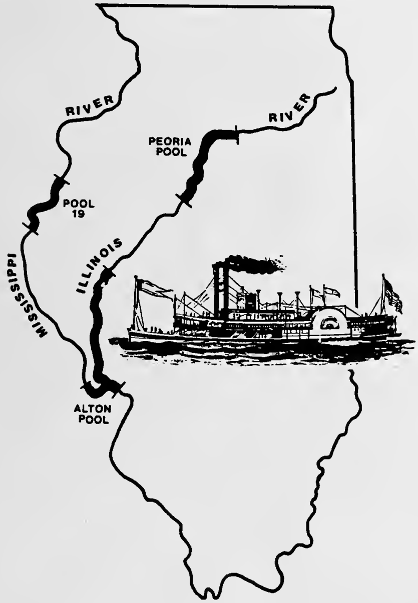
ILLINOIS LARGE RIVERS

NSF LTER



Illinois Natural History Survey
Illinois Water Survey
Illinois Geological Survey
Western Illinois University
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Aquatic Biology Tecnnical Series 1984 (8)

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1984 PROGRESS REPORT

Ecological Structure and Function of Major Rivers in Illinois "Large River LTER"

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Richard E. Sparks, Project Director
Illinois Natural History Survey
River Research Laboratory
Havana, Illinois 62644

Richard E. Sparks
Richard E. Sparks, Project Director

Robert W. Gorden
Robert W. Gorden, Head
Aquatic Biology Section
Natural History Survey

Paul G. Risser by [signature]
Paul G. Risser, Chief, Natural History Survey, and Chairman, Large River LTER Executive Committee

21 August 1984

RIVER LTER
SCIENTIFIC AND TECHNICAL STAFF
Richard E. Sparks, Project Director

<u>Illinois Geological Survey</u>

David L. Gross, Ph.D., Geologist and Head of Environmental Studies and Assessment Unit
Richard A. Cahill, M.S., Chemist

<u>Illinois Natural History Survey</u>

Robert W. Gorden, Ph.D., Aquatic Biologist and Head of Aquatic Biology Section
Michael S. Henebry, Ph.D., Assistant Aquatic Biologist
Kenneth S. Lubinski, Ph.D., Assistant Aquatic Biologist
Paul G. Risser, Ph.D., Chief
Richard E. Sparks, Ph.D., Aquatic Biologist
Michael J. Wiley, Ph.D., Asst. Aquatic Biologist
K. Douglas Blodgett, M.S., Technical Assistant
Frank M. Brookfield, M.S., Computer Programmer
Jack W. Grubaugh, M.S., Technical Assistant
Jens-Dieter Sandburger, M.S., Assistant Supportive Scientist

<u>Illinois State Museum</u>

James King, Ph.D., Head of Scientific Sections

<u>Illinois Water Survey</u>

J. Rodger Adams, Ph.D., Professional Scientist
Nani G. Bhowmik, Ph.D., Principal Scientist and Assistant Head, Surface Water Section
Misganaw Demissie, Ph.D., Associate Professional Scientist
Donald Gatz, Ph.D., Principal Scientist and Head, Atmospheric Chemistry Section
Wayne W. Wendland, Ph.D., Principal Scientist
Frank Dillon, M.S., Assistant Supportive Scientist

<u>Western Illinois University</u>

Richard V. Anderson, Ph.D., Assistant Professor
Dave Day, M.S., Technical Assistant
Daniel J. Holm, B.S., Graduate Research Assistant

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August 1984
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SECTION I: ACCOMPLISHMENTS

A. Scientific Accomplishments

Introduction (Sparks)

The 1983 annual report described the lateral and longitudinal structures of our floodplain rivers. We identified 7 main compartments where physical conditions (substrate, depth, velocity) create habitats for distinct biological communities: main channels, main channel borders, tailwaters, tributary mouths, vegetation beds, riparian areas, and backwaters. In 1984, we continued gathering data on populations of key organisms and on key physical/chemical factors in each compartment which drive or control the biological components.

We also continued development of a river ecosystem model, which includes the 7 compartments and 22 state variables representing key organisms and nonliving sinks and sources of carbon. The model represents our best conceptualization to date of how our system works, integrates our information, and shows us where we need more data.

Since data are used both to develop and verify the model, our data management and modeling efforts are being carefully coordinated. In response to our external advisory committee and our own sense that our original data management program overemphasized data archiving at the expense of data analysis, we made significant changes in our program with the help of a new data manager, Mr. Frank Brookfield, and a $50,000 supplemental allotment from the National Science Foundation for computer equipment and software.

The improvement in data management is particularly important at our site, because much of our analysis depends on extension of measurements on relatively small areas to large habitat compartments by area and volume weighting. The ability to exchange and merge data likewise is important at our site where 5 institutions work out of 3 field stations and 2 main campuses.

Our field and laboratory methods have been compiled by Mr. Richard Cahill. Our principal investigators prepared abstracts describing each data set, which were compiled and indexed by Dr. Walt Conley of the Jornada site. The methods handbook, data abstracts, and the conceptualization of how our system works (contained in the handbook for our simulation model) have helped us organize the our project and will be helpful to outside investigators wishing to use our site.

Ten people from the Large River site participated in the LTER all scientists' meeting at Lake Itasca, Minnesota, 13-17 May 1984, where we presented 21 posters describing our research, discussed matters of mutual interest with scientists from other sites, and heard from 3 speakers outside the LTER network who have gathered and used long-term measurements and who were involved in the initial meetings leading to the establishment of the LTER program. Several intersite workgroups were formed at the meeting and our site was honored to have Dr. Nani Bhowmik chosen as chairman of the group on hydrological processes. This group will collate information on the hydrological features of each site and make recommendations for standardization of methods for intersite comparisons.

The meeting at Lake Itasca reaffirmed the importance of maintaining a core set of long-term measurements at each site: thus it seems appropriate to begin this annual report with a section on the number of measurements added to our core data in each year of our LTER project to date. Subsequent sections of the report describe our major findings during 1984.

Additions to Core LTER Data Sets (Sparks)

The LTER program has enabled us to continue several long-term data sets which were interrupted or on tenuous year-to-year funding and to add data which will help interpret and explain trends in the older data sets (Table 1). The measurements have been designed to test hypotheses about how large river systems work, particularly, hypotheses which deal phenomena which occur on time scales longer than a conventional funding cycle or which are stochastic and require before- and after-measurements (floods and droughts).

The following sections describe highlights of 1984, including reports on both on core data and shorter term studies designed to elucidate mechanisms or fill information gaps.

Sources and Fate of Organic Matter (Sparks)

Our LTER research has concentrated on Pool 19 (Keokuk Pool) of the Mississippi River. We estimate that 1.5 million metric tons of carbon per year enter the pool, of which 92% comes from upstream and 7% from a major tributary, the Skunk River of Iowa. It appears that most of this material passes through the pool, but shunting even a small portion of this material into food chains could fuel high secondary productivity. Our hydrologists are measuring and modeling the movement of water and sediment in and out of the pool and its 7 habitat compartments. The geologists are determining the rate of deep burial of carbon in sediments, both in recent times and before the dam was constructed, and are independently verifying rates of sedimentation using sediment cores and radioisotope markers. The biologists are measuring production and utilization of organic matter within compartments.

Of the total surface area within the floodplain boundaries of Keokuk Pool, approximately 70% is land at mean low flow,

Table 1

Cumulative Number of Measurements or Records
Large River LTER

	PI	Before 1982	1982	1983	Estimate 1984
Computerized Illinois and Mississippi River daily water levels (No. records)	Lubinski	0	365	730	1,094
Water discharge (No. measurements)	Adams	0	62	104	144
Pool 26, Mississippi and Illinois River comparative water quality (5 variables) (No. records)	Lubinski	68	68	101	145
Physical-chemical measurements made in conjunction with biological, water, or sediment sampling: DO, temperature, conductivity, pH, turbidity, velocity (No. samples)	Anderson, Lubinski, Sparks, Adams, Gross	55	545	1,295	1,895
Nutrients: N, P (No. samples)	Sparks	0	376	740	1,215
POC, DOC (No. samples)	Sparks	0	376	740	1,215
Suspended Sediment					
Concentration (No. samples)	Adams	0	464	854	1,262
Particle size analyses	Adams	0	11	19	36
Bed Sediment					
Grab samples	Gross	many	310	425	450
Core samples	Gross	many	60	66	66
Particle size analyses	Gross, Adams	many	30	30	164
Geochemistry	Cahill	34	50	63	63
Sediment maps (7 1/2' quadrangles)	Gross	8	8	8	17
Aerial photos (No. flights)	Anderson	5	9	15	19
Bathymetric profiles	Gross, Adams	0	0	83	143
Flow patterns (No. vane-float tracks)	Adams	0	16	36	56

Table 1 (con't.)

Cumulative Number of Measurements or Records
Large River LTER

	PI	Before 1982	1982	1983	Estimate 1984
Water column photosynthesis, respiration (No. samples)	Sparks	0	220	1,452	2,124
Water column and sediment bacteria (No. samples)	Henebry, Gorden	24	24	51	250
Phytoplankton (No. samples)	Anderson	46	118	593	793
Macrophyte production and decomposition (No. samples)	Anderson, Lubinski	0	20	104	314
Zooplankton (No. samples)	Anderson	65	181	576	801
Benthic macroinvertebrates (No. samples)	Anderson, Sparks	2,238	2,593	2,953	3,353
Macroinvertebrate drift (No. samples)	Anderson	34	168	412	637
Fish collections on longitudinal or lateral gradients-- No. collections (No. fish)	Lubinski	575 (60,000)	769 (64,225)	1,036 (73,414)	1,336 (83,414)

consisting of islands, ephemeral ponds, mud flats and bottomland forests which are seasonally inundated. In 1984, we began to measure woody debris and litter on Burlington Island in Pool 19. Burlington Island represents one floodplain pattern, where flood water slowly flows over the land. A second pattern occurs at the mouths of tributaries and in some bottomland lakes, where the river flows into an area on the rising hydrograph and out on the falling hydrograph, like a very slow tidal cycle.

Of the total water area in Keokuk Pool at low flow, 63% is in the channel border compartment, part of which is vegetated (submergent and emergent macrophytes) and part unvegetated. The channel border is not only one of the most extensive aquatic areas within the pool, but also one of the most productive on a unit area basis. For both reasons, our within pool modeling and sampling efforts are concentrating first on the channel border compartment.

Allochthonous Inputs--Burlington Island Studies (Anderson and Sparks)

In February 1984 transects and permanent plots were set up in 4 locations on Burlington Island. Coarse particulate organic matter was sampled along transects and within plots and large woody debris was marked and measured for volume and mass determinations. The Illinois Water Survey surveyed the elevation at several points around the island so that we can determine whether the island is aggrading or degrading with time. The preliminary results indicate that significant sorting of woody material occurs on the islands. Coarse material composed of fallen trees and large limbs collect on the channel margins of the island and at the wooded vegetation line. Transport of leaf litter follows a complex pattern dependent on flow patterns and presence or absence of retention structures, such as brush piles.

Autochthonous Inputs (Anderson and Grubaugh)

Phytoplankton (Anderson). Phytoplankton community composition was dominated by diatoms throughout the year with spring (April) and summer (August) maxima in both density and calculated biomass (Table 2). Although these densities are relatively high for lotic environments, total phytoplankton production in Keokuk Pool could account for only approximately 20% of the estimated invertebrate production (mostly filter feeders in nonvegetated channel borders), even if we assumed a high turnover rate for phytoplankton of 4 times a day.

Macrophytes (Anderson, Grubaugh, and Lubinski). The other autochthonous source of fuel for secondary production is the aquatic macrophyte beds. Maximum live biomass was found to occur in August in floating and emergent macrophytes in Pool 19, Mississippi River. The greatest change in biomass, 4.87 g AFDW/day/m^2 for lotus, *Nelumbo lutea*, and 9.69 g AFDW/day/m^2 for

Table 2

Phytoplankton Biomass Data
River Mile 364.2 to 378.0
Pool 19, Mississippi River

	Measured		Calculated values			
	Density No. X 10^6/l		Volume X 10^{-3} l		grams dry wt. X 10^{-8}/l	g C X 10^{-8}/l
Date	Mean	(S.D.)	Mean	(S.D.)	Mean	Mean
Channel						
1982						
October	2.875	(0.742)	3.015	(0.967)	6.415	3.015
December	2.687		1.841		3.917	1.841
1983						
January	4.556	(2.325)	2.247	(1.038)	4.781	2.247
March	10.528	(4.148)	4.879	(1.828)	10.381	4.879
April	21.741	(9.247)	10.078	(4.243)	21.442	10.078
May	14.130	(1.976)	7.957	(1.039)	16.930	7.957
June	2.143	(0.545)	1.679	(0.428)	3.572	1.679
July	2.004	(0.720)	1.500	(0.684)	3.191	1.500
August	8.479	(1.435)	7.465	(1.374)	15.883	7.465
Channel Border						
1982						
October	2.289	(0.717)	2.439	(0.487)	5.189	2.439
December	2.030		1.209		2.572	1.209
1983						
January	2.960	(1.995)	1.433	(0.865)	3.049	1.433
March	3.303	(1.679)	1.863	(0.982)	3.964	1.863
April	15.582	(9.649)	7.422	(4.557)	15.791	7.422
May	10.422	(2.901)	4.339	(3.709)	9.232	4.339
June	1.997	(0.639)	1.854	(0.572)	3.945	1.854
July	1.999	(0.158)	1.480	(0.142)	3.149	1.480
August	6.624	(1.006)	5.317	(0.488)	11.313	5.317

arrowhead, *Sagittaria latifolia*, occurred between July and August samplings. If we estimate production from monthly changes in biomass, the net annual production is 724 g above-ground biomass/yr/m^2 for arrowhead and 432 g/yr/m^2 for lotus.

We made a rough estimate of annual net production by assuming that it equalled the largest combined live and standing-dead biomass recorded for any one sampling trip, 615.79 g AFDW/m^2 for arrowhead in August and 336.66 g AFDW/m^2 for lotus in September. To compare these findings to other studies, it is necessary to convert to dry-weight values and use only above-ground biomass (Table 3). Results for *S. latifolia* at Pool 9, Mississippi River (Clark et al. 1983) are similar to our findings (Table 3). Good et al. (1978) reported somewhat lower values for tidal wetland areas, indicating arrowhead production may diminish with increased salinity. Boyd (1968), examining tissue protein, reported a standing crop of 99 g dry weight/m^2 for lotus, but he did not report collection date, diminishing the comparative value of the finding.

Salt reedgrass (*Spartina cynosuroides*) and fertilized corn (*Zea mays*) represent two highly productive plant types (Good et al. 1978; Transeau 1926). Arrowhead and lotus appear to be half as productive. *Sagittaria* is more productive than most noncultivated terrestrial plants (Table 3).

The above values considerably underestimate the actual productivity of *Nelumbo* and *Sagittaria* because they do not account for the high rate of leaf and shoot turnover, leakage of DOC, and below-ground production. Maximum new/total shoot ratios of 0.51 in 2 weeks for *Sagittaria* indicate that annual production estimates should be revised upward by 2-3x. We are currently measuring turnover, DOC leakage, and below-ground production to better estimate macrophyte production, and the effects of the annual water level regime on production.

In spite of the evident high productivity of the plant beds, the amount of organic matter does not increase significantly during the growing season or during plant senescence in autumn (Figure 1). Thus, much of the production from aquatic macrophytes is either exported to other riverine compartments or rapidly used by primary decomposers within the beds.

Most macroinvertebrate production in the river occurs in channel border areas adjacent to macrophyte beds, coinciding with peak macrophyte production. Organic matter produced in the plant beds may be moved out and over the border area by currents and waves. The Water Survey is investigating secondary circulation patterns and the recurrence intervals of summer storms with strong winds. Dr. Michael Henebry is investigating another hypothesis: that organic matter is rapidly used in microbial respiration. The most likely possibility is a combination of the two: microbial processing and physical export.

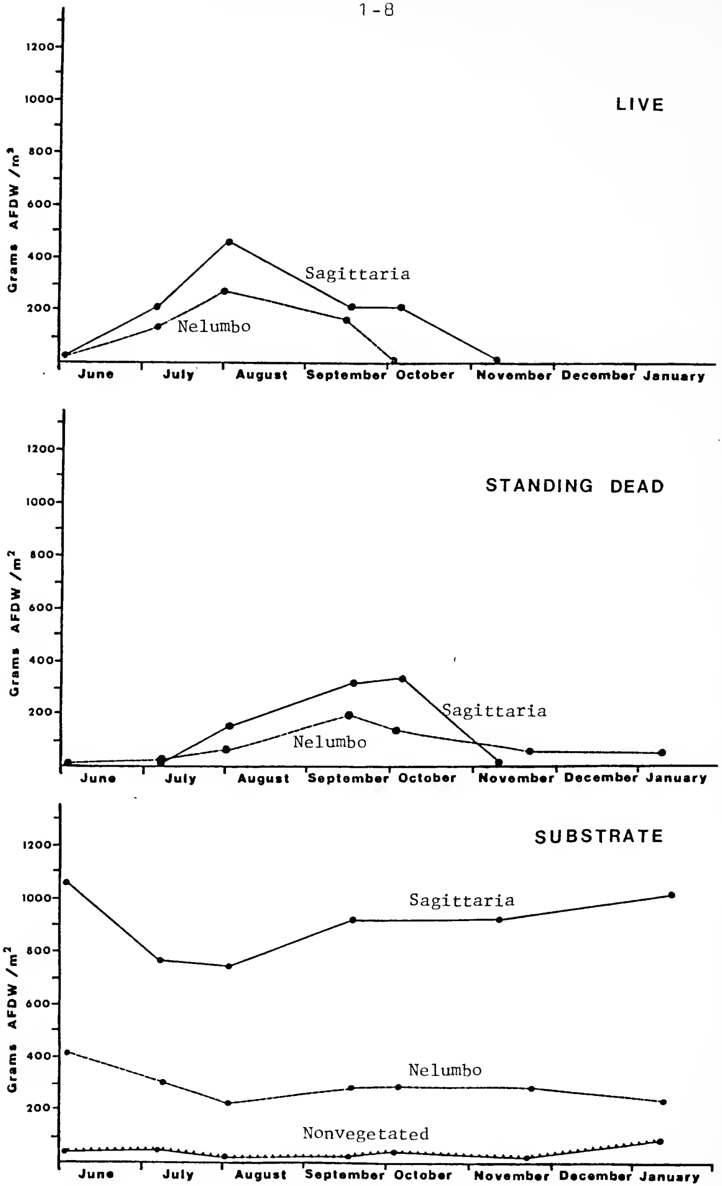


Figure 1. Patterns in organic matter (AFDW) in Nauvoo Plant Bed, Pool 19, Mississippi River.

Table 3

Comparative Estimations of Annual Net Productivity
(Findings are expressed as grams dry-weight of above-ground biomass/year/m^2)

PLANT and/or ECOSYSTEM	ANNUAL NET PRODUCTIVITY
Zea mays (fertilized)	
Illinois (Transeau 1926)	1400
Minnesota (Ovington et al. 1963)	946
Spartina cynosuroides	
Tidal wetlands (Good et al. 1978)	1113
Sagittaria latifolia	
Pool 19, Miss. River (this study)	724
Pool 9, Miss. River (Clark et al. 1983)	765
Tidal wetlands (Good et al. 1978)	432
Nelumbo lutea	
Pool 19, Miss. River (this study)	452
Various Ecosystems (Ovington et al. 1963)	
Oakwood	819
Savanna	526
Prairie	93
Oldfield (Odum 1960)	
Well-drained upland	494
Poorly-drained lowland	425

Losses to Sediment (Cahill and Gross)

The analysis of the organic carbon carbon content of sediment has been completed on 135 sediment samples. Most values are between 1.5 and 2.5% organic carbon, although high levels (up to 12%) can occur in the upper Illinois River.

Sedimentation rates in Pool 19 are being measured independently using (1) sediment cores dated by Cs-137 and Pb-210, (2) suspended-sediment budget analysis of several data sets covering 3-12 yr periods, and (3) total accumulation of bottom sediment as observed by repetitive bathymetric surveys. In Pool 19, sedimentation rates vary from 0 to more than 14 cm/yr. When calculated by suspended-sediment budget analysis and averaged over the whole pool the rate is 2.8 cm/yr. In those areas of the pool accumulating sediment, deposition rates of organic carbon have been measured at 300 to 700 $g/m^2/yr$.

Specific sedimentation rates are being measured in sediment cores from selected compartments of both the Illinois and Mississippi rivers. Cesium-137 determined sedimentation rates have been completed on 10 cores (150 subsamples), with rates measured ranging from 0.6 to 3.5 cm/yr. Cesium-137 can only be used for measuring sedimentation rates since 1954, so a lead-210 procedure was developed which is capable of going back about 100 years. Comparative sedimentation rates for Swan Lake (Illinois River) were 1.0 and 1.1 cm/yr using the Cs-137 and Pb-210 techniques, respectively. Further comparison and refinement of the two techniques are underway and a manuscript is planned on their successful application in a large river system.

Detention and Distribution Devices for Nutrients and Sediments (Bhowmik and Adams)

Streams and rivers are impacted by natural phenomena, such as wind, and geometrical characteristics such as intersection angle at the confluence of two rivers or a change in the gradient at certain locations. A combination of hydraulic, geomorphic, and geometric characteristics of the river and external forces can generate localized episodes that drastically alter the expected patterns of transport, deposition and availability of nutrients. If these episodes occur frequently or are of sufficient magnitude, they may control the structure and function of the ecosystem in the locale.

Water Driven Mechanisms (Bhowmik and Adams)

In October 1982, we detected a large eddy with a clockwise flow pattern below the confluence of Devil's Creek and the Mississippi River in Pool 19. The circulation patterns were measured using a float-and-vane system (Bhowmik and Stall 1978). This "detention device" is about 5 km long and 1.25 km wide with an average depth of 1 m (Figure 2). If it is assumed that the entire flow within this detention device is contributed by Devil's

Creek, then the average residence time of water is 8 days. If the water comes from the main channel, the residence time is 1.5 days. We estimate that Devil's Creek contributes about 73,100 tons of sediment annually. Depending upon the distribution of the sediment load with flow, the eddy may retain most of the sediment and nutrient load delivered by Devil's Creek.

During a fairly high-flow period there was no eddy, but a uniform flow of water and sediment in the downstream direction. This difference between the high and low flow periods in the formation and persistence of the eddy will be researched further.

The detention device shown in Figure 1 is not an isolated case. Knowledge of river mechanics and flow pattern indicate that similar detention devices are present in meandering segments of rivers, near the convex zones of a bend, behind snags and large features protruding in the water, and at or near the confluence of many streams and tributaries. The secondary circulation that is present in both the straight and curved reaches of rivers also changes the patterns of sediment and nutrient deposition in the river (Bhowmik 1982). Presence of these water-driven circulation patterns is another facet of river mechanics that directly affects the biological continuum in a river basin.

Wind Driven Mechanisms (Bhowmik and Adams)

Presence of prolonged wind on a water body not only generates waves (Bhowmik et al. 1982; Bhowmik and Schicht 1980); but also circulation patterns within the water body (Bhowmik and Stall 1978). The pattern, direction, and magnitude of the wind-generated circulation pattern on a reach of a large river, is a predictable function of wind velocity, direction, duration, the hydraulic geometry of the river, the wind fetch, orientation of the river, and the shape of the river cross section. On large rivers in the Midwest wind-generated circulation patterns are generally present in the spring during high river stages. Summer thunderstorms can generate waves and secondary circulation patterns which resuspend bottom sediments, fragment plants and other organic matter, increase turbidity and reduce light penetration, and redistribute sediment and nutrients. The recurrence interval of storms of various magnitudes may be an important control on biota. We gathered data on one storm event in 1984 which are now being analyzed.

Our findings on both water and wind-driven events do not support the concept of a large river as a homogeneous, continuous or uniformly mixed system.

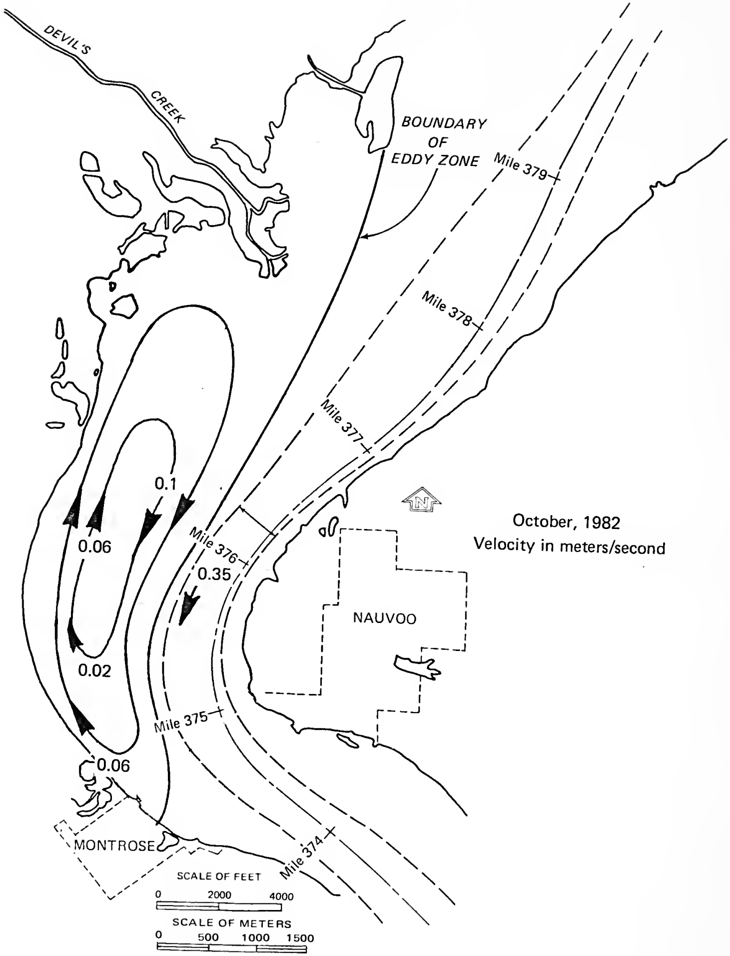


Figure 2. Eddy on Montrose Flats, Q = 1560 m^3/sec.

Relationship Between Geomorphic and Manmade Structure and Community Structure

Lateral Pattern

Phytoplankton and Invertebrate (Anderson). Habitat specificity has been demonstrated in 4 major groups of organisms: phytoplankton, zooplankton, meiofauna, and benthic macroinvertebrates. Few habitat generalists have been found within the invertebrate community. There is greater variation between habitats within a navigation pool than within the same habitats in widely separated pools, particularly among trophic groups of the invertebrates. The same pattern of association between species diversity and standing crop and the lateral structure of the Mississippi River occurs in Pools 19 and 26 (Figure 3), although the transects are 175 miles apart. Both transects are in the downstream ends of their respective pools. Phytoplankton communities in vegetated sites are characterized by high densities of pennate diatoms while backwaters support communities characteristic of organically enriched areas. In both phytoplankton and zooplankton the greatest community habitat specificity occurs during summer months when differences between habitats are most pronounced.

Fishes (Lubinski). Fish are not permanently associated with relatively static substrate conditions as some macroinvertebrates are, but can respond immediately to environmental changes.

A subset of the data collected in 1983 was used to examine changes in fish activity in main channel border habitats in the lower Illinois River during a short-term drought and subsequent low discharges. Hoopnet results showed that species composition changed dramatically in these habitats from riverine- to backwater-associated species when current velocities dropped below 0.3 m/sec. When velocities remained below this level, movement of centrachids between main channel border and backwater habitats appeared to be controlled by the preference of the fish for water at the lowest temperatures available. We concluded that during periods of low flow, lower Illinois River main channel borders provide suitable, if not preferred, habitat for species that are usually associated with backwaters. From a broader perspective, the results illustrated that functional roles of floodplain river habitats can be flow dependent even near the low end of the flow spectrum.

Longitudinal Pattern (Anderson)

Species composition of invertebrate and phytoplankton communities shift along an upstream-downstream continuum within each pool (Figure 4). Physical conditions control community structure. This control may be indirect, by affecting the quantity, quality and average particle size of detritus, for example. Figure 5 shows the mean length of 100 randomly chosen particles from subsamples of collections made with a plankton net held collected 0.5 m below the surface in May and June 1983. The

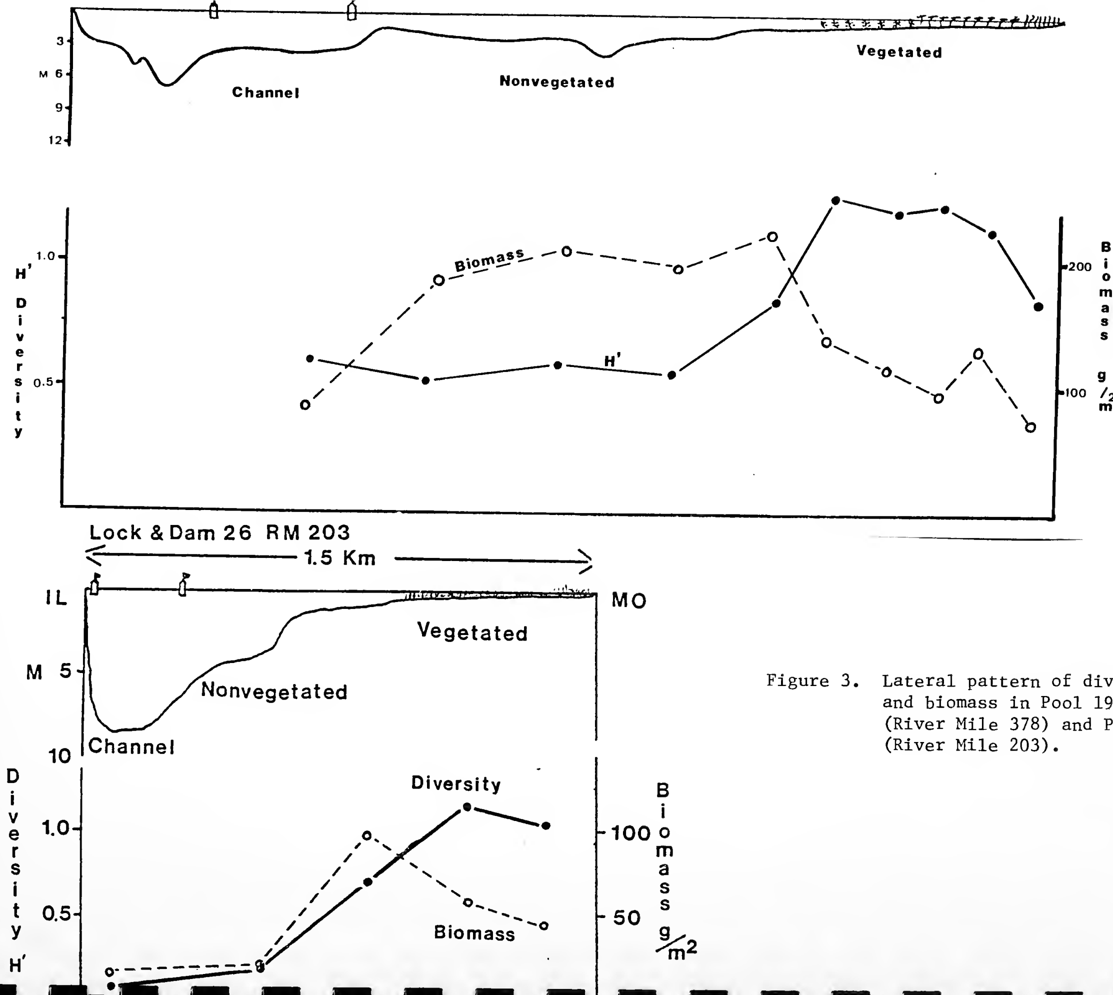
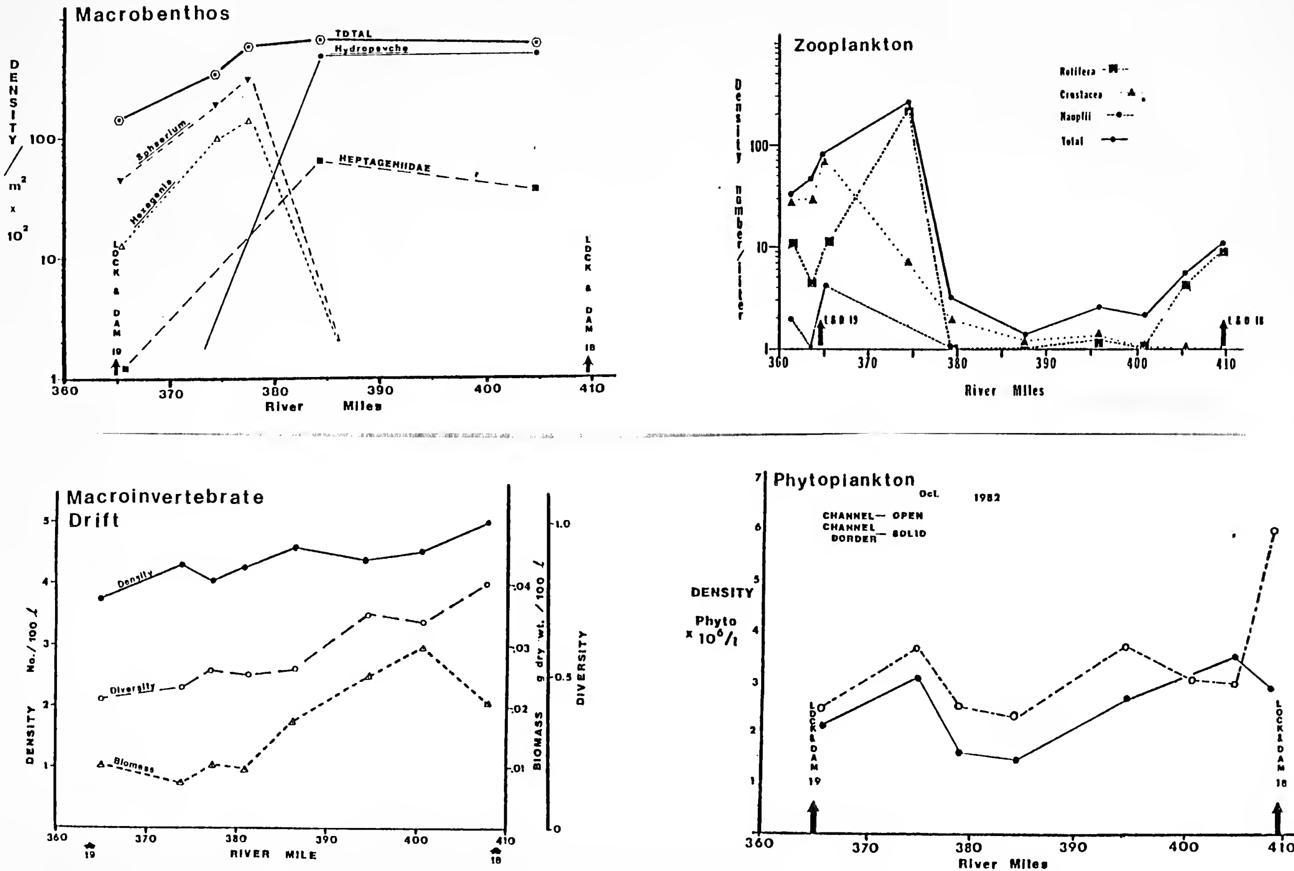


Figure 3. Lateral pattern of diversity and biomass in Pool 19 (River Mile 378) and Pool 26 (River Mile 203).

Figure 4. Longitudinal distribution patterns of macroinvertebrates, zooplankton, and phytoplankton in Pool 19.



quantity and average particle size is greatest near the upper end of the pool, where the Skunk River enters and where the spring flood was washing litter off the floodplain and islands. Large particles are probably mechanically fragmented or settle out in the downstream, lentic portion of the pool, while the small particles continue downstream to Dam 19. The insets in Figure 5 show the length/frequency distribution of particles in the upstream and downstream portion of the pool.

Average particle size and quality of substrate also shows a predictable upstream-downstream pattern (described in the next section) which controls the distribution of organisms. Firm substrates are available on the upstream dam and in tailwaters below the dam, so net-spinning hydropsychid caddisflies and heptageniid mayflies dominate the upstream end of the pool (Figure 4). The macroinvertebrate groups which tend to drift are characteristically found on coarse substrate in current, so the biomass, diversity and density of drift organisms diminishes in the downstream direction (Figure 4). Burrowing mayflies (*Hexagenia*) and fingernail clams (*Musculium* and *Sphaerium*) dominate the soft substrates in the downstream portion of the pool (Figure 4).

Phytoplankton are rather uniformly dispersed longitudinally from upstream to downstream and laterally from main channel to channel border (Figure 4), while zooplankton are most abundant in the downstream lentic portion of the pool (Figure 4). The extreme upstream portion of the main channel has a high density of phytoplankton (Figure 4), evidently washed in from Pool 18.

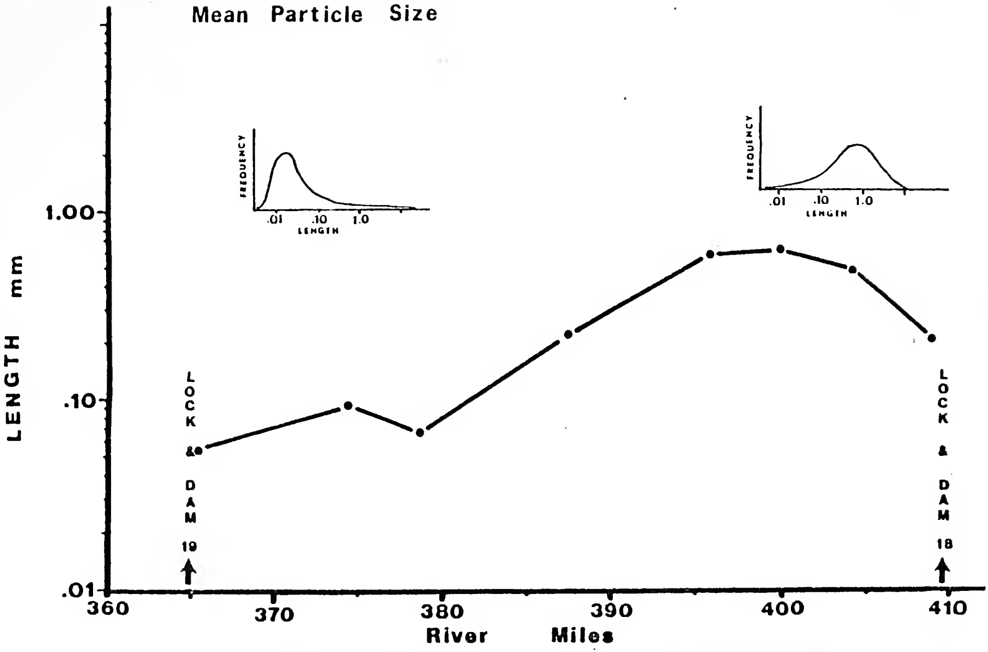
Substrate Patterns (Gross and Casavant)

In 1982 and 1983, gravity cores up to 1 m long were collected at 60 sites in fine-grained sediment. Grab samples of the top 5 cm of sediment were collected at 377 sites using a Ponar and a Shipek sampler. Those samples were used to define 12 sediment types and the areal distribution of each type was mapped using bathymetric profiles to extrapolate between sampling sites. Substrate maps for Pool 19 are being entered on the geographic information system on the Prime computer.

The distribution of bed material in the pool is characterized by a pronounced trend of downstream fining, presumably a result of hydraulic sorting processes related to the backwater effect created at the downstream dam. Sand and gravelly sand are restricted to the main channel and the larger secondary channels of the upper pool, island-braided reach. Mud and interbedded mud and sand predominate in backwaters, over submerged islands, and in the main channel and channel border areas of the lower pool.

In the next 2 years, we will compare Pool 19 with Pool 26. Pool 19 is accumulating sediment rapidly, while Pool 26 is not (but may when the new lock and dam are completed). We do not

Figure 5. Mean length of organic particles obtained 0.5 meter below the surface in Keokuk Pool, May-June, 1983.



know which model is the norm. Reconnaissance sampling has started on the five pools between 19 and 26. Unfortunately, high water and mechanical problems with the boats disrupted that effort in 1984, but pools 20 and 21 do not show the downstream fining sequence of bottom sediment, indicating that they are not accumulating great quantities of sediment.

Sedimentation Rates of Pool 19 (Gross and Casavant)

Pool 19 was created by the construction of a lock and dam in 1913. The pool has since filled with sediment, a natural phenomenon of any pool. From 1913 through 1928, the sedimentation rate was about 7,200 Gg per year. In subsequent years, the rate has decreased, and in 1967-79 the pool filled at an estimated rate of 3,200 Gg per year. As of 1979, the pool had lost 55% of its original capacity (Figure 6). By the year 2000, the pool will have lost about 67% of its original capacity and will be close to dynamic equilibrium. The highest sedimentation rate within the pool has occurred for a distance of about 3 to 5 km upstream of the dam, where approximately 10 m of sediment has deposited since construction of the lock. Montrose Flat near the Iowa shore opposite the city of Nauvoo and an area downstream of Nauvoo Point have also experienced significant sedimentation rates.

Maintenance dredging on the pool has decreased from a high of 165 million kg in 1938 to an average of 59 million kg in recent years, indicating that the main channel of the river is attaining an equilibrium position.

The 1973 flood and the drought of 1977 significantly impacted the river environment. During 1973, the river carried a record sediment load including sediments scoured from upstream of the dam. The record daily sediment load of 1.623×10^6 kg occurred on 23 April 1973. The high flow rate and the high sediment transport rate continued for about 4 months.

Water year 1977 had very low flows and extremely low sediment transport. This low sediment load was in turn responsible for very low turbidity which allowed aquatic plants to colonize areas such as Montrose Flat and upstream of Keokuk Dam, where sedimentation had decreased water depths to 1.5 m or less. For the month of April 1973, the average sediment concentration was 497 mg/l compared to the average of 39 mg/l in April 1977. The permanent change in benthic communities and vegetation patterns since 1977 (discussed in last year's report) demonstrates the long-term impact of low sediment loads. No persistent impact of the 1973 flood on the ecosystem has been identified.

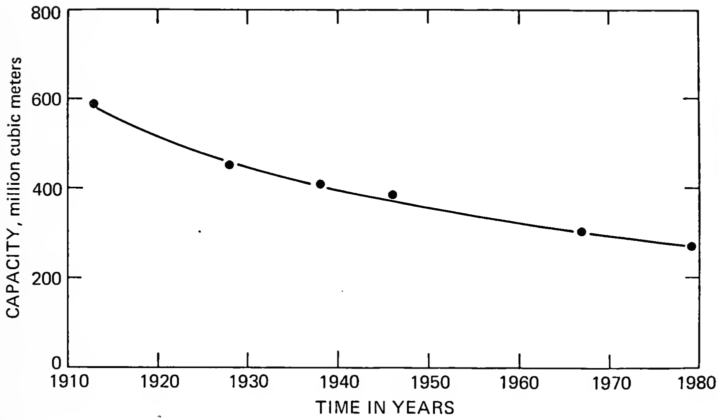


Figure 6. Sedimentation rates of Pool 19 since 1913.

<u>History of Perturbation</u> (Gross, Cahill, King, and Wendland)

Detailed chemical analysis of small increments of sediment cores provide a history of man-induced perturbation. For example, in a core collected above Lock and Dam 19 the organic carbon percentage and sediment porosity correlate with the mean annual flow of the river; the extreme drought of 1977 can be identified in the sediment by lower organic carbon percentage and a decrease in porosity.

Chemical analyses have been completed on samples from all 3 LTER study areas. In general, the sediment composition of pools 19 and 26 are similar. The areas sampled along the lower Illinois River have lower metal concentrations than the middle section of the Illinois River. The sediments of the upper Illinois River are highly contaminated by a number of metals, values including 64 ppm Cd, 206 ppm Pb and 2580 ppm Zinc, for example. Cores from Lake Peoria show decreased Pb concentrations in the uppermost increments, indicating improved water quality in the last 10 years.

River Ecosystem Model

Mathematical Model for Water and Sediment Transport in Pool 19, Mississippi River (Demissie, Adams, and Bhowmik)

The objectives of the mathematical modeling of water and sediment for Pool 19 are:

1. To simulate the flow of water through Pool 19 and the 7 habitat compartments within the pool and to provide information on water depth, velocity of flow, and the interchange of water from one compartment to another.

2. To simulate the transport of sediment in Pool 19 including scour and deposition in the stream channel, side channels, and channel border areas.

The results of the water and sediment model will then be utilized as an input to the biological model.

Background on Mathematical Modeling of Water and Sediment Transport (Demissie, Adams, and Bhowmik)

The basic formulation of the mathematical models for water and sediment transport include a complete set of equations to describe water flow and sediment transport. The fundamental equations are:

1. The equation for the conservation of the mass of the water and sediment mixture within a control volume. The control volume in this case is bounded by upstream and downstream cross-sections and the boundary of the river floodplain on both sides of the river. In simple terms, the conservation equation states that the difference between what comes into the control volume and what goes out of it is the change in what is stored in the control volume,

2. the equation for the conservation of sediment, and

3. the equation for the conservation of momentum for the water and sediment mixture.

To solve these basic equations, some supplemental equations are needed that relate the unknowns to other variables in the basic equations. These closure equations usually are:

1. Sediment transport functions. These are usually empirically selected for good agreement between measured data and computed results.

2. Friction slope as a function of flow and channel characteristics. Manning's equation is most commonly used.

3. Density relations.

4. Geometric properties of the channel cross sections as functions of water surface elevation.

Various numerical techniques can be used to solve the system of partial differential equations: implicit or explicit finite difference methods. The HEC-6 and Colorado State University (SLAM, Simons, Li and Associates) models used in this study employ implicit finite difference techniques.

The input requirements of the models are cross section geometry, distance between cross sections, flow resistance coefficients (Manning's n), inflow hydrographs at the upstream or downstream end and for tributaries, sediment rating curves by size fractions, and sediment inputs at tributaries.

Thirty cross-section profiles were measured in 1983 for sediment transport modeling in Pool 19. The model outputs include water surface elevation in the study reach, water discharge distribution, sediment discharge distribution, average velocities in a given cross section, and bed elevation change in the various cross sections.

Calibration and sample results [HEC-6 and SLAM models] (Demissie, Adams, and Bhowmik)

The first step in the calibration procedure was to reproduce the actual water-surface profiles for a range of flow discharges. A rating curve that gives Manning's n as a function of the water discharge in Pool 19 was developed. In all the overbank sections a value of 0.06 was assumed. The calibration was done using cross-sections taken in 1946. After 1983 cross-sections became available, the model was run again using the calibrated Manning's n values. The newly computed water surface elevations are shown in Figure 6 together with the computed water surface elevations, obtained using 1946 cross sections, and the measured stages in Pool 19. The agreement of model results and measured stages is good (Figure 7). The flow discharge ranges shown are for high flow (120,000 cfs), for mean flow (62,000 cfs), and for low flow (28,000 cfs). The SI (metric) values for these discharges are: 3,398, 1,754, and 793 m^3/sec.

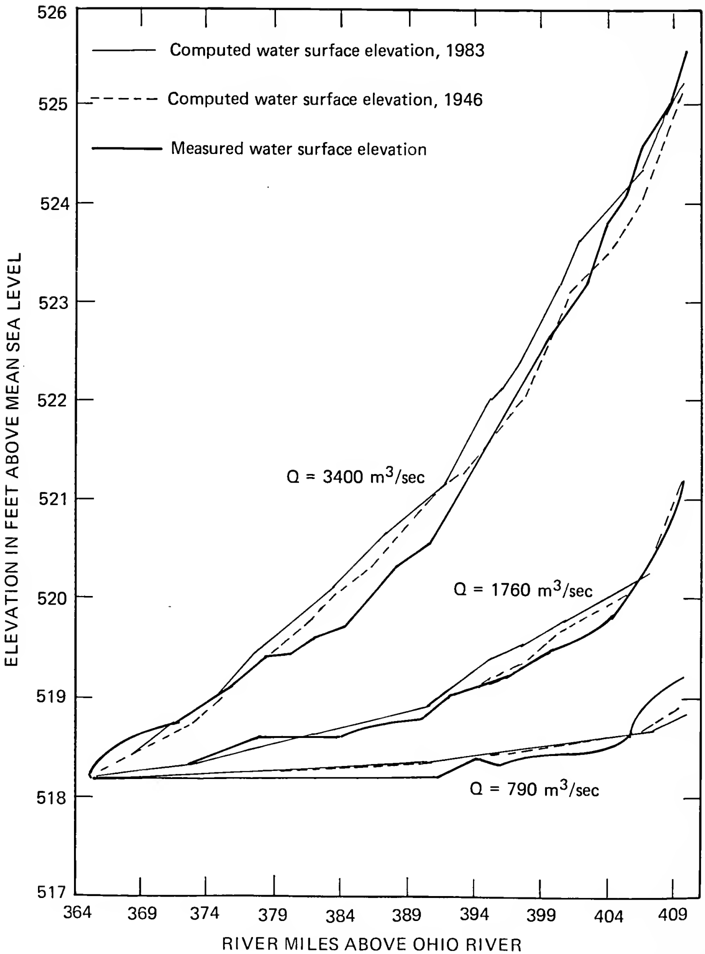


Figure 7. Comparison of computed and measured stages for Pool 19.

Since bed material size distributions were not yet available, no attempt was made to reproduce the sediment transport quantities and the bed-profile trends. Instead, data from a Pool 20 study were assumed to be applicable to Pool 19. Figure 8 shows a sample output of the HEC-6 model results using Pool 20 bed material data. These results were obtained by discretizing the 1982 water year hydrograph at the downstream end of the reach (Keokuk station). The first graph in the figure shows the loads of clay, silt, and sand through the study reach. The fourth graph is the change of bed elevation in feet over the water year 1982 in which the average discharge was 2,490 m^3/sec or 87,930 cfs; a negative number means that scour occurred in that cross-section and a positive number means that deposition occurred.

Figure 9 shows a comparison between 1983, 1946, and 1928 bed elevations in Pool 19. The 1983 bed elevations were obtained from the model while the 1946 and 1928 bed elevations are actual field measurements. The next step involves running the model for the 1946 to 1983 period with the actual water discharge record and the sediment rating curves for various sizes of sediment. The bed material particle size distribution for each cross section will be used now that we have obtained these data from the Geological Survey.

Similar calibration runs have been made with the SLAM program, and the additional data will also be used in that model.

Inter-Compartment Fluxes (Demissie, Adams and Bhowmik)

One objective of water and sediment transport models is to describe the movement of water, dissolved materials, and suspended materials from one compartment to another. The boundary between two compartments is a surface within the aqueous habitat and all fluxes are related to the water flux across the boundary. The water flux per unit time is equal to the integral of the velocity perpendicular to the bounding surface over the entire area of the surface. The flux of any other material such as dissolved carbon or suspended sediment is determined by integrating the concentration of that material times the water velocity over the boundary surface area. If volumes entering or leaving a compartment over a period of time are required, an integration over time is also necessary.

The hydraulic models currently in operation are one-dimensional and do not include lateral flows between main channel and channel border areas. One of our goals is to modify a model, or develop a new model that will determine these lateral flows between compartments. This will provide the compartment fluxes needed for carbon and other nutrients. In some cases two-dimensional models may be needed to provide sufficiently detailed flux patterns for important habitats.

Another element of the hydraulic models that needs refinement is the division of flow around islands. Side channels often are biologically very productive, but are not modeled by the one-

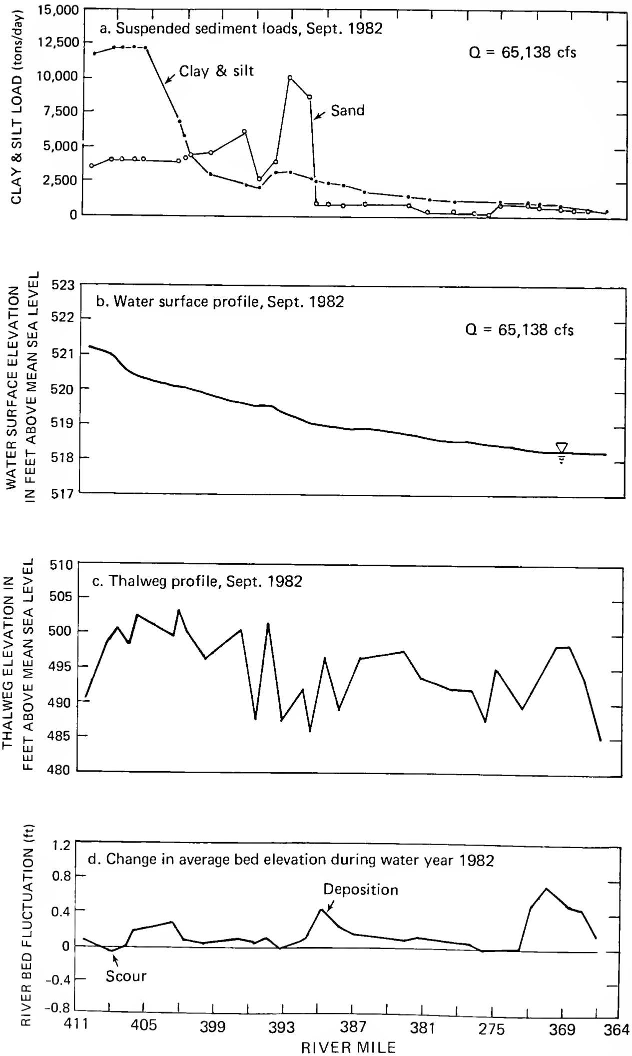


Figure 8. Model results for 1982 water year, Pool 19.

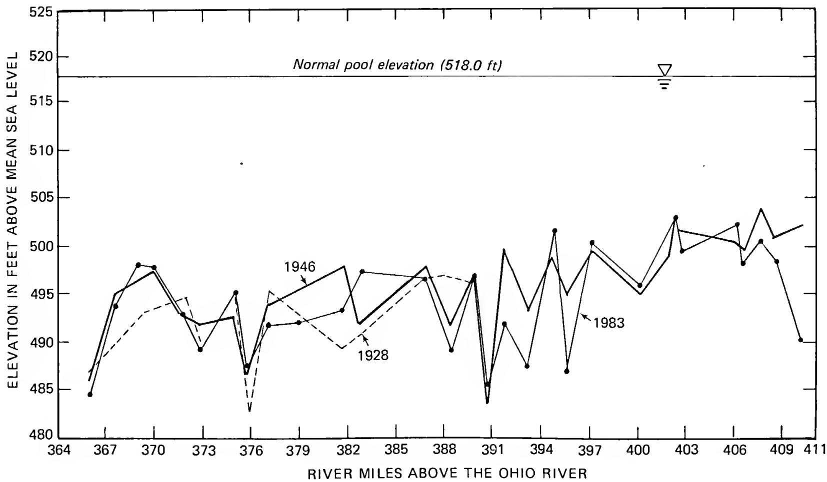


Figure 9. Average bed elevation for 1928, 1946, and 1983 in Pool 19.

dimensional models. Side channel areas are included in the cross section, but the velocity, sediment transport rate, and depth are average values for the cross section. We have instituted a field data collection program to measure the water and sediment fluxes in the vicinity of islands.

Biological Component (Brookfield and Sparks)

The model is structured around state variables, representing key species or groups of organisms and nonliving reservoirs. The structure allows us to change each state variable while holding the others constant so that we can debug one part at a time. Anderson, Henebry, Lubinski, and Sparks and their respective staffs have the responsibility for modeling one or more of the 22 state variables. The first habitat compartment selected for modeling is the downstream third of the nonvegetated main channel border of Pool 19.

Our procedure is to first prepare booklets for each state variable describing carbon flows and controls on the flows, based on a combination of our own data, literature, and intuition. Assumptions are spelled out and literature cited. In many cases, the relationship between some rate process and a controlling factor is displayed as a graph or table. Second, we condense descriptive booklets into a series of codes and statements written in a form as close to FORTRAN as a principal investigator can manage. Both booklets are then reviewed by two internal advisors, Dr. Mike Wiley of the Aquatic Biology Section and Dr. Bill Ruesink of the Economic Entomology Section, both in the Natural History Survey. One member of our External Advisory Committee, Dr. Richard Wiegert, has introduced our group to carbon and energy-flow modeling in two workshops held at the Natural History Survey in Champaign, and one at the field station on the Illinois River at Grafton. He has continued to offer advice and encouragement as we progress. Revisions are made in consultation with the PIs, and the semi-FORTRAN booklets are then translated into FORTRAN by our programmer, Frank Brookfield. First and second drafts of the informational booklets have been prepared for several state variables, (Table 4).

Table 4
Status of Biological Model

State Variables	PIs, Staff	Descriptive Booklet Drafts 1st	Descriptive Booklet Drafts 2nd	Semi-FORTRAN Booklet	FORTRAN Program Completed
00 Air					
X15 --Terrestrial plants	Anderson, Grubaugh, Sparks				
20 --Water					
X1 --Phytoplankton	Anderson	x			
X2 --Zooplankton	Anderson	x			
X3 --Benthic fish	Lubinski	x			
X4 --Planktivorous fish	Lubinski	x			
X7C --Coarse particulate organic carbon (CPOC)	Henebry, Sparks	x			
X7 --Particulate organic organic carbon. (POC)	Henebry	x			
X8 --Dissolved organic carbon (DOC)	Henebry	x			
X9 --Periphyton	Anderson				
X10 --Macrophytes	Anderson, Grubaugh				
X13 --Dabbling ducks	Sparks				
X14 --Diving ducks	Grubaugh, Sparks	x			
X20 --Bacteria-planktonic	Henebry	x			
30 Sediment					
X5A --Fingernail clams-adult	Sparks	x	x	x	
X5 --Fingernail clams-subadult	Sparks	x	x		
X6A --*Hexagenia*-adult	Anderson	x	x		
X6 --*Hexagenia*-nymph	Anderson	x	x		
X11A--*Hydropsyche*-adult	Anderson	x	x		
X11 --*Hydropsyche*-nymph	Anderson	x	x		
X12 --Non insect-other	Anderson				
X16 --Other mollusks	Anderson				
X17A--Other insect-adult	Anderson				
X17 --Other insect-nymph	Anderson				
X19 --Gastropods	Anderson				
X21 --Bacteria-benthic	Henebry	x			
X22 --*Glossiphonia complanta* and *Helobdella stagnalis*	Anderson, Sparks				

Some of the environmental forcing factors, such as temperature and dissolved oxygen, have already been entered as tables in a FORTRAN "skeleton" program, which is written to run on both the PRIME system and on the IBM PCs at each of the field stations. This program is structured so that state variables can be added as they are completed, or tabled values can be used in the interim. Also, each PI will be able to change the functions in their state variables with very little knowledge of FORTRAN and do simulation runs to check their results. The original program will reside on the PRIME in read-only format and is readily accessible for the PIs to copy and use. However, any changes to this program have to be documented and approved by our Executive Committee. Changes can only be made on the system version by our programmer, Frank Brookfield.

A description of the state variables for fishes is presented next, to give some idea of the complexity of the programs and the approach used in modeling.

State variables for fish (Lubinski). Two major riverine fish groups are represented in the model, benthic feeders and plankton feeders. Carbon in each group is further subdivided into adults, eggs and sperm, young of the year and immatures. Initial efforts emphasized benthic feeders to maximize interaction with other model components. Information specific to carp, *Cyprinus carpio*, a representative and abundant benthic feeder in main channel border habitats, was reviewed.

In the model, carbon flows from fish eggs and sperm into the planktivorous fish component once eggs hatch. Carbon flows into benthic-feeding young-of-the-year as the fry become large enough to use benthic macroinvertebrates in addition to plankton.

At levels of benthic macroinvertebrate biomass above 0.5 kg C/m^2, temperature, day of the year, and benthic fish biomass control consumption by the adult fish, young-of-the-year and immatures. Selection of certain prey classes is controlled by the proportions of the classes available. When benthic biomass falls below 0.5 kg/m^2, consumption starts being limited to rates that cannot support maximum growth. When benthic biomass falls below 0.05 kg/m^2, benthic feeding fish begin to emigrate to other habitats to seek more plentiful or new food resources.

Development of the fish simulation model has already shown a need for additional kinds of data. As a result, enclosure and exclosure experiments with carp are being conducted in Pool 19 main channel borders in 1984 to determine specific feeding rates in vegetated and non-vegetated areas and to test the hypothesis that carp control, at least partially, benthic macroinvertebrate biomass in vegetated main channel border habitats.

B. Data Management and Analysis

Introduction (Brookfield)

The major objectives of our data management program are to: (1) create an information system rather than a data storage system, which means that the PIs can obtain results rapidly and enter and verify data easily, (2) coordinate data entry and electronic filing, (3) address data entry and analysis problems and help formulate solutions, (4) archive original data sheets, maps and other paper documentation on microfiche.

Geographic Information System (Brookfield)

We have now moved our map processing to the ARC/INFO system. This system offers a wide range of tools for interpreting and display of cartographic information. To date we have digitized base maps and sampling stations for Pool 19, sent final copies on mylar to each PI to coordinate sampling points, and we can now display bathymetric maps. The data used to create these maps are being used in the hydrologic model. Several maps are electronically available to all PIs.

Future plans include the development of a directory of maps available and an accessing program that allows users with little or no knowledge of the system to view or plot these maps. Digitizing is time consuming but, with continued support, maps should be readily available to everyone who requires them.

Data Base Management (Brookfield)

The INFO data base management system (DBMS) is now the primary electronic filing system for all data from this project. The PRIME computer at the Natural History Survey at Champaign is the hub for all our LTER data, with outlying stations having copies of their own data.

Field Stations (Lubinski and Brookfield)

Portions of this system are still under development. The major accomplishments at this time are the purchase and distribution of four minicomputer work stations, training of field station personnel in the use of the equipment and software, the development of transfer procedures, and the creation of accessing routines on the PRIME.

LTER fish data sets from 1982 have been down-loaded from the University of Illinois CYBER computer and are available on the field station computers. Fish data sets from 1983 are being downloaded from the PRIME computer and should be available in late summer 1984. The 1984 fish data sets are being entered directly into the field station computers for future transferral to the PRIME and are, therefore, available immediately.

Water level regimes are primary controlling factors for communities and populations in floodplain rivers. River stage data in our study areas are available from federal agencies but only in hard copy format. Staff at the Grafton field station have begun computerizing daily water levels for 8 Illinois and 9 Mississippi River stations. Data from 1982 to the present are now being entered. historical data will follow. The data will be used in the river model to compute surface area changes that correspond to changing river discharges or lock and dam operations.

SECTION 2: SHORTFALLS AND PROBLEMS

A. Hydrological Modeling (Adams, Bhowmik, and Demissie)

Our decision to model water and sediment flows represents a major new direction for the hydrologic component. The sediment transport models are large, complex programs which require large amounts of carefully prepared data. It takes one person several months of intensive use of these models to become familiar with their operation, sensitivity, and product.

When we began this program in late 1983, we had no one with the time to become expert with these newly acquired models. Time and money remain limiting factors to the rate at which we can develop predictive capabilities. Inadequate computer terminals have also limited the use of graphics which help greatly in understanding the results of various model options. This problem will be overcome if the $40,000 increment for computer equipment and personnel is granted (See Appendix H). We have also been unable to send anyone to Colorado State University for hands-on training in the use of SLAM and their two-dimensional models because of the lack of funds.

Data which we expected to be available took months to obtain and then were not clearly described in quantitative terms. This is mentioned to highlight the fact that mathematical models are dependent on good, precise input data.

B. Biological Modeling (Sparks)

Ecological modeling is a new assignment for our PIs and our LTER program, and while we have had much help from one member of our External Advisory Committee, Dr. Richard Wiegert, and two members of the Natural History Survey, Dr. William Ruesink and Dr. Michael Wiley, we are not progressing as quickly as we might if we had an experienced modeler on the LTER staff. We have twice revised the number of state variables and our approach since our last meeting on 28 September 1983 with Richard Wiegert. While we believe these changes have improved both the model and our concept of how the river system works, they also cost us time. We spent some time treating life history stages as subunits within state variables before we adopted the easier approach (from a conceptual and programming point of view) of treating them as separate state variables. We found it difficult to bridge the gap between the graphical, mathematical, and verbal descriptions of our biologists and the programming language of FORTRAN. We are overcoming this problem by inserting an intermediate step, where the biologists, with coaching from our advisors, reduce their explanations and descriptions into a concise set of statements we are calling semi-FORTRAN, which our programmer then can translate into FORTRAN.

The replacement of our data manager/programmer in January set our modeling back temporarily, because the model requires information derived from field and laboratory data. We also moved most of our LTER programs and files (the exceptions are the large, complex hydrological models) from the University of Illinois CYBER to the Survey's PRIME where we can take advantage of a geographic based information system (ARC/INFO) and the services of our own support staffs. Our PIs and their technical assistants are still learning how to use the computer software and hardware we purchased with the $50,000 increment last year.

The pace of our modeling is accelerating as our PIs and new programmer gain experience, and we expect to have results of our first simulation runs ready for our External Advisory Committee Meeting in February, 1985.

C. Merging of Data Sets (Sparks)

Field measurements of current velocities and sampling for sediments and nutrients are conducted jointly by the Natural History and Water Surveys. Samples are sent to separate laboratories for analysis and results are obtained several days or weeks later. To measure fluxes, the concentration data must be multiplied by flow and integrated across the tributary stream, main river, side channel, or habitat boundary. Although it has been our goal since the inception of the project to computerize the merging and computation, our analyses to date have been done by hand during coordination meetings.

Merging of discharge and concentration data sets is now the highest priority of our new Data Manager, Frank Brookfield, and we have had two meetings regarding the format of the data sets and procedures for linking the derived data (sample concentrations) to the sampling locations and times. We expect to overcome the merging problem shortly, and then work on computation and graphical display of results.

D. Substrate Distribution Patterns in Pools of the Mississippi (Gross)

Reconnaissance sampling has begun on the five pools between 19 and 26. Unfortunately, high water and mechanical problems with the boats disrupted that effort (our diesel-powered workboat, the OMI, was nearly crushed between a lock wall and a Coast Guard barge), but it is already apparent that pools 20 and 21 do not show the downstream fining sequence of bottom sediment, indicating that they are not accumulating great quantities of sediment. The sampling has been rescheduled for 1985, with two backup dates.

E. Decomposition of Macrophytes (Lubinski)

Several attempts were made to develop techniques to measure decomposition rates of lotus, *Nelumbo lutea*. All efforts using whole plant leaves tethered in the water column, regardless of whether the water was flowing or not, failed when all or most of the leaf broke away from the tether. Known areas of plant leaves were placed in litter bags in other trials, but the bags interfered with water flow over the plant leaf surface. More trials will be made this year using litter bags with greater mesh sizes to reduce this effect.

SECTION 3: PROJECT PLAN

A. Overview (Sparks)

The project plan in our original proposal to NSF was to study one of our three sites for 5 years, then rotate to the next. In response to reviewers' comments, we amended our plan so that baseline measurements would be made on all 3 pools and intensive sampling would rotate on a 1-year cycle. The amended plan, in turn, has been revised on the basis of our first 3 years of experience and with the encouragement of our External Advisory Committee. Some of our studies now purposely precede others, some samples are taken outside our 3 pools, and most of our sampling and modeling concentrates on one pool, Pool 19.

There are good reasons for some of our studies to range over 3 pools and even reaches of the rivers outside the 3 pools. Our predictions about relationships between community structure and physical structure of the pools will be tested by sampling sediments, water velocities, and biological communities in five pools, from pool 19 to pool 26, during a low-flow period in 1985. In taking cores from trees to reconstruct our site history, we must go where the old trees occur, not necessarily confining ourselves to just three pools.

We also have found that there is a marked advantage to making physical measurements and hydrographic maps before we do our biological sampling, especially in a pool such as 26, where we have the least historical data. The maps and measurements help us define habitat compartments and plan our biological sampling.

In 1985, we plan again to concentrate our sampling and modeling on Pool 19 because we feel we should understand and model processes in this pool before moving on to another. We have good background data on this pool, which is subject to less disturbance by man than the Illinois River or Pool 26. We would like to describe and model a "semi-natural" system, before we superimpose the stresses induced by man.

Pool 19 is biologically interesting because of its high secondary productivity and because it seems to be at a critical stage in succession. The downstream third of the pool was fairly deep for many years after closure of the dam in 1913, and it probably did not make a great deal of difference to benthic macroinvertebrates whether they were in a depth of 5 meters or 10 meters. However, once sedimentation had raised bottom elevations into the euphotic zone (1.0-1.5 m) submergent vegetation developed and macroinvertebrate communities changed markedly. Vegetation beds have expanded since 1976-77 and we have the opportunity to capture this transition and to test the ability of our model to predict where and when community structure will change. We then should be able to transfer our knowledge to Pool 26, where the new dam will be closed in the late 1980's, presumably initiating some long-term changes.

Another reason for concentrating our efforts in one pool and developing our model as rapidly as possible is that our results may find practical application in the very near future. As a result of a political compromise, the navigation capacity at new Lock and Dam 26 will be increased and funds will be provided to enhance existing fish and wildlife resources along the river, mitigate any damage attributable to increased traffic, undertake a long-term resource monitoring program, and develop a computerized inventory and analysis system. While our model is primarily a vehicle for formalizing our concept of how the system works, we are aware that it could be used to predict the effects of different management plans.

If we receive the proposed $40,000 increment, we will increase the pace of our modeling and data analysis by adding a computer work station for hydrological modeling by the Water Survey and two graduate research assistants, one for carbon analyses essential to our carbon flow model, and one to help digitize maps and aerial photographs (see Appendix G). Specific plans for the hydrological studies and documentation of the history of perturbation follow.

B. Hydrologic Studies (Adams)

Continued effort on the water and sediment transport models will be focused on long-term bed elevation changes using historical discharges, and extension of the output beyond strictly one-dimensional analysis. Several empirical techniques and field measurements will be used to distribute water and sediment across a cross section. A critical habitat, the Montrose Flat channel border area, has been chosen for preliminary efforts at two-dimensional modeling. The hydrologic models also will be expanded to include the transport of nutrients.

Tributary suspended sediment sampling will be continued. Also, water and sediment sampling in conjunction with biological intensive sampling will be conducted as needed. Water and sediment measurements at Burlington Island and in the Devil's Creek to Nauvoo reach will be done to refine the results of the mathematical models. Equipment will be installed on Burlington Island and measurements will be taken during floods to determine the erosion or deposition on the island, the flow patterns and the transport or trapping of organic matter.

The LTER Steering Committee has approved an intersite workshop on sediment movement: mechanics and measurement. This workshop will take place during 1985, probably at Pere Marquette

State Park. The park is near the confluence of the Illinois and Mississippi rivers and is reasonably close to the St. Louis airport.

C. History of Perturbation (Gross, Cahill, King, and Wendland)

Work will begin in August 1984 on reconstruction of climate and stream flow from tree-ring records. As a budgeting compromise, the start of these later two efforts was delayed for 2 years. Obviously, that history has been recorded in the sediments and tree rings and we can schedule this research whenever it fits best with the ecological sampling of the dynamic systems.

Twenty-inch increment borers will be used to extract cores from paired trees, trees in the floodplain and trees on the adjacent bluffs. Using the 70 years of measured stream flow as a base, the hydrologic record of the Mississippi and Illinois rivers will be extended back for about 200 years.

SECTION 4: MOST SIGNIFICANT ACCOMPLISHMENTS

O The circulation pattern on Montrose Flats was found to vary depending on the discharge of the Mississippi. The flow in this channel border area is determined by geometry, discharge, and wind-generated waves. Further measurements will be made to increase our knowledge of the controlling factors such as the largest discharge at which the eddy exists, the wind speeds and directions that affect the water currents, and the geometric parameters. (Bhowmik and Adams)

O Water and sediment fluxes were successfully measured above and below the junction of the Illinois and Mississippi Rivers. These measurements satisfy the continuity or conservation of mass condition within acceptable limits. This encouraged us to do similar measurements at two locations in Pool 19. At this time the water discharge at successive cross sections balances within 5 to 10% which is quite good for discharge measurements from a boat. (Bhowmik and Adams)

O Verification of the HEC-6 and SLAM sediment transport models for Pool 19 by reproduction of the water surface profile is a good beginning. The models are now being calibrated for suspended sediment and bed material characteristics in the movable bed mode. (Bhowmik and Adams)

O A handbook of the laboratory and field methods used in the LTER project has been compiled. This handbook is especially critical for our site because it involves five independent agencies located in widely separated areas. The handbook serves also as a mechanism to standardize our data sets with other sites and eliminate within-site duplication of measurements. (Cahill)

O The purchase, set-up and operation of coulometric carbon analysis equipment have resulted in a significant improvement over our previous methods. We measured carbon in 135 sediment samples from the Illinois River and from Mississippi River pools 19 and 26. Sixty-six samples were analyzed as part of the LTER plant bed study, ranging from live plants with 39 $\pm$ 2.2% organic carbon for 18 plants to 0.2 $\pm$ 0.1% organic carbon in nine ash samples. We anticipate determining carbon in a variety of key organisms to provide critical information for the carbon flow model. (Cahill)

O Geological mapping of sediment in Pool 19 on nine 7 1/2' quadrangles has been completed and the digitizing and entry of the data in our geographic information system is nearly complete. By combining these maps with point measurements of sedimentation rates we can compute the total quantities of sediment and of organic carbon deposited annually in the pool and its habitat compartments.

O Our analyses of sedimentation rates, dredging records and historical hydrographs for Pool 19 indicate that the main channel has assumed a nearly stable position and sedimentation will reach dynamic equilibrium (as much sediment will wash out of the pool as enters the pool, with no net accumulation) by the year 2000, when the pool will have lost 67% of its original volume. (Bhowmik and Adams)

O Counts of new and old shoots produced by _Sagittaria latifolia_ indicate the above-ground biomass turns over 2-3x during the growing season. Literature estimates of primary production by macrophytes in the Mississippi River grossly underestimate actual production and the relative importance of autochthonous versus allochthonous sources of organic matter. (Lubinski)

O During periods of low flow when current velocities were less than 0.3m/s, the main channel borders of the Illinois River were occupied by fishes usually associated with backwaters. The functional roles of floodplain river habitats are dependent on flow even near the low end of the flow spectrum. (Lubinski)

SECTION 5: PUBLICATIONS AND PRODUCTS

A. INTRODUCTION

Fifty-one posters and papers presented at meetings are listed in Appendix 6. This appendix lists: 3 LTER reports, 28 papers, and 4 theses. Eight of the papers have been published, 7 are with editors, 8 are first or second draft manuscripts, and 5 are in preparation, but not yet in manuscript form. The journals where the manuscripts will be submitted are listed.

B. LTER REPORTS

Cahill, R.A., ed. (manuscript). Handbook of field and laboratory techniques used by the Long Term Ecological Research Project, Illinois River and Upper Mississippi River. 99 pp.

Sparks, R.E. 1984. Ecological Structure and Function of Major Rivers in Illinois -- Large River LTER. 1984 Progress Report to National Science Foundation.

Sparks, R.E. (with editor). Large River LTER. In J. Halfpenny, ed. "LTER a Network of Sites". LTER Steering Committee.

C. PUBLICATIONS

Anderson, R.V. (manuscript). Implications of distribution patterns of freshwater mollusks Pool 19, Mississippi River. Oecologia.

Anderson, R.V. (in preparation). Temporal and habitat variation in benthic macroinvertebrates of a navigation pool, Mississippi River. J. Freshwater Ecology.

Anderson, R.V. (with editor). Distribution of nematodes in Pool 19, Mississippi River. Hydrobiologia.

Anderson, R.V. (with editor). Predictive quality of macroinvertebrate habitat associations in lower navigation pools of the Upper Mississippi River. In M. Smart, ed., "The Ecology of the Upper Mississippi River". Developments in Hydrobiology Series. Junk Publishers, The Hague, Netherlands.

Anderson, R.V., R.E. Sparks, D.L. Gross, J.R. Adams, and N.G. Bhowmik (in preparation). Source and availability of organic matter in relation to heterotrophic activity of a large river. Oecologia.

Anderson, R.V. and R.E. Sparks. (in preparation). Effects of a short-term drought on long-term succession in a pooled reach of the Mississippi River. Ecology.

Anderson, R.V. and W.S. Vinikour. 1984. Use of Molluscs as Pupation Sites by Oecetis inconspicua (Trichoptera; Leptoceridae). J. Freshwater Ecology.

Bhowmik, N.G. 1982. Shear stress distribution and secondary currents in straight open channels. Pages 31-61 In R.D. Hey, J.C. Bathrust, and C.R. Thorne, eds. "Gravel-Bed Rivers". John Wiley & Sons Ltd.

Bhowmik, N.G. 1984. Instream sediment movement in Illinois. Ill. Conference on Soil and Water Conservation, Illinois Department of Energy and Natural Resources Document No. 84/02, Springfield, Illinois.

Bhowmik, N.G. and J.R. Adams. (with editor). The hydrologic environment of Pool 19 of the Mississippi River. In M. Smart, ed. "The Ecology of the Upper Mississippi River". Developments in Hydrobiology Series. Junk Publishers, The Hague, Netherlands.

Blodgett, K.D., R.E. Sparks, A.A. Paparo, R.A. Cahill, and R.V. Anderson. 1984. Distribution of toxicity in sediments of the Illinois Waterway. Proceedings of the conference on Urban Effects on Water Quality and Quantity. Urbana, Illinois. 20-21 October 1983.

Cahill, R.A. and J.D. Steele. (manuscript). Sediment geochemistry of backwater lakes associated with the Illinois River. Illinois State Geological Survey Environmental Geology Notes. 58 pp.

Day, D.M. and R.V. Anderson. (manuscript). Activity patterns as an indicator of habitat use by diving ducks on Pool 19, Mississippi River. J. Wildlife Management.

Engman, J.A., R.V. Anderson, and L.M. O'Flaherty. (manuscript). Temporal and spatial variation in phytoplankton populations of Pool 19, Mississippi River. Hydrobiologia.

Gross, D.L., R.A. Cahill, D.I. Casavant, J.R. Adams, and N.G. Bhowmik. (in preparation). History of sedimentation in Mississippi River Pool 19: Geological Society of America, Abstracts of the Annual Meeting.

Grubaugh, J.W., R.V. Anderson, D. Day, K.S. Lubinski, and R.E. Sparks. (manuscript). Production of Sagittaria latifolia and Nelumbo lutea on Pool 19, Mississippi River. Aquatic Botany.

Henebry, M.S. and R.W. Gorden. (manuscript). The temporal and spatial distribution of bacterial populations of Pool 19, Mississippi River. Hydrobiologia.

Lubinski, K.S., S.D. Jackson, J. Janecek, G. Farabee, and A. Van Vooren. (with editor). The ecology of carp on the Upper Mississippi and Illinois rivers. In M. Smart, ed. "The Ecology of the Upper Mississippi River". Developments in Hydrobiology Series. Junk Publishers, The Hague, Netherlands.

Pillard, D.A. and R.V. Anderson. (In preparation). The effects of aquatic macrophytes on zooplankton. J. Freshwater Ecology.

Pillard, D.A. and R.V. Anderson. (with editor). A note on the parasitism of Rotifera by _Plistophora_ (Protista; Sporozoa) in Pool 19 Mississippi River. American Midland Naturalist.

Pillard, D.A. and R.V. Anderson. (with editor). A survey of the zooplankton of Pool 19, Mississippi River. Hydrobiologia.

Reed, R.C., M.L. Sargent, and D.L. Gross. (In preparation). Use of natural-gamma logging for characterization of bottom sediments in Mississippi River: Illinois State Geological Survey Environmental Geology Note.

Reese, M.C. and K.S. Lubinski. 1983. A survey and annotated check list of late summer aquatic and floodplain vascular flora, middle, and lower Pool 26, Mississippi and Illinois rivers. Castanea 48:305-316.

Sparks, R.E. 1984. The role of contaminants in the decline of the Illinois River: Implications for the Upper Mississippi. In J.G. Weiner, R.V. Anderson, D.R. McConville, eds. "Contaminants in the Upper Mississippi River". Butterworth Publishers, Stoneham, Massachusetts. 384 pp.

Sparks, R.E. 1984. LTER aquatic research. Aquatic Ecology Newsletter, Volume 17, No. 1.

Sparks, R.E. (with editor). Improving methods of data analysis and interpretation for environmental management programs. Council on Environmental Quality, Washington, D.C. Conference on Long-Term Environmental Research and Development.

Swecker, S.J. and K.S. Lubinski. (manuscript). Decomposition rates of sago pondweed, _Potamogeton_ _pectinatus_, in Pool 19, Mississippi River. Transactions Illinois State Academy of Science.

Wiener, J.G., R.V. Anderson, and D.R. McConville. 1984. Introduction. Pages 1-4 _In_ J.G. Wiener, R.V. Anderson, and D.R. McConville, eds. "Contaminants in the Upper Mississippi River". Butterworth Publishers, Stoneham, Massachusetts. 384 pp.

D. THESES

Blodgett, K.D. 1983. Toxicity of sediments in the upper Illinois Waterway. Master's thesis, Western Illinois University, Macomb. 72 p. (R.V. Anderson, Advisor).

Casavant, D.E. (in preparation). Sedimentary patterns and sedimentary history of Pool 19 of the Mississippi River. Master's thesis, University of Illinois, Urbana. (W.H. Johnson, Advisor).

Day, D.M. 1984. Use of diving duck activity patterns to examine seasonal and habitat utilization of lower reaches of Pool 19, Mississippi River. Master's thesis, Western Illinois University, Macomb. 143 p. (R.V. Anderson, Advisor).

Engman, J.A. 1984. Phytoplankton distribution in Pool 19, Mississippi River. Master's thesis, Western Illinois University, Macomb. (L.M. O'Flaherty, Advisor).

SECTION 6: OTHER SIGNIFICANT ACCOMPLISHMENTS

Poster Presentations at LTER Scientists' Meeting

The following is a list of posters presented at the LTER All Scientists' Meeting at Lake Itasca, Minnesota, May 13-17, 1984:

Adams, J.R. and N.G. Bhowmik. Circulation patterns on Montrose Flats.

Anderson, R.V. Meiofauna density and distribution in a navigation pool, Mississippi River.

Anderson, R.V. Predictive quality of habitat/invertebrate associations.

Anderson, R.V. Seston utilization by net spinning caddisfly larvae (Hydropsychidae) in a large river.

Anderson, R.V. Macroinvertebrate drift in a navigation pool, Mississippi River.

Anderson, R.V. and D.M. Day. Benthic macroinvertebrate community structure in a navigation pool, Mississippi River.

Anderson, R.V. and D.M. Day. Shallow channel border habitat of Pool 19, Mississippi River: unionid mussel nurseries?

Anderson, R.V., R.E. Sparks, D.L. Gross, J.R. Adams, and N.G. Bhowmik. Source and availability of organic matter in relation to heterotrophic activity of a large river.

Bhowmik, N.G. and J.R. Adams. Sediment transport in Pool 19, Mississippi River.

Cahill, R.A. and A.D. Autrey. Pb-210, Cs-137, organic carbon and trace element measurements in sediments of the Illinois and Mississippi rivers.

Casavant, D.I. and D.L. Gross. Bed material mapping for ecological research.

Day, D.M. Diving duck behavior as an index of resource availability.

Day, D.M., R.V. Anderson, and R.E. Sparks. Long-term changes in peak standing crop and productivity in dominant benthic macroinvertebrates, Pool 19, Mississippi River.

Engman, J.A. Seasonal phytoplankton density and distribution in a navigation pool, Mississippi River.

Gross, D.L., J.R. Adams, and D.I. Casavant. Sediment accumulation in Mississippi River Pool 19.

Grubaugh, J.W., D.M. Day, R.V. Anderson, K.S. Lubinski. Macrophyte production in a navigation pool, Mississippi River.

Henebry, M.S. and R.W. Gorden. Distribution of bacterial populations in large rivers.

Lubinski, K.S. Winter diving observations of main channel habitats and fishes at Thalweg disposal sites in navigation Pool 13, Mississippi River.

Pillard, D.A. Seasonal zooplankton density and distribution in a navigation pool, Mississippi River.

Sparks, R.E. and R.V. Anderson. Effects of a short-term drought on long-term succession in a pooled reach of the Mississippi River.

Sparks, R.E., R.V. Anderson, J.R. Adams, N.G. Bhowmik, M. Demissie, R.W. Gorden, M. Henebry, K.S. Lubinski, K.D. Blodgett, J.W. Grubaugh, D. Day, and M.J. Wiley. Why large floodplain rivers do not fit the river continuum concept: An alternative model.

<u>Hydrology Intersite Activities</u>

During the LTER Scientists' meeting at Itasca Park in May 1984, the hydraulic engineers from our site agreed to summarize the hydraulic, hydrologic, and meteorological data being collected at all the LTER sites. A detailed information form has been sent to all LTER Project Directors. A composite listing will be made and distributed to all the sites. The benefits of such an intersite activity will be:

1. Compilation of the hydraulic, hydrologic, and sediment data collected at all sites.

2. Identification of areas where additional data should be collected.

3. Exchange of intersite know-how and assistance.

4. Formulation of intersite comparative studies.

5. Close cooperation between scientists working at various sites in different geographic, physiographic, and climatic settings.

<u>Presentations at Meetings</u>

Adams, J.R. Instream sediment movement in Illinois. Presented at the Illinois Conference on Soil Conservation and Water Quality, Springfield, Illinois, November 9-10, 1983.

Adams, J.R. Long term ecological research on the Mississippi River. Presented at St. Anthony Falls Hydraulic Laboratory Colloquium, Minneapolis, Minnesota, April 12, 1984.

Adams, J.R. and N.G. Bhowmik. Circulation patterns on Montrose Flat. 16th annual meeting, Mississippi River Research Consortium, La Crosse, Wisconsin, April 19-20, 1984.

Adams, J.R. Long term ecological research and management of the Upper Mississippi River. Proceedings of the ASCE Hydraulics Division Conference, "Water for Resource Development," Coeur d'Alene, Idaho, August 14-17, 1984.

Anderson, R.V. Spatial distribution and size frequency of unionidmussels in the shallow channel border areas of Pool 19, Mississippi River. 45th annual meeting of Midwest Fish and Wildlife Conference, St. Louis, Missouri, December 14-17, 1983.

Anderson, R.V. Consistency of invertebrate associations: within and between pool comparisons on UMR Pools 19 and 26. (invited paper). 40th Meeting, Upper Mississippi River Conservation Committee, Rochester, Minnesota, March 14-16, 1984.

Anderson, R.V. Predictive quality of macroinvertebrate habitat associations in lower navigation pools of the Upper Mississippi River. Upper Mississippi Research Consortium, La Crosse, Wisconsin, April 19-20, 1984.

Anderson, R.V. Influence of tributary stream order on invertebrate community structure, Upper Mississippi River. AIBS/Ecological Society of America, Ft. Collins, Colorado, August 5-9, 1984.

Anderson, R.V., D.M. Day, and D.A. Pillard. Macroinvertebrate drift in Pool 19, Mississippi River. 77th annual meeting, Illinois State Academy of Science, DeKalb, Illinois, April 27-28, 1984.

Bhowmik, N.G. Stream bank erosion. In: Peoria Lake a Question of Survival. Tri-County Regional Planning Commission, Interim Campus, Illinois Central College, East Peoria, Illinois, September, 1983.

Bhowmik, N.G. Stream bank stabilization techniques. National Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation, University of Kentucky, Kentucky, November-December, 1983.

Bhowmik, N.G. River basin development: Role of hydraulics and hydrology, ASCE Hydraulics Division Specialty Conference, Coeur d' Alene, Idaho, August 14-17, 1984.

Bhowmik, N.G. and M. Demissie. Momence Wetland--A riverine wetland: its influence on sediment load and water discharge. 3rd International Symposium on the Interactions Between Sediments and Water, Geneva, Switzerland, August 28-31, 1984.

Day, D.M. and R.V. Anderson. Seasonal variation in diving duck activities in the lower reach of Pool 19, Mississippi River. 45th Midwest Fish and Wildlife Conference, St. Louis, Missouri, December 14-17, 1983.

Day, D.M. and R.V. Anderson. An evaluation of changes in size and peak densities of dominant benthic organisms from lower reaches of Pool 19, Mississippi River. 16th annual meeting, Mississippi River Research Consortium, La Crosse, Wisconsin, April 19-20, 1984.

Day, D.M. and R.V. Anderson. Developing submerged vegetation as habitat islands in shallow channel border areas of the Mississippi River. AIBS/Ecological Society of America, Ft. Collins, Colorado, August 5-9, 1984.

Demissie, Misganaw. Sediment load during flood events. Spring meeting of Ameerican Geophysical Union, Cincinnati, Ohio, May 14-17, 1984.

Engman, J.A., R.V. Anderson, and L.M. O'Flaherty. Phytoplankton density and distribution in Pool 19, Mississippi River. 16th annual meeting, Mississippi River Research Consortium, La Crosse, Wisconsin, April 19-20, 1984.

Grubaugh, J.W., R.V. Anderson, D.M. Day, B.S. Clark, D.J. Holm, and K.S. Lubinski. Methods of analysis and preliminary results of aquatic macrophyte production, Pool 19, Mississippi River. 16th annual meeting, Mississippi River Research Consortium, La Crosse, Wisconsin, April 19-20, 1984.

Hartsfield, B.N., K.S. Lubinski, and S.D. Jackson. Comparison of carp, Cyprinus carpio, aging methods using scales, dorsal spines, otoliths, and opercles. 22nd annual meeting, Illinois Chapter of the American Fisheries Society. Urbana, Illinois.

Henebry, M.S. and R.W. Gorden. Factors affecting the distribution of bacterial populations in the Mississippi and Illinois rivers. AIBS/Ecological Society of America, Ft. Collins, Colorado, August 5-9, 1984.

Jackson, S.D. and K.S. Lubinski. Effects of a short-term drought and subsequent low flows on fish activity in main channel border habitats of the lower Illinois River. 16th annual meeting, Mississippi River Research Consortium. La Crosse, Wisconsin, April 19-20, 1984.

Jackson, S.D. and K.S. Lubinski. Temporally consistent carp population characteristics in the Illinois River. 22nd annual meeting, Illinois Chapter of the American Fisheries Society. Urbana, Illinois.

Lubinski, K.S. Potential relationships between annual carp recruitment and water levels in the Mississippi and Illinois rivers. 45th Midwest Fish and Wildlife Conference. St. Louis, Missouri, December 14-17, 1983.

Lubinski, K.S. Summer shoot growth characteristics of undisturbed and transplanted arrowhead, Sagittaria latifolia, L., along the lower Illinois River. AIBS/Ecological Society of America, Ft. Collins, Colorado, August 5-9, 1984.

Lubinski, K.S. Winter diving in Pool 13, problems and initial findings. 40th annual meeting, Upper Mississippi River Conservation Committee. Rochester, Minnesota.°

Lubinski, K.S., S.D. Jackson, J. Janecek, G. Farabee, and A Van Vooren. Ecology of carp in the upper Mississippi River. 16th annual meeting, Mississippi River Research Consortium, La Crosse, Wisconsin, April 19-20, 1984.

Pillard, D.A. and R.V. Anderson. Within and between pool variation in zooplankton density and diversity on the Upper Mississippi River. 16th annual meeting, Mississippi River Research Consortium, La Crosse, Wisconsin, April 19-20, 1984.

Reed, P.C., M.L. Sargent, and D.L. Gross. 1984. Use of natural-gamma logging for characterization of bottom sediment in the Mississippi River: 16th annual meeting, Mississippi River Research Consortium, 16th annual meeting, La Crosse, Wisconsin, April 19-20, 1984.

Sparks, R.E. 1984. Improving methods of data analysis and interpretation for environmental management programs. Expert Panel on Monitoring, Assessment, and Environmental Management. Conference on Long Term Environmental Research and Development. Council on Environmental Quality, Washington, D.C., May 21-22, 1984.

SECTION 7: LITERATURE CITED

Bhowmik, N.G. 1982. Shear stress distribution and secondary currents in straight open channels. Pages 31-61 In R.D. Hey, J.C. Bathurst, and C.R. Thorne, eds. "Gravel-Bed Rivers". John Wiley & Sons Ltd.

Bhowmik, N.G., M. Demissie, and C.Y. Guo. 1982. Waves generated by river traffic and wind on the Illinois and Mississippi rivers. University of Illinois Water Resources Center Report 167.

Bhowmik, N.G. and R.J. Schicht. 1980. Bank erosion of the Illinois River. Illinois State Water Survey Report of Investigation 92.

Bhowmik, N.G. and J.B. Stall. 1978. Circulation patterns in the Fox Chain of Lakes in Illinois. Water Resources Research 14(4):633-642.

Appendix A: Changes in Personnel

Richard Allgire, Technician, resigned 31 December 1983. His position has been filled by Frank S. Dillon who joined the Water Survey 1 December 1983. Mr. Dillon has an M.S. in Biology from Western Illinois University.

Robert Sinclair, Data Manager, resigned in January 1983, and has been replaced by Frank Brookfield. Mr. Brookfield has a B.S. in business and management information systems and is the Programmer at the Natural History Survey.

Deborah Casavant, Graduate Research Assistant in Geology, completed her employment on the LTER project in May. She is continuing voluntary work on the project through the remainder of 1984. Another graduate student in geology will be employed in January 1985.

APPENDIX B
External Advisory Committee

This appendix consists of 3 parts: (1) the written report of the External Advisory Committee (EAC) following a review of the Large River LTER Project, 26-28 September 1983, integrated and edited by Chairman Richard Wiegert, (2) the minutes of a meeting on modeling, 28 September 1983, attended by the PIs from the Large River LTER and our advisor, Richard Wiegert, and (3) a letter regarding data base management and hydrological modeling from EAC member Daryl Simons to LTER PI Nani Bhowmik. The response to the EAC report is in Appendix C.

The members of our External Advisory Committee are listed below. Dr. Daryl Simons joined the Committee in 1983 -- the others have been members since the inception of the LTER project in the spring of 1982. The chair has rotated each year, from Wayne Minshall, to Richard Wiegert, to Colbert Cushing, who will be Chairman of the 1984/85 meeting in Champaign, Illinois, 20-22 February 1985. The members of the Committee have paid particular attention to their charge to advise our group, and we are grateful for much personal help from each member, not reflected in the summary documents in this Appendix. We look forward to their continuing assistance in the future.

Colbert E. Cushing Chairman	Environmental Sciences Dept. Battelle-Pacific Northwest Lab. Richland, WA 99352
James Eckblad	Department of Biology Luther College Decorah, IA 52101
G. Wayne Minshall Chairman, 1982	Department of Biology Idaho State University Pocatello, ID 83201
Daryl B. Simons	Engineering Research Center Colorado State University Fort Collins, CO 80523
Richard Wiegert Chairman, 1983	Department of Zoology University of Georgia Athens, GA 30601

REPORT OF THE EXTERNAL ADVISORY COMMITTEE FOLLOWING A REVIEW OF THE LARGE RIVER LTER

26-28 September 1983
Grafton, Illinois

Report of the External Advisory Committee following a review of the Mississippi River LTER, Sept. 26-28, 1983.

This second review of the Mississippi R. LTER program comprised verbal presentations of progress and proposed research by key personnel, consulations with the program directors and a brief trip to acquaint us with Pool 26 of the Mississippi R. Our report considers, in order, 1) Accomplishments of the program since our first review in June, 1982, 2) Progress towards implementation of suggestions made in our first report, and 3) Suggestions for further improvements in the coming year.

Accomplishments

a)The large size of the river pools, the difficulties presented by river currents, bottom heterogeneity, barge traffic and the geographic distance separating the three study sites created some initial logistical problems which have now been largely overcome.

b)Integration of what were initially largely separate and distinct sampling/experimental sections has proceeded in a satisfactory manner. At the same time this integration has led to a gratifying convergence of estimates of rates and amounts from different groups studying the same process or variable.

c)At the same time, this integration has led to a convergence of those parts of the program regarded as large scale 'whole system' studies with the specific population studies.

d)Finally,without emphasizing input/output measurements, some whole system budget estimates now seem to be emerging from the process measurements.

Progress implementing suggestions from the first review

In our first report we identified five areas where significant improvement was needed. These comprised the hypotheses, methods, the overemphasis on input/output budget measurements, the management of the data storage and retrieval, and the modeling.

Considerable progress in formulating good explanatory hypotheses has been made. This is evident in the annual report and in our conversations with individual investigators, but there is still much room for improvement. In the verbal presentations by most investigators there was still a noticeable lack of emphasis on explanation and the experimental/observational data necessay for testing. This needs immediate attention and could, in our opinion, be combined with a careful restatement of the overall goals of the study. We feel that the rapid progess that has been made in the first years of this program now necessitates such a reconsideration of goals because the data now availble suggest some new objectives that may be feasible. Conversely, some of the original goals may, upon reflection, turn out to have a lowered priority. We propose that such reconsideration be done as part of a regularly scheduled monthly meeting of the investigators and directors of the program. Such a meeting would, in our opinion, improve communication between the investigators and efficiently solve routine problems in addition to the aid it would give the overall planning.

The program has advanced in terms of evaluating the methodology, a point of serious criticism in our earlier report; but continued attention to this area is needed. Details of methods should be given and continued evaluation must be carried out on such things as the efficacy of the sampling and the statistical validity of the data. The proposed handbook of methods would be very valuable and we urge that it be completed as soon as possible.

The view of this LTER study as primarily an input/output budget oriented program, which we detected during our first review, is no longer prevalent, but we urge continued vigilance.

Finally, our earlier report contained several comments about both the data management and the modeling. Because some serious problems remain, a detailed discussion of these two areas is contained in the third section of the present report.

<u>Suggestions for further improvement</u>

1)Data management.
Our perception of the present system is that it is primarily one for archiving data, not the retrieval/analysis system that is needed for a scientific program like the Mississippi R. LTER. The various invesigators in the program need a system which will give them access to analyzed data, analyzed to their specifications, not simply let them retrieve masses of raw data. We saw little evidence that the present system will accomplish this goal nor was it apparent that it would be changed to do so in the future. In this regard we felt that far too much attention was being given to the site retrieval aspect of the system.

We suggest that a system be implemented that will a) permit the entry of all data pertinent to the program(i.e. climatological, hydrological, hydraulic, biological, etc.), 2) permit accessing these data in any way desired,(i.e. by type, specific time, specific location, characteristic etc.), and most importantly, 3) permit access and <u>analysis</u> of the data in any way desired,(i.e. tabular, graphical, location, statistical), the latter implemented by the incorporation of software for limited analyses such as curve fitting, sediment transport, flow duration and frequency, and standard statistical tests.

2) Physical measurements.

The sediment studies would be much more valuable if particle size was included, at the very least a breakdown into sand vs. clay-/silt. Some consideration of the probable ultimate fate of the pools and possible methods of prolonging the useful life of the system would not be out of place.

Measurement of such abiotic components as dissolved organic carbon and particulate organic carbon needs to consider the effect of biogical processes(particularly in the case of DOC), sediment-water interchanges, and the details of methodology (such as the manner in which inorganic dry wt. is obtained).

Finally, the use of different functional equations describing the dynamics of such physical/chemical components can be very useful in estimating probable range of error and is thus encouraged.

3) Nutrient fluxes.

We noted an inexplicable failure to consider the possible importance of agricultural runoff as a source of much of the nutrient load entering the river. Similarly, we urge more consideration of whether the nutients are adsorbed onto particles or not since this can drastically affect their availability to living organisms as well as their rates of sedimentation. Better integration of the nutrient flux measurements into the modeling effort is needed.

4) Biological populations.

The desriptive aspects of the biological sampling seem to be going along very well. We felt that the present emphasis on habitat units as the basis of sampling was a good one and the habitat divisions make sense. With the exception of some rather minor comments concerning the emphasis on fresh weights instead of dry weight we find little to recommend changing. In the decomposition studies some experimentation with different mesh sizes and modification in sample placement (level of burial for example) might pay dividends.

Our major criticism of this segment of the program centers around the proposal to make a major shift in the third year to work in the Peoria pool. Based on the experience of the first two years such a major shift, entailing as it must a considerable reduction in the studies of pools 19 and 26 would, in our opinion, be a mistake. We think the work on these latter two sites is just arriving at the point where some excellent formulation and testing of hypotheses can be done. We suggest that in the coming year the work proposed for the Peoria pool be scaled down to encompass only measurements that can clearly be seen to be impor tant to the integration aspect of the study and which cannot be inferred from comparable measurements on the Mississippi or from prior sampling on the Peoria pool. In a word, we are suggesting the continuation and consolidation of the work on the first two sites before, not instead of, the detailed study of the Peoria site.

5) Modeling.

As a result of our earlier comments and following the modeling workshop of last spring, a detailed conceptual model of the Mississippi R. sites was developed. A start was made in translating this conceptual model into one that could be used to simulate alternative choices of interaction and/or parameter value. In this model, the basic unit of subdivision was the habitat site that forms the basis for much of the sampling of physical and biological processes. Understandably, further work on the model was slowed as a result of the intensive sampling and analysis required during the summer research period. However, the value of this or any other model as a tool for interacting with and guiding the research program will be largely negated if a dynamic simulation model is not developed, debugged and used prior to the coming field research season. The LTER personnel have been apprised of our views and have agreed that the effort will be made. We recommend that, in addition to pushing ahead with the translation into equations and the assignment of preliminary values for the parameters, the following recommendations be considered, a) Tie the experimental/observational data more tightly into the conceptual model. That is, use the conceptual model itself, in the absence of a dynamic version, to justify, or to change, the type of data being obtained. b) In constructing the dynamic model and in choosing values of the parameters, take into account the possibility of thresholds, limits and the importance of episodic events as they may influence the system and thus be necessary components of the model.

In discussion with the committee chairman on the afternoon following the close of the committee review, a plan of procedure was agreed upon whereby the development of both the hydrological and the biological aspects of the model would be developed simultaneously (the participants and decisions of this meeting are given in the attached minutes prepared by Rip Sparks).

Finally, we stress that the rapid development and implementation of the necessary model depends greatly on the availability of a competent programmer who can take the equations and parameters supplied by the investigators and turn out a debugged, working simulation model.

In conclusion, we found the scientists working on the Mississippi R. LTER to be a highly competent, productive group. We found several areas where we thought certain changes might improve the work. But we found relatively little to change our initial opinion that this study can and will contribute in major ways to ecological science.

We appreciate the effort that went into the clear and informative review presentations by all investigators. The help and assistance of Ken Lubinski and his staff as well as the organizational work of the PI, Rip Sparks, were vital to the success of the review.

MINUTES OF MEETING
Large River LTER Modelling
Held at
River Research Laboratory
Grafton, Illinois 62644
28 September 1983
Minutes Prepared by Richard E. Sparks

Participants:

Richard Weigert, University of Georgia
Nani Bhowmik, IWS
Mike Demissie, IWS
Rodger Adams, IWS
Ken Lubinski, NHS
Rip Sparks, NHS
Rick Anderson, WIU

Physical Model Which Drives Biological Model:

1. Water Survey to develop a one-dimensional main channel model of water flow and flow of at least two (perhaps three) sediment fractions. Sand has different dynamics than silt/clay. Nutrients, toxicants, and microorganisms ride on particles. Sparks will sort nutrients into the fraction moving with water and the fraction moving as particles.
2. Estimate densities of biologically important particles, such as POC and algae. IWS will estimate fall velocities.
3. IWS will develop a so-called 1 1/2 dimensional model to estimate flows into compartments (main channel border, backwaters, etc.). Rodger Adams discussed use of a closing valve model to describe flow into plant beds. Biologists need to know the water flow in and out of compartments and sediment flow in/out, and deposited within the compartment. We need to know concentration of nutrients in the water and in the sediment fraction.
4. Turnover time can be computed from standing stock and input and output.
5. The suggested approach is as follows: (a) For simplicity, determine flows for three or four times of the year, such as the spring flood, summer lowflow, the fall period of slightly increased water levels, and winter lowflow. (b) Write deterministic algorithms, stochastic processes can be added later. (c) Regard each compartment as a tank.

Biological Model:

1. Model should operate on a square meter or cubic meter basis. The model can be extended later by area or volume weighting.

2. If we can not find a modeller within our group or on campus, Dick Wiegert agreed to look over our equations and descriptions. He will be gone the last part of October and the first half of November, but could look at material before or after.

Specific Suggestions:

1. Store functions which are used repetitively, and call them up as subroutines.
2. Equations should be compiled in a model, and kept separate from parameter values which are stored in a table or matrix. The matrix is accessed by the compiled model. This makes it easier to change parameter values than having them built into the model itself.

Action:

1. Nani Bhowmik will develop a schedule for implementation of the physical model and submit the schedule and plan to Rip Sparks.
2. Ken Lubinski, Rick Anderson and Rip Sparks will meet in the Laboratory at Havana on Tuesday 11 October, 1983 at 9 a.m. to help each other complete the equations for the biological parts of the model. Each principal investigator is to prepare a booklet to hand out at the meeting. The booklet contains a verbal description of the flows, state variables, controlling factors, thresholds for each component. Include descriptive graphs and do the best you can with the equation. Sparks will ask Risser if someone with modelling experience can attend the meeting at Havana, or a follow-up meeting.
3. Sparks will assemble the booklets, have them typed, and submit them to Paul Risser for comment and for programming assistance.
4. Model should be used for sensitivity analyses during winter, 1983, so that we can use the outcome to plan our sampling before our season begins in earnest in early spring of 1984.

SIMONS, LI & ASSOCIATES, INC.

3555 STANFORD ROAD
POST OFFICE BOX 1816
FORT COLLINS, COLORADO 80522

TELEPHONE (303) 223-4100
TLX: 469370 SLA FTCN CI
CABLE CODE: SIMONSLI

October 5, 1983

Dr. Nani G. Bhowmik
Hydraulic Systems Section
State Water Survey
Post Office Box 5050
Champaign, IL 61820

Dear Mr. Bhowmik:

I am pleased to serve as a member of the External Advisory Committee of the Long Term Ecological Research Program (LTER). The recent committee meeting has improved my understanding and appreciation of the objectives and research plan of the LTER. I believe that this program will significantly improve our knowledge of the response of ecological systems to change if the major objectives are kept in focus throughout the life of the project.

As I commented in the meeting, a hydrodynamic model that is capable of simulating the hydraulic characteristics, sediment transport, water quality, chemical response and nutrient loading, considering both natural processes and man-made controls, is required to evaluate the system response to changes. Also, a data storage and retrieval system that is capable of storing, retrieving, updating and processing data and that can be easily accessed through interactive terminals, will greatly facilitate the information transfer, data analysis and results. For comparative purposes please consider the following hydrodynamic model and a data base management system developed to model river systems and to process data.

The proposed hydrodynamic model is a model developed in conjunction with my research at Colorado State University in 1973, and later modified by staff of Simons, Li & Associates, Inc. (SLA). The model was originally developed based on the complete St. Venant equations (one dimensional continuity and momentum equations) to simulate the hydraulic and sediment transport behaviors of a river network consisting of branches and loops. In 1975, the model was modified to consider effects of operation of a series of locks and dams, dredging and lateral inflows and outflows between the main channel and backwater areas. This model was applied to predict the long term physical changes and effects of alternative operation plans in pools 24-26 of the Upper Mississippi River and Lower Illinois River. In 1978, a dispension equation was incorporated into the model to simulate biochemical oxygen demand, dissolved oxygen and any conservative substance. The dispersion equation has the advection, dispersion and source and sink terms. The simulation of other substances can be added to the model by including the mathematical description of the reaction processes in the source and sink terms of the dispersion equation. This system of equations was solved by an implicit scheme using modified Guass elimination procedure. The model was applied to Jacui Delta, Brazil to assess water quality problems in the Delta and to identify and evaluate mitigation measures.

In 1981, the principals and senior staff of SLA conducted a study for the Environmental Protection Agency to develop a hydrologic simulation for generalized forest management alternative planning model. The model considers nutrient and temperature routing including nitrogen and phosphorus. The biological conversion processes (mineralization, nutrification, denitrification, plant uptake), absorption-desorption for ammonium and orthophosphorus, and sediment as a pollutant transport medium were considered. These and other processes can be included in the hydrodynamic model described above to study the river ecological system in your study reaches of Pools 19 and 26 on the Upper Mississippi River and Peoria Pool in the Illinois River. Additional information regarding the proposed model can be provided if desired.

Regarding the database, we developed the Upper Mississippi River Data Base Management System (MISSIDB) in 1979 for the St. Paul District, Corps of Engineers. The data included in the data base consists of stage, discharge, suspended load, bed load, bed material size, cross-section, and control structures in Pools 1 - 10 and major tributaries. The objectives of developing the MISSIDB were to: (1) design an efficient data base management system that will retrieve and process the data to analyze the evolution of the Upper Mississippi River system, (2) expedite the daily duties of the Corps of Engineers, (3) Provide a system that can be used by persons not proficient with the computer and (4) develop a system with a flexible structure to enable improvements or expansions without major modifications. This system enables users with varying amounts of computer experience to efficiently access, retrieve, store and analyze large amount of hydraulic and hydrological data. This data base management system is a modified version of the Yazoo Data Base (YAZDB) which is now routinely utilized by the Vicksburg District for hydraulic analysis and design for the Yazoo basin. Other types of data such as water quality, precipitation, primary products can be included in the data base with minor modifications. The structure of this data base may be useful to the LTER data management. A report describing this data base is attached for your information. Demonstration of this data base can be arranged if desired.

Also, a report on monitoring and evaluation of watershed management practices is enclosed. Similar concepts described in the report can be applied to design of data collection system in river basins.

I hope that the enclosed material is useful to you. After you finish reading the reports, please route these reports or a copy to Dr. Rip Spasks and other members of the LTER and IWS who may be interested in these topics. If you need additional information or if you have any questions, please contact me.

Sincerely yours,

Daryl B Simons /fb

Daryl B. Simons
President

DBS/kdw

Enclosures: Upper Mississippi data base manual
: Watershed management workshop

LD11/1006YHC

APPENDIX C

Response to External Advisory Committee

The complete report of the External Advisory Committee is given in Appendix B. A synopsis of the major recommendations is given below, followed by our response.

1. Reconsider and restate goals of the study, emphasize explanation and collection of data to test hypotheses.

2. Hold monthly meetings of PIs to improve communication and aid planning.

3. Methods. Provide details and continue to evaluate.

4. Data management. Change emphasis from an archiving system to a retrieval/analysis system.

5. Nutrient fluxes. Consider agricultural runoff as a source of nutrients entering the river. Determine whether nutrients are absorbed on particles. Integrate nutrient flux measurements into model.

6. Physical measurements. Divide sediment into particle size classes, consider processes and mechanisms affecting organic carbon and nutrients, use functional equations to estimate errors, and evaluate methods.

7. Continue and consolidate work on pools 19 and 26 before intensive effort on the Peoria Pool.

8. Modeling. Develop and run a dynamic simulation model before the 1984 field research season. Use the conceptual model to justify or change the type of data being obtained. Consider and include thresholds, limits, and episodic events. Obtain services of a programmer who can take equations and parameters and turn out a debugged, working simulation model.

1. We have reconsidered our goals after analyzing data collected during the first three years of the project. While not every new goal or concept can be developed in detail here, we can give one example of the sequence leading from an observed pattern to an explanatory hypothesis to a new approach. The maximum biomass of benthic macroinvertebrates in pools 19 and 26 occur in main channel border areas adjacent to macrophyte beds. We hypothesize that organic matter produced in the macrophyte beds fuels secondary production in adjacent channel borders. This hypothesis is derived from what we now perceive as a major question for our study to answer: why are large floodplain rivers so productive? We are adopting several new approaches to answer this question and related questions. One is to examine the carbon isotope ratios of terrestrial and aquatic vegetation to determine whether there is enough difference to trace the origin of

detritus in the gut of macroinvertebrates. Another is to test whether an alternative hypothesis is true: most of the plant production during the growing season fuels microbial respiration within the plant bed. A third approach is to examine the mechanisms which could move detritus from beds to channel borders, such as waves and currents generated by winds during summer thunderstorms.

2. We have chosen not to have monthly meetings of all our PIs, but to have frequent meetings of subgroups of PIs to work on particular problems. Our PIs represent a mix of disciplines which have state, regional, national, and international professional meetings on different schedules. It is difficult to schedule a general meeting of the entire group which does not conflict with someone's professional meeting, departmental meeting, or class schedule. In addition, each general meeting requires some of our people to make a round trip of 300 miles. The entire goup meets on an ad hoc basis, 4-5 times per year, and the subgroup meetings average one per month. An example of a recent subgroup meeting is one in July at Western Illinois University on merging of Water Survey and Natural History Survey data sets and use of the minicomputer work stations.

3. A draft compilation of our field and laboratory methods has been edited by Richard Cahill, Chemist with the Geological Survey, and a final version should be ready for the EAC in February. We are continuing to evaluate our methods in the light of our revised objectives.

4. We have a new data manager/programmer, Mr. Frank Brookfield, and we have established computerized work stations at Western Illinois University, the Natural History Survey in Champaign, and the field stations at Havana and Grafton. We will add a fifth work station at the Water Survey in 1985, if the $40,000 increment from NSF is approved. We have moved our files and programs from the University of Illinois CYBER to the Surveys' PRIME, where we can take advantage of a geographic based information system, ARC/INFO, and computer staff support from the Surveys.

5. We are well aware of the impact of agricultural runoff, not only on phosphorus and nitrogen loads, but also on sediment loads, because our project director, Richard Sparks, served on the Illinois Task Force on Agricultural Pollution, and the Surveys are currently assessing agricultural impacts on several tributary streams. We feel that measurement of agricultural contributions to nutrient loads in our study reaches are beyond the scope of our LTER project. Modeling such contributions also is difficult because factors controlling sediment and nutrient delivery from agricultural watersheds to tributaries are not completely known or well quantified. We are considering the fate and impact of nutrients once they enter our system. We have been measuring nitrogen in filtered and unfiltered samples so we can determine what fraction is associated with particles, and we adopted a similar procedure for phosphorus in August. We are measuring nitrogen and phosphorus

within plant beds during the growing season to determine whether either nutrient could limit primary production or decomposition. We also plan to measure microbial activity and nitrogen content of aquatic macrophyte leaves in various stages of decomposition.

6. We are now measuring and modeling sand and silt/clay. We have added state variables to our model for planktonic and attached bacteria and we are considering interactions between microorganisms, organic matter, and nutrients.

7. We are now concentrating on Pools 19 and 26. Our model will be developed and tested first with data from the downstream third of Pool 19.

8. We did not meet the objective of running a simulation model before the 1984 research season, but we have used the conceptual model to revise our goals, approaches and sampling methods. Our conceptual and mathematical models for our state variables do include thresholds and limits. Our model will respond to episodic events. For example, during a major flood, the hydrologic model will simulate depth changes due to scouring and change the composition of bed material. The biological model includes substrate preferences of some macroinvertebrates and a depth limit for aquatic plants, based on light penetration. Our modeling is not progressing as quickly as we hoped, for reasons detailed in the section on shortfalls (Section 2).

APPENDIX D: CURRENT AND PENDING SUPPORT

	A	B	C	D	E	F
	Supporting Agency	Project Title	Amount (x$1000)	Period Covered	Man-Months	Research Location
. Principal Investigators						
. V. Anderson						
A. Current Support						
1. LTER	NSF*	LTER on MI an IL Rivers	259/yr	1/15/82-1/15/87	5	MI and IL Rivers
2. Duck Creek Survey	CILCO*	Morphometry and Sediment Deposition in Duck Creek Reservoir	13	2/1/84-12/31/84	1	Duck Creek Res., IL
3. Ecological Profile	USFWS	The Ecology of Pools 19 and 20, Mississippi River	10	12/1/83-10/31/84	1	WIU, IL
B. Proposals Pending						
1. Scanning Electron Microscope	NSF*	Multi-user request for an ISI SS-60 Scanning Electron Microscope	60	1/1/85-12/31/86		WIU,IL

Appendix D

CURRENT AND PENDING SUPPORT

	A Supporting agency	B Project title	C Amount (x$1000)	D Period covered	E Man-Months	F Research location
N.G. Bhowmik						
A. Current Support						
1. LTER	NSF*	LTER on MI & IL Rivers	259/yr	1/15/82-1/14/87	2/yr	MI and IL Rivers
2. Highland-Silver Lake	USDA*	Watershed Erosion & Sedimentation	70/yr	1/82-10/85	0.5	Highland-Silver Lake
3. Secondary Circulation	WRC*	Secondary Circulation of Natural Rivers	38	7/1/83-6/30/85	1	Kankakee and Vermilion River
4. Horseshoe Lake	IDOC/ USFWS*	Sedimentation Investigation, Horseshoe,	107	10/1/83-8/30/85	1	Horseshoe Lake-Alexander County
5. Sediment Analysis	ENR*	Suspended Sediment Data Analysis	62	9/83-6/85	1	Champaign
6. Sediment Analysis	COE-RID*	Suspended Sediment Transport. Miss. River and Ill. River Basin	34	9/83-12/84	1	Champaign
7. Sedimentation	City of Sprgfld	Sedimentation Survey of Lake Springfield	20	3/84-2/85	0.5	Springfield
8. Cache River	IDOC	Hydrualic Investigation of Cache River	20	6/84-6/85	0.5	Cache River, Illinois

Appendix D
(continued)

CURRENT AND PENDING SUPPORT

	A Supporting agency	B Project title	C Amount (x$1000)	D Period covered	E Man-Months	F Research location
N.G. Bhowmik						
B. Proposals Pending						
1. Bank Erosion	ENR	Modeling of Bank Erosion Process	180	9/84-12/86	3	Champaign
2. Erosion and Water Level Fluctuations	RID-COE	Impact of Water Level Fluctuations on Bank Erosion	60	10/84-9/86	1	Illinois

Appendix D
(continued)

CURRENT AND PENDING SUPPORT

	A	B	C	D	E	F
	Supporting agency	Project title	Amount (x$1000)	Period covered	Man-Months	Research location
II. Co-Investigators						
J.R. Adams						
A. Current Support						
1. LTER	NSF*	LTER on MI & IL Rivers	259/yr	1/15/82-1/14/87	4/yr	MI & IL Rivers
2. Horseshoe Lake	IDOC/ USFWS*	Sedimentation Investigation of Horseshoe Lake	107	10/1/83-6/30/85	1	Horseshoe Lake, Alexander County
3. Sediment Analysis	COE-RID*	Suspended Sediment Transport: Miss. R.	34	9/83-12/84	3	Champaign
4. Kankakee Dam	IDOC*	Field Verification of Discharge Capacity of Kankakee Dam	11.6	10/1/83-9/30/85	1	Champaign/ Kankakee

APPENDIX D: CURRENT AND PENDING SUPPORT

Richard A. Cahill

Current Support

1.	LTER	U.S. NSF	January 15, 1984- January 14, 1985	$28,784
2.	Cl in Coal	Center for Res Sulfur in Coal	September 1, 1984- August 31, 1985	$77,600

Proposals Pending

1.	Toxicity of River Sediments	Commonwealth Edison	September 1, 1984- December 31, 1985	$94,100

David L. Gross

Current Support

1.	LTER	U.S. NSF	January 15, 1984- January 14, 1985	$28,784
2.	LUMP	U.S. Office of Surface Mining	July 1, 1984- June 30, 1984	$72,740
3.	Fermilab Env. Screening	Univ. Res. Associates	May 1, 1984- December 31, 1985	$50,253

CURRENT AND PENDING SUPPORT

	A Supporting Agency	B Project Title	C Amount (x$1000)	D Period Coveredd	E Man-Months	F Research Location
I. Demissie						
A. Current Support						
1. LTER	NS*	LTER on MI and IL	259/yr	1/15/82-	2.5	MI and IL Rivers
2. Secondary Circulation	WRC*	Secondary Circulation of Natural Streams	38	7/1/83-6/30/85	2	Kakakee R. & Vermilion R.
3. Horseshoe Lake	IDOC/ USFWS*	Sedimentation Investigation of Horseshoe Lake	107	9/83-8/85	3	Hors shoe Lake, Alexander County
4. Sdiment Analysis	ENR*	Suspended Sediment Data Analysis	62	9/83-6/85	2	Champaign
5. Cache River	IDOC	Hydraulic Investigation of Cache River	20	6/84-6/85	2	Champaign and Cache River
B. Proposas Pending						
1. Bank Erosion	ENR	Modeling of Bank Erosion Processes	180	9/84-12/86	4	Champaign and Spoon River
2. Sediment Quality in Illinois Streams and Lakes	ENR	Investigation of Sediment Quality in Streams and Lakes	140	9/84-12/86	4	Champaign

CURRENT AND PENDING SUPPORT

	A Supporting Agency	B Project Title	C Amount (x$1000)	D Period Coveredd	E Man-Months	F Research Location
K.S. Lubinski						
A. Current Support						
1. LTER	NSF*	LTER on MI and IL Rivers	259/yr	1/15/82- 1/14/87	6	MI and IL Rivers
2. Thalweg Disposal	USCOE*	Winter Utilization of Main Channel Habitats by Fish	18/yr	1/12/82- 1/06/84	1	Pool 13, MI River-
3. Carp Age	IDOC*	Age Structure of River Carp Populations	10/yr	1/10/83- 3/31/84	1	MI and IL Rivers

CURRENT AND PENDING SUPPORT

	A Supporting Agency	B Project Title	C Amount (x$1000)	D Period Covered	E Man-Months	F Research Location
E. Sparks						
A. Current Support						
1. LTER	NSF*	LTER on MI and IL Rivers	259/yr	1/15/82-1/14/87	7.4	MI and IL Rivers
2. Fleeting Areas	NMFS*	Effects of Barge Fleeting on Mussel Beds	27	10/1/82-5/31/85	1.0	Illinois River
B. Proposals Pending						
1. Facilities Support	NSF*	Expansion of Facilities for Visiting Scientists and New Staff at the River Research Laboratory	100	6/1/85-5/31/88	1.0	Havana, IL
2. Toxicity of River Sediments	Commonwealth Edison		94	7/1/85-6/30/87	1.0	Illinois River

Appendix E: Collaborative Research and Liaison Activities

J. Roger Adams visited the St. Louis District, U.S. Army Corps of Engineers on 25 April 1984. Soundings and contour maps of the river bed in the immediate vicinity of the construction site for Replacement Lock and Dam 26 have been furnished by the Corps. Additional hydrographic data will be provided to us in the future by Jerry Rap of the St. Louis District staff.

The Upper Mississippi River Basin Association has continued the long-term loan to the LTER project of approximately $50,000 worth of electronic distance measuring equipment, an electronic oceanographic current meter, minicomputer, and miscellaneous sampling gear. The Association receives copies of our publications and annual reports.

The Large Rivers LTER project is making extensive use of the Prime 750 computer and Geographic Information System software belonging to the Illinois Lands Unsuitable for Mining Program (ILUMP). The LTER project has added terminals and disk storage capacity to the system, with the understanding there will be no charge to LTER for computer time. Thus LTER benefits substantially from use of facilities of another federally funded project and contributes map information (vegetation, bed substrate) and a floodplain river model to ILUMP. It is interesting that the first case considered by ILUMP was a fish and wildlife conservation area in the floodplain of the Illinois River. The area included a floodplain lake, wetlands and bottomland forest, underlain by an economically extractable coal deposit. While LTER was just starting up and did not contribute to the decision to declare the area unsuitable for mining, we expect LTER data and models will be useful in future decisions involving alteration of floodplain rivers.

Summary
PROPOSAL BUDGET

LONG TERM ECOLOGICAL RESEARCH (LTER) ON THE ILLINOIS AND MISSISSIPPI RIVERS

	Administration	Data Management	Component 1	Component 2	Component 3	Component 4	Line Totals
A. Senior personnel, man-mo.							
1. R.E. Sparks							
2. P.G. Risser							
3. R.W. Gorden							
4. K.S. Lubinski							
5. R.V. Anderson						4,972	4,972
6. D.L. Gross							
7. R. Cahill							
8. W. Wendland							
9. J. King							
10. N.G. Bhowmik							
11. R. Adams							
12. M. Demissie				4,800			4,800
13. F. Brookfield							
14. M. Wiley							
15.							
Total Senior Personnel							
B. Other personnel, man-mo.							
1. (4) Post doctoral						6,168	6,168
2. (5) Other prof.				15,500	12,700	37,620	65,820
3. (5) Graduate students		15,000	16,676	8,800			40,476
4. (1) Undergrad. students					1,050		1,050
5. (1) Secretarial	12,935						12,935
6. (4) Other	1,304				11,015	2,642	14,961
Total Salaries & Wages	14,239	15,000	16,676	29,100	24,765	51,402	151,182

	Administration	Management	Component 1	Component 2	Component 3	Component 4	Line Totals
C. Fringe Benefits	1,719	48	53	2,720	1,723	5,830	12,093
Total Salaries & Benefits	15,958	15,048	16,729	31,820	26,488	57,232	163,275
D. Permanent equipment	2,068	7,879				1,500	11,447
E. Travel - domestic	3,185	1,300	1,900	2,200	1,400	1,500	11,485
- foreign			600	1,000			1,600
F. Participant support costs							
G. Other direct costs							
1. Materials & supplies	1,200	1,312	2,050	1,302	1,001	2,127	8,992
2. Publication, pg. charge	1,200	300	300	1,000	349	200	3,349
3. Consultant services	2,123						2,123
4. Computer services		493		1,000			1,493
5. Subcontracts			12,678				12,678
6. Other	1,455	640		7,750	2,850	15,735	28,430
Total other direct costs	5,978	2,745	15,028	11,052	4,200	18,062	57,065
H. Total direct costs (A - G)	27,189	26,972	34,257	46,072	32,088	78,294	244,872
I. Indirect costs	6,054	10,639	12,208	16,802	7,733	18,508	71,944
J. Total direct & indirect costs	33,243	37,611	46,465	62,874	39,821	96,802	316,816
K. Residual funds							
L. Amount of this request	33,243	37,611	46,465	62,874	39,821	96,802	316,816

F-3

(SEE INSTRUCTIONS ON REVERSE BEFORE COMPLETING)

1985
SUMMARY PROPOSAL BUDGET

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
AWARD NO.		

ORGANIZATION
Board of Trustees, University of Illinois

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Richard E. Sparks

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)		NSF FUNDED PERSON-MOS. CAL.	ACAD	SUMR	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
1. R.E. Sparks, P.D.	7.4				$	$
2. P.G. Risser	1.25					
3. R.W. Gorden	1.7					
4. K.S. Lubinski	6					
5. (10) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					9772	
6. (14) TOTAL SENIOR PERSONNEL (1-5)					9772	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (4) POST DOCTORAL ASSOCIATES					6,168	
2. (5) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					65,820	
3. (5) GRADUATE STUDENTS					40,476	
4. (1) UNDERGRADUATE STUDENTS					1,050	
5. (1) SECRETARIAL-CLERICAL					12,935	
6. (4) OTHER					14,961	
TOTAL SALARIES AND WAGES (A+B)					151,182	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					12,093	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)					163,275	

D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000; ITEMS OVER $10,000 REQUIRE CERTIFICATION)

Letter quality printer for IBM PC $2,068
Sytec Port $3,000 (private line)
Sytec Port $1,000 (public access)
Visual 500 $1,795 (graphic terminal)
Visual 300 $900 (terminal)
Amadex Dp-9620 $1,184 (printer
IBM Personal Computer (PC) $1,500

	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
TOTAL PERMANENT EQUIPMENT	11,447	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)	11,485	
2. FOREIGN	1,600	
F. PARTICIPANT SUPPORT COSTS		
1. STIPENDS $		
2. TRAVEL		
3. SUBSISTENCE		
4. OTHER		
TOTAL PARTICIPANT COSTS		
G. OTHER DIRECT COSTS		
1. MATERIALS AND SUPPLIES	8,992	
2. PUBLICATION COSTS/PAGE CHARGES	3,349	
3. CONSULTANT SERVICES	2,123	
4. COMPUTER (ADPE) SERVICES	1,493	
5. SUBCONTRACTS	12,678	
6. OTHER	28,430	
TOTAL OTHER DIRECT COSTS	57,065	
H. TOTAL DIRECT COSTS (A THROUGH G)	244,872	
I. INDIRECT COSTS (SPECIFY) As specified on individual budgets		
TOTAL INDIRECT COSTS	71,944	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)	316,816	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS GPM 252 AND 253)		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)	$316,816	$

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Richard E. Sparks RICHARD E. SPARKS	7/23/84	INDIRECT COST RATE VERIFICATION		
INST. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date of Rate Sheet	Initials - DGC
Linda S. Wilson				

Western Illinois University (subcontract), Component #3, P.I. Richard V. Anderson

F-5

(SEE INSTRUCTIONS ON REVERSE BEFORE COMPLETING)

1985 SUMMARY PROPOSAL BUDGET

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
AWARD NO.		

ORGANIZATION Illinois Natural History Survey, U. of Ill.
WIU subcontract budget

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR P.D. Richard E. Sparks
P.I., Component #3, Richard V. Anderson (WIU)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	NSF FUNDED PERSON-MOS. CAL.	ACAD	SUMR	FUNDS REQUESTED BY PROPOSER	FUNDS GRANTED BY NSF (IF DIFFERENT)
1. Richard V. Anderson				$	$
2.					
3.					
4.					
5. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
6. ( ) TOTAL SENIOR PERSONNEL (1-5)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS $500/month X 12				6000	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL-CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				6000	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				6000	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000; ITEMS OVER $10,000 REQUIRE CERTIFICATION)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2000	
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $					
2. TRAVEL					
3. SUBSISTENCE					
4. OTHER					
TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1270	
2. PUBLICATION COSTS/PAGE CHARGES					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				1270	
H. TOTAL DIRECT COSTS (A THROUGH G)				9270	
I. INDIRECT COSTS (SPECIFY) 56.8% X 6000 = $3408					
TOTAL INDIRECT COSTS				3408	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				12678	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS GPM 252 AND 253)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 12678	$

PI/PD TYPED NAME & SIGNATURE	DATE	FOR NSF USE ONLY		
Richard V. Anderson *Richard V. Anderson*	7-23-84	INDIRECT COST RATE VERIFICATION		
INST. REP. TYPED NAME & SIGNATURE	DATE	Date Checked	Date of Rate Sheet	Initials - DGC
Shirley J. Myers *[signature]*				

Program

Appendix G

USE OF INTERPROJECT INCREMENT OF $40,000 at the Large River LTER Site 1985

Budget

Computer Equipment		
Sytec port (private line)		3,000
Sytec port (public access)		1,000
Visial 500 (graphic terminal)		1,795
Visial 300 (terminal)		900
Amadex Dp-9620b (printer)		1,184
	Subtotal	7,879
Personnel		
Graduate Research Assistants		
1 in chemistry, 7.25 man-mo. @ 1,150/mo		8,338
1 in computer science, 7.1753 man-mo. @ 1,614/mo.		11,581
	Subtotal	19,919
Fringe Benefits		
Workmen's Compensation, 0.32% x 19,919		
	Subtotal	64
TOTAL DIRECT COSTS		27,862
Indirect Costs		
Tuition, 18.6% x 19,919		3,705
Overhead, 27,862-7,879=19,983 42.2% x 19,983		8,433
	Subtotal	12,138
TOTAL COSTS		40,000

APPENDIX H

Justification for Equipment

The $7,879 for computer equipment will establish a computer work station at the Illinois Water Survey compatible with the four work stations established in 1984 at the three LTER field stations and the main offices of the Natural History Survey. The additional work station will link the Water Survey to the main computer used for LTER, the PRIME system at the Natural History Survey. This is an important link because the Water Survey provides the water discharge data which are used to compute nutrient and sediment fluxes. Our ability to make intersite comparisons will be enhanced because our basic discharge and concentration data, the programs to compute fluxes, and the derived values for nutrient and sediment loading will all be available on one computer system.

The Water Survey will be able to transfer their data files to the PRIME, access other LTER data sets, use the powerful INFO data base management system and the ARC mapping and digitizing system. They also will be able to communicate and transfer files to the other four LTER work stations--an important consideration at our site where principal investigators are located at field stations and another campus (Western Illinois University) over one hundred miles from the University of Illinois.

Two ports are included in the equipment list. The private line will provide access to the University of Illinois Cyber computer for the purpose of running the hydrological model for the Illinois and Mississippi rivers. This model is too large and complex to run on the PRIME at the Natural History Survey. Output data from the hydrological model will be used to drive the biological model, which resides on the PRIME. The second port gives the Water Survey access to one of the public lines on PRIME. Private access is not yet necessary on PRIME because communications service has kept up with demand. The two ports are one-time hardware costs, not recurring service fees.

Justification for Personnel

The graduate research assistant (GRA) in chemistry will assist Dr. Richard Cahill (Illinois Geological Survey) in radioisotope dating of sediments and analysis of sediments, organisms, and their waste products for carbon. The dating is necessary to document the disturbance history of our site, for comparison with other sites. The carbon analysis provides data essential to our carbon flow model. The model is a major vehicle for synthesizing information about our large rivers and for developing and testing hypotheses.

The GRA in computer programming will assist the Natural History Survey programmer, Mr. Frank Brookfield, and geologist Dr. David Gross (Illinois Geological Survey), in the digitizing of maps and aerial photographs generated by our LTER research: hydrography, vegetation, bed material. Some of our LTER core data are best recorded as maps, such as the annual development pattern of submergent plant beds. Once the maps are digitized, we can use the powerful ARC/INFO software available on the PRIME computer to extend samples and measurements on small areas to entire habitat compartments by volume or area weighting. Mapping and use of mapping techniques are essential for many types of intersite comparisons and syntheses, such as comparison of geomorphic features of streams and relationships between community structure and stream morphometry.