekemianus.* Insecta: Hemiptera: Gerridae: *Aquarius remigis.*

Flora: Dual Springs are located at the base of a north-facing wooded slope in the valley formed by Fountain Creek. Dual Springs flows west-northwest about 250 meters along the base of this wooded slope and empties into Fountain Creek. The vegetation in the immediate vicinity of Dual Springs is heavily disturbed.

The dominant trees are *Salix nigra* and *Acer saccharum*. Other trees included *Acer negundo, Aesculus glabra, Fraxinus americana, Juglans nigra, Platanus occidentalis, Populus deltoides, Tilia americana*, and *Ulmus americana.*

Shrubs are infrequent but *Salix exigua* and *Lindera benzoin* were present.

Woody vines are also infrequent, but *Parthenocissus quinquefolia* and *Smilax hispida* were present.

The dominant herbs are *Humulus japonicus, Agropyron repens, Impatiens capensis, Festuca pratensis*, and *Leersia oryzoides*. Other herbs included *Acalypha rhomboidea, Agrostis* sp., *Alopecurus carolinianus, Ambrosia trifida, Amphicarpaea bracteata, Anthemis cotula, Aster pilosus, Aster* sp., *Barbarea vulgaris, Bidens* sp., *Boehmeria cylindrica, Bromus* sp., *Calystegia sepium, Carex blanda, Carex frankii, Carex grisea, Carex normalis, Carex radiata, Carex vulpinoidea, Cerastium nutans, Chaerophyllum procumbens, Cinna arundinacea, Cirsium* sp., *Cryptotaenia canadensis, Cyperus strigosus, Daucus carota, Echinochloa crus-galli, Elymus virginicus, Equisetum arvense, Erigeron annuus, Erigeron philadelphicus, Eupatorium rugosum, Festuca obtusa, Geum canadense, Glyceria striata, Hasteola suaveolens, Helianthus* sp., *Hypericum punctatum, Iva annua, Juncus tenuis, Lactuca* sp., *Leersia virginica, Lolium perenne, Ludwigia peploides glabrescens, Medicago sativa, Melilotus alba, Melilotus officinalis, Mimulus alatus, Myosotis macrosperma, Oenothera biennis, Penthorum sedoides, Phalaris arundinacea, Phlox divaricata laphamii, Plantago rugelii, Poa pratensis, Polygonum caespitosum* var. *longisetum, Polygonum pensylvanicum, Ranunculus abortivus, Ranunculus recurvatus, Ranunculus sceleratus, Rorippa palustris* var. *fernaldiana, Rudbeckia laciniata, Rumex crispus, Senecio glabellus, Solidago canadensis, Solidago gigantea, Sonchus asper, Sphenopholis obtusata var. major, Stachys palustris, Taraxacum officinale, Thlaspi arvense, Trifolium hybridum, Trifolium pratense, Trifolium repens, Typha latifolia, Valerianella radiata, Verbena urticifolia, Veronica peregrina*, and *Viola sororia.*

Floral abundance and importance values are given in Appendix 2.

Current Status: The two springheads which form Dual Springs are enclosed within a retention pond. The sediment load emanating from these two springheads forms upward opening cone structures around each of the spring openings. This dominance of a clay/silt substrate has greatly modified the diversity of the macroinvertebrates in and around these two springheads. The fauna is dominated by macroinvertebrates typical of a pond habitat. The springbrook is characterized by a scoured, hardpan clay substrate which offers little habitat for aquatic macroinvertebrates as indicated by only two taxa collected there, including *Aquarius remigis*, a predaceous surface-dwelling hemipteran. Nitrate nitrogen and herbicides were detected during each sampling period. Alachlor, Atrazine, and Metolachlor were detected in the four water samples, but not at levels above the EPA MCL or HAL. Cyanazine was collected in three of the four water samples, with the November sample (1.74 ppb) recorded at a level above the EPA HAL. The paucity of macroinvertebrates within the springbrook is apparently a reflection of the scoured hardpan clay substrate.

No federally endangered nor Illinois threatened or endangered vascular plant species was found during this study. However, *Hasteola (=Cacalia) suaveolens* (Sweet Indian Plantain), which is presently under consideration for Illinois threatened status was found at this site. This species ranges from Connecticut to southern Minnesota south to Missouri and North Carolina. In Illinois it has been historically found in nineteen counties scattered throughout the state. However since 1950 it has only been recorded in 7 of these counties. This species is now much less common than it was 50 years ago (Anderson 1994), no doubt because of loss of habitat.

Kelly Spring

Kelly Spring (Fig. 8), which ranks as one of the most distinctive springs in Illinois, is situated at the base of an 24.4 m (80 ft) high Mississippian age St. Louis limestone bluff in the floodplain of Horse Creek. The spring discharges from at least three cave passageways aligned N 36^{o} W, N 70^{o} W and N 20^{o} E from the semicircular head of the spring and at low flow supplies all of the waters for Horse Creek. Water depths at the spring head reach 0.9-1.8 m (3-6 ft) in places. A natural limestone bridge, located about 4.6 m (15 ft) east of the springhead and about 0.9 m (3ft) in width spans the spring outflow. The springbrook flows over several flatlying limestone ledges and in and around several prominent sand and gravel bars before entering Horse Creek. The stream gradient from the springhead to a point 70.7 m (732 ft) downstream in Horse Creek is 0.56 m:30.5 m (1.85 ft:100ft). The discharge rate taken in November, 1994, and February, May, and August, 1995, ranged from 0-535 gpm (<DL-33.7 L/sec) (Fig. 8). Substrate analysis at the springhead (Fig. 9) indicates a wide diversity of substrates from clay/silt to sand, to coarse gravel).

Water Quality: Table 4. Nitrate nitrogen ranged from 2.97-5.16 mg/L, and was detected in all four water samples but not at levels above the EPA MCL. Atrazine ranged from <DL-0.45 µg/L, and was detected in the November, February, and August water samples but not at levels above the EPA MCL. Metolachlor ranged from <DL-0.18 µg/L, and was detected in the May water sample, but not at levels above the EPA HAL. Mercury ranged from <DL-0.49 µg/L, and was detected in the November water sample, but not at levels above the EPA Maximum Level. Alachlor and Cyanazine were not detected.

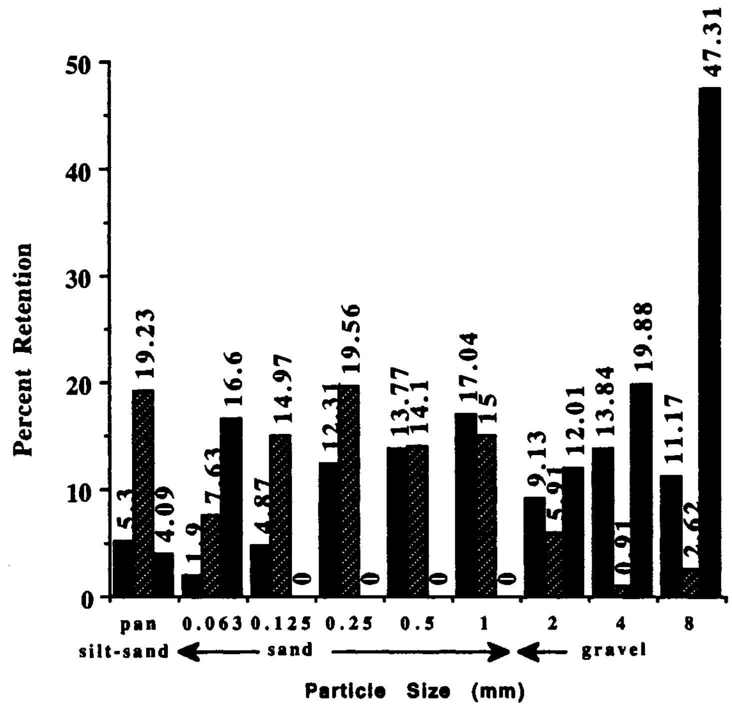

Figure 9. Substrate Analysis at springhead of Kelly Spring, Monroe County, Illinois.

Fauna (springhead): Cnidaria: Hydrozoa: Anthomedusae: Hydridae: *Hydra* sp. Nematoda (unidentifiable). Nematomorpha: Gordioidea: Gordiidae: *Gordius* sp. Annelida: Oligochaeta: Enchytraeidae (unidentifiable). Lumbricidae (unidentifiable). Naididae: *Dero digitata, D. nivea, Nais communis, N. elinguis, N. pardalis, N. variabilis, Nais* sp., *Slavina appendiculata, Stylaria lacustris*. Tubificidae: *Limnodrilus cervix, L. hoffmeisteri.* Hirudinea: Erpobdellidae: (unidentifiable). Crustacea: Amphipoda: Gammaridae: *Gammarus pseudolimnaeus*. Hyalellidae: *Hyalella azteca*. Isopoda: Asellidae: *Caecidotea brevicaudus*. Insecta: Coleoptera: Dryopidae: *Helichus* sp. Dytiscidae: dytiscid sp. 1. Haliplidae: *Peltodytes* sp. Diptera: Simuliidae: *Simulium tuberosum* complex, *Simulium vittatum* complex. Ephemeroptera: Baetidae: *Baetis* sp. Caenidae: *Caenis* sp. Heptageniidae: *Stenonema* sp. Hemiptera: Corixidae: *Trichocorixa* sp. Gerridae: *Aquarius remigis*. Mesoveliidae: *Mesovelia mulsanti.* Notonectidae: *Notonecta* sp. Mollusca: Gastropoda: Physidae: *Physella* sp. Gastropodids sp. 1, sp. 4, sp. 5. Pelecypoda: Sphaeriidae: *Pisidium* sp.

Fauna (springbrook): Turbellaria: Planariidae: *Dugesia dorotocephala.* Nematoda (unidentifiable). Annelida: Oligochaeta: Lumbricidae (unidentifiable). Naididae: *Dero nivea.* Tubificidae: *Limnodrilus hoffmeisteri.* Crustacea: Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus pseudolimnaeus, G. troglophilus.* Hyalellidae: *Hyalella azteca.*

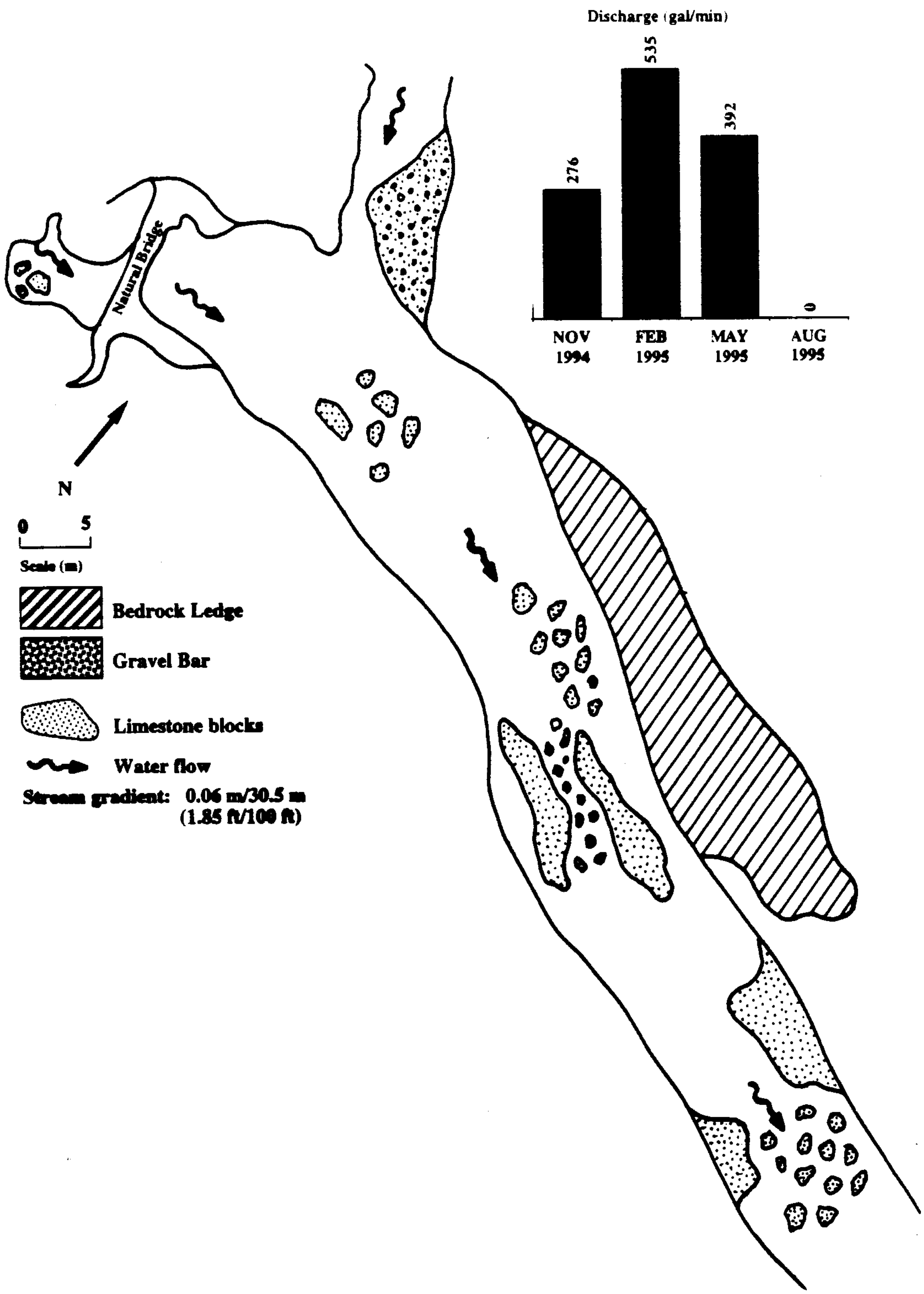

Figure 8. Kelly Spring, Monroe County, Illinois.

TABLE 4	County	Monroe	Monroe	Monroe	Monroe	
Kelly Spring Water: Quality	**Location**	Head	Head	Head	Head	
Analysis 1994 - 1995.	**Sample Date**	11/16/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					
Field Measurements						**Range**
Air Temperature (° C)	-	9	17	19.5	23.5	
Water Temperature (° C)	-	13	11	16	16	11-16
Dissolved Oxygen	never < 5.0	6.2	9.5	7.6	8.5	6.2-9.5
Hydrogen Ion Concentration (pH)	6.5 to 9.0		8.1	8.0	8.1	8.0-8.1
Alkalinity, as CaCO3 [<1]	-	199	237	188	255	188-237
Specific Conductivity (µmhos/cm)	-	598	728	432	608	432-728
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		48.2	56.8	46.1	58.3	46.1-58.3
Dissolved Organic Carbon [<0.1]		17.8	0.5	42.1	1.5	0.5-42.1
Total Dissolved Carbon [<0.1]		66.0	57.3	88.2	59.7	57.3-88.2
Sulfur as Sulfate [<0.01]	500.0	68.9	97.4	52.9	66.6	52.9-97.4
Ammonia Nitrogen [<0.01]	1.5 **	0.03	0.01	0.03	<DL	<DL-0.03
Nitrite Nitrogen [<0.01]	-	<DL	<DL	0.05	<DL	<DL-0.05
Nitrate Nitrogen [<0.01]	-	2.97	4.12	3.84	5.16	2.97-5.16
Total Phosphate [<0.01]		0.41	0.04	0.14	0.14	0.04-0.41
Hardness (EDTA)	*	199	295	213	302	199-302
Chlorides [<0.1]	500.	17.7	22.7	12.9	20.1	12.9-22.7
Total Dissolved Solids [<4]	1000.	432	464	364	432	364-464
Turbidity (NTU)	-		2	38	8	2-38
Dissolved Aluminum [<0.02]	-	0.05	0.04	<DL	0.09	<DL-0.09
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	<0.02	<0.02	<0.02	<0.02	<0.02
Dissolved Barium [0.005]	5.00	0.08	0.08	0.09	0.13	0.08-0.13
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolved Calcium [0.005]	-	55.2	80.5	63.1	86.8	55.2-86.8
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	0.02	<DL	0.01	0.07	<DL-0.07
Dissolved Potassium [1.0]	-	5	3	2	4	2-5
Dissolved Lanthanum		<0.002	<0.005	<0.003	<0.005	<0.002-<0.005
Dissolved Lithium [0.01	-	<DL	<DL	<DL	<DL	<DL

TABLE 4 (concluded).	County	Monroe	Monroe	Monroe	Monroe	
Kelly Spring: Water Quality	**Location**	Head	Head	Head	Head	
Analysis 1994 - 1995.	**Sample Date**	11/16/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					**Range**
Dissolved Magnesium [<0.01]	-	14.9	22.7	13.3	20.4	13.0-22.7
Dissolved Manganese [<0.01]	1.00	<DL	<DL	<DL	0.04	<DL-0.04
Dissolved Molybdenum [0.016]	-	<0.02	<0.02	<0.02	0.01	<0.02-0.01
Dissolved Sodium [<2]	-	31.6	47.6	26.2	40.7	26.2-47.6
Dissolved Nickel [0.03]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Lead [0.004]	0.1	<0.06	<0.04	<0.08	<0.04	<0.04-<0.08
Dissolved Antimony [0.06]	-	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Scandium		<0.003	<0.005	<0.003	<0.003	<0.003-<0.005
Dissolved Selenium [0.015]	1.0	<0.2	<0.1	<0.1	<0.1	<0.1-<0.2
Dissolved Silicon [0.010]	-	5.80	4.81	6.33	7.25	4.81-7.25
Dissolved Strontium [0.0015]	-	0.15	0.20	0.17	0.22	0.15-0.22
Dissolved Thallium [0.08]	-	<0.3	<0.3	<0.3	<0.3	<0.3
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	<DL	0.11	0.74	<DL	<DL-0.74
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	0.49	<DL	<DL	<DL	<DL-0.49
Atrazine	0.05	0.45	0.16	<DL	0.31	<DL-0.45
Alachlor	0.02	<DL	<DL	<DL	<DL	<DL
Metolachlor	0.02	<DL	<DL	0.18	<DL	<DL-0.18
Cyanazine	0.1	<DL	<DL	<DL	<DL	<DL

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

Isopoda: Asellidae: *Caecidotea brevicaudus*, *C. packardi*. Ostracoda: *Ilyocypris bradyi*. Insecta: Coleoptera: Dryopidae: *Helichus* sp. Dytiscidae: dytiscid sp. 1. Haliplidae: *Peltodytes* sp. Hydrophilidae: hydrophilid sp. 1, sp. 2, sp. 3, sp. 4, sp. 5, sp. 6. Diptera: Ceratopogonidae: ceratopogonid sp. 1, sp. 2, sp. 3. Chaoboridae: *Chaoborus (Sayomyia) punctipennis*. Chironomidae: *Ablabesmyia illinoense, Chironomus decorus, Cricotopus bicinctus, Cricotopus* sp. 1, *Dicrotendipes nervosus, Glyptotendipes paripes, Phaenopsectra flavipes, Polypedilum scalaenum, Procladius bellus, , P. sublettei, Stenochironomus hilaris, Tanytarsus* sp. Tipulidae: *Tipula* sp. 1, *Tipula* sp. 2. Ephemeroptera: Baetidae: *Baetis* sp. Caenidae: *Caenis sp.* Heptageniidae: *Stenonema* sp. Hemiptera: Corixidae: *Trichocorixa* sp. 1, sp. 2. Gerridae: *Aquarius remigis*. Mesoveliidae: *Mesovelia mulsanti*. Nepidae: *Ranatra fusca*. Pleidae: *Neoplea striola*. Plecoptera: Capniidae: *Allocapnia vivipara*. Perlidae: *Perlinella drymo*. Trichoptera: Helicopsychidae: *Helicopsyche borealis*. Hydropsychidae: *Cheumatopsyche analis, Hydropsyche betteni, Potomyia flava*. Hydroptilidae: *Hydroptila* possibly *scolops*. Leptoceridae: *Oecetis inconspicua*. Phryganeidae: *Phryganea sayi*. Polycentropodidae: *Nyctiophylax vestitus, Polycentropus centralis*. Rhyacophilidae: *Rhyacophila fenestra*. Mollusca: Gastropoda: Physidae: *Physella* sp. Gastropodids sp. 1, sp. 3. Osteichthyes: Cyprinidae: *Semotilus atromaculatus*.

Flora: Kelly Spring forms a stream that flows north-northwest from a steep wooded slope. The run has a dry second growth young forest on its north bank; the south bank is open and dominated by forb.

The dominant trees are *Platanus occidentalis, Cercis canadensis, Carya ovata*, and *Ulmus americana*. Other trees included *Acer negundo, Acer saccharum, Carya cordiformis, Carya tomentosa, Cornus florida, Fraxinus americana, Juglans nigra, Ostrya virginiana, Quercus alba, Quercus rubra, Quercus velutina*, and *Tilia americana*.

The dominant shrubs are *Rosa multiflora* and *Corylus americana*. Other shrubs included *Cephalanthus occidentalis, Cornus drummondii, Hydrangea arborescens, Lonicera maackii, Ribes missouriense, Rosa carolina, Rubus* sp., *Sambucus canadensis, Staphylea trifolia, Symphoricarpos orbiculatus*, and *Viburnum prunifolium*.

The dominant woody vines are *Parthenocissus quinquefolia, Smilax hispida*, and *Toxicodendron radicans*. Other woody vines included *Vitis aestivalis* and *Vitis riparia*.

The dominant herbs are *Festuca pratensis* and *Amphicarpaea bracteata*. Other herbs included *Acalypha* sp., *Achillea millefolium, Agrimonia pubescens, Agrimonia rostellata, Allium canadense, Apios americana, Aquilegia canadensis, Asplenium platyneuron, Asplenium rhizophyllum, Aster pilosus, Aster* sp., *Anemone virginica, Apios americana, Aquilegia canadensis, Boehmeria cylindrica, Carex blanda, Carex cephalophora, Carex normalis, Carex radiata, Carex* sp., *Cerastium vulgatum, Chasmanthium latifolium, Circaea lutetiana canadensis, Cryptotaenia canadensis, Cystopteris tennesseensis, Daucus carota, Desmodium glutinosum,* *Desmodium paniculatum, Elymus virginicus, Equisetum arvense, Equisetum hyemale* var. *affine, Erigeron annuus, Erigeron philadelphicus, Eupatorium rugosum, Festuca obtusa, Galium aparine, Galium circaezans, Galium concinnum, Galium triflorum, Geranium maculatum, Geum canadense, Glyceria striata, Helianthus divaricatus, Hypericum punctatum, Heuchera americana* var. *hirsuticaulis, Hemerocallis fulva, Impatiens* sp., *Juncus tenuis, Lactuca* sp., *Leersia virginica, Lespedeza intermedia, Lespedeza violacea, Lobelia inflata, Lobelia siphilitica, Lycopus* sp., *Lysimachia nummularia, Medicago sativa, Melilotus alba, Melilotus officinalis, Panicum clandestinum, Panicum lanuginosum* var. *fasciculatum, Parietaria pensylvanica, Phleum pratense, Penstemon digitalis, Phlox divaricata laphamii, Physostegia virginiana* var. *virginiana, Pilea pumila, Plantago rugelii, Poa compressa, Poa pratensis, Polystichum acrostichoides, Potentilla simplex, Prunella vulgaris, Pycnanthemum tenuifolium, Ranunculus recurvatus, Rudbeckia subtomentosa, Ruellia pedunculata, Rumex crispus, Rumex obtusifolium, Sanicula canadensis, Sanicula odorata, Scutellaria australis, Sium suave, Solidago gigantea, Sphenopholis obtusa* var. *major, Taraxacum officinale, Trifolium pratense, Trifolium repens, Verbena urticifolia, Vernonia missurica, Viola sororia*, and *Woodsia obtusa.*

Floral abundance and importance values are given in Appendix 2.

Current Status: Both the springhead (36 taxa) and the springbrook (64 taxa) of Kelly Spring supported an abundant diversity of both insect and non-insectan macroinvertebrates. The troglophilic cave amphipods *Crangonyx forbesi* and *Gammarus troglophilus* and the cave isopod *Caecidotea packardi* were collected from the springbroook. Nitrate nitrogen was detected in each of the four water samples collected, Atrazine in three samples, and Metolachlor in one sample, but not at levels above the EPA MCL or HAL. No aquatic macrophytes were found in the springhead or the springbrook.

Little Carr Spring

Little Carr Spring (Fig. 10) is located east of a paved road at the base of a near vertical, partially excavated loess-covered bluff of St. Louis and Ste. Genevieve limestone of Mississippian age. Water from the spring emerges from several St. Louis limestone ledges 1.5-2.1 m (5-7 ft) below the water surface of a small silt- and clay-filled pool. Silt and clay in the pool form a distinct cone opening upwards around the submerged ledges. Sand and gravel are the principal earth materials forming Little Carr Creek west from the pool. The springbrook gradient from the springhead to the road 33.5 m (110 ft) away is 0.19 m:30.5m (0.62 ft:100ft). The discharge rate taken in November, 1994, and February, May, and August, 1995, ranged from 38-116 gpm (2.4-7.3 L/sec) (Fig. 10). Substrate analysis at the springhead (Fig. 11) is dominated by a silt-clay substrate, with the short stretch of springbrook dominated by a sand-gravel substrate.

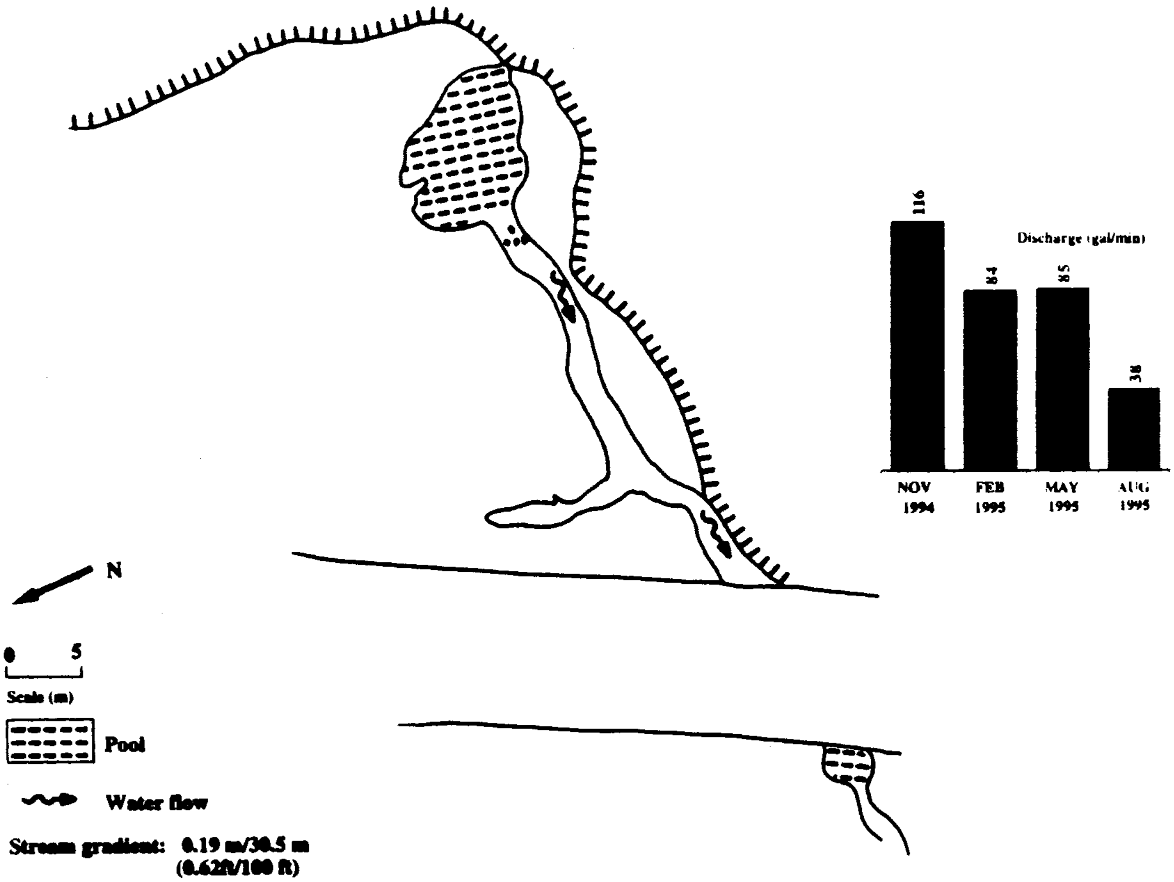

Figure 10. Little Carr Spring, Monroe County, Illinois.

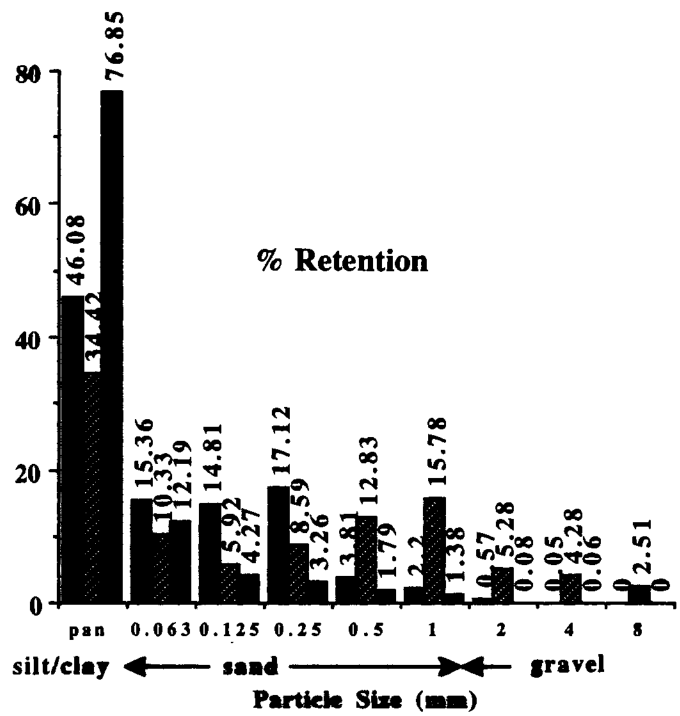

Figure 11. Substrate Analysis at springhead of Little Carr Spring, Monroe County, Illinois.

Table 5	County	Monroe	Monroe	Monroe	Monroe	
Little Carr Spring: Water	Location	Head	Head	Head	Head	
Quality Analysis 1994 - 1995.	Sample Date	11/17/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					
Field Measurements						**Range**
Air Temperature (° C)	-	9.5	9	22	22.5	
Water Temperature (° C)	-	13	11.0	14.2	11.5	11.0-14.2
Dissolved Oxygen	never < 5.0	4.8	6.3	6.5	8.8	4.8-8.8
Hydrogen Ion Concentration (pH)	6.5 to 9.0	-	8.0	7.8	7.5	7.5-8.0
Alkalinity, as CaCO3 [<1]	-	257	306	267	298	257-306
Specific Conductivity (μmhos/cm)	-	576	714	700	700	576-714
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		67.5	75.3	68.1	69.4	67.5-75.3
Dissolved Organic Carbon [<0.1]		10.5	0.1	59.2	26.9	0.1-59.2
Total Dissolved Carbon [<0.1]		78.0	75.4	127.3	96.3	75.4-127.3
Sulfur as Sulfate [<0.01]	500.0	26.5	35.8	45.2	38.5	26.5-45.2
Ammonia Nitrogen [<0.01]	1.5 **	0.04	<DL	0.06	0.02	<DL-0.06
Nitrite Nitrogen [<0.01]	-	<DL	<DL	<DL	<DL	<DL
Nitrate Nitrogen [<0.01]	-	3.87	5.02	3.50	4.94	3.50-5.02
Total Phosphate [<0.01]		0.26	0.07	0.06	0.11	0.06-0.26
Hardness (EDTA)	*	285	347	300	363	285-347
Chlorides [<0.1]	500.	13.0	15.7	12.1	15.9	12.1-15.9
Total Dissolved Solids [<4]	1000.	484	456	440	452	440-484
Turbidity (NTU)	-		1	6	6	1-6
Dissolved Aluminum [<0.02]	-	0.03	<DL	0.04	0.08	<DL-0.08
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	<0.02	<0.02	<0.02	<0.02	<0.02
Dissolved Barium [0.005]	5.00	0.10	0.10	0.12	0.11	0.10-0.12
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolved Calcium [0.005]	-	91.6	113.0	97.4	118.0	91.6-118.0
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	<DL	<DL	<DL	0.09	<DL-0.09
Dissolved Potassium [1.0]	-	4	2	2	2	2-4
Dissolved Lanthanum		<0.002	<0.005	<0.003	<0.005	<0.002-<0.005
Dissolved Lithium [0.01	-	<DL	<DL	<DL	<DL	<DL

TABLE 5 (concluded). Little Carr Spring: Water Quality Analysis 1994 - 1995.	County	Monroe	Monroe	Monroe	Monroe	
	Location	Head	Head	Head	Head	
	Sample Date	11.17/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					**Range**
Dissolved Magnesium [<0.01]	-	13.5	15.7	13.6	16.4	13.5-16.4
Dissolved Manganese [<0.01]	1.00	0.14	0.07	0.15	0.13	0.07-0.14
Dissolved Molybdenum [0.016]	-	<0.02	<0.02	<0.02	<DL	<DL-0.02
Dissolved Sodium [<2]	-	15.0	17.9	17.5	21.0	15.0-17.9
Dissolved Nickel [0.03]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Lead [0.004]	0.1	<0.06	<0.04	<0.08	<0.04	<0.04-<0.08
Dissolved Antimony [0.06]	-	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Scandium		<0.003	<0.005	<0.003	<0.003	<0.005-<0.003
Dissolved Selenium [0.015]	1.0	<0.2	<DL	<DL	<DL	<DL-<0.2
Dissolved Silicon [0.010]	-	11.2	12.2	11.5	13.2	11.2-13.2
Dissolved Strontium [0.0015]	-	0.22	0.24	0.24	0.26	0.22-0.26
Dissolved Thallium [0.08]	-	<0.3	<0.2	<0.3	0.3	<0.2-<0.3
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	<0.01	0.02	0.14	0.01	<0.01-0.14
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	<DL	<DL	<DL	<DL	<DL
Atrazine	0.05	0.63	0.53	0.64	0.26	0.26-0.64
Alachlor	0.02	<DL	<DL	<DL	<DL	<DL
Metolachlor	0.02	1.11	0.22	0.58	0.08	0.08-1.11
Cyanazine	0.1	<DL	<DL	<DL	<DL	<DL

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

Water Quality: Table 5. Nitrate nitrogen ranged from 3.50-5.02 mg:L, and was detected in all four water samples but not at levels above the EPA MCL. Atrazine ranged from 0.26-0.64 μg:L, and was detected in all four water samples but not at levels above the EPA MCL. Metolachlor ranged from 0.08-1.11 μg:L, and was detected in all four water samples, but not at levels above the EPA HAL. Alachlor, Cyanazine, and Mercury were not detected.

Fauna (springhead): Annelida: Oligochaeta: Enchytraeidae (unidentifiable). Naididae: *Dero digitata.* Tubificidae: *Ilyodrilus templetoni, Limnodrilus cervix, L. claparedianus, L. hoffmeisteri.* Crustacea: Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus pseudolimnaeus.* Isopoda: Asellidae: *Caecidotea brevicauda, C. intermedia.* Ostracoda: *Ilyocypris bradyi.* Insecta: Coleoptera: dytiscid sp. 1. Coleoptera: Hydrophilidae: hydrophilid sp. 1. Diptera: Ceratopogonidae: ceratopogonid sp. 1, sp. 2. Chironomidae: *Polypedilum* sp., *Procladius bellus, P. sublettei, Tanypus neopunctipennis, Tanytarsus* sp. Hemiptera: Gerridae: *Aquarius remigis.* Mollusca: Gastropoda: Physidae: *Physa* sp. Gastropodid sp. 2. Osteichthyes: Centrarchidae: *Lepomis cyanellus.*

Fauna (springbrook): Annelida: Lumbricidae (unidentifiable). Tubificidae: *Limnodrilus hoffmeisteri.* Crustacea: Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus pseudolimnaeus.* Isopoda: Asellidae: *Caecidotea brevicauda, C. intermedia.* Insecta: Diptera: Tipulidae: *Tipula* sp. 1. Hemiptera: Gerridae: *Aquarius remigis.* Trichoptera: Hydropsychidae: *Cheumatopsyche analis, Hydropsyche betteni.* Polycentropodidae: *Cyrnellus lateralis.* Mollusca: Gastropoda: Physidae: *Physa* sp. Gastropodid sp. 2.

Flora: Little Carr Spring is the origin of Little Carr Creek, a stream that flows west through a cleared farm on the north and a roadside on the south. A young second growth forested steep slope is present on the south-southeast edge of the springbrook; a recently graded forb dominated area occurs on the northwest edge of the springbrook, extending approximately 20 m to the road.

The dominant trees are *Acer saccharum* and *Tilia americana.* Other trees included *Acer negundo, Carpinus caroliniana, Cercis canadensis, Celtis laevigata, Fraxinus americana, Morus rubra, Platanus occidentalis, Quercus rubra, Salix nigra*, and *Ulmus americana.*

The dominant shrub is *Cornus drummondii.* Other shrubs included *Cephalanthus occidentalis, Hydrangea arborescens, Sambucus canadensis*, and *Viburnum prunifolium.*

The dominant woody vine is *Toxicodendron radicans.* Other woody vines included *Campsis radicans, Parthenocissus quinquefolia, Smilax hispida*, and *Vitis* sp.

The dominant herbs are *Equisetum arvense, Leersia virginica*, and *Cryptotaenia canadensis.* Other herbs included *Acalypha rhomboidea, Agrostis sp., Amaranthus* sp., *Ambrosia artemisiifolia, Ambrosia trifida, Amphicarpaea bracteata, Apios americana, Arabis laevigata, Aster* spp., *Campanula americana, Carex blanda, Carex cephalophora, Carex projecta, Carex radiata, Cinna arundinacea, Dicentra cucullaria, Elymus virginicus, Erigeron annuus, Erigeron* *philadelphicus, Eupatorium rugosum, Festuca obtusa, Galium triflorum, Glyceria striata, Hypericum punctatum, Impatiens capensis, Juncus tenuis, Lobelia inflata, Melilotus alba, Oxalis* sp., *Penstemon digitalis, Phlox divaricata laphamii, Pilea pumila, Plantago rugelii, Poa pratensis, Phalaris arundinacea, Phytolacca americana, Polygonum pensylvanicum, Rumex crispus, Rumex obtusifolius, Sanicula odorata, Scirpus atrovirens, Solidago canadensis, Taraxacum officinale, Teucrium canadense, Trifolium pratense,* and *Viola sororia.*

Floral abundance and importance values are given in Appendix 2.

Current Status: Little Carr Spring is a sinkhole spring set along the base of a hillside on the edge of a severely disturbed area. The springhead has a moderate diversity of macroinvertebrates (23 taxa), primarily due to the availability of the clay:silt substrate which surrounds the springhead. The springbrook, Little Carr Creek, is comprised of a sand-gravel substrate. A limited fauna occurs in this springbrook (13 taxa), although specimens of the troglophilic cave amphipod *Crangonyx forbesi* were collected. Low habitat diversity for aquatic macroinvertebrates may be the limiting factor of their populations in the springbrook. Nitrate nitrogen, Atrazine, and Metolachlor were detected in each of the four water samples collected, but never at levels above the EPA MCL or HAL. No aquatic macrophytes were found in the springhead or the springbrook.

Madonnaville Cave Spring

Madonnaville Spring (Fig. 12) is located at the base of an 24.4 m (80 ft) ravine composed of Salem limestone of Mississippian age. Water from the spring forms the headwater of a tributary to Monroe City Creek, which then discharges into the Mississippi River floodplain 5.5 km (3.4 miles) to the west. The cave has an elliptical shaped opening with a maximum height of 1.5 m (5 ft) and width of 7.8 m (25.5 ft). At low flow, water discharges from a narrow 0.9 m (3 ft) bedrock channel on the north side of the cave opening. The cave opening extends northward 10-13 m (30-40 ft.) forming a distinct cavern away from the entrance. An extensive shallow pooled area is present in a cave corridor starting about 6.1 m (20 ft) west from the cave entrance. A chert and limestone boulder gravel apron occupies a considerable part of the cave near the entrance. Bedrock joints aligned N 60-65^{o} E are present at the cave face and downstream in the bedrock outflow channel. The springbrook gradient from the cave entrance to a point 51.8 m (170 ft) downstream is 0.9 m/30.5m (2.91 ft/100ft). The discharge rate taken in November, 1994, and February, May, and August, 1995, ranged from 17-156 gpm (6.8-31.3 L/sec) (Fig. 12). Substrate analysis at the springhead (Fig. 13) is highly variable with areas of silt:clay, sand, coarse gravel, and cobble.

Water Quality: Table 6. Nitrate nitrogen ranged from 6.72-7.64 mg:L, and was detected in all four water samples but not at levels above the EPA MCL. Alachlor ranged from <DL-0.15 µg:L, and was detected in the May water sample but not at levels above the EPA MCL. Atrazine

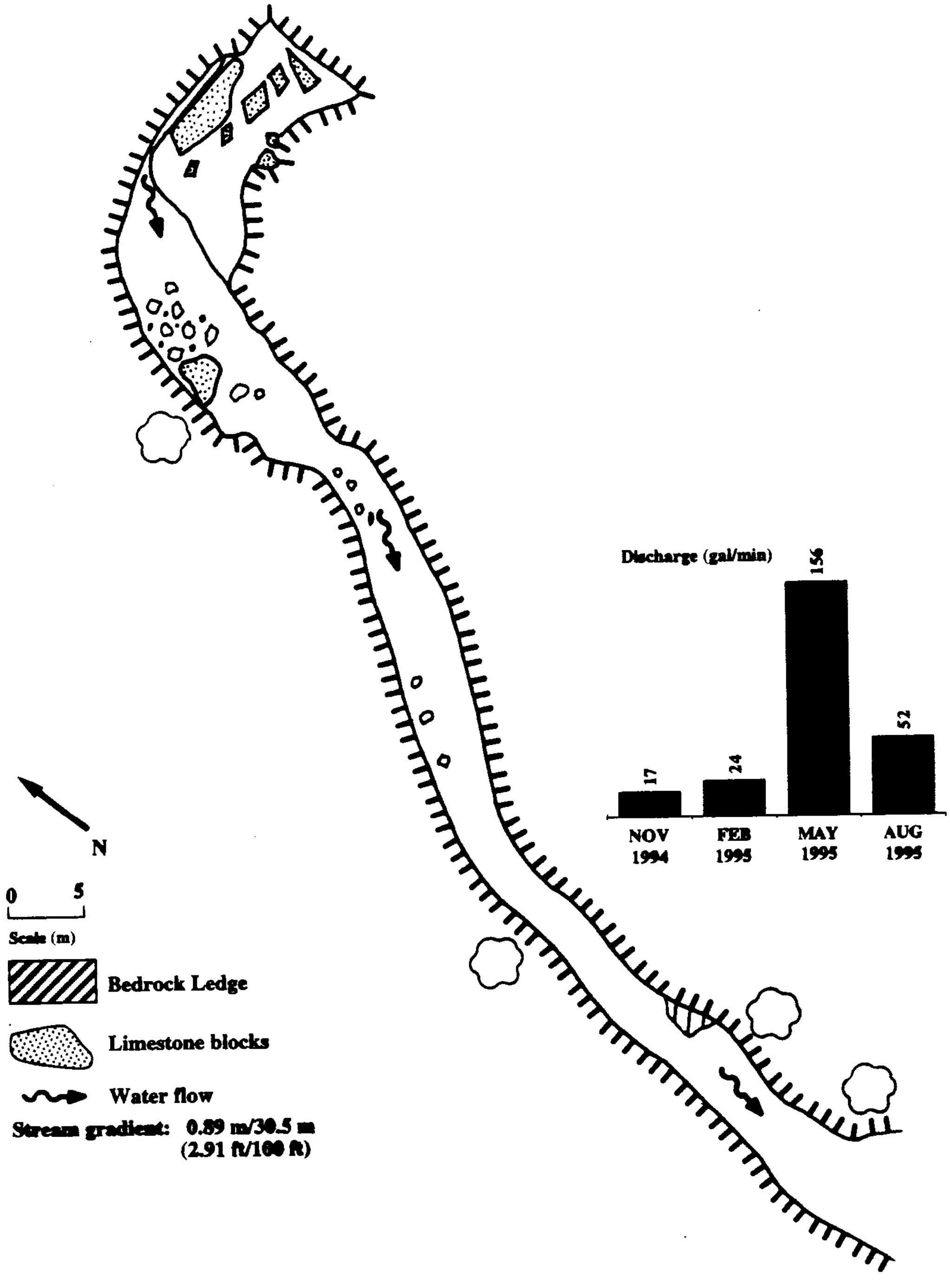

Figure 12. Madonnaville Spring, Monroe County, Illinois.

Table 6	County	Monroe	Monroe	Monroe	Monroe	
Madonnaville Spring: Water Quality	**Location**	Head	Head	Head	Head	
Analysis 1994 - 1995.	**Sample Date**	11/17/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					
Field Measurements						**Range**
Air Temperature (° C)	-	11	15	21	22	
Water Temperature (° C)	-	13.0	14.0	13.6	12.0	12-14
Dissolved Oxygen	never < 5.0	10.0	11.0	9.6	11.2	9.6-11.2
Hydrogen Ion Concentration (pH)	6.5 to 9.0		8.0	7.9	8.0	7.9-8.0
Alkalinity, as CaCO3 [<1]	-	245	239	222	234	222-245
Specific Conductivity (µmhos/cm)	-	675	603	516	519	516-675
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		63.3	57.0	55.9	56.8	55.9-63.3
Dissolved Organic Carbon [<0.1]		7.5	0.1	42.9	15.3	0.1-42.9
Total Dissolved Carbon [<0.1]		70.8	57.1	98.8	72.0	57.1-98.8
Sulfur as Sulfate [<0.01]	500.0	39.9	41	37.2	37.9	37.2-41.0
Ammonia Nitrogen [<0.01]	1.5 **	<DL	<DL	<DL	<DL	<DL
Nitrite Nitrogen [<0.01]	-	<DL	<DL	<DL	<DL	<DL
Nitrate Nitrogen [<0.01]	-	7.30	7.64	6.72	7.30	6.72-7.64
Total Phosphate [<0.01]		0.13	0.07	0.06	0.08	0.06-0.13
Hardness (EDTA)	*	250	254	222	276	222-254
Chlorides [<0.1]	500.	15.4	16.9	14.7	15.7	14.7-16.9
Total Dissolved Solids [<4]	1000.	500	416	404	392	404-500
Turbidity (NTU)	-		1	2	2	1-2
Dissolved Aluminum [<0.02]	-	<DL	<DL	0.06	0.02	<DL-0.06
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	<0.02	<0.02	<0.02	<0.02	<0.02
Dissolved Barium [0.005]	5.00	0.08	0.07	0.06	0.08	0.06-0.08
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolved Calcium [0.005]	-	84.5	86.6	75.5	94.3	75.5-94.3
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	<DL	<DL	<DL	0.01	<DL-0.01
Dissolved Potassium [1.0]	-	<DL	1	2	<DL	<DL-2
Dissolved Lanthanum		<0.002	<0.005	0.003	<0.005	<0.002-<0.005
Dissolved Lithium [0.01	-	<DL	<DL	0.01	<DL	<DL-0.01

TABLE 6 (concluded).	County	Monroe	Monroe	Monroe	Monroe	
Madonnaville Spring: Water Quality	Location	Head	Head	Head	Head	
Analysis 1994 - 1995.	Sample Date	11/17/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					**Range**
Dissolved Magnesium [<0.01]	-	9.45	9.21	7.97	9.82	7.97-9.82
Dissolved Manganese [<0.01]	1.00	<DL	<DL	0.01	0.02	<DL-0.02
Dissolved Molybdenum [0.016]	-	<0.02	<0.02	<0.02	<DL	<DL-<0.02
Dissolved Sodium [<2]	-	30.9	31.4	23.4	30.9	23.4-31.4
Dissolved Nickel [0.03]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Lead [0.004]	0.1	<0.06	<0.04	<0.08	<0.04	<0.04-<0.08
Dissolved Antimony [0.06]	-	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Scandium		<0.003	<0.005	<0.003	<0.003	<0.003-<0.005
Dissolved Selenium [0.015]	1.0	<0.2	<0.1	<0.1	<0.1	<0.1-<0.2
Dissolved Silicon [0.010]	-	11.3	11.2	10.0	12.0	11.2-12.0
Dissolved Strontium [0.0015]	-	0.15	0.14	0.14	0.16	0.14-0.16
Dissolved Thallium [0.08]	-	<0.3	<0.2	<0.3	<0.3	<0.2-<0.3
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	<0.01	0.07	0.14	<0.01	<0.01-0.14
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	<DL	<DL	<DL	<DL	<DL
Atrazine	0.05	<DL	<DL	1.74	0.29	<DL-1.74
Alachlor	0.02	<DL	<DL	0.15	<DL	<DL-0.15
Metolachlor	0.02	<DL	<DL	0.37	<0.02	<DL-0.37
Cyanazine	0.01	<DL	<DL	<DL	<DL	<DL

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

ranged from <DL-1.74 µg:L, and was detected in the May and August water samples but not at levels above the EPA MCL. Metolachlor ranged from DL-0.37 µg:L, and was detected in the May water sample but not at levels above the EPA HAL. Cyanazine and Mercury were not detected.

Fauna (springhead): Turbellaria: Planariidae: *Phagocata gracilis.* Annelida: Oligochaeta: Enchytraeidae (unidentifiable). Naididae: *Stylaria lacustris.* Crustacea: Amphipoda: Gammaridae: *Gammarus minus, G. troglophilus.* Isopoda: Asellidae: *Caecidotea brevicauda.* Mollusca: Gastropoda: gastropodid sp. 2.

Fauna (springbrook): Turbellaria: Planariidae: *Phagocata gracilis.* Nematoda (unidentifiable). Annelida: Oligochaeta: Lumbriculidae (unidentifiable). Tubificidae: *Limnodrilus hoffmeisteri.* Crustacea: Amphipoda: Gammaridae: *Gammarus minus, G. troglophilus.* Isopoda: Asellidae: *Caecidotea brevicauda.* Insecta: Coleoptera: Hydrophilidae: hydrophilid sp. 1. Diptera: Ceratopogonidae: *Bezzia* sp. Chaoboridae: *Chaoborus (Sayomyia) punctipennis.* Chironomidae: *Glyptotendipes paripes, Polypedilum* sp., *Tanytarsus* sp. Psychodidae: *Psychoda* sp. Tipulidae: *Tipula* sp. 1 Ephemeroptera: Heptageniidae: *Stenonema* sp. Hemiptera: Gerridae: *Aquarius remigis.* Trichoptera: Hydropsychidae: *Cheumatopsyche analis, Diplectrona modesta.* Hydroptilidae: *Hydroptila* possibly *scolops.* Leptoceridae: *Oecetis inconspicua.*

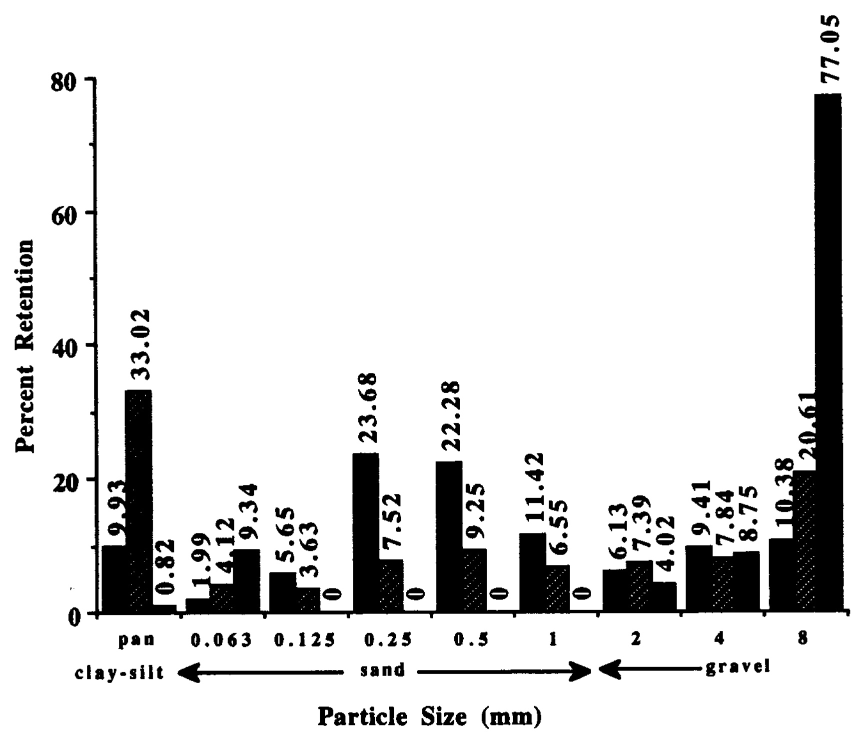

Figure 13. Substrate Analysis at springhead of Madonnaville Spring, Monroe County, Illinois.

Phryganeidae: *Phryganea* possibly *sayi*. Polycentropodidae: *Polycentropus centralis*. Mollusca: Gastropoda: Physidae: *Physa* sp. Gastropodid sp. 1, sp. 2, sp. 4.

Flora: Madonnaville Spring forms a stream that flows southwest from a steep wooded slope through a forested ravine.

The dominant trees are *Platanus occidentalis* and *Ulmus americana*. Other trees included *Acer negundo, Acer saccharum, Carya ovata, Carya ovalis, Celtis laevigata, Celtis occidentalis, Cercis canadensis, Cornus florida, Crataegus calpodendron, Fraxinus americana, Morus rubra, Prunus serotina, Quercus alba, Quercus prinoides* var. *acuminata, Quercus rubra*, and *Sassafras albidum.*

The dominant shrubs are *Cornus drummondii* and *Viburnum rufidulum*. Other shrubs are *Euonymus atropurpurea, Hydrangea arborescens, Ilex decidua, Rhamnus caroliniana, Rosa multiflora*, and *Sambucus canadensis.*

The dominant woody vines are *Parthenocissus quinquefolia* and *Toxicodendron radicans.* Other woody vines included *Campsis radicans, Celastrus scandens, Smilax hispida*, and *Vitis aestivalis.*

The dominant herb is *Sanicula odorata*. Other herbs included *Agrimonia pubescens, Allium canadense, Amphicarpaea bracteata, Anemone virginiana, Aristolochia serpentaria, Asplenium platyneuron, Aster lateriflorus, Aster* sp., *Botrychium virginianum, Bromus pubescens, Carex blanda, Carex grisea, Campanula americana, Circaea lutetiana canadensis, Cryptotaenia canadensis, Cystopteris tennesseensis, Desmodium glutinosum, Desmodium nudiflorum, Elymus hystrix, Elymus virginiana, Erigeron annuus, Erigeron philadelphicus, Eupatorium rugosum, Festuca obtusa, Galium aparine, Galium concinnum, Galium triflorum, Geum canadense, Helianthus divaricatus, Juncus tenuis, Leersia virginica, Lobelia siphilitica, Osmorhiza longistylis, Panicum boscii, Passiflora lutea* var. *glabriflora, Penstemon digitalis, Phlox divaricata laphamii, Phryma leptostachya, Physostegia virginiana, Pilea pumila, Plantago rugelii, Poa pratensis, Polystichum acrostichoides, Prunella vulgaris, Ranunculus abortivus, Ranunculus recurvatus, Rumex crispus, Sanicula canadensis, Sanicula odorata, Silene stellata, Solidago* sp., *Sphenopholis obtusata* var. *major, Taraxacum officinale, Veronica* sp., and *Viola sororia.*

Floral abundance and importance values are given in Appendix 2.

Current Status: The springhead of Madonnaville Spring is the continuation of a cave stream. The diversity of macroinvertebrates (7 taxa) is limited and lack any aquatic insects, although the troglophilic cave amphipod *Gammarus troglophilus* is present. In contrast, the springbrook (27 taxa) supports a diversity of aquatic insect and non-insectan macroinvertebrates. Nitrate nitrogen was detected in each of the four water samples collected, but never at levels above the EPA MCL. Alachlor and Metolachlor were detected in the May water sample and Atrazine in the May and August water samples but never at levels above the EPA MCL or HAL. No aquatic macrophytes were found in the springhead or the springbrook.

Ritter Spring

Ritter Spring (Fig. 14) is located at the base of a 36.6 m (120 ft) sloping hill composed of Ste. Genevieve limestone of Mississippian age. The 30-32^{o} slope closely approximates the inclination of the bedding plane of the limestone layer at the spring. Water from the springhead flows from a triangular shaped opening about 1.5 m (5 ft) wide and 0.9 m (3 ft) high. The opening is in an exposed face of limestone and chert which extends northward but is not entirely present to the south. At times impoundment water was observed to enter the spring opening reducing the flow of the spring. The springbrook gradient of the sand and gravel channel from the springhead to the pond is 0.02 m:30.5m (0.05 ft:100ft). The discharge rate taken in November, 1994, and February, May, and August, 1995, ranged from 49-160 gpm (3.1-10.1 L/sec) (Fig. 14). Substrate analysis at the springhead (Fig. 15) is highly variable with areas of silt/clay, sand, and coarse gravel.

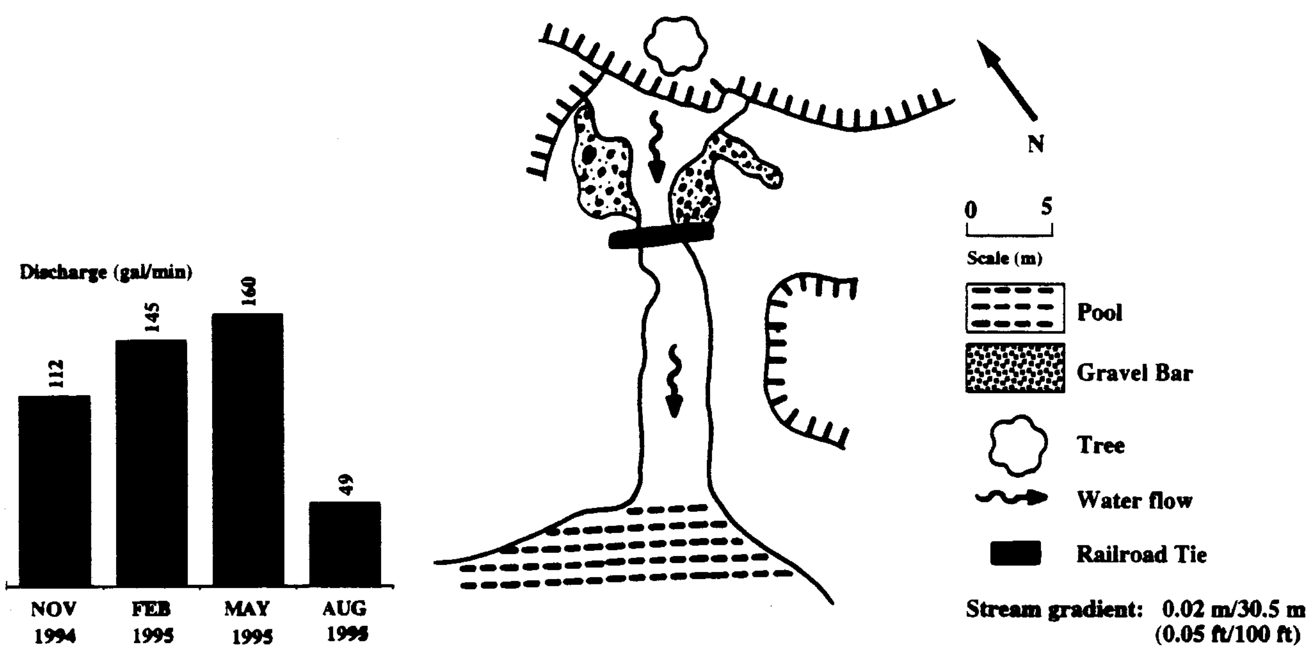

Figure 14. Ritter Spring, Monroe County, Illinois.

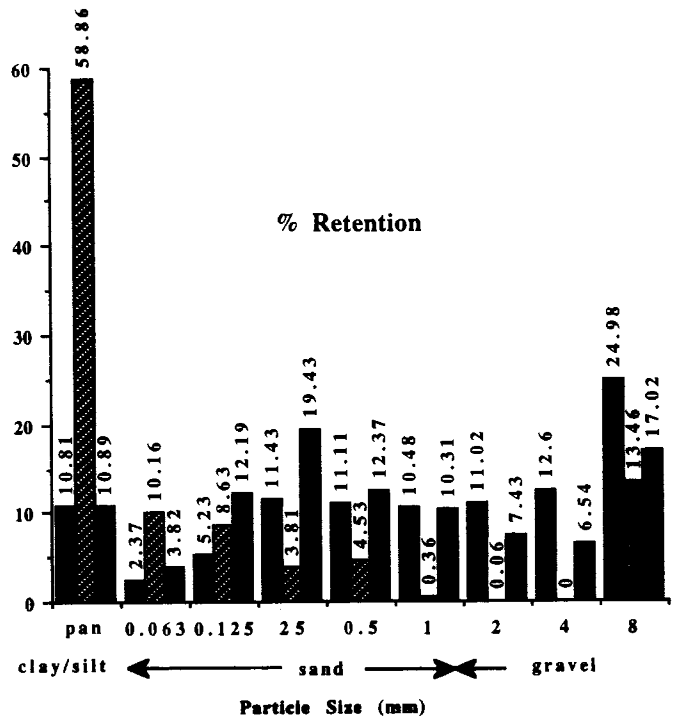

Figure 15. Substrate Analysis at springhead of Ritter Spring, Monroe County, Illinois.

Water Quality: Table 7. Nitrate nitrogen ranged from 4.13-5.26 mg/L, and was detected in all four water samples but not at levels above the EPA MCL. Atrazine ranged from <DL-0.17 μg/L, and was detected in only the May sample but not at levels above the EPA MCL. Metolachlor ranged from <DL-0.24 μg/L, and was detected in November and February water samples but not at levels above the EPA HAL. Alachlor, Cyanazine, and Mercury were not detected.

Fauna (springhead): Platyhelminthes: Tubellaria: Planariidae: *Phagocata gracilis.* Annelida: Aeolosomatida: Aeolosomatidae: *Aeolosoma* sp. Oligochaeta: Enchytraeidae (unidentifiable). Naididae: *Nais communis, Nais* sp., *Pristina aequiseta, Specaria josinae.* Tubificidae: *Ilyodrilus templetoni, Limnodrilus claparedianus, L. hoffmeisteri.* Arthropoda: Crustacea: Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus pseudolimnaeus, G. troglophilus.* Isopoda: Asellidae: *Caecidotea brevicauda.* Insecta: Coleoptera: Dytiscidae: dytiscid sp. 1. Haliplidae: *Peltodytes* sp. Hydrophilidae: hydrophilid sp. 1. Ephemeroptera: Baetidae: *Baetis* sp. Hemiptera: Corixidae: *Trichocorixa* sp. 1. Mollusca: Gastropoda: Physidae: *Physa* sp. Gastropodids sp. 1, sp. 2, sp. 4.

TABLE 7 Ritter Spring: Water Quality Analysis 1994 - 1995.	**County** **Location** **Sample Date**	Monroe Head 11/15/95	Monroe Head 2/22/95	Monroe Head 5/16/95	Monroe Head 8/22/95	
PARAMETERS *	**Standard****					
Field Measurements						**Range**
Air Temperature (° C)	-	6	18	27.00	23.5	
Water Temperature (° C)	-	12.5	14.0	15.0	8.6	8.6-15.0
Dissolved Oxygen	never < 5.0	8.5	11.8	9.6	8.6	8.5-11.8
Hydrogen Ion Concentration (pH)	6.5 to 9.0		8.1	7.9	7.6	7.6-8.1
Alkalinity, as CaCO3 [<1]	-	280	299	283	275	275-299
Specific Conductivity (µmhos/cm)	-	664	728	730	746	664-746
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		70.9	71.3	69.0	67.9	69.0-71.3
Dissolved Organic Carbon [<0.1]		12.7	0.4	76.3	28.0	0.4-76.3
Total Dissolved Carbon [<0.1]		83.6	71.7	145.3	109.6	71.7-145.3
Sulfur as Sulfate [<0.01]	500.0	49.4	66.4	65.5	73.6	49.4-73.6
Ammonia Nitrogen [<0.01]	1.5 **	0.03	<DL	<DL	0.02	<DL-0.03
Nitrite Nitrogen [<0.01]	-	<DL	<DL	<DL	<DL	<DL
Nitrate Nitrogen [<0.01]	-	4.13	4.86	4.58	5.26	4.13-5.26
Total Phosphate [<0.01]		0.54	0.22	0.23	0.16	0.16-0.54
Hardness (EDTA)	*	307	373	326	410	307-410
Chlorides [<0.1]	500.	17.6	20.5	16.5	16.1	16.1-20.5
Total Dissolved Solids [<4]	1000.	544	496	508	544	496-544
Turbidity (NTU)	-		1	21	9	1-21
Dissolved Aluminum [<0.02]	-	0.05	<DL	0.05	0.09	<DL-0.09
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	<0.02	<0.02	<0.02	<0.02	<0.02
Dissolved Barium [0.005]	5.00	0.1	<0.08	0.09	0.10	<0.08-0.10
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolved Calcium [0.005]	-	102	123	108	136	102-136
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	<DL	<DL	<DL	0.06	<DL-0.06
Dissolved Potassium [1.0]	-	3	<DL	<DL	1	<DL-3
Dissolved Lanthanum		<0.002	<0.005	<0.003	<0.005	<0.002-<0.005
Dissolved Lithium [0.01	-	0.01	0.01	<DL	<DL	<DL-0.01

TABLE 7 (continued). Ritter Spring: Water Quality Analysis 1994 - 1995.	County	Monroe	Monroe	Monroe	Monroe	
	Location	Head	Head	Head	Head	
	Sample Date	11/15/95	2/22/95	5/16/95	8/22/95	
PARAMETERS *	**Standard****					**Range**
Dissolved Magnesium [<0.01]	-	12.6	15.9	13.5	16.9	12.6-16.9
Dissolved Manganese [<0.01]	1.00	0.01	0.01	<DL	0.01	<DL-0.01
Dissolved Molybdenum [0.016]	-	<0.02	<0.02	<0.02	<DL	<DL-<0.02
Dissolved Sodium [<2]	-	18.9	26.0	20.7	27.5	18.9-27.5
Dissolved Nickel [0.03]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Lead [0.004]	0.1	<0.06	<0.04	<0.08	<0.04	<0.04-<0.08
Dissolved Antimony [0.06]	-	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Scandium		<0.003	<0.005	<0.003	<0.003	<0.003-<0.005
Dissolved Selenium [0.015]	1.0	<0.2	<0.1	<0.1	<0.1	<0.1-<0.2
Dissolved Silicon [0.010]	-	11.5	13.5	11.6	15.0	11.5-15.0
Dissolved Strontium [0.0015]	-	0.22	0.25	0.24	0.28	0.22-0.28
Dissolved Thallium [0.08]	-	<0.3	<0.2	<0.3	<0.3	<0.2-<0.3
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	<0.01	0.10	0.19	<0.01	<0.01-0.19
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	<DL	<DL	<DL	<DL	<DL
Atrazine	0.05	<DL	<DL	0.17	<DL	<DL-0.17
Alachlor	0.02	<DL	<DL	<DL	<DL	<DL
Metolachlor	0.02	0.24	0.02	<DL	<DL	<DL-0.24
Cyanazine	0.1	<DL	<DL	<DL	<DL	<DL

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

Flora: Ritter Spring is located at the base of a southwest-facing wooded slope. The second growth woods on this dry slope are heavily grazed by cattle. The run from Ritter Spring flows south by southwest for about 15 meters into an impoundment.

The dominant trees are *Populus deltoides* and *Platanus occidentalis*. Other trees included *Celtis occidentalis, Diospyros virginiana, Juniperus virginiana, Liriodendron tulipifera, Morus alba*, and *Quercus prinoides* var. *acuminata*.

The dominant shrub is *Sambucus canadensis*. Other shrubs included *Cornus drummondii*, and *Lonicera maackii*.

The dominant woody vines are *Vitis aestivalis* and *Toxicodendron radicans*. Other woody vines included *Lonicera japonica, Parthenocissus quinquefolia*, and *Vitis riparia*.

The dominant herb is *Festuca pratensis*. Other herbs included *Agrostis alba, Aster* sp., *Calystegia sepium, Carex albolutescens, Carex blanda, Cerastium vulgatum, Chaerophyllum procumbens, Daucus carota, Equisetum arvense, Erigeron philadelphicus, Erysimum repandum, Eupatorium rugosum, Eupatorium serotinum, Galium aparine, Juncus tenuis, Kummerowia stipulacea, Leersia virginica, Medicago lupulina, Medicago sativa, Mollugo verticillatus, Muhlenbergia* sp., *Oenothera biennis, Phyla lanceolata, Plantago rugelii, Poa pratensis, Polygonum neglectum, Ranunculus sceleratus, Rorippa* sp., *Rumex altissimus, Sedum sarmentosum, Solidago canadensis, Taraxacum officinale, Trifolium pratense, Trifolium repens, Triodanis perfoliata, Veronica arvensis*, and *Veronica peregrina*.

Floral abundance and importance values are given in Appendix 2.

Current Status: Ritter Spring emanates from a small cave. The springhead has a variable substrate of silt, sand, and gravel that provides habitat for a moderate diversity (21 taxa). The fauna is composed predominately of non-insectan macroinvertebrates, including the troglophilic cave amphipods *Crangonyx forbesi* and *Gammarus troglophilus*. Nitrate nitrogen was detected in each of the four water samples collected, but not at levels above the EPA MCL. Atrazine was detected in the May water sample and Metolachlor in the November and February water samples, but not at levels above the EPA MCL or HAL. No aquatic macrophytes were found in the springhead or the springbrook.

Sparrow Spring

Sparrow Spring (Fig 16) is the point of the origin of Sparrow Creek. The spring is located at the base of a 24.4 m (80 ft) sloping hill composed of Mississippian age St. Louis limestone. Water from the springhead flows from a bedding plane opening 1.5 m (4.8 ft) high and 4.5 m (15 ft) wide half filled with water 0.73 m (2.5 ft) deep. The slope above the springhead is shored up with a wall of bridge timbers 0.85 m (2.8 ft) high and 30.5 m (100 ft) long. The springbrook

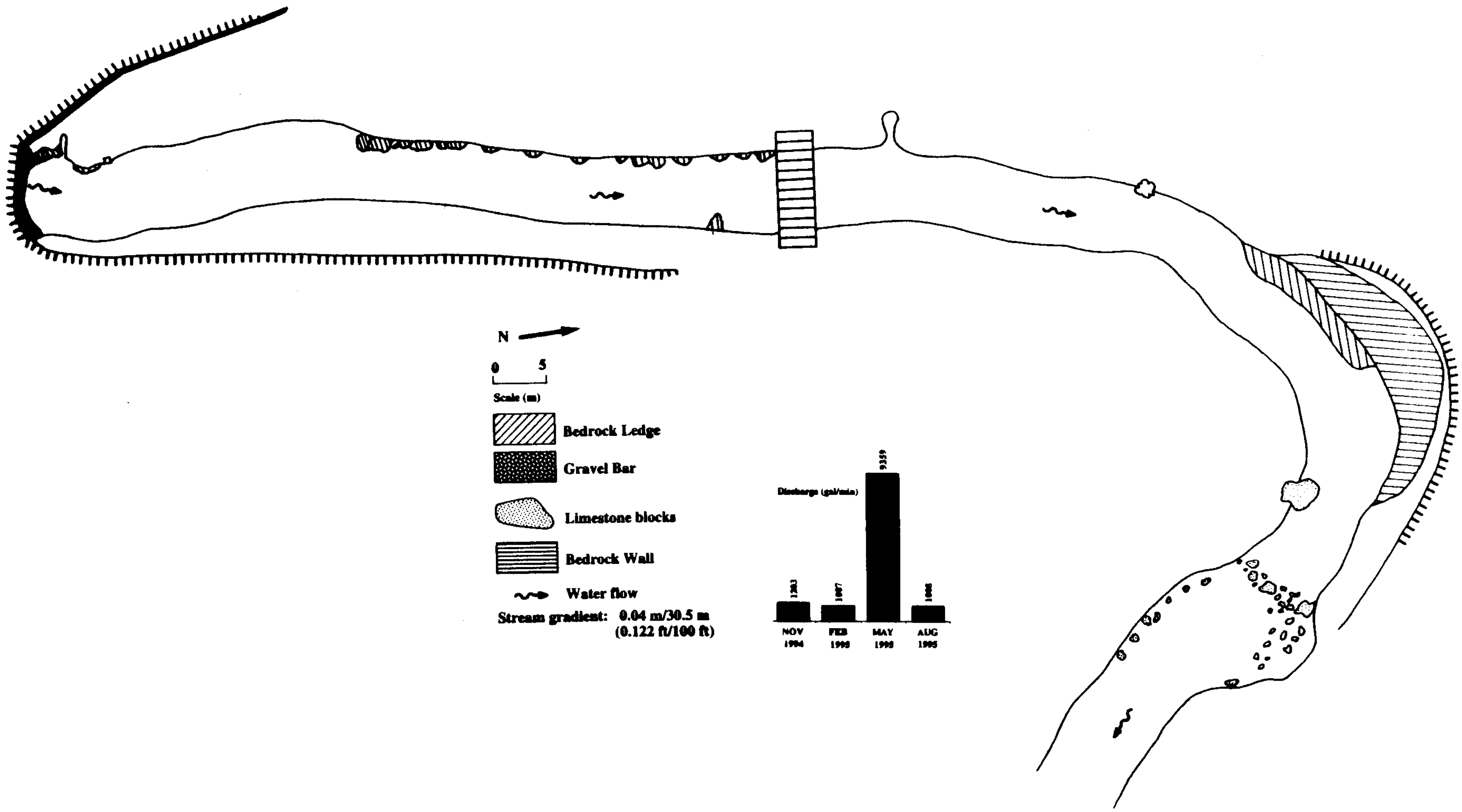

Figure 16. Sparrow Spring, St. Clair County, Illinois.

flows in a very uniform width bedrock channel with little sand and gravel. Joints in the bedrock channel are oriented N 65° E at several locations. The chief bedrock exposure along the channel is 103.6 m (340 ft) downstream from the springhead. The springbrook gradient is 0.004 m:30.5 m (0.12 ft:100 ft). The discharge rate taken in November, 1994, and February, May, and August, 1995, ranged from 1007-9359 gpm (63.5-590 L/sec) (Fig. 16). Substrate analysis at the springhead (Fig. 17) is moderately variable with areas of clay/silt and sand-gravel.

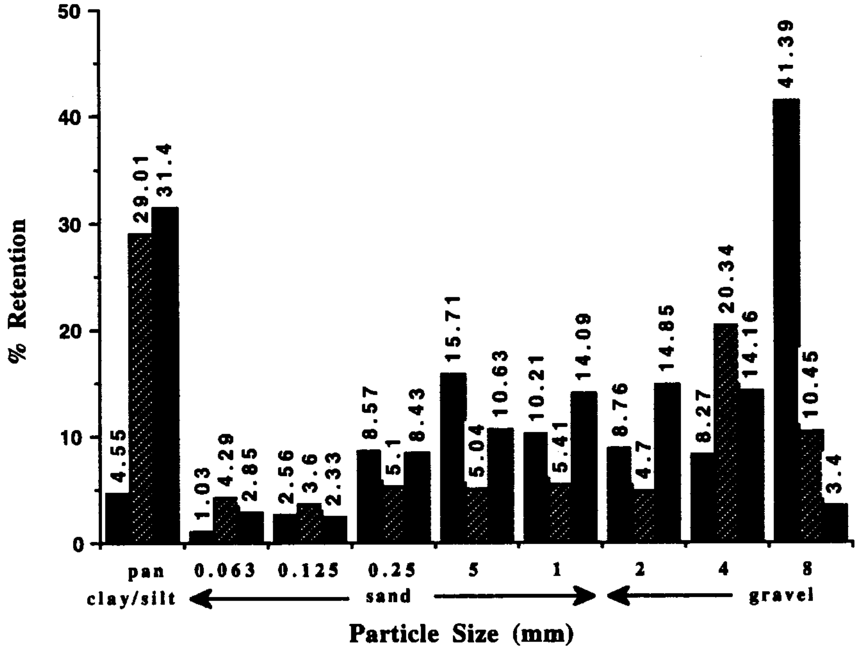

Figure 17. Substrate Analysis at springhead of Sparrow Spring, St. Clair County, Illinois.

Water Quality: Table 8. Nitrate nitrogen ranged from 2.72-4.70 mg/L, and was detected in all four water samples but not at levels above the EPA MCL. Alachlor ranged from <DL-0.26 µg/L, and was detected in the November, February, and May water samples but not at levels above the EPA MCL. Atrazine ranged from <DL-5.09 µg/L, and was detected in the May and August water samples; the concentration for the May sample was 5.09 µg/L, which is above the EPA MCL. Cyanazine ranged from <DL-0.44 µg/L, and was detected in the May water sample, but not at levels above the EPA HAL. Metolachlor ranged from <DL-2.39 µg/L, and was detected in the May water sample but not at levels above the EPA HAL. Mercury ranged from <DL-0.06 µg/L, and was detected in the May water sample, but not at a level above the EPA Maximum Level.

Table 8 Sparrow Spring: Water Quality Analysis 1994 - 1995.	County	St. Clair	St. Clair	St. Clair	St. Clair	
	Location	Head	Head	Head	Head	
	Sample Date	11/15/94	2/22.95	5/16/95	8/22/95	
PARAMETERS *	**Standard****					
Field Measurements						Range
Air Temperature (° C)	-	9.5	11	23	22.5	
Water Temperature (° C)	-	13.8	12.0	15.0	12.0	12-15
Dissolved Oxygen	never < 5.0	8.6	9.5	7.4	8.3	7.4-9.5
Hydrogen Ion Concentration (pH)	6.5 to 9.0		8.1	7.6	7.5	7.5-8.1
Alkalinity, as CaCO3 [<1]	-	191	261	190	275	190-275
Specific Conductivity (µmhos/cm)	-	440	651	483	654	483-654
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		48.5	63.1	49	67.9	48.5-67.9
Dissolved Organic Carbon [<0.1]		16.3	0.1	71.1	39.4	0.1-71.1
Total Dissolved Carbon [<0.1]		64.8	63.2	120.1	107.3	63.2-120.1
Sulfur as Sulfate [<0.01]	500.0	38.6	66.9	47.2	66.5	38.6-66.9
Ammonia Nitrogen [<0.01]	1.5 **	0.12	0.01	1.02	0.02	0.01-1.02
Nitrite Nitrogen [<0.01]	-	<DL	<DL	0.08	<DL	<DL-0.08
Nitrate Nitrogen [<0.01]	-	2.72	4.63	3.86	4.70	2.72-4.70
Total Phosphate [<0.01]		0.46	0.12	1.28	0.12	0.12-1.28
Hardness (EDTA)	*	212	323	245	358	212-358
Chlorides [<0.1]	500.	13.1	20.3	16.3	15.6	13.1-20.3
Total Dissolved Solids [<4]	1000.	384	440	440	492	384-492
Turbidity (NTU)	-		5	81	14	5-81
Dissolved Aluminum [<0.02]	-	0.05	<DL	<DL	0.08	<DL-0.08
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	<0.02	<0.02	<0.02	<0.02	<0.02
Dissolved Barium [0.005]	5.00	0.08	0.08	0.08	0.10	0.08-0.10
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolved Calcium [0.005]	-	65	97.8	72.4	110.0	65-110
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	0.02	<DL	<DL	0.11	<DL-0.11
Dissolved Potassium [1.0]	-	5	<DL	9	2	<DL-9
Dissolved Lanthanum		<0.002	<0.005	0.003	<0.005	<0.002-<0.003
Dissolved Lithium [0.01	-	<DL	<DL	<DL	<DL	<DL

Table 8 (concluded)	County	St. Clair	St. Clair	St. Clair	St. Clair	
Sparrow Spring: Water Quality	**Location**	Head	Head	Head	Head	
Analysis 1994 - 1995.	**Sample Date**	11/15/94	2/22.95	5/16/95	8/22/95	
PARAMETERS *	**Standard****					Range
Dissolved Magnesium [<0.01]	-	12.0	19.0	15.4	20.1	12.0-20.1
Dissolved Manganese [<0.01]	1.00	<DL	0.04	<DL	0.10	<DL-0.04
Dissolved Molybdenum [0.016]	-	<0.02	<0.02	<0.02	<DL	<DL-<0.02
Dissolved Sodium [<2]	-	13.2	24.9	17.6	24.3	13.2-24.9
Dissolved Selenium [0.015]	1.0	<0.2	<DL	<DL	<DL	<DL-<0.2
Dissolved Silicon [0.010]	-	8.70	10.40	8.27	12.3	8.27-12.3
Dissolved Strontium [0.0015]	-	0.17	0.21	0.17	0.23	0.17-0.23
Dissolved Thallium [0.08]	-	<0.3	<0.2	<0.3	<0.3	<0.2-<0.3
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	0.12	0.02	0.36	<0.01	<0.01-0.36
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	<DL	<DL	0.06	<DL	<DL-0.06
Atrazine	0.05	<DL	<DL	5.09	0.25	<DL-5.09
Alachlor	0.02	0.26	0.02	0.19	<DL	<DL-0.26
Metolachlor	0.02	<DL	<DL	2.39	<DL	<DL-2.39
Cyanazine	0.1	<DL	<DL	0.44	<DL	<DL-0.44

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

Fauna (springhead): Nematoda (unidentifiable). Annelida: Oligochaeta: Enchytraeidae (unidentifiable). Lumbricidae (unidentifiable). Naididae: *Bratislavia unidentata, Dero digitata, D. nivea, Nais communis, N. pardalis, N. variabilis, Nais* sp. LCC1, *Paranais frici, Slavina appendiculata, Stylaria lacustris.* Tubificidae: *Limnodrilus cervix, L. hoffmeisteri.* Hirudinea: Erpobdellidae (unidentifiable). Crustacea: Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus pseudolimnaeus, G. troglophilus.* Hyalellidae: *Hyalella azteca.* Decapoda: Cambaridae: *Orconectes virilis.* Isopoda: Asellidae: *Caecidotea brevicauda.* Insecta: Coleoptera: Dytiscidae: dytiscid sp. 1. Gyrinidae: *Dineutus* sp. Diptera: Simuliidae: *Simulium tuberosum* complex. Ephemeroptera: Caenidae: *Caenis* sp. Heptageniidae: *Stenonema* sp. Hemiptera: Gerridae: *Aquarius remigis.* Trichoptera: Hydropsychidae: *Cheumatopsyche analis.* Hydroptilidae: *Hydroptila* possibly *scolops.* Leptoceridae: *Oecetis inconspicua.* Mollusca: Gastropoda: gastropodid sp. 2, sp. 4.

Fauna (springbrook): Nematoda (unidentifiable). Annelida: Branchobdellida: Cambarincolidae: (unidentifiable). Oligochaeta: Enchytraeidae (unidentifiable). Lumbricidae (unidentifiable). Naididae: *Allonais paraguayensis, Bratislavia unidentata, Dero digitata, D. nivea, Nais variabilis, Slavina appendiculata, Stylaria lacustris.* Tubificidae: *Limnodrilus hoffmeisteri.* Arthropoda: Crustacea: Amphipoda: Gammaridae: *Gammarus pseudolimnaeus.* Hyalellidae: *Hyalella azteca.* Crustacea: Decapoda: Cambaridae: *Orconectes* sp. (immature). Isopoda: Asellidae: *Caecidotea brevicauda.* Insecta: Coleoptera: Dryopidae: *Helichus* sp. Dytiscidae: dytiscid sp. Gyrinidae: *Dineutus* sp. Hydrophilidae: hydrophilid sp. 1, sp. 2. Diptera: Ceratopogonidae: *Bezzia* sp. Chaoboridae: *Chaoborus (Sayomyia) punctipennis.* Chironomidae: *Cricotopus* sp. 1, *Dicrotendipes nervosus, Glyptotendipes paripes, Orthocladius* sp. 3. *Phaenopsectra flavipes, Polypedilum halterale, Procladius bellus, Tanypus neopunctipennis, Tanytarsus* sp. Psychodidae: *Psychoda* sp. Simuliidae: *Simulium vittatum* complex. Ephemeroptera: Caenidae: *Caenis* sp. Heptageniidae: *Stenonema* sp. Hemiptera: Corixidae: *Trichocorixa* sp. 1. Gerridae: *Aquarius remigis.* Mesoveliidae: *Mesovelia mulsanti.* Nepidae: *Ranatra fusca.* Notonectidae: *Notonecta* sp. Trichoptera: Hydropsychidae: *Cheumatopsyche analis.* Hydroptilidae: *Hydroptila* cf. *scolops.* Leptoceridae: *Oecetis inconspicua, Oecetis* sp. 1. Mollusca: Gastropoda: gastropodid sp. 4, sp. 5.

Flora: Sparrow Creek Spring is located at the base of a north-facing disturbed hillside. The run formed by the spring has been heavily disturbed and the west side of the run is planted in non-native grasses. The east side of the run is lightly wooded.

The dominant trees are *Quercus prinoides* var. *acuminata, Fraxinus americana*, and *Ulmus americana.* Other trees included *Acer negundo, Asimina triloba, Celtis occidentalis, Cercis canadensis, Juglans nigra, Morus alba, Platanus occidentalis*, and *Prunus serotina.* Most of the trees were represented only as seedlings or saplings.

The dominant shrubs are *Rosa multiflora* and *Sambucus canadensis*. Other shrubs included *Lonicera maackii*, and *Symphoricarpos orbiculatus*.

The dominant woody vines are *Lonicera japonica* and *Toxicodendron radicans*. Other woody vines included *Parthenocissus quinquefolia*, and *Vitis riparia*.

The dominant herb is *Festuca pratensis*. Other herbaceous plants included *Agrostis alba, Amaranthus* sp., *Ambrosia artemisiifolia, Ambrosia trifida, Amphicarpaea bracteata, Asclepias syriaca, Asplenium platyneuron, Aster pilosus, Aster* sp., *Barbarea vulgaris, Boehmeria cylindrica, Bromus* sp., *Calystegia sepium, Carex grisea, Chenopodium album, Cichorium intybus, Coronilla varia, Dactylis glomerata, Echinochloa crus-galli, Elymus villosus, Elymus virginicus, Equisetum arvense, Erigeron philadelphicus, Erysimum repandum, Eupatorium rugosum, Eupatorium serotinum, Galium aparine, Glechoma hederacea, Glyceria striata, Humulus* sp., *Impatiens capensis, Juncus torreyi, Lamium purpureum, Leersia oryzoides, Leersia virginica, Lycopus* sp., *Melilotus alba, Melilotus officinalis, Mollugo verticillata, Muhlenbergia* sp., *Oxalis dillenii, Passiflora lutea* var. *glabriflora, Phalaris arundinacea, Phleum pratense, Phlox divaricata laphamii, Pilea pumila, Plantago rugelii, Poa annua, Poa pratensis, Polygonum neglectum, Polygonum pensylvanicum, Prunella vulgaris, Ranunculus abortivus, Rumex altissimus, Rumex crispus, Scirpus atrovirens, Scrophularia marilandica, Solanum carolinense, Solidago canadensis, Stellaria media, Taraxacum officinale, Teucrium canadense, Thlaspi arvense, Torilis japonica, Trifolium pratense, Trifolium repens, Triodanis perfoliata, Verbena urticifolia, Valerianella radiata, Veronica peregrina, Viola sororia*, and *Xanthium strumarium*.

Floral abundance and importance values are given in Appendix 2.

Current Status: Sparrow Creek Spring is the largest spring in this study, both in terms of size and discharge. It arises from the base of a low hillside on the edge of a severely disturbed area. The springhead has a high diversity of macroinvertebrates (32 taxa), both aquatic insects and non-insectan macroinvertebrates. The troglophilic cave amphipods *Crangonyx forbesi* and *Gammarus troglophilus* were collected from the springhead. The springbrook is the beginning of Sparrow Creek which has a diversity of substrates with areas of clay/silt, sand, coarse gravel, cobble, and bedrock. This diversity of habitats is exemplified in the fauna of the springbrook (46 taxa). No specimens of the troglophilic cave amphipods were collected from the springbrook, although the rare oligochaete *Allonais paraguayensis* was collected. Nitrate nitrogen was detected in all four of the water samples collected, but not at levels above the EPA MCL. Alachlor was detected in the November, February, and May water samples, Atrazine in the May and August water samples, and Cyanazine and Metolachlor in the May water sample, but not at levels above the EPA MCL or HAL. Mercury was detected in the May water sample, but not above the EPA Maximum Level. No aquatic macrophytes were found in the springhead or the springbrook.

Terry Spring

Terry Spring (Fig. 18) is situated about 7.6 m (25 ft) above a lowland road in a near vertical bluff which rises 39.6 m (130 ft) above the Mississippi River floodplain. The bluff is composed of St. Louis and Ste. Genevieve limestone of Mississippian age. Springwater emerges from the bluff as a 1.8 m (6 ft) waterfall emanating from an elliptical shaped cave opening 1.1 m (3.5 ft) high and 4.6 m (15 ft) wide. A relatively thick 3.5 m (11.5 ft) dolomite layer below the waterfall forms a breached bowl or cirque-like structure 7.6 m (25 ft) in diameter that acts as a shallow retention pond for spring outflow. The dolomite exfoliates in a concave manner along the margin of the bowl shaped exposure. Weathered blocks of a freshwater limestone deposit filled with moss rootlets or possibly remnant *Amblystegium* fragments are present at several locations along the margin of the bowl shaped exposure. Careful examination and analysis of the freshwater limestone revealed a radiocarbon age date of 10,840-plus/minus 170 years BP, a gastropod specimen of *Amnicola,* and a juvenile ostracod *Cypidopsis vidua.* The mineralogical composition of the freshwater limestone was found to be similar to the freshwater limestone at Auctioneer Spring near Valmeyer, Monroe County (Appendix 1). The radiocarbon date suggest that dissolution of the limestone at the spring may have been ongoing 10-11,000 years ago. The springbrook gradient from the waterfall to the road is 7.8 m:30.5m (27.7 ft:100 ft). The discharge rates in November, 1994, and February, May, and August, 1995, ranged from 22-146 gpm (1.4-9.2 L/sec) (Fig. 18). The substrate of the springhead is a bedrock limestone ledge.

Water Quality: Table 9. Nitrate nitrogen ranged from 1.69-5.00 mg/L, and was detected in all four water samples but not at levels above the EPA MCL. Atrazine ranged from <DL-0.07 µg/L, and was detected in the May and August water samples but not at levels above the EPA MCL. Metolachlor ranged from <DL-0.2 µg/L, and was detected in the November and May water samples but not at levels above the EPA HAL. Alachlor, Cyanazine, and Mercury were not detected.

Fauna (springhead): Turbellaria: *Phagocata gracilis.* Annelida: Oligochaeta: Enchytraeidae (unidentifiable). Naididae: *Nais communis, Nais* sp. Crustacea: Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus pseudolimnaeus, G. troglophilus.* Isopoda: Asellidae: *Caecidotea brevicauda, C. packardi.* Insecta: Coleoptera: Hydrophilidae: hydrophylid sp. 1. Ephemeroptera: Heptageniidae: *Stenonema* sp. Hemiptera: Corixidae: *Trichocorixa* sp. 1. Mesoveliidae: *Mesovelia mulsanti.* Mollusca: Gastropoda: gastropodid sp. 2.

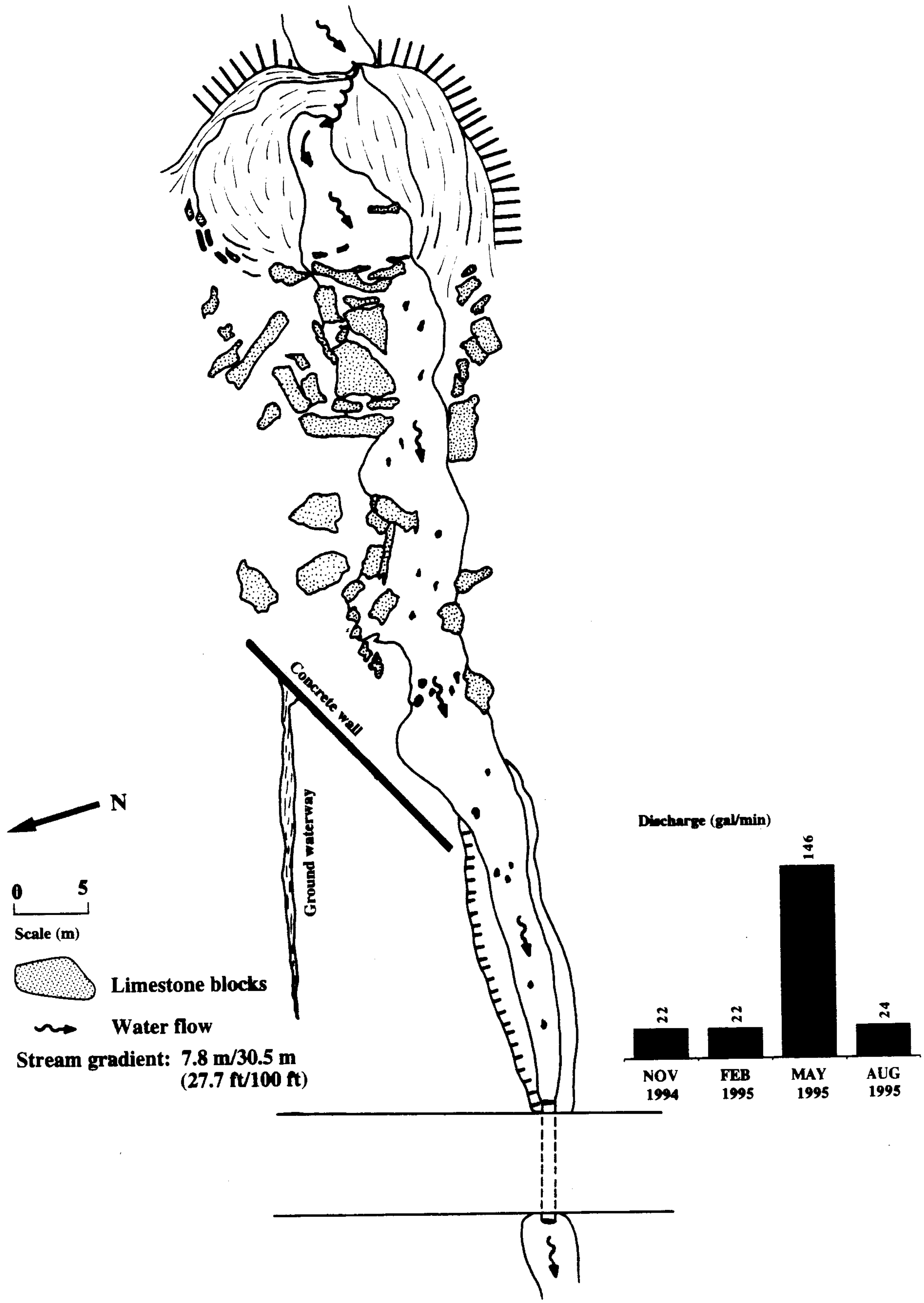

Figure 18. Terry Spring, Monroe County, Illinois.

TABLE 9	County	Monroe	Monroe	Monroe	Monroe	
Terry Spring: Water Quality	Location	Head	Head	Head	Head	
Analysis 1994 - 1995.	Sample Date	11/17/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					
Field Measurements						**Range**
Air Temperature (° C)	-	10	16	23.5	22.5	
Water Temperature (° C)	-	12.8	11.9	13.5	11.5	11.5-13.5
Dissolved Oxygen	never < 5.0	10.9	6.4	8.7	8.8	6.4-10.9
Hydrogen Ion Concentration (pH)	6.5 to 9.0		8.1	7.9	7.3	7.3-8.1
Alkalinity, as CaCO3 [<1]	-	223	309	246	293	223-309
Specific Conductivity (μmhos/cm)	-	522	659	577	689	522-689
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		57.7	74.4	62.0	68.5	57.7-74.4
Dissolved Organic Carbon [<0.1]		13.6	0.3	51.0	29.8	0.3-51.0
Total Dissolved Carbon [<0.1]		71.3	74.7	113.0	98.4	71.3-98.4
Sulfur as Sulfate [<0.01]	500.0	35.6	42.6	43.1	51.4	35.6-51.4
Ammonia Nitrogen [<0.01]	1.5 **	0.04	0.02	0.04	0.01	0.01-0.04
Nitrite Nitrogen [<0.01]	-	<DL	<DL	<DL	<DL	<DL
Nitrate Nitrogen [<0.01]	-	1.69	3.39	2.93	5.00	1.69-5.00
Total Phosphate [<0.01]		0.72	0.13	0.15	0.09	0.09-0.72
Hardness (EDTA)	*	243	336	266	379	243-379
Chlorides [<0.1]	500.	11.20	11.30	8.42	15.60	8.42-15.60
Total Dissolved Solids [<4]	1000.	456	460	424	476	424-476
Turbidity (NTU)	-		3	19	3	3-19
Dissolved Aluminum [<0.02]	-	<DL	<DL	<DL	0.05	<DL-0.05
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	<0.02	<0.02	<0.02	<0.02	<0.02
Dissolved Barium [0.005]	5.00	0.09	0.09	0.08	0.09	0.08-0.09
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolved Calcium [0.005]	-	64.8	97.1	79.4	108.0	64.8-108.0
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	0.05	<DL	<DL	0.13	<DL-0.13
Dissolved Potassium [1.0]	-	7	2	<DL	<DL	<DL-7
Dissolved Lanthanum		<0.002	<0.005	<0.003	<0.005	<0.002-<0.005
Dissolved Lithium [0.01	-	<DL	<DL	<DL	0.01	<DL

TABLE 9 (concluded).	County	Monroe	Monroe	Monroe	Monroe	
Terry Spring: Water Quality	Location	Head	Head	Head	Head	
Analysis 1994 - 1995.	Sample Date	11/17/94	2/23/95	5/23/95	8/23/95	
PARAMETERS *	**Standard****					**Range**
Dissolved Magnesium [<0.01]	-	19.5	22.5	16.2	26.0	16.0-22.5
Dissolved Manganese [<0.01]	1.00	0.25	0.17	0.25	0.22	0.17-0.25
Dissolved Molybdenum [0.016]	-	<0.02	<0.02	<0.02	<DL	<DL-<0.02
Dissolved Sodium [<2]	-	9.51	13.70	11.30	17.80	9.51-17.80
Dissolved Nickel [0.03]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Lead [0.004]	0.1	<0.06	<0.04	<0.08	<0.04	<0.04-<0.08
Dissolved Antimony [0.06]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Scandium		<0.003	<0.005	<0.003	<0.003	<0.003-<0.005
Dissolved Selenium [0.015]	1.0	<0.2	<DL	<DL	<DL	<DL-<0.2
Dissolved Silicon [0.010]	-	9.0	14.0	12.6	16.3	9.0-16.3
Dissolved Strontium [0.0015]	-	0.16	0.18	0.16	0.19	0.16-0.19
Dissolved Thallium [0.08]	-	<0.3	<0.2	<0.3	<0.3	<0.2-<0.3
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	0.03	0.12	0.08	<0.01	<0.01-0.12
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	<DL	<DL	<DL	<DL	<DL
Atrazine	0.05	<DL	<DL	0.07	0.06	<DL-0.07
Alachlor	0.02	<DL	<DL	<DL	<DL	<DL
Metolachlor	0.02	0.20	<DL	0.06	<DL	<DL-0.20
Cyanazine	0.1	<DL	<DL	<DL	<DL	<DL

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

Fauna (springbrook): Turbellaria: *Phagocata gracilis.* Annelida, Oligochaeta: Naididae: *Dero digitata.* Tubificidae: *Limnodrilus hoffmeisteri.* Crustacea: Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus pseudolimnaeus.* Isopoda: Asellidae: Caecidotea *brevicauda.* Insecta: Coleoptera: Dytiscidae: dytiscid sp. Hydrophilidae; hydrophilid sp. 1. Trichoptera; Hydroptilidae: *Hydroptila* sp. 1. Mollusca: Gastropoda: gastropodid sp. 2.

Flora: Terry Spring forms a stream that flows west from a vertical rock cliff and runs through a steep forested slope for about 15 meters before it crosses under Bluff Road through a corrugated culvert and enters the Mississippi River bottomland.

The dominant trees are *Acer saccharum* and *Celtis occidentalis.* Other trees included *Fraxinus americana, Gymnocladus dioicus, Quercus prinoides* var. *acuminata,* and *Ulmus americana.*

The dominant shrubs are *Lindera benzoin* and *Symphoricarpos orbiculatus.* One other shrub associated was *Hydrangea arborescens.*

The dominant woody vine is *Parthenocissus quinquefolia.* Other woody vines included *Campsis radicans*, and *Smilax hispida.*

The dominant herbs are *Carex grisea, Carex jamesii,* and *Eupatorium rugosum.* Other herbs included *Acalypha rhomboidea, Arabis shortii, Aster* sp., *Bidens* sp., *Carex albursina, Carex* sp., *Conyza canadensis, Cystopteris tennesseensis, Daucus carota, Elymus virginicus, Erigeron philadelphicus, Festuca obtusa, Festuca pratensis, Glyceria striata, Hydrophyllum appendiculatum, Impatiens* sp., *Leersia virginica, Melilotus* sp., *Osmorhiza longistylis, Oxalis stricta, Perilla frutescens, Phryma leptostachya, Pilea pumila, Plantago rugelii, Poa pratensis, Polygonum amphibium, Polygonum caespitosum* var *longisetum, Polygonum persicaria, Ranunculus abortivus, Rumex crispus, Rumex obtusifolium, Sanicula canadensis, Scrophularia marilandica, Silene stellata, Taraxacum officinale, Trifolium campestre*, unknown dicot herb, and *Viola sororia.*

Floral abundance and importance values are given in Appendix 2.

Current Status: Terry Spring is a cave spring near the base of a vertical limestone bluff. The springhead flows from a cave opening in limestone. This bedrock substrate provides a limit amount of habitat for macroinvertebrates, although 13 taxa were collected. The turbellarian *Phagocata gracilis* and the troglophilic cave amphipods *Crangonyx forbesi* and *Gammarus troglophilus* and isopod *Caecidotea packardi* were collected at the springhead. The springbrook is very short, with a sand-gravel substrate. Their is a limited fauna in this springbrook (11 taxa), although specimens of the troglophilic cave amphipod *Crangonyx forbesi* were collected. Nitrate nitrogen was detected in each of the four water samples collected, but never at levels above the EPA MCL. Atrazine was detected in the May and August water samples and Metolachlor in the November and May water samples, but not at levels above the EPA MCL or HAL. No aquatic macrophytes were found in the springhead or the springbrook.

Walsh Spring

Walsh Spring (Fig. 19) is situated in Mississippian Ste. Genevieve limestone at the base of a ravine. The base of the ravine is located at the edge of a flood plain which contains an intermittent tributary to Horse Creek. The upland surrounding the ravine has a relief of 15.2-22.9 m (50-75 ft) and is formed in Au Vases sandstone and Renault limestone of Mississippian age. Water from the spring discharges over a rock ledge then through and beneath large blocks of limestone and several deposits of sand and silt at the west side of the cave opening. The cave opening is elliptical shaped with a maximum height of 0.7 m (2.4 ft) and length of 11.0 m (36 ft). The stream gradient from the springhead to a mapped point 36.6 m (120 ft) downstream is 1 m:30.5m (3.2 ft:100ft). The discharge rate taken in November, 1994, and February, May, and August, 1995, ranged from 39-1675 gpm (2.5-105.7 L/sec) (Fig. 19). Three substrate analyses below the springhead (Fig. 20) are dominated by a coarse gravel-cobblestone substrate, with scattered pockets of sand-gravel.

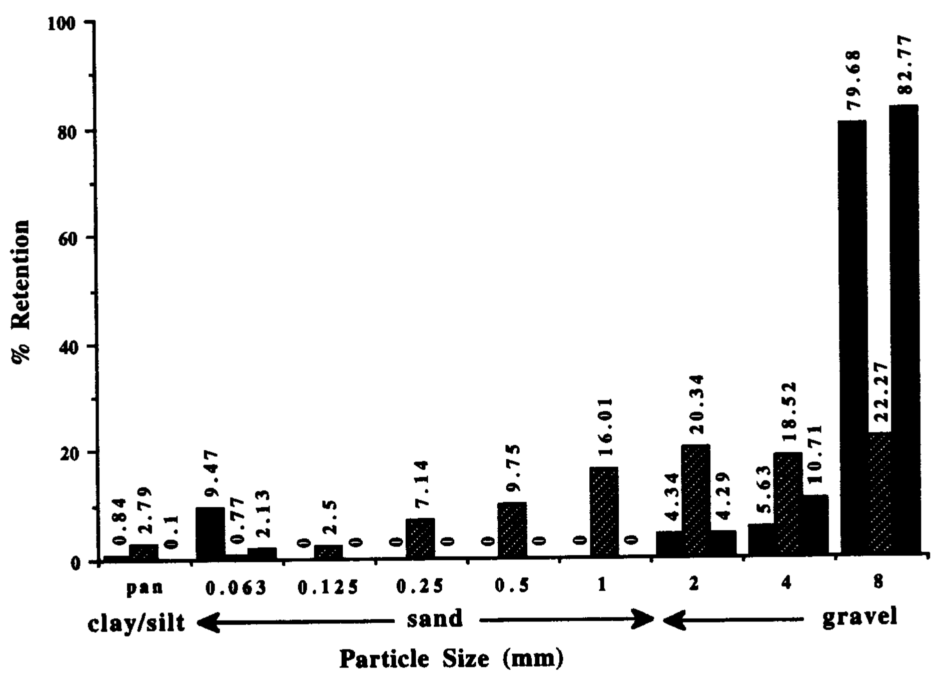

Figure 20. Substrate Analysis at springhead of Walsh Spring, Monroe County, Illinois

Water Quality: Table 10. Nitrate nitrogen ranged from 1.74-3.53 mg/L, and was detected in all four water samples, all below the EPA MCL. Alachlor ranged from <DL-2.89 µg/L, and was

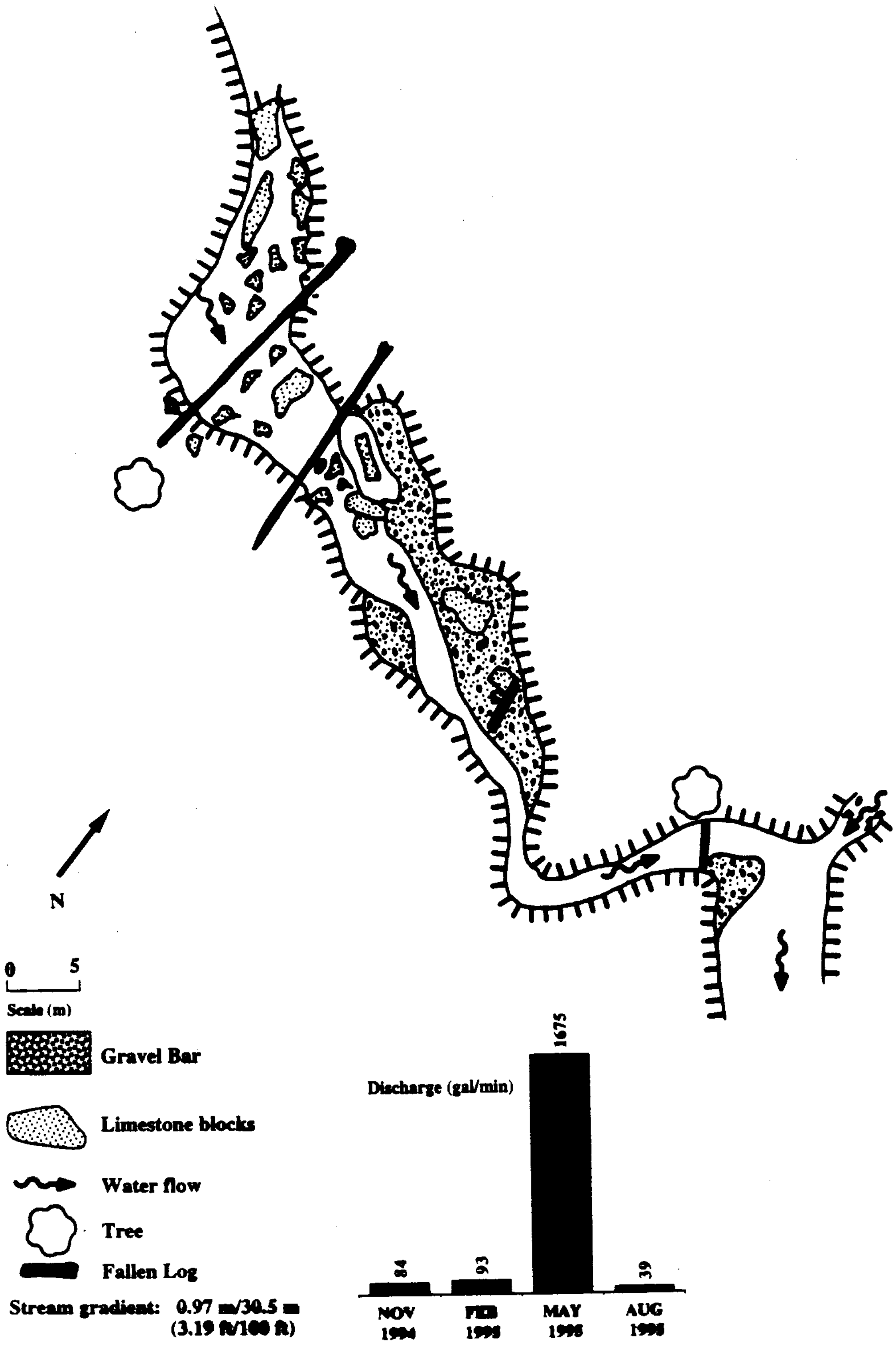

Figure 19. Walsh Spring, Monroe County, Illinois.

TABLE 10	County	Monroe	Monroe	Monroe	Monroe	
Walsh Spring: Water Quality	Location	Head	Head	Head	Head	
Analysis 1994 - 1995.	Sample Date	11/16/94	2/22/95	5/16/95	8/22/95	
PARAMETERS *	**Standard****					
Field Measurements						**Range**
Air Temperature (° C)	-	11.5	14	21	25	
Water Temperature (° C)	-	13.4	11.8	15.0	15.0	11.8-15.0
Dissolved Oxygen	never < 5.0	7.4	9.2	10.8	7.5	7.4-10.8
Hydrogen Ion Concentration (pH)	6.5 to 9.0		7.8	8.1	8.0	7.8-8.1
Alkalinity, as CaCO3 [<1]	-	73.4	154.0	109.0	144.0	73.4-154.0
Specific Conductivity (μmhos/cm)	-	223	505	472	385	223-505
Laboratory Measurements						
Inorganic Dissolved Carbon [<0.1]		18.6	37.6	25.0	33.3	18.6-37.6
Dissolved Organic Carbon [<0.1]		20.5	0.1	35.0	25.7	0.1-35.0
Total Dissolved Carbon [<0.1]		39.1	37.7	60.0	59.0	37.7-60.0
Sulfur as Sulfate [<0.01]	500.0	23.4	77.4	30.1	33.6	23.4-77.4
Ammonia Nitrogen [<0.01]	1.5 **	0.04	0.01	0.02	0.02	0.01-0.04
Nitrite Nitrogen [<0.01]	-	<DL	<DL	<DL	<DL	<DL
Nitrate Nitrogen [<0.01]	-	1.74	3.53	3.46	2.20	1.74-3.53
Total Phosphate [<0.01]		0.67	0.19	0.23	0.16	0.16-0.67
Hardness (EDTA)	*	94.7	218.0	82.0	180.0	82.0-218.0
Chlorides [<0.1]	500.	9.07	18.2	10.70	7.11	7.11-18.20
Total Dissolved Solids [<4]	1000.	268	352	216	256	216-352
Turbidity (NTU)	-		3	29	9	3-29
Dissolved Aluminum [<0.02]	-	0.15	<DL	<DL	0.10	<DL-0.15
Dissolved Arsenic [0.1]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Boron [0.008]	1.0	<0.02	<0.02	0.02	<0.2	<0.02-0.2
Dissolved Barium [0.005]	5.00	0.06	0.08	0.02	0.10	0.02-0.10
Dissolved Beryllium [0.0006]	-	<0.001	<0.002	<0.001	<0.002	<0.001-<0.002
Dissolved Calcium [0.005]	-	27.6	63.1	18.8	54.5	18.8-63.1
Dissolved Cadmium [0.01]	0.05	<DL	<DL	<DL	<DL	<DL
Dissolved Cobalt [0.014]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Chromium [0.014]	**	<DL	<DL	<DL	<DL	<DL
Dissolved Copper [0.011]	0.02	<DL	<DL	<DL	<DL	<DL
Dissolved Iron [<0.01]	1.00	<0.09	<DL	<DL	0.10	<DL-0.10
Dissolved Potassium [1.0]	-	7	4	3	4	3-7
Dissolved Lanthanum		<0.002	<0.005	<0.003	<0.005	<0.002-<0.005
Dissolved Lithium [0.01	-	<DL	<DL	<DL	<DL	<DL

TABLE 10 (concluded). Walsh Spring: Water Quality Analysis 1994 - 1995.	County	Monroe	Monroe	Monroe	Monroe	
	Location	Head	Head	Head	Head	
	Sample Date	11/16/94	2/22/95	5/16/95	8/22/95	
PARAMETERS *	**Standard****					**Range**
Dissolved Magnesium [<0.01]	-	6.02	14.80	8.54	10.50	6.02-14.80
Dissolved Manganese [<0.01]	1.00	<DL	<DL	<DL	0.04	<DL-0.04
Dissolved Molybdenum [0.016]	-	<0.02	<0.02	<0.02	<DL	<DL-<0.02
Dissolved Sodium [<2]	-	4.66	18.30	13.00	12.30	4.66-18.30
Dissolved Nickel [0.03]	1.0	<DL	<DL	<DL	<DL	<DL
Dissolved Lead [0.004]	0.1	<0.06	<0.04	<0.08	<0.04	<0.04-<0.08
Dissolved Antimony [0.06]	-	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Scandium		<0.003	<0.005	<0.003	<0.003	<0.003-<0.005
Dissolved Selenium [0.015]	1.0	<0.2	<DL	<DL	<DL	<DL-<0.2
Dissolved Silicon [0.010]	-	4.90	6.07	0.86	5.70	0.86-6.07
Dissolved Strontium [0.0015]	-	0.08	0.17	0.06	0.15	0.06-0.17
Dissolved Thallium [0.08]	-	<0.3	<0.2	<0.3	<0.3	<0.2-<0.3
Dissolved Titanium [0.008]	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Vanadium [0.015]	-	<DL	<DL	<DL	<DL	<DL
Dissolved Zinc [0.004]	1.0	<0.01	<0.01	0.04	0.01	<0.01-0.04
Dissolved Zirconium [0.01]	-	<DL	<DL	<DL	<DL	<DL
Total Mercury [0.00005]	0.0005	<DL	<DL	<DL	<DL	<DL
Atrazine	0.05	<DL	0.23	5.83	0.75	<DL-5.83
Alachlor	0.02	<DL	<DL	2.89	<DL	<DL-2.89
Metolachlor	0.02	<DL	<DL	1.00	0.07	<DL-1.0
Cyanazine	0.1	<DL	<DL	<DL	<DL	<DL

*Unless otherwise specified, all measurements are expressed in milligrams per liter (mg/l).

**Surface water quality standards are taken from: Illinois Environmental Protection Agency. 1989. Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I. Pollution Control Board. Part 302 - Water Quality Standards. Sections 302.201 through 302.212.

Ammonia Nitrogen and Un-ionized Ammonia: a) Ammonia nitrogen shall in no case exceed 15 mg/l; b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l; c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration. [If total ammonia is >1.5 mg/l, then calculations must be made to determine the unionized ammonia concentration based upon pH and temperature.]

Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

Although no current standard for total chromium has been established, the current standard for total hexavalent chromium is 0.05 mg/l; the current standard for total trivalent chromium is 1.0 mg/l; the sum of these two constituents would infer that the total chromium standard is 1.05 mg/l.

detected in the May water sample at a level above the EPA MCL. Atrazine ranged from <DL-5.83 µg/L, and was detected in the February, May, and August water samples. The May sample was at a level well above the EPA MCL. Metolachlor ranged from <DL-1.00 µg/L, and was detected in the May and August water samples, each below the EPA HAL. Cyanazine and Mercury were not detected.

Fauna (springhead): Turbellaria: Planariidae: *Phagocata gracilis.* Nematoda (unidentifiable). Annelida: Aeolosomatida: Aeolosomatidae: *Aeolosoma* sp. Oligochaeta: Enchytraeidae (unidentifiable). Lumbricidae (unidentifiable). Naididae: *Allonais paraguayensis, Nais communis, N. pardalis, N. variabilis, Nais* sp., *Ophidonais serpentina.* Tubificidae: *Limnodrilus cervix, L. hoffmeisteri.* Crustacea: Amphipoda: Gammaridae: *Gammarus pseudolimnaeus, G. troglophilus.* Isopoda: Asellidae: *Caecidotea brevicauda.* Insecta: Coleoptera: Hydrophilidae: hydrophilid sp. 1, sp. 2, sp. 3, sp. 4, sp. 5, sp. 6, sp. 7, sp. 8. Diptera: Ceratopogonidae: *Bezzia* sp. Chaoboridae: *Chaoborus* (*Sayomyia*) *punctipennis.* Chironomidae: *Conchapelopia* sp., *Glyptotendipes paripes, Phaenopsectra flavipes, Polypedilum scalaenum, Tribelos jucundum* . Tipulidae: *Tipula* sp. 1. Ephemeroptera: Heptageniidae: *Stenonema* sp. Leptophlebiidae: *Leptophlebia* sp. Hemiptera: Notonectidae: *Notonecta* sp. Trichoptera: Hydropsychidae: *Cheumatopsyche analis.* Hydroptilidae: *Orthotrichia americana.* Leptoceridae: *Oecetis inconspicua.* Polycentropodidae: *Polycentropus centralis.*

Fauna (springbrook): Annelida: Oligochaeta: Lumbricidae (unidentifiable). Lumbriculidae (unidentifiable). Enchytraeidae (unidentifiable). Naididae: *Allonais paraguayensis, Dero digitata, Nais communis, N. pardalis, N. variabilis, Nais* sp. LC1. Tubificidae: *Limnodrilus hoffmeisteri, Varichaetadrilus angustipenis.* Amphipoda: Crangonyctidae: *Crangonyx forbesi.* Gammaridae: *Gammarus pseudolimnaeus, G. troglophilus.* Isopoda: Asellidae: Caecidotea *brevicauda.* Insecta: Trichoptera: Hydropsychidae: *Cheumatopsyche analis.* Hydroptilidae: *Orthotrichia americana.* Leptoceridae: *Oecetis inconspicua.*

Flora: Walsh Spring is located in and helps form a stream which flows through a young second growth forest. The resulting wooded ravine eventually flows into Horse Creek.

The dominant trees are *Acer negundo, Sassafras albidum, Ulmus americana*, and *Cornus florida.* Other trees included *Amelanchier arborea, Carya cordiformis, Carya ovalis, Carya ovata, Celtis occidentalis, Cercis canadensis, Cornus florida, Diospyros virginiana, Fraxinus americana, Platanus occidentalis, Prunus serotina, Quercus alba, Quercus imbricaria, Quercus prinoides* var. *acuminata, Salix nigra, Sassafras albidum*, and *Ulmus americana.*

The dominant shrub is *Cornus drummondii.* Other shrubs included *Rhamnus caroliniana, Rosa multiflora*, and *Sambucus canadensis.*

The dominant woody vines are *Vitis* sp. and *Parthenocissus quinquefolia*. Other woody vines included *Campsis radicans, Smilax hispida*, and *Toxicodendron radicans*.

The dominant herbs are *Amphicarpaea bracteata, Leersia virginica*, and *Festuca obtusa*. Other herbs included *Agrimonia pubescens, Allium canadense, Ambrosia artemisiifolia, Amphicarpaea bracteata, Asplenium platyneuron, Aster* sp., *Barbarea vulgaris, Botrychium virginianum, Bromus pubescens, Cacalia atriplicifolia, Calystegia sepium, Carex blanda, Carex cephalophora, Carex granularis, Carex grisea, Carex normalis, Carex tribuloides, Chaerophyllum procumbens, Chasmanthium latifolium, Cinna arundinacea, Circaea lutetiana canadensis, Cirsium altissimum, Cryptotaenia canadensis, Desmodium glutinosum, Dioscorea villosa, Elymus villosus, Elymus virginicus, Equisetum arvense, Eupatorium rugosum, Erigeron annuus, Erigeron philadelphicus, Eupatorium rugosum, Festuca elatior, Festuca obtusa, Galium aparine, Galium triflorum, Geranium maculatum, Geum canadense, Glyceria striata, Helianthus divaricatus, Impatiens capensis, Juncus tenuis, Lactuca* sp., *Lilium michiganense, Osmorhiza longistylis, Panicum boscii, Panicum clandestinum, Phryma leptostachya, Phlox divaricata laphamii, Phryma leptostachya, Physostegia virginiana* var. *virginiana, Pilea pumila, Poa sp., Poa sylvestris, Polystichum acrostichoides, Prunella vulgaris, Ranunculus abortivus, Ranunculus recurvatus, Sanicula canadensis, Sanicula odorata, Scutellaria incana, Senecio glabellus, Smilacina racemosa, Solidago canadensis, Solidago gigantea, Sphenopholis obtusata* var. *major, Stellaria media, Taraxacum officinale*, and *Viola sororia*.

Floral abundance and importance values are given in Appendix 2.

Current Status: Walsh Spring is a cave spring set along the base of a hillside in a natural forested area. The springhead has a high diversity of macroinvertebrates (38 taxa), primarily due to the availability of the diverse habitats surrounding the springhead. The springbrook is relatively short, with a sand-gravel substrate. There is a moderate fauna in this springbrook (20 taxa), with specimens of the troglophilic cave amphipod *Crangonyx forbesi* and *Gammarus troglophilus* collected. The reduced habitat available for aquatic macroinvertebrates is likely the limiting factor here compared to the springhead. Nitrate nitrogen was detected in each of the four water samples collected, all below the EPA MCL. Alachlor was detected in the May water sample at a level above the EPA MCL. Atrazine was detected in the February, May, and August water samples with the May sample at a level well above the EPA MCL. Metolachlor was detected in the May and August water samples but at levels below the EPA HAL. No aquatic macrophytes were found in the springhead or the springbrook.

HYDROGEOLOGY

Springs are collection points of groundwater discharge within a stream basin. The ten springs investigated during this study are the origin of or contribute water and habitat for animals and plants to eight named creeks in Monroe and St. Clair counties. All of the springs examined are situated in limestone terrain of the Salem Plateau Section of the Plateau Province of Illinois where karst features are prevalent. In many areas away from municipal supply in this region, the only water sources capable of meeting the expanding needs of land owners are wells open to solution cavities in the underlying limestone formations. Since spring flow is often analagous to pumped well data, the discharge and water quality information provided in this report should assist well owners and drillers tapping cavernous limestone networks in the vicinity of the springs.

This hydrogeological study of springs will contribute to a sound technical basis for future work and predictions relating to the supply of groundwater to karst springs. The supply of groundwater varies seasonally, with precipitation and changes in the earth materials. Variations in flow rate, water quality and temperature are also related to land use and to the lithologic type, distribution, and structural altitude of the earth materials at any given spring. Distinctive relationships between the diversity and abundance of aquatic animals and plants can only be established through detailed study, inventory, and earth material analysis at springheads and outflow channels. For example, water filled cavernous joint and bedding plane openings provide underground corridors for sustaining blind cavefish. Boils and fast moving temperate water in sand and gravel layers at other spring sites provide a distinctive habitat for microcrustaceans (ostracods) while boulder rubble with sand and gravel characteristically provides a habitat for gastropods (snails) and other macroinvertebrate organisms.

The elevation of the topography varies in the area studied from as much as 216.4 m (710 ft) MSL in the upland along the drainage divide near Waterloo separating the Kaskaskia and Mississippi River basins (Singh *et al.* 1988) in Monroe and St. Clair counties to 121.9 m (400 ft) in the lowland of the Mississippi River. Well exposed limestone bluffs rise almost vertically from the Mississippi River lowland to a height of 76.2 m (250 ft) along the western margin of both Monroe and St. Clair counties. The upland in this part of Illinois is characterized by subsurface drainage caves and sinkholes which often are interrelated hydraulically below and between surface drainage basins. The sinkholes are densely pocketed and are developed in the Mississippian Salem, St. Louis, and Ste. Genevieve limestone formations which form a somewhat regular, hummocky topography. Most of the sinkholes in the study area have gently sloped sides (dolines), although a few have steep sides (ponors), some are relatively deep and open to caverns, some are closed, and some contain water periodically or continuously. Ponors are sometimes called collapse sinks because they are usually deep with steep walls. Sinkholes form in two ways, by roof collapse of caves near the surface from underground solution, or by solution and abrasive enlargement of fissures from the surface downward (Reinertsen 1981). In the first way, sinkhole formation takes place following uplift and entrenchment of major drainage, an initial period of cavern development by vadose water (percolating groundwater above the zone of saturation, i.e. above the water table). In the second way, large subterranean cavities may not even exist to form the sinkhole. These depressions (dolines) are usually shallow, saucer-shaped depressions whose depth is controlled by the depth of the water table at the time of formation. Both types of sinks are present in the area studied and are believed to have initially developed during the late Pliocene, more than 1.5 million years ago and in early Pleistocene before entrenchment of the Mississippi River valley.

Geology

The earth materials outcropping in the study area from oldest to youngest consist principally of Mississippian limestone, chert, shale and dolomite (Fig. 21), and in places Pennsylvanian shale, sandstone, siltstone, limestone and coal. Overlying these units in many areas in the upland are Wisconsinan till, silt, sand and gravel and loessial silt and clay. In the lowland of the Mississippi River, Holocene sand, silt, and clay deposits overlie the Mississippian Silurian and Ordovician bedrock. A generalized geologic map of parts of Monroe and St. Clair counties along with the locations of the spring sites studied is presented in Figure 22.

A columnar section and detailed lithologic description of Mississippian strata from Columbia Quarry in the study area, situated in T.1S, R.10W, Section 3, in St. Clair County, is shown in Figure 23 and described in Appendix 3. The geologic units present at this locality, principally limestone, have undergone a considerable amount of weathering in places; water pathways from excavated sinkholes joints and bedding planes are apparent from the surface downward to a distance of 15 m (50 ft) at some exposures. Structurally, Monroe and Randolph counties are on the western margin of the Illinois Basin (Willman *et al.* 1968) where bedrock units generally dip at low angles eastward toward the center of the basin. Two paired anticline - syncline structures in the north central and west central part of Monroe County have influenced water movement in the study area (Panno *et al.* 1995). The Columbia syncline and Waterloo-Dupo anticline are oriented in a slightly west of north direction near Columbia and Waterloo, while the Valmeyer anticline and Monroe City syncline are oriented in a northwest-southeast direction, southwest of Waterloo (Fig. 22). With the exception of the Waterloo-Dupo anticline extending into Missouri, all of the other structures lie mainly within Monroe and St. Clair counties (Nelson 1995). Specific information on the dip and inclination of the rock strata at the springs studied in the investigation are given in the individual spring hydrogeology sections.

SYSTEM	SERIES	GROUP, STAGE	FORMATION, MEMBER	ROCK TYPE	THICKNESS	DESCRIPTION
QUATERNARY		Holocene				Sand, silt, clay
QUATERNARY	Pleistocene	Wisconsinan	Peoria			Loess
QUATERNARY	Pleistocene	Wisconsinan	Roxana			Loess
QUATERNARY	Pleistocene	Illinoian				Till, some outwash
PENNSYLVANIAN		Kewanee	Carbondale: Hanover Ls, No. 4 Coal, No. 2 Coal		40	Sandstone; siltstone; shale; limestone; coal; underclay
PENNSYLVANIAN		McCormick			25	Sandstone; siltstone; shale; thin coal
MISSISSIPPIAN	Valmeyeran		Ste. Genevieve		70	Limestone, oolitic, some chert
MISSISSIPPIAN	Valmeyeran		St. Louis		245	Limestone, some dolomite, some chert
MISSISSIPPIAN	Valmeyeran		Salem		80	Limestone, some oolites, some chert
MISSISSIPPIAN	Valmeyeran		Ullin		65	Limestone, some chert
MISSISSIPPIAN	Valmeyeran		Warsaw		25	Shale
MISSISSIPPIAN	Valmeyeran		Keokuk		60	Limestone, very cherty
MISSISSIPPIAN	Valmeyeran		Burlington		100	Limestone very cherty
MISSISSIPPIAN	Kinderhookian		Fern Glen		60	Limestone, some chert; shale
MISSISSIPPIAN	Kinderhookian		Chouteau		30	Limestone and shale
DEVONIAN		New Albany			15	Shale
SILURIAN					75	Dolomite, cherty
ORDOVICIAN	Cincinnatian	Maquoketa			150	Siltstone; shale; some limestone
ORDOVICIAN	Cham.	Kimmswick			100	Limestone
OLDER ORDOVICIAN AND CAMBRIAN STRATA					2450	Limestone; dolomite; sandstone; shale
PRECAMBRIAN						Granite; other igneous and metamorphic rocks

Figure 21. Generalized geologic column, Columbia - Waterloo area, Monroe County, Illinois.

Information on the unconsolidated samples that were collected, sieved, and studied from the springhead at 8 sites are given in the Appendix 4 and Figures 5, 7, 9, 11, 13, 15 17, and 20. The particle size of the earth materials at these sites indicate that cavernous development in the spring systems has also been accomplished by abrasion and by solution of the limestone bedrock. Sites

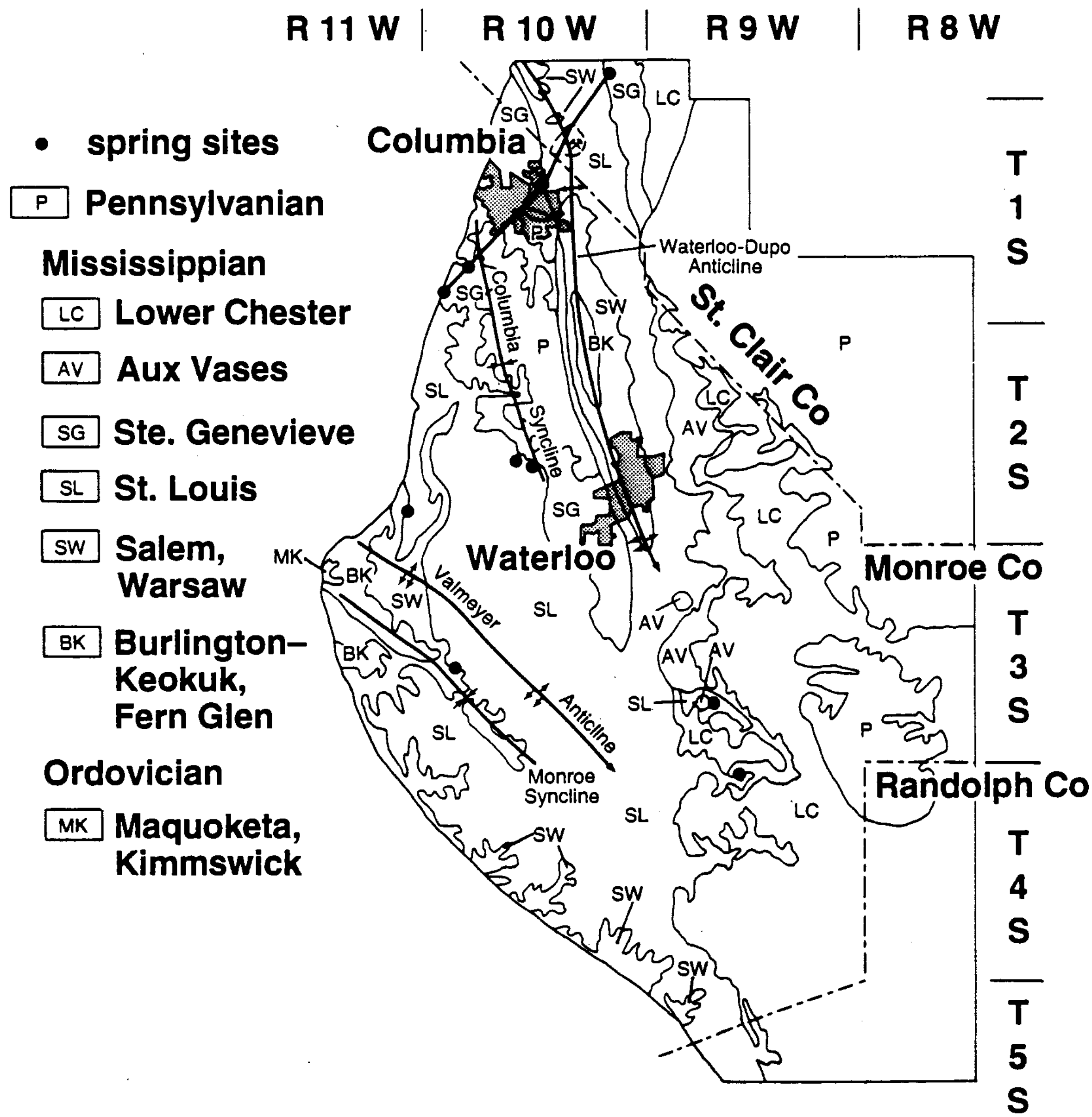

Figure 22. Generalized geologic map of Monroe County and part of St. Clair County, Illinois.

with a glacial drift or glacial outwash suite of sediments include Kelly, Madonnaville, Ritter, Camp Vandeventer, and Walsh Springs. The remainder of the sites had no drift or outwash sediment. Quarry, Section 3, T.1S, R10W, St. Clair County, Illinois.

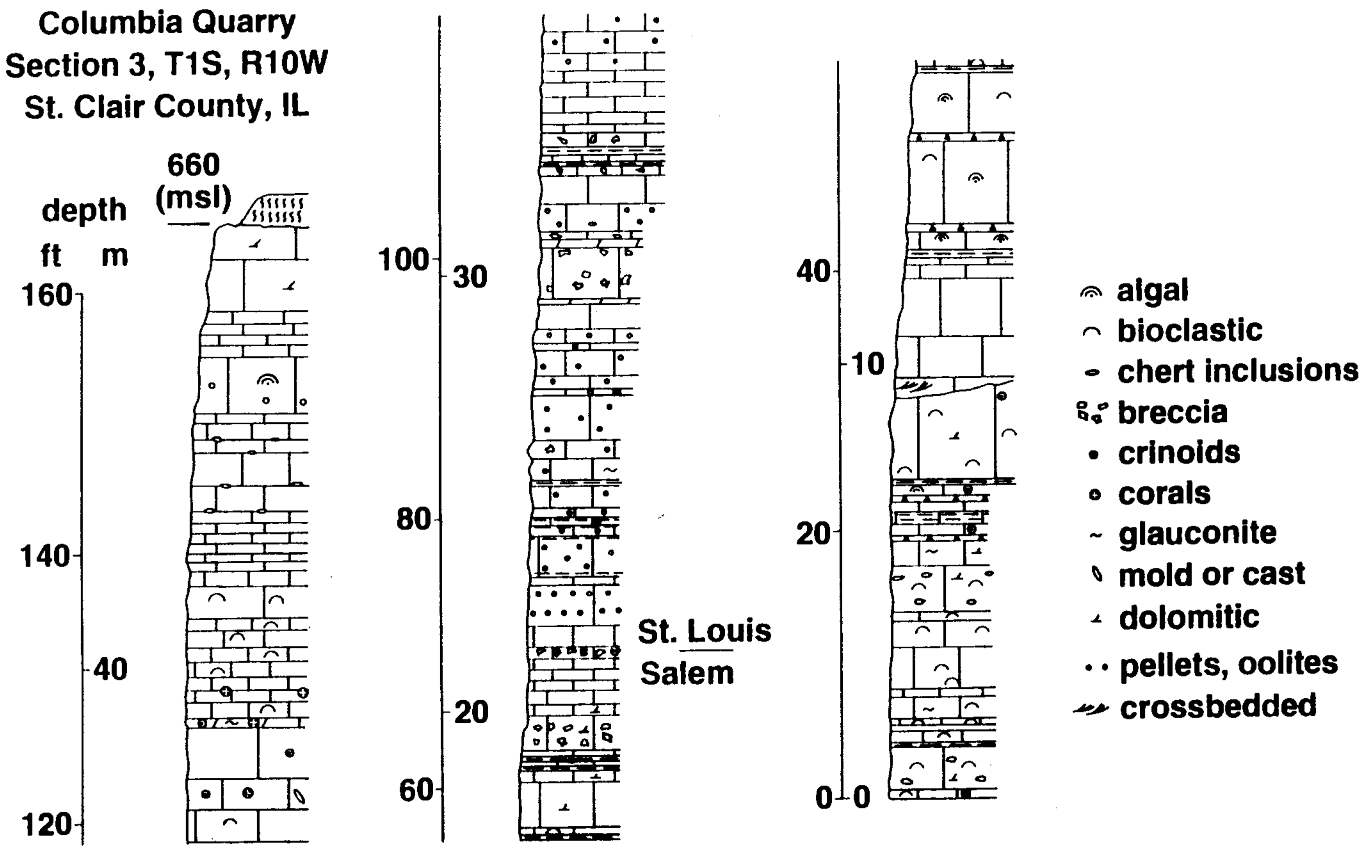

Figure 23. Columnar section of Mississippian Salem and St. Louis limestone strata, Columbia

Relationship of Precipitation and Spring Discharge

During the present study (November 1994 - August 1995), the monthly average precipitation for the period of record 1912-1995 at the Waterloo weather station (119002) (Appendix 5) was exceeded in January, May, and June, 1995. The greatest monthly May rainfall ever recorded, 33.7 cm (13.25 in.) (personal communication, W. Wendland, Illinois State Water Survey, 1996) occurred in May, 1995. The May, 1995, record rainfall exceeded the average monthly precipitation of 10.4 cm (4.11 in) almost 3 times. On May 16, 1995, discharge measurements were taken at Sparrow and Walsh Springs after a 3.8 cm (1.49 in) rain on May 14, and a 2.7 cm (1.07 in) rain on May 16, 1995. On May 22 and 23, 1995, discharge measurements were made after a 4.9 cm (1.92 in) rainfall on May 17, a 7.8 cm (3.06 in) rainfall on May 18, a 0.9 cm (0.34 in) rainfall on May 19, and a 0.3 cm (0.13 in) rain on May 21, 1995 at Auctioneer, Camp Vandeventer, Dual, Kelly, Little Carr, Madonnaville, Ritter, and Terry Springs. When the May 1995 rainfall and previous February discharge values were compared, the values at Kelly Spring were 25% lower; the values at Little Carr Spring and Ritter Spring were about the same after the May 14, 16-18, 21, 1995, rainfall period and the values at all other springs were 5-121 times greater. This indicates that the record rainfall of May, 1995, had little effect on the spring discharge at Kelly, Little Carr, and Ritter Springs during the period May 14-21, 1995. This broad range of values indicates differing rainfall amounts, varying runoff, recharge and discharge rates within each cavernous spring network and catchment area. The variability of streamflow in the study area is further emphasized by stream flow records (Singh 1988). Within the area studied, streams have a zero 7-day 10-year low flow; stated more simply, on the average the lowest mean flow for 7 consecutive days is zero once in 10-years.

The relationship of monthly average precipitation (period of record 1912-1995), monthly precipitation, springflow, and chloride concentration is shown on Figure 24 for Camp Vandeventer Spring. The linear correlation coefficient for monthly rainfall and spring discharge is r^2=0.93030 and the linear correlation coefficient for discharge and chloride concentration is r^2=0.98210.

The paired values at Camp Vandeventer (4) may be insufficient for a linear relationship test but other discharge and chloride linear relationship values (15) r^2=0.84126 of the under 200 gpm flows made at Auctioneer, Camp Vandeventer, Dual, Little Carr, Madonnavile, Ritter, Terry, and Walsh springs during November, 1994 and February, 1995 suggest that the discharge and chloride concentration relationship may be intrinsic to specific springs.

The geologic unit in which the springbrook is formed, the estimated drainage basin area, estimated percent farmland and farmland acreage, method and date of spring measurement, and spring discharge are presented in Table 11. The range of spring discharge values varied greatly from 0-9787 gpm (0-617 L/sec). This variability is attributed to the timing of spring discharge measurement during a period of minimal monthly rainfall (February, 1995) and the record monthly rainfall (May, 1995).

The effect of the 83-year monthly record rainfall in May, 1995 on spring discharge containing elevated levels of Atrazine provided insight on the residence time of the herbicide in a cavernous spring flow system. Four scenarios were determined by using three fold division of six elements (A to F) to test the periodic presence or absence of Atrazine in the spring flow system relative to the record monthly rainfall (RMR), as follows:

A). Detected before RMR.
B). Not detected before RMR.
C). Flushed in during RMR.
D). Flushed out during RMR.
E). Detected after RMR.
F). Not detected after RMR.

The A, C, and E Atrazine pattern was the most frequently occurring pattern, observed at Camp Vandeventer (Fig. 25), Dual, Little Carr, Sparrow, Terry, and Walsh Springs.

The A, D, and E Atrazine pattern occurred at Auctioneer and Kelly Springs.

The B, C, and E Atrazine pattern occurred only at Madonnaville Spring.

The B, C, and F Atrazine pattern occurred only at Ritter Spring.

Using the threefold division of six elements (A-F) to test the periodic presence or absence of Alachlor, we found the A-C-E pattern at Dual, the A-C-F pattern at Camp Vandeventer and Sparrow Springs, the B-C-F pattern at Madonnaville and Walsh Springs (Fig. 26). Alachlor was not detected at Auctioneer, Kelly, Little Carr, Ritter, or Terry springs.

Using the threefold division of six elements (A-F) to test the periodic presence or absence of Metolachlor, we found the A-C-F pattern at Camp Vandeventer, Dual, Madonnaville, and Terry Springs, the A-C-E pattern at Little Carr Spring, the A-D-F patter at Ritter Spring, the B-C-F pattern at Kelly and Sparrow Spring, and the B-C-E pattern at Walsh Spring (Fig. 27). No Metolachlor was detected at Auctioneer Spring.

Other linear correlation relationships established during this study included specific conductance with alkalinity (as $CaCO_3$) $r^2=0.89540$ (39), specific conductance with dissolved calcium $r^2=0.83744$ (39), specific conductance and hardness (EDTA) $r^2=0.86259$ (39), and specific conductance with total dissolved solids $r^2=0.85812$ (39).

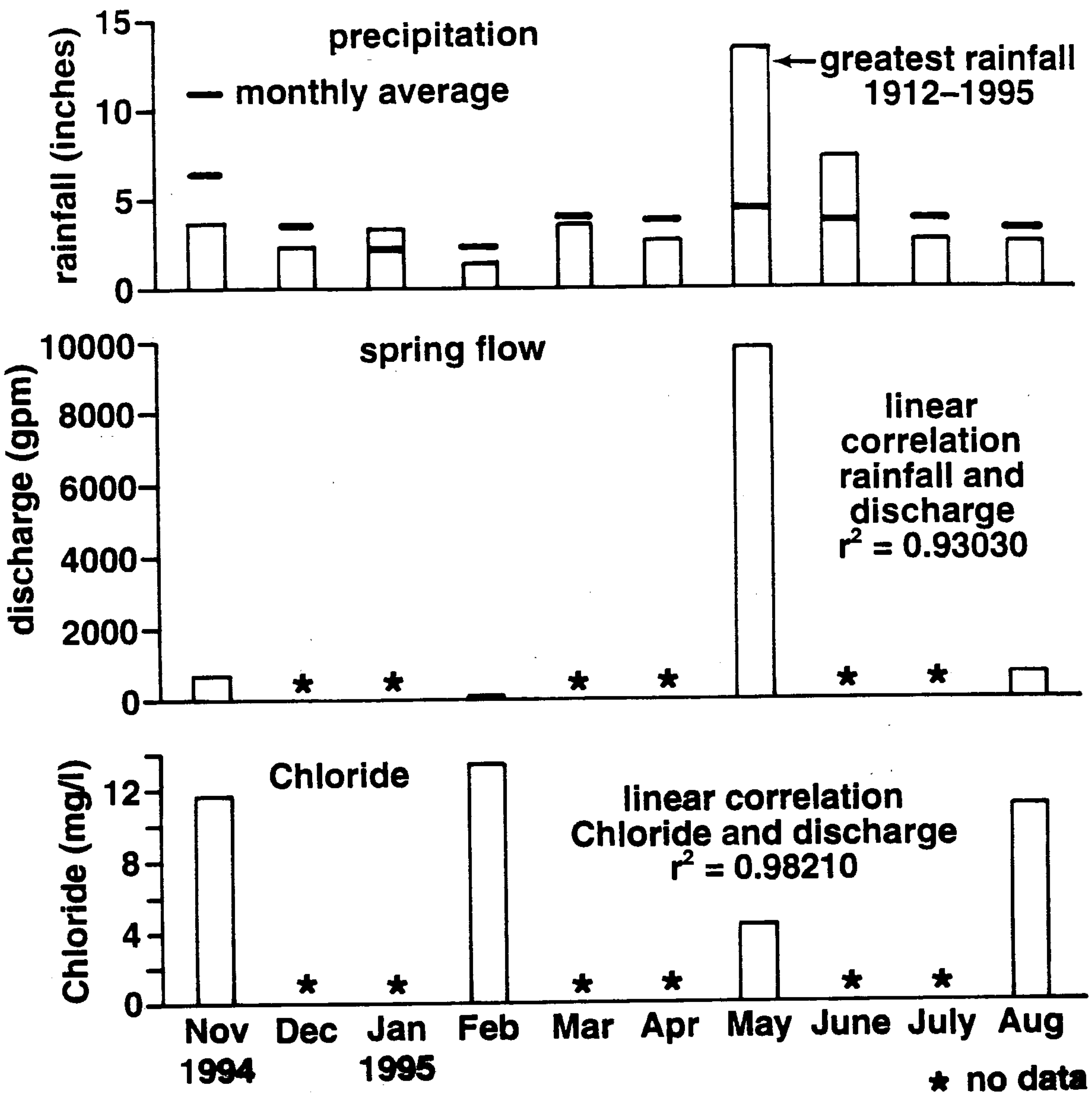

Figure 24. Average monthy precipitation from November, 1994, to August, 1995; spring flow; and chloride concentration at Camp Vandeventer Spring, Monroe County, Illinois, and the highest monthly rainfall for the period of record 1912 -1995 at the Waterloo weather station, Monroe County, Illinois.

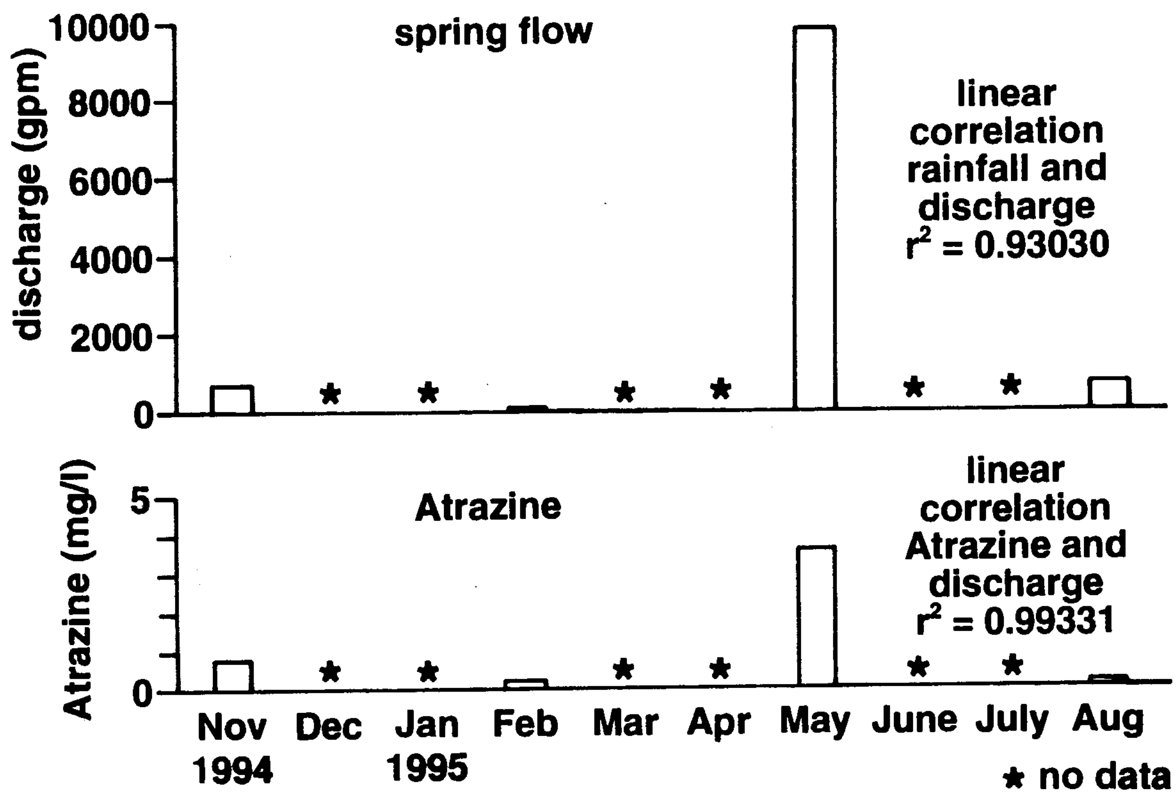

Figure 25. Spring discharge and Atrazine concentrations, Camp Vandeventer Spring, Monroe County, Illinois.

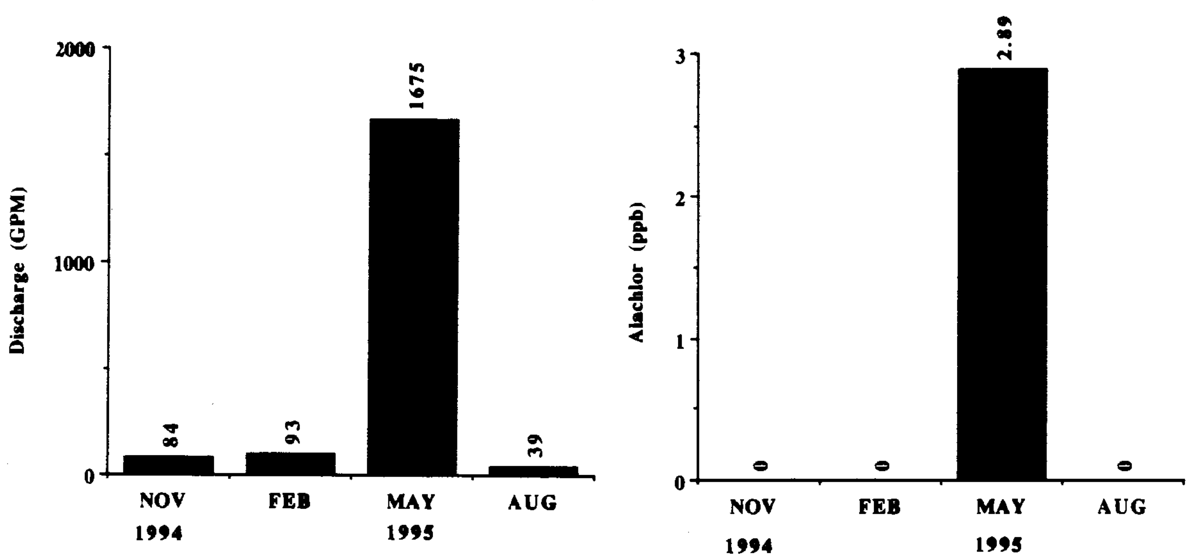

Figure 26. Spring discharge and Alachlor concentrations, Walsh Spring, Monroe County, Illinois

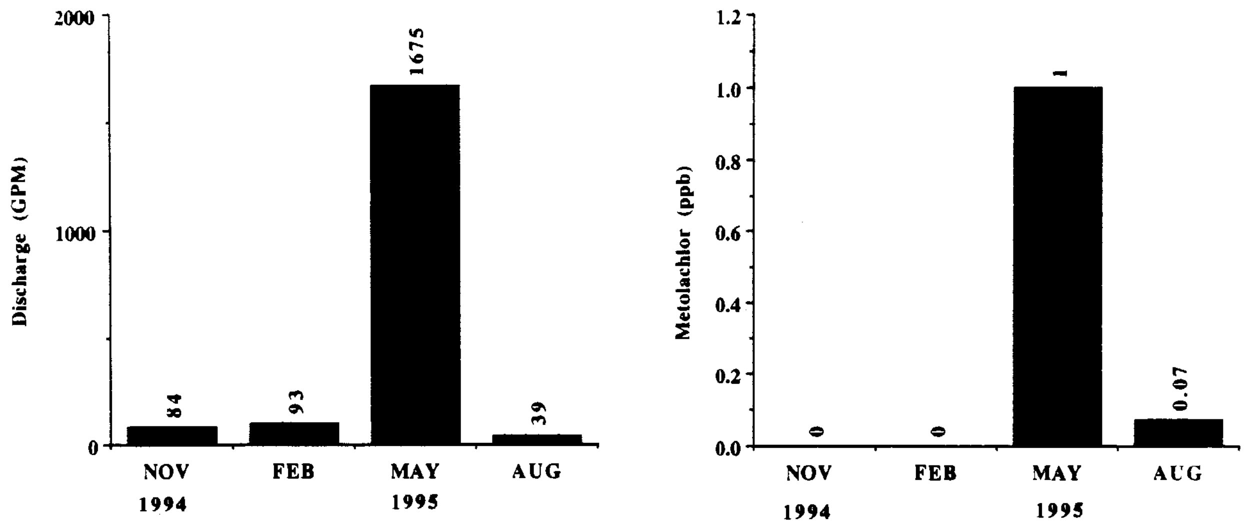

Figure 27. Spring discharge and Metolachlor concentrations, Walsh Spring, Monroe County, Illinois

DISCUSSION

Until the 1990's, little or no scientific information had been gathered on the various springs that dot the landscape of Illinois, particularly in the karst regions of the Shawnee Hills, the Sinkhole Plain, the Lincoln Hills, and the Driftless Area (Fig. 1). In 1991, a cooperative program between the Illinois Natural History Survey and the Illinois State Geological Survey was initiated to evaluate the current status of Illinois springs. The location of Illinois springs were determined from historical records; a computerized database was then developed to bring together all the available information on the hydrogeology, water quality, fauna, flora, and history of these springs. At the turn of the century, 88 springs (Bartow *et al.* 1909) were reported in Illinois. These springs were utilized as sources of domestic drinking and bathing water or for the perceived health benefits derived from the minerals contained in the water. To date, over 300 springs have been entered into our database.

During 1991 and 1992, the first intensive survey of springs in Illinois was conducted. Seven springs in the Shawnee Hills of southern Illinois were studied (Webb, Reed, and Wetzel 1992; Webb *et al.* 1995); four of these were examined bimonthly for a year. Springs in the Shawnee Hills were selected because they lay outside areas of intensive agriculture where groundwater contamination by agricultural fertilizers and pesticides presumably would be minimal.

Springs in the Shawnee Hills tend to be small, with a low discharge rate, and a springhead and springbrook substrate consisting generally of sand and small gravel (Webb *et al.* 1995). Water temperatures fluctuated less than 4 ^{o}C over the year; oxygen levels ranged from 0.5-10.1 mg/L; *p*H ranged from 6.9-8.0; total dissolved solids ranged from 139-17,167 mg/L; and chloride ranged from 1-17,313 mg/L. High concentrations of total dissolved solids and chlorides were measured at both Saline Spring and Salt Well Spring, which are both located in an area of high salinity southeast of Equality, Illinois. Springs in this area historically were used as salt wells by native Americans and early settlers to or passing through the Midwest. Nitrate nitrogen levels were extremely low, ranging from 0-0.66 mg/L for 56 water samples. Pesticide levels in water samples were not measured during this initial study.

During this initial study of seven springs in the Shawnee Hills, 85 taxa of aquatic macroinvertebrates and two species of aquatic macrophytes were collected. Species richness (the number of taxa recorded collectively from the springhead and springbrook; identical taxa collected from the springhead and the springbrook are counted as one taxa) (Fig. 28) ranged from 11 to 46. These springs in the Shawnee Hills supported a predominantly non-insectan macroinvertebrate fauna. The turbellarian *Phagocata gracilis*, the amphipods *Gammarus minus* and *G. pseudolimnaeus*, the isopod *Caecidotea brevicauda*, and several snail taxa represented the majority of species collected throughout the year and are species common to most small surface streams in the Shawnee Hills. Oligochaete worms (24 taxa), represented the most diverse group of organisms observed during this study. *Varichaetadrilus angustipenis*, an oligochaete worm (Family Tubificidae) which has rarely been collected in Illinois or in the other disjunct localities in North America from which it has been collected (Coates and Wetzel 1996), was recorded from six of the seven springs in the Shawnee Hills. The collection of the oligochaete worm *Allonais paraguayensis* from Old Driver Spring and Salt Well Spring was the most interesting of the taxa collected, previously known only from a locality in Louisiana, South Carolina, and an aquarium in New York (Wetzel 1992; Coates and Wetzel 1996). Only scattered representatives of various aquatic insect orders were collected, and seldom in abundance. The water quality of these seven springs in the Shawnee Hills is high; the biodiversity of the aquatic macroinvertebrates occurring in these springs is considered low but stable.

During the present study of 10 springs in the Sinkhole Plain of Monroe and St. Clair counties in southwestern Illinois, we expected a "worst case scenario" with regard to the water quality and the biodiversity of aquatic macroinvertebrates. Contamination of the springs from nitrate nitrogen and herbicides were expected to be extreme and that this would adversely affect the biodiversity of the aquatic macroinvertebrates. We expected to observe a low diversity of macroinvertebrates in these springs, represented by taxa that are common to the study area and tolerant of a wide range of environmental perturbations.

Nitrate Nitrogen

Nitrate nitrogen in groundwater is an anion that can be derived from several naturally occurring sources, and, as an anion, is not readily adsorbed to soil components. Thus, it readily migrates through the soil into the groundwater system (Burt *et al.* 1993; Panno *et al.* 1996). Panno *et al.* (1996) were able to determine a background threshold of 1.4 mg/L for nitrate nitrogen in the Sinkhole Plain Region of Illinois based on a probability technique developed by Sinclair (1974). Concentration levels below 1.4 mg/L were considered natural in their derivation, and those above 1.4 mg/L were considered to be of man-made origin (Panno *et al.* 1996).

Nitrate nitrogen was present in all 40 water samples collected in November, 1994, and February, May, and August, 1995. Levels of nitrate nitrogen ranged from 0.26-7.64 mg/L, with a mean concentration of 3.83 mg/L. Levels of nitrate nitrogen in 37 of the 40 water samples (92.5%) were above the background level of 1.4 mg/L; all were below the EPA MCL of 10 mg/L.

Herbicides

Atrazine was detected in 29 of the 40 (73%) water samples collected in November, 1994, and February, May, and August, 1995. Levels of Atrazine ranged from <DL-5.83 µg/L, with a mean concentration of 0.67 µg/L. Levels in 3 samples (7.5%) were above the EPA MCL of 3 µg/L.

Alachlor was detected in 11 of the 40 (27.5%) water samples collected in November, 1994, and February, May, and August, 1995. Levels of Alachlor ranged from <DL-2.89 µg/L, with a mean concentration 0.11 µg/L. The concentration of Alachlor in one sample was above the EPA MCL of 2 µg/L.

Cyanazine was detected in 9 of the 40 (22.5%) water samples collected in November, 1994, and February, May, and August, 1995. Levels of Cyanazine ranged from <DL-1.74 µg/L, with a mean concentration of 0.13 µg/L. The concentration of Cyanazine in 2 samples (5%) was above the EPA HAL of 1 µg/L.

Metolachlor was detected in 19 of the 40 (47.5%) water samples collected in November, 1994, and February, May, and August, 1995). Levels of Metolachlor ranged from <DL-3.28 µg/L, with a mean concentration of 0.29 µg/L. Metolachlor levels in all 40 water samples were below the EPA HAL of 100 µg/L.

Biodiversity of Aquatic Macroinvertebrates

During the present study of 10 karst springs located in the Sinkhole Plain in Monroe and St. Clair counties, southwestern Illinois, 141 taxa of aquatic macroinvertebrates were collected (Table 12). Species richness ranged from 18 taxa in Terry Spring to 82 taxa in Kelly Spring. The non-insectan fauna of amphipods, isopods, and turbellarians were most abundant. The aquatic insect fauna, with 80 recorded taxa, comprised the most diverse group of organisms in these springs,

Table 12. The distribution of aquatic macroinvertebrates in 10 karst springs in the Sinkhole Plain, Monroe and St. Clair counties, Illinois.

Aquatic Macroinvertebrates	**Springs**									
	AC	CVS	DS	KS	LCS	MS	RS	SS	TS	WS
Turbellaria										
Dugesia dorotocephala		X		X						
Phagocata gracilis						X	X		X	X
Phagocata velata	X									
Hydrozoa: Hydridae										
Hydra sp.				X						
Nematoda		X		X		X		X		X
Nematomorpha: Gordiidae										
Gordius sp.				X						
Annelida										
Aeolosomatida: Aeolosomatidae										
Aeolosoma sp.							X			X
Branchobdellida: Cambarincolidae		X						X		
Oligochaeta: Enchytraeidae	X	X	X	X	X	X	X	X	X	X
Oligochaeta: Haplotaxidae										
Haplotaxis gordioides		X								
Oligochaeta: Lumbricidae	X	X	X	X	X			X		X
Oligochaeta: Lumbriculidae		X	X			X				X
Oligochaeta: Naididae										
Allonais paraguayensis		X						X		X
Bratislavia unidentata								X		
Dero digitata			X	X	X			X	X	X
Dero nivea		X	X	X				X		
Nais bretscheri		X								
Nais communis	X	X	X	X			X	X	X	X
Nais elinguis				X						
Nais pardalis		X		X				X		X
Nais variabilis			X	X				X		X
Nais sp. LCC1		X						X		X
Nais sp.			X	X			X		X	X
Ophidonais serpentina		X	X							X
Paranais frici								X		
Pristina aequiseta							X			
Pristina leidyi		X								
Slavina appendiculata				X				X		
Specaria josinae							X			
Styaria lacustris			X	X		X		X		
Oligochaeta: Tubificidae										
Branchiura sowerbyi			X							
Ilyodrilus templetoni			X		X		X			
Limnodrilus cervix			X	X	X			X		X
Limnodrilus claparedianus			X		X		X			

Table 12 (continued)	AC	CVS	DS	KS	LCS	MS	RS	SS	TS	WS
Limnodrilus hoffmeisteri		X	X	X	X	X	X	X	X	X
Limnodrilus udekemianus			X							
Limnodrilus sp.		X	X							
Quistadrilus multisetosus			X							
Spirosperma cf. ferox	X									
Varichaetadrilus angustipenis		X	X							X
Hirudinea: Erpobdellidae				X				X		
Hirudinea: Glossiphoniidae			X							
Crustacea										
Amphipoda: Crangonyctidae										
Crangonyx forbesi		X		X	X		X	X	X	X
Amphipoda: Gammaridae										
Gammarus minus						X				
Gammarus pseudolimnaeus			X	X	X		X	X	X	X
Gammarus troglophilus	X	X		X		X	X	X	X	X
Amphipoda: Hyalellidae										
Hyalla azteca			X	X				X		
Decapoda: Cambaridae										
Orconectes virilis		X						X		
Orconectes sp. (immature)			X					X		
Isopoda: Asellidae										
Caecidotea brevicauda	X	X	X	X	X	X	X	X	X	X
Caecidotea intermida					X					
Caecidotea packardi			X	X					X	
Ostracoda: Cypridae										
Candona caudata			X							
Cypria opthalmica		X	X							
Ilyocypris bradyi				X	X					
Physocypria pustulosa			X							
Insecta										
Coleoptera: Dryopodidae										
Helichus sp.			X	X				X		
Coleoptera: Dytiscidae										
dytiscid sp.	X		X	X	X		X	X	X	
Coleoptera: Gyrinidae										
Dineutus sp.								X		
Coleoptera: Haliplidae										
Peltodytes sp.			X	X			X			
Coleoptera: Hydrophilidae										
hydrophilid sp. 1	X	X	X	X	X	X	X	X	X	X
hydrophilid sp. 2		X		X				X		X
hydrophilid sp. 3		X		X						X
hydrophilid sp. 4				X						X
hydrophilid sp. 5				X						X
hydrophilid sp. 6				X						X

Table 12 (continued)	AC	CVS	DS	KS	LCS	MS	RS	SS	TS	WS
hydrophilid sp. 7.										X
hydrophilid sp. 8.										X
Tropisternus lateralis		X								
Diptera: Ceratopogonidae										
Bezzia sp.						X		X		X
ceratopogonid sp. 1		X		X	X					
ceratopogonid sp. 2				X	X					
ceratopogonid sp. 3				X						
Diptera: Chaoboridae										
Chaoborus punctipennis (Say)		X	X	X		X		X		X
Diptera: Chironomidae										
Ablabesmyia illinoensis		X		X						
Chironomus decorus			X	X						
Clinotanypus scapularis		X								
Conchopelopia sp.										X
Cricotopus bicinctus		X		X						
Cricotopus sp. 1		X	X	X				X		
Dicrotendipes nervosus				X				X		
Glyptotendipes paripes			X	X		X		X		X
Harnischia curtilamellatus		X								
Orthocladius sp. 1		X								
Orthocladius sp. 2		X								
Orthocladius sp. 3		X						X		
Phaenopsectra flavipes				X				X		X
Polypedilum halterale								X		
Polypedilum scalaenum		X		X						X
Polypedilum sp.					X	X				
Procladius bellus		X		X	X			X		
Procladius sublettei		X		X	X					
Stenochironomus hilaris				X						
Tanypus neopunctipennis					X			X		
Tanytarsus sp.		X	X	X	X	X		X		
Tribelos jucundum										X
Diptera: Psychodidae										
Psychoda sp.	X	X				X		X		
Diptera: Simuliidae										
Simulium tuberosum complex		X		X				X		
Simulium vittatum complex			X	X				X		
Diptera: Tipulidae										
Tipula sp. 1	X	X	X	X	X	X				X
Tipula sp. 2				X						
Ephemeroptera: Baetidae										
Baetis sp. 1		X	X	X			X			
Ephemeroptera: Caenidae										
Caenis sp. 1			X	X				X		

Table 12 (continued)	AC	CVS	DS	KS	LCS	MS	RS	SS	TS	WS
Ephemeroptera: Heptageniidae										
Stenonema sp. 1	X	X	X	X		X		X	X	X
Ephemeroptera: Leptophlebiidae										
Leptophlebia sp. 1										X
Hemiptera: Belostomatidae										
Belostoma fluminea			X							
Hemiptera: Corixidae										
Trichocorixa sp. 1	X	X	X	X			X	X	X	
Trichocorixa sp. 2				X						
Hemiptera: Gerridae										
Aquarius remigis	X	X	X	X	X	X		X		
Hemiptera: Mesoveliidae										
Mesovelia mulsanti		X	X	X				X	X	
Hemiptera: Nepidae										
Ranatra fusca			X	X				X		
Hemiptera: Notonectidae										
Notonecta sp.			X	X				X		X
Hemiptera: Pleiidae										
Neoplea striola				X						
Megaloptera: Sialidae										
Sialis sp.			X							
Plecoptera: Capniidae										
Allocapnia vivipara				X						
Plecoptera: Perlidae										
Perlinella drymo				X						
Trichoptera: Helicopsychidae										
Helicopsyche borealis		X		X						
Trichoptera: Hydropsychidae										
Cheumatopsyche analis	X	X	X	X	X	X		X		X
Diplectrona modesta						X				
Hydropsyche betteni		X		X	X					
Potomyia flava		X		X						
Trichoptera: Hydroptilidae										
Hydroptila cf. scolops		X		X		X		X		
Hydroptila waubesiana		X								
Hydroptila sp. 1									X	
Ochrotricha shawnee		X								
Orthotrichia americana										X
Trichoptera: Leptoceridae										
Athripsodes cf. transversus		X								
Oecetis inconspicua				X		X		X		X
Oecetis sp. 1								X		
Trichoptera: Philopotomidae										
Chimarra feria		X								
Chimarra obscura		X								

Table 12 (concluded)	AC	CVS	DS	KS	LCS	MS	RS	SS	TS	WS
Trichoptera: Phryganeidae										
Phryganea sayi				X						
Phryganea possibly sayi (female)						X				
Trichoptera: Polycentropdidae										
Cyrnellus marginalis					X					
Nyctiophylax vestitus		X		X						
Polycentropus centralis				X		X				X
Trichoptera: Rhyacophildae										
Rhyacophila fenestra		X		X						
Mollusca: Gastropoda										
gastropodid sp. 1	X	X		X		X	X			
gastropodid sp. 2	X	X	X		X	X	X	X	X	
gastropodid sp. 3				X						
gastropodid sp. 4	X	X		X		X	X	X		
gastropodid sp. 5				X				X		
gastropodid sp. 6	X									
Physella sp.	X		X	X	X	X	X			
Mollusca: Pelecypoda										
Pisidium sp.		X		X						

although their abundance was, in general, rather low. Only the mayfly genera *Baetis* and *Stenonema* and the caddisfly *Cheumatopsyche analis* were moderately abundant. The oligochaete worm fauna, represented by 30 taxa, was the most diverse group of non-insectan aquatic macroinvertebrates. *Varichaetadrilus angustipenis*, an oligochaete worm (Family Tubificidae) rare in Illinois as well as throughout its range in North America, was recorded from Dual Springs, Camp Vandeventer springbrook, and Walsh springbrook. The collection of another oligochaete worm *Allonais paraguayensis* (Family Naididae) from Camp Vandeventer, Sparrow Creek, and Walsh Springs was the most interesting of the taxa collected, as it was previously known only from a locality in Louisiana, South Carolina, an aquarium in New York city, and Old Driver and Salt Well Springs in the Shawnee Hills (Wetzel 1992, Coates and Wetzel 1996).

In comparison with the seven springs of the Shawnee Hills (Fig. 28), the biodiversity of the aquatic macroinvertebrates of Sinkhole Plain averaged 42 taxa per spring, compared to an average of 27 taxa per spring in the Shawnee Hills.

In the Sinkhole Plain, the amphipods *Gammarus troglophilus* and *Crangonyx forbesi* were collected in eight and seven springs, respectively. These two species are typically cave stream inhabiting species, and reflect the subterranean cave origin of many of these springs. Similarly the cave inhabiting isopods *Caecidotea packardi* and *C. intermedia* were collected in several of the springs. In the Shawnee Hills, the only two species of amphipods, *Gammarus minus* and

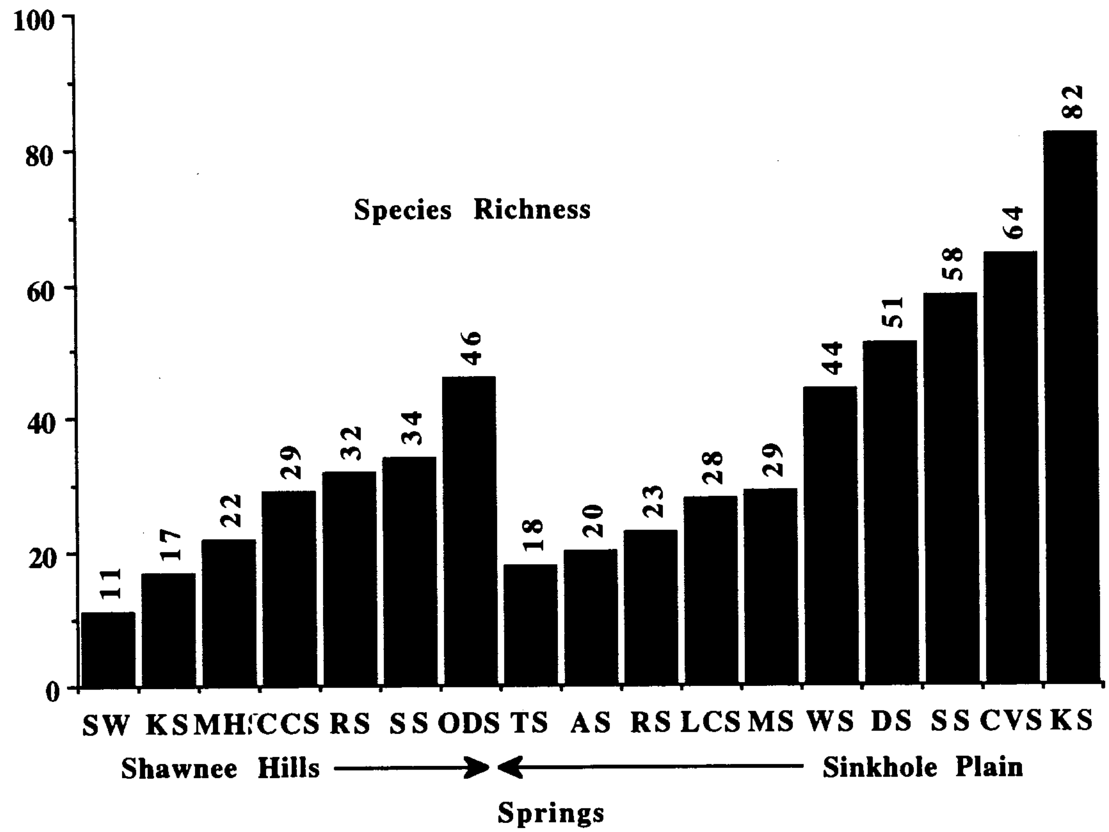

Figure 28. The species richness of aquatic macroinvetebrates recorded from seven springs in the Shawnee Hills, and ten springs in the Sinkhole Plain, Monroe and St. Clair counties, Illinois. Shawnee Hills Springs: (CCS) Clear Creek Spring, Jackson County, (KS) Kaskaskia Spring, Hardin County, (MHS) McGee Hill Spring, Union County, (ODS) Old Driver Spring, Hardin County, (RS) Rose Spring, Hardin County, (SS) Saline Spring, Gallatin County, (SW) Salt Well, Gallatin County.

Gammarus pseudolimnaeus were collected. These two species are relatively common in the various streams of that area.

No aquatic macrophytes were collected from any of the ten springs in the Sinkhole Plain. In the Shawnee Hills, two species of aquatic macrophytes were abundant. *Mentha piperita,* in the springbrooks of Old Driver and Rose springs, and *Leptodictyum riparium* at the springhead of Old Driver Spring.

In general, a "Worst Case Scenario" regarding the biodiversity of aquatic macroinvertebrates was not observed in the 10 karst springs studied in the Sinkhole Plain. Nitrate nitrogen levels in all of the springs were generally above background levels of 1.4 mg/L, but they were never recorded above the EPA MCL of 10 mg/L. The herbicides Atrazine, Alachlor, Cyanazine, and Metolachlor were detected in 68 of the 140 water samples (42.5%). Atrazine exceeded EPA MCL levels of 3 µg/L three times; Alachlor exceeded EPA MCL levels of 2 µg/L once, Cyanazine exceeded EPA HAL levels of 1 µg/L once, and Metalochlor never exceeded EPA HAL levels of 100 µg/L. Under these conditions, the 10 springs in the Sinkhole Plain supported a moderately strong diversity of aquatic macroinvertebrates with an average of 42 taxa per spring compared to an average of 27 taxa for seven springs studied in the Shawnee Hills. Compared to the springs in the Shawnee Hills, these 10 springs exhibited a greater diversity of amphipods and aquatic insects. In conjunction with this, no aquatic macrophytes and little filamentous algae were observed in any of the springs.

CONCLUSIONS

1. Nitrate nitrogen concentrations ranged from 0.26-7.64 mg/L, mean 3.83 mg/L; detected in all 40 water samples; the concentrations in 37 of the 40 water samples (92.5%) were above the background level of 1.4 mg/L; all were below the EPA MCL of 10 mg/L.
2. Atrazine concentrations ranged from <DL-5.83 µg/L, mean concentration 0.67 µg/L; detected in 29 of the 40 water samples (73%); and concentrations in 3 samples (7.5%) were at levels above the EPA MCL of 3 µg/L.
3. Alachlor concentrations ranged from <DL-2.89 µg/L, mean 0.11 µg/L; detected in 11 of the 40 water samples (27.5%); and concentrations in one sample (2.5%) were at levels above the EPA MCL of 2 µg/L.
4. Cyanazine concentrations ranged from <DL-1.74 µg/L, mean 0.13 µg/L; detected in 9 of the 40 water samples analyzed (22.5%); and concentrations in 2 samples (5%) were at levels above the EPA HAL of 1 µg/L.
5. Metolachlor concentrations ranged from <DL-3.28 µg/L, mean 0.29 µg/L; detected in 19 of the 40 water samples (47.5%); and no concentrations were at levels above the EPA HAL of 100 µg/L.
6. One hundred and forty one taxa of aquatic macroinvertebrates were collected. Species richness ranged from 18-82, with an average of 42 taxa per spring. Amphipods, isopods, and Turbellaria dominated in terms of abundance. The 80 taxa of aquatic insects composed the most diverse group of macroinvertebrate, but generally in low abundance. The 30 taxa of oligochaete worms was the most diverse group of non-insectan aquatic macroinvertebrates. *Varichaetadrilus angustipenis*, a rare species in Illinois, was recorded from Dual Springs, Camp Vandeventer springbrook and Walsh springbrook. The collection of the oligochaete worm *Allonais paraguayensis* in Camp Vandeventer, Sparrow, and Walsh Springs was the most interesting of the taxa collected. In addition, the amphipods *Gammarus troglophilus* and *Crangonyx forbesi* were collected in seven or

more of the springs. These two species are typically cave stream inhabiting species, and reflect the subterranean cave origin of many of these springs. Similarly the cave inhabiting isopods *Caecidotea packardi* and *C. intermedia* were collected in several of the springs.

In comparison, the species richness recorded for seven springs in the Shawnee Hills ranged from 11-46 with an average of 27 taxa per spring. Although the dominant taxa were the amphipods *Gammarus minus* and *Gammarus pseudolimnaeus*, these species were common to the surrounding streams. Oligochaete worms, with 24 taxa, were the most diverse group of taxa. *Varichaetadrilus angustipenis*, a rare species of oligochaete worm in Illinois, was recorded from six of the seven springs. The collection of the oligochaete worm *Allonais paraguayensis* in Old Driver and Salt Well Springs was the most interesting of the taxa collected, previously known only from a locality in Louisiana, South Carolina, and an aquarium in New York City (Wetzel 1992, Coates and Wetzel 1996). Only scattered representative of various aquatic insects were collected, and seldom in abundance.

7. The ten karst springs in the Sinkhole Plain supported a moderately strong diversity of aquatic macroinvertebrates with an average of 42 taxa per spring compared to an average of 27 taxa for seven springs studied in the Shawnee Hills.

8. No State or Federally endangered species of aquatic macroinvertebrates were collected in these springs.

9. No aquatic macrophytes were collected from any of the ten karst springs in the Sinkhole Plain.

10. Springs in Monroe and St. Clair counties were actively discharging 10,840 ± 170 years BP. The 83-year record monthly rainfall in 1995 gave valuable insight on the ubiquitous nature of herbicides in the groundwater system associated with these 10 springs. Five distinctive patterns of residence and non residence of herbicides were recognized.

11. Chloride concentrations correlated linearly with discharge (r^2=0.84126) at nine karst springs in November, 1994, and in February, 1995, when discharge was <200 gpm. Specific conductance correlated linearly with alkalinity (as $CaCO_3$) (r^2=0.89540), dissolved Ca (r^2=0.83744), hardness (EDTA) (r^2=0.86259), and total dissolved solids (r^2=0.85812).

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Turbellaria were identified by Dr. A. M. Hampton, Castleton State College, Castleton, Vermont. Aquatic amphipods and isopods were identified by Dr. L. M. Page, Center for Biodiversity, Illinois Natural History Survey. Decapods were identified by C. Taylor, Center for Biodiversity, Illinois Natural History Survey. Ostracods were identified by Dr. B. B. Curry, Illinois State Geological Survey.

Illinois State Geological Survey personnel B. B. Curry and R. D. Norby identified and sketched fossils; J. W. Baxter, Z. Lasemi, J. M. Masters, and R. D. Norby assisted with stratigraphic interpretations; R. R. Frost and D. M. Moore identified and analyzed the freshwater limestone and dolomite samples; K. C. Hackley and C. Liu completed radiocarbon dating analysis on the Terry Spring freshwater limestone deposit; and S. Panno assisted in interpreting water quality data.

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APPENDIX 1: Wave length dispersion and X-ray fluorescence analyses of freshwater limestone at Auctioneer Spring and dolomite at Terry Spring, Monroe County Illinois.

Elements Major-Minor %	Auctioneer SPL #1	Auctioneer SPL #3	Terry SPL #2
SiO_2	10.75	7.50	8.59
Al_2O_3	2.16	1.46	1.80
Fe_2O_3	0.92	0.45	0.74
CaO	45.73	48.79	26.95
MgO	0.42	0.90	19.10
K_2O	0.37	0.26	0.48
Na_2O	0.16	0.12	0.06
TiO_2	0.15	0.09	0.10
P_2O_5	0.21	0.16	0.02
MnO	0.27	0.019	0.017
SO_3	0.21	0.05	0.05
1000°C Loss on Ignition	38.47	40.04	41.93
	99.82	**99.84**	**99.85**
Trace Elements (ppm)			
Sr	121	128	237
Ba 1	85	115	<50
Zr	97	49	35
H_2O - 110°C	0.62	0.58	0.18

*Note: r^2 for SPLS#1 & #3= 0.99795 indicating similar minerology.

APPENDIX 2: The frequency, mean cover, and importance values of trees, shrubs, vines, and herbs in the vicinty of ten springs in the Sinkhole Plain Region of Monroe and St. Clair counties, Illinois.

Auctioneer Spring:

TREES	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Tilia americana	60.00	31.00	28.58	35.90	32.24
Acer saccharum	55.00	25.80	26.19	29.88	28.04
Ulmus americana	45.00	18.90	21.43	21.89	21.66
Quercus prinoides	05.00	04.25	02.38	04.92	03.65
Sassafras albidum	05.00	04.25	02.38	04.92	03.65
Asimina triloba	10.00	00.90	04.76	01.04	02.90
Carya ovata	10.00	00.30	04.76	00.35	02.56
Celtis occidentalis	05.00	00.75	02.38	00.87	01.62
Cornus florida	05.00	00.15	02.38	00.17	01.28
Fraxinus americana	05.00	00.03	02.38	00.03	01.20
Quercus rubra	05.00	00.03	02.38	00.03	01.20
SHRUBS					
Staphylea trifolia	45.00	10.70	56.25	66.13	61.19
Hydrangea arborescens	30.00	03.60	37.50	22.25	29.87
Lindera benzoin	05.00	01.88	06.25	11.62	08.94
VINES					
Parthenocissus quinquefolia	35.00	02.60	70.00	71.23	70.62
Smilax hispida	05.00	00.75	10.00	20.55	15.28
Toxicodendron radicans	05.00	00.15	10.00	04.11	07.05
Vitis sp.	05.00	00.15	10.00	04.11	07.05
HERBS					
Impatiens capensis	35.00	07.55	08.04	24.50	16.27
Pilea pumila	80.00	03.00	18.39	09.73	14.06
Circaea lutetiana	25.00	02.83	05.75	09.18	07.47
Laportea canadensis	30.00	02.28	06.89	07.40	07.15
Arisaema triphyllum	40.00	01.05	09.19	03.41	06.30
Cryptotaenia canadensis	25.00	01.70	05.75	05.51	05.63
Phryma leptostachya	25.00	01.70	05.75	05.51	05.63
Uvularia grandiflora	20.00	00.95	04.59	03.08	03.84
Polygonum virginianum	05.00	01.88	01.15	06.10	03.62
Solidago flexicaulis	05.00	01.88	01.15	06.10	03.62
Hybanthus concolor	15.00	01.05	03.45	03.41	03.43
Polystichum acrostichoides	15.00	01.05	03.45	03.41	03.43
Osmorhiza claytonii	10.00	00.78	02.30	02.53	02.42
Carex albursina	15.00	00.20	03.45	00.65	02.05
Phlox divaricata	15.00	00.20	03.45	00.65	02.05
Adiantum pedatum	05.00	00.75	01.15	02.43	01.79
Galium aparine	05.00	00.75	01.15	02.43	01.79
Leersia virginica	10.00	00.30	02.30	00.97	01.64
Campanula americana	10.00	00.18	02.30	00.58	01.44
Viola sororia	10.00	00.05	02.30	00.16	01.23

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Cystopteris protrusa	05.00	00.15	01.15	00.49	00.82
Festuca obtusa	05.00	00.15	01.15	00.49	00.82
Geum canadense	05.00	00.15	01.15	00.49	00.82
Poa pratensis	05.00	00.15	01.15	00.49	00.82
Actaea pachypoda	05.00	00.03	01.15	00.10	00.62
Dicentra cucullaria	05.00	00.03	01.15	00.10	00.62
Oxalis sp.	05.00	00.03	01.15	00.10	00.62

Camp Vandeventer Spring:

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
TREES					
Carpinus caroliniana	57.10	24.04	19.51	19.21	19.36
Quercus rubra	42.90	20.57	14.66	16.44	15.55
Acer negundo	42.90	14.54	14.66	11.62	13.14
Cornus florida	21.40	15.18	07.31	12.13	09.72
Quercus prinoides	21.40	13.39	07.31	10.70	09.00
Fraxinus americana	21.40	12.36	07.31	09.87	08.59
Tilia americana	14.30	05.54	04.89	04.43	04.66
Ostrya virginiana	14.30	05.49	04.89	04.39	04.64
Ulmus americana	21.40	01.32	07.31	01.05	04.18
Celtis occidentalis	07.10	04.46	02.43	03.56	03.00
Acer saccharum	07.10	02.74	02.43	02.19	02.31
Asimina triloba	07.10	02.74	02.43	02.19	02.31
Cercis canadensis	07.10	02.74	02.43	02.19	02.31
Pinus sylvestris	07.10	00.04	02.43	00.03	01.23
SHRUBS					
Hydrangea arborescens	71.40	04.00	55.56	46.73	51.14
Rosa multiflora	28.60	01.57	22.26	18.34	20.30
Cornus drummondii	07.10	02.74	05.52	32.01	18.77
Symphoricarpos orbiculatus	14.30	00.04	11.13	00.47	05.80
Staphylea trifolia	07.10	00.21	05.53	02.45	03.99
VINES					
Parthenocissus quinquefolia	35.70	05.82	83.41	99.32	91.36
Smilax hispida	07.10	00.04	16.59	00.68	08.64
HERBS					
Cryptotaenia canadensis	71.40	10.61	06.99	13.53	10.27
Solidago flexicaulis	50.00	09.75	04.90	12.43	08.67
Leersia virginica	71.40	07.39	06.99	09.43	08.21
Polystichum acrostichoides	50.00	08.82	04.90	11.25	08.08
Equisetum hyemale	35.70	08.85	03.49	11.29	07.39
Polygonum amphibium	07.10	07.30	00.70	09.31	05.01
Festuca obtusa	71.40	02.11	06.99	02.69	04.84
Aster sp.	64.30	01.57	06.30	02.00	04.15
Elymus virginicus	42.90	02.82	04.19	03.60	03.90
Carex blanda	64.30	01.04	06.30	01.33	03.82
Viola sororia	71.40	00.36	06.99	00.46	03.73
Rudbeckia laciniata	21.40	04.06	02.10	05.18	03.64

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Phlox divaricata	42.90	01.61	04.19	02.05	03.12
Amphicarpaea bracteata	28.60	02.63	02.80	03.35	03.08
Prunella vulgaris	35.70	01.54	03.49	01.96	02.73
Erigeron philadelphicus	35.70	01.43	03.49	01.82	02.66
Ranunculus recurvatus	42.90	00.57	04.19	00.73	02.46
Eupatorium rugosum	28.60	01.36	02.80	01.74	02.27
Pilea pumila	28.60	00.50	02.80	00.64	01.72
Arabis laevigata	21.40	00.29	02.10	00.37	01.24
Carex granularis	07.10	01.10	00.70	01.40	01.05
Sanicula odorata	07.10	01.10	00.70	01.40	01.05
Agrostis perennans	14.30	00.30	01.40	00.38	00.89
Plantago rugelii	14.30	00.07	01.40	00.10	00.75
Circaea lutetiana	07.10	00.21	00.70	00.27	00.49
Equisetum arvense	07.10	00.22	00.70	00.28	00.49
Scutellaria incana	07.10	00.22	00.70	00.28	00.49
Agrimonia pubescens	07.10	00.04	00.70	00.05	00.38
Bidens sp.	07.10	00.04	00.70	00.05	00.38
Cystopteris tennesseensis	07.10	00.04	00.70	00.05	00.38
Juncus tenuis	07.10	00.04	00.70	00.05	00.38
Lactuca sp.	07.10	00.04	00.70	00.05	00.38
Oxalis sp.	07.10	00.04	00.70	00.05	00.38
Panicum sp.	07.10	00.04	00.70	00.05	00.38
Ranunculus abortivus	07.10	00.04	00.70	00.05	00.38
Taraxacum officinale	07.10	00.04	00.70	00.05	00.38
Viola striata	07.10	00.22	00.70	00.28	00.38

Dual Springs

TREES					
Salix nigra	75.00	19.15	26.78	48.44	37.61
Acer saccharum	25.00	13.65	08.93	34.53	21.73
Populus deltoides	55.00	02.35	19.64	05.95	12.79
Acer negundo	55.00	01.95	19.64	04.93	12.29
Platanus occidentalis	35.00	01.15	12.50	02.91	07.71
Ulmus americana	25.00	01.10	08.93	02.78	05.86
Juglans nigra	05.00	00.15	01.79	00.38	01.08
Tilia americana	05.00	00.03	01.79	00.08	00.93
SHRUBS					
Salix exigua	15.00	02.78	60.00	42.57	51.28
Lindera benzoin	10.00	03.75	40.00	57.43	48.72
VINES					
Smilax hispida	05.00	00.15	100.00	100.00	100.00
HERBS					
Humulus japonicus	65.00	16.45	06.32	12.83	09.58
Agropyron repens	50.00	13.58	04.86	10.59	07.73
Impatiens capensis	50.00	12.85	04.86	10.02	07.44
Festuca pratensis	50.00	11.98	04.86	09.35	07.11

(**Appendix 2: Continued**)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Leersia oryzoides	60.00	10.03	05.83	07.83	06.83
Mimulus alatus	40.00	07.10	03.88	05.54	04.71
Elymus virginicus	50.00	05.48	04.86	04.28	04.57
Polygonum pensylvanicum	40.00	05.73	03.88	04.47	04.18
Penthorum sedoides	35.00	04.85	03.40	03.78	03.59
Leersia virginica	20.00	05.78	01.94	04.51	03.23
Polygonum caespitosum	45.00	01.93	04.37	01.51	02.94
Cinna arundinacea	35.00	02.45	03.40	01.91	02.66
Trifolium repens	30.00	02.58	02.92	02.01	02.47
Erigeron annuus	25.00	03.15	02.43	02.46	02.45
Cryptotaenia canadensis	25.00	01.95	02.43	01.52	01.97
Hasteola suaveolens	05.00	04.25	00.48	03.31	01.89
Bidens sp.	35.00	00.30	03.40	00.23	01.82
Rumex crispus	25.00	01.35	02.43	01.05	01.74
Juncus tenuis	25.00	01.23	02.43	00.96	01.69
Festuca obtusa	15.00	02.18	01.46	01.70	01.58
Carex frankii	10.00	02.03	00.98	01.58	01.28
Helianthus sp.	20.00	00.48	01.94	00.37	01.15
Calystegium sepium	15.00	01.05	01.46	00.82	01.14
Trifolium pratense	20.00	00.35	01.94	00.27	01.10
Rudbeckia laciniata	15.00	00.93	01.46	00.73	01.09
Bromus sp.	10.00	01.50	00.98	01.17	01.07
Plantago rugellii	15.00	00.33	01.46	00.26	00.86
Cyperus strigosus	10.00	00.90	00.98	00.70	00.84
Melilotus officinalis	10.00	00.78	00.98	00.61	00.79
Poa pratensis	15.00	00.08	01.46	00.06	00.76
Solidago canadensis	10.00	00.30	00.98	00.23	00.60
Rorippa palustris	10.00	00.18	00.98	00.14	00.56
Solidago gigantea	10.00	00.18	00.98	00.14	00.56
Carex radiata	05.00	00.75	00.48	00.58	00.53
Equisetum arvense	05.00	00.75	00.48	00.58	00.53
Boehmeria cylindrica	10.00	00.05	00.98	00.04	00.51
Ambrosia trifida	05.00	00.15	00.48	00.12	00.30
Amphicarpaea bracteata	05.00	00.15	00.48	00.12	00.30
Aster pilosus	05.00	00.15	00.48	00.12	00.30
Carex sp. #1	05.00	00.15	00.48	00.12	00.30
Carex sp. #2	05.00	00.15	00.48	00.12	00.30
Carex sp. #3	05.00	00.15	00.48	00.12	00.30
Echinochloa crus-gallii	05.00	00.15	00.48	00.12	00.30
Erigeron philadelphicus	05.00	00.15	00.48	00.12	00.30
Hypericum punctatum	05.00	00.15	00.48	00.12	00.30
Lactuca sp.	05.00	00.15	00.48	00.12	00.30
Lolium perenne	05.00	00.15	00.48	00.12	00.30
Stachys palustris	05.00	00.15	00.48	00.12	00.30
Taraxacum officinale	05.00	00.15	00.48	00.12	00.30
Trifolium hybridum	05.00	00.15	00.48	00.12	00.30
Acalypha rhomboidea	05.00	00.03	00.48	00.02	00.25
Agrostis sp.	05.00	00.03	00.48	00.02	00.25
Aster sp.	05.00	00.03	00.48	00.02	00.25
Glyceria striata	05.00	00.03	00.48	00.02	00.25

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Juncus scirpoides	05.00	00.03	00.48	00.02	00.25
Medicago sativa	05.00	00.03	00.48	00.02	00.25
Ranunculus abortivus	05.00	00.03	00.48	00.02	00.25
Ranunculus sceleratus	05.00	00.03	00.48	00.02	00.25
Unknown herb	05.00	00.03	00.48	00.02	00.25
		Kelly Spring:			
TREES					
Platanus occidentalis	30.00	13.75	16.21	20.97	18.59
Cercis canadensis	35.00	07.23	18.92	11.02	14.97
Carya ovata	20.00	09.40	10.81	14.33	12.57
Ulmus americana	25.00	05.93	13.51	09.04	11.28
Cornus florida	10.00	06.25	05.41	09.53	07.47
Quercus alba	10.00	06.25	05.41	09.53	07.47
Carya cordiformis	10.00	06.13	05.41	09.35	07.38
Quercus velutina	05.00	04.25	02.70	06.48	04.59
Ostrya virginiana	10.00	02.03	05.41	03.10	04.26
Acer negundo	05.00	03.13	02.70	04.77	03.73
Quercus rubra	10.00	00.30	05.41	00.46	02.93
Tilia americana	05.00	00.75	02.70	01.14	01.92
Carya tomentosa	05.00	00.15	02.70	00.23	01.47
Juglans nigra	05.00	00.03	02.70	00.05	01.37
SHRUBS					
Rosa multiflora	05.00	04.80	05.56	39.22	22.39
Corylus americana	05.00	03.13	05.56	25.57	15.57
Staphylea trifolia	10.00	01.50	11.11	12.25	11.68
Viburnum prunifolium	10.00	00.90	11.11	07.35	09.23
Sambucus canadensis	15.00	00.20	16.67	01.63	09.15
Symphoricarpos orbiculatus	10.00	00.78	11.11	06.37	08.74
Hydrangea arborescens	10.00	00.30	11.11	02.45	06.78
Ribes missouriense	10.00	00.30	11.11	02.45	06.78
Cornus drummondii	05.00	00.15	05.55	01.23	03.39
Lonicera maackii	05.00	00.15	05.55	01.23	03.39
Rubus sp.	05.00	00.03	05.56	00.25	02.90
VINES					
Parthenocissus quinquefolia	20.00	02.80	30.77	35.99	33.38
Toxicodendron radicans	25.00	01.58	38.46	20.31	29.38
Smilax hispida	15.00	02.65	23.07	34.06	28.57
Vitis sp.	05.00	00.75	07.70	09.64	08.67
HERBS					
Festuca pratense	50.00	16.15	04.56	18.15	11.36
Amphicarpaea bracteata	70.00	13.10	06.39	14.73	10.57
Equisetum arvense	50.00	07.83	04.56	08.80	06.69
Carex normalis	15.00	09.25	01.37	10.40	05.90
Panicum clandestinum	30.00	03.58	02.74	04.03	03.39
Aster sp.	45.00	02.30	04.11	02.59	03.35

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Viola sororia	50.00	01.48	04.55	01.66	03.11
Apios americana	20.00	03.53	01.82	03.97	02.90
Leersia virginica	40.00	01.90	03.65	02.14	02.90
Chasmanthium latifolium	35.00	02.25	03.19	02.53	02.86
Trifolium pratense	30.00	02.45	02.74	02.75	02.75
Carex radiata	30.00	01.98	02.74	02.23	02.49
Polystichum acrostichoides	25.00	02.30	02.28	02.59	02.44
Equisetum hyemale	25.00	02.23	02.28	02.51	02.40
Plantago rugellii	35.00	01.28	03.20	01.44	02.32
Prunella vulgaris	20.00	01.08	01.82	01.22	01.52
Geum canadense	25.00	00.63	02.28	00.71	01.50
Desmodium paniculatum	20.00	00.95	01.82	01.07	01.45
Lobelia siphilitica	20.00	00.95	01.82	01.07	01.45
Erigeron philadelphicus	20.00	00.83	01.82	00.93	01.38
Rudbeckia subtomentosa	05.00	01.88	00.46	02.11	01.29
Hemerocallis fulva	15.00	01.05	01.37	01.18	01.28
Trifolium repens	20.00	00.60	01.82	00.67	01.25
Sanicula canadensis	25.00	00.13	02.28	00.15	01.22
Anemone virginica	15.00	00.93	01.37	01.05	01.21
Festuca obtusa	15.00	00.93	01.37	01.05	01.21
Agrimonia pubescens	20.00	00.25	01.82	00.28	01.05
Pilea pumila	20.00	00.23	01.82	00.26	01.04
Hypericum punctatum	15.00	00.33	01.37	00.37	00.87
Cryptotaenia canadensis	15.00	00.20	01.37	00.23	00.80
Geranium maculatum	15.00	00.20	01.37	00.23	00.80
Juncus tenuis	15.00	00.20	01.37	00.23	00.80
Acalypha sp.	15.00	00.08	01.37	00.09	00.73
Erigeron annuus	15.00	00.08	01.37	00.09	00.73
Ranunculus recurvatus	15.00	00.08	01.37	00.09	00.73
Desmodium glutinosum	05.00	00.75	00.46	00.84	00.65
Lespedeza intermedia	05.00	00.75	00.46	00.84	00.65
Physostegia virginiana	05.00	00.75	00.46	00.84	00.65
Solidago gigantea	05.00	00.75	00.46	00.84	00.65
Galium concinnum	10.00	00.18	00.91	00.20	00.56
Carex sp.	10.00	00.05	00.91	00.06	00.49
Taraxacum officinale	10.00	00.05	00.91	00.06	00.49
Verbena urticifolia	10.00	00.05	00.91	00.06	00.49
Aster pilosus	05.00	00.15	00.46	00.17	00.31
Carex cephalophora	05.00	00.15	00.46	00.17	00.31
Elymus virginicus	05.00	00.15	00.46	00.17	00.31
Eupatorium rugosum	05.00	00.15	00.46	00.17	00.31
Helianthus divaricatus	05.00	00.15	00.46	00.17	00.31
Lespedeza violacea	05.00	00.15	00.46	00.17	00.31
Medicago sativa	05.00	00.15	00.46	00.17	00.31
Melilotus alba	05.00	00.15	00.46	00.17	00.31
Melilotus officinalis	05.00	00.15	00.46	00.17	00.31
Penstemon digitalis	05.00	00.15	00.46	00.17	00.31
Phlox divaricata	05.00	00.15	00.46	00.17	00.31
Ruellia pedunculata	05.00	00.15	00.46	00.17	00.31
Vernonia missurica	05.00	00.15	00.46	00.17	00.31

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Aquilegia canadensis	05.00	00.03	00.46	00.03	00.24
Asplenium platyneuron	05.00	00.03	00.46	00.03	00.24
Asplenium rhizophyllum	05.00	00.03	00.46	00.03	00.24
Boehmeria cylindrica	05.00	00.03	00.46	00.03	00.24
Carex blanda	05.00	00.03	00.46	00.03	00.24
Cystopteris tennesseensis	05.00	00.03	00.46	00.03	00.24
Daucus carota	05.00	00.03	00.46	00.03	00.24
Galium triflorum	05.00	00.03	00.46	00.03	00.24
Lobelia inflata	05.00	00.03	00.46	00.03	00.24
Lycopus sp.	05.00	00.03	00.46	00.03	00.24
Panicum lanuginosum	05.00	00.03	00.46	00.03	00.24
Poa compressa	05.00	00.03	00.46	00.03	00.24
Sanicula odorata	05.00	00.03	00.46	00.03	00.24
Sium suave	05.00	00.03	00.46	00.03	00.24
Viola sororia	05.00	00.03	00.46	00.03	00.24

Little Carr Spring:

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
TREES					
Acer saccharum	90.00	54.55	40.91	47.15	44.03
Tilia americana	60.00	38.05	27.27	32.89	30.08
Quercus rubra	30.00	07.80	13.64	06.74	10.19
Platanus occidentalis	10.00	09.75	04.55	08.43	06.49
Celtis laevigata	10.00	03.75	04.55	03.24	03.89
Ulmus americana	10.00	01.50	04.54	01.29	02.92
Carpinus caroliniana	10.00	00.30	04.54	00.26	02.40
SHRUBS					
Cornus drummondii	20.00	05.25	50.00	40.38	45.19
Hydrangea arborescens	10.00	06.25	25.00	48.08	36.54
Sambucus canadensis	10.00	01.50	25.00	11.54	18.27
VINES					
Toxicodendron radicans	20.00	03.00	40.00	88.24	64.12
Parthenocissus quinquefolia	20.00	00.35	40.00	10.29	25.15
Vitis sp.	10.00	00.05	20.00	01.47	10.73
HERBS					
Equisetum arvense	20.00	12.50	02.74	31.49	17.11
Leersia virginica	90.00	04.60	12.32	11.59	11.95
Cryptotaenia canadensis	70.00	03.75	09.59	09.44	09.51
Ambrosia trifida	30.00	04.35	04.11	10.96	07.53
Carex sp.	70.00	01.10	09.59	02.77	06.18
Plantago rugellii	30.00	03.05	04.11	07.68	05.89
Aster sp. #1	30.00	02.10	04.11	05.29	04.70
Pilea pumila	40.00	00.20	05.48	00.50	02.99
Aster sp. #2	10.00	01.80	01.37	04.53	02.95
Eupatorium rugosum	30.00	00.65	04.11	01.64	02.87
Scirpus atrovirens	10.00	01.50	01.37	03.78	02.58
Phlox divaricata	30.00	00.40	04.11	01.01	02.56

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Acalypha rhomboidea	30.00	00.35	04.11	00.88	02.50
Phytolacca americana	30.00	00.15	04.11	00.38	02.25
Viola sororia	20.00	00.40	02.74	01.01	01.88
Erigeron annuus	20.00	00.35	02.74	00.88	01.81
Polygonum pensylvanicum	20.00	00.10	02.74	00.25	01.50
Galium triflorum	10.00	00.35	01.37	00.88	01.13
Carex radiata	10.00	00.30	01.37	00.75	01.06
Cinna arundinacea	10.00	00.30	01.37	00.75	01.06
Festuca obtusa	10.00	00.30	01.37	00.75	01.06
Hypericum punctatum	10.00	00.30	01.37	00.75	01.06
Teucrium canadense	10.00	00.30	01.37	00.75	01.06
Agrostis sp.	10.00	00.10	01.37	00.25	00.81
Amaranthus sp.	10.00	00.05	01.37	00.13	00.75
Amphicarpaea bracteata	10.00	00.05	01.37	00.13	00.75
Campanula americana	10.00	00.05	01.37	00.13	00.75
Elymus virginicus	10.00	00.05	01.37	00.13	00.75
Erigeron philadelphicus	10.00	00.05	01.37	00.13	00.75
Oxalis sp.	10.00	00.05	01.37	00.13	00.75
Rumex obtusifolius	10.00	00.05	01.37	00.13	00.75
Taraxacum officinale	10.00	00.05	01.37	00.13	00.75

Madonnaville Spring

TREES					
Platanus occidentalis	75.00	40.63	16.48	27.02	21.75
Ulmus americana	75.00	30.45	16.48	20.25	18.37
Acer saccharum	35.00	19.78	07.69	13.15	10.42
Quercus prinoides	30.00	15.78	06.59	10.49	08.54
Quercus rubra	30.00	12.15	06.59	08.08	07.33
Quercus alba	25.00	10.28	05.49	06.84	06.16
Cornus florida	30.00	06.75	06.59	04.49	05.54
Prunus serotina	40.00	02.15	08.79	01.43	05.11
Acer negundo	20.00	02.28	04.40	01.52	02.96
Cercis canadensis	15.00	03.30	03.30	02.19	02.75
Celtis laevigata	20.00	01.08	04.40	00.72	02.56
Morus rubra	10.00	03.28	02.20	02.18	02.19
Carya ovata	15.00	00.45	03.30	00.30	01.80
Sassafras albidum	15.00	00.33	03.30	00.22	01.76
Fraxinus americana	10.00	00.90	02.20	00.60	01.40
Carya ovalis	05.00	00.75	01.10	00.50	00.80
Celtis occidentalis	05.00	00.03	01.10	00.02	00.56
SHRUBS					
Cornus drummondii	25.00	05.40	41.67	41.70	41.69
Viburnum rufidulum	20.00	05.90	33.34	45.56	39.45
Hydrangea arborescens	05.00	00.75	08.33	05.79	07.06
Ilex decidua	05.00	00.75	08.33	05.79	07.06
Euonymus atropurpurea	05.00	00.15	08.33	01.16	04.74

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
VINES					
Parthenocissus quinquefolia	80.00	16.35	53.33	53.36	53.34
Toxicodendron radicans	35.00	09.28	23.33	30.29	26.81
Vitis aestivalis	25.00	04.08	16.68	13.31	15.00
Celastrus scandens	05.00	00.78	03.33	02.55	02.94
Smilax hispida	05.00	00.15	03.33	00.49	01.91
HERBS					
Sanicula odorata	70.00	13.60	11.68	47.30	29.49
Viola sororia	60.00	01.78	10.00	06.19	08.10
Carex blanda	70.00	01.23	11.68	04.28	07.98
Phlox divaricata	70.00	00.98	11.67	03.41	07.54
Elymus virginicus	25.00	01.35	04.17	04.70	04.44
Amphicarpaea bracteata	15.00	00.93	02.50	03.23	02.86
Cryptotaenia canadensis	15.00	00.93	02.50	03.23	02.86
Solidago sp.	15.00	00.93	02.50	03.23	02.86
Poa pratensis	25.00	00.38	04.17	01.32	02.75
Agrimonia pubescens	20.00	00.60	03.34	02.09	02.72
Polystichum acrostichoides	10.00	00.90	01.67	03.13	02.40
Leersia virginica	20.00	00.10	03.34	00.35	01.85
Phryma leptostachya	15.00	00.33	02.50	01.15	01.83
Desmodium glutinosum	05.00	00.75	00.83	02.61	01.72
Eupatorium rugosum	05.00	00.75	00.83	02.61	01.72
Helianthus divaricatus	05.00	00.75	00.83	02.61	01.72
Desmodium nudiflorum	10.00	00.30	01.67	01.04	01.37
Circaea lutetiana	10.00	00.18	01.67	00.63	01.15
Galium concinnum	10.00	00.18	01.67	00.63	01.15
Botrychium virginianum	10.00	00.05	01.67	00.17	00.92
Galium aparine	10.00	00.05	01.67	00.17	00.92
Galium circaezans	10.00	00.05	01.67	00.17	00.92
Asplenium platyneuron	05.00	00.15	00.83	00.53	00.67
Aster sp. (#1)	05.00	00.15	00.83	00.52	00.67
Aster sp. (#2)	05.00	00.15	00.83	00.52	00.67
Bromus pubescens	05.00	00.15	00.83	00.53	00.67
Elymus hystrix	05.00	00.15	00.83	00.53	00.67
Osmorhiza longistylis	05.00	00.15	00.83	00.53	00.67
Panicum boscii	05.00	00.15	00.83	00.53	00.67
Passiflora lutea	05.00	00.15	00.83	00.53	00.67
Silene stellata	05.00	00.15	00.83	00.52	00.67
Allium canadense	05.00	00.03	00.83	00.10	00.47
Carex sp.	05.00	00.03	00.83	00.10	00.47
Erigeron annuus	05.00	00.03	00.83	00.10	00.47
Erigeron philadelphicus	05.00	00.03	00.83	00.10	00.47
Galium triflorum	05.00	00.03	00.83	00.10	00.47
Geum canadense	05.00	00.03	00.83	00.10	00.47
Penstemon digitalis	05.00	00.03	00.83	00.10	00.47
Pilea pumila	05.00	00.03	00.83	00.10	00.47
Ranunculus abortivus	05.00	00.03	00.83	00.10	00.47
Ranunculus recurvatus	05.00	00.03	00.83	00.10	00.47

(Appendix 2: Continued)

Ritter Spring

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
TREES					
Populus deltoides	62.50	26.69	29.41	42.66	36.03
Platanus occidentalis	50.00	19.06	23.53	30.46	27.00
Celtis occidentalis	25.00	09.38	11.77	14.99	13.38
Diospyros virginiana	37.50	02.31	17.65	03.69	10.67
Morus alba	12.50	04.69	05.88	07.49	06.69
Quercus prinoides	12.50	00.38	05.88	00.61	03.24
Liriodendron tulipifera	12.50	00.06	05.88	00.10	02.99
SHRUBS					
Sambucus canadensis	25.00	06.56	50.00	56.40	53.20
Cornus drummondii	12.50	04.69	25.00	40.33	32.67
Lonicera maackii	12.50	00.38	25.00	03.27	14.13
VINES					
Vitis aestivalis	12.50	01.88	20.00	61.04	40.52
Toxicodendron radicans	25.00	00.44	40.00	14.28	27.14
Lonicera japonica	12.50	00.38	20.00	12.34	16.17
Vitis riparia	12.50	00.38	20.00	12.34	16.17
HERBS					
Festuca pratensis	75.00	38.81	11.54	48.00	29.77
Leersia virginica	62.50	06.06	09.62	07.50	08.56
Equisetum arvense	25.00	09.69	03.85	11.99	07.92
Agrostis alba	62.50	02.44	09.62	03.02	06.32
Plantago rugellii	50.00	01.19	07.70	01.47	04.59
Trifolium repens	37.50	02.31	05.77	02.86	04.32
Juncus tenuis	50.00	00.56	07.70	00.69	04.20
Kummerowia sp.	12.50	04.69	01.92	05.80	03.86
Solidago canadensis	25.00	02.25	03.85	02.78	03.32
Taraxacum officinale	25.00	00.75	03.85	00.93	02.39
Aster sp.	25.00	00.44	03.85	00.54	02.20
Medicago sativa	25.00	00.44	03.85	00.54	02.20
Calystegia sepium	12.50	01.88	01.92	02.33	02.12
Carex albolutescens	12.50	01.88	01.92	02.33	02.12
Carex blanda	12.50	01.88	01.92	02.33	02.12
Eupatorium serotinum	12.50	01.88	01.92	02.33	02.12
Phyla lanceolata	12.50	01.88	01.92	02.33	02.12
Eupatorium rugosum	12.50	00.38	01.92	00.47	01.20
Polygonum neglectum	12.50	00.38	01.92	00.47	01.20
Rumex altissimum	12.50	00.38	01.92	00.47	01.20
Trifolium pratense	12.50	00.38	01.92	00.47	01.20
Mollugo verticillatus	12.50	00.06	01.92	00.07	00.99
Muhlenbergia sp.	12.50	00.06	01.92	00.07	00.99
Oenothera biennis	12.50	00.06	01.92	00.07	00.99
Rorippa sp.	12.50	00.06	01.92	00.07	00.99
Unknown herb seedling	12.50	00.06	01.92	00.07	00.99

(Appendix 2: Continued)

Sparrow Spring

Frequency	% Cover	Ave. Mean Frequency	% Relative Mean Cover	% Relative Ave. I.V.	%
TREES					
Quercus prinoides	35.00	19.38	30.43	44.87	37.65
Fraxinus americana	20.00	13.50	17.39	31.26	24.33
Ulmus americana	25.00	07.18	21.73	16.62	19.18
Cercis canadensis	10.00	02.63	08.70	06.09	07.39
Acer negundo	10.00	00.05	08.70	00.11	04.40
Juglans nigra	05.00	00.15	04.35	00.35	02.35
Morus alba	05.00	00.15	04.35	00.35	02.35
Prunus serotina	05.00	00.15	04.35	00.35	02.35
SHRUBS					
Rosa multiflora	10.00	03.88	22.22	50.92	36.57
Sambucus canadensis	20.00	01.08	44.44	14.17	29.30
Lonicera maackii	05.00	01.88	11.12	24.67	17.90
Symphoricarpos orbiculatus	10.00	00.78	22.22	10.24	16.23
VINES					
Lonicera japonica	30.00	10.75	35.29	46.54	40.91
Toxicodendron radicans	25.00	07.05	29.41	30.52	29.97
Parthenocissus quinquefolia	15.00	02.65	17.65	11.47	14.56
Vitis riparia	15.00	02.65	17.65	11.47	14.56
HERBS					
Festuca pratensis	85.00	35.43	10.18	45.39	27.79
Phalaris arundinacea	20.00	10.00	02.39	12.81	07.60
Melilotus alba	30.00	06.20	03.59	07.94	05.77
Agrostis alba	35.00	03.65	04.19	04.68	04.44
Calystegia sepium	35.00	03.13	04.19	04.01	04.10
Aster sp.	40.00	00.58	04.79	00.74	02.77
Trifolium pratense	35.00	00.90	04.19	01.15	02.67
Polygonum pensylvanicum	30.00	01.00	03.59	01.28	02.44
Glyceria striata	05.00	03.13	00.60	04.01	02.31
Muhlenbergia sp.	20.00	01.68	02.39	02.15	02.27
Asclepias syriaca	15.00	01.53	01.80	01.96	01.88
Impatiens capensis	20.00	01.08	02.39	01.38	01.88
Leersia oryzoides	25.00	00.50	02.99	00.64	01.81
Elymus virginicus	20.00	00.95	02.39	01.22	01.80
Poa pratensis	20.00	00.95	02.39	01.22	01.80
Trifolium repens	20.00	00.95	02.39	01.22	01.80
Plantago rugellii	25.00	00.25	02.99	00.32	01.66
Teucrium canadense	15.00	01.05	01.80	01.35	01.58
Oxalis dillenii	25.00	00.13	02.99	00.17	01.58
Boehmeria cylindrica	20.00	00.35	02.39	00.45	01.42
Melilotus officinalis	15.00	00.80	01.80	01.03	01.42
Verbena urticifolia	20.00	00.23	02.39	00.30	01.35
Ambrosia artemisiifolia	20.00	00.10	02.39	00.13	01.26
Juncus torreyi	10.00	00.78	01.20	01.00	01.10

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Amaranthus sp.	15.00	00.08	01.80	00.10	00.95
Carex grisea	15.00	00.08	01.80	00.10	00.95
Echinochloa crus-galli	15.00	00.08	01.80	00.10	00.95
Taraxacum officinale	15.00	00.08	01.80	00.10	00.95
Solanum carolinense	10.00	00.30	01.20	00.39	00.79
Amphicarpaea bracteata	05.00	00.75	00.60	00.96	00.78
Chenopodium album	10.00	00.05	01.20	00.06	00.63
Eupatorium rugosum	10.00	00.05	01.20	00.06	00.63
Phleum pratensis	10.00	00.05	01.20	00.06	00.63
Pilea pumila	10.00	00.05	01.20	00.06	00.63
Prunella vulgaris	10.00	00.05	01.20	00.06	00.63
Torilis japonica	10.00	00.05	01.20	00.06	00.63
Xanthium strumarium	10.00	00.05	01.20	00.06	00.63
Leersia virginica	05.00	00.15	00.60	00.19	00.39
Lycopus sp.	05.00	00.15	00.60	00.19	00.39
Solidago canadensis	05.00	00.15	00.60	00.19	00.39
Coronilla varia	05.00	00.15	00.60	00.19	00.39
Aster pilosus	05.00	00.03	00.60	00.04	00.32
Bromus sp.	05.00	00.03	00.60	00.04	00.32
Dactylis glomerata	05.00	00.03	00.60	00.04	00.32
Elymus villosus	05.00	00.03	00.60	00.04	00.32
Erigeron philadelphicus	05.00	00.03	00.60	00.04	00.32
Eupatorium serotinum	05.00	00.03	00.60	00.04	00.32
Glechoma hederacea	05.00	00.03	00.60	00.04	00.32
Humulus sp.	05.00	00.03	00.60	00.04	00.32
Mollugo verticillatus	05.00	00.03	00.60	00.04	00.32
Phlox divaricata	05.00	00.03	00.60	00.04	00.32
Polygonum neglectum	05.00	00.03	00.60	00.04	00.32
Rumex altissimus	05.00	00.03	00.60	00.04	00.32
Rumex crispus	05.00	00.03	00.60	00.04	00.32

Sparrow Creek Downstream

TREES					
Quercus rubra	60.00	32.90	20.34	34.31	27.32
Ostrya virginiana	45.00	16.05	15.25	16.74	16.00
Platanus occidentalis	20.00	09.50	06.78	09.91	08.35
Cercis canadensis	25.00	07.03	08.47	07.33	07.90
Cornus florida	25.00	07.03	08.47	07.33	07.90
Quercus imbricaria	20.00	07.63	06.78	07.96	07.37
Quercus prinoides	20.00	07.55	06.78	07.87	07.33
Fraxinus americana	30.00	02.10	10.17	02.19	06.18
Prunus serotina	15.00	02.78	05.08	02.90	03.99
Ulmus americana	15.00	01.05	05.08	01.09	03.08
Carya ovata	05.00	00.75	01.70	00.78	01.24
Crataegus mollis	05.00	00.75	01.70	00.78	01.24
Quercus alba	05.00	00.75	01.70	00.78	01.24
Acer negundo	05.00	00.03	01.70	00.03	00.86

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
SHRUBS					
Cornus drummondii	55.00	16.90	55.00	76.75	65.87
Symphoroicarpos orbiculatus	15.00	01.53	15.00	06.95	10.98
Rosa multiflora	10.00	02.63	10.00	11.94	10.97
Sambucus canadensis	05.00	00.75	05.00	03.40	04.20
Lonicera maackii	05.00	00.15	05.00	00.68	02.84
Hydrangea arborescens	05.00	00.03	05.00	00.14	02.57
Viburnum rufidulum	05.00	00.03	05.00	00.14	02.57
VINES					
Toxicodendron radicans	55.00	16.05	40.75	54.50	47.63
Parthenocissus quinquefolia	50.00	05.30	37.04	17.99	27.52
Lonicera japonica	05.00	04.55	03.70	15.45	09.57
Vitis riparia	15.00	02.05	11.11	06.96	09.04
Celastrus scandens	05.00	00.75	03.70	02.55	03.12
Smilax hispida	05.00	00.75	03.70	02.55	03.12
HERBS					
Festuca pratensis	80.00	24.55	15.54	51.67	33.61
Equisetum arvense	50.00	04.78	09.71	10.07	09.89
Poa pratensis	20.00	03.80	03.89	08.00	05.95
Aster sp. #1	50.00	02.80	09.71	05.90	07.81
Elymus virginicus	30.00	02.58	05.83	05.43	05.63
Sanicula odorata	10.00	01.90	01.94	04.00	02.97
Eupatorium rugosum	20.00	00.95	03.89	02.00	02.95
Leersia virginica	20.00	00.95	03.89	02.00	02.95
Viola sororia	25.00	00.25	04.86	00.53	02.70
Geum canadense	15.00	00.93	02.91	01.96	02.44
Asplenium platyneuron	10.00	00.78	01.94	01.65	01.80
Carex grisea	15.00	00.20	02.91	00.43	01.67
Carex radiata	05.00	00.75	00.97	01.58	01.28
Polystichum acrostichoides	05.00	00.75	00.97	01.58	01.28
Boehmeria cylindrica	10.00	00.18	01.94	00.38	01.16
Prunella vulgaris	10.00	00.05	01.94	00.11	01.03
Trifolium repens	10.00	00.05	01.94	00.11	01.03
Agrostis sp.	05.00	00.15	00.97	00.32	00.65
Glyceria striata	05.00	00.15	00.97	00.32	00.65
Phleum pratense	05.00	00.15	00.97	00.32	00.65
Solidago canadensis	05.00	00.15	00.97	00.32	00.65
Allium sp.	05.00	00.03	00.97	00.06	00.52
Ambrosia artemisiifolia	05.00	00.03	00.97	00.06	00.52
Aster sp. #2	05.00	00.03	00.97	00.06	00.52
Bidens sp.	05.00	00.03	00.97	00.06	00.51
Erigeron philadelphicus	05.00	00.03	00.97	00.06	00.51
Eupatorium serotinum	05.00	00.03	00.97	00.06	00.51
Festuca obtusa	05.00	00.03	00.97	00.06	00.51
Galium sp.	05.00	00.03	00.97	00.06	00.51
Impatiens capensis	05.00	00.03	00.97	00.06	00.51
Juncus tenuis	05.00	00.03	00.97	00.06	00.51
Leersia oryzoides	05.00	00.03	00.97	00.06	00.51

(Appendix 2: Continued)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Lysimachia nummularia	05.00	00.03	00.97	00.06	00.51
Melilotus alba	05.00	00.03	00.97	00.06	00.51
Physostegia virginiana	05.00	00.03	00.97	00.06	00.51
Plantago rugelii	05.00	00.03	00.97	00.06	00.51
Poa compressa	05.00	00.03	00.97	00.06	00.51
Poaceae sp.	05.00	00.03	00.97	00.06	00.51
Polygonum pensylvanicum	05.00	00.03	00.97	00.06	00.51
Polygonum sp.	05.00	00.03	00.97	00.06	00.51
Teucrium canadense	05.00	00.03	00.97	00.06	00.51
Triodanus perfoliata	05.00	00.03	00.97	00.06	00.51
Woodsia obutsa	05.00	00.03	00.97	00.06	00.51

Terry Spring:

TREES					
Acer saccharum	100.00	45.94	36.36	39.39	37.88
Celtis occidentalis	62.50	33.81	22.73	28.99	25.86
Quercus prinoides	37.50	14.38	13.64	12.33	12.98
Fraxinus americana	25.00	14.06	09.09	12.06	10.57
Gymnocladus dioicus	37.50	06.56	13.64	05.62	09.63
Ulmus americana	12.50	01.88	04.54	01.61	03.08
SHRUBS					
Lindera benzoin	12.50	00.38	50.00	50.00	50.00
Symphoricarpos orbiculatus	12.50	00.38	50.00	50.00	50.00
VINES					
Parthenocissus quinquefolia	50.00	04.19	80.00	98.59	89.30
Smilax hispida	12.50	00.06	20.00	01.41	10.70
HERBS					
Carex grisea	12.50	07.81	04.17	32.67	18.42
Carex jamesii	37.50	02.63	12.50	11.00	11.75
Eupatorium rugosum	37.50	02.31	12.50	09.66	11.08
Polygonum amphibium	25.00	02.25	08.33	09.41	08.87
Festuca obtusa	12.50	01.88	04.17	07.86	06.01
Festuca pratensis	12.50	01.88	04.17	07.86	06.01
Leersia virginica	12.50	01.88	04.17	07.86	06.01
Elymus virginicus	25.00	00.75	08.33	03.14	05.73
Carex albursina	12.50	00.38	04.17	01.59	02.88
Carex sp.	12.50	00.38	04.17	01.59	02.88
Phryma leptostachya	12.50	00.38	04.17	01.59	02.88
Poa pratensis	12.50	00.38	04.17	01.59	02.88
Sanicula canadensis	12.50	00.38	04.17	01.59	02.88
Unknown dicot herb	12.50	00.38	04.17	01.59	02.88
Arabis shortii	12.50	00.06	04.16	00.25	02.21
Bidens sp.	12.50	00.06	04.16	00.25	02.21
Ranunculus abortivus	12.50	00.06	04.16	00.25	02.21
Viola sororia	12.50	00.06	04.16	00.25	02.21

(Appendix 2: Continued)

Walsh Spring:

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
TREES					
Acer negundo	85.00	50.78	25.00	51.73	38.36
Sassafras albidum	50.00	16.55	14.71	16.86	15.78
Ulmus americana	65.00	06.98	19.12	07.11	13.11
Cornus florida	35.00	10.85	10.30	11.05	10.67
Carya ovata	15.00	01.05	04.41	01.07	02.74
Prunus serotina	15.00	00.33	04.41	00.34	02.38
Carya cordiformis	05.00	03.13	01.47	03.19	02.33
Platanus occidentalis	05.00	03.13	01.47	03.19	02.33
Carya ovalis	10.00	00.90	02.94	00.92	01.93
Cercis canadensis	10.00	00.90	02.94	00.92	01.93
Amelanchier arborea	05.00	01.88	01.47	01.91	01.69
Fraxinus americana	10.00	00.30	02.94	00.31	01.63
Quercus imbricaria	10.00	00.30	02.94	00.31	01.63
Quercus alba	05.00	00.75	01.47	00.76	01.12
Quercus prinoides	05.00	00.15	01.47	00.15	00.81
Salix nigra	05.00	00.15	01.47	00.15	00.81
Celtis occidentalis	05.00	00.03	01.47	00.03	00.75
SHRUBS					
Cornus drummondii	35.00	05.58	58.34	65.41	61.88
Rosa multiflora	15.00	02.65	25.00	31.07	28.04
Rhamnus caroliniana	05.00	00.15	08.33	01.76	05.04
Sambucus canadensis	05.00	00.15	08.33	01.76	05.04
VINES					
Vitis sp.	45.00	09.45	29.03	48.64	38.84
Parthenocissus quinquefolia	60.00	05.33	38.71	27.43	33.07
Toxicodendron radicans	25.00	03.55	16.13	18.27	17.20
Smilax hispida	20.00	00.35	12.90	01.80	07.35
Campsis radicans	05.00	00.75	03.23	03.86	03.54
HERBS					
Amphicarpaea bracteata	45.00	14.68	03.86	16.33	10.10
Leersia virginica	80.00	08.58	06.87	09.54	08.21
Festuca obtusa	70.00	09.10	06.00	10.12	08.06
Carex grisea/blanda	70.00	05.70	06.00	06.34	06.17
Geum canadense	65.00	04.33	05.58	04.82	05.20
Circaea lutetiana	60.00	04.08	05.15	04.54	04.85
Solidago gigantea	40.00	03.60	03.43	04.00	03.72
Galium triflorum	40.00	03.15	03.43	03.50	03.47
Equisetum arvense	20.00	04.05	01.72	04.50	03.11
Viola sororia	60.00	00.93	05.15	01.03	03.09
Cinna arundinacea	40.00	02.28	03.43	02.54	02.99
Sanicula canadensis	55.00	01.03	04.72	01.15	02.94
Botrychium virginianum	55.00	00.53	04.72	00.59	02.66
Aster sp.	30.00	02.45	02.57	02.73	02.65

(Appendix 2: Concluded)

	% Frequency	Ave. Mean Cover	% Relative Frequency	% Relative Ave. Mean Cover	% I.V.
Eupatorium rugosum	25.00	01.95	02.14	02.17	02.16
Cirsium altissimum	05.00	03.13	00.43	03.48	01.95
Polystichum acrostichoides	15.00	02.05	01.29	02.28	01.78
Elymus virginicus	15.00	01.65	01.29	01.84	01.56
Cryptotaenia canadensis	25.00	00.85	02.14	00.95	01.54
Chasmanthium latifolium	20.00	01.20	01.72	01.33	01.52
Phlox divaricata	30.00	00.28	02.57	00.31	01.44
Bromus pubescens	25.00	00.63	02.14	00.70	01.42
Carex sp.	05.00	01.88	00.43	02.09	01.26
Festuca elatior	10.00	01.50	00.86	01.67	01.26
Dioscorea villosa	15.00	00.93	01.29	01.03	01.16
Phryma leptostachya	15.00	00.93	01.29	01.03	01.16
Sanicula odorata	15.00	00.45	01.29	00.50	00.89
Geranium maculatum	10.00	00.78	00.86	00.87	00.86
Galium aparine	15.00	00.33	01.29	00.37	00.83
Glyceria striata	15.00	00.33	01.29	00.37	00.83
Pilea pumila	15.00	00.08	01.29	00.09	00.69
Carex cephalophora	05.00	00.75	00.43	00.83	00.63
Carex tribuloides	05.00	00.75	00.43	00.83	00.63
Elymus villosus	05.00	00.75	00.43	00.83	00.63
Lilium michiganense	05.00	00.75	00.43	00.83	00.63
Scutellaria incana	05.00	00.75	00.43	00.83	00.63
Lactuca sp.	10.00	00.30	00.86	00.33	00.59
Cacalia atriplicifolia	10.00	00.18	00.86	00.20	00.53
Juncus tenuis	10.00	00.18	00.86	00.20	00.53
Panicum clandestinum	10.00	00.18	00.86	00.20	00.53
Ranunculus recurvatus	10.00	00.18	00.86	00.20	00.53
Agrimonia pubescens	05.00	00.15	00.43	00.17	00.30
Carex granularis	05.00	00.15	00.43	00.17	00.30
Carex sp.	05.00	00.15	00.43	00.17	00.30
Carex sp.	05.00	00.15	00.43	00.17	00.30
Desmodium glutinosum	05.00	00.15	00.43	00.17	00.30
Impatiens capensis	05.00	00.15	00.43	00.17	00.30
Osmorhiza longistylis	05.00	00.15	00.43	00.17	00.30
Poa sp.	05.00	00.15	00.43	00.17	00.30
Panicum boscii	05.00	00.15	00.43	00.17	00.30
Solidago canadensis	05.00	00.15	00.43	00.17	00.30
Ambrosia artemisiifolia	05.00	00.03	00.43	00.03	00.23
Calystegia sepium	05.00	00.03	00.43	00.03	00.23
Helianthus divaricatus	05.00	00.03	00.43	00.03	00.23
Poa sylvestris	05.00	00.03	00.43	00.03	00.23
Ranunculus abortivus	05.00	00.03	00.43	00.03	00.23
Smilacina racemosa	05.00	00.03	00.43	00.03	00.23
Unknown dicot	05.00	00.03	00.43	00.03	00.23

APPENDIX 3: Lithologic description of limestone stratigraphy in Columbia Quarry, St. Clair County, Illinois.

COLUMBIA QUARRY SW 1/4 SECTION 3, T.1S., R.10W., ST. CLAIR CO., IL.				
UNIT		CUMULATIVE THICKNESS AND (ALTITUDE) OF INTERVAL ABOVE QUARRY FLOOD FT	THICKNESS (FT)	LITHOLOGIC DESCRIPTION
49	LEVEL 9	180.10 (665.10-680.10)	15.0	Loess-brownish yellow 10 YR 6/8 mottled deeply weathered to top of hill.
48		165.10 (655.10-665.10)	10.0	Limestone, brownish yellow 10 YR 6/8, microcrystalline to earthy, slightly dolomitic, deeply weathered numerous pin-point iron specs after pyrite or glauconite 15% porosity; shale, gray, thin partings on some bedding planes. Bedding planes from top at 2.5, 6.3, 7.4, 8.4 and 9.2 feet.
47	LEVEL 8	155.10 (650.70-655.10)	4.4	Limestone, very pale brown 10 YR 7/8, lithographic, massive, alternating layers of algal and very fine to fine pellets in clear calcite cement, cross bedded.
46		150.70 (642.00-650.70)	8.7	Limestone, very pale brown 10 YR 7.8 lithographic, 3% clear calcite inclusions, contains irregular rounded, blebs of chert, light gray 10 YR 7/1 along bedding planes to a maximum of 4 feet long axis and 0.4 feet high, solution features on some bedding plane surfaces. Bedding planes from top at 0.6, 2.0, 3.0, 5.5, 7.4 feet.
45		142.00 (638.50-642.00)	3.5	Limestone, very pale brown 10 YR 7/3 lithographic with 1% clear calcite inclusions, shale, gray-green, thin bedded between bedding planes. Bedding planes from top at 0.1, 0.5, 0.85, 1.2, 1.45, 1.7, 1.9, 2.2, 2.4, 2.7, 2.9 and 3.1 feet.
44		138.50 (637.60-638.50)	0.9	Limestone, very pale brown 10 YR 7/3 lithographic 1% clear calcite inclusions, slightly silty.

Appendix 3 (continued)

COLUMBIA QUARRY SW 1/4 SECTION 3, T.1S., R.10W., ST. CLAIR CO., IL.				
UNIT		CUMULATIVE THICKNESS AND (ALTITUDE) OF INTERVAL ABOVE QUARRY FLOOD FT	THICKNESS (FT)	LITHOLOGIC DESCRIPTION
43	LEVEL 7	137.60 (635.30-637.60)	2.3	Limestone, very pale brown 10 YR 7/3, very fine to coarse bioclastic, slightly silty.
42		135.30 (628.00-635.30)	7.3	Limestone, pale brown 10 YR 6/3, very fine to coarse bioclastic mottled with light gray 10 YR 7/1 solitary corals, 5.2-5.4 feet from top, slightly dolomitic, slightly argillaceous, slightly silty. Bedding planes from top at 0.5, 0.7, 2.1, 3.1, 3.6, 3.8, 4.0, 4.5, 5.2, 5.4 and 6.4.
41		128.0 (627.30-628.00)	0.7	Dolomite, gray 5 YR 6/1 green cast, calcareous, argillaceous, silty, disseminated pyrite, traces glauconite or green clay inclusions; limestone (0.01 feet) pale brown 10 YR 6/8 dolomitic, silty at base of unit. Corals.
40		127.30 (623.50-627.30)	3.8	Limestone, light brown 10 YR 7/1, mottled, pale brown, 10 YR 6/3 and gray 10 YR 6/4 (green cast) with green specs, disseminated pyrite. Bedding plane from top at 2.0 feet. Crinoids.
39		123.50 (621.10-623.50)	2.4	Limestone, pale brown 10 YR 6/3 very fine to coarse bioclastic dolomitic, disseminated pyrite, slightly silty, contains pelycypod molds to 1 inch infilled with green clay. Crinoids, Corals.
38	LEVEL 6	121.10 (618.60-621.10)	2.5	Limestone, light yellow brown 10 YR 6/4 to brown 10 YR 4/4 fine to medium, dolomitic sucrosic, weathered slightly, argillaceous, slightly silty, clear calcite inclusions, disseminated pyrite specs. Impart pin-point porosity.
37		118.60 (614.15-618.60)	4.5	Limestone, pale brown 10 YR 6/3 fine to medium oolites and pellets in clear sparry calcite, slightly silty. Bedding plane from top at 1.5, 2.2 and 3.7.
36		114.1 (608.60-614.15)	5.5	Limestone, pale brown 10 YR 6/3 lithographic to microcrystalline, clear calcite inclusions and shell impressions, has a detrital zone and vugs to 1-inch in lower foot. Bedding planes from top at 0.7, 1.8, 2.2, 3.0, 4.5 feet.
35		108.60 (608.45-608.60)	0.15	Shale, gray 5 YR 7/1 (green cast), calcareous.

Appendix 3 (continued)

COLUMBIA QUARRY SW 1/4 SECTION 3, T.1S., R.10W., ST. CLAIR CO., IL.				
UNIT		CUMULATIVE THICKNESS AND (ALTITUDE) OF INTERVAL ABOVE QUARRY FLOOD FT	THICKNESS (FT)	LITHOLOGIC DESCRIPTION
34		108.45 (607.25-608.45)	1.2	Limestone, very pale brown 10 YR 7/3 lithographic, to medium, clear calcite inclusions, contains darker brown angular detrital fragments, traces shell fragments.
33		107.25 (607.15-607.25)	0.1	Shale, light greenish gray 5 GY 7/1 calcareous.
32		107.15 (604.10-607.15)	3.05	Limestone, light yellowish brown 10 YR 6/4 microcrystalline, contains brownish yellow 10 YR 7/8 pinpoint specs after disseminated pyrite, slightly silty, slightly dolomitic, clear calcite inclusions, upper 0.2-0.3 feet reworked with coarse to very coarse brown lithographic limestone fragments.
31		104.1 (602.10-604.10)	2.0	Limestone, pale brown 10 Yr 6/3 very fine, pelletal, clear calcite cement.
30	L E	102.1 (601.10-602.10)	1.0	Limestone, very pale brown 10 YR 7/3 lithographic, clear calcite inclusions contains floating dark brown detrital fragments to 0.15 feet, slightly silty, traces micro fossil debris.
29	V E	101.1 (600.80-601.10)	0.3	Dolomite gray 10 YR 7/1, and limestone pale brown 10 YR 6/3 contain floating darker brown detrital fragments from bed below.
28	L 5	100.8 (597.80-600.80)	3.0	Limestone, very pale brown 10 YR 7/3 lithographic, clear calcite inclusions, contains floating dark brown detrital fragments to 0.15 feet, slightly silty, trace fossils.
27		97.8 (596.60-597.80)	1.2	Dolomite, gray 10 YR 6/1 microcrystalline, calcareous, slightly argillaceous, slightly silty, disseminated pyrite, intercrystalline and pin-point vugular porosity 10%.
26		96.6 (594.70-596.60)	1.9	Limestone, very pale brown 10 YR 6/3, lithographic slightly silty.
25		94.7 (586.20-594.70)	8.5	Limestone, pale brown 10 YR 6/3, very fine oolitic and pelletal, clear calcite cement, trace white calcite inclusions. Bedding planes from top at 0.6, 1.6, 3.6, 4.6 and 5.0 feet.
24		86.2 (584.70-586.20)	1.5	Chert and limestone, very pale brown 10 YR 7/3 microcrystalline to very fine part pelletal, banded.

Appendix 3 (continued)

COLUMBIA QUARRY SW 1/4 SECTION 3, T.1S., R.10W., ST. CLAIR CO., IL.				
UNIT		CUMULATIVE THICKNESS AND (ALTITUDE) OF INTERVAL ABOVE QUARRY FLOOD FT	THICKNESS (FT)	LITHOLOGIC DESCRIPTION
23	L E	84.7 (582.90-584.70)	1.8	Limestone, brown 10 YR 5/3 very fine to very coarse pelletal and bioclastic, bright green clay inclusions to 0.5 inches, glauconite, slightly silty, trace of organic material.
22	V	82.9 (582.65-582.90)	0.25	Shale, gray with traces of green specs, traces Crinoids.
21	E L 4	82.65 (580.05-582.65)	2.6	Limestone, brown 10 YR 5/3 very fine to medium, oolitic and pelletal, clear calcite cement, slightly argillaceous, slightly silty. Bedding planes from top at 0.5, 1.5 and 2.0 feet.
20		80.05 (575.05-580.05)	5.0	Limestone, pale brown 10 YR 6/3 very fine to medium, oolitic, styolitic, scattered brown calcite inclusions to 1.0 inch. Thin gray shale in bedding planes. Bedding planes from top at 1.4, 2.1 and 2.7 feet.
19		75.05 (570.55-575. 05)	4.5	Limestone, pale brown 10 YR 6/3 very fine to medium pellets, styolitic at top, slightly silty, contains bright green inclusions. Bedding planes from top at 0.4, 0.8 and 1.8 feet.
18	L E	70.55 (565.55-570.55)	5.0	Limestone, light brown 10 YR 7/1 lithographic has marcasite concretious 0.01 feet in diameter and reworked zone of broken limestone fragments in upper foot.
17	V E L 3	65.55 (562.75-565.55)	2.8	Limestone light brownish gray 10 YR 6/2, coarsely crystalline with scattered very fine green shale flecks. Very dolomitic, slightly argillaceous, weathered with brown lithographic limestone fragments to 0.3 feet from underlying units, contains calcite or gypsum, crystal inclusions to 0.1 foot. Shale at top.
16		62.75 (562.5-562.75)	0.25	Limestone, pale brown 10YR 6/3 lithographic, algal, slightly argillaceous, slightly silty traces green shale and bright green shale flecks (glauconite?). Several fractures filled with white calcite.
15		62.5 (557.0-562.5)	5.5	Limestone, gray microcrystalline, dolomitic. Bedding planes from top at 0.4 (contains chert) 0.7 (contains shale) and 2.1 feet.

Appendix 3 (continued)

COLUMBIA QUARRY SW 1/4 SECTION 3, T.1S., R.10W., ST. CLAIR CO., IL.				
UNIT		CUMULATIVE THICKNESS AND (ALTITUDE) OF INTERVAL ABOVE QUARRY FLOOD FT	THICKNESS (FT)	LITHOLOGIC DESCRIPTION
14	L E	57.0 (543.5-557.0)	13.5	Limestone, brown 10 YR 5/3 bioclastic and algal, clear sparry calcite cement, slightly silty. Contains gray steaks and gray casts. Bedding planes from top at 2.0, 4.0, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5 and 9. Chert 0.2 feet layered at 6.5 foot bedding plane. Shale gray to dark gray thin bedded in bedding planes.
13	V	43.5 (543.3-543.5)	0.2	Chert, light gray to gray 10 YR 6/1 bedded.
12	E L	43.3 (541.2-543.3)	2.1	Limestone, very pale brown 10 YR 7/3 algal, very fine to lithographic clear sparry calcite cement and inclusions, slightly silty.
11	2	41.2 (540.9-541.2)	0.3	Shale, gray 10 YR 6/1, calcareous.
10		40.9 (531.9-540.9)	9	Limestone, pale brown 10 YR 6/3 mottled, streaked and banded gray in places, dolomitic, slightly silty, slightly argillaceous, traces organic flecks and traces brown flecks after disseminated pyrite, few styolites, few hairline fractures with white calcite cement. Bedding planes from top at 0.5, 1.0, and 1.5 and 6.0 feet.
9		31.9 (530-3-531.9)	1.6	Limestone, pale brown 10 YR 6/3 microcrystalline with 0.1 feett shale, gray 10 YR 6/1 at top, merges laterally (pinches out) with limestone, dark gray 10 YR 4/1, bioclastic with Crinoids.
8		30.3 (523.7-530.3)	6.6	Limestone, pale brown 10 YR 6/3, very fine, bioclastic, clear calcite cement, dolomitic, silty scattered dark organic flecks.
7		23.7 (522.3-523.7)	1.4	Limestone, grayish brown 10 YR 5/3 very fine, partly algal, clear calcite cement, streaked and mottled gray; shale, gray, 0.1 feet at top. Chert, dark brown partly banded with white inclusions 0.1 high and 0.5-1.0 feet long in lower 0.3-0.5 feet.

Appendix 3 (concluded)

COLUMBIA QUARRY SW 1/4 SECTION 3, T.1S., R.10W., ST. CLAIR CO., IL.				
UNIT		CUMULATIVE THICKNESS AND (ALTITUDE) OF INTERVAL ABOVE QUARRY FLOOD FT	THICKNESS (FT)	LITHOLOGIC DESCRIPTION
6		22.3 (521.0 - 522.3)	1.3	Limestone, light gray 10 YR 6/3, very fine, dolomitic, traces pyrite, pin-point porosity in part, weathered. Shale gray 0.2 feet at base. Deeply weathered vertical joints (cutters) extend 50-60 feet upward from unit appear to be connected with sinks at surface.
5		21.0 (519.1-521.0)	1.9	Limestone, gray 10 YR 6/1, fine to coarse bioclastic, silty, argillaceous, banded in part with two thin 0.01 shale zones in top 0.5 feet, Crinoids.
4		19.1 (517.5-519.1)	1.6	Limestone, brown 10 YR 6/4 very fine, bioclastic, dolomitic, clearly sparry calcite cement, sandy, trace glauconite. Chert, light gray, shaley 0.2-0.3 feet at top.
3		17.5 (514.0-517.5)	3.5	Limestone, brown, 10 yr 6/4 very fine, bioclastic, dolomitic, traces of organic flakes, chert nodules white fossiliferous.
2		14.0 (506.0-514.0)	8.0	Limestone, pale brown 10 YR 6/3 very fine, bioclastic clear sparry calcite cement traces of organic flecks, sandy, trace glauconite. Bedding planes from top at 0.5 and 2.5 feet.
1	LEVEL 1	6.0 (500.5-506.0)	5.5	Limestone, dark brown 10 yr 4/3, grayish brown 10 yr 5/2, very fine, bioclastic, mottled, streaked,, slightly argillaceous, stylolitic, gray and green flecks, sand size secondary quartz crystals. Chert inclusions white rounded to 1.0 feet. Crinoids. Bedding planes from top at 0.5 and 2.0 feet.
Quarry floor		0.5 (500-500.5)	0.5	Limestone, dark brown 10 yr 4/3, very fine, trace coarse, bioclastic, argillaceous, slightly dolomitic, slightly silty, trace bituminous flecks. Crinoids.

Appendix 4: Lithologic description of sediment samples from 5 centimeter cores collected at springhead of eight springs in the Sinkhole Plain Region, Monroe and St. Clair counties, Illinois.

Camp Vandeventer Spring

Sample	10411	Sand, dark yellowish brown, 10YR 4/4, very fine to coarse, rounded, varicolored grains, few granules, sandstone, plant remains, partly calcareous.
	10412	Granule gravel, dark grayish brown, 10YR 4/2, sandy, light and dark grains, composed of sandstone, shale, chert, igneous, and limestone fragments, clean.
	10413	Sand, brown, 10YR 4/2, fine to very coarse grained, granules 15%, very colored light and dark grains composed of sandstone, shale, chert, limestone, and igneous fragments, clean.

Dual Springs

Sample	10414	Silt, dark yellowish brown, 10YR 4/4, argillaceous, scattered black organic flakes.
	10415	Silt, dark yellowish brown, 10YR 4/4, argillaceous, scattered black organic flakes, non-calcareous.
	10416	Silt, dark yellowish brown, 10YR 3/4, scattered black organic flakes.

Kelly Spring

Sample	10420	Sand, medium to very coarse grained, gravely brown, 10YR 5/3, subangular to rounded, primarily quartz, light and dark colored sandstone and chert grains, bioclastic limestone fragments, slightly calcareous in part.
	10421	Sand, medium to coarse grained dark brown, 10YR 4/3, some gravel, primarily quartz, grains are rounded, frosted and pitted, slightly calcareous.
	10422	Granule gravel, dark yellowish brown, 10YR 4/4, light and dark colored, carbonaceous sandstone, light and dark chert with traces of granite, trace of plant remains, slightly calcareous in part.

Little Carr Creek Spring

Sample	10423	Silt and sand, very fine-grained, dark brown, 10YR 5/3, slightly calcareous, numerous plant remains.
	10424	As above, scattered quart, dark, 10YR 5/3, sand grains, traces of plant remains.
	10425	Clay, dark brown, 10YR 6/3, slightly calcareous, traces plant remains.

Appendix 4 (Concluded).

Madonnaville Spring

Sample 10426 Sand, dark yellowish brown, 10YR 3/4, very coarse grained, rounded, argillaceous, granules and pebbles composed of light and dark sandstone, chert, granite 1%, organic matter, slightly calcareous in part.

10427 Silt to very coarse sand, rounded, dark yellow brown, 10YR 4/4, argillaceous, light and dark granules, scattered organic flakes.

10428 Granules and pebbles, yellowish brown, 10YR 5/6, rounded, pitted sandy, argillaceous, composed of chert, sandstone, limestone, partly calcareous.

Ritter Spring

Sample 10408 Light and dark colored sand granules and yellowish brown pebbles, (chert, 10YR 5/4, very fine to coarse limestone, sandstone), rounded, 30%, argillaceous. Traces of organic and carbonaceous material.

10409 Clay, sandy, dark brown, 10YR 4/3, slightly calcareous organic flakes.

10410 Sand, very fine to coarse, 10YR 4/4, varicolored white, red, black, brown, rounded, plant remains, 15% granules, part igneous, part shale, trace calcareous, slightly argillaceous, partly calcareous, clean.

Sparrow Spring

Sample 10720 Sand, dark brown, 10YR 4/3, very fine to very coarse, few granules, rounded, varicolored grains (clear quartz, red, brown), argillaceous, silty, traces of sandstone, igneous, and limestone fragments, slightly calcareous.

10721 Sand, dark brown, 10YR 3/3, very fine to very coarse, few granules, rounded, varicolored grains (black, brown, white, red), argillaceous, sitly, numerous black plant remains, slightly calcareous.

10722 Sand, dark brown, 10YR 3/3, very fine to very coarse, few granules, rounded, varicolored grains (clear quartz, white, red, brown), argillaceous, trace sandstone, slightly calcareous.

Walsh Spring

Sample 10417 Gravel, 10YR 3/2, granule to pebble sized sandy, consists of sandstone, chert, quart, rounded.

10418 Sand, dark yellowish brown, 10YR 4/3, rounded with granules of sandstone, chert, quartz, shale, part slightly calcareous.

10419 Gravel, very dark, grayish brown, 10YR 3/2, consists of sandstone, chert, quartz, shale, traces of light colored igneous rock, rounded, with very fine to coarse sand, clean.

APPENDIX 5: Daily precipitation from November 1994 through August 1995 at Waterloo, Monroe County, Illinois. Monthly total in bold.

November	December	January	February	March	April	May	June	July	August
0.30	0.00	0.09	0.00	0.00	0.00	0.47	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.06	0.14	0.74	1.90	0.00	0.29
0.00	0.06	0.00	0.27	0.00	0.00	0.00	0.02	0.02	0.15
0.46	0.00	0.00	0.19	0.00	0.14	0.29	0.00	0.28	0.00
1.27	0.00	0.00	0.00	0.15	0.00	0.13	0.00	0.26	0.16
0.88	0.00	0.59	0.00	0.00	0.00	0.00	0.07	0.20	0.14
0.00	0.16	0.23	0.05	2.26	0.00	0.03	0.54	0.00	0.04
0.00	0.00	0.00	0.00	0.16	0.00	0.59	0.03	0.00	0.00
0.16	0.35	0.00	0.00	0.00	0.00	0.24	0.23	0.00	0.00
0.20	0.01	0.00	0.00	0.00	0.00	0.04	0.61	0.00	1.20
0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.11	0.00	0.00
0.01	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00
0.56	0.00	0.68	0.00	0.00	0.00	1.49	0.00	0.00	0.00
0.16	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00
0.04	0.46	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00
0.00	0.12	0.03	0.00	0.00	0.02	1.92	0.00	0.31	0.00
0.00	0.00	0.00	0.00	0.00	0.05	3.06	0.00	0.00	0.00
0.00	0.00	0.83	0.00	0.00	0.00	0.34	0.00	0.00	0.00
0.11	0.13	0.07	0.00	0.23	0.61	0.00	0.00	0.00	0.41
0.94	0.07	0.00	0.00	0.00	0.00	0.13	0.00	0.49	0.00
0.00	0.82	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00
0.00	0.01	0.00	0.00	0.00	0.03	0.00	0.00	0.27	0.00
0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.41	0.03	0.00
0.00	0.00	0.00	0.00	0.00	0.02	1.09	0.00	0.16	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.92	0.78	0.00
0.35	0.00	0.30	0.26	0.65	0.02	0.03	0.33	0.00	0.00
0.17	0.00	0.36	0.32	0.00	0.00	1.18	0.02	0.00	0.00
0.00	0.00	0.08		0.00	0.00	0.00	1.98	0.00	0.00
0.00	0.00	0.00		0.00	0.45	0.00	0.03	0.00	0.00
	0.08	0.00		0.00		0.00		0.00	0.00
5.61	**2.27**	**3.26**	**1.23**	**3.51**	**2.61**	**13.25**	**7.21**	**2.80**	**2.39**

APPENDIX 6: Drainage basin area, percent farmland, measurement method, date, and discharge at ten karst springs in Monroe and St. Clair counties, Illinois 1994-1995.

SPRING	MISSISSIPPIAN FORMATION	*DRAINAGE BASIN AREA (ACRES/km²)	*FARMLAND (ACRES/%) km²	METHOD	DATE	DISCHARGE (GPM/L/SEC)
AUCTIONEER	SALEM	130/.526	45/35	BUCKET	11/17/94	17/1.1
			.182	BUCKET	2/23/95	24/1.5
				SWOFFERT METER	5/23/95	156/9.8
				SWOFFERT METER	8/23/95	52/3.3
CAMP VANDEVENTER	ST. LOUIS	190/.769	65/35	SWOFFERT METER	11/16/94	712/44.9
			.263	90° V-NOTCH WEIR	2/22/95	*81/5.1
				SWOFFERT METER	5/16/95	9787/617
				SWOFFERT METER	8/22/95	661/41.7
DUAL	ST. LOUIS	80/.324	40/50	BUCKET	11/16/94	113/7.1
			.162	BUCKET	2/22/95	200/12.6
				SWOFFERT METER	5/16/95	1836/115.8
				SWOFFERT METER	8/22/95	343/21.6
KELLY	ST. LOUIS	470/.1902	235/50	CUTTHROAT FLUME	11/16/95	*276/17.4
			.951	SWOFFERT METER	2/23/95	535/33.7
				SWOFFERT METER	5/23/95	392/24.7
				SWOFFERT METER	8/23/95	< DL
LITTLE CARR	ST. LOUIS	175/.708	75/43	PARSHALL FLUME	11/17/94	107/6.7
			.304	CUTTHROAT FLUME	11/17/94	116/7.3
				PARSHALL FLUME	2/23/95	84/5.3
				SWOFFERT METER	5/23/95	85/5.4
				SWOFFERT METER	8/23/95	38/2.4
MADONNAVILLE	SALEM	110/.445	90/82	PARSHALL FLUME	11/17/94	150/9.5
			.364	SWOFERT METER	2/23/95	108/6.8
				SWOFFERT METER	5/23/95	496/31.3
				SWOFFERT METER	8/23/95	329/20.8
RITTER	STE. GENEVIEVE	100/.405	40/40	60°V-NOTCH WEIR	11/17/94	129/8.1
			.162	PARSHALL FLUME	2/22/95	145/9.1
				SWOFFERT METER	5/16/95	160/10.1
				SWOFFERT METER	8/22/95	49/3.1
SPARROW	ST. LOUIS	440/.178	390/87	SWOFFERT METER	11/15/94	1203/75.9
			.158	CUTTHROAT FLUME	11/15/94	*1065/67.2
				SWOFFERT METER	2/22/95	1007/63.5
				SWOFFERT METER	5/16/95	9359/590
				SWOFFERT METER	8/22/95	1008/63.6
TERRY	ST. LOUIS	100/.405	40/40	BUCKET	11/17/95	22/1.4
			.162	BUCKET	2/23/95	22/1.4
				SWOFFERT METER	5/23/95	146/9.2
				SWOFFERT METER	8/23/95	24/1.5
WALSH	ST. LOUIS	95/.384	70/75	PARSHALL FLUME	11/16/94	84/5.3
			.283	PARSHALL FLUME	2/22/95	93/5.9
				SWOFFORT METER	5/16/95	1676/105.7
				SWOFFORT METER	8/22/95	39/2.5

*approximate

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APPENDIX 7: Faunal list of taxa collected from ten karst springs in the Sinkhole Plain, Monroe and St. Clair counties, Illinois.

PHYLUM PLATYHELMINTHES
Class Turbellaria
Order Tricladida
Family Planariidae
Dugesia dorotocephata (Woodworth)
Phagocata gracilis (Haldeman)
Phagocata velata (Stringer)
PHYLUM COELENTERATA
Class Hydrozoa
Order Hydroida
Family Hydridae
Hydra sp.
PHYLUM ANNELIDA
SUBPHYLUM ACLITELLATA
CLASS APHANONEURA
Order Aeolosomatida
Family Aeolosomatidae
Aeolosoma sp.
SUBPHYLUM CLITELLATA
CLASS BRANCHIOBDELLIDA
Order Branchiobdellida
Family Cambarincolidae
CLASS OLIGOCHAETA
Order Lumbriculida
Family Lumbriculidae
Order Haplotaxida
Family Haplotaxidae
Haplotaxis gordioides (Hartmann)
Suborder **Tubificina**
Superfamily Tubificoidea
Family Naididae
Allonais paraguayensis Michaelsen
Bratislavia unidentata (Harman)
Dero (Dero) digitata (Müller)
Dero (Dero) nivea Aiyer
Nais bretscheri Michaelsen
Nais communis Piguet
Nais elinguis Müller
Nais pardalis Piguet
Nais variabilis Piguet
Nais LCC1
Nais sp.
Ophidonais serpentina (Müller)
Paranais frici Hrabe
Pristina aequiseta Bourne
Pristina leidyi Smith
Slavina appendiculata (d'Udekem)
Specaria josinae (Vejdovsky)
Stylaria lacustris (Linnaeus)
Family Tubificidae
Branchiura sowerbyi Beddard
Ilyodrilus templetoni (Southern)
Limnodrilus cervix Brinkhurst
Limnodrilus claparedianus Ratzel
Limnodrilus hoffmeisteri Claparède
Limnodrilus udekemianus Claparède
Limnodrilus sp.
Quistadrilus multisetosus (Smith)
Varichaetadrilus angustipenis (Brinkhurst & Cook)
Superfamily **Enchytraeoidea**
Family Enchytraeidae
Suborder Lumbricina
Superfamily Lumbricoidea
Family Lumbricidae
CLASS HIRUDINEA
Order Rhynchobdellida
Family Glossiphoniidae
Order Pharyngobdellida
Family Erpobdellidae
Class Crustacea
Order Amphipoda
Family Crongonyctidae
Crangonyx forbesi Hubricht and Mackin
Family Gammaridae
Gammarus acherondytes Hubricht and Mackin
Gammarus minus Say
Gammarus pseudolimnaeus Bousfield
Gammarus troglophilus Hubrich and Mackin
Famiy Hyallelidae
Hyalella azteca (Saussure)
Order Decapoda
Family Cambaridae
Orconectes virilis (Hagen)
Order Isopoda
Family Asellidae
Caecidotea brevicauda (Forbes)
Caecidotea intermedia (Forbes)
Caecidotea packardi Mackin and Hubricht

Order Ostracoda
Family Cypridae
Candona caudata Kaufman
Cypria opthalmica (Jurine)
Ilyocyrpis bradyi Sars
Physocypria pustulosa (Sharpe)
Class Insecta
Order Coleoptera
Family Dryopidae
Helichus
Family Dytiscidae
dytiscid sp.
Family Gyrinidae
Dineutus
Family Haliplidae
Peltodytes
Family Hydrophilidae
hydrophilid sp. 1
hydrophilid sp. 2
hydrophilid sp. 3
hydrophilid sp. 4
hydrophilid sp. 5
hydrophilid sp. 6
hydrophilid sp. 7
hydrophilid sp. 8
Tropisternus lateralis (Fabricius)
Order Diptera
Family Ceratopogonidae
Bezzia sp.
ceratopogonid sp. 1
ceratopogonid sp. 2
ceratopogonid sp. 3
Family Chaoboridae
Chaoborus (*Sayomyia*) *punctipennis* (Say)
Family Chironomidae
Ablabesmyia illinoensis (Malloch)
Chironomus decorus Johannsen
Clinotanypus scapularis (Loew)
Conchopelopia sp.
Cricotopus bicinctus (Meigen)
Cricotopus sp. 1
Dicrotendipes nervosus (Staeger)
Glyptotendipes paripes (Edwards)
Harnischia curtilamellatus (Malloch)
Orthocladius sp. 1
Orthocladius sp. 2
Orthocladius sp. 3
Phaenopsectra flavipes (Meigen)
Polypedilum halterale (Coquillett)
Polypedilum scalaenum (Schrank)
Polypedilum sp. 1
Procladius bellus (Loew)
Procladius sublettei Roback
Stenochironomus hilaris (Walker)
Tanypus neopunctipennis Sublette
Tanytarus sp.
Tribelos jucundum (Walker)
Family Psychodidae
Psychoda sp.
Family Simuliidae
Simulium tuberosum complex
Simulium vittatum complex
Family Tipulidae
Tipula sp. 1
Tipula sp. 2
Order Ephemeroptera
Family Baetidae
Baetis sp.
Family Caenidae
Caenis
Family Heptageniidae
Stenonema sp.
Family Leptophlebiidae
Leptophlebia sp.
Order Hemiptera
Family Belostomatidae
Belostoma fluminea Say
Family Corixidae
Trichocorixa sp. 1
Trichocorixa sp. 2
Family Gerridae
Aquarius remigis (Say)
Family Mesovelidae
Mesovelia mulsanti White
Family Nepidae
Ranatra fusca Palisot de Beauvois
Family Notonectidae
Notonecta.
Family Pleiidae
Neoplea striola (Fieber)

Appendix 7 (continued)

Order Megaloptera
Family Sialidae
Sialis sp.
Order Plecoptera
Family Capniidae
Allocapnia vivipara (Claassen)
Family Perlidae
Perlinella drymo (Newman)
Order Trichoptera
Family **Helicopsychidae**
Helicopsyche borealis Hagen
Family **Hydropsychidae**
Cheumatopsyche analis (Banks)
Diplectrona modesta Banks
Hydropsyche betteni Ross
Potomyia flava (Hagen)
Family **Hydroptilidae**
Hydroptila cf. scol*ops* Ross
Hydroptila waubesiana Betten
Hydroptila sp. 1
Ochrotrichia shawnee (Ross)
Orthotrichia americana Banks
Family **Leptoceridae**
Athripsodes near *transversus* (Hagen)
Oecetis inconspicua (Walker)
Oecetis species 1
Family **Philopotomidae**
Chimarra feria Ross
Chimarra obscura (Walker)
Family **Phryganeidae**
Phryganea sayi Milne
Family **Polycentropodidae**
Cyrnellus marginalis Banks
Nyctiophylax vestitus (Hagen)
Polycentropus centralis Banks
Family **Rhyacophilidae**
Rhyacophila fenestra Ross
Class Mollusca
Order Gastropoda
gastropodid sp. 1
gastropodid sp. 2
gastropodid sp. 3
gastropodid sp. 4
gastropodid sp. 5
gastropodid sp. 6
Family Physidae
Physella sp.
Order Pelecypoda
Family Sphaeriidae
Pisidium sp.