WORK PLAN FOR THE

SANGAMON RIVER BASIN, ILLINOIS

By J. K. Stamer and D. M. Mades

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Factors for converting inch-pound units to International System units (SI):

Multiply inch-pound unit	By	To obtain SI unit
foot (ft)	3.048×10^{-1}	meter (m)
cubic foot per second (ft^3/s)	2.832×10^{-2}	meter per second (m^3/s)
inch (in)	2.540	centimeter (cm)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
ton per acre	2.242	metric ton per hectare
acre foot (acre-ft)	1.233×10^{-3}	cubic hectometer (hm^3)
degrees Fahrenheit (°F)	-32×0.556	degree Celsius (°C)
million gallons per day (Mgal/d)	4.381×10^{-2}	cubic meter per second (m^3/s)
acre	4.047×10^{-1}	hectare

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first order level nets of both the United States and Canada, formerly called "Mean Sea Level." NGVD of 1929 is referred to as sea level in this report.

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ABSTRACT

The U.S. Geological Survey, in cooperation with the Division of Water Resources of the Illinois Department of Transportation and other State agencies, recognizes the need for basin-type assessments in Illinois. This report describes a plan of study for a water-resource assessment of the Sangamon River basin in central Illinois. The purpose of the study would be to provide information to basin planners and regulators on the quantity, quality, and use of water to guide management decisions regarding basin development.

Water quality and quantity problems in the Sangamon River basin are associated primarily with agricultural and urban activities, which have contributed high concentrations of suspended sediment, nitrogen, phosphorus, and organic matter to the streams. The impact has resulted in eutrophic lakes, diminished capacity of lakes to store water and attenuate flood waves, low concentrations of dissolved oxygen downstream from Decatur during the summer, and turbid stream and lake waters.

The four elements of the plan of study include: (1) determining suspended-sediment and nutrient transport, which includes calculating the concentration-duration curves of suspended sediment, nitrogen, and phosphorus and average annual loadings of those constituents; (2) determining the distribution of selected inorganic and organic residues in streambed sediments, by which the impacts of agricultural and urban land on stream quality could be assessed; (3) determining the waste-load assimilative capacity of the Sangamon River, which would primarily evaluate the effect of the city of Decatur's treated wastewater on the dissolved-oxygen regime in the reach between Decatur and Springfield; and (4) applying a hydraulic model to high streamflows, which could be used to evaluate flood-control alternatives.

INTRODUCTION

River basins have been studied nationwide by the U.S. Geological Survey as part of a 10-year Federally funded program. The purpose of the program was to demonstrate the value of river-basin studies for basin planning and water-resource management. River-basin studies under the Federal program have been completed for the Willamette River in Oregon (Rickert and Hines, 1975), the Chattahoochee River in Georgia (Cherry and others, 1980), the Yampa River in Colorado and Wyoming (Steele and others, 1976), the Carson and Truckee River basins in Nevada and California (Nowlin and others, 1980), and the Schuylkill River in Pennsylvania (Pederson and others, 1980).

The U.S. Geological Survey, in cooperation with the Division of Water Resources of the Illinois Department of Transportation and other State agencies, recognizes a need for basin-type assessments in Illinois. This report describes a plan for a water-resource assessment of the Sangamon River basin in central Illinois. The study of the Sangamon River basin, thus, represents a transition from the Federal program to a Federal-State cooperative program.

The purpose of the study would be to assess the water resources of the Sangamon River basin in terms of its quantity, quality, and use. The purpose of this paper is to present a plan of study for the assessment. This paper includes a description of the basin, water and land use, and water quality and quantity problems.

PHYSICAL SETTING

The Sangamon River basin (fig. 1) lies entirely within central Illinois and drains 5,419 mi^2 (square miles). Principal tributaries are South Fork Sangamon River, which drains 885 mi^2, and Salt Creek, which drains 1,868 mi^2. The Sangamon River rises on the southern slopes of the Bloomington Moraine, 12 miles east of Bloomington, and flows 241 miles to its confluence with the Illinois River. The total fall of the river is 420 feet, 120 feet of which is in the first 10 miles.

The Sangamon River basin (fig. 1) lies in two physiographic regions (Leighton and others, 1948). The upper part of the basin, from Decatur upstream, lies in the Bloomington Ridged Plain; the lower part lies in the Springfield Plain. The Bloomington Ridged Plain is characterized by low, broad ridges separated by wide, gently undulating moraines and wooded areas in the river valleys. Altitudes in the Bloomington Ridged Plain range from about 600 to 900 feet above sea level. The Springfield Plain is characterized by gently rolling uplands and less extensive moraines and wooded areas in the river valleys. Downstream from the Salt Creek confluence, the Springfield Plain is nearly flat. Altitudes in the Springfield Plain range from about 480 to 600 feet.

Illinois lies about midway between the continental divide and the Atlantic Ocean and is about 500 miles north of the Gulf of Mexico. The climate of the basin is typically continental, characterized by cold winters, warm summers, and frequent but short variations in temperature, humidity, cloudiness, and wind direction. Mean monthly air temperatures range from 28°F (degrees Fahrenheit) in January to 78°F in July, with a mean annual temperature of 54°F. Precipitation is greatest in May and June, least in February, and averages 35 inches per year.

page 3 is oversize figure

Agriculture is the dominant land use (Illinois Environmental Protection Agency, 1976). Of the 81 percent of the land in agriculture, 73 percent is in cropland, and 8 percent is in pastureland. Corn and soybeans are the major crops. Urban land constitutes 8 percent of the basin. Principal cities are Springfield, Decatur, Bloomington and Normal. The principal industry is grain processing.

Surface water is the major source of water supply. In 1978, surface water accounted for 96 percent of the total water withdrawals or about 1,340 million gallons per day (Kirk and others, 1979). Industrial water use accounts for 93 percent of the total surface withdrawals, and public water supply accounts for 5 percent. Much of the water used is withdrawn from reservoirs, of which there are 11 with surface areas greater than 40 acres.

Lake Springfield (64,500 acre-ft), which drains 265 mi^2, and Lake Decatur (19,738 acre-ft), which drains 906 mi^2, are the two largest reservoirs (fig. 1). Both impoundments are used for public water supply and recreation. In addition, Lake Springfield supplies cooling water for a thermoelectric powerplant. Lake Springfield impounds Sugar and Lick Creeks, and Lake Decatur impounds the mainstream of the Sangamon River.

The average yield of water for gaged streams in the basin (fig. 1) ranges from 0.43 to 1.41 $(ft^3/s)/mi^2$ (table 1). For the Sangamon River near Oakford, (map ref. no. 31, fig. 1), the average yield is 0.63 $(ft^3/s)/mi^2$ or an average streamflow of 3,230 ft^3/s. The 7-day, 10-year low flow of the Sangamon River near Oakford is 206 ft^3/s. For many streams, the 7-day, 10-year low flow is 0.0 ft^3/s. This includes some streams whose drainage areas are as large as 276 mi^2; for example, Flat Branch near Taylorville (map ref. no. 11, fig. 1).

During periods of runoff, the streams rise slowly and can remain in flood for relatively long periods. The mean annual floodflow for the Sangamon River near Oakford is estimated to be 21,100 ft^3/s (Curtis, 1977).

WATER QUALITY AND QUANTITY PROBLEMS

Water quality and quantity problems are associated primarily with agriculture and urbanization (Rogers, 1971). Agriculture has impacted the quality of stream waters in several ways. Although the basin has little topographic relief, cultivation of row crops, such as corn and soybeans, promotes soil erosion. Soil erosion contributes to the high concentrations of suspended sediment in the streams. During a high-flow period in May 1981, synoptic water-quality data were collected by the U.S. Geological Survey in the Sangamon River basin (table 2). Instantaneous concentrations of suspended sediment ranged from 52 to 1,250 mg/L (milligrams per liter). Although the concentrations of suspended sediment show considerable variation, the percentage of suspended sediment that is silt- and clay-sized (less than 62 microns) shows little variation. The average percentage is 91, with a standard deviation of 7.2 percent.

Table 1.--Map reference number and hydrologic information for selected stations

Average discharge: Mean annual discharge for period of record through 1980 water year. Given for stations having 5 or more complete water years of record.

Type of gage: (C) peak stage and peak discharge only; (CQ) chemical quality; (D) continuous record of stage and discharge; (L) discharge measurements at low flow; (M) miscellaneous measurement of discharge; (MQ) miscellaneous measurement of discharge with one or more parameters of chemical or physical quality; (MR) monitor at which one or more parameters of chemical or physical quality are measured; (SD) suspended sediment; (SR) continuous record of stage and discharge during flood period.

Map reference number (fig. 1)	Station number	Station name	Drainage area (mi^2)	Average discharge (ft^3/s)	Type of gage	Period of record
1	05570910	Sangamon River at Fisher	240	---	D CQ MQ	10/78- 10/78- 1981
2	05571000	Sangamon River at Mahomet	362	261	D CQ	03/48-09/78 12/77-09/78
3	05572000	Sangamon River at Monticello	550	 398	D D	02/08-12/12 06/14-
4	05572125	Sangamon River at Allerton Park near Monticello	573	---	CQ M	10/78- 1980
5	05572450	Friends Creek at Argenta	111	96.3	D MQ	10/66- 1981
6	05572500	Sangamon River near Oakley	774	---	D	[1]07/51-09/77
7	05573540	Sangamon River at Route 48 at Decatur	938	---	CQ	10/78-

[1]No low-flow records since 09/56.

Table 1.--Map reference number and hydrologic information for selected stations--Continued

Map reference number (fig. 1)	Station number	Station name	Drainage area (mi^2)	Average discharge (ft^3/s)	Type of gage	Period of record
8	05573650	Sangamon River near Niantic	1,054	---	CQ	10/77-
9	05573800	Sangamon River at Roby	1,264	---	L	06/67-04/70
					CQ	01/78-
10	05574000	South Fork Sangamon River near Nokomis	11.0	7.25	D	12/50-09/75
					C	10/75-
11	05574500	Flat Branch near Taylorville	276	199	D	07/49-
					CQ	04/79-
					MQ	1981
12	05575500	South Fork Sangamon River at Kincaid	562		D	05/17-11/27
					D	04/28-09/30
					D	08/31-11/33
				408	D	10/44-09/61
					C	10/61-
					CQ	10/77-
13	05575800	Horse Creek at Pawnee	52.2	40.5	D	10/67-
					MQ	1981
14	05575830	Brush Creek near Divernon	32.4	21.1	D	10/73-
					MQ	1979-81
15	05576000	South Fork Sangamon River near Rochester	867	560	D	07/49-
					MQ	1979-80
16	05576022	South Fork Sangamon River below Rochester	870	---	CQ	10/77-
17	05576250	Sugar Creek near Springfield	270	---	CQ	04/79-

Table 1.--Map reference number and hydrologic information for selected stations--Continued

Map reference number (fig. 1)	Station number	Station name	Drainage area (mi^2)	Average discharge (ft^3/s)	Type of gage	Period of record
18	05576500	Sangamon River at Riverton	2,618		D	03/08-12/12
				1,691	D	09/14-10/56
					C	11/56-
					CQ	11/77-
19	05577500	Spring Creek at Springfield	107		D	01/48-09/48
				63.4	D	12/48-
					MQ	1979-81
20	05577505	Spring Creek at Burns Lane Bridge at Springfield	109	---	CQ	04/79-
21	05577700	Sangamon River tributary at Andrew	1.50	---	C	10/55-09/80
					SR	10/60-09/65
					SR	06/72-09/74
22	05578000	Sangamon River at Petersburg	3,063	---	D	01/48-09/49
					M	1950-51
					M	1958-77
					CQ	01/78-
23	05578500	Salt Creek near Rowell	335	237	D	10/42-
					CQ	01/78-
					MQ	1981
24	05579500	Lake Fork near Cornland	214	143	D	01/48-
					CQ	10/77-
					MQ	1981
25	05580000	Kickapoo Creek at Waynesville	227	149	D	01/48-
					CQ	01/78-
					MQ	1981

Table 1.--Map reference number and hydrologic information for selected stations--Continued

Map reference number (fig. 1)	Station number	Station name	Drainage area (mi^2)	Average discharge (ft^3/s)	Type of gage	Period of record
26	05580500	Kickapoo Creek near Lincoln	306	187	D	10/44-09/71
					C	10/71-
					CQ	09/78-
27	05580950	Sugar Creek near Bloomington	34.4	48.8	D	10/74-
					CQ	12/74-06/77
28	05581500	Sugar Creek near Hartsburg	333	197	D	10/44-09/71
					C	10/71-
					CQ	01/78-
					MQ	1981
29	05582000	Salt Creek near Greenview	1,804	1,218	D	10/41-
					CQ	10/77-
30	05582500	Crane Creek near Easton	26.5	16.5	D	10/49-09/75
					C	10/75-
31	05583000	Sangamon River near Oakford	5,093		D	10/09-10/11
					D	12/11-03/12
					D	08/14-06/19
					D	03/21-09/22
					D	10/28-12/33
				3,230	D	10/39-
					MQ	1970
					MR	05/76-09/77
					CQ	10/76-
					MR	05/79-
					SD	10/80-09/82

Table 2.--Selected water-quality parameters for the May 11-15, 1981, high-flow sampling period

[Constituent concentrations are in milligrams per liter unless specified otherwise]

Station number	Station name	Date	Time	Stream-flow (ft^3/s)	Total phosphorus (as P)	Total organic nitrogen (as N)
05570910	Sangamon River at Fisher	May 15	1000	2,700	0.39	2.8
05572000	Sangamon River at Monticello	May 14	1330	448	.14	1.0
05572450	Friends Creek at Argenta	May 12	1530	363	.07	.5
05573880	Buckhart Creek near Rochester	May 14	1045	247	.18	.9
05574500	Flat Branch near Taylorville	May 15	1115	678	.23	1.2
05575050	Bear Creek near Palmer	May 15	0745	68	.27	1.4
05575800	Horse Creek at Pawnee	May 14	1630	83	.15	.6
05575830	Brush Creek near Divernon	May 14	1500	36	.32	.9
05576190	Sugar Creek near Glenarm	May 14	1330	58	.33	.9
05576600	Wolf Creek near Sherman	May 13	1400	103	.15	.2
05577500	Spring Creek at Springfield	May 14	0800	239	.17	1.0
05578200	North Fork Salt Creek near Farmer City	May 11	1400	594	.58	3.2
05578500	Salt Creek near Rowell	May 13	1000	910	.11	.8
05579500	Lake Fork near Cornland	May 13	1200	610	.13	.6
05580000	Kickapoo Creek at Waynesville	May 11	1830	1,270	.85	5.0
05581500	Sugar Creek near Hartsburg	May 12	1130	1,550	.42	2.9
05583580	Panther Creek near Chandlerville	May 12	1750	104	.38	1.2

Table 2.--Selected water-quality parameters for the May 11-15, 1981, high-flow sampling period--Continued

Station number	Total nitrite plus nitrate nitrogen (as N)	Total ammonium nitrogen (as N)	Total nitrogen (as N)	Specific conductivity (µmhos/cm at 25°C)	Suspended sediment	Suspended sediment finer than 62 microns (percent)
05570910	13	0.1	15.9	398	587	99.5
05572000	18	.1	19.1	a	a	a
05572450	22	.1	22.6	730	110	76.0
05573880	14	.1	15.0	693	160	98.2
05574500	12	.1	13.3	453	215	82.5
05575050	12	.2	13.6	475	145	85.6
05575800	18	.1	18.7	519	123	98.5
05575830	17	.2	18.1	579	52	98.0
05576190	19	.2	20.1	600	98	98.5
05576600	22	.1	22.3	739	159	86.6
05577500	13	.1	14.1	642	163	94.0
05578200	11	.1	14.3	454	1,250	94.7
05578500	4.4	.1	5.3	502	103	85.1
05579500	18	.1	18.7	731	168	83.7
05580000	14	.2	19.2	499	909	86.1
05581500	18	.1	21.0	691	392	92.5
05583580	14	.1	15.3	a	599	93.6

a No data.

As a stream enters a reservoir, the velocity generally decreases, which allows for all or a part of the suspended-sediment load to be deposited in the reservoir. The deposition of sediment can bury bottom fauna and reduce the capacity of the reservoir to store water. The silt- and clay-sized particles, because they are small, can remain in suspension for long periods and thereby cause highly turbid waters. The turbid waters can lower the esthetic and recreational value of reservoirs.

Lake Decatur, formed in 1922, had an initial storage capacity of 19,738 acre-feet at an altitude of 610 feet; by 1956, the storage capacity was reduced to 14,077 acre-feet, which is a decrease of 29 percent (Illinois Environmental Protection Agency, 1976). Based on sedimentation surveys and an assumed constant rate of deposition, the authors of this report compute the storage of Lake Decatur in 1981 to be about 9,200 acre-feet or a reduction of 53 percent since 1922.

The extensive use of fertilizers and pesticides to promote high yields of corn and soybeans has also adversely affected the quality of stream waters. Rains during the latter part of spring and early summer leach soluble nutrients out of the soil and transport them to nearby streams. Concentrations of nitrate nitrogen exceeding the U.S. EPA's Drinking Water Regulations (1975) of 10 mg/L frequently occur in the stream waters of each spring (U.S. Geological Survey, 1979, 1980, and 1981). When the drinking water regulations are not met, bulletins are issued by public health officials to alert parents not to use these waters for the preparation of infant formula. Nitrate can interfere with the ability of hemoglobin to take up oxygen in an infant and cause a condition known as methemoglobinemia ("blue baby") (National Academy of Sciences, 1978).

For the 17 stream sites for which nutrient data were collected (table 2), concentrations of $NO_2 + NO_3$ as N (nitrite plus nitrate as nitrogen) exceed the 10 mg/L regulatory limit for public water supply at 16 stream sites and average 15.3 mg/L, with a standard deviation of 4.4 mg/L. Concentrations of $NO_2 + NO_3$ as N represent the largest component, 90.5 percent on the average, of total nitrogen. Because nitrite is rapidly oxidized to nitrate in oxygenated waters, $NO_2 + NO_3$ as N can be considered a close estimate of nitrate nitrogen. Although the public water supplies for Decatur and Springfield were not sampled during the May 1981 data-collection effort, the nutrient data for sites just upstream from the intakes suggest that concentrations of $NO_2 + NO_3$ as N exceeded the regulatory limit. Furthermore, the data in table 2 were collected during a 5-day period, which indicates that the high concentrations of $NO_2 + NO_3$ as N persisted during the high-flow period. The emphasis on presenting these data is made in view of a recent study of nitrate in the environment by the National Academy of Sciences (1978). The Academy reports that concentrations of nitrate as nitrogen that exceed 10 mg/L are rare in public water supplies in the United States.

Concentrations of organic nitrogen as nitrogen (table 2), average 1.5 mg/L and represent 9 percent of the total nitrogen. Organic nitrogen represents the second largest component of total nitrogen. Concentrations of NH_4 as N (ammonium as nitrogen) (table 2) show little variation and are the smallest component of total nitrogen (less than 1 percent). Nitrogen is applied to the farm fields in early spring in the form of anhydrous ammonia. As indicated by low concentrations of NH_4 as N in the streams, much of the ammonium in the soil seems to have been oxidized to nitrate by May. The high concentrations of nutrients in the streams have produced eutrophic conditions in several of the reservoirs. Of the 31 lakes in Illinois surveyed by the U.S. EPA in 1975 as part of the National Eutrophication Survey, Lake Decatur and Lake Springfield had the 28th and 17th worst rankings.

Some of the pesticides used to control weeds and insects, particularly the chlorinated insecticides, are sparingly soluble, persistent, and tend to accumulate in the fatty tissues of animals. These pesticides also sorb onto soil particles and become available for transport. Once the sorbed pesticides enter the aquatic environment, their distribution becomes dependent upon the processes that control fluvial sediment and upon uptake by aquatic biota.

Urbanization has also impacted the quality and quantity of stream waters in the Sangamon River basin. The city of Decatur withdraws its water supply from Lake Decatur and disposes of its treated wastewaters back into the Sangamon River just downstream from the lake. During some periods of low flow, Decatur has withdrawn the entire flow of the Sangamon River for water supply. During such periods, the flow of the Sangamon River 1.2 miles downstream from the Lake Decatur Dam at RM (river mile) 130.1 has ranged from 3 to 6 ft^3/s. Just downstream from RM 130.1, the treated wastewaters from the city of Decatur combine with and augment the flow of the Sangamon River. The resulting water quality is characterized by high concentrations of chloride, ammonium, and sulfate and low concentrations of dissolved oxygen. In spite of this situation, the city of Springfield has under consideration a plan to construct a dam across the Sangamon River just downstream from the South Fork Sangamon River confluence (RM 58.3) for the purpose of using the river as a supplemental supply of drinking water (H. E. Hudson, Jr., oral commun., 1981). Treated wastewater from Decatur will constitute about 50 percent of a 7-day, 10-year low flow of the Sangamon River at the site where the city of Springfield plans to withdraw water. Based on the present level of wastewater treatment by the city of Decatur and the proportion of the streamflow that is treated wastewater in the Sangamon River, drinking water standards could be exceeded during some periods of low flow.

Flooding is a particularly acute problem. During high runoff, the low topographic relief causes the streams to rise slowly but remain in flood for long periods. Floods are most common in winter or spring due to a combination of heavy snowmelt and rainfall. Floods can be severe, however, at any time of the year. The U.S. Army Corps of Engineers (1971) reports that the most severe flood in the Sangamon River basin occurred in May 1943. The river remained above bankfull stage for 15 days. The second most severe was in October 1926. The river remained above bankfull stage for 25 days, but the peak stage was less than in 1943.

The estimated annual dollar value of flood damages in the Sangamon River basin is not known. Annual flood damages in the State, however, are estimated to be 350 million dollars (Governor's Task Force, 1981), 300 million dollars of which was concentrated in urban areas. Despite the effort and expenditures of hundreds of millions of dollars by the State and Federal governments for flood-control works, flood damages have steadily increased (U.S. Army Corps of Engineers, 1971; Governor's Task Force, 1981). Urban development in the flood-prone areas and subsequent flood damages have outpaced flood-control measures.

STUDY DESIGN

The hydrologic assessment of the Sangamon River basin would assess primarily the quality and quantity impact of agriculture and urbanization on the streams. Erosion and sedimentation and the interrelationship of quality and quantity of water have been identified by the Govenor's Task Force (1981) as the two most important water-resource issues in the State. Results of the study should provide basin planners with information for managing the water and land resources.

The study would include four elements that address the major water issues:

1. Suspended sediment and nutrient transport would determine concentration-duration curves for suspended sediment, nitrogen, and phosphorus as well as the average annual stream loadings of these constituents.

2. Distribution of selected inorganic and organic residues in streambed sediments would assess the potential impact of agricultural and urban land on stream quality.

3. Waste-load assimilative capacity of the Sangamon River would evaluate, primarily, the effect of the city of Decatur's wastewater on the dissolved-oxygen regime of the reach of the Sangamon River between Decatur and Springfield.

4. Hydraulic model of high streamflows would provide basin planners with a calibrated and verified mathematical model that can be used to evaluate flood-control alternatives.

The objectives and approaches of each study element are presented in the following sections.

Suspended Sediment and Nutrient Transport

Objectives

1. Determine suspended-sediment and nutrient transport on an average annual basis at selected sites.

2. Construct concentration-duration curves for suspended-sediment and nutrients at selected sites.

3. Determine particle-size distribution of concentrations of suspended sediment.

4. Compute suspended-sediment and nutrient yields between growing and non-growing seasons at a selected site.

Approach

Suspended-sediment and nutrient-concentration data would be collected at all stations listed in table 1 that have drainage areas greater than 30 mi^2. These data would be collected over a wide range of hydrologic and climatic conditions to insure that the rates of discharge throughout the flow-duration curve are represented for each station. About 32 sediment-water mixtures would be collected at each site by depth-integrating procedures described by Guy and Norman (1970). Each of the samples would be analyzed for concentrations of suspended sediment, percentage finer than 62 microns, dissolved NO_2 + NO_3 and NH_4, suspended and dissolved organic nitrogen, orthophosphorus, and total phosphorus. At selected sites along the main stem, Salt Creek, and South Fork Sangamon River, particle-size distribution would be determined for each sample of suspended sediment.

Average annual constituent loads would be computed by the transport flow-duration curve method described by Miller (1951) and Colby (1956). Constituent concentrations are first related to streamflow as shown by the example curve A in figure 2. The average annual constituent load can be estimated from the concentration-duration curve developed by substituting concentrations from curve A into curve B at corresponding discharge rates.

Lake Fork near Cornland (map ref. no. 24, fig. 1) drains 214 mi^2 of agricultural land. About 60 samples of sediment-water mixtures would be analyzed for nutrients, suspended sediment, and particle-size distribution. Data would be used to compare nutrient and sediment yields between growing and non-growing seasons.

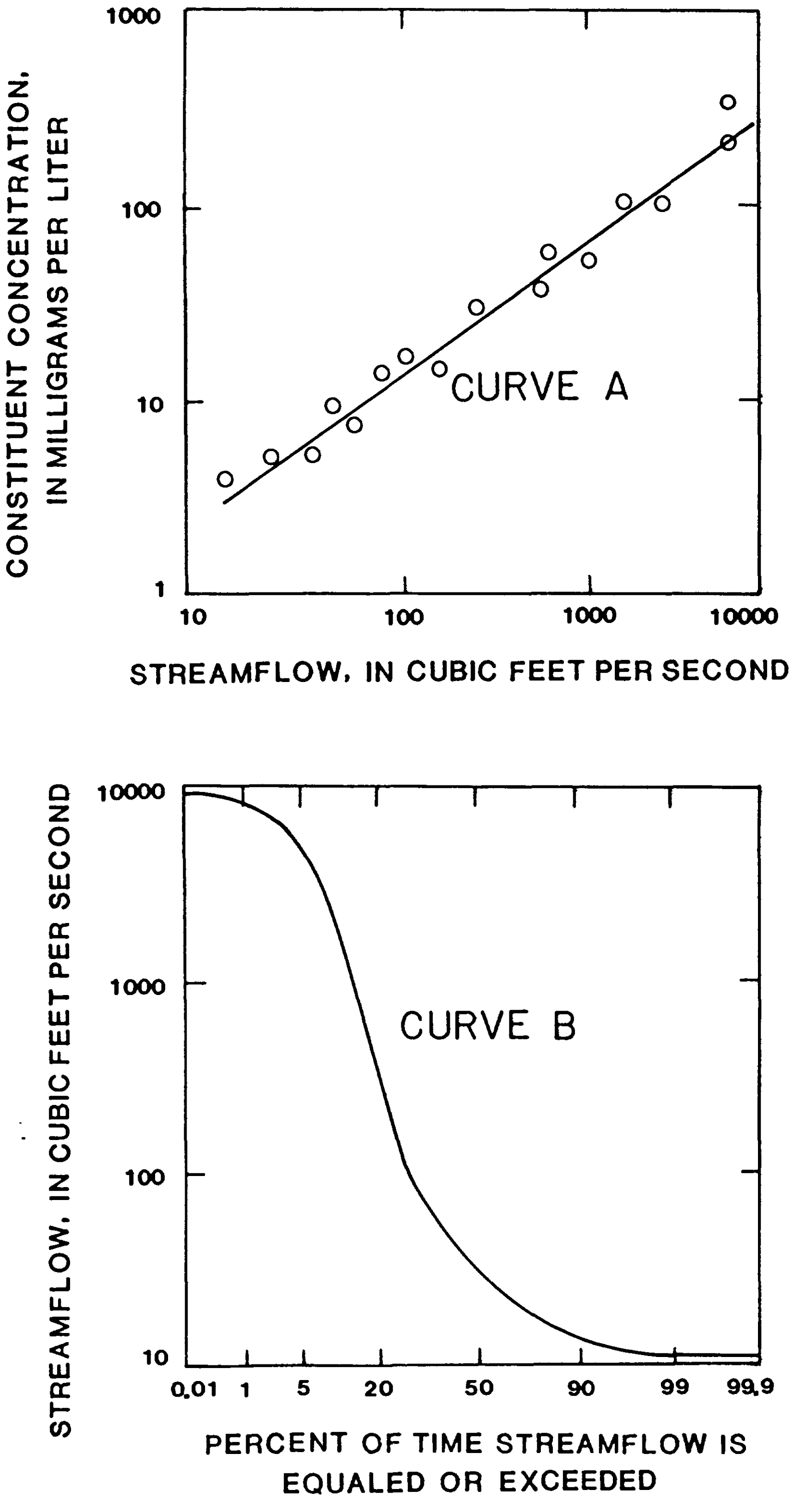

Figure 2.--Constituent concentration related to discharge, curve A, and a flow-duration curve, curve B.

Distribution of Selected Inorganic and Organic Residues in Streambed Sediments

Objectives

1. Determine the occurrence and distribution of pesticide residues in the streambed sediments.

2. Evaluate the effect of urbanization on a primarily agricultural basin.

Approach

Streambed sediments would be analyzed for chlorinated pesticides and lead. The occurrence and distribution of the chlorinated pesticides and lead could be used to assess the impact of agriculture and urbanization, respectively, on the aquatic environment. Samples of bed sediments would be sieved in the field, and the particles less than 62 microns (silt- and clay-sized particles) analyzed. This procedure reduces variation in constituent concentration due to variation in particle-size distribution from site to site and thus provides a common basis for evaluating numerous sites in a drainage basin.

The approach is based on the sparing solubility of chlorinated pesticides in water (California State Water Resources Control Board, 1963) and the affinity of silt- and clay-sized particles for lead. The sediments act as a sink and thus a long-term integrator of water quality.

Bed sediments would be collected at 50 sites, 27 of which are on the main stem of the Sangamon River. The remaining 23 sites are tributaries having drainage areas of 48 mi^2 or greater; this includes tributaries of tributaries. A listing of the proposed sites is shown in table 3. Data interpretation would be based on probability analysis and river-mile plots.

For naturally occurring constituents such as lead, probability analysis can be used to distinguish natural background concentrations from anthropogenic sources. Fine bed sediments are primarily derived from the weathering of rock and, given that no substantial geologic differences are present in a stream basin, concentrations of a particular constituent resulting from such weathering could be expected when widely sampled to be approximately normally distributed. Concentrations of the same constituent may also result from non-geologic sources within the basin and, however they are distributed statistically, would not be expected to be included in the population of data resulting from geologic contributions.

A simple means of distinguishing the two sources (two populations of data) is to plot the cumulative relative frequencies (probabilities) of the aggregated data on normal probability paper and examine the plots for segments having different slopes. Figure 3 shows an example of a situation wherein two populations of data, both normally distributed, plot as two lines of differing slope. The

Table 3.--Proposed sampling sites for bed-material study

Station number	Station name	Drainage area (mi^2)	River mile
	Sangamon River at road in sec.28, T.23 N., R.5 E.	---	230.3
	Sangamon River at State Highway 54	---	219.6
	Sangamon River upstream from Lone Tree Creek	---	213.2
	Lone Tree Creek at mouth at Sangamon River mile 213.2	48.8	0.0
	Sangamon River upstream from Drummer Creek	---	210.8
	Drummer Creek at mouth at Sangamon River mile 210.8	---	0.0
05570910	Sangamon River at Fisher	240	201.1
	Sangamon River upstream from Big Ditch	---	191.5
	Big Ditch at mouth at Sangamon River mile 191.5	---	0.0
05571000	Sangamon River at Mahomet	362	185.7
	Sangamon River upstream from Goose Creek	435	164.0
	Goose Creek at mouth at Sangamon River mile 164.0	58.9	0.0
05572000	Sangamon River at Monticello	550	162.2
05572125	Sangamon River at Allerton Park near Monticello	573	158.0
	Sangamon River upstream from Friends Creek	632	146.3
	Friends Creek at mouth at Sangamon River mile 146.3	129	0.0
05572500	Sangamon River near Oakley	774	143.9
05573000	Sangamon River at Decatur	820	133.4
05573500	Sangamon River at Lake Decatur	925	130.4

Table 3.--Proposed sampling sites for bed-material study--Continued

Station number	Station name	Drainage area (mi^2)	River mile
05573540	Sangamon River at Route 48 at Decatur	938	129.0
	Sangamon River upstream from Stevens Creek	---	126.4
	Stevens Creek at mouth at Sangamon River mile 126.4	---	0.0
05573650	Sangamon River near Niantic	1,054	116.9
05573800	Sangamon River at Roby	1,264	98.5
	Sangamon River upstream from South Fork Sangamon River	1,443	85.3
	Flat Branch at mouth at South Fork Sangamon River mile 55.0	278	0.0
	Clear Creek at mouth at South Fork Sangamon River mile 23.5	---	0.0
	Horse Creek at mouth at South Fork Sangamon River mile 7.4	132	0.0
	South Fork Sangamon River at mouth at Sangamon River mile 85.3	885	0.0
	Lick Creek at mouth at Sugar Creek mile 14.9	---	0.0
	Sugar Creek at mouth at Sangamon River mile 85.3	283	0.0
05576500	Sangamon River at Riverton	2,618	83.1
	Sangamon River upstream from Spring Creek	2,737	73.4
	Spring Creek at mouth at Sangamon River mile 73.4	125	0.0
	Sangamon River upstream from Richland Creek	2,913	57.6
	Richland Creek at mouth at Sangamon River mile 57.6	89.7	0.0
05578000	Sangamon River at Petersburg	3,063	45.9

Table 3.--Proposed sampling sites for bed-material study--Continued

Station number	Station name	Drainage area (mi^2)	River mile
	Sangamon River upstream from Salt Creek	3,116	34.5
	South Fork upstream from confluence with North Fork at North Fork mile 21.6	65.9	0.0
	North Fork at head of Lake Fork	85.9	21.6
	Lake Fork at mouth at Salt Creek mile 34.4	277	0.0
	Kickapoo Creek at mouth at Salt Creek mile 25.5	332	0.0
	Middle Fork Sugar Creek at mouth at West Fork Sugar Creek mile 3.7	96.2	0.0
	West Fork Sugar Creek at mouth at Sugar Creek mile 22.9	186	0.0
	Sugar Creek at mouth at Salt Creek mile 11.0	498	0.0
	Salt Creek at mouth near Curtis at Sangamon River mile 34.5	1,868	0.0
	Sangamon River upstream from Crane Creek	4,995	26.6
	Crane Creek at mouth near Kilbourne at Sangamon River mile 26.6	97.7	0.0
05583500	Sangamon River near Chandlerville	5,208	14.8
	Sangamon River at mouth near Browning	5,419	0.0

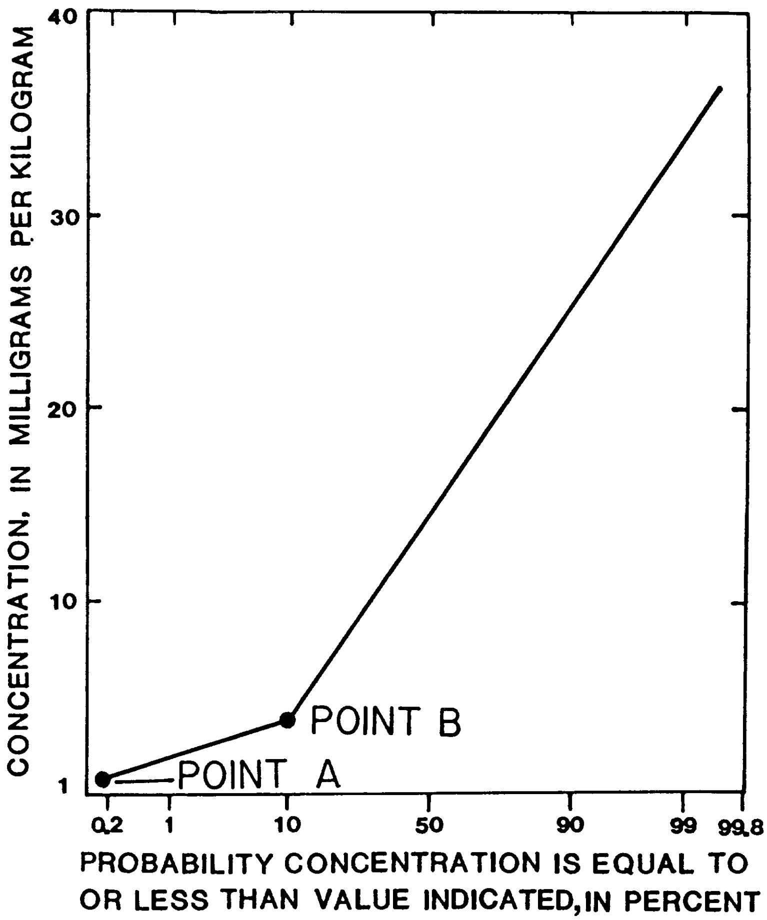

Figure 3.--Cumulative frequency distribution representing two normally distributed populations.

point at which the slope changes can be interpreted as the upper limit of the population containing the lower values. The plot in figure 3 indicates that 10 percent of the observed values represent the lower distribution or presumably background concentrations resulting from natural (geologic) sources.

Waste-Load Assimilative Capacity of the Sangamon River

Objective

Determine the waste-load assimilative capacity of the Sangamon River from Decatur (RM 130.1) to Springfield (RM 83.1).

Approach

A steady-state one dimensional dissolved-oxygen model, such as the model developed by U.S. Geological Survey (D. P. Bauer, M. E. Jennings, and J. E. Miller, written commun., 1978), would be used to compute the desired constituent profiles. Constituent profiles include DO (dissolved oxygen), NH_4, NO_3 + NO_2, organic nitrogen, and BOD_u (ultimate carbonaceous biochemical oxygen demand). Data for calibrating the model would be collected during a low-flow period when the water is warm (about 77°F). During another warm-water, low-flow period, data would be collected for model verification. The model would then be used to evaluate combinations of waste loads from the Decatur sewage-treatment plant and flows from Lake Decatur.

Data requirements for modeling the 47-mile reach, which drains an intervening area of 1,691 mi^2, include time of travel and streamflow measurements on the main stem, streamflow of the seven tributaries in the intervening drainage area, and water quality. Water-quality data include measurements of DO, water temperature, pH, nitrogen and phosphorus species, and BOD_u. Field measurements would be made and water samples collected every 3 hours during the intensive data-collection efforts. A list of proposed stream stations for this study element is given in table 4.

The approach is based on the fact that the DO concentration is affected by deoxygenation and reoxygenation (Velz, 1970). Stream deoxygenation results mainly from the oxidation of decomposable organic material and reduced forms of nitrogen. The amount and rate of deoxygenation are dependent on the magnitude and distribution of BOD_u and ammonium loads, time of travel, and water temperature. Stream reoxygenation depends on the amount of streamflow and atmospheric reaeration. The latter depends on physical factors, which include water temperature, channel morphology, channel volume, and the extent of the oxygen deficit. Rates of deoxygenation and reoxygenation would be estimated from extensive analyses of river and tributary water and wastewater samples, and from detailed time of travel measurements in the river channel. The potential effects of planktonic algae on rates of deoxygenation and reoxygenation would be estimated using the method described by Stephens and Jennings (1976).

Table 4.--Proposed stream stations for the waste-load assimilative study

Station number	Station name	Sangamon River mile
	Sangamon River below Lake Decatur	130.1
	Stevens Creek at mouth	126.4
	Sangamon River at road in sec.27, T.16 N., R.1 E.	119.3
	Sangamon River at road in sec.25, T.16 N., R.1 W.	113.8
	Sangamon River at road in sec.30, T.16 N., R.1 W.	108.8
	Long Point Slough at mouth	108.0
	Mosquito Creek at mouth	106.8
	Sangamon River tributary at mouth	99.7
05573800	Sangamon River at Roby	98.5
	Buckhart Creek at mouth	92.1
	Sangamon River at road in sec.7, T.15 N., R.3 W.	92.0
	Clear Creek at mouth	89.6
	Sangamon River at road in sec.25, T.15 N., R.4 W.	88.2
	South Fork Sangamon River at mouth	85.3
	Sugar Creek at mouth	85.3
05576500	Sangamon River at Riverton	83.1

Hydraulic Model of High Streamflows

Objectives

1. Evaluate the use of Lake Decatur for flood control.

2. Evaluate the effectiveness of future in-stream structures (such as the proposed damming of the Sangamon River by the city of Springfield) for flood control.

3. Evaluate the use of Lakes Decatur and Springfield for water supply and flood control.

Approach

Flood damages are related to peak streamflow, velocity of flow, and duration and depth of inundation. The selection of an appropriate hydraulic flood-routing model is dependent on which flood characteristics are most critical. A study would be made to determine which flood characteristics are critical and to determine which stream reaches should be modeled for planning purposes.

It is anticipated that an existing gradually varied unsteady flow model would be calibrated and verified for two sections of the Sangamon River. Tributary flows to the channel upstream from Lake Decatur would be routed to the lake. Releases from Lake Decatur and flow from tributaries entering the channel downstream from the lake would be routed through a second study reach extending from the lake to the Illinois River.

The morphology of Lakes Decatur and Springfield would be determined to calculate elevation versus capacity relations. Cross-section altitudes of the Sangamon River and roughness coefficients would be determined from air-photo and field surveys at about 100 sites. Historic streamflow records for gaging stations listed in table 5 would be reviewed to determine where additional data should be collected. Time-series data would be collected for at least two flood periods for calibrating and verifying the flow model. These data would include hourly discharge at stations with established stage-discharge relations and mean daily discharge at gaged tributaries. Crest-stage gages would be installed at sites where additional peak-stage data are needed to map an accurate flood profile. The peak discharge of each flood would be measured at selected locations between gaging stations.

The verified flow model would then be used to demonstrate its value as a planning tool. Alternative reservoir-release rules for Lake Decatur or Springfield would be evaluated. Structural flood-control measures such as lake dredging, stream channelization, levee construction, or adding in-stream impoundments could also be evaluated. The model could also be used to evaluate trade-offs between using Lakes Decatur and Springfield for water supply and flood control.

Table 5.--Selected gaging stations having streamflow records

Type of gage: (C) peak stage and peak discharge only; (D) continuous record of stage and discharge; (M) miscellaneous measurement of discharge.

Station number	Station name	Drainage area (mi^2)	Type of gage	Period of record
05571000	Sangamon River at Mahomet	362	D	03/48-09/78
05572000	Sangamon River at Monticello	550	D	02/08-12/12
			D	06/14-
05572500	Sangamon River near Oakley	774	D	07/51-09/77
05576000	South Fork Sangamon River near Rochester	867	D	07/49-
05576500	Sangamon River at Riverton	2,618	D	03/08-12/12
			D	09/14-10/56
			C	11/56-
05578000	Sangamon River at Petersburg	3,063	D	01/48-09/49
			M	1950-51
			M	1958-77
05581500	Sugar Creek near Hartsburg	333	D	10/44-09/71
			C	10/71-
05582000	Salt Creek near Greenview	1,804	D	10/41-
05583000	Sangamon River near Oakford	5,093	D	10/09-10/11
			D	12/11-03/12
			D	08/14-06/19
			D	03/21-09/22
			D	10/28-12/33
			D	10/39-

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