ILLINOIS STATE WATER SURVEY
PRAIRIE RESEARCH INSTITUTE

Report of Investigation 122 | Executive Summary

The Sediment Budget of the Illinois River: 1981-2015

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ILLINOIS

The Sediment Budget of the Illinois River: 1981-2015

An Extended Executive Summary of Illinois State Water Survey Report of Investigation 122*

by
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Introduction

The Illinois River is the most significant river in Illinois. The river drains nearly half of the state and has a drainage area of 28,906 square miles. Except for about a 4,000-square-mile area in Indiana and Wisconsin, the watershed is located in Illinois (see Figure 1). The watershed contains the drainage basins of several of the state's significant rivers such as the Sangamon, La Moine, Spoon, Mackinaw, Vermilion, Fox, Kankakee, and Des Plaines Rivers. Historically, the Illinois River has played a significant role in the development of the state's commerce and transportation. It is the only waterway that links the Great Lakes to the Mississippi River, and thus to the Gulf of Mexico. In addition, with its numerous backwater lakes, wetlands, and floodplain forests, the Illinois River valley is an important ecological resource by providing a significant habitat for fish, waterfowl, and other birds and animals.

The Illinois River's environment has been subjected to many impacts associated with watershed development, including waste discharges from urban areas, water-level control for navigation, and sediment and chemical inflow from agricultural and urban watersheds. The river quality was severely degraded for several decades prior to the 1970s when environmental regulations were enacted to control pollutant discharges. Since then, the quality of the river has been improving gradually.

The most persistent and still unmanaged problem facing the Illinois River is sedimentation in the river channel and backwater lakes. Based on sedimentation data for Peoria Lake, which is located along the Illinois River, it is very clear that the rate of sedimentation in the Peoria Pool was significantly higher from 1965 to 1985 than from 1903 to 1965 (Demissie and Bhowmik, 1986; Demissie, 1997). Of special concern are the main channel and backwater lakes along the Illinois River.

Erosion and sedimentation have long been recognized as the principal causes of most environmental and ecological problems in the Illinois River valley. The Illinois River Action Plan of the Illinois State Water Plan Task Force (1987) ranks soil erosion combined with siltation as the number-one priority problem. In their "Conference Summary and Suggestions for Action," *Proceedings of the Governor's Conference on Management of the Illinois River System: The 1990s and Beyond*, Mathis and Stout (1987) state: "Most of the problems uppermost on the minds of participants included significant problems with soil erosion and siltation. All discussion groups recognized that soil erosion and siltation from land use practices threatened the Illinois River, its backwater lakes and associated biota." Many bottomland lakes along the river valley have already lost a large part of their capacity to accumulate sediment, and continue to do so at a very high rate. Several lakes in the valley have completely filled in with sediment, and others will follow in the near future. Even though it is repeatedly acknowledged that erosion and sedimentation are the main problems in the Illinois River valley, detailed studies on the issues are rare.

* This extended executive summary is a condensed version of Illinois State Water Survey Report of Investigation 122. For more details, the reader is encouraged to consult that report which can be downloaded from the Illinois State Water Survey publications website, http://www.isws.illinois.edu/pubs/isearch.asp.

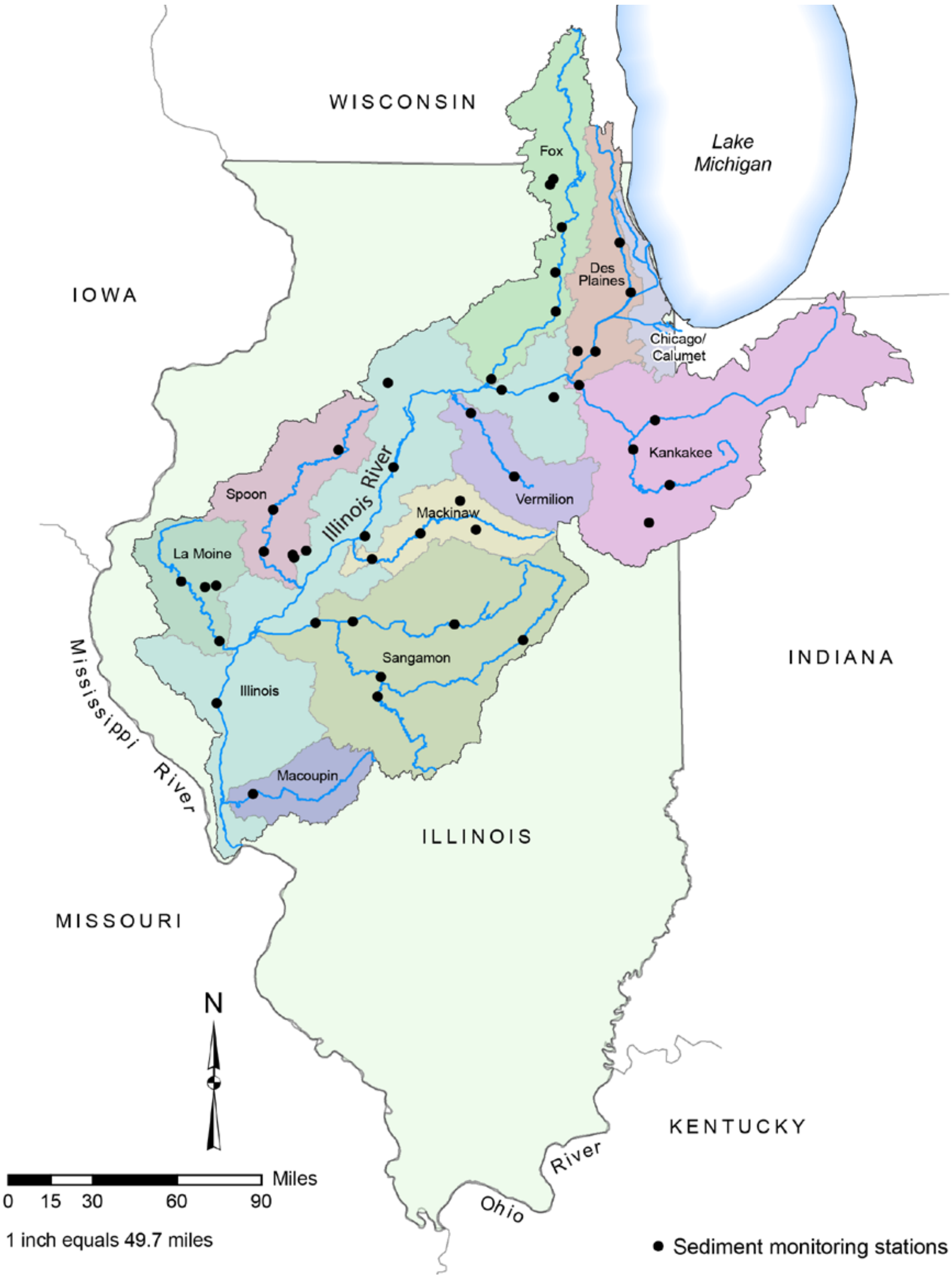

Figure 1. Locations of the Illinois River basin and available in-stream sediment data sites within the Illinois River watershed, 1981-2015
(*adapted from Figures 1 and 2 in ISWS Report of Investigation 122*)

One study for the Peoria Lake segment of the Illinois River, completed by the Illinois State Water Survey (ISWS) (Demissie and Bhowmik, 1986), has resulted in tremendous public interest and a call for action to remedy the problems associated with erosion and sedimentation in the Illinois River valley. For the first time, the attention and efforts of local, state, and federal agencies have been focused on attainable erosion control and lake restoration projects. Findings and recommendations from the 1986 report have formed the basis for most projects and proposals for managing sediment in Peoria Lake.

A follow-up study analyzed erosion and sedimentation problems for the entire Illinois River (Demissie et al., 1992, 2004). The 1992 report provided important facts and numbers on erosion and sedimentation based on data available up to that time. It has been used as a basis for developing management alternatives in the Illinois River watershed and along the river valley. Several recommendations developed as part of the *Integrated Management Plan for the Illinois River Watershed* (State of Illinois, 1997) were based on the results of the study. Stream sediment data used for the 1992 report were collected by the U.S. Geological Survey (USGS) in 1981-1990 (Coupe et al., 1989; Fitzgerald et al., 1984, 1985, 1986, 1987, 1988; Richards et al., 1983, 1991; Sullivan et al., 1990; USGS, 1982).

Demissie et al. (1992) estimated the delivery of 13.8 million tons of sediment to the Illinois River valley annually for the period 1981-1990. The average annual sediment outflow at Valley City was calculated to be 5.6 million tons, resulting in an estimated 8.2 million tons of sediment deposition in the Illinois River valley annually. All suspended sediment data collected by the USGS since 1990 appear in the USGS Water Resources Data reports (Harris et al., 2002; La Tour et al., 1993, 1999, 2000, 2001; Richards et al., 1992; Wicker et al., 1995, 1996, 1997, 1998; Zuehls et al., 1994). The sediment budget analysis was further updated by including sediment data collected until 2000 (Demissie et al., 2004). The purpose of one of the major data collection efforts in 1994-1997 by the USGS was to develop a suspended sediment budget for the LaGrange Pool (Gaugush, 1999). This USGS study reported that suspended sediment discharges from the LaGrange Pool were significantly higher than that of Pool 13, whose drainage area is threefold. The suspended sediment loads per unit area contributed by the Illinois River and its tributaries in the area of the LaGrange Pool were much higher than that at the Mississippi River and its tributaries at Pool 13 (Guagush, 1999). The study also showed that the LaGrange Pool receives most of its sediment from tributaries, not the main stem, whereas the reverse is true for Pool 13.

Since 2000, additional sediment data have become available for some of the USGS monitoring stations that were used to perform the sediment budget analysis in the past. This current report extended the sediment budget analysis to year 2015, using 15 more years of data. The average annual sediment delivery to the Illinois River valley in 1981-2015 was estimated to be 12.9 million tons. The average annual sediment outflow at Valley City for the same period was 5.2 million tons, indicating an estimated sediment deposition of 7.7 million tons in the Illinois River valley annually.

Acknowledgments

This extended executive summary was prepared as part of the authors' regular duties at the Illinois State Water Survey. Sangeetha Chandrasekaran has greatly contributed to this report by developing MATLAB codes necessary for extensive data processing and regression analyses. Lisa Sheppard edited the report and Sara Olson produced some of the illustrations.

Erosion and Sediment Yield

Sediment Data

The main task of this study was to collect and analyze sediment data from different sources so that reliable and consistent procedures could be developed to calculate sediment movement to and from the Illinois River valley. The most relevant data for this purpose are the sediment discharge data at gaging stations. All streamgaging stations with sediment discharge data within the Illinois River watershed were identified, and then the data were assembled in a consistent format for further analysis. Two types of sediment discharge data were available: mean daily sediment discharge from the USGS and instantaneous sediment discharge based on daily and weekly data collected by the ISWS and the U.S. Army Corps of Engineers (USACE). The period of record varied from a partial year to 34 years.

Sediment Yield Calculations for the Illinois River Basin

After evaluating the availability of different types of sediment data for the Illinois River watershed, it was decided that sediment yield calculations based on available suspended sediment load data would provide the most reliable values. Even though most station data are for short periods, suspended sediment data are available for about 44 stations within the watershed. Data from some of these stations eventually were used to develop regional sediment yield equations so as to estimate sediment yield in cases where no other monitoring data were available. A procedure based on these data should provide more reliable values than other procedures that rely on empirical equations.

The first task for this procedure was to evaluate the available suspended sediment data and develop the best sediment rating curves that relate sediment load and streamflow for each sediment monitoring station. Once sediment rating curves are developed, sediment yields over selected periods of time can be calculated based on streamflow records that are generally for much longer periods than records for sediment load data.

After developing the sediment load equations that relate the daily suspended sediment loads to the daily mean discharges, annual sediment loads were calculated. This was done by adding daily loads estimated using the daily water discharge records for all 17 sediment monitoring stations within the watershed for a 35-year period (1981-2015). Regional relationships were then developed between annual sediment loads (i.e., both measured and calculated) and annual water discharges of these 17 stations for estimating sediment loads from watersheds without sediment monitoring stations. As illustrated in Figure 2, these relationships were aggregated into four groups represented by the following equations:

$$\log(Q_s^{\ A}) = -3.52 + 1.97 \log(Q_w^{\ A}) \qquad (1)$$

$$\log(Q_s^{\ A}) = -3.30 + 1.63 \log(Q_w^{\ A}) \qquad (2)$$

$$\log(Q_s^{\ A}) = -5.10 + 1.79 \log(Q_w^{\ A}) \qquad (3)$$

$$\log(Q_s^{\ A}) = -4.98 + 1.69 \log(Q_w^{\ A}) \qquad (4)$$

where $Q_s^{\ A}$ and $Q_w^{\ A}$ are the annual sediment load and water discharge, respectively.

The group with the highest annual sediment yield rate, represented by Equation 1 (Equation 2 in ISWS RI-122), includes mainly smaller tributary streams in the Spoon and La Moine River watersheds. The group with the second highest annual sediment yield rate, represented by Equation 2 (Equation 3 in ISWS RI-122), includes the main stems of the Spoon, La Moine, Vermilion, and Mackinaw Rivers. The group with the third highest annual sediment yield rate, represented by Equation 3 (Equation 4 in ISWS RI-122), includes the Sangamon, Iroquois, Des Plaines, and Fox Rivers. The group with the least annual

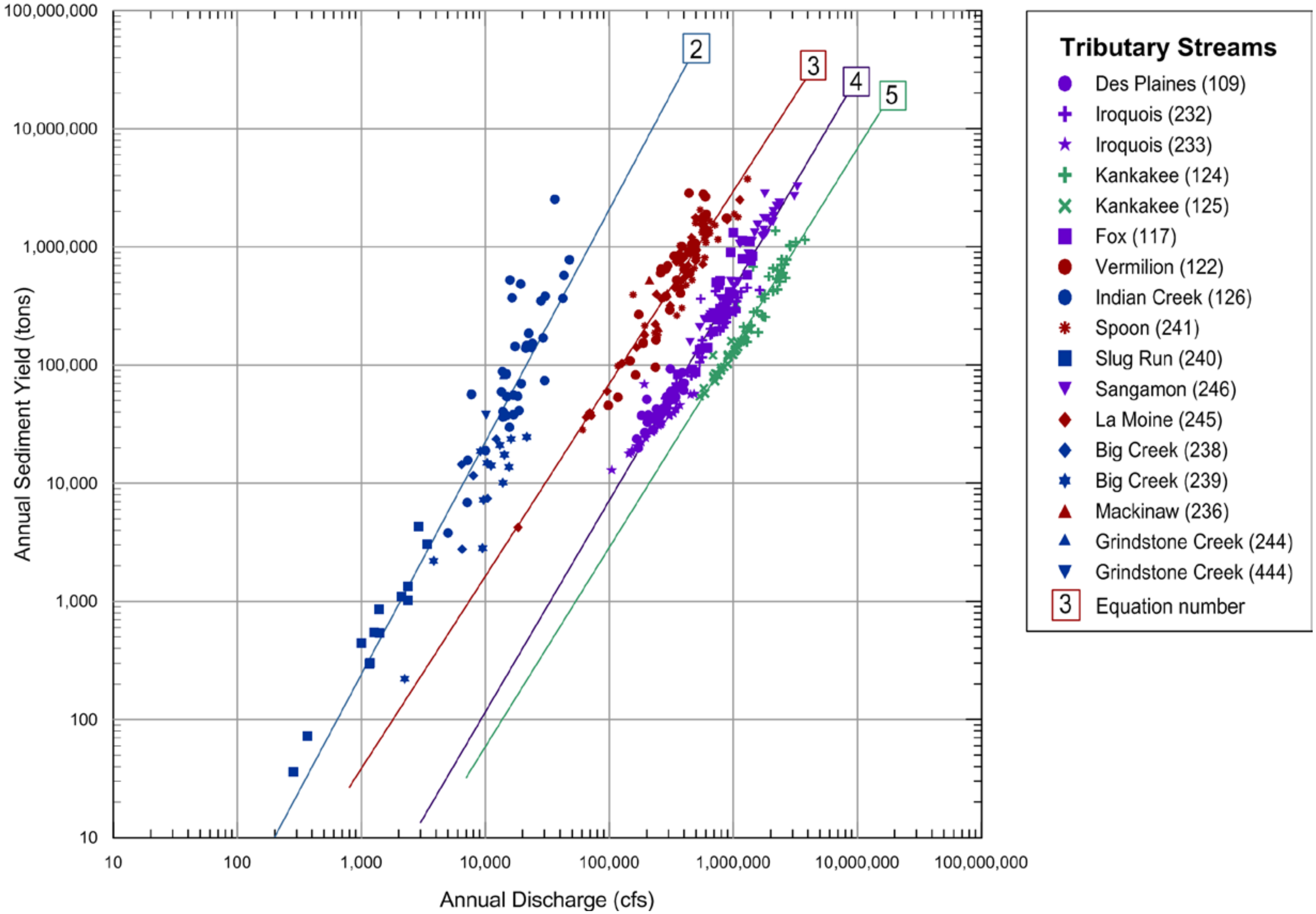

Figure 2. Annual sediment yield equations for tributary streams in the Illinois River valley
(same as Figure 6 in ISWS Report of Investigation 122)

sediment yield rate, represented by Equation 4 (Equation 5 in ISWS RI-122), includes stations on the Kankakee River. These four equations were then used to calculate annual sediment yields of tributary streams to the Illinois River.

Table 1 summarizes the results of the annual water discharges and sediment yield calculations for the 35-year analysis period, including annual water discharges and sediment yield values calculated for all tributary streams.

Sediment Budget Estimate for the Illinois River Valley

The main purpose of collecting and analyzing all the sediment load data for the tributary streams is to develop a quantitative sediment budget for the Illinois River valley. By calculating the difference between the amount of sediment that flows into and out of the valley, it is possible to estimate the amount of sediment deposited in the valley. Because sediment inflow/outflow varies significantly from year to year, it is necessary to select a reasonable period of time to represent long-term records of the Illinois River. After evaluating the USGS streamflow records for the Illinois River and the period during which most of the sediment data were collected, a 35-year period of analysis (1981-2015) was used, extending the analysis period of the previous study (Demissie et al., 2004) by 15 more years. For the duration of the analysis period, the sediment inflow from all tributary streams and the sediment outflow from the Illinois River needed to be determined. The data used to estimate sediment inflows to and outflows from the Illinois River are shown in Table 1.

The measured sediment load of the Illinois River at the USGS Valley City gaging station was used as the sediment outflow for the 35-year analysis period. The amount and percentage of sediment deposited in the Illinois River valley were calculated by determining the difference between the computed total inflow from tributary streams and outflow at Valley City. Table 2 provides estimates of the total sediment deposited annually in the valley in magnitude and as a percentage of the total sediment inflow.

The sediment budget estimate for the Illinois River valley given in Table 2 shows that, in the period 1981-2015, tributary streams delivered an average of 12.9 million tons of sediment to the Illinois River valley per year. The measured sediment load for the Illinois River at Valley City, which is 61.3 miles upstream of the junction of the Illinois River with the Mississippi River, averaged 5.2 million tons per year. This means that, on average, about 7.8 million tons or 60 percent of the sediment estimated to be delivered from tributary streams was deposited within the valley every year.

The total amount of sediment deposited in the valley may be higher than the estimated amount as a result of additional deposition of sediment load generated from the river bank and bluff erosion along the main stem of the Illinois River. Insufficient data availability makes it difficult to provide reasonable estimates of the additional sediment deposition.

Figure 3 illustrates the variability and trends of total sediment inflow, outflow, and deposition in the Illinois River valley, and the dashed lines show their respective mean values for the 35-year period, 1981-2015. The major flux of sediment into the valley in 1993 was due to major floods in Illinois and Upper Mississippi River basin that year. The low-flow years of 1988, 1989, 2000, 2003, 2006, and 2012 resulted in the least amount of sediment inflows into the valley. The percentage of sediment deposited in the valley tends to follow the total inflow, with the highest percentage (89 percent) during a high inflow in 1993 and the lowest percentage (8 percent) during a low inflow in 2012. The very high sediment deposition rate in 1993 was caused primarily by the high floodwaters along the Mississippi River during the Great Mississippi Flood, which created a backwater effect on the Illinois River. However, not all high sedimentation rates were due to Mississippi River backwater effects; other factors such as high flows from tributary streams would have increased sedimentation rates independent of Mississippi River backwaters.

Table 1. Computed Annual Water Discharge and Annual Sediment Yield of Tributary Streams in the Illinois River Basin, 1981-2015
(adapted from Tables 3 and 4 in ISWS Report of Investigation 122)

River/stream	*Drainage area (sq mi)*	*Average water discharge (cfs-days * 1000)*	*Average sediment yield (tons * 1000)*
Des Plaines River	2111	1788.0	143.5
Kankakee River	5165	2140.5	672.0
Mazon River	524	180.5	224.6
Fox River	2658	868.3	428.5
Vermilion River	1331	417.1	838.2
Big Bureau Creek	536.8	172.5	270.2
Mackinaw River	1136	337.8	677.1
Spoon River	1855	567.3	1453.1
Sangamon River	5418	1671.5	1586.3
La Moine River	1350	399.6	939.1
McKee Creek	444	131.4	408.4
Aux Sable Creek	187	64.4	266.4
Nettle Creek	53.2	18.3	83.9
Waupecan Creek	57.3	19.7	97.1
Bills Run	33.2	11.4	33.2
Hog Run	40	13.8	47.9
Covel Creek	74.1	25.5	51.9
Little Vermilion	126	40.5	107.2
Cedar Creek	51.2	16.5	67.7
Spring Creek	92.1	29.6	69.0
Negro Creek	48.6	15.6	61.1
Allforks Creek	44.3	14.2	50.9
Sandy Creek	146	43.2	132.7
Crow Creek (west)	81.7	24.2	59.4
Strawn Creek	33.8	10.0	27.7
Crow Creek	130	38.5	105.8
Senachwine Creek	90	26.6	71.8
Snag Creek	99.1	29.3	73.9
Richland Creek	47	13.9	53.1
Farm Creek	61.3	23.5	77.5
Kickapoo Creek	306	90.5	563.3
Lost Creek	46.9	17.9	91.0
Lamarsh Creek	40.9	12.1	40.4
Copperas Creek	127	37.6	101.1
Spring Lake Slough	36.5	14.0	55.6
Buckheart Creek	39.1	11.6	37.0
Quiver Creek	261	99.9	707.8
Otter Creek	126	37.3	105.0
Sugar Creek	162	48.0	171.5
Little Creek	30.8	9.1	24.4
Indian Creek	286	70.8	355.5
Camp Creek	38.6	9.6	25.9
Coon Run Ditch	61.7	15.3	42.3
Mauvaise Terre Creek	178	44.1	140.8
	25765.2	9670.8	11640.8
Missing area	977.8	343.2	1295.2
Total inflow	26921	10014.1	12935.9
Total inflow	26743.0	9951.0	12087.0
Outflow from Illinois River at Valley City	26743.0	9565.9	5170.8
Percent difference		-5	60

Table 2. Sediment Budget Estimate for the Illinois River, 1981-2015
(same as Table 5 in ISWS Report of Investigation 122)

Water Year	*Total inflow from tributary streams (tons × 1000)*	*Outflow from Illinois River at Valley City (tons × 1000)*	*Deposition (tons × 1000)*	*Percent deposited*
WY1981	19,433	7,351	12,083	62
WY1982	16,246	9,019	7,227	44
WY1983	18,193	5,986	12,207	67
WY1984	12,880	5,217	7,663	59
WY1985	10,475	5,438	5,036	48
WY1986	13,489	7,882	5,608	42
WY1987	6,978	4,629	2,349	34
WY1988	3,309	2,060	1,250	38
WY1989	2,027	1,805	222	11
WY1990	12,556	7,052	5,504	44
WY1991	16,080	10,053	6,027	37
WY1992	5,346	3,727	1,619	30
WY1993	49,489	5,464	44,025	89
WY1994	11,805	5,483	6,322	54
WY1995	14,771	5,561	9,211	62
WY1996	8,774	5,386	3,388	39
WY1997	6,723	4,096	2,627	39
WY1998	19,416	4,628	14,788	76
WY1999	10,927	4,415	6,512	60
WY2000	2,217	2,911	-694	-31
WY2001	9,369	5,130	4,239	45
WY2002	16,460	7,397	9,063	55
WY2003	2,509	3,162	-654	-26
WY2004	6,887	4,440	2,447	36
WY2005	10,474	3,710	6,764	65
WY2006	2,038	2,170	-133	-7
WY2007	13,427	4,119	9,309	69
WY2008	17,935	6,057	11,878	66
WY2009	24,674	5,908	18,766	76
WY2010	34,877	8,491	26,386	76
WY2011	12,950	4,362	8,588	66
WY2012	1,894	1,748	145	8
WY2013	14,554	4,937	9,617	66
WY2014	7,715	5,091	2,624	34
WY2015	15,858	6,091	9,767	62
Average	**12,936**	**5,171**	**7,765**	**60**

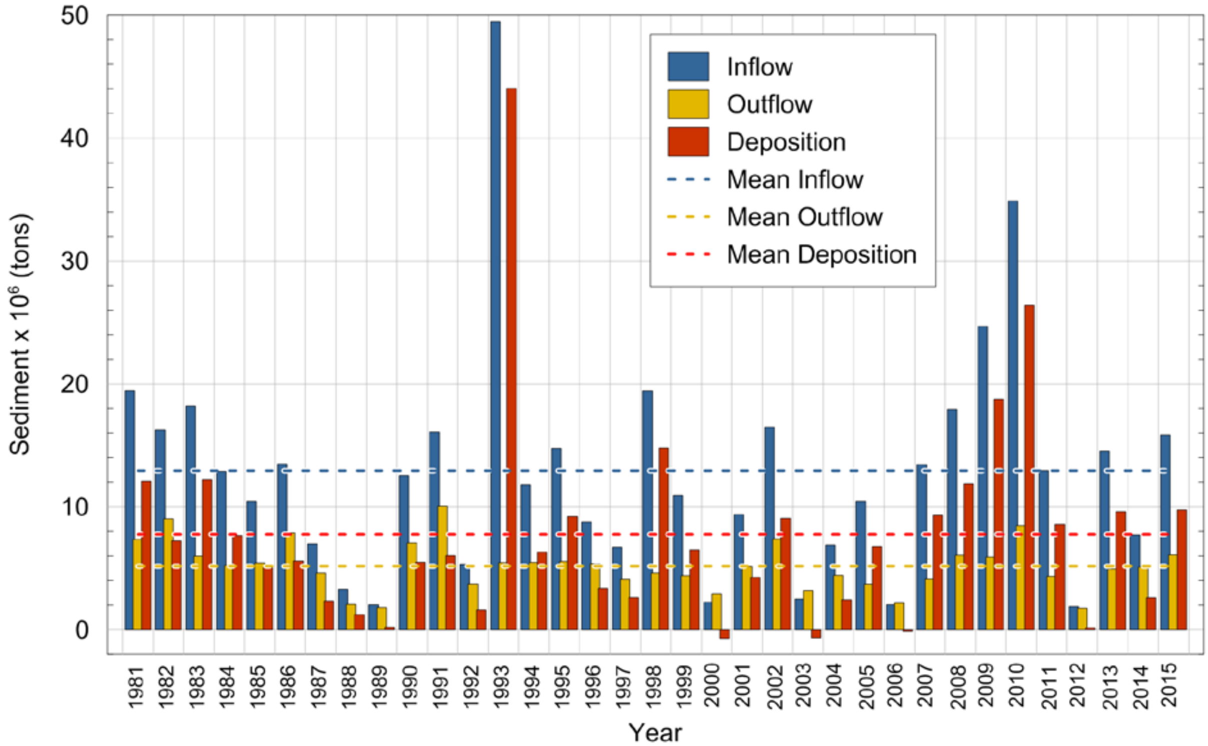

Figure 3. Variability and trends in the computed inflow, outflow, and deposition of sediment in the Illinois River valley, 1981-2015
(same as Figure 7a in ISWS Report of Investigation 122)

Figure 4 schematically represents the water and sediment budget estimates of the Illinois River. The computed inflow of water and sediment from tributary streams is shown at the inlet points, and the width of the core represents either the water discharge or sediment load. No unexpected variation appears in the water budget (Figure 4). The discharge of the Illinois River increases gradually in the downstream direction, with the Kankakee and Sangamon Rivers being the major contributors. On the other hand, the computed sediment load in the Illinois River drastically increases both in the Peoria and LaGrange Pools. As shown in the figure, the main contributors of sediment inflow into the LaGrange Pool are Spoon, Sangamon, La Moine, and Mackinaw Rivers. Spoon River delivers the most sediment per unit area (i.e., 3 tons/hectare) among the major tributaries to the Illinois River. The Vermilion and Kankakee Rivers contribute significant sediment into the Peoria and the Dresden Pools, respectively. In general, the lower Illinois River receives much more sediment than the upper Illinois River. It also should be noted that Figure 4 is a cumulative sediment budget for the whole Illinois River valley. Sediment entrapment and thus deposition within each pool could not be calculated for each pool from available data. Therefore, sediment deposition within each pool is not quantified and shown at each lock and dam location (Figure 4); instead the estimated total sediment deposition within the valley is shown at Valley City.

The research results provided in this report should form the basis for the sediment and water budgets of the Illinois River. When additional field data are available in the future, the water and sediment budgets could be updated every 10 to 20 years.

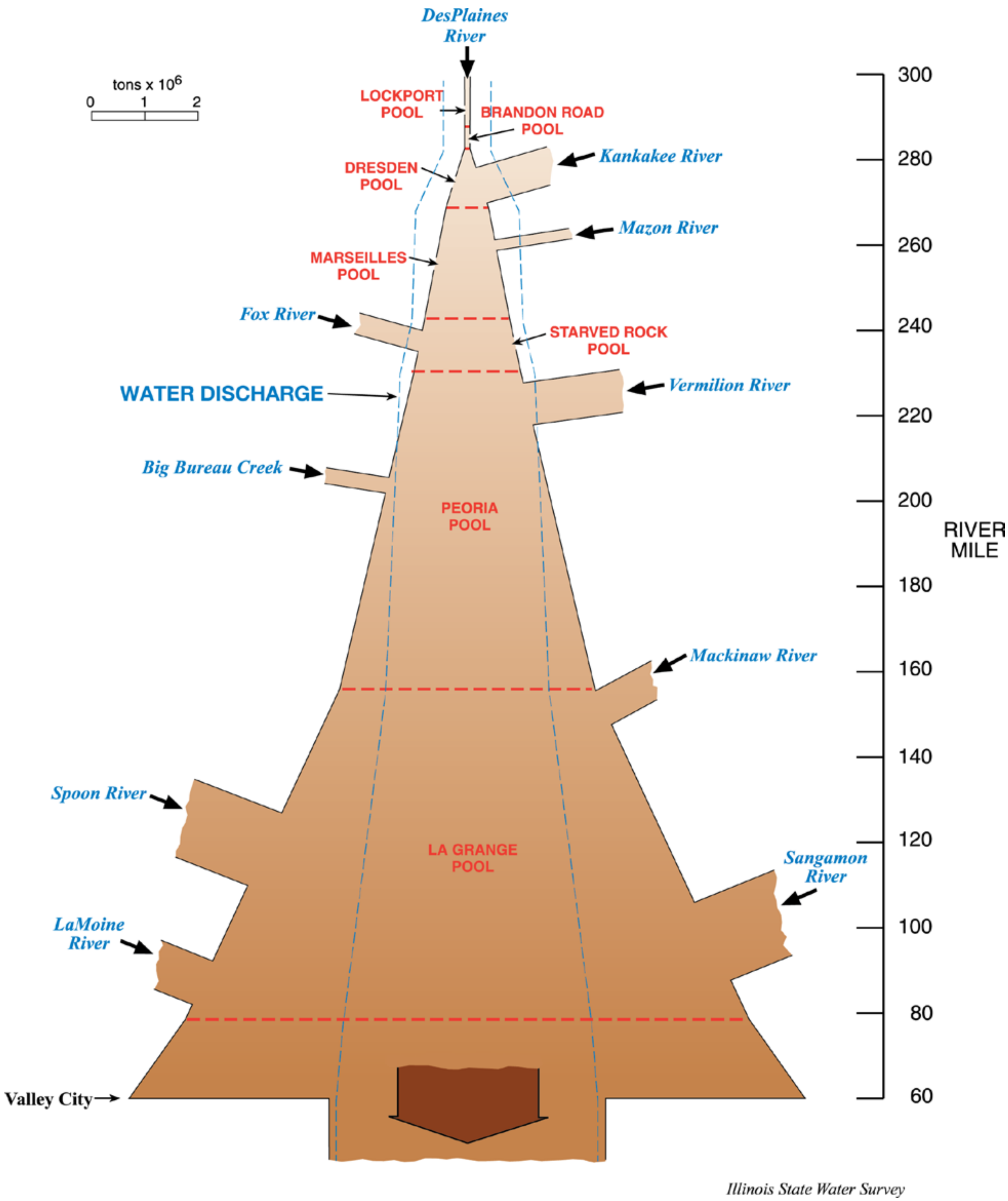

Figure 4. Water and sediment budget estimate for the Illinois River, 1981-2015
(adapted from Figures 8 and 9 in ISWS Report of Investigation 122)

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