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INCREASED DURATIONS OF HIGH FLOWS ALONG THE ILLINOIS AND MISSISSIPPI RIVERS: TRENDS AND AGRICULTURAL IMPACTS (PHASE 1)

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Prepared for the
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I. INTRODUCTION

This project deals with the economics of farming in the bottomlands of the floodplains along the Illinois and Mississippi Rivers. Climate change, increased urbanization, and reduced flood storage capacity due to severance of floodplain areas by levees have increased the magnitude and duration of flooding along the major rivers. The magnitude, frequency, and duration of the flood determine the costs incurred for pumping and other related activities such as cleaning and maintenance of drainage ditches. This expense varies from year to year, adding to the uncertainty in income realized by farmers in the levee districts.

Fluctuations in price and yield are the two major uncertainties that every farmer confronts. If the yield uncertainty of a crop is uniform throughout the production area, then the resulting impact on the supply affects price levels inversely. This phenomenon helps to keep revenues stable. However, the yield uncertainty is usually local in nature though at times it can extend to a very large area. With the advent of faster transportation and means of communication and with lesser trade barriers, price uncertainty is becoming a global phenomenon, especially in the case of grains. Therefore for individual fanners the yield and price risks are becoming independent risks. This volatility in revenue levels adversely affects the survivability of farm firms in general. Farmers operating in levee districts have to bear the additional cost of pumping and the risk associated with it The total risk borne by farmers within levee districts is therefore higher than that borne by other fanners. In an economic climate that presents multi-dimensional problems for Illinois agriculture, the additional risks inherent in farming within levee districts threaten the long-term survivability of these farms.

Previous research on these issues concerning farms in levee districts is very limited. The focus of this project is the determination of the extent to which present high-flow trends in major rivers affect the economics of farming in the levee districts. Selected levee districts along the Illinois and Mississippi Rivers are being analyzed to determine the economic impact of ground-water pumping on profitability of the farms. Our preliminary analyses are based on the results of a questionnaire sent to levee district commissioners. A second questionnaire has been developed and mailed to levee district farmers to collect data on the economic aspects of farming in levee districts.

In the following sections we discuss previous literature, organizational aspects of levee districts, identification . of levee districts, the information gathered through field visits, primary and secondary sources of data, results of preliminary analyses, and an economic model. Finally, we outline the remaining tasks.

Literature Review

A catalog and shelf search of the Illinois State Water Survey library, and use of the University of Illinois Library Computer System (LCS) produced about 30 citations on related subjects. Information on water law and water rights and on involved government agencies was also researched.

Previous studies in this area have been identified for reference and comparison. A study by the Illinois Department of Conservation (19S0) looked at the possibility of converting low-lying levee district land into lateral reservoirs for flood control and environmental conservation purposes. This study met with strong opposition from district representatives and landowners.

A more recent study conducted by Gibb et al. (1979) examined the effects of increased diversion of Lake Michigan water to the Illinois Waterway on the farms in drainage and levee districts. Regression analysis was used to estimate the relationship between monthly river stages and monthly power consumption and to simulate the power costs for various levels of water diversion. Gibb et al. found that for the simulated year of normal flows, 1971, average percentage increases in power costs were 10.3 percent and 20.0 percent for diversions of 6,600 cfs and 10,000 cfs, respectively. The percentage increase in the power cost for the simulated year of high flows, 1973, was 3.5 percent for 6,600 cfs diversion. For the simulated year of low flows, 1977, average percentage increases in power costs were 23.9 percent and 42.7 percent for 6,600 and 10,000 cfs diversions.

Acknowledgments

This study was conducted under the general guidance of Richard G. Semonin, Chief, and Richard J. Schicht, Assistant Chief, Illinois State Water Survey. Gopal Naik and Natalie Yockey (graduate students in agricultural economics at the University of Illinois) and George Graettinger (part-time research associate) assisted in preparing questionnaires, conducting statistical analyses, and developing the econometric model. We thank the commissioners of the different levee districts who responded to our first questionnaire. In particular, the commissioners of the Farmers Levee and River, Lacey, West Matanzas, and Sny Island Drainage and Levee Districts provided information on the operational aspects of levee districts and made suggestions for improving the questionnaires.

This study was jointly supported by the Illinois Department of Energy and Natural Resources and the Illinois State Water Survey. Linda Vogt of the Department of Energy and Natural Resources served in a liaison capacity during the study and provided helpful suggestions.

II. ILLINOIS DRAINAGE AND LEVEE DISTRICTS: A SURVEY

Organization and Economic Role of Levee Districts

About 95 percent of the floodplain area in Illinois is highly productive agricultural land (USCOE, 1961). Most of these lands are protected by agricultural levees. Larger levees are usually constructed or rehabilitated by the federal government under the flood control program. The U. S. Army Corps of Engineers is responsible for such construction or rehabilitation. Smaller levees are usually constructed with private funds.

Levee construction in Illinois started as early as 1812, but few levees were constructed before 1890. A comprehensive mapping survey of the Illinois River performed by the Corps of Engineers in 1902-1904 helped in the rapid progress of levee construction along the Illinois River. This progress continued until the 1930's.

The Farm Drainage Act of 1879 and the Levee Act of 1879 are the earliest laws concerning levee districts in Illinois. A levee could be constructed under either of these Acts. Between 1873 and 1890, 30 drainage districts were formed under the Drainage Act and 7 under the Levee Act. After 1890 most districts were organized under the Levee Act, which provided for larger districts (League of Women Voters of Champaign County, 1977). According to the Inventory of Illinois Drainage and Levee Districts (Illinois Department of Business and Economic Development, 1971) there are approximately 1654 drainage districts in Illinois, of which 800 are reportedly active.

A drainage district may be organized by filing a petition in the county court signed by a majority of the landowners who own one-third of the land within the proposed district, or by one-third of the landowners who own a majority of all land in the proposed district. Alternatively, a petition signed by at least one-tenth of the adult owners who own at least one-fifth of the land can be filed in the county court. In this case, a referendum must be held and passed by a majority of the landowners within the proposed district boundaries.

A levee district has three commissioners appointed by the county court, who serve staggered terms. They have the power to levy assessments upon all the landowners within the district to maintain district facilities such as pumping plants and the levees.

The role of levees in protecting the farmlands is undoubtedly very important The importance of drainage and levee districts from an economic standpoint has been aptly summarized by the Illinois Department of Business and Economic Development (1971) as follows: "Drainage districts have played an important part in the development of Illinois - both agriculturally and economically. Through their formation and operation, the fertile wetlands and major floodplains of the State have been developed into prime agricultural lands. Continued operation and

improvement of these drainage districts will allow this progress to continue."

The approximate percentages of agricultural land under levee districts in counties located along the Sangamon, Illinois, Kaskaskia, and Mississippi Rivers are presented in Table A1 in Appendix A. Data on total cropland for each county were obtained from Illinois Agricultural Statistics, 1986. The percentage of area under levee district for each county is the area under levee district divided by the total cropland in the county (multiplied by 100). Data on the area under levee districts are obtained from the Inventory of Illinois Drainage and Levee Districts (Illinois Department of Business and Economic Development, 1971). These values were checked against the data obtained from the preliminary survey of levee district commissioners and modified where necessary. The percentage of cropland area under levee districts varies from 1.5 in Carroll County to 49.S in Union County. These figures do not include the levee districts along small tributaries or those that are inactive. In ten counties the percentage of cropland area under levee districts exceeds 10%, which suggests that profitability of the farms within the levee districts can substantially affect the counties' economy.

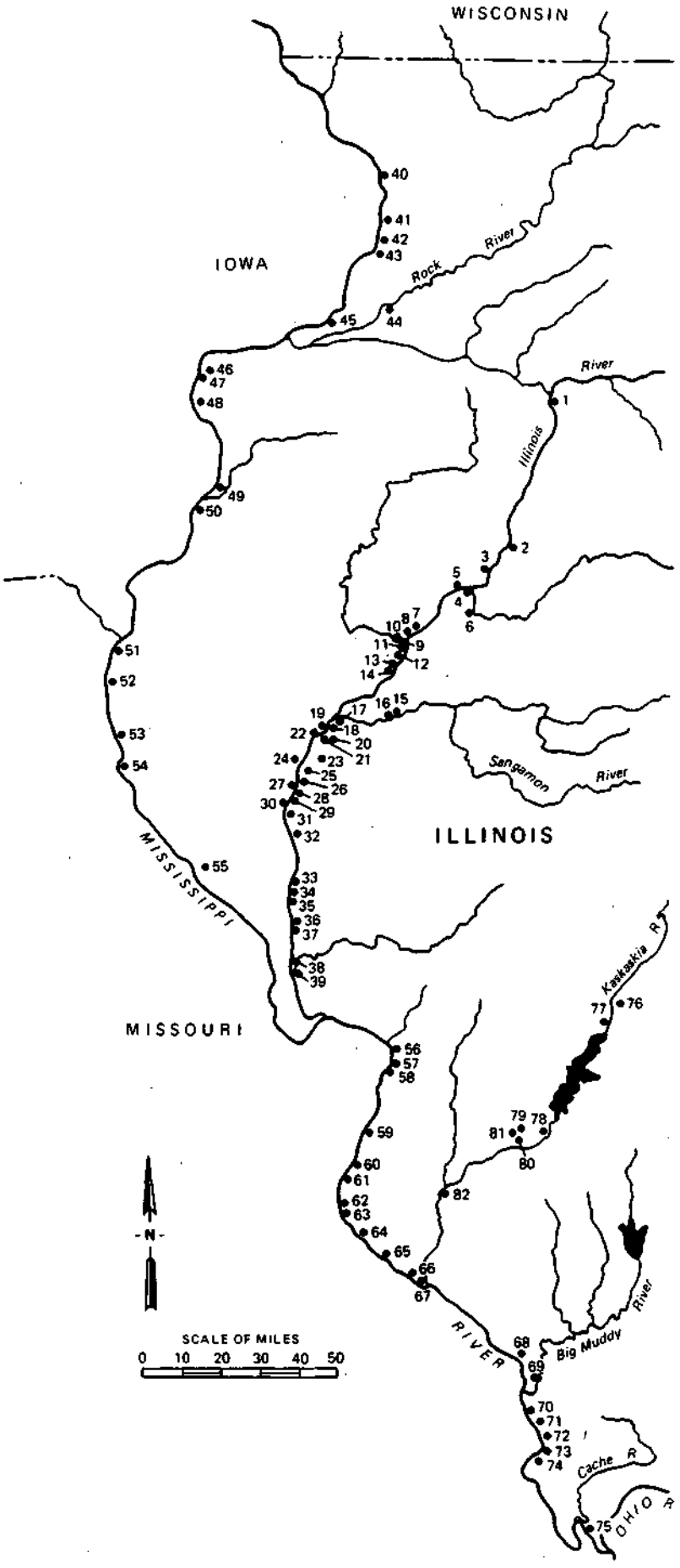
Identification of Levee Districts

The first major task of this project was the identification of levee districts along the Mississippi River (from Jo Daviess County to the city of Cairo) and along the Illinois River (from Bureau County to the confluence with the Mississippi River). The total number of drainage and levee districts is difficult to determine. There is no central authority governing them, and some districts have prolonged periods of inactivity.

From the information obtained from the U.S. Army Corps of Engineers (USCOE) Districts in Rock Island and St. Louis, and the Division of Water Resources, Illinois Department of Transportation (DWR), a total of 77 active drainage and levee districts along the Illinois and Mississippi Rivers have been identified. Of these districts 41 are located along the Illinois River, 16 along the Upper Mississippi River (north of Grafton), and the remaining 20 along the Lower Mississippi River. The locations of these levee districts and the districts along the Sangamon and Kaskaskia Rivers are shown in Figure 1.

Field Visits

In order to gather first-hand information on the levee districts, field visits were made to three different levee districts. The first visit was to the Farmers Drainage and Levee District in Saidora in Mason County. This district is located along the Sangamon River about 10 miles upstream of its mouth at the Illinois River. During this visit we



NO.	COUNTY	DRAINAGE AND LEVEE DISTRICT
1	PUTNAM	HENNEPIN
2	TAZEWELL	EAST PEORIA
3	PEORIA	PEKIN & LA MARSH
4	TAZEWELL	SPRING LAKE
5	PEORIA	BANNER SPECIAL
6	TAZEWELL	MACKINAW RIVER
7	FULTON	EAST LIVERPOOL
8	FULTON	LIVERPOOL
9	FULTON	THOMPSON LAKE
10	FULTON	ZEMPEL MUTUAL
11	FULTON	KERTON VALLEY
	FULTON	LACEY
	FULTON	LANGELLIER
	FULTON	WEST MATANZAS
12	FULTON	SEAHORN
13	SCHUYLER	BIG LAKE
14	SCHUYLER	KELLY LAKE
15	MASON	HERGET
16	MASON	FARMERS LEVEE AND RIVER
17	CASS	HAGER SLOUGH
18	CASS	LOST CREEK
19	SCHUYLER	COAL CREEK
20	CASS	VALLEY
21	CASS	SOUTH BEARDSTOWN
22	SCHUYLER	CRANE CREEK
23	CASS	MUD CREEK
24	BROWN	LITTLE CREEK
25	CASS	MEREDOSIA LAKE
26	MORGAN	WILLOW CREEK
27	BROWN	MCGEE CREEK
28	MORGAN	COON RUN
29	SCOTT	MAUVAISE TERRE
30	PIKE	VALLEY CITY
31	SCOTT	SCOTT COUNTY
32	SCOTT	BIG SWAN
33	GREENE	HILLVIEW
34	GREENE	HARTWELL
35	GREENE	KEACH
36	GREENE	SPANKEY
37	GREENE	ELDRED
38	GREENE	MACOUPIN CREEK
39	JERSEY	NUTWOOD
40	CARROLL	CARROLL COUNTY MUTUAL
41	WHITESIDE	JOHNSON CREEK
42	WHITESIDE	CATTAIL
43	WHITESIDE	MEREDOSIA
44	HENRY	PENNY SLOUGH
45	ROCK ISLAND	CAMPBELLS ISLAND
46	ROCK ISLAND	DRURY
47	ROCK ISLAND	SUBDISTRICT #1
48	MERCER	BAY ISLAND
49	HENDERSON	HENDERSON COUNTY #1
50	HENDERSON	HENDERSON COUNTY #2
51	HANCOCK	HUNT
52	ADAMS	LIMA LAKE
53	ADAMS	INDIAN GRAVE
54	ADAMS	SOUTH QUINCY
55	PIKE	SNY ISLAND
56	MADISON	WOOD RIVER
57	MADISON	CHOUTEAU, NAMEOKI, & VENICE
58	MADISON	CHOUTEAU ISLAND
59	ST. CLAIR	PRAIRIE DUPONT
60	MONROE	FISH LAKE
61	MONROE	COLUMBIA
62	MONROE	HARRISONVILLE & IVY LANDING
63	MONROE	MOREDOCK & IVY LANDING
64	MONROE	FORT CHARTRES & IVY LANDING
65	MONROE	STRINGTOWN-FORT CHARTRES & IVY LAND
66	RANDOLPH	PRAIRIE DUROCHER & MODOC
67	RANDOLPH	EDGAR LAKE
68	JACKSON	DEGOGNIA & FOUNTAIN BLUFF
69	JACKSON	GRAND TOWER
70	UNION	PRESTON
71	UNION	MILLER POND
72	UNION	CLEAR CREEK
73	ALEXANDER	NORTH ALEXANDER
74	UNION	EAST CAPE GIRARDEAU & CLEAR CREEK
75	ALEXANDER	CAIRO
76	FAYETTE	DIVELY
77	FAYETTE	VANDALIA
78	CLINTON	SANTA FE
79	CLINTON	GERMANTOWN
80	CLINTON	HANOVER
81	CLINTON	HEIMANN
82	ST. CLAIR	VILLAGE OF NEW ATHENS

Figure 1. Locations of selected drainage and levee districts in Illinois

were able to get detailed information on some of the problems encountered by levee districts. The commissioner of this district also provided valuable suggestions that were later incorporated in the final version of the preliminary questionnaire.

The second field trip included a meeting with commissioners of the Lacey and West Matanzas Drainage and Levee Districts located in Fulton County, followed by a visit to the pumphouse serving the Lacey, West Matanzas, and Langlier Districts. We also went to Lewistown, Fulton County, to determine the extent of data available at the county courthouse on the financial and operating aspects of levee districts. Finally, we visited the ASCS office in Lewistown to determine the type of data collected from farmers participating in government programs.

The discussions with the commissioners provided insights on the arrangements made by cooperating levee districts to operate as a single unit The commissioners also provided valuable suggestions for improving the second questionnaire, which will be used to collect data on the economics of farming within levee districts. The operator at the pumphouse provided a brief overview of the pumping operations. During the summer, differential power rates exist for night and day periods. To reduce costs, pumping is usually restricted to nighttime, when power rates are lower.

We also visited the Sny Island Levee Drainage District on the Mississippi River, which is the largest district in our study area. This district is 51 miles long and protects 113,397 acres of land. The district has kept detailed and well-recorded information on its operational aspects for many years. We obtained information on daily pumping hours, river levels, and precipitation data for the last 12 years. We also obtained data on fuel consumption and detailed cost items for the last 20 years. These data will enable us to establish a relationship between river stages and pumping expenses. The final version of the second questionnaire was also tested here.

III. ECONOMIC ANALYSES OF DRAINAGE AND LEVEE DISTRICTS

Primary Data Collection and Analysis

To meet the objectives of this study, detailed information is needed on the operation and functioning of levee and drainage districts located along the Illinois and Mississippi Rivers. Also needed are time series data on production and financial aspects of the individual farms within the levee districts. Since secondary-source data on the functioning of levee districts are scanty, data need to be collected from primary sources. This is being accomplished in two stages by using mail-in surveys. In the first stage, information on the operational characteristics of levee districts was collected from commissioners of the various districts. In the second stage, data pertaining to the financial and production aspects of farms in the levee districts will be collected from individual farmers.

The questionnaire for drainage and levee district commissioners was mailed to commissioners of 77 districts located along the Illinois and the Mississippi Rivers. We also sent questionnaires to 7 districts along the Kaskaskia River and 2 districts along the Sangamon River. This questionnaire is given in Appendix B. The initial response rate was around 30 percent A follow-up letter was then sent to the district commissioners who had not responded. Statistics on the number of questionnaires sent and received are presented in Table 1.

Table 1. Number of questionnaires sent and received

River	Questionnaires sent	Questionnaires received	Percentage response
Illinois	41	28	68
U. Mississippi	16	8	50
L. Mississippi	20	9	45
Kaskaskia	7	3	43
Sangamon	2	2	100
Total	86	50	58

U. Mississippi refers to Mississippi River north of Grafton
L. Mississippi refers to Mississippi River south of Grafton

The highest percentage response was obtained from the districts along the Illinois River, and the lowest percentage response was from the districts along the Lower Mississippi River (excluding the Kaskaskia and Sangamon Rivers). The overall response rate was 58 percent The response rate by size of the levee districts (number of acres of land protected) is given in Table 2.

Table 2. Response rate by size of levee districts

Size (acres)	Questionnaires sent	Questionnaires received	Percentage response
< 2000	16	7	44
2001 - 5000	28	17	61
5001 - 10000	15	7	47
> 10000	27	19	70

The districts that responded to the questionnaire represent a stratified random sample of the population of levee districts in terms of size and location (Table 1 and Table 2). Thus it is possible to generalize our findings on the basis of the data obtained from the questionnaires. The information gathered from the questionnaires was classified, coded, and analyzed. A brief discussion of the summary statistics follows.

The utilization and ownership characteristics of land within the levee districts along the Illinois and Mississippi Rivers are summarized in Table A2 in Appendix A. The average acreage protected by a levee district in the combined area is 9,843.3 acres. The average acreage for the Upper Mississippi River is much higher than for other areas because the Sny Island District located along the Upper Mississippi River covers a very large area (around 113,000 acres). The percentage of area under agriculture varies from 88.67 for levee districts along the Lower Mississippi to 98.46 for districts along the Illinois River. The percentage of land under agriculture for the combined area is 96.58, which emphasizes the importance of agriculture within levee districts. Except in the case of levee districts along the Lower Mississippi River, the land used for industrial and residential use is negligible.

The average number of farms in a district varies from 19 for the districts along the Illinois River to 139 for districts along the Upper Mississippi River. This number for the Upper Mississippi is high because the Sny Island Levee District consists of a very large number of farms (600). The number of corporate farms in the levee districts is very small irrespective of the location of the districts. The large number of family-owned farms suggests the need for careful consideration of the profitability of the farms in the levee districts.

The percentages of districts growing corn, soybeans, and wheat are given in Table 3. Com and soybeans are grown in every district along the Illinois and Upper Mississippi Rivers. For the districts along the Lower Mississippi River, corn, soybeans, and wheat are equally important Other crops grown in the levee districts such as milo, hay, and clover are mainly for forage purposes.

Table 3. Percentage of levee districts growing different crops

Crop	Illinois River	U. Mississippi River	L. Mississippi River	Combined
Corn	100	100	88.9	98.0
Soybeans	100	100	88.9	98.0
Wheat	71.4	62.5	88.9	72.0

Flooding seems to be a regular problem, especially for the districts along the Lower Mississippi and Illinois Rivers. About 90% of the districts along the Lower Mississippi River and 60% along the Illinois River reported flooding as a major problem at least once every five years. This compares with only 40 percent of the districts along the Upper Mississippi River experiencing similar problems. The different drainage systems in use are indicated in Table 4.

Table 4. Percentage of levee districts using drainage systems

Drainage system	Percentage of levee districts			
	Illinois River	U. Mississippi River	L. Mississippi River	Combined
Open ditch	85.7	100.0	88.9	88.0
Tile system	57.1	25.0	22.2	40.0
Pump station	96.4	75.0	44.4	80.0

Open ditches and pump stations are the major drainage systems used by the districts along both the Illinois and Mississippi Rivers. Open ditches are the main type of drainage for most districts along the Mississippi River. Pump stations are the primary means of drainage for districts along the Illinois River. This indicates that the need for pumping may be higher for districts along the Illinois River than for other districts.

Some of the important characteristics of the levees along the Illinois and Mississippi Rivers are summarized in Table A3 in Appendix A. A majority of levee districts were established more than SO years ago. An average of 87.4 percent of the levees are designed to protect against the 50-year flood. Some new levees have been constructed during the last 10 years.

The pumping requirements of the levee districts are summarized in Table A4 of Appendix A. Pumping is required in all the districts along the Illinois River and in 87.5% of the districts along the Upper Mississippi River. Only SO percent of the districts along the Lower Mississippi River need pumping. All the districts along the Illinois and Upper Mississippi, and 60 percent along the Lower Mississippi, pumped eight or more years during the last ten years. It was generally felt that without pumping the crop-growing season would be severely curtailed.

The pumping and total expenses per acre for the levee districts for the period 1981 through 1986 are presented in Table 5.

Table 5. Pumping and total expenses of the levee districts for the period 1981-86, in $/acre

Expenses	Year	Illinois River	U. Mississippi River	L. Mississippi River	Combined
Pumping					
	1981	5.78	3.63	0.37	4.65
	1982	8.54	6.19	0.43	7.07
	1983	7.78	4.93	1.09	6.62
	1984	6.38	5.95	1.20	5.58
	1985	5.63	5.45	0.96	4.98
	1986	5.11	6.83	1.04	4.78
Total					
	1981	10.26	8.05	1.45	7.76
	1982	13.53	9.72	1.38	10.05
	1983	13.27	9.10	2.10	10.48
	1984	11.67	10.56	1.73	9.45
	1985	10.34	9.51	1.58	8.49
	1986	11.17	10.51	1.49	9.11

Total expenses of the districts include general maintenance in addition to pumping costs. Both pumping and total expenses per acre were higher for the districts along the Illinois River than for districts along the Mississippi River. These expenses were lowest for the districts along the Lower Mississippi River. The pumping cost varied from $5.11 in 1986 to $8.54 in 1982 for the districts along the Illinois River, and from $3.63 in 1981 to $6.83 in

1986 for the Upper Mississippi River. The variations in total expenses were similar to the variations in pumping cost The total cost per acre was as high as $13.53 in 1982 for districts along the Illinois River and $10.56 in 1984 for the districts along the Upper Mississippi River.

Costs of repair and maintenance of equipment and the levees seem to be a major concern of most of the district commissioners. The commissioners of the districts along the Illinois River are also concerned about any future increased diversions from Lake Michigan into the Illinois River.

Secondary Data Collection and Analysis

Three sets of secondary information have been collected to meet the objectives of this project The first set of information deals with the location, topographical features, and administration of the levee districts. In the second set, data relating to agriculture - such as data on crop yields and prices, percent acreage under cultivation, and net returns for Illinois farms - are obtained from *Farm Incomes and Production Cost Summary* published by the Department of Agricultural Economics, University of Illinois. In the third set, data on river stages and discharges, and precipitation at different locations, are analyzed

As part of the first set of information, we have obtained copies of the following publications:

1. Upper Mississippi River Navigation Charts

2. Charts of the Illinois Waterway

3. Drainage District Commissioners of Illinois

The. charts, which are published by the USCOE, show the drainage and levee districts that border the Illinois and Mississippi Rivers and their locations in terms of river mileage. The third item is a list of drainage district commissioners compiled by the Water Resources Commission in 1977.

To determine the topography and floodplain characteristics of the levee districts, the locations have been delineated on appropriate topographical maps. A total of 115 quadrangle (7.5 minute) topographical maps that show the Illinois River (from Grafton to the confluence with the Kankakee River) and the Mississippi River (from Grafton to the Illinois-Wisconsin border) were obtained from the Illinois State Geological Survey. These maps provide information on the areas that are protected by the different levee districts.

Data on physiographic and hydrologic factors pertaining to the levee districts have been collected and computerized. River stage data for selected locations on the Illinois and Mississippi Rivers have been requested from the USGS office in Champaign. Available river cross-sectional data will be obtained and analyzed to

determine any rise in streambed due to sedimentation, and the resulting effect on stage-discharge rating curves.

For the second set of data, we have gathered data relating to acreage under cultivation, crops, yields, and prices for Illinois from Illinois Agricultural Statistics, and data on net returns for Illinois farms from the annual report of the Farm Business and Farm Management Association. The yields and prices of com, soybeans, and wheat for the period 1977 through 1986 are shown in Figures 2 through 4. It can be seen from these figures that price and yield do not necessarily move in opposite directions at all times. For example, in 1986 the yields remained more or less at the level of 1985, but prices dropped from 198S to 1986. Wheat prices have been less dependent on yields than com and soybean prices have been.

The operator's share labor and management income per acre on representative Illinois grain farms for the same period is shown in Figure 5. The operator's share labor and wage is equal to the net farm income minus unpaid family labor and interest on capital. This income varied substantially from a minimum of -$15.52 per acre (a net loss) in 1981 to a maximum of $43.05 per acre in 1979. This volatility in income indicates the level of net-return risks inherent in Illinois agriculture. The pumping cost adds to this risk for farms operating within levee districts and can have an adverse impact, especially during a period of low net returns.

For the third set of data, we have obtained data on river stages and discharges at four gaging stations located on the Illinois River and four gaging stations on the Mississippi River. Data on daily precipitation at several locations along the Illinois and Mississippi Rivers have also been collected and computerized. The flow data at the four gaging stations on the Illinois River were analyzed to determine the magnitude of high flows for various durations. Specifically, the magnitudes of the 7-, 15-, 31-, and 61-day high flows for each year for the period of record were computed. The 10-year moving average of the various high-flow parameters (7-, 15-, 31-, and 61-day high flows), plotted with respect to time for the Illinois River at Marseilles, is shown in Figure 6. There is a trend toward increasing high flows starting in 1960. In Figure 7, flow-duration curves for the Illinois River at Marseilles are plotted for two separate periods: 1920-1939 and 1940-1983. The first of these two periods was prior to the regulation affecting diversions from Lake Michigan to the Illinois River. It can be seen from figure 7 that although the diversions from Lake Michigan were sharply reduced to an average of 3,200 cfs starting in 1939, the high flows (starting from about the 5% exceedance probability, or flows exceeded 5% or less of the time) are higher now than they were prior to regulation. Highlights of these initial findings were presented at the Illinois Lake Management Association Conference held in Peoria in April 1987.

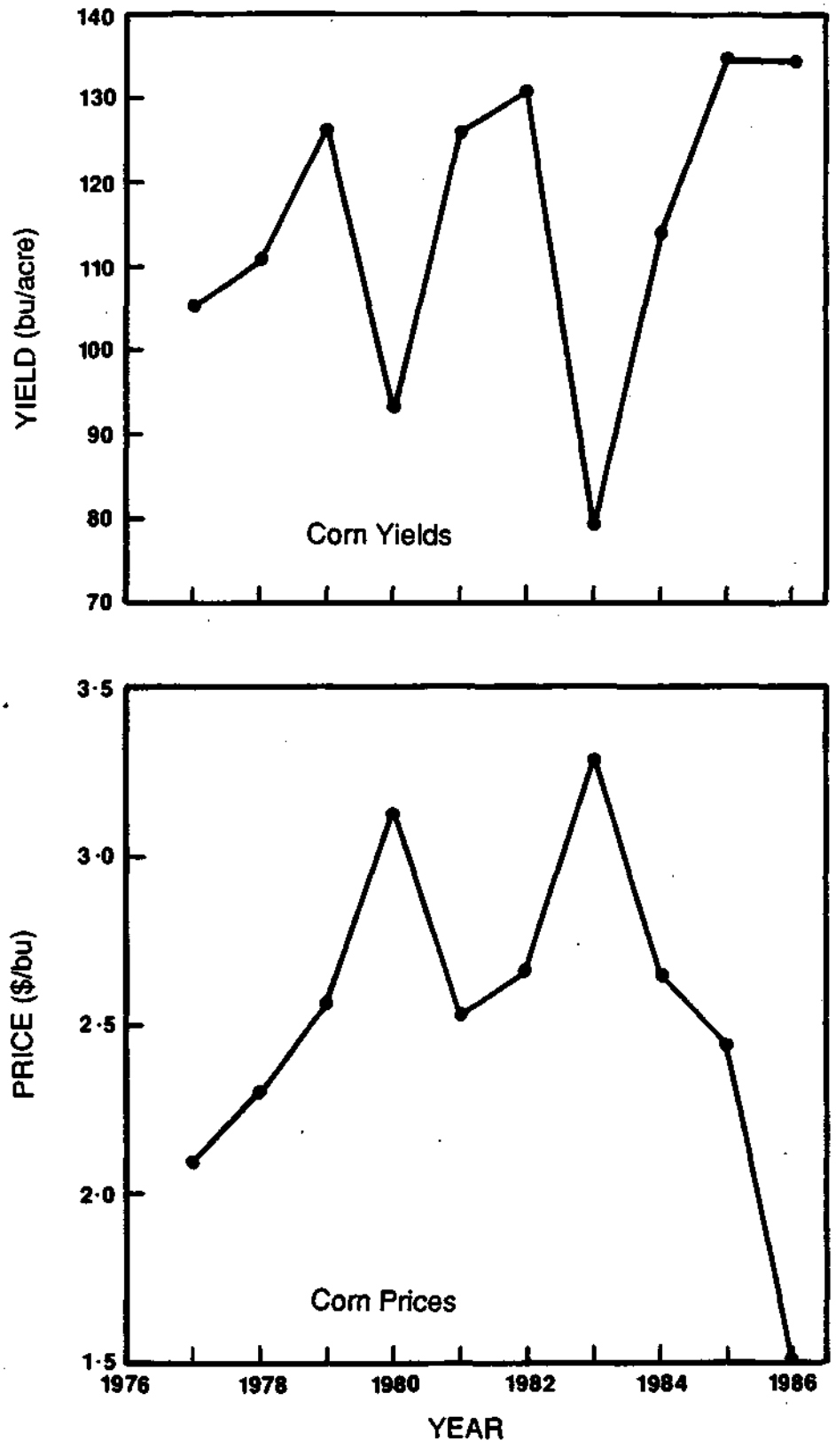


Figure 2. Corn yields and prices in Illinois for the period 1977-1986

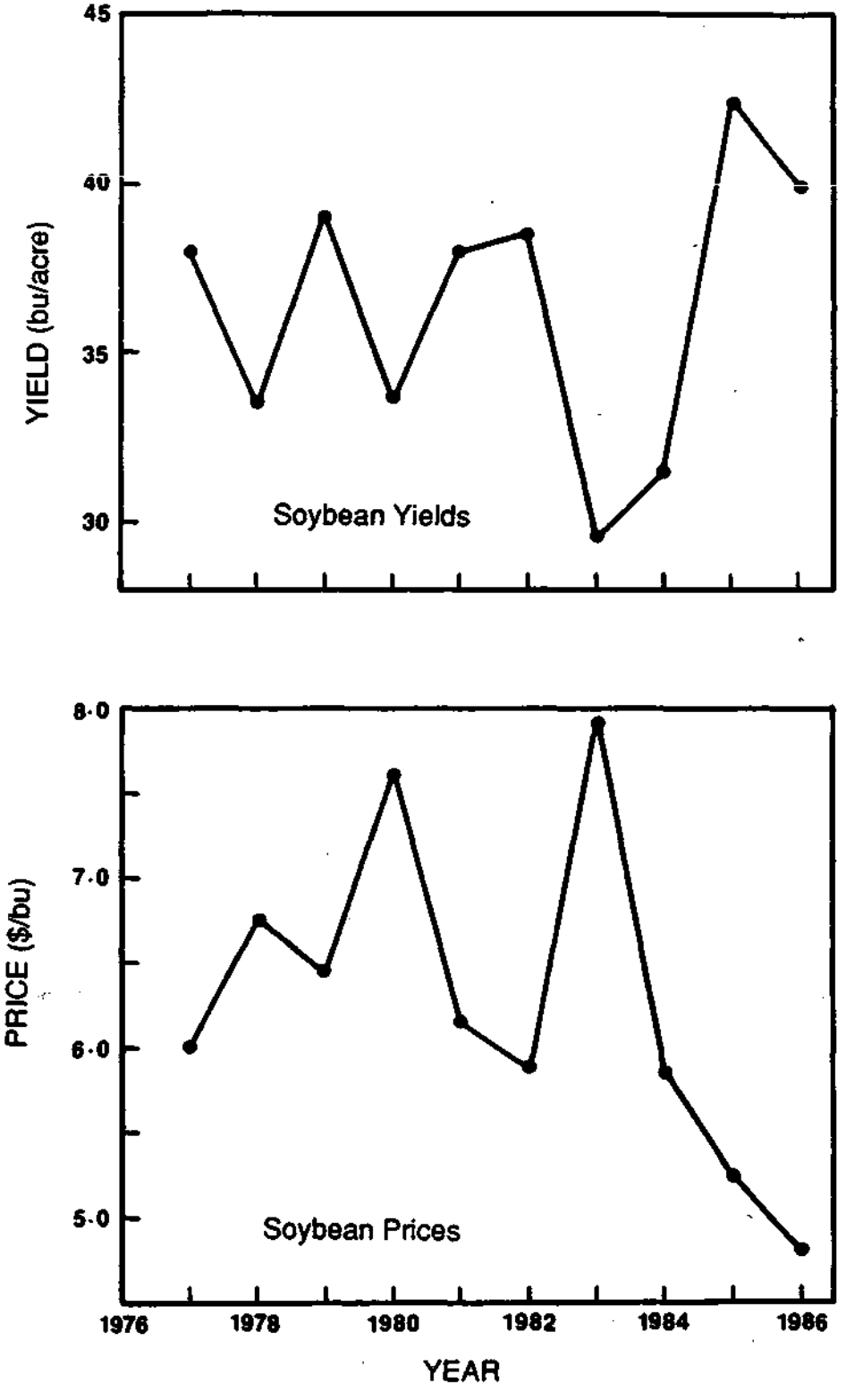


Figure 3. Soybean yields and prices in Illinois for the period 1977-1986

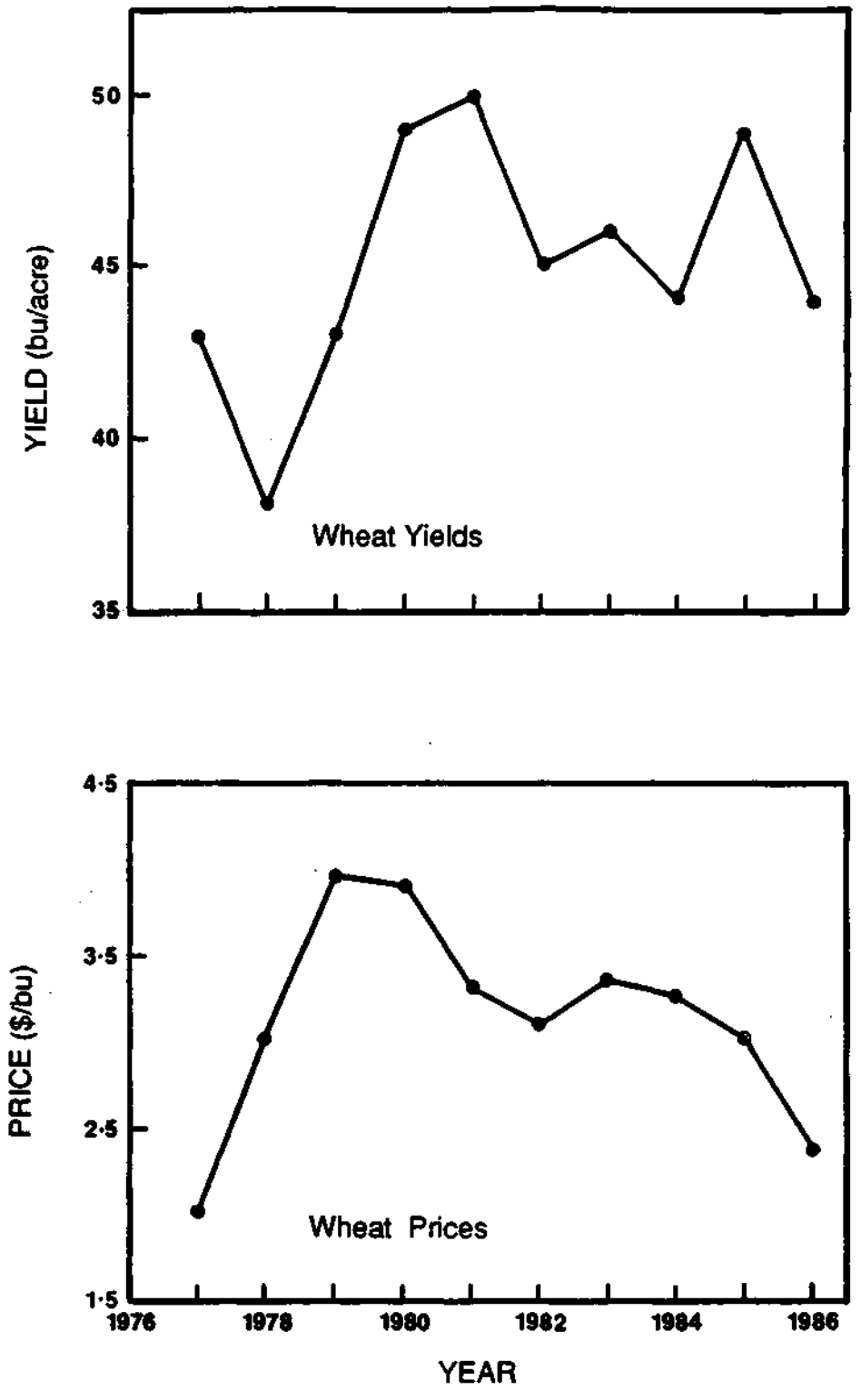


Figure 4. Wheat yields and prices in Illinois for the period 1977-1986

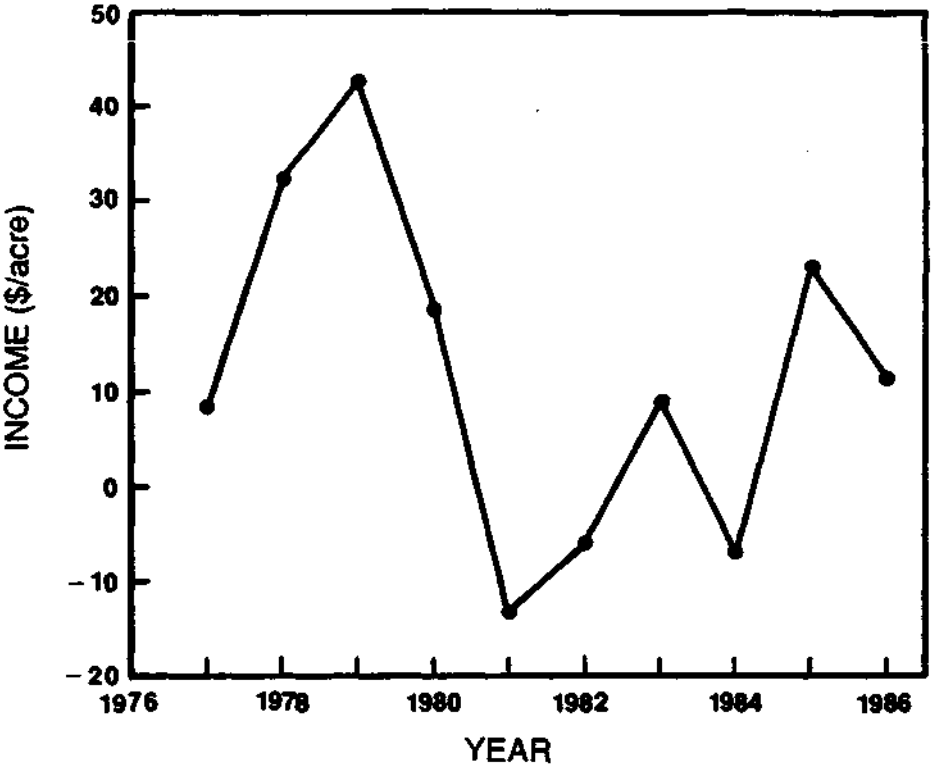


Figure 5. Operator's share labor and management income on Illinois grain farms for the period 1977-1986

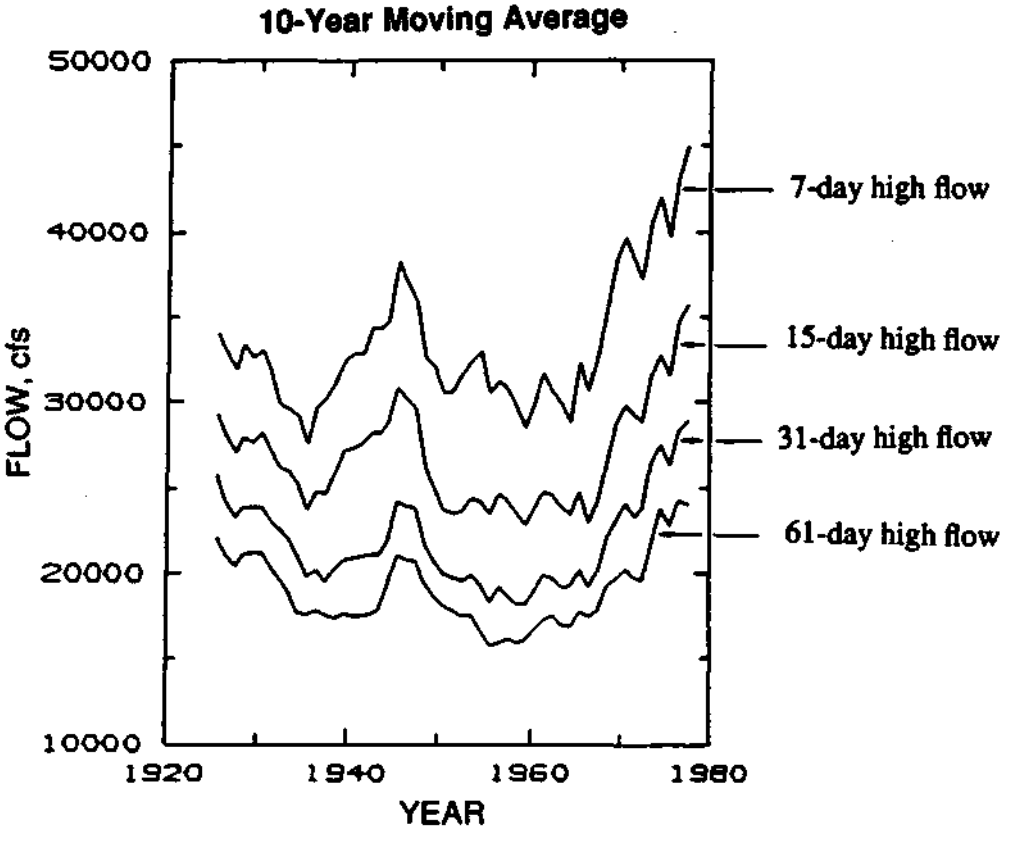


Figure 6. Trends in high flows, Illinois River at Marseilles

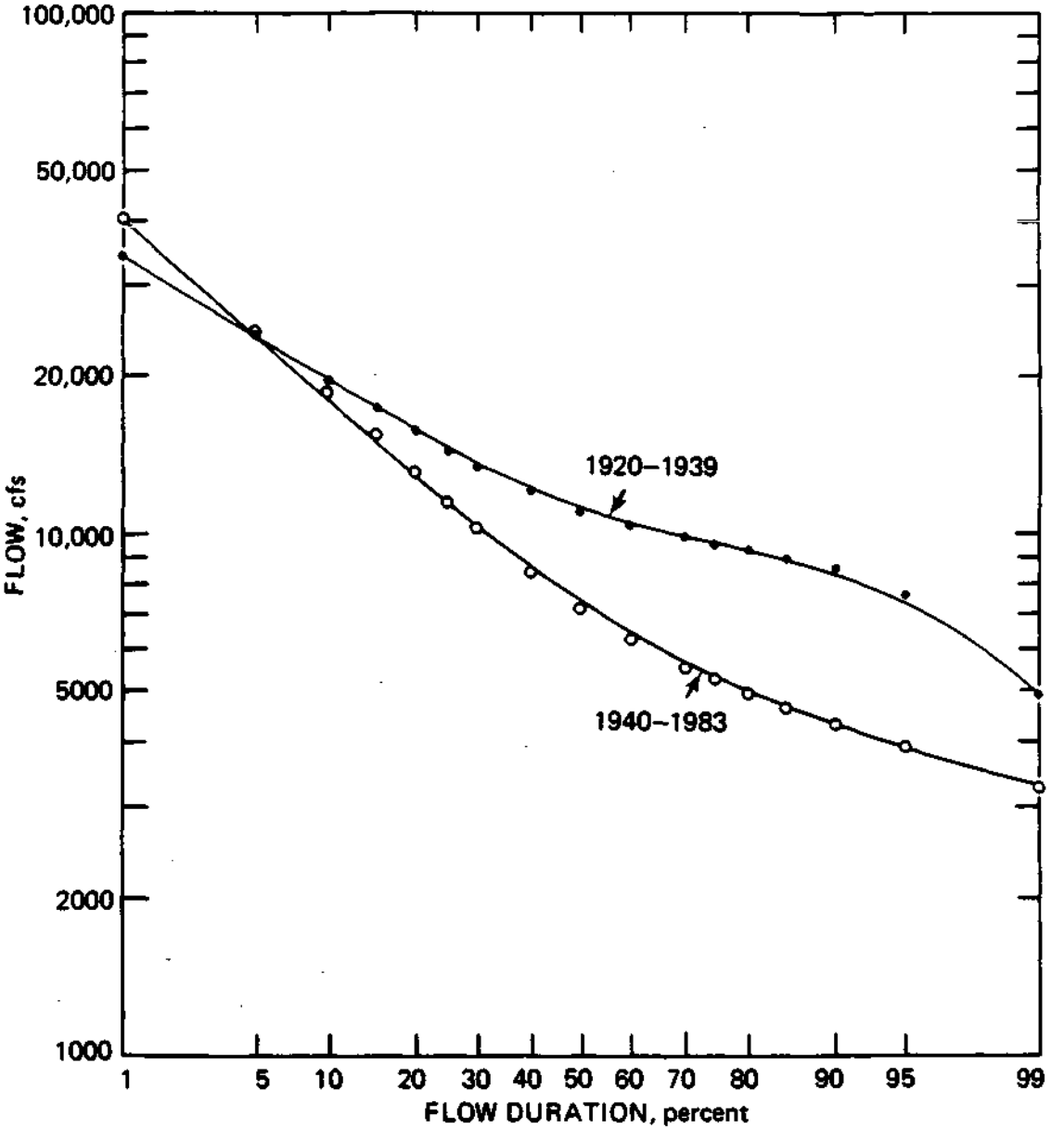


Figure 7. Flow-duration curves for the periods 1920-1939 and 1940-1983, Illinois River at Marseilles

High Flows and Pumping Costs

The relationship between high flows and pumping costs was examined by using a regression model. The pumping costs were obtained from the preliminary survey of drainage and levee districts. The high-flow variables were computed by using daily-flow values observed at the Kingston Mines gaging station on the Illinois River for the period 1981-1986. The data set consists of a time series of 6 yearly values across a cross section of 20 districts for a total of 120 observations. The relationship estimated on the basis of 87 observations (there were 33 missing values) is as follows:

$$\underset{(3.45)}{PUMPCOST = -1.737 + 0.000093\,KM7DHF + DV} \qquad [R^2 = 0.82] \qquad (1)$$

$$\underset{(3.06)}{PUMPCOST = -1.419 + 0.000098\,KM15DHF + DV} \qquad [R^2 = 0.81] \qquad (2)$$

where PUMPCOST is the pumping expenses per acre of individual districts, KM7DHF and KM15DHF are the 7-day and 15-day high flows at Kingston Mines, and DV is the dummy variable for individual levee districts. The results show that high flows together with the dummy variables explain a large percentage of the variation (around 80 percent) in pumping costs of the levee districts along the Illinois River. The coefficients of high flows are significant in both equations at the 1% level (the t-ratios are given in parentheses), indicating the strong impact of high flows on the pumping costs. The results indicate that for every 1000 cfs increase in the high flow, the pumping cost per acre increases by about 10 cents.

Economic Model

The survivability of the farms in levee districts as compared to the survivability of farms that are not in levee districts is of particular interest The primary objective of this economic analysis is to determine the impact of high flows and duration of high flows on the farm economy of levee districts, particularly those along the Illinois and Mississippi Rivers. The net farm income or net return is an appropriate index or measure of the survivability of farm firms in the long run. The proxy variables for high flows and durations of high flows are the 7-, 15-, 31-, and 61-day high flows, which are respectively the highest average flows over 7-, 15-, 31-, and 61-day periods.

Econometric Model

The model under consideration consists of a system of four equations as follows:

$$NETRET_t \equiv YIELD_t \times PRICE_t - COSTPRO_t - COSTPUM_t \quad (3)$$

$$HIGHFLO_t = \Phi (PRECIP_t, TREND, e_{1,t}) \quad (4)$$

$$COSTPUM_t = \Pi (HIGHFLO_t, ENERGY_t, e_{2,t}) \quad (5)$$

$$YIELD_t = \Psi (HIGHFLO_t, INPUT_t, e_{3,t}) \quad (6)$$

where NETRET = net return per acre ($)
YIELD = yield in bushels per acre
PRICE = price of output ($/bushel)
COSTPRO = cost of crop production ($)
COSTPUM = cost of pumping ($)
HIGHFLOW = average flow during a high-flow period (cfs)
PRECIP = effective watershed precipitation (in.)
TREND = trend factor for high flows
ENERGY = cost per kilowatt-hour ($)
INPUT = quantity of inputs used per acre (pounds)
e = random error vector
t refers to the t^{th} year and T_0 is the base year

Equation 3 is an identity. The functional forms of the three remaining equations need to be investigated. Daily flow data at four gaging stations each along the Illinois and Mississippi Rivers will be used to develop the 7-, 15-, 31-, and 61-day high flows for the period of record. Precipitation data at several gaging stations will be used to determine the effective precipitation for the different watersheds. The preliminary questionnaire provides data on the cost of pumping. Data on net returns, yields, cost of production, and inputs will be collected from the second questionnaire that will be sent to a random sample of farm firms in selected levee districts. The Farm Business Farm Management (FBFM) database at the University of Illinois will also be used as a source for some of the economic variables.

Remaining Tasks

The desired goals for the first year of the project have been achieved. Much of the effort was directed towards gathering background and preliminary information about the operational and functional aspects of levee districts, which has enabled us to better understand levee districts. The results from the preliminary analysis performed on the basis of this information support the hypotheses that the magnitude and duration of high flows are increasing and that they increase the pumping-related costs borne by levee districts. This in turn determines the

survivability of farms, especially in financially difficult years. More detailed analysis requires data from individual farmers in the levee districts. A questionnaire for this purpose has already been prepared and is shown in Appendix C. We have randomly selected 15 levee districts for collection of data from the individual farmers. Lists of farmers in 10 districts have already been received, and contacts have been made with the remaining districts. We have sent this questionnaire to a randomly selected sample of farmers in the pre-selected districts. This sample should constitute about 30 percent of the total population. We have also requested the assistance of the Illinois Farm Business and Farm Management Association in this regard.

We are now in the process of contacting the various power companies that supply electric power to the levee districts so as to obtain time-series data on monthly power consumption. These data will enable us to examine the impact of high flows on pumping costs more precisely.

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APPENDIX A

ILLINOIS DRAINAGE AND LEVEE DISTRICTS: SELECTED STATISTICS

Table A1. Percentage of area under active levee districts in counties located along the Sangamon, Illinois, Kaskaskia and Mississippi Rivers*

River	County	Total cropland (in acres)	Percentage of area under levee districts
Sangamon			
	Mason	268724	4.7
	Pike	340876	1.3
Illinois			
	Putnam	69232	4.2
	Peoria	231630	2.8
	Tazewell	311348	4.9
	Fulton	299473	8.3
	Schuyler	153151	10.6
	Cass	177044	17.8
	Brown	101482	3.4
	Morgan	281595	2.8
	Scott	109944	26.1
	Greene	238845	24.0
	Pike	340876	1.3
	Jersey	150384	6.9
Kaskaskia			
	Fayette	272681	4.6
	Clinton	215951	3.5
Mississippi			
	Carroll	220379	1.5
	Whiteside	355561	10.8
	Henry	442695	2.2
	Rock Island	140334	6.5
	Mercer	267520	6.8
	Henderson	175654	7.4
	Hancock	358319	4.2
	Adams	353367	10.3
	Pike	340876	6.4
	Madison	280915	7.3
	St. Clair	252914	4.7
	Monroe	162368	45.0
	Randolph	215716	8.3
	Jackson	165188	30.7
	Union	96693	49.5
	Alexander	63750	15.7

* The area under levee districts is approximate

Table A2. Ownership characteristics of land within levee districts				
Land utilization characteristics	Illinois River	U. Mississippi River	L. Mississippi River	Combined
Average acreage protected by a levee district	6558.0	24950.0	9825.0	9843.3
Percentage of land in agriculture	98.46	97.37	88.67	96.58
Percentage of land in industrial use	0.96	0.00	7.22	1.84
Percentage of land in residential use	0.57	2.63	4.11	1.58
Average number of farms in a district	19	139	51	40
Average number of corporately owned farms	1	1	2	1
Average number of family-owned farms	18	138	49	39
Average farm size in acres	345.15	179.49	192.65	246.07

Table A3. Levee characteristics				
Characteristics	Percentage of levee districts along Illinois River	U. Mississippi River	L. Mississippi River	Combined
Age ≥ 50 years	94.7	100.0	85.7	91.9
Design ≥ 50-year flood	87.4	85.8	100.0	84.8
Levee construction during last 10 years	14.3	12.5	11.1	12.0

Table A4. Pumping requirements of the levee districts				
Pumping characteristics	Percentage of levee districts along Illinois River	U. Mississippi River	L. Mississippi River	Combined
Required pumping	100.0	87.5	50.0	85.7
Pumped 8 years or more during the last 10	100.0	100.0	60.0	88.4
Quantity of water pumped increased over years	68.0	57.1	60.0	62.5
Crop yields severely affected without pumping	100.0	100.0	60.0	95.2

APPENDIX B

DRAINAGE AND LEVEE DISTRICT QUESTIONNAIRE I

DRAINAGE AND LEVEE DISTRICTS QUESTIONNAIRE

Name of Drainage and Levee District: _____
Year established: _____ Number of Commissioners: _____

Your Name: _____
Title: _____
Address: _____
_____
Daytime phone: _____

General

(1) How often are District meetings held? _____

(2) What percentage of land in your District is:
agricultural _____ industrial _____ residential _____

(3) How many farms are there in your District? _____
Of these, how many are: corporate _____ family _____

(4) What are the principal crops grown in your district?
Corn _____ Soybeans _____ Wheat _____ Other _____

(5) Do you have a listing of landowners in your district? Yes____ No____

Flooding

(6) Do you prepare reports on flood damage? Yes____ No____
If yes, how often? _____

(7) Do you keep records of District flooding? Yes____ No____
If yes, do you have records of crop damage? Yes____ No____

(8) When was the last major flood in your District? _____

(9) Approximately how often during the last ten years was flooding a major problem in your District?
Every year. _____
Every 2 years: _____
Every 5 years: _____
Every 10 years: _____
Not at all: _____

(10) What frequency flood is the levee designed to protect against?
2-year_____ 10-year_____ 25-year_____ 50-year_____ 100-year____

(11) Is interior flooding a problem in your District? Yes____ No____

Drainage

(12) Approximately how much land is the levee designed to protect?_____

(13) What is the total length of the levees in miles?_____

(14) Is the present drainage system adequate ? Yes____No___
If not, what is the percentage of area not covered?_____

(15) Have any new levees been constructed in the last 10 years? Yes___No___

(16) Has any construction work been done on existing levees in your District during the last 10 years? Yes___No___

(17) What drainage systems are used in your District?
Open ditch____Tile system____Pump stations____Other_____

(18) Does your District have records of ground-water or water-table levels? Yes___No___

(19) Is pumping required in your District? Yes___No___
(If not, please skip to question 26)

(20) In how many years during the last ten was pumping required? _____

(21) Do you have records on the number of pumping days per year? Yes_No___

(22) Has the quantity of water pumped increased over me last 5 years? Yes_No___

(23) If no pumping was done, what would be the effect on me crop growing season?
Severely curtailed:___
Delayed:____by how many days?_____
No effect:___

(24) How many pumping stations does your District operate?_____

(25) Have any new pumping stations been added in the last 5 years? Yes___No___

Income and Expenditure

(26) Do you keep records of total expenses and assessments? Yes___No___
(If not, please skip to question 32)

(27) What were the annual expenses for pumping during 1981-86?
1981$_____1982$_____1983$_____
1984$_____1985$_____1986$_____

(28) What were the total annual expenditures for your District during 1981-86?
1981$_____1982$_____1983$_____
1984 $_____1985 $_____1986 $_____

(29) Is mere an annual maintenance assessment for your District? Yes____No___
If yes, what is the current assessment per acre?_____

(30) What were the total annual assessments for your District during 1981-86?
1981$_____1982$_____1983$_____
1984 $_____1985 $_____1986 $_____

(31) Please specify any other factors that have contributed to increased operating costs:

_____
_____
_____

Funding Sources

(32) Does your District have any other sources of income? Yes____No____
If yes, what are they?_____

(33) Does your District receive funding from any of the following agencies?

Army Corps of Engineers_____for_____

U.S. Dept. of Agriculture_____for_____

Soil Conservation Service_____for_____

Illinois Dept. of Transportation__for_____

Other_____for_____

Please list any current problems faced by your Drainage and Levee District:

_____
_____
_____

Would you like a copy of the results of this survey? Yes__ No____

THANK YOU

APPENDIX C

DRAINAGE AND LEVEE DISTRICT QUESTIONNAIRE II

DRAINAGE AND LEVEE DISTRICTS QUESTIONNAIRE II

Name of Drainage and Levee District: _____

Your name: _____
Address: _____
Phone: _____

(1) How many acres of your land were in corn, soybeans, wheat, other crops, and or set-aside program during 1981-86?

Crops	Acreages for the year					
	1986	1985	1984	1983	1982	1981
Corn						
Soybean						
Wheat						
Other						
Set-aside						

(2) What was the ownership status of the land you farmed during 1981-86?

	Land (in acres) cultivated for the year					
	1986	1985	1984	1983	1982	1981
Owned land						
Rented land						

(3) Did you crop-share and/or pay cash rent for the rental land during 1981-86?

Crop-share: Yes_____No_____Cash rent: Yes_____No____

If you have cash rented land, what were the rents per acre on this land?

Rent ($/acre): 1986_____1985_____1984_____
1983_____1982_____1981_____

(4) For land cultivated in 1986 what was the predominant soil type?

Owned land_____Rented land _____

(5) What were the yields (bu/acre) obtained for different crops during 1981-86?

Crops	Yield (bu/acre) for the year					
	1986	1985	1984	1983	1982	1981
Corn						
Soybean						
Wheat						
Other						

(6) Were there any crop damages due to floods during 1981-86? Yes____No___
If yes, what were the estimated yield reductions (in bu/acre) within the levee district?

Crops	Yield reductions (bu/acre)					
	1986	1985	1984	1983	1982	1981
Corn						
Soybean						
Wheat						
Other						

(7) What were the total costs ($) of following inputs (including landlord's) during 1981-86?

Inputs	Total costs ($) for the year					
	1986	1985	1984	1983	1982	1981
Fertilizers						
Seeds						
Chemicals						
Labor(wages paid)						

(8) What is the average number of man-hours of family labor used in your farm?
_____hours/year

(9) What were the expenses ($) incurred on the following items during 1981-86?

Items	Expenses ($) for the year					
	1986	1985	1984	1983	1982	1981
Interest Charges						
Fuel & Electricity						
Drying & Storage						
Repairs						
Depreciation on Equipment						
Miscellaneous						

(10) What were the average prices ($ per bushel) received for the crops you have sold during 1981-86?

Crops	Price ($/bushel) received for the year					
	1986	1985	1984	1983	1982	1981
Corn						
Soybean						
Wheat						
Other						

If you have cultivated any land outside the levee district, please complete questions 11 through 14. Otherwise please skip to question 15.

(11) How many acres of your land outside the levee district were in corn, in soybeans, in wheat, in other crops, and or set-aside during 1981-86?

Crops	Acreages for the year					
	1986	1985	1984	1983	1982	1981
Corn						
Soybean						
Wheat						
Other						
Set-aside						

(12) Was the predominant soil type or soil productivity rating of the land outside the levee district different from that inside the levee district? Yes_____No_____

If yes, what was the soil type of the land outside the levee district? _____

(13) Were the yields (bu/acre) obtained from outside of district different from the yields realized from land within the district for different crops during 1981-86? Yes_____No_____

If yes, what are the percentage increases (+) or decreases (-) in yields for the crops planted?
Com_____Soybean_____Wheat_____Other_____

(14) Were the amounts of inputs used per acre outside of district different from that within the district for different crops during 1981-86? Yes_____No____

If yes, what were the percentage increases (+) or decreases (-) in input usage for the crops planted?

Inputs	Crops			
	Cora	Soybean	Wheat	Other
Fertilizers				
Seeds				
Chemicals				

(15) Would you like to receive a copy of our findings based on this survey? Yes_____No____

THANK YOU

Please return the completed questionnaire in the enclosed prestamped envelope to:
Illinois State Water Survey, 2204 Griffith Drive, Champaign IL 61820
Attn. Gana Ramamurthy