FINAL

ENVIRONMENTAL STATEMENT

MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
(REGULATING WORKS)

Prepared by

U.S. ARMY ENGINEER DISTRICT
St. Louis, Missouri
April, 1976

PREFACE

To adequately assess the impacts of the continuing action upon the environment, the Office for Environmental Studies, Waterways Experiment Station (WES), Vicksburg, Mississippi, was contacted in early 1972 to conduct an extensive environmental inventory and assessment. Certain parts of the inventory and assessment were performed for WES under contract by the Missouri Department of Conservation, Southern Illinois University, Illinois Natural History Survey, and Colorado State University. A listing of the reports which were prepared as a result of this study, and are utilized frequently in this environmental statement, are shown below:

Johnson, J. H., et al. 1974. Environmental analysis and assessment of the Mississippi River 9-ft. channel project between St. Louis, Missouri, and Cairo, Illinois. U. S. Army Eng. Wat. Exp. Sta., Vicksburg. Cont. Rep. Y-74-5.

Ragland, D. V. 1974. Evaluation of three side channels and the main channel border of the Middle Mississippi River as fish habitat. U. S. Army Eng. Wat. Exp. Sta., Vicksburg. Cont. Rep. Y-74-1.

Schramm, H. D., Jr., and W. M. Lewis. 1974. Study of Importance of backwater chutes to a riverine fishery. U. S. Army Eng. Wat. Exp. Sta., Vicksburg. Cont. Rep. Y-74-4.

Simons, D. B., S. A. Schumm, and M. A. Stevens. 1974. Geomorphology of the Middle Mississippi River. U. S. Army Eng. Wat. Exp. Sta., Vicksburg. Cont. Rep. Y-74-2.

Terpening, V. A., et al. 1974. A survey of the fauna and flora occurring in the Mississippi River flood plain between St. Louis, Missouri, and Cairo, Illinois. U. S. Army Eng. Wat. Exp. Sta., Vicksburg. Cont. Rep. Y-74-3.

Copies of the studies are available for review by contacting the library of the U. S. Army Engineer District, St. Louis, 210 North 12th Street, St. Louis, Missouri 63101.

STATEMENT OF FINDINGS
MISSISSIPPI RIVER
BETWEEN THE
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REGULATING WORKS

1. I have reviewed and evaluated, in light of the overall public interest, the documents concerning the proposed action, as well as the stated views of other interested local, state, and Federal agencies and the concerned public. I have also evaluated other pertinent data and information relative to the operation and maintenance of the 9-foot navigation channel on the Middle Mississippi River between the Ohio and Missouri Rivers (miles 0-195). As part of this evaluation I have considered various operation and maintenance alternatives including a "no action" alternative.

2. The possible consequences of these alternatives have been studied for environmental, social well-being, and economic effects, including regional and national economic development and engineering feasibility. Significant factors bearing on my review include consideration of the conflicts which arise from implementing operation and maintenance procedures so as to provide for a year-round 9-foot navigation channel while at the same time being cognizant of the need for the preservation and enhancement of the environmental quality of the Middle Mississippi River (miles 0-195). Other significant factors bearing on my review include:

a. The 9-foot channel project, is a part of a well-integrated transportation network which serves the Mid-West, the nation, and the world.

b. The communities along the river are dependent upon the environmental, recreational, and economic opportunities which the Middle Mississippi River and the 9-foot channel project provides.

c. The 9-foot channel will continue to play an important role in shaping the future of the Mississippi River system and its associated values to the communities served by its economic and environmental benefits.

d. The Middle Mississippi River is valued for its esthetic and recreation potential even though at present it is only moderately used because of poor access due to very little Federal ownership along this section of the river. These and other environmental values are in need of further consideration and recognition.

e. The River is a dynamic system and in order to be fully aware of the nature and significance of its changes continuing environmental studies must be initiated.

3. I find that operation and maintenance of the Middle Mississippi River 9-foot navigation channel is absolutely necessary if the project purposes, as established by Congress, are to continue to be met. A blockage of commercial navigation, with extremely significant economic consequences would result should operation and maintenance activities be halted. However, operation and maintenance as currently practiced does conflict, in varying degrees, with the environmental values of the river system. In order to alleviate or minimize these conflicts and to assure management and development of the river resources in the best interest of the public, I have prepared and forwarded, for consideration for inclusion in a congressional resolution, pertinent information regarding the framework for initiating a comprehensive river management plan. Approval of this resolution by Congress would provide an authorized means for funding and incorporating the total river and related land resource requirements and potentialities, in accordance with national economic development and environmental quality objectives, into the presently authorized nine-foot navigation project.

4. I believe that the increasing environmental, conservational, and special interest concerns regarding the effects incidental to constructing and maintaining the nine-foot navigation project indicate a definite need for a coordinated study of the total demands on the river system and that the action described above is the proper approach for satisfying this need.

5. In addition to the above described action, I will continue to pursue the development of a post-authorization change for fish and wildlife purposes, to the extent that it is either acted upon separately or completely integrated into the river management plan defined above.

6. Based on a thorough analysis and evaluation of the various practicable alternative courses of action for achieving the stated objectives, I find that the operation and maintenance of the Middle Mississippi River as currently practiced, subject to the actions identified above, is consonant with national policy, statutes, and administrative directives; and that on balance, the total public interest should best be served with continuation of the operation and maintenance of the project. However, within a 5-year period, based upon the information obtained from the studies and actions recommended herein, the impacts attributable to operation and maintenance activities and the feasibility and effects of practicable alternatives should be reevaluated to assure that proper consideration is given to maintaining the Middle Mississippi River and, as necessary, the Environmental Impact Statement should be revised and updated.

29 September 1975

Thorwald R. Peterson

THORWALD R. PETERSON
Colonel, CE
District Engineer

SUBJECT: Statement of Findings - Mississippi River Between the Ohio and Missouri Rivers (Regulating Works)

I concur with the preceding Statement of Findings.

23 Dec 75

F. P. Koisch
F. P. KOISCH
Major General, USA
Division Engineer

I concur with the preceding Statement of Findings.

8 April 1976
(Date)

Ernest Graves
ERNEST GRAVES
Major General, USA
Director of Civil Works

SUMMARY SHEET

MISSISSIPPI RIVER BETWEEN OHIO AND
MISSOURI RIVERS (REGULATING WORKS)

( ) Draft (X) Final Environmental Statement

Responsible Office: U.S. Army Engineer District, 210 North 12th Street, St. Louis, Missouri 63101 Phone: (314) 268-2822

1. Name of Action: (X) Administrative ( ) Legislative

2. Description of the Action: The project, authorized in 1927, consists of the continuing attainment and operation and maintenance of a 9-foot-deep by 300-foot-wide navigation channel within the Mississippi River between the Ohio and Missouri Rivers by the use of channel contraction dikes, protective bankline revetments, and any necessary dredging.

3. Environmental Impacts: The purpose of this EIS is to investigate environmental changes which have occurred on the Middle Mississippi River that may have been brought about by the 9-foot navigation project. As mentioned above, the 9-foot channel project was authorized in 1927; however, first attempts to improve the river for navigation date back to 1824. A major river such as the Middle Mississippi River constitutes a very complex hydraulic system which is dynamic in nature and constantly in a state of change. Numerous studies to improve navigation and to provide flood protection in the floodplain have been made during the past 150 years. Many changes have taken place in the science of river mechanics based upon data as it became available and the state of the knowledge is still expanding on this subject. Most recently the science of river mechanics has been expanded to include the assessment of environmental impacts caused by the efforts of man to develop the natural river system. The information presented in this EIS pertains to present day river conditions and is compared to available data on natural river conditions to present what effects development of the river system has had upon the riverine environment. The continuance of the 9-foot channel project will, no doubt, facilitate the normal economic expansion of waterborne commerce and stimulate industries dependent upon this mode of transportation. Continued maintenance of the project insofar as bankline stabilization is concerned is essential to prevent the ultimate destruction of flood protective works presently in existence and those which may be constructed in the future. Such stabilization of the river into a fixed configuration protects the inhabitants of the floodplain, urban and rural communities, and many thousands of acres of productive farmland. The contraction of the river by dikes, to improve the navigation channel, in the past has

eliminated side channels but at the same time created new side channels. Sufficient expertise does not exist to accurately predict future configurations of the river relative to side channels and other physical features of the river. Some of the existing side channels may eventually fill up and new ones may or may not form. It is unrealistic to predict, based on the wide variation of flows that occur annually, that the surface banklines of the river channel will be at or close to the riverward end of dike systems which would mean a bank to bank width of 1,800 feet or less. Cessation of the ongoing efforts to obtain and maintain the authorized project in an effort to maintain the river system in its present environmental status would not alter the processes which are now going on due to the dynamic nature of the river. In reaches where dredging takes place (primarily in river crossings), the placement of dredge material within main channel dike fields will cause a disruption to benthic (bottom-dwelling) organisms, that serve as a food source for fish. The narrowing of the river, and its subsequent channel bottom scour (deepening) has caused low flow discharge stages to become lower as compared to the past, which in turn, provides less water for existing fish habitat along border areas and side channels. Similarly, the construction of flood protective works has been a cause for an increase in flood stages for the same flow.

4. Adverse Environmental Impacts: To adequately assess the impacts of the continuing action upon the environment, the Office for Environmental Studies, Waterways Experiment Station (WES), Vicksburg, Mississippi, was contacted in early 1972 to conduct an extensive environmental inventory and assessment. Certain parts of the inventory and assessment were performed for WES under contract by the Missouri Department of Conservation, Southern Illinois University, Illinois Natural History Survey, and Colorado State University (CSU). The effects of the 9-foot channel project upon the environment are mainly based on conclusions contained in the CSU study which are: eventual loss of side channels as fish and wildlife habitat, narrowing of the river channel and its further corresponding loss in aquatic habitat, less water for side channels due to lower river stages, increased flood stages due to development within the floodplain, and utilization of the floodplain by man.

5. Alternatives: The following types of alternatives are discussed in the environmental statement.

a. Maintain existing action.

b. Cease all operation and maintenance.

c. Locks and dams.

d. Post-Authorization Change - to include environmental considerations in project purposes.

6. Comments Received:

U.S. Senator Thomas F. Eagleton
The Honorable Mrs. Leonor K. Sullivan - Member of Congress
United States Department of Housing and Urban Development
United States Department of Commerce
United States Department of Agriculture Forest Service
United States Department of Agriculture Soil Conservation Service
United States Department of the Interior
United States Department of Health, Education, and Welfare
United States Department of Transportation Regional Representative of the Secretary
United States Department of Transportation United States Coast Guard
United States Department of Transportation Federal Highway Administration
United States Environmental Protection Agency
Advisory Council on Historic Preservation
Federal Power Commission
Illinois Natural History Survey
Illinois State Geological Survey
Illinois Archeological Survey
Missouri State Highway Commission
Missouri Department of Conservation
University of Missouri - Columbia, Missouri Archeological Survey
Missouri Department of Natural Resources
Missouri Chapter of the American Fisheries Society
Waterways Journal
Sierra Club
Bootheel Regional Planning Commission and Economic Development Council
Union Electric Company
The American Waterways Operators, Inc.
Mrs. Marty Nelson

7. Draft Statement to CEQ 13 June 1975.

Final Statement to CEQ ______________.

FINAL ENVIRONMENTAL STATEMENT

MISSISSIPPI RIVER BETWEEN THE
OHIO AND MISSOURI RIVERS REGULATING WORKS

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

Par. No. — Title

TABLES

TABLES (Cont'd)

PLATES

FIGURES

FIGURES (Cont'd)

PART 1

1. PROJECT DESCRIPTION AND HISTORY

1.1. LOCATION

The existing 9-foot Channel project was authorized by Congress in 1927 for the purpose of obtaining and maintaining a 9-foot deep by 300-foot wide channel for navigation within the Mississippi River between the Missouri and Illinois Rivers from St. Louis, Missouri, southward to Cairo, Illinois (PLATE 1-1).

The Mississippi River can be divided by its physical characteristics into three segments - the upper, middle, and lower Mississippi River. The upper portion of the river extends from Lake Itaska, Minnesota, to the mouth of the Missouri River, a distance of 1,171 river miles; the section known as the Middle Mississippi River extends from the mouth of the Missouri River to the mouth of the Ohio River, a distance of 195 miles; and the lower river, about 964 miles in length, extends from the mouth of the Ohio River to the Gulf of Mexico. The relatively small reach known as the Middle Mississippi River is the hub of an interconnected inland river system, providing passage from the East via the Ohio River, from the North via the Upper Mississippi, from the Great Lakes via the Illinois Waterway System, from the Northwest via the Missouri River, from the West via the Arkansas River, and from the Gulf of Mexico and southern parts via the Lower Mississippi River (PLATE 1-2).

1.2 HISTORY AND AUTHORIZATION OF THE PROJECT

The first steamboat to enter the Middle Mississippi River was the GENERAL ZEBULON M. PIKE, which arrived at St. Louis in August 1817. The first work performed by the Federal Government for improvement of the Middle Mississippi River was authorized by Congress in 1824. This work provided for the Corps of Engineers to remove snags and trees from the river channel which were a hazard for wooden hull vessels. The work also included the removal of standing timber from the high bankline which was subject to falling into the river by erosive action to prevent the formation of additional obstructions to navigation.

Between 1836 and 1840, Lieutenant Robert E. Lee, of the U.S. Army, Corps of Engineers, built the first channel stabilization works within the Middle Mississippi River. He designed and constructed two dikes within the St. Louis Harbor area to direct the current of the river so as to remove a large sandbar in front of the City of St. Louis which was seriously curtailing river traffic.

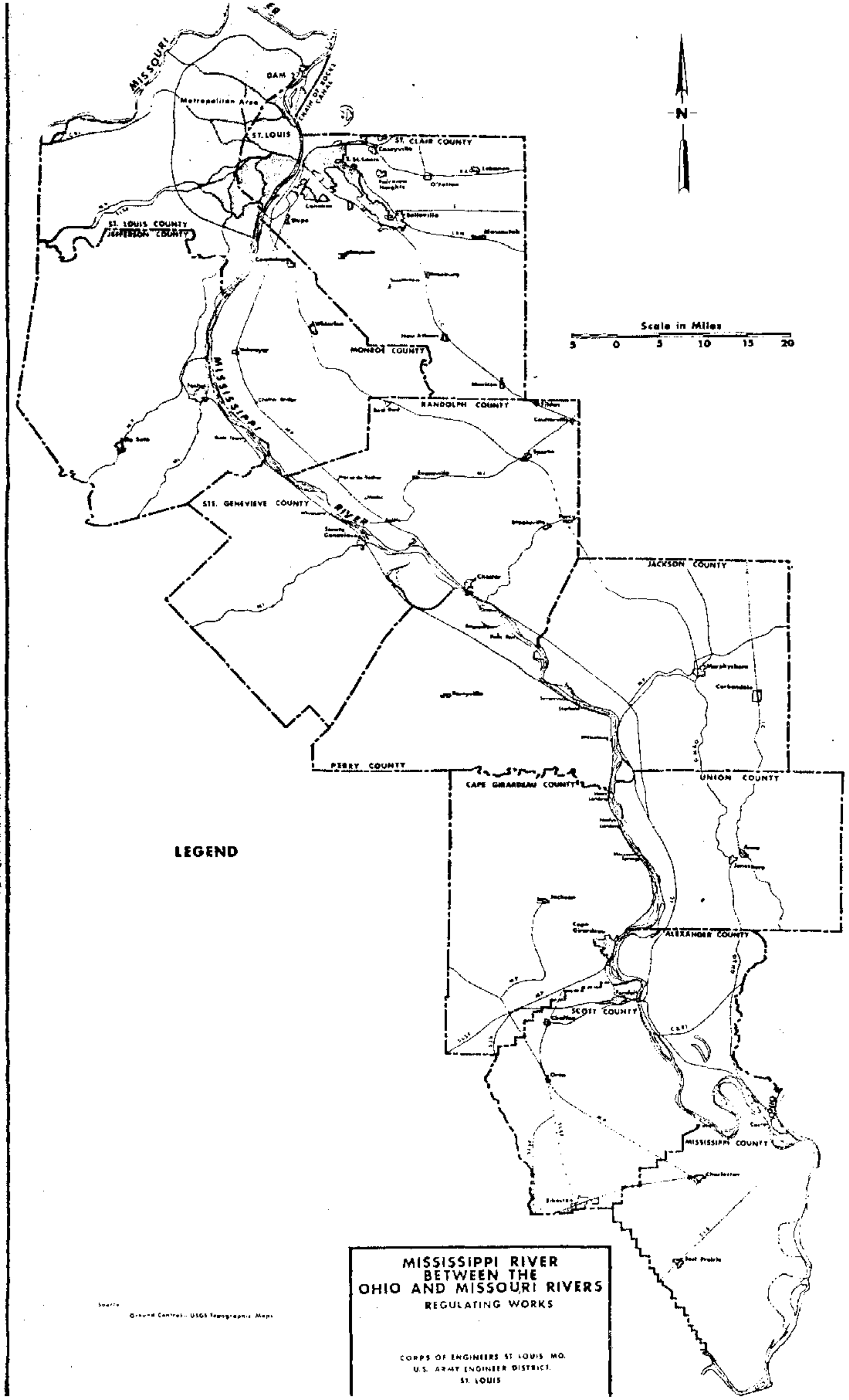


PLATE 1-1. Base Map

PLATE 1-2. Mississippi River Inland Waterways System and Gulf Intracoastal Waterway

Despite the apparent flourishing of steamboat traffic, safe, navigable waterways did not exist. Even during period of high water, the rapid build-up and migration of sandbars continued to limit navigation depths. The difficulty of navigation during this pre-channel stabilization era was attested by Pilot I. H. Baldwin, for example, who stated that when the river had fallen to bankfull stage after the flood of 1844, he found it difficult to chart a navigable channel between St. Louis and the Ohio River.

With the exception of snagging operations and timber clearing, Federally financed channel improvements essentially ceased during the period between 1840 and 1872. Some minor isolated improvements were performed by local interests.

In 1880 the river between high banks was wide and generally shallow, with the channel being occasionally divided by bars and islands. Depths at low water were usually 3-1/2 to 7 feet, with low-water channel widths varying from 125 to 3,600 feet. At bankfull stage, depths at channel crossings were 10 to 15 feet, with widths of 4,000 to 7,000 feet. Depths at flood stages were 25 to 60 feet, with widths of 7,000 to 25,000 feet.

Due to the fact that there had been a significant increase in the width of the river between 1824 and 1880, with an attendant decrease in channel depth, the first comprehensive channel improvement project was authorized by Congress in 1881. The plan called for constructing bankline revetments and permeable dikes to contract the low water flow of the river to a width of 2,500 feet between dike ends. The intent of the project was to develop and maintain a low water navigation channel 8-feet deep and 200-feet wide. The plan also called for the reduction and/or the elimination of flows through sloughs and secondary side channels so as to confine low-water discharges to the main stem of the river for navigation.

This authority served as the basis for subsequent river regulating works until 1927 when Congress authorized the U.S. Army Corps of Engineers to obtain and maintain a 9-foot-deep channel due to the increased river traffic and a demand for deeper draft vessels.

The existing 9-foot Channel project was authorized by Congress in 1927 for the purpose of securing a 9-foot-deep by 300-foot-wide channel for navigation within the Mississippi River from St. Louis, Missouri, to Cairo, Illinois. It was assumed that a channel having a depth of 9 feet below a low-water reference (datum) plane, based on a minimum project flow of 40,000 cfs (cubic feet per second), could be obtained through the construction of channel stabilization works to constrict the low-water channel to a width of 1,800 feet between opposite dike ends by means of pile dikes and bankline revetments. The low-water project flow was increased from 40,000 cfs to 54,000 cfs in about 1933, when it was felt that advantage could be taken of low-flow augmentation from upstream reservoirs on the Missouri River.

By 1960, it was evident that the 1,800-foot contraction plan, which consisted of over 800 timber pile dikes, was not capable of maintaining a 9-foot channel during low-flow periods. For a time, it was thought that this was due to the fact that many of the pile dikes had deteriorated and were losing their effectiveness. However, by 1965, numerous pile dikes had been converted to stone-fill dikes and still a dependable 9-foot channel had not developed.

Subsequently, the Corps was authorized in 1966 to construct a prototype reach in a typical troublesome portion of the river, using a 1,200-foot contraction width between dike ends, for the purpose of developing additional empirical design criteria which would assure successful implementation of the 9-foot Channel project. Prototype reach construction was initiated in July 1967 and completed in March 1969. No dredging has been necessary within the prototype reach since its completion, while the objective of river regulating works, i.e., dikes and revetments, is to develop a dependable navigation channel with an accompanying reduction in the costly dredging operations, it is felt that dredging will never be entirely eliminated, especially at troublesome channel crossings.

To obtain a 9-foot channel with the least amount of contractive effort, reaches of the river are currently being contracted to a 1,500-foot width between opposite dike ends. Preliminary investigation has revealed that the 1,500-foot contraction width, with additional contractive effort at troublesome channel crossings and the aforementioned dredging, is capable of achieving a dependable year round, 9-foot navigation channel.

The authorizations pertaining to the existing project are listed in Table 1-1.

Table 1-1. Project Authorizations

	Description	Documents and Reports
	Project for regulating works adopted in 1881. (To obtain a minimum depth of 8 feet.)	Annual Report, 1881, p. 1536
Jun 3, 1896) Jun 13, 1902) Mar 2, 1907)	Dredging introduced as part of the project	
Mar 3, 1905 Mar 2, 1907	These acts practically abrogated that part of the project for Middle Mississippi which proposed regulating works.	
Jun 25, 1910	Regulating works restored to project and appropriations begun with a view to completion of improvement between Ohio and Missouri Rivers within 12 years at an estimated cost of $21,000,000 exclusive of amounts previously expended.	H. Doc. 50, 61st Cong., 1st Sess., and H. Doc. 168, 58th Cong., 2d Sess. (Contains latest published map.)
Jan 21, 1927	For a depth of 9 feet and width of 300 feet from Ohio River to northern boundary of City of St. Louis, with estimated cost of maintenance increased to $900,000 annually.	Rivers and Harbors Committee Doc. 9, 69th Cong., 2d Sess.
Jul 3, 1930	Project between northern boundary of City of St. Louis and Grafton (mouth of Illinois River) modified to provide a channel 9 feet deep and generally 200 feet wide with additional width around bends, at an estimated cost of $1,500,000, with $125,000 annually for maintenance.	Rivers and Harbors Committee, Doc. 12, 70th Cong., 1st Sess.

Table 1-1, Project Authorizations (cont'd)

	Description	Documents and Reports
Mar 2, 1945	Modified to provide for construction of a lateral canal with lock at Chain of Rocks, at an estimated first cost to the United States of about $10,290,000, with $70,000 annually for maintenance and operation.	H. Doc. 231, 76th Cong., 1st Sess.
Sep 3, 1954	Modified to provide for construction of a small-boat harbor opposite Chester, Ill., at an estimated first cost to United States of $57,700, and to local interest of $58,700.	H. Doc. 230, 83d Cong., 1st Sess.
Jul 3, 1958	Modified to provide for construction of a fixed-crest rock-fill dam (Dam 27) 900 feet below Chain of Rocks Bridge at a first cost to United States of $5,810,000, including $8,000 navigation aids.	S. Doc. 7, 85th Cong., 1st Sess.

1.3 GENERAL DESCRIPTION OF THE AREA

That portion of the Mississippi River which lies between the confluences of the Missouri and Ohio Rivers is commonly known as the Middle Mississippi River. Flowing in a general southeasterly direction, this reach of river has a length of about 195 river miles.1/

Rolling topography characterizes most of the surrounding region adjacent to the river, with elevations ranging from 400 to 1,900 feet above mean sea level. The only region with extensive rugged topography is the submountainous Ozark Uplift section which is drained principally by the Meramec River in Missouri and the Big Muddy River in Illinois.

1/ River miles within the Middle Mississippi River are measured in an upstream direction. River miles 0.0 and 195.0 are at the confluences of the Ohio and Missouri Rivers, respectively. St. Louis, Missouri, is located at mile 180.0.

The present river, from St. Louis downstream to river mile 46, near Thebes, Illinois, follows a course between low alluvial banks in a flood plain bordered by the moderately high sedimentary rock bluffs of Missouri and Illinois. The distance between bluffs averages about five miles for this entire reach except for one locality at river mile 189, where it attains a maximum width of 12 miles.

The river enters a narrow rock-bound gap called the Thebes Gap, at mile 46. This water gap is about 7 miles in length; 3,000 feet in width; and extends downstream to Commerce, Missouri, mile 39. Upon leaving Thebes Gap, the river flows south in the much wider flood plain of the Lower Mississippi Valley.

With the exception of three localities, the river generally flows on a bed of alluvial material derived from prior glaciation cycles, with bedrock at a considerable distance below the stream bed.

The drainage area of the Middle Mississippi River drainage basin, as measured immediately downstream of the confluence with the Missouri River, is about 700,000 square miles. The principal tributaries of the Middle Mississippi River are the Meramec, Kaskaskia, and Big Muddy Rivers, which drain a combined area of about 12,000 square miles, and have average annual discharges of 3,000; 3,600; and 1,800 cfs, respectively.

The surrounding bi-state region of Missouri and Illinois which is adjacent to the Middle Mississippi River has a temperate, semi-humid climate as characterized by a mean annual precipitation and temperature of 37.5 inches and 56.2 degrees Fahrenheit, respectively. The formation and movement of ice during the winter months of January, February, and March can be a hazard to navigation and cause destruction to channel stabilization works. Floating ice occurs on an average of 43 days per year.

Discharge measurements, as taken at St. Louis, Missouri, indicate a mean annual discharge of approximately 175,000 cfs, with known maximum and minimum discharges of 1,300,000 cfs and 18,000 cfs, respectively.

The average annual discharges of the Missouri and Upper Mississippi Rivers of 80,000 cfs and 95,000 cfs, respectively, combine immediately above St. Louis to form the flow for the Middle Mississippi River. The flood seasons in the Missouri and Upper Mississippi River basins occur primarily during the period March to July. Except for periods of drought, the low-water season is generally during the winter months, December through February.

Fragmentary and intermittent river stage records were kept in St. Louis, Missouri, between 1837 and 1860. The first continuous records of stage on the Mississippi River were initiated in 1861 when the present gage was established in St. Louis, at mile 179.6 above the mouth of the Ohio River. This gage is the main reference gage for the Middle Mississippi River. As of this date, there are 20 gages on the Middle Mississippi River.

The variation in stage is wide, ranging from -6.2 feet in 1940 to 43.3 in 1973, as measured on the St. Louis gage. Bankfull stage, i.e., flood stage, at St. Louis, is 30 feet. Average stage is considered to be approximately 11 feet. A discharge-duration curve, covering a period from 1955 to 1968, is shown in Figure 1-1. A recent stage-discharge curve is shown in Figure 1-2.

Approximately 90 percent of the sediment load of the Middle Mississippi River, as measured at St. Louis, is contributed by the Missouri River (Jordan, 1965). The flows of the Missouri and Upper Mississippi Rivers are not fully mixed as they pass St. Louis, a distance of 15 miles downstream of their confluence. The suspended sediment concentration near the west bank of St. Louis can be as much as 2,400 parts per million greater than that of the east bank.

Suspended sediment discharges taken at St. Louis range from 4,250 to 7,010,000 tons per day and average approximately 500,000 tons per day. The measured suspended sediment discharge at St. Louis averages about 95 percent of the total sediment discharge.

Analysis of the suspended sediment reveals a composition of approximately 47 percent clay, 38 percent silt, and 15 percent sand size particles.

The channel of the Middle Mississippi River of today is quite different from that of the 1880's which was characterized by numerous sand bars, islands, shallow depths, and erratic channel alinement. The present river is characterized by deeper and more stable channel alinement with fewer mid-channel bars and islands. The average channel slope is about 0.5 foot per mile and velocities generally range from 3.0 to 6.5 feet per second, except during times of flood.

The present channel boundary has a relatively low sinuosity. No typical large meander loops are present from the upper terminus at mile 195.0 downstream to mile 25.0. There is one large S-type meander loop called Dogtooth Bend from mile 25.0 to 10.0. This meander loop has been extensively protected by revetment works to prevent the river from cutting a new channel, which would shorten the river by several miles, cause extensive damages to the flood plain, and temporarily increase current velocities to the point where it would be difficult to navigate.

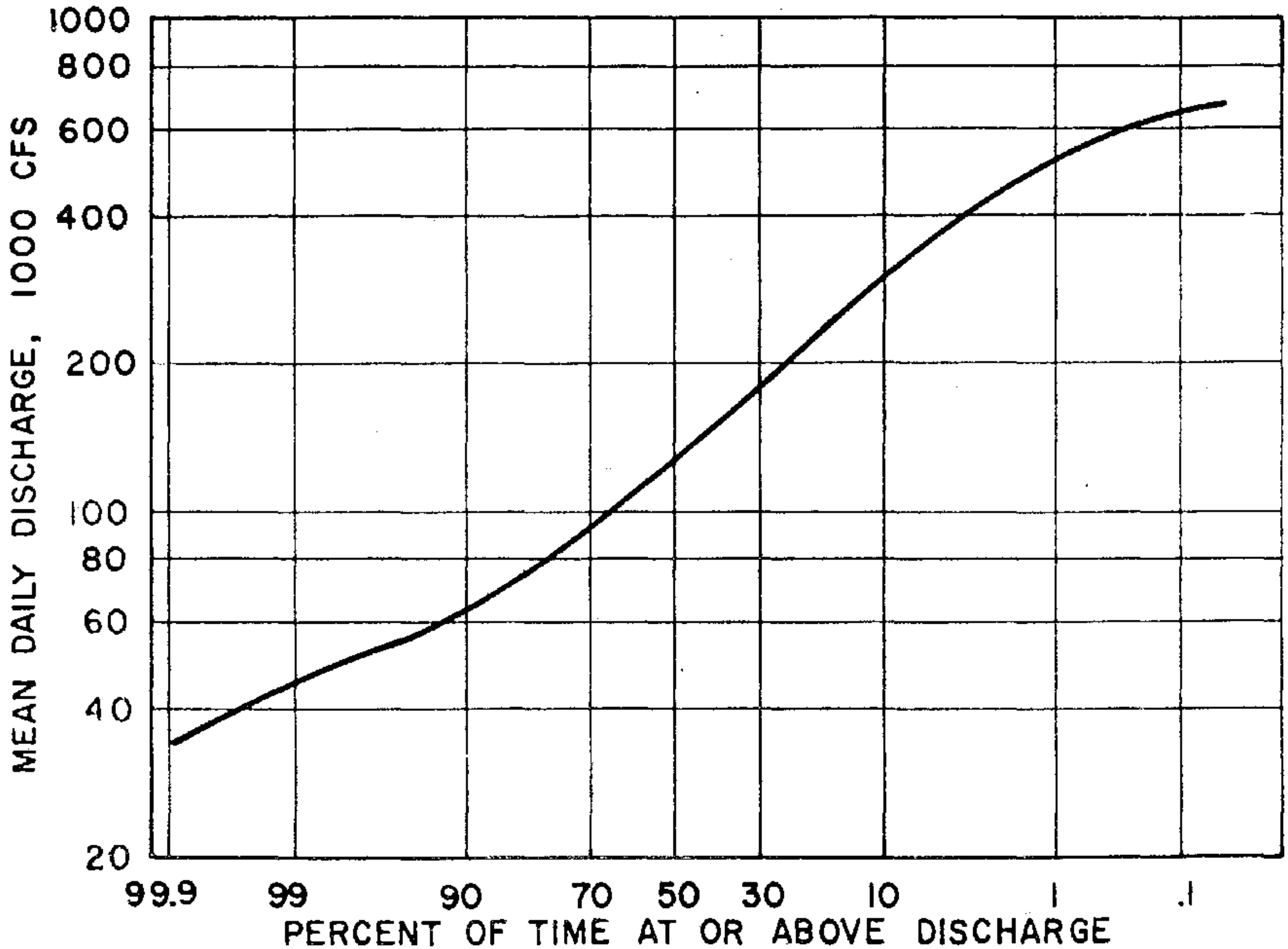


FIGURE 1-1. Discharge-duration curve at St. Louis gage, 1955-1968

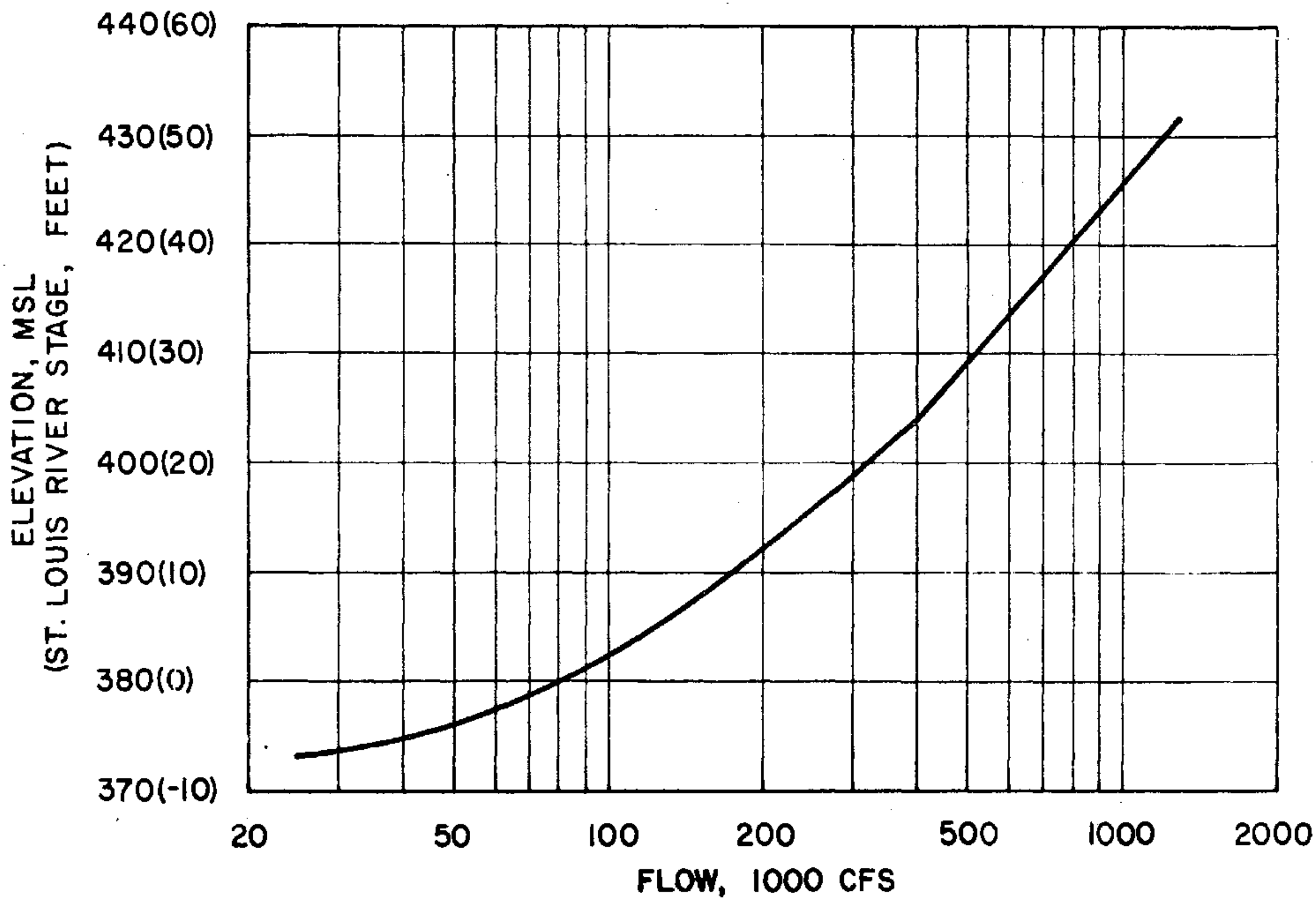


FIGURE 1-2. Generalized Stage-Discharge Curve, St. Louis

1.4. PROJECT DESCRIPTION

1.4.1. DIKES

As of June 1974, over 800 dikes have been built under the authorized project (Table 1-2). They are normally constructed extending riverward from the bankline either perpendicnlar to the main flow or inclined at a slight downstream angle (PLATES 1-3a through 1-31). Their purpose is to confine the low flows within the main channel and temporarily increase the velocities within the contracted reach, thereby increasing the river's ability to carry sediment, and thus deepen the channel by the resultant bed scour. Dikes may also be used to move the channel into a new alinement and/or to offer bank protection as a secondary goal.

In addition to confining flows within the main channel, chute closures were constructed within side channels adjacent to the main channel to confine the flows during periods of low flow. The sedimentation and eventual loss of these side channels as fish and wildlife habitat is a topic of concern that will be discussed in detail later.

The slackwater created between adjacent dikes within the main channel causes the sediment-laden water of the Middle Mississippi River to enter these areas and to form sand bars between them. The natural depositional patterns are such that a temporary side channel can be created landward of this sandbar and adjacent to the existing high bank (Figure 1-3).

Table 1-2. Regulating Works - Mississippi River (River Mile 0.0 - 195.0 Above the Mouth of the Ohio River)

PROGRESS: As of 30 June 1974

Regulating works are considered to be operative if they are exposed, at some river stage, to the river currents. Those which are not are considered to be inoperative.

The operative length listed below is a compilation of scaled dimensions, taken from current hydrographic surveys or other data, plus new construction. As a general rule, new surveys generally result in a negative change of operative dike length because portions of old dikes are being buried under fills. Inoperative works buried under fills and subsequently uncovered are automatically returned to operative status when hydrographic surveys, or other data, indicate they are again effective.

Table 1-2. Continued

DIKES

Locality	River Mile (Above Mouth of Ohio River)	Operative Length lin. ft.
Greenfield Bend, Missouri	0.0 - 6.0R	2,000
Cairo Protection, Illinois	0.0 - 8.0L	10,050
Hurricane Island, Missouri	6.0 - 11.0R	1,250
Boston Bar, Illinois	8.0 - 12.0L	7,600
Missouri Sister Island, Illinois	11.0 - 16.0R	4,600
Grand Lake, Illinois	12.0 - 20.0L	2,800
Thompson Towhead, Missouri	16.0 - 19.5R	9,050
Dogtooth Bend, Missouri	19.5 - 26.0R	5,900
Brooks Point, Illinois	20.0 - 28.0L	10,900
Price Landing, Missouri	26.0 - 33.0R	11,200
Price Towhead, Illinois	28.0 - 32.0L	2,300
Goose Island, Illinois	32.0 - 40.0L	16,800
Powers Island, Missouri	33.0 - 40.0R	9,600
Thebes Reach, Illinois	40.0 - 47.0L	11,350
Graysboro, Missouri	40.0 - 47.0R	3,800
Giboney Island, Illinois	47.0 - 54.0L	21,180
Cape Girardeau, Missouri	47.0 - 57.0R	2,950
Devil's Island, Illinois	54.0 - 61.5L	8,900
Schenimann, Missouri	57.0 - 65.0R	24,450
Willard, Illinois	61.5 - 68.0L	10,750
Neelys Landing, Missouri	65.9 - 75.0R	6,650
Hanging Dog Island, Illinois	68.0 - 75.5L	15,700
Wittenberg, Missouri	75.0 - 85.0R	2,250
Grand Tower Island, Ill. & Mo.	75.5 - 83.0L	3,000
Wilkinson, Illinois & Missouri	83.0 - 94.0L	6,400
Seventy Six, Missouri	85.0 - 96.0R	3,150
Liberty Bend, Illinois	94.0 - 100.0L	1,250
Liberty, Missouri	96.0 - 103.0R	19,100
Rockwood, Illinois	100.0 - 109.5L	11,500
Crain Island, Missouri & Illinois	103.0 - 109.5R	16,600
Kaskaskia Island, Illinois	109.5 - 116.0R	8,500
Chester, Illinois	109.5 - 116.0L	15,900
Ste. Genevieve, Mo. & Ill.	116.0 - 127.0R	18,750
Ste. Genevieve, Illinois	116.0 - 127.0L	22,100
Fort Chartres, Illinois	127.0 - 132.5L	4,600
Establishment Island, Missouri	127.0 - 136.0R	11,460
Fish Bend, Illinois	132.5 - 144.0L	41,050
Danby Landing, Missouri	136.0 - 146.0R	10,600
Calico Island, Illinois	144.0 - 153.0L	34,900
Cornice Island, Missouri	146.0 - 157.0R	7,550
Sulphur Springs, Illinois	153.0 - 158.5L	13,060
Chesley Island, Missouri	157.0 - 163.0R	1,360
Pulltight, Illinois	158.5 - 167.0L	14,960
Twin Hollows, Missouri	163.0 - 172.0R	4,480
Horsetail East, Illinois	167.0 - 172.0L	3,600
Arsenal Island, Illinois	172.0 - 178.0L	750
St. Louis Harbor, Missouri	172.0 - 183.0R	0

Table 1-2. Continued

Locality	River Mile (Above Mouth of Ohio River)	Operative Length lin. ft.
East St. Louis Harbor, Illinois	178.0 - 184.0L	650
Sawyer Bend, Missouri	183.0 - 190.0R	0
Cabaret Island, Illinois	184.0 - 191.0L	3,600
Wilson Island, Missouri	190.0 - 195.0R	1,700
Mouth of Missouri River, Ill.	191.0 - 195.0L	0
Total		482,600
	REVETMENT	
Greenfield Bend, Missouri	0.0 - 6.0R	22,700
Cairo Protection, Illinois	0.0 - 8.0L	8,300
Hurricane Island, Missouri	6.0 - 11.0R	13,400
Boston Bar, Illinois	8.0 - 12.0L	6,760
Missouri Sister Island, Illinois	11.0 - 16.0L	2,400
Grand Lake, Illinois	12.0 - 20.0L	38,750
Thompson Towhead, Missouri	16.0 - 19.5R	350
Dogtooth Bend, Missouri	19.5 - 26.0R	32,150
Brooks Point, Illinois	20.0 - 28.0L	9,500
Price Landing, Missouri	26.0 - 33.0R	24,900
Price Towhead, Illinois	28.0 - 32.0L	950
Goose Island, Illinois	32.0 - 40.0L	20,700
Powers Island, Missouri	33.0 - 40.0R	13,000
Thebes Reach, Illinois	40.0 - 47.0L	750
Graysboro, Missouri	40.0 - 47.0R	5,200
Giboney Island, Illinois	47.0 - 54.0L	2,180
Cape Girardeau, Missouri	47.0 - 57.0R	37,100
Devil's Island, Illinois	54.0 - 61.5L	24,100
Schenimann, Missouri	57.0 - 65.0R	0
Willard, Illinois	61.5 - 68.0L	8,450
Neelys Landing, Missouri	65.0 - 75.0R	0
Hanging Dog Island, Illinois	68.0 - 75.5L	0
Wittenberg, Missouri	75.0 - 85.0R	8,180
Grand Tower, Illinois & Missouri	75.5 - 83.0L	16,400
Wilkinson, Illinois & Missouri	83.0 - 94.0L	20,300
Seventy Six, Missouri	85.0 - 96.0R	16,800
Liberty Bend, Illinois	94.0 - 100.0L	27,400
Liberty, Missouri	96.0 - 103.0R	12,100
Rockwood, Illinois	100.0 - 109.5L	8,440
Crain Island, Missouri & Illinois	103.0 - 109.5R	4,300
Kaskaskia Island, Illinois	109.5 - 116.0R	23,400
Chester, Illinois	109.5 - 116.0L	7,070
Ste. Genevieve, Mo. & Ill.	116.0 - 127.0R	23,260

Table 1-2. Concluded.

Locality	River Mile (Above Mouth of Ohio River)	Operative Length lin. ft.
Ste. Genevieve, Illinois	116.0 - 127.0L	23,600
Fort Chartres, Illinois	127.0 - 132.5L	22,000
Establishment Island, Missouri	127.0 - 136.0R	19,280
Fish Bend, Illinois	132.5 - 144.0L	13,500
Danby Landing, Missouri	136.0 - 146.0R	25,400
Calico Island, Illinois	144.0 - 153.0L	7,700
Cornice Island, Missouri	146.0 - 157.0R	16,600
Sulphur Springs, Illinois	153.0 - 158.5L	2,400
Chesley Island, Missouri	157.0 - 163.0R	9,650
Pulltight, Illinois	158.5 - 167.0L	6,800
Twin Hollows, Missouri	163.0 - 172.0R	18,400
Horsetail East, Illinois	167.0 - 172.0L	0
Arsenal Island, Illinois	172.0 - 178.0L	4,330
St. Louis Harbor, Missouri	172.0 - 183.0R	38,450
East St. Louis Harbor, Illinois	178.0 - 184.0L	20,800
Sawyer Bend, Missouri	183.0 - 190.0R	36,550
Cabaret Island, Illinois	184.0 - 191.0L	7,100
Wilson Island, Missouri	190.0 - 195.0R	4,400
Mouth of Missouri River, Ill.	191.0 - 195.0L	20,750
Total		737,000

As of June 1973, over 482,600 lineal feet of dikes are operative, within the reach of river from St. Louis, Missouri to Cairo, Illinois.

Wooden pile dikes, which have been built in the past, were permeable enough so as to pass water through them quite freely (Figure 1-4). Their success depended upon their ability to slow the current passing through them and induce sediment to deposit between adjacent dikes. Substantial sediment deposition must take place for a significant contractional effect throughout a reach of river to be realized. Sufficient velocities and high sediment concentrations must be present so that the coarse sediment fractions can be induced to deposit by a moderate reduction in velocity as they pass through the permeable dikes.

Due to the increased cost of labor and the abundant availability of stone, pile dike construction on the Middle Mississippi River ceased in about 1963-65. When necessary, existing pile dikes were converted to impermeable stone dikes. Decreases in sediment concentrations and particle sizes due to reservoir construction on the

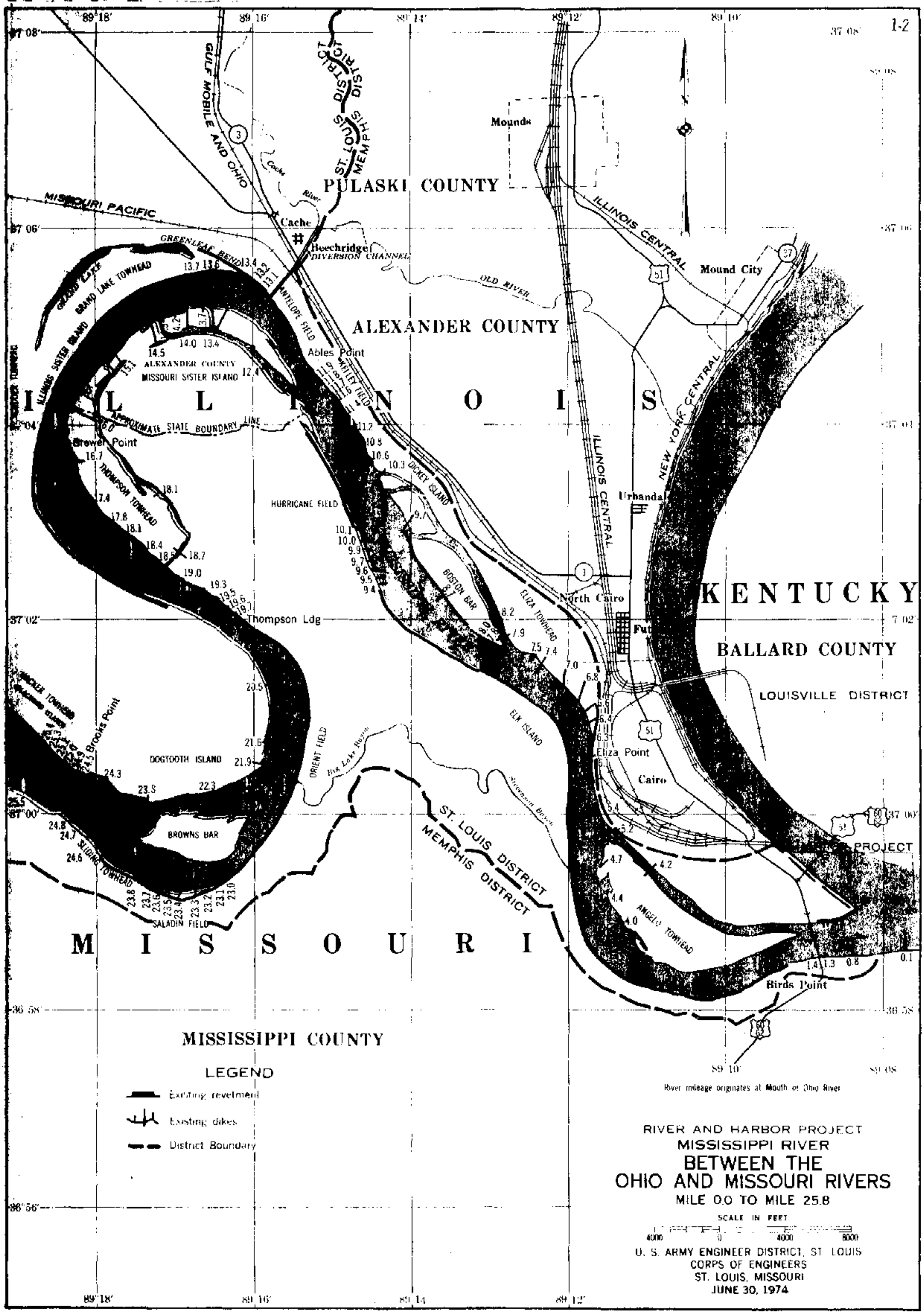

1-2
PULASKI COUNTY
ALEXANDER COUNTY
ILLINOIS
KENTUCKY
BALLARD COUNTY
MISSOURI
MISSISSIPPI COUNTY
LOUISVILLE DISTRICT
ST. LOUIS DISTRICT
MEMPHIS DISTRICT
GULF MOBILE AND OHIO
MISSOURI PACIFIC
ILLINOIS CENTRAL
NEW YORK CENTRAL
Mounds
Mound City
Cache
Beechridge
DIVERSION CHANNEL
OLD RIVER
GREENLEAF BEND
GRAND LAKE TOWHEAD
ILLINOIS SISTER ISLAND
ALEXANDER COUNTY
MISSOURI SISTER ISLAND
Ables Point
APPROXIMATE STATE BOUNDARY LINE
Brewer Point
THOMPSON TOWHEAD
HURRICANE FIELD
DICKEY ISLAND
BOSTON BAR
ELIZA TOWHEAD
North Cairo
Urbandale
Thompson Ldg
ELK ISLAND
Eliza Point
Cairo
DOGTOOTH ISLAND
Brooks Point
BROWNS BAR
ORIENT FIELD
SALADIN FIELD
ANGELO TOWHEAD
Birds Point
PROJECT
River mileage originates at Mouth of Ohio River
LEGEND
Existing revetment
Existing dikes
District Boundary
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 0.0 TO MILE 25.8
SCALE IN FEET
4000 0 4000 8000
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974

PLATE 1-3a

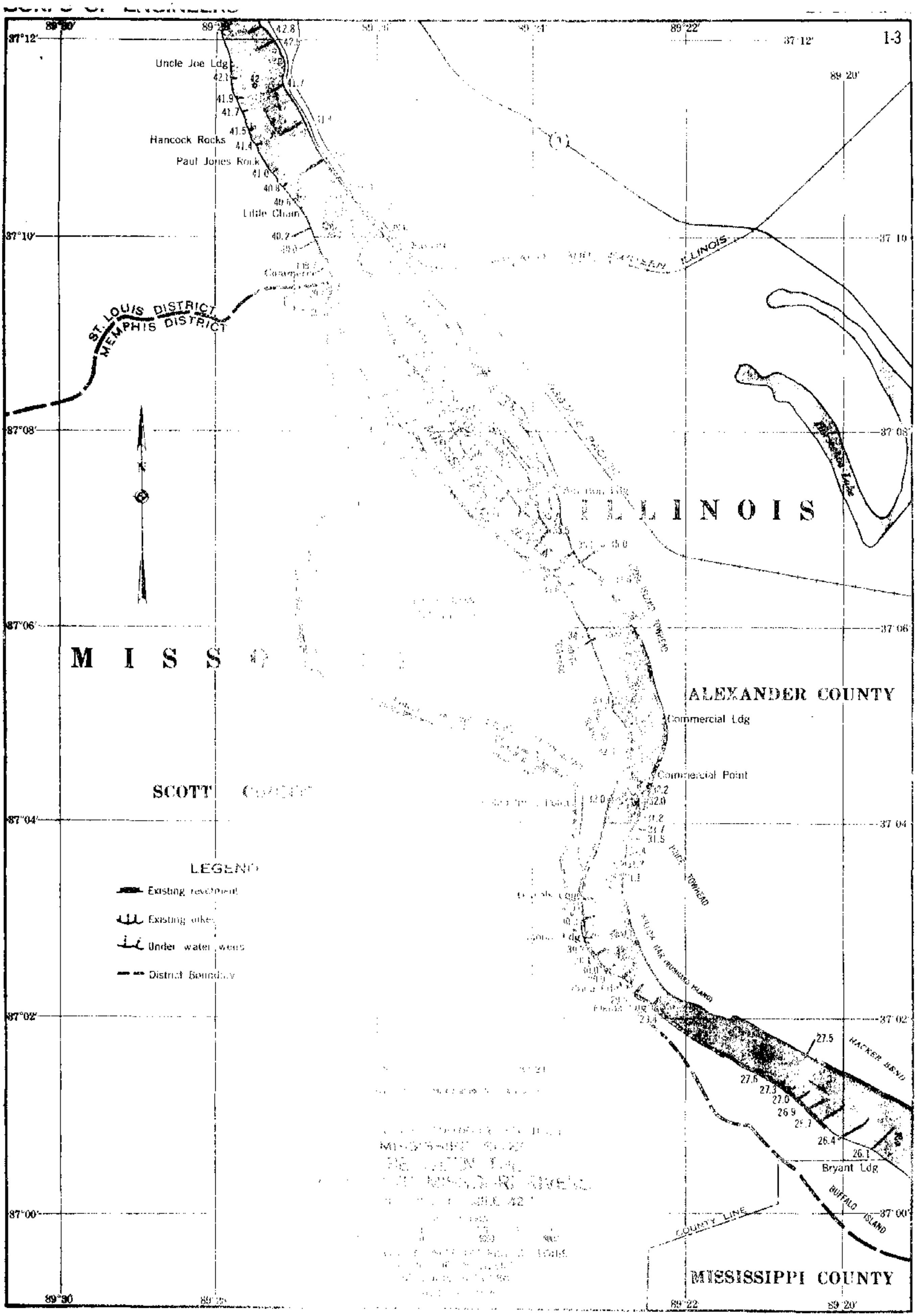
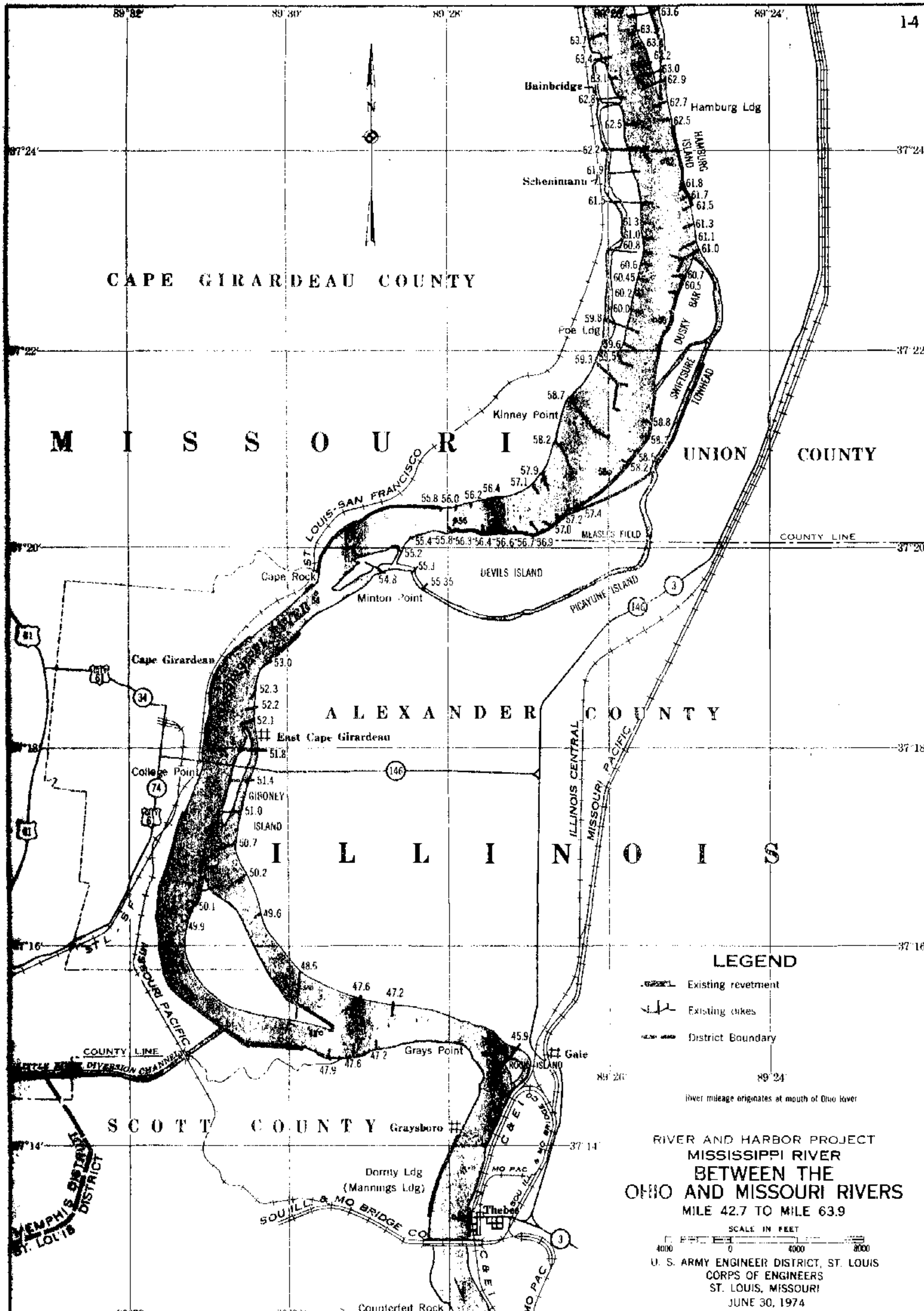

1-3
Uncle Joe Ldg
Hancock Rocks
Paul Jones Rock
Little Chain
ST. LOUIS DISTRICT
MEMPHIS DISTRICT
ILLINOIS
MISS
SCOTT
ALEXANDER COUNTY
Commercial Ldg
Commercial Point
LEGEND
Existing revetment
Existing dikes
Under water weirs
District Boundary
HACKER BEND
Bryant Ldg
BUFFALO ISLAND
COUNTY LINE
MISSISSIPPI COUNTY

PLATE 1–3b


14
CAPE GIRARDEAU COUNTY
MISSOURI
UNION COUNTY
ALEXANDER COUNTY
ILLINOIS
SCOTT COUNTY
Bainbridge
Hamburg Ldg
HAMBURG ISLAND
Scheniman
Poe Ldg
DUSKY BAR
SHIFTSURE
TOWHEAD
Kinney Point
ST LOUIS-SAN FRANCISCO
MEASLES FIELD
COUNTY LINE
DEVILS ISLAND
PICAYUNE ISLAND
Cape Rock
Minton Point
Cape Girardeau
East Cape Girardeau
College Point
GIBONEY ISLAND
ILLINOIS CENTRAL
MISSOURI PACIFIC
DIVERSION CHANNEL
Grays Point
Gale
ROCK ISLAND
Graysboro
Dorrity Ldg
(Mannings Ldg)
SOU ILL & MO BRIDGE CO
Thebes
C & E I
MO PAC
Counterfeit Rock
MEMPHIS DISTRICT
ST. LOUIS DISTRICT
LEGEND
Existing revetment
Existing dikes
District Boundary
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 42.7 TO MILE 63.9
SCALE IN FEET
4000 0 4000 8000
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974

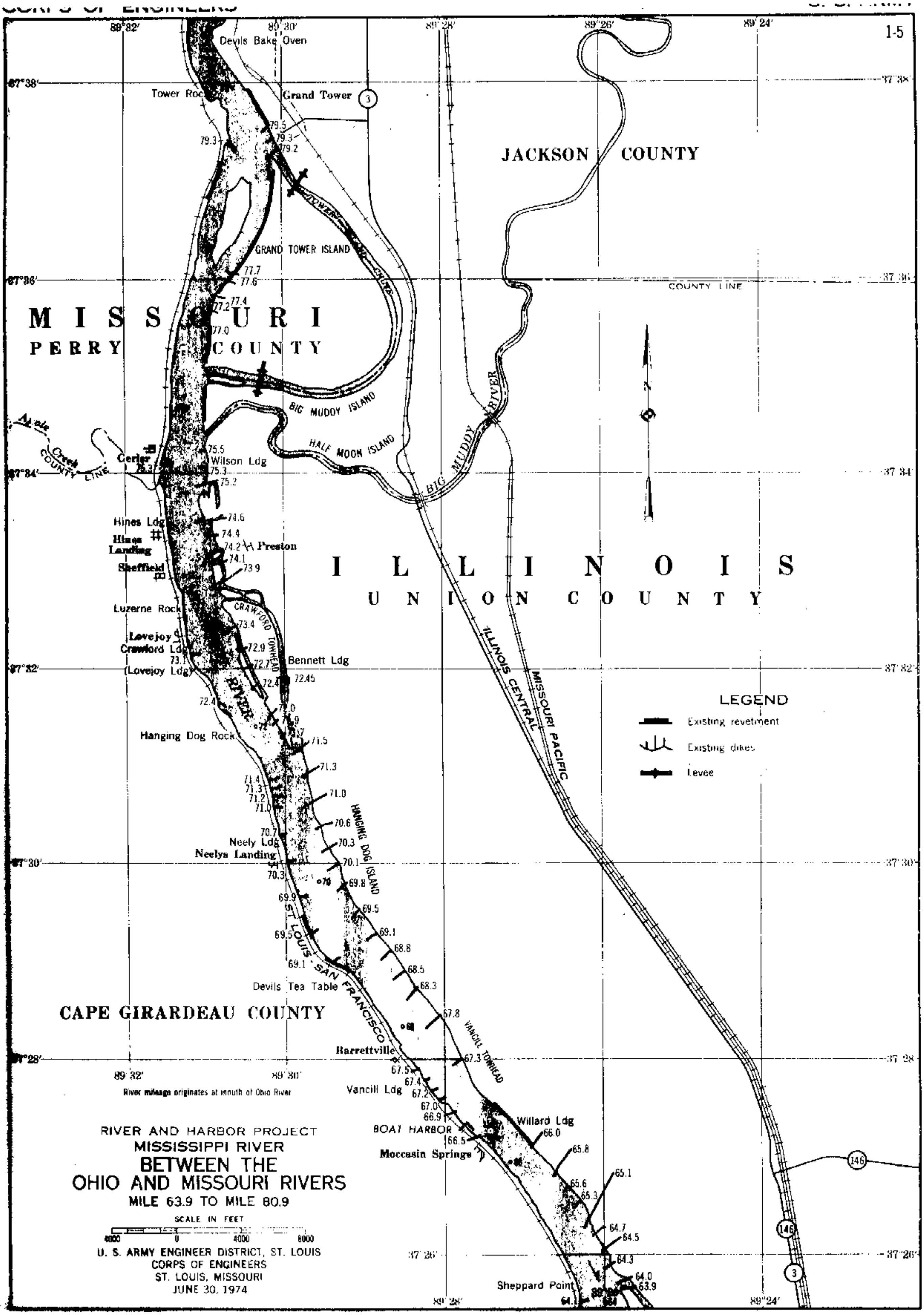
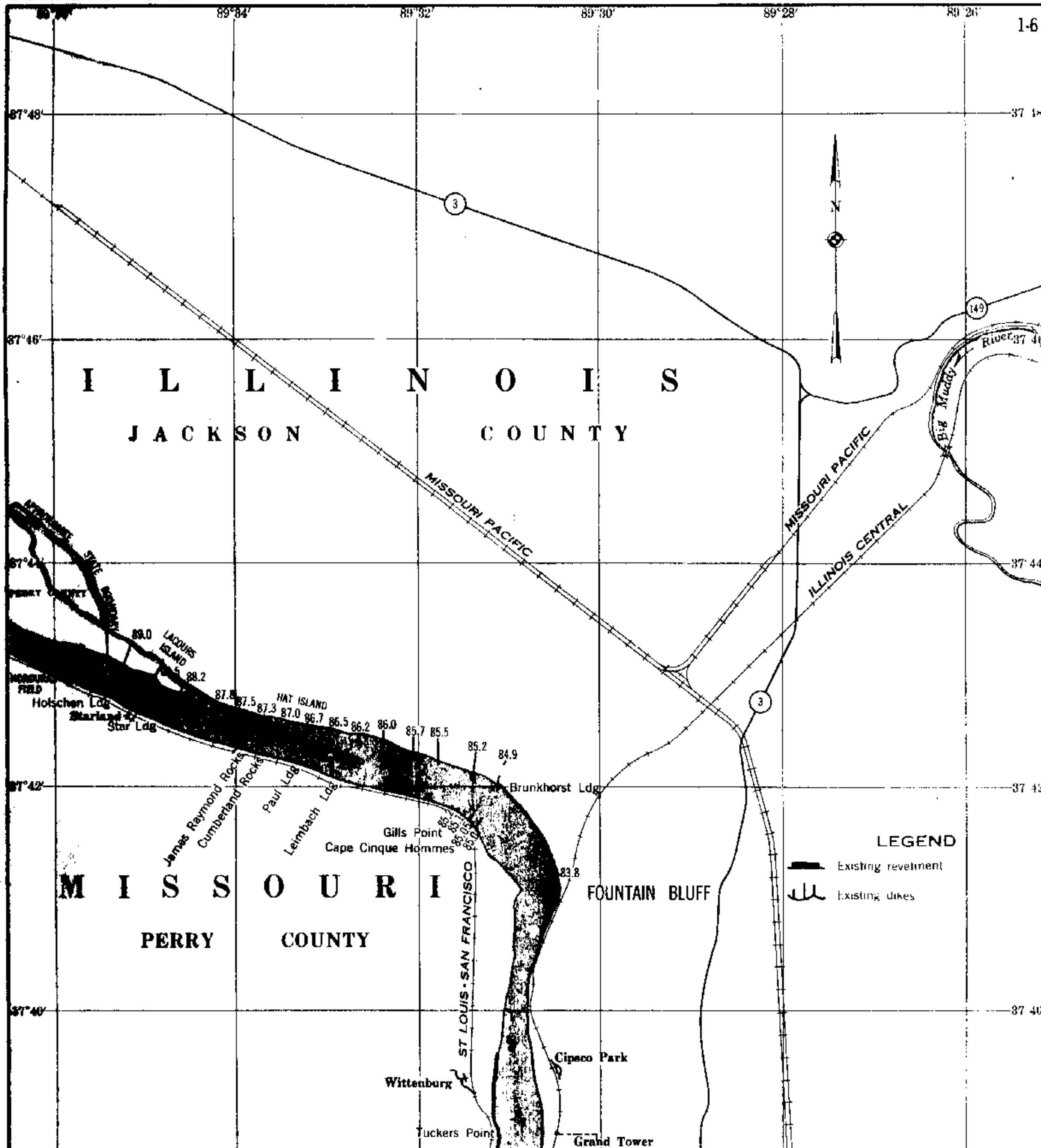

1-5
Devils Bake Oven
Tower Rock
Grand Tower
JACKSON COUNTY
GRAND TOWER ISLAND
COUNTY LINE
MISSOURI
PERRY COUNTY
BIG MUDDY ISLAND
HALF MOON ISLAND
BIG MUDDY RIVER
Cerler
Wilson Ldg
Hines Ldg
Hines Landing
Preston
Sheffield
ILLINOIS
UNION COUNTY
Luzerne Rock
Lovejoy
Crawford Ldg
(Lovejoy Ldg)
CRAWFORD TOWHEAD
Bennett Ldg
RIVER
ILLINOIS CENTRAL
MISSOURI PACIFIC
LEGEND
Existing revetment
Existing dikes
Levee
Hanging Dog Rock
HANGING DOG ISLAND
Neely Ldg
Neelys Landing
ST LOUIS SAN FRANCISCO
Devils Tea Table
CAPE GIRARDEAU COUNTY
VANCILL TOWHEAD
Barrettville
Vancill Ldg
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 63.9 TO MILE 80.9
SCALE IN FEET
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974
BOAT HARBOR
Moccasin Springs
Willard Ldg
Sheppard Point

PLATE 1-3d

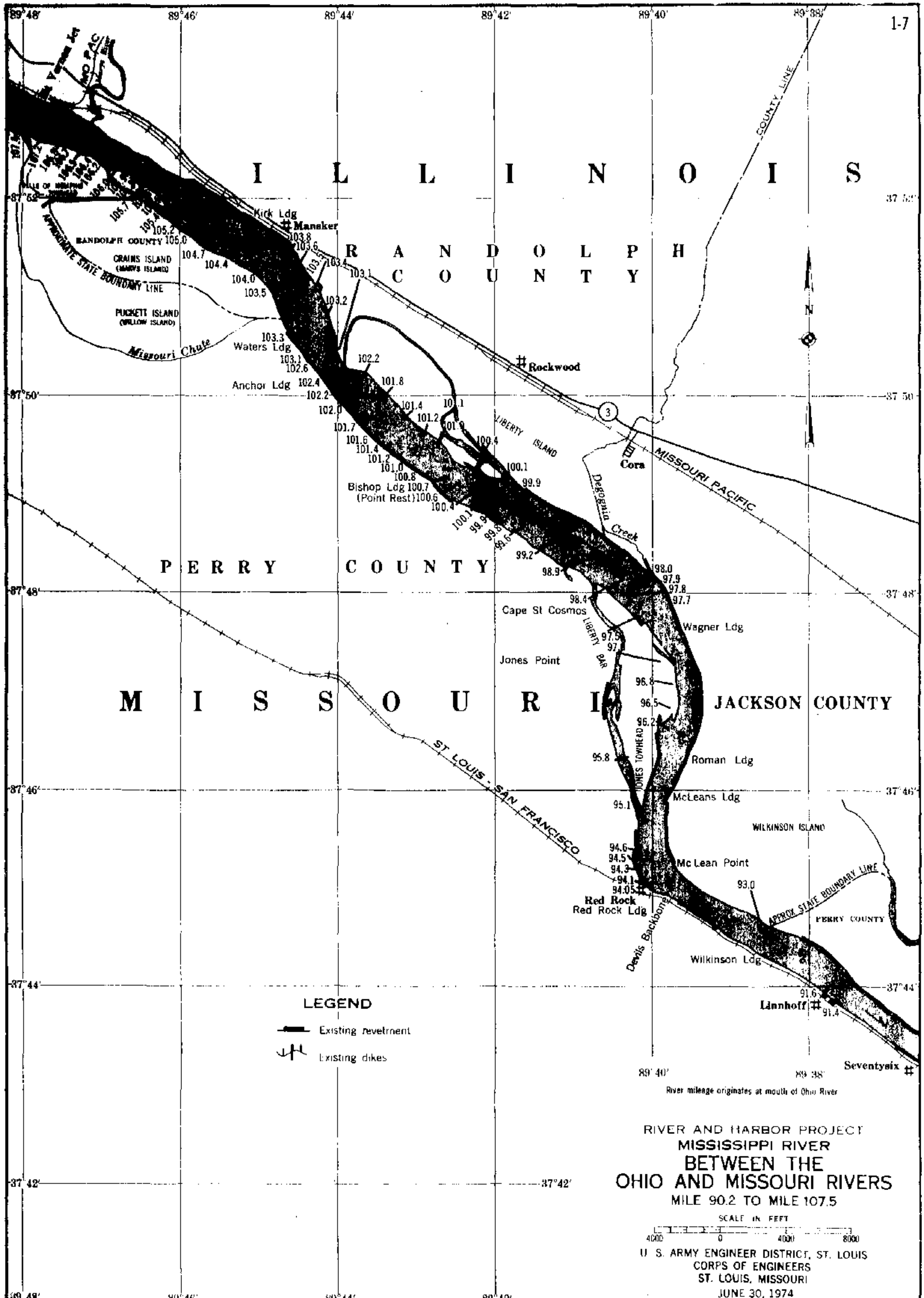


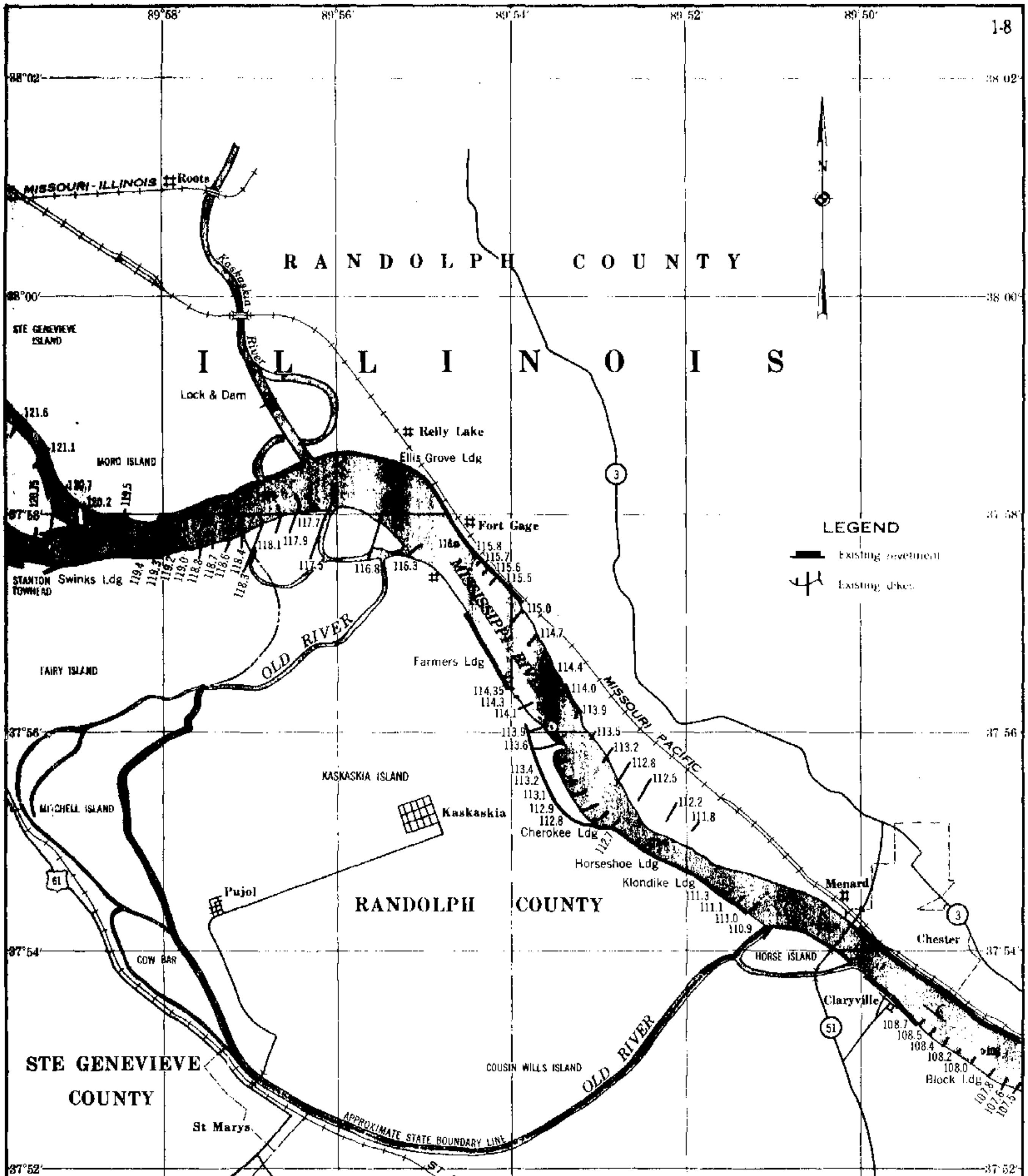
River mileage originates at mouth of Ohio River

RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 80.9 TO MILE 90.2

SCALE IN FEET
4000 0 4000 8000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974

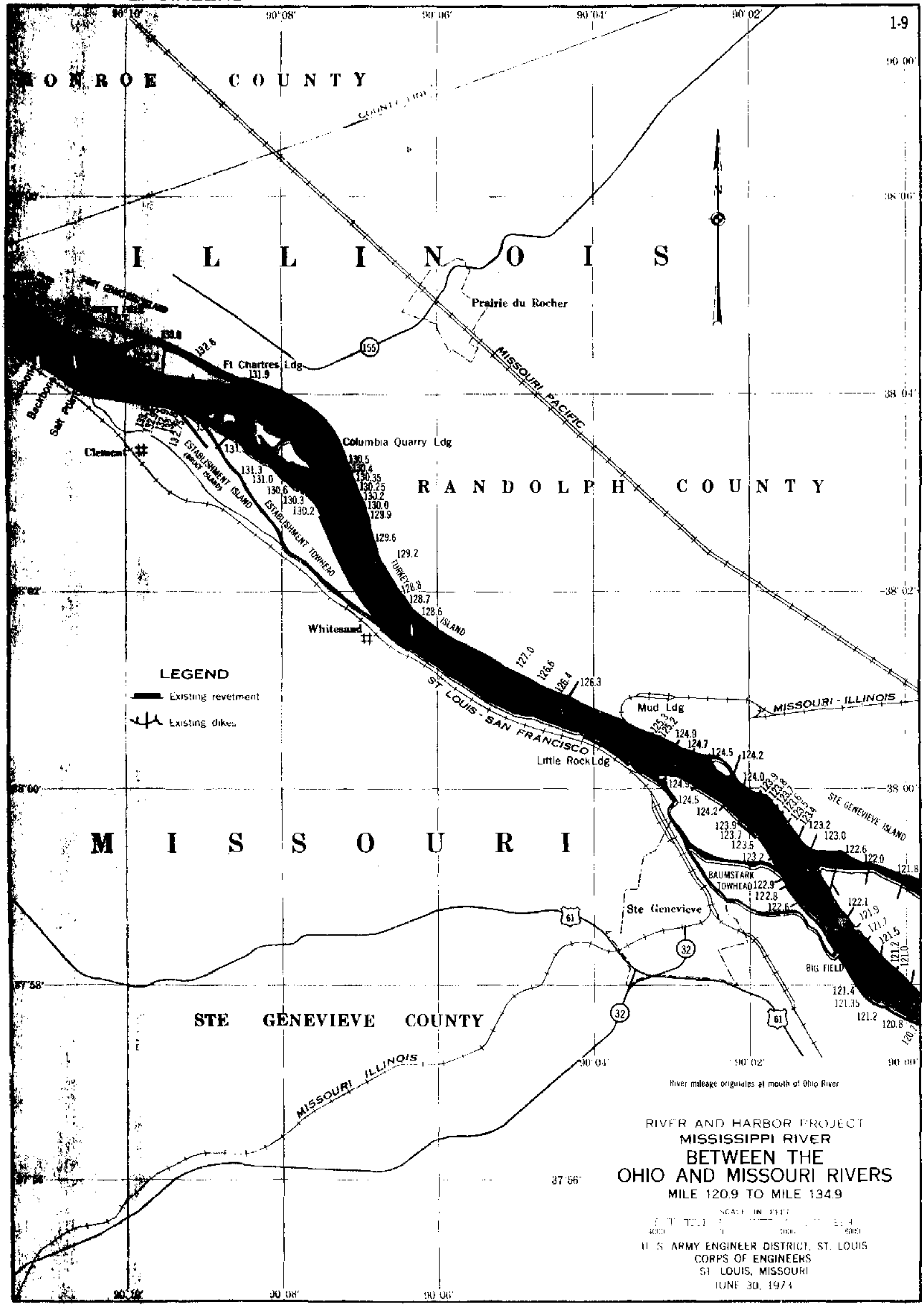

ILLINOIS
RANDOLPH COUNTY
PERRY COUNTY
MISSOURI
JACKSON COUNTY
COUNTY LINE
Kick Ldg
Manaker
Rockwood
Cora
MISSOURI PACIFIC
RANDOLPH COUNTY
CRAINS ISLAND
(MARYS ISLAND)
APPROXIMATE STATE BOUNDARY LINE
PUCKETT ISLAND
(WILLOW ISLAND)
Missouri Chute
Waters Ldg
Anchor Ldg
LIBERTY ISLAND
Bishop Ldg
(Point Rest)
Degognia Creek
Cape St Cosmos
LIBERTY BAR
Jones Point
Wagner Ldg
JONES TOWHEAD
Roman Ldg
McLeans Ldg
WILKINSON ISLAND
Mc Lean Point
APPROX STATE BOUNDARY LINE
PERRY COUNTY
Red Rock
Red Rock Ldg
Devils Backbone
Wilkinson Ldg
Linnhoff
Seventysix
ST LOUIS - SAN FRANCISCO
LEGEND
Existing revetment
Existing dikes
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 90.2 TO MILE 107.5
SCALE IN FEET
4000 0 4000 8000
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974

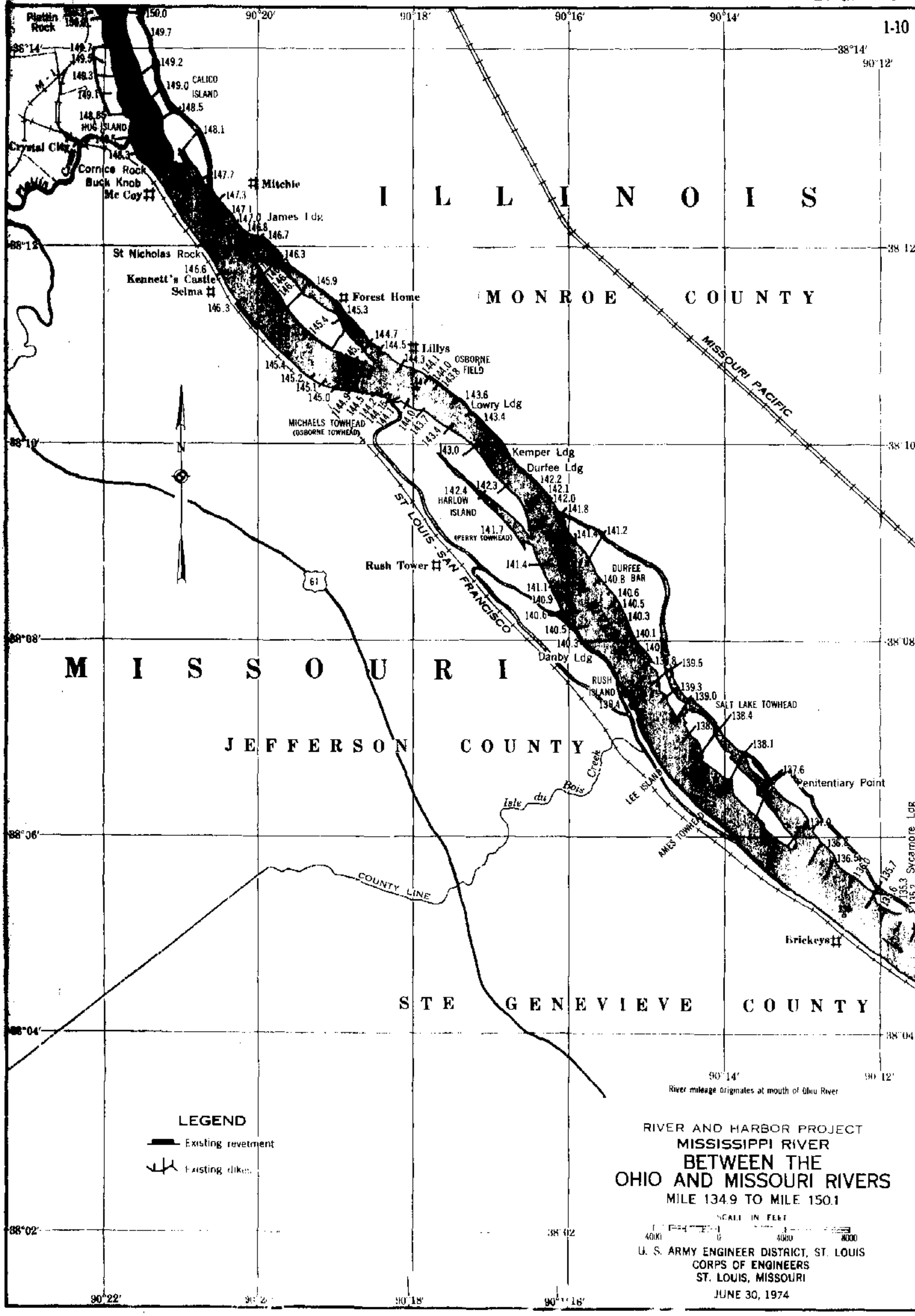


RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 107.5 TO MILE 120.9

SCALE IN FEET
4000 0 4000 8000

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974


1-9
MONROE COUNTY
ILLINOIS
RANDOLPH COUNTY
MISSOURI
STE GENEVIEVE COUNTY
Prairie du Rocher
Ft Chartres Ldg
Columbia Quarry Ldg
Whitesand
Mud Ldg
Little Rock Ldg
Ste Genevieve
BIG FIELD
MISSOURI PACIFIC
ST LOUIS - SAN FRANCISCO
MISSOURI - ILLINOIS
ESTABLISHMENT ISLAND
ESTABLISHMENT TOWHEAD
TURKEY ISLAND
STE GENEVIEVE ISLAND
BAUMSTARK TOWHEAD
LEGEND
Existing revetment
Existing dikes
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 120.9 TO MILE 134.9
SCALE IN FEET
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974


1-10
ILLINOIS
MONROE COUNTY
MISSOURI
JEFFERSON COUNTY
STE GENEVIEVE COUNTY
MISSOURI PACIFIC
ST LOUIS - SAN FRANCISCO
COUNTY LINE
Isle du Bois Creek
Crystal City
Plattin Rock
CALICO ISLAND
HOG ISLAND
Cornice Rock
Buck Knob
Mc Coy
Mitchie
James Ldg
St Nicholas Rock
Kennett's Castle
Selma
Forest Home
Lillys
OSBORNE FIELD
Lowry Ldg
MICHAELS TOWHEAD (OSBORNE TOWHEAD)
Kemper Ldg
Durfee Ldg
HARLOW ISLAND
(PERRY TOWHEAD)
Rush Tower
DURFEE BAR
Danby Ldg
RUSH ISLAND
SALT LAKE TOWHEAD
Penitentiary Point
LEE ISLAND
AMES TOWHEAD
Sycamore Ldg
Brickeys
River mileage originates at mouth of Ohio River
LEGEND
Existing revetment
Existing dikes
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 134.9 TO MILE 150.1
SCALE IN FEET
4000 0 4000 8000
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974

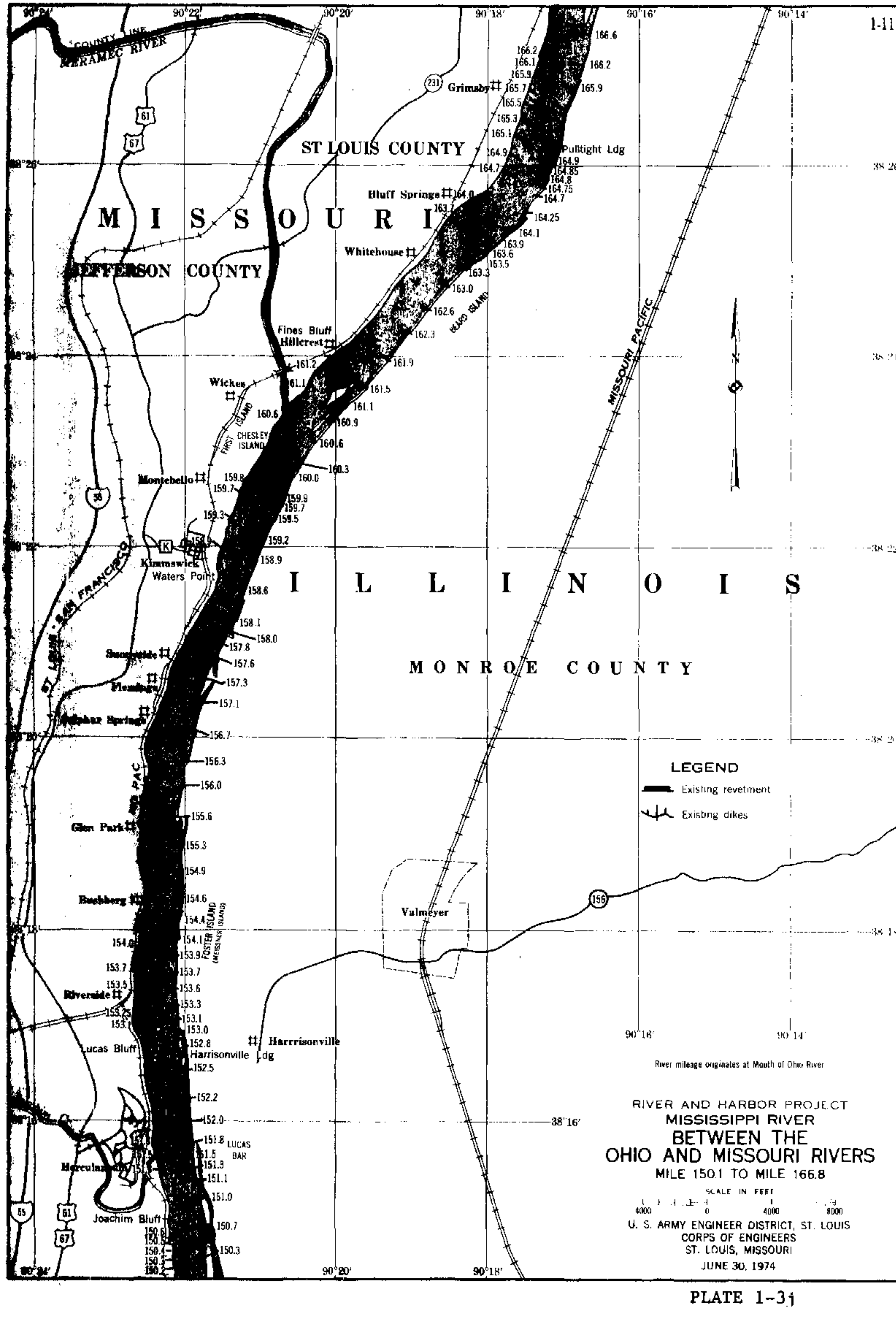
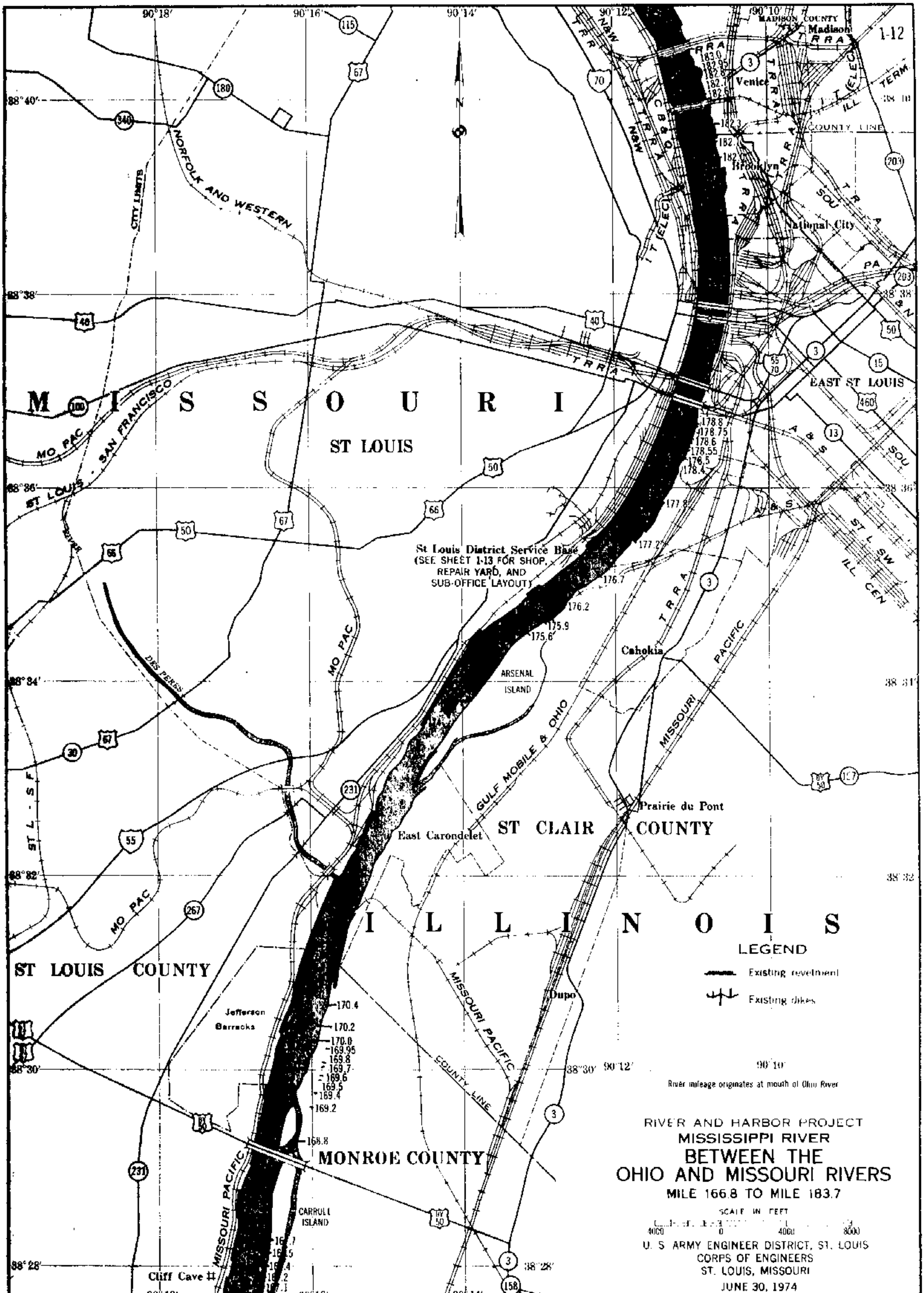

1-11
COUNTY LINE
MERAMEC RIVER
ST LOUIS COUNTY
M I S S O U R I
JEFFERSON COUNTY
I L L I N O I S
MONROE COUNTY
MISSOURI PACIFIC
ST LOUIS - SAN FRANCISCO
Grimsby
Pulltight Ldg
Bluff Springs
Whitehouse
Fines Bluff
Hillcrest
Wickes
FIRST ISLAND
CHESLEY ISLAND
Montebello
Kimmswick
Waters Point
Flemings
Glen Park
Bushberg
FOSTER ISLAND (MEISSNER ISLAND)
Riverside
Lucas Bluff
Harrisonville Ldg
Harrisonville
LUCAS BAR
Herculaneum
Joachim Bluff
Valmeyer
LEGEND
Existing revetment
Existing dikes
River mileage originates at Mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 150.1 TO MILE 166.8
SCALE IN FEET
4000 0 4000 8000
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974

PLATE 1-31


1-12
MISSOURI
ST LOUIS
ILLINOIS
ST CLAIR COUNTY
ST LOUIS COUNTY
MONROE COUNTY
EAST ST LOUIS
Madison
Venice
Brooklyn
National City
Cahokia
Prairie du Pont
East Carondelet
Dupo
Jefferson Barracks
Cliff Cave
ARSENAL ISLAND
CARROLL ISLAND
St Louis District Service Base (SEE SHEET 1-13 FOR SHOP, REPAIR YARD, AND SUB-OFFICE LAYOUT)
NORFOLK AND WESTERN
ST LOUIS - SAN FRANCISCO
MO PAC
GULF MOBILE & OHIO
MISSOURI PACIFIC
COUNTY LINE
DES PERES
CITY LIMITS
LEGEND
Existing revetment
Existing dikes
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 166.8 TO MILE 183.7
SCALE IN FEET
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974

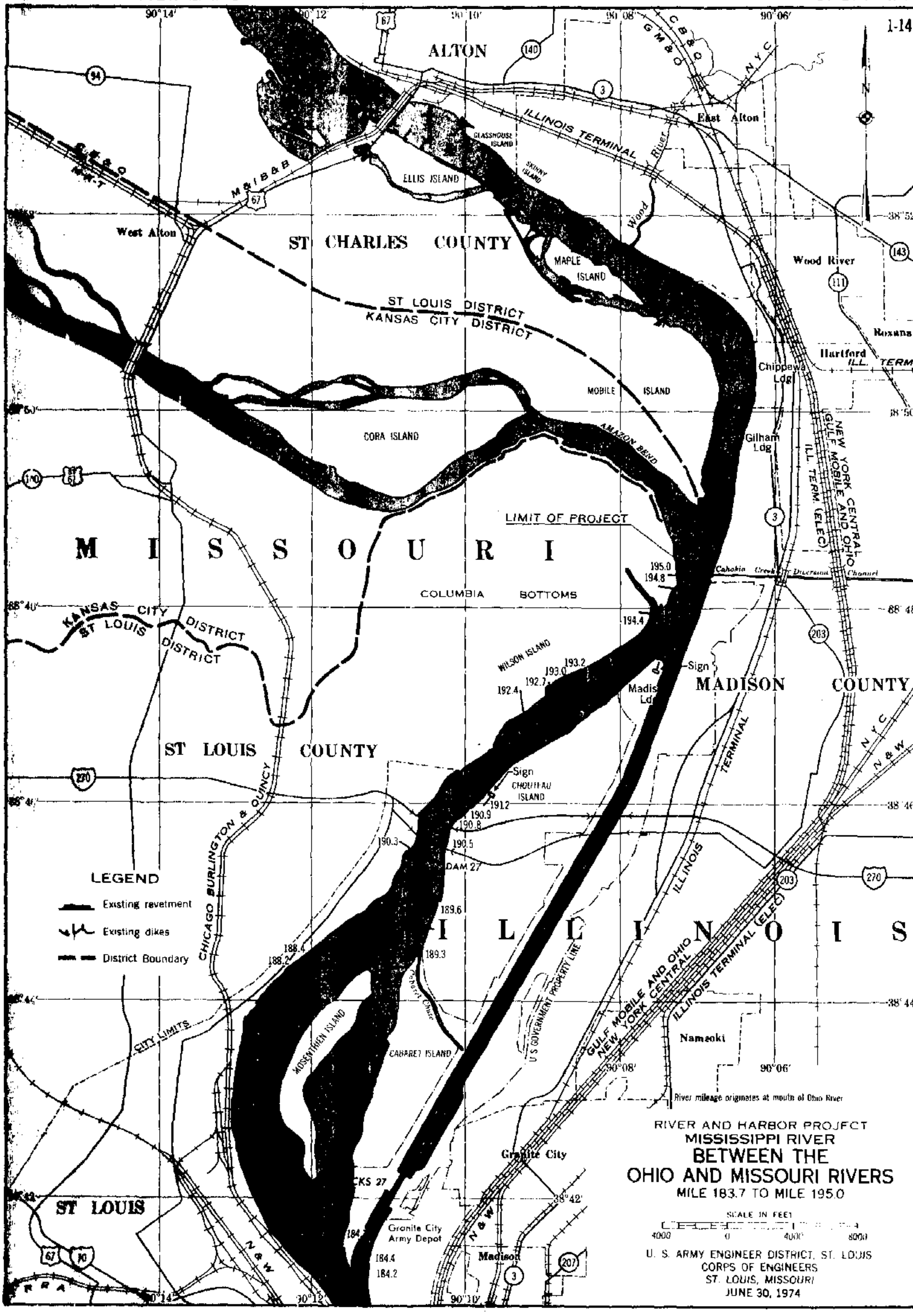

1-14
ALTON
East Alton
ILLINOIS TERMINAL
GLASSHOUSE ISLAND
SKINNY ISLAND
ELLIS ISLAND
Wood River
West Alton
ST CHARLES COUNTY
MAPLE ISLAND
ST LOUIS DISTRICT
KANSAS CITY DISTRICT
Hartford
Roxana
Chippewa Ldg
MOBILE ISLAND
CORA ISLAND
AMAZON BEND
Gilham Ldg
LIMIT OF PROJECT
M I S S O U R I
COLUMBIA BOTTOMS
195.0
194.8
194.4
WILSON ISLAND
193.2
193.0
192.7
192.4
Sign
Madison Ldg
MADISON COUNTY
ST LOUIS COUNTY
CHOUTEAU ISLAND
191.2
190.9
190.8
190.5
190.3
DAM 27
189.6
189.3
188.4
188.2
CHICAGO BURLINGTON & QUINCY
NEW YORK CENTRAL
GULF MOBILE AND OHIO
ILLINOIS TERMINAL (ELEC)
U S GOVERNMENT PROPERTY LINE
I L L I N O I S
LEGEND
Existing revetment
Existing dikes
District Boundary
MOSENTHEIN ISLAND
CABARET ISLAND
CITY LIMITS
Nameoki
River mileage originates at mouth of Ohio River
Granite City
ST LOUIS
Granite City Army Depot
184.4
184.2
Madison
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 183.7 TO MILE 195.0
SCALE IN FEET
4000 0 4000 8000
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
JUNE 30, 1974

FIGURE 1-3. DIKE FIELDS IN THE MISSISSIPPI RIVER

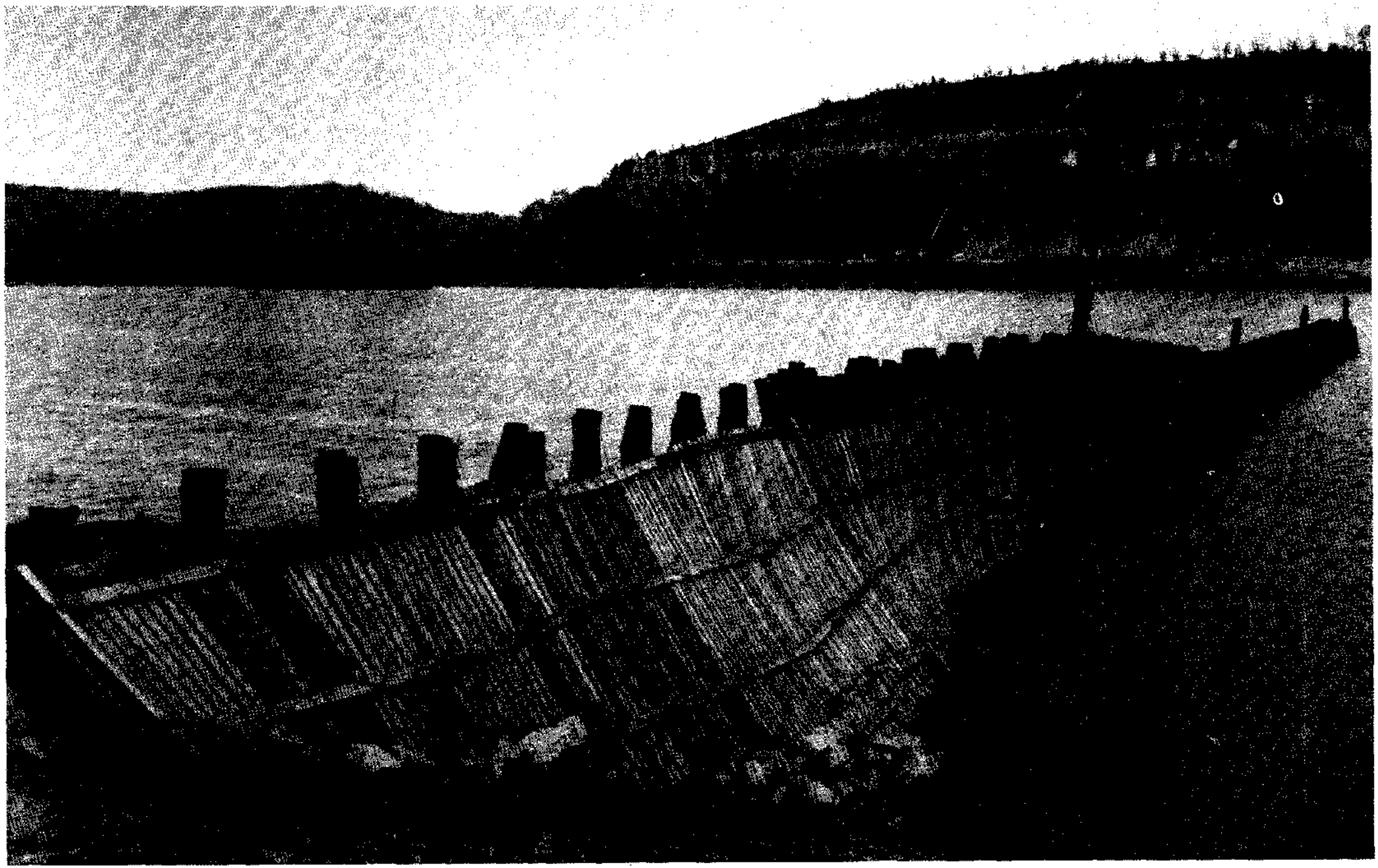


FIGURE I-4. Typical Wooden Pile Dike with Screen

Missouri River in the 1940's would possibly have reduced the effectiveness of permeable dikes if the transformation to impermeable stone dikes had not been made. Pile dikes were subject to deterioration by exposure to the elements, ice floes, damage by towboats, and even by burning when friction by moving piles within a cluster would cause self-ignition.

Stone dikes do not depend upon the deposition of sediment for their contractional effect to the extent as permeable dikes. When the tops (crowns) of dikes are exposed above the water level, deposition between them occurs when sediments are brought in by eddy action.

Quarry-run stone is normally used in the construction of stone dikes (Figure 1-5). In addition to size-class specifications, limitations are placed on the maximum size of stone and amount of fines. Sufficient bank protection and underwater stone blankets are provided both upstream and downstream of where the dike ties into the bank to prevent the scour that would otherwise normally occur adjacent to the high bank due to eddy currents caused by water level differentials. The crown of a dike normally slopes downward from the top of high bank riverward for at least 300 feet to minimize bank scour.

Of the over 800 dikes present in the Middle Mississippi River, new stone-fill dikes and timber-pile dikes converted to stone-fill dikes number about 500. The remaining 300 dikes are timber-pile dikes which are generally in a state of disrepair.

1.4.1.1. Dike Design Criteria

Due to the characteristics of a dynamic alluvial river such as the Middle Mississippi, it would be futile to attempt to describe optimum design criteria and procedures for the utilization of dikes in any specific location since no two situations in the same river are alike. Experience has shown that each reach of a river must be treated individually, and that work performed in one reach will affect adjacent reaches.

It is generally agreed that dike fields with stepped-down crests are more effective in providing a comparatively uniform contractional effect (Franco, 1967). With a system such as this, the elevation of each succeeding downstream dike crest is lower in elevation. Flow from the channel moves around the end of the high dike into the area behind the high dike and toward the next lower dike downstream. The faster moving surface currents continue in a relatively straight line, whereas the slower, sediment-laden bottom currents move into the dike field and deposit their loads of sand. The downstream dike of any two dikes should be overtopped for a sufficient length of time before the next upstream dike is overtopped so that there will be a reasonable period of time for the sand-carrying bottom currents to be diverted into

FIGURE 1-5. Stone Dike Construction

the area between the two dikes. The design of an "ideal" stepped-down arrangement becomes almost impossible in many reaches of the Middle Mississippi River due to pre-existing dikes which are built to relatively high elevations.

The height to which a dike is to be built is generally dependent upon the effect desired. Where bank protection is desired, such as on the outside of a bend, the dike may be built to a relatively high elevation. Generally speaking, dikes are built for the purpose of providing an increasing greater contractional effect at lower river stages. The majority of dikes are designed to contract flows up to about midbank stages.

During the past five years, the trend has been to build dikes to lower elevations so that the resultant sandbars which develop between adjacent dikes will be lower in elevation and subsequently submerged for greater periods of time, thus precluding substantial vegetative growth which would cause increased deposition to occur. This was done in an attempt to develop the authorized navigation channel and to lessen the impact of the project on existing aquatic habitat.

The spacing between adjacent dikes is generally dependent upon the prevailing conditions at a location; however, the distance between dikes usually varies from one to two times the dike length. Generally speaking, the dike spacing and contraction width determine the degree of contraction, whereas the average height of dikes within a dike field determines the amount of contractional effort at a particular river stage.

Chute closures are a form of dike used to restrict the flows of water through backwater chutes and sloughs in an effort to confine the low water flow to the main channel. The closures are usually constructed of the same material as dikes. Some chute closures are, in actuality, landward portions of earlier constructed dikes which caused the formation of small islands. The backwater region behind the newly created man-made island became known as a chute and the existing portion of dike within this backwater area thus became known as a chute closure.

1.4.1.2. Future Dike Construction

At present, the results of model tests and actual experiences with the river stabilization works in place indicate that a plan using a 1,500-foot low water contraction between dike ends with additional contractive effort of troublesome channel reaches and with selective dredging of problem reaches, will be sufficient to insure a dependable navigation channel. In general, an extension (usually 300 feet) of existing dikes, which now provide an 1,800-foot contraction, and some new dikes, will be required to provide for a 1,500-foot contraction plan.

1.4.2. BANKLINE REVETMENTS

Bank stabilization works play an important part in maintaining a navigation channel (Table 1-2) (Plates 1-3a through 1-31). If concave banks on the outside of a river bend were allowed to erode for sustained periods of time, excessive channel widths and poor navigation alinements would result, accompanied by a probable decrease in the river's ability to transport sediment in that segment of the stream. A secondary benefit of the bankline revetments is the protection of numerous agricultural levees which are situated near the edge of the river. The banks on the opposite side of a dike field are normally protected by revetment to maintain the alinement of the navigation channel.

The earliest forms of river bank protection consisted of placing stone revetment on a pregraded bank and sinking a lumber mattress into the stream with rock (Figure 1-6).

Hand-placed stone riprap was used in numerous locations during the depression era as a method of stabilizing caving banks. The hand-placed riprap has a very neat appearance and has proven to be quite durable in many locations; however, the increasing cost of labor has eliminated its use.

The present method of bank protection on the Middle Mississippi River makes use of either quarry-run or paving stone. Quarries are adjacent to the river at numerous localities within the reach which can supply good quality limestone. The stone is loaded on flat-top barges and placed on the bank by a barge-mounted dragline.

1.4.3. DREDGING

Dredging currently plays an important role in maintaining a dependable navigation channel by removing excess sediment from regions where navigation could be hindered. Ideally, it is desirable that stabilization works, such as dikes, chute closures, and revetments be designed in such a manner so that practically all the sediment that enters a reach would also leave the reach at the downstream end. However, due to the ever-changing transport capacity of a stream from section to section, certain reaches of a river will experience bed scour while deposition of sediment will occur in other reaches.

Although the dikes are designed to reduce the amount of maintenance dredging, considerable dredging is still required to maintain a dependable navigation channel. PLATES 1-4a through 1-4j illustrate the extent of dredging required in this stretch of the river for the period 1969 to 1974. The wide fluctuation in discharge makes it virtually impossible to design a navigation channel within an alluvial river which will have a uniform transport capacity at all times. For example, the rapid fall in stages following a major flood event may allow insufficient time for the excess sediment to be "flushed away" which was deposited during the high water period. In addition, high water flows will be diverted via overbank flows and secondary channels, thus robbing the main channel of some of its sediment transport capacity. Conversely, the contraction exerted by existing dikes are sometimes insufficient to provide sufficient scouring action during extreme low stages.

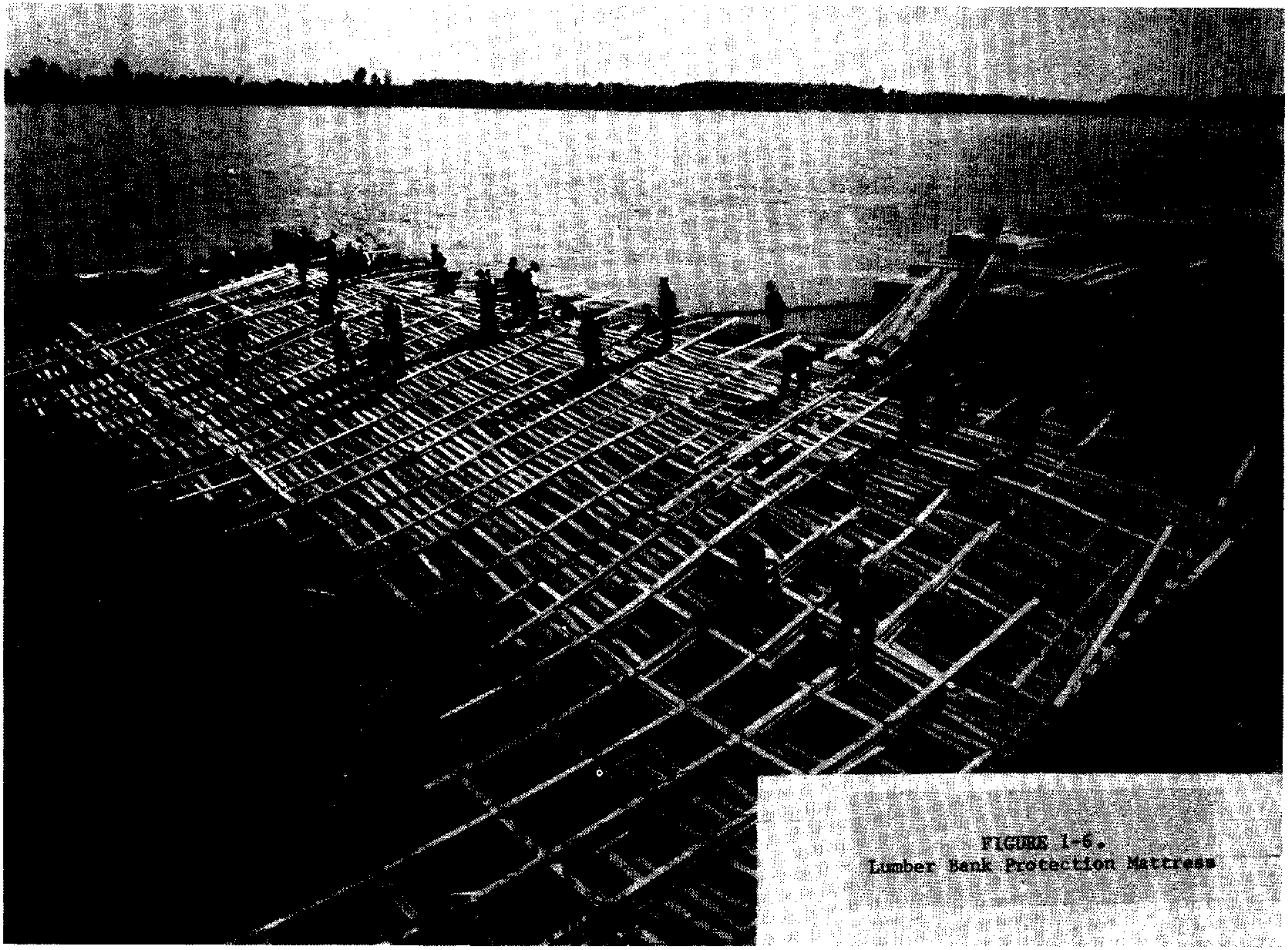
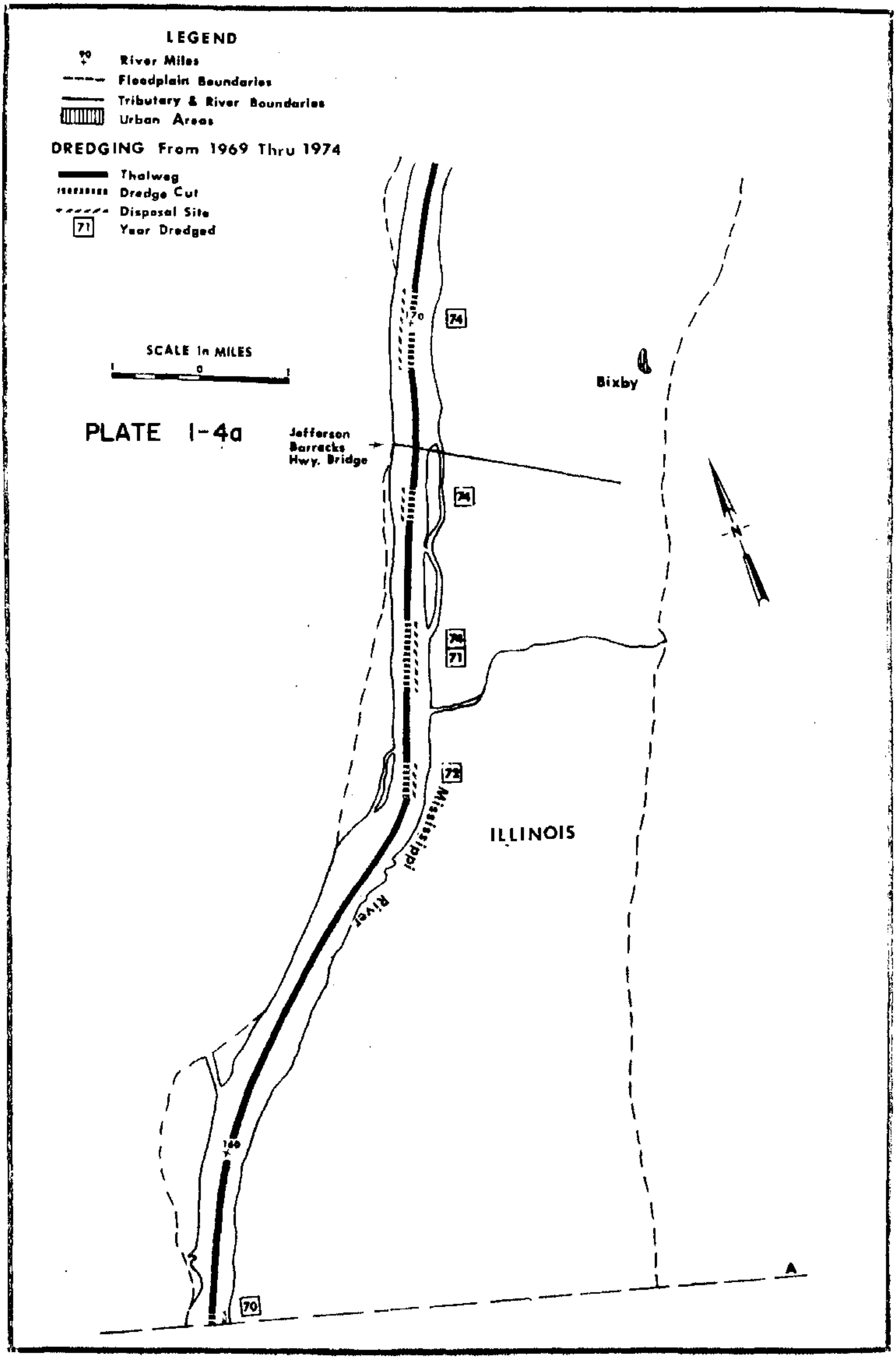


FIGURE 1-6.
Lumber Bank Protection Mattress


LEGEND
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
71 Year Dredged
SCALE In MILES
1 0 1
PLATE I-4a
Jefferson Barracks Hwy. Bridge
170
74
74
70
71
72
70
160
Bixby
N
ILLINOIS
Mississippi River
A

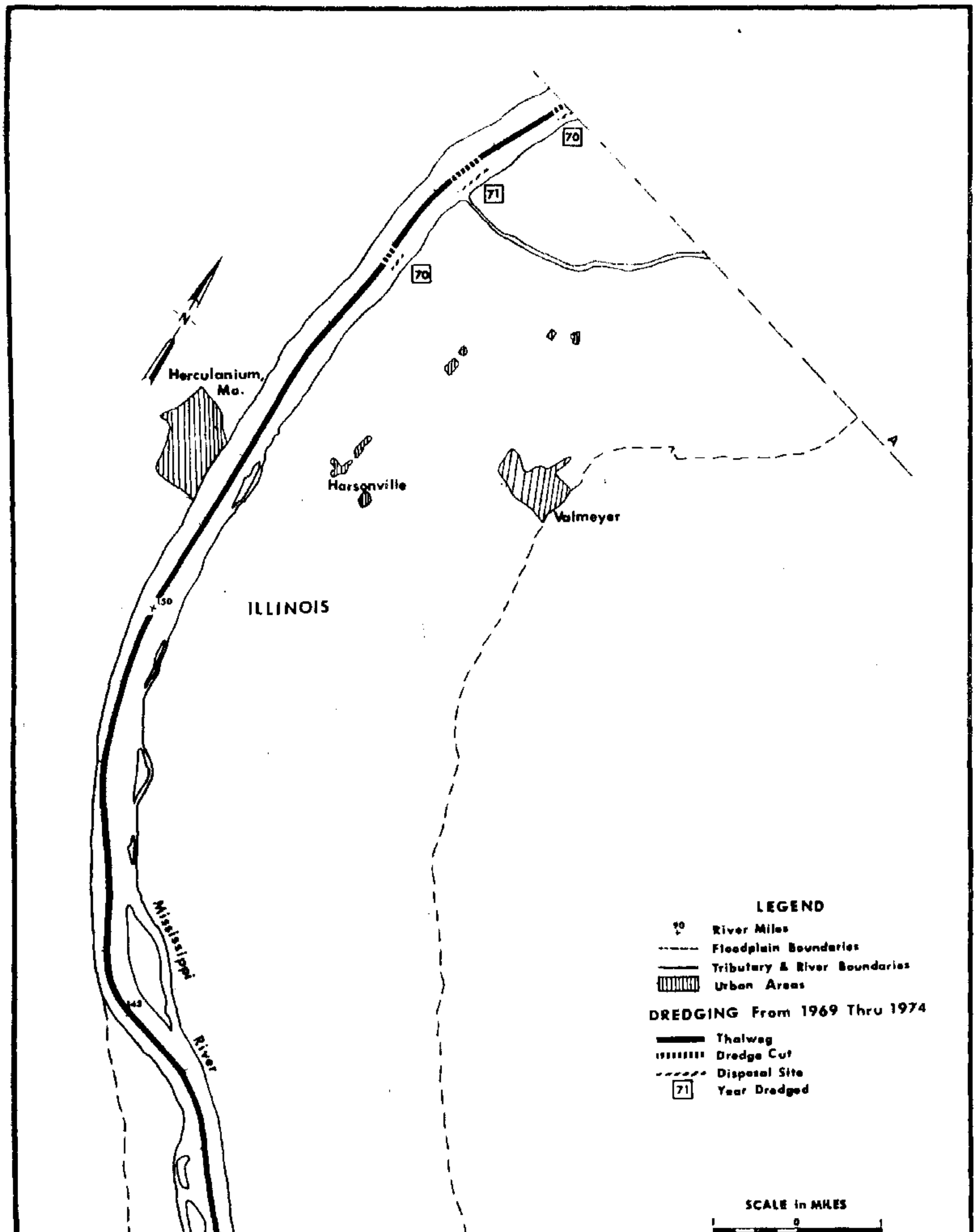
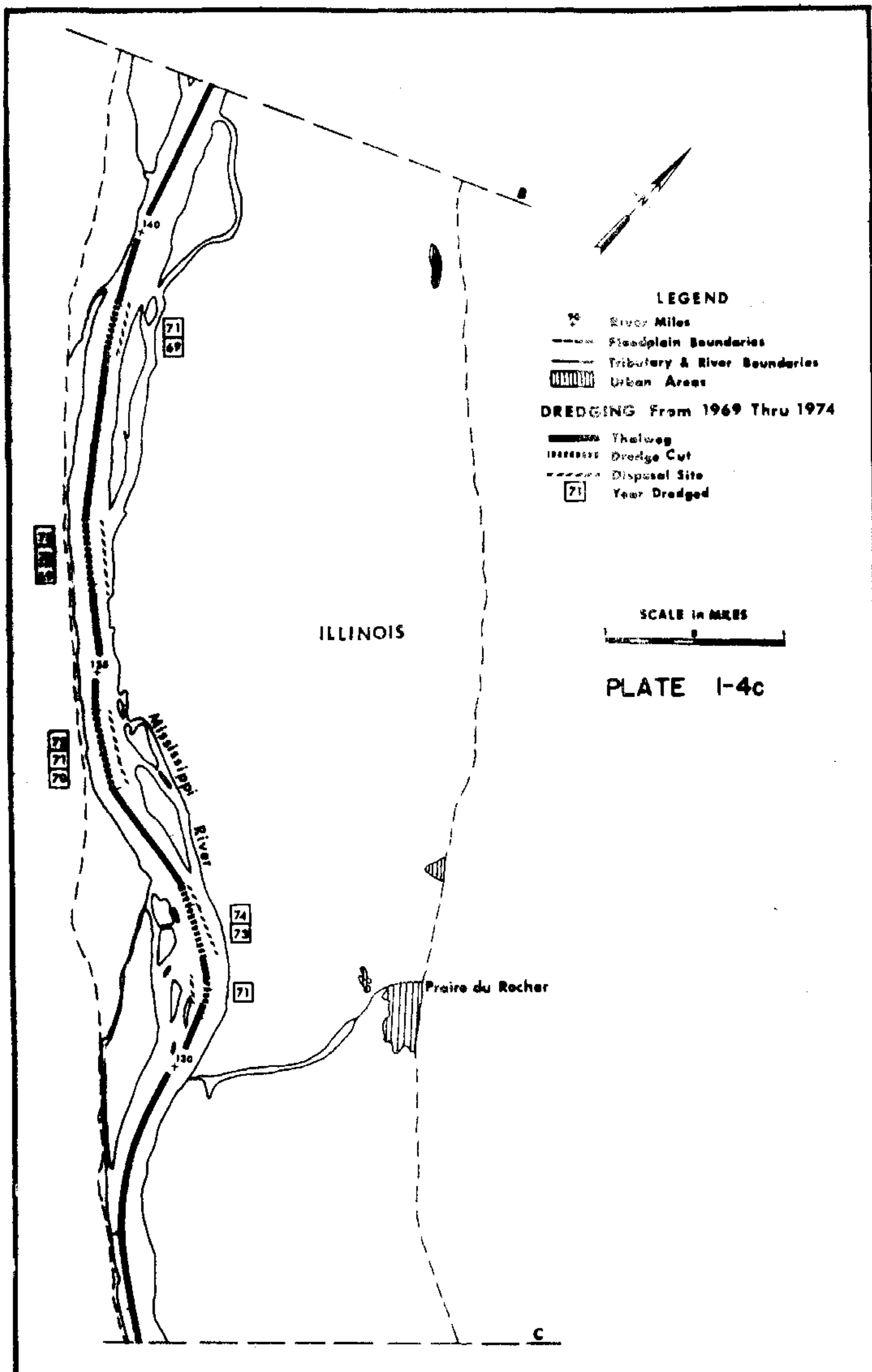
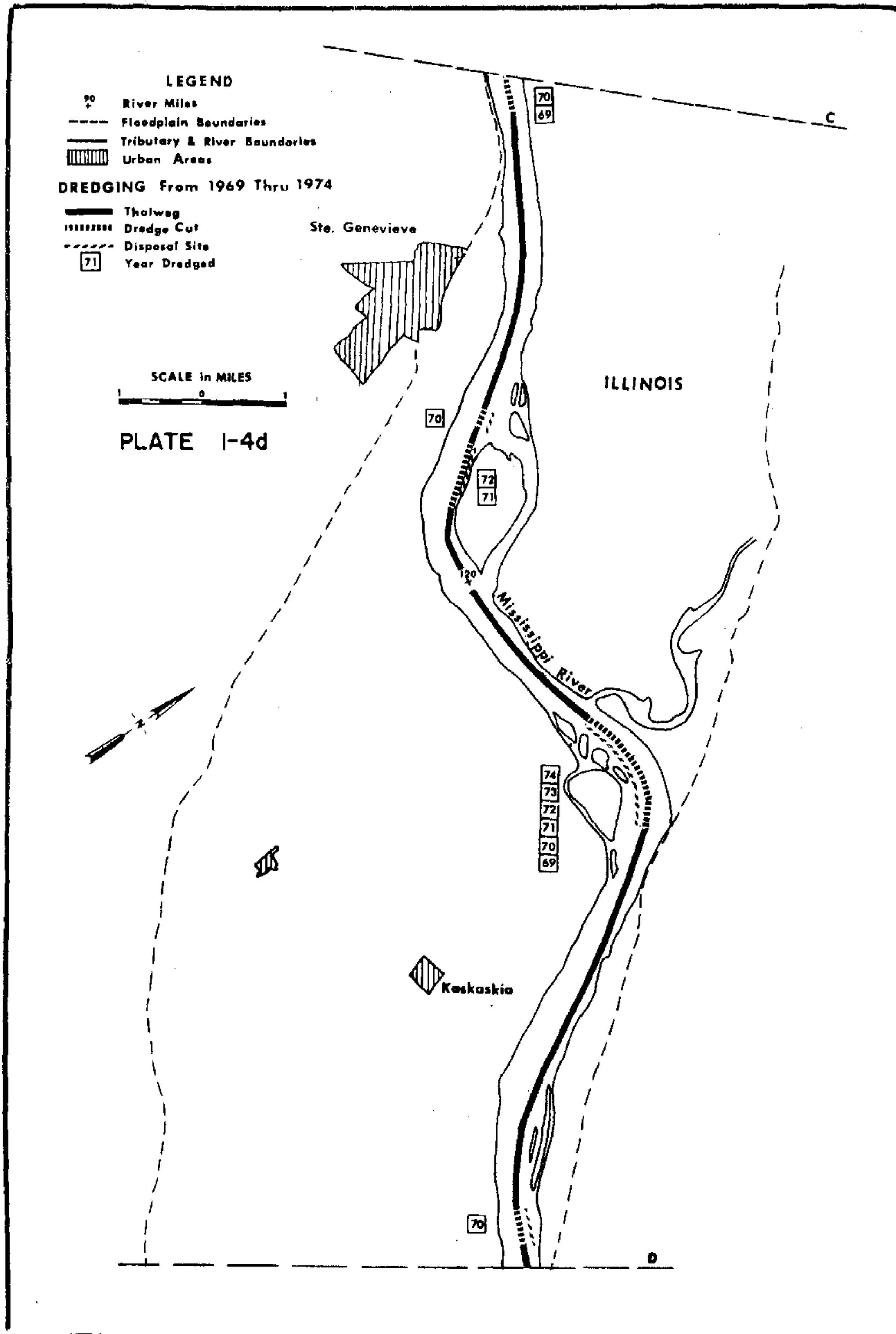

70
71
70
N
Herculanium, Mo.
Harsonville
Valmeyer
ILLINOIS
150
145
Mississippi River
A
B
LEGEND
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
71 Year Dredged
SCALE in MILES
0

PLATE I-4b

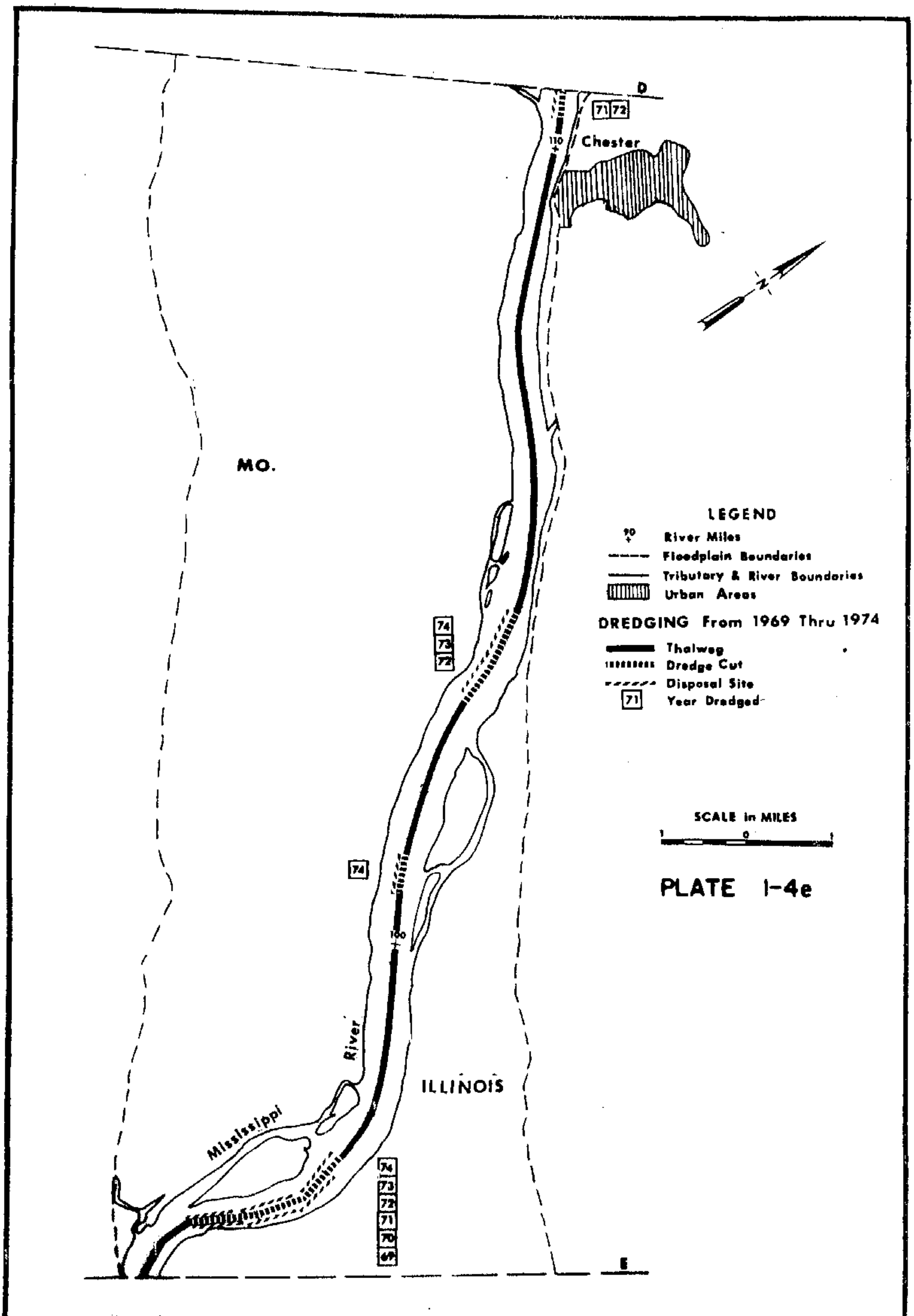


LEGEND
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
Year Dredged
SCALE in MILES
ILLINOIS
Mississippi River
Praire du Rocher
140
130
71
69
74
73
71
B
C

PLATE I-4c

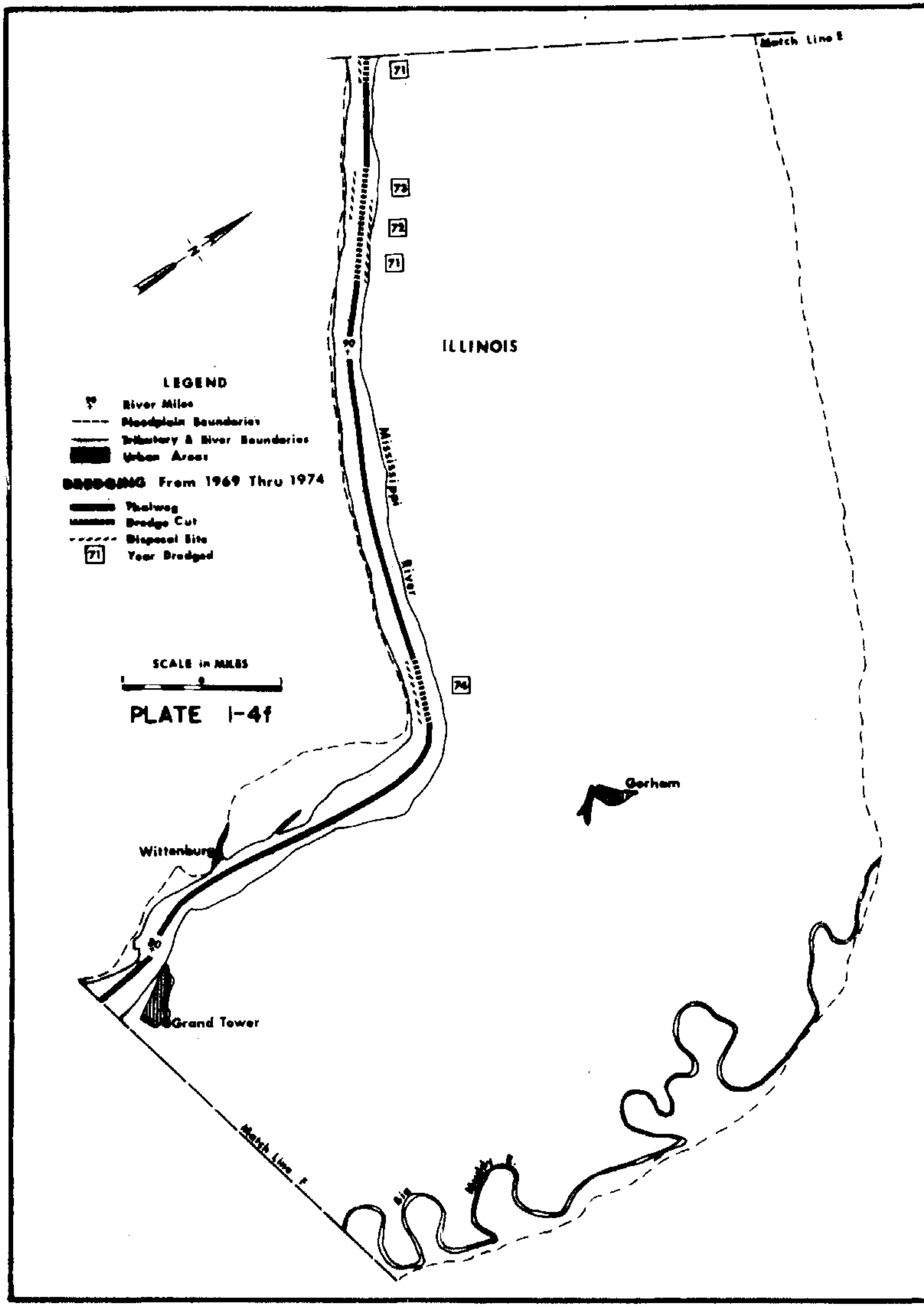


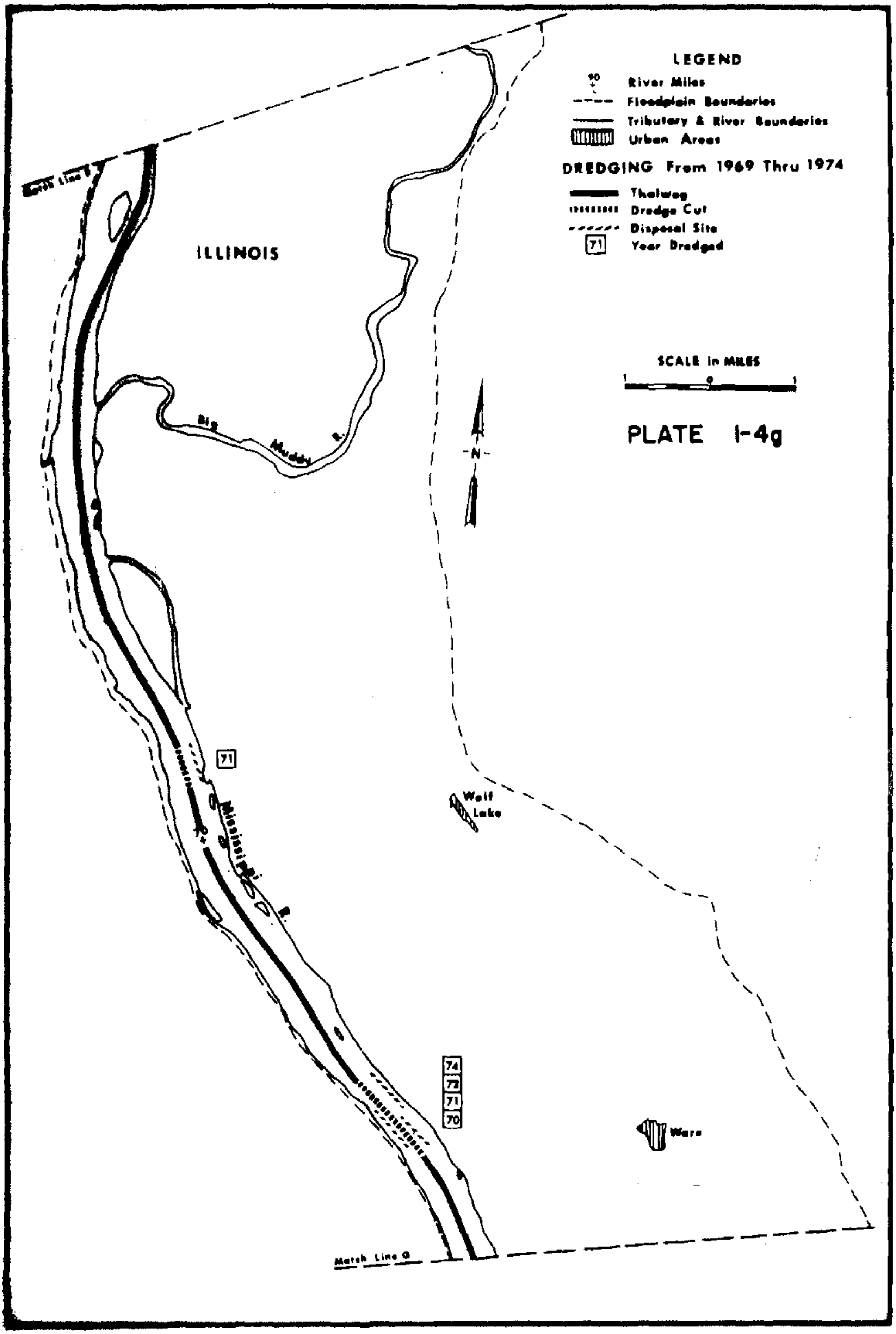
LEGEND
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
71 Year Dredged
SCALE in MILES
1 0 1
PLATE I-4d
Ste. Genevieve
ILLINOIS
Mississippi River
Kaskaskia
C
D
70
69
72
71
74
73
120
N



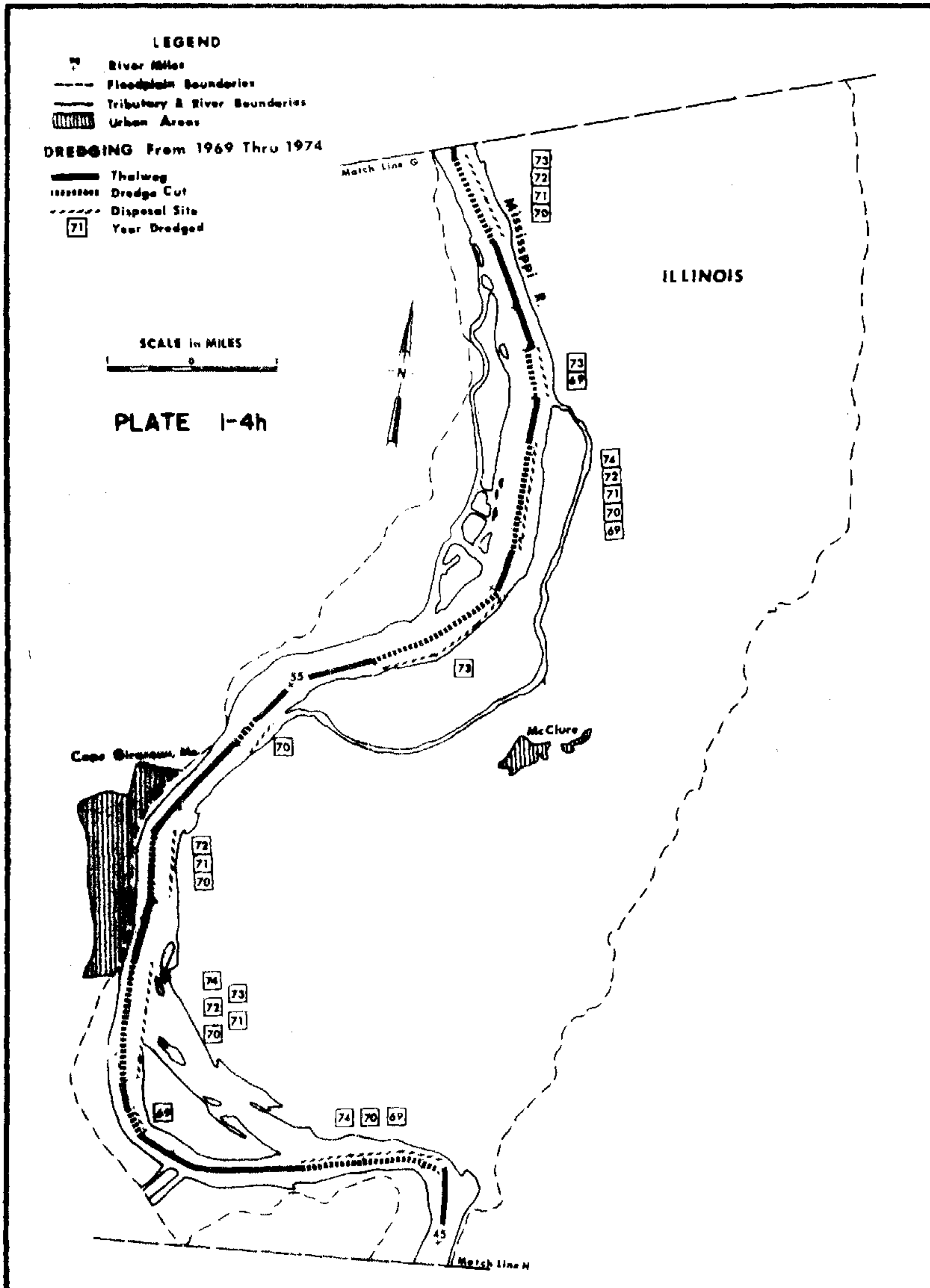
D
71 72
110
Chester
MO.
LEGEND
90
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
71 Year Dredged
74
73
72
SCALE in MILES
1 0 1
74
100
River
Mississippi
ILLINOIS
74
73
72
71
70
69
E

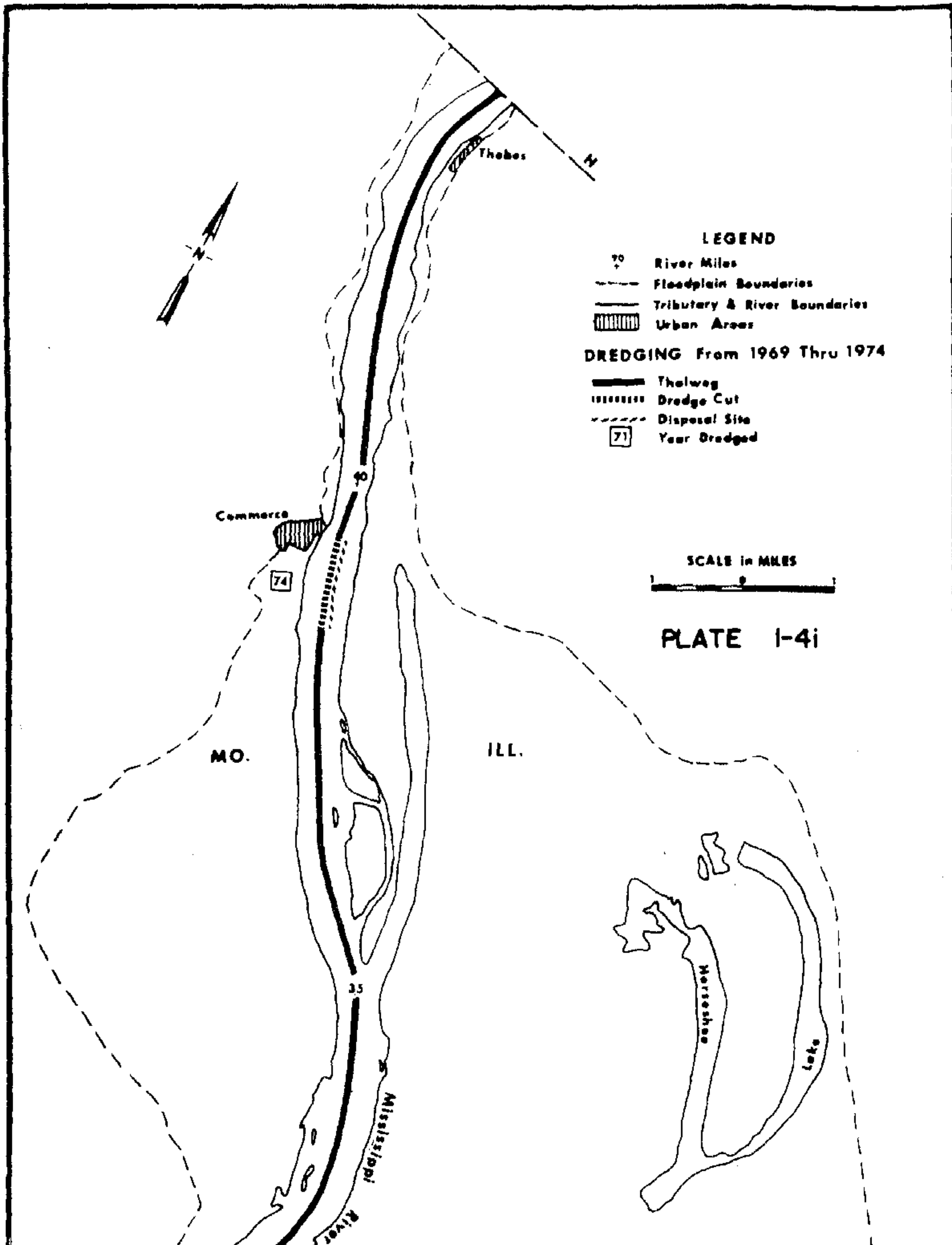
PLATE I-4e


Match Line E
ILLINOIS
LEGEND
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
71 Year Dredged
SCALE in MILES
Mississippi River
Wittenburg
Gorham
Grand Tower
Match Line F
PLATE I-4f



LEGEND
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
71 Year Dredged
ILLINOIS
SCALE in MILES
PLATE I-4g
Big Muddy R.
N
71
Mississippi R.
Wolf Lake
74
72
71
70
Ware
Match Line G


LEGEND
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
71 Year Dredged
SCALE in MILES
1 0 1
N
PLATE I-4h
Match Line G
Mississippi R.
ILLINOIS
73
72
71
70
73
69
74
72
71
70
69
73
55
McClure
70
Cape Girardeau, Mo.
72
71
70
74
73
72
71
70
69
74 70 69
45
Match Line H



Thebes
N
LEGEND
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
71
Year Dredged
Commerce
74
40
SCALE in MILES
MO.
ILL.
35
Horseshoe
Lake
Mississippi
River

PLATE I-4i

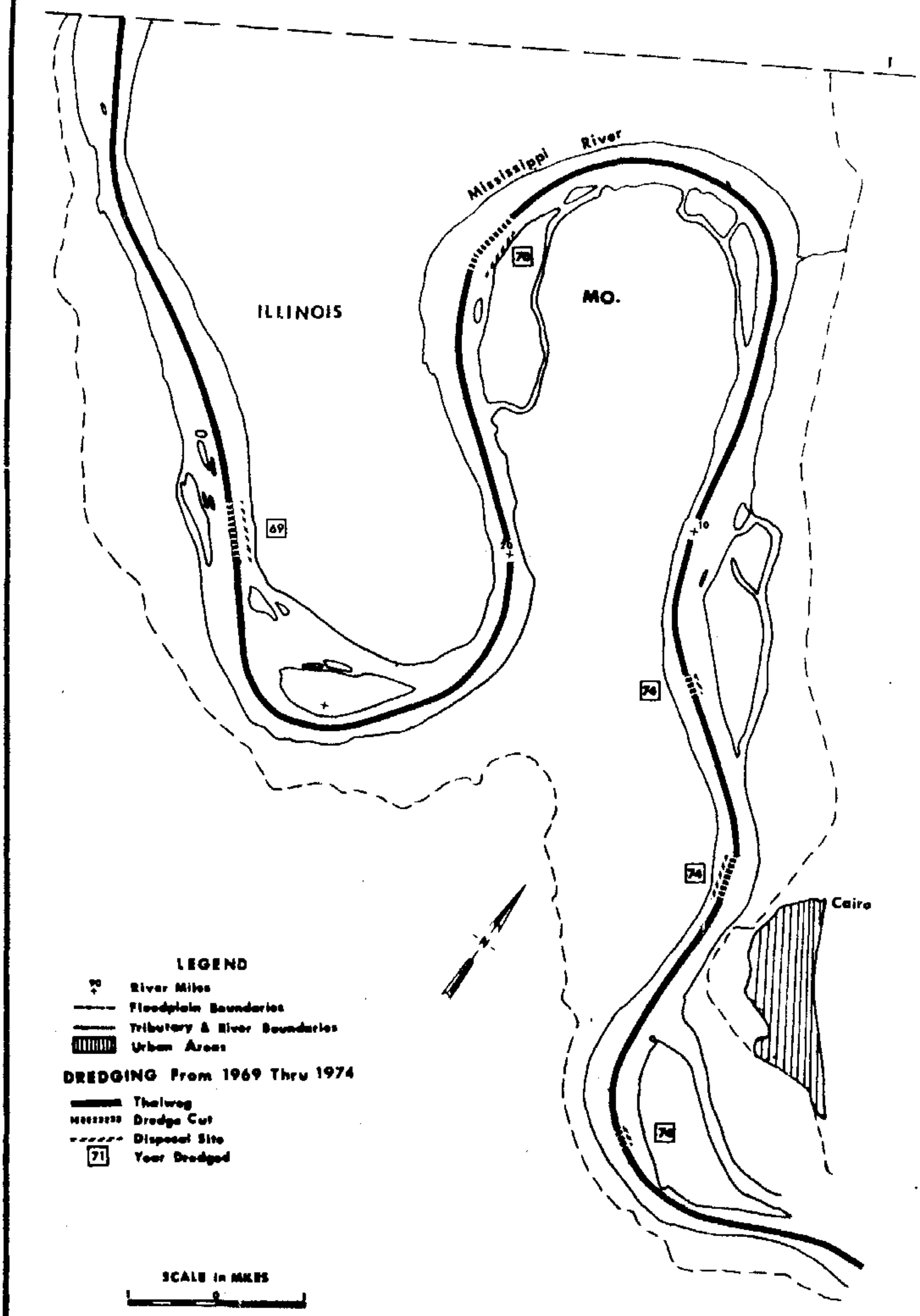

Mississippi River
ILLINOIS
MO.
Cairo
69
LEGEND
River Miles
Floodplain Boundaries
Tributary & River Boundaries
Urban Areas
DREDGING From 1969 Thru 1974
Thalweg
Dredge Cut
Disposal Site
71
Year Dredged
SCALE in MILES

PLATE I-4j

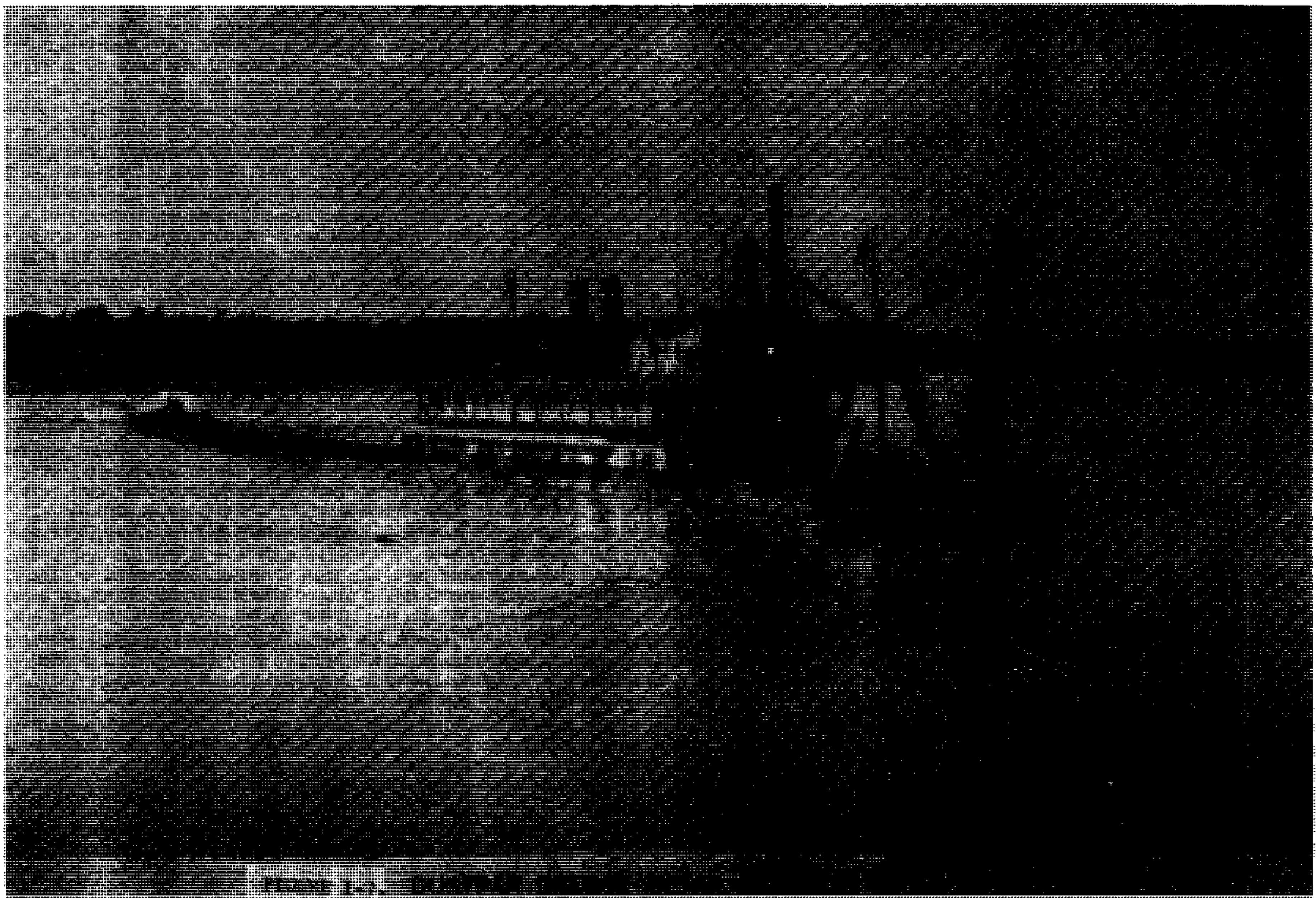
Although a relatively short segment of river, such as the 14-mile prototype reach discussed previously, can be contracted to eliminate the need for dredging, the segment of river immediately downstream will temporarily exhibit increased dredging requirements due to its inability to transport the material which was scoured from the river bed in the contracted reach. In addition, as the contractional effort which produces increase in stream velocities is continued, a point could be reached in which the self-armoring tendencies of an alluvial river bed could be resistant enough so as to preclude further deepening of the channel; at which point, the stream velocities could begin to attack the channel banklines and the dikes themselves. Also, it should be remembered that towboats would experience difficulty in maneuvering if velocities are temporarily increased excessively.

The St. Louis District presently uses two types of dredges to maintain the navigation channel from St. Louis to Cairo, Illinois; a dustpan and a cutterhead dredge. Due to the non-cohesive nature of the sand-size material, the dustpan dredge is used more frequently. The purpose of a dredge is to remove the sand and silt-size material from the bottom of the main channel and deposit it outside the navigation channel.

The Dredge KENNEDY is a dustpan dredge (Figure 1-7). It has a 28-foot wide dustpan and moves upstream in a straight line loosening the sediments in the river bottom with the aid of high-pressure water jets. Immediately behind the water jets, suction intakes are provided which pull in the loosened material and discharge the sediments through a 24-inch diameter floating pipeline, generally 1,000 feet long, outside of the navigation channel boundaries. A series of 28-foot wide parallel cuts are made until the desired channel width is achieved.

The Dredge STE. GENEVIEVE is a cutterhead-type dredge which consists of a series of revolving circular blades which can cut through coarser and more cohesive materials (Figure 1-8). A suction intake is positioned within the blade assembly which collects the loosened sediments and discharges the material through a floating pipeline up to 3,000 feet in length, outside of the navigation channel. The dredge makes a sweeping motion as it moves downstream and is able to make a 300-foot wide cut in a single pass.

Since the river consists of an alternating series of deep pools and shallow crossings in which the thalweg crosses from one side of the river to the other, the dredging localities are usually at the



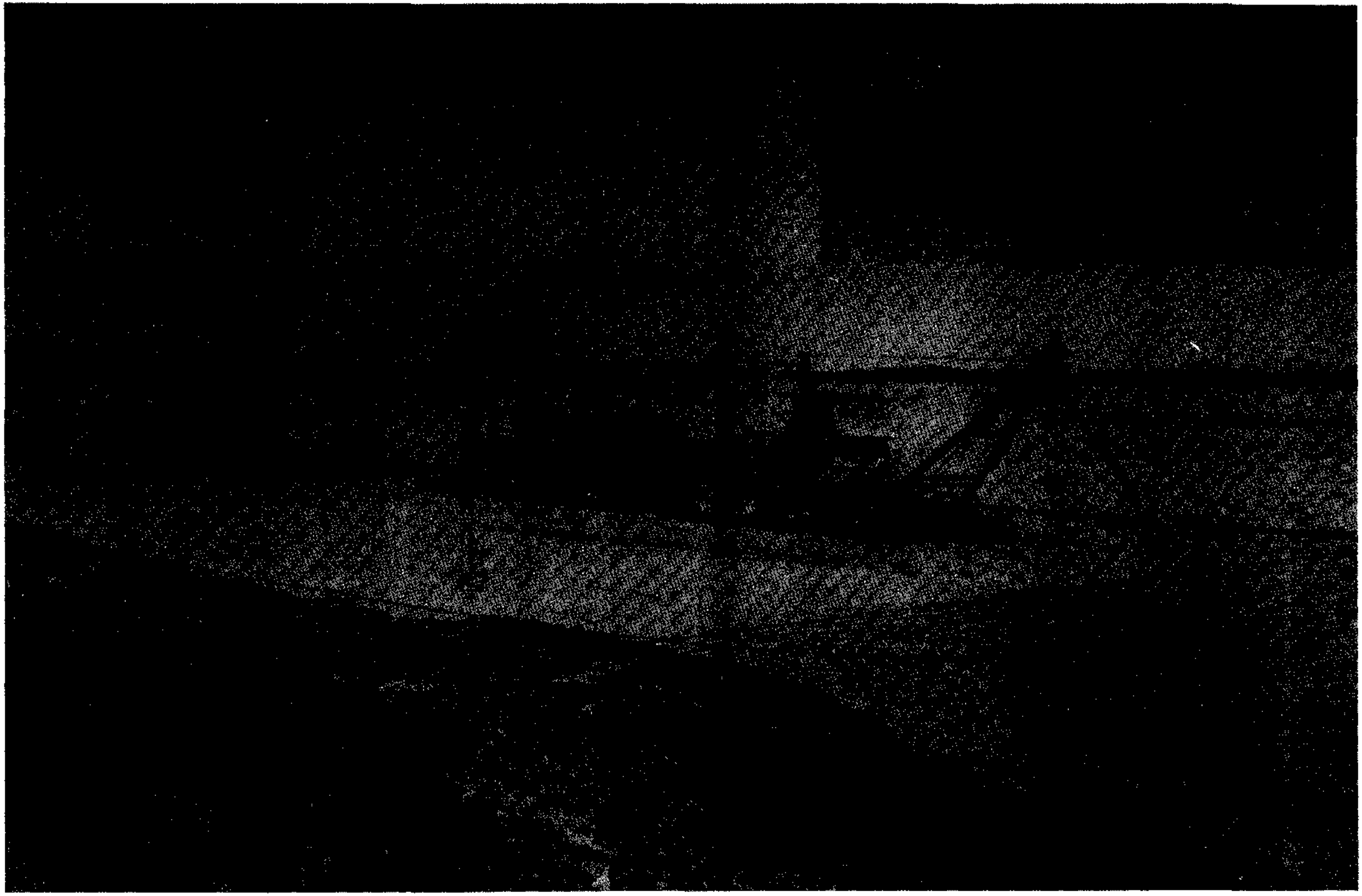


FIGURE 1-8. CUTTERHEAD DREDGE · DETAIL OF OPERATION

crossings where the sediment transport capacity of the stream is reduced. To maintain a minimum nine-foot navigation channel through these reaches, during low river stages, dredge cuts are usually made to a depth of nine feet below the low water reference plane elevation (project depth). Material from the dredging operations is usually deposited within the river adjacent to the main navigation channel. Although coordination is maintained with the proper state and federal agencies regarding the placement of dredge material, it is felt that the subject of placement is one of the issues in this environmental statement and will be addressed further in subsequent sections. Indications are that the placement of dredged material can, in addition to blocking off the entraces to side channels if improperly placed, cause damage to the benthic communities which are present in the main channel border areas.

In summary, it should be noted that some dredging in conjunction with dikes will always be required to obtain and maintain a dependable navigation channel.

1.4.4 CHAIN OF ROCKS (CANAL & LOCKS)

In 1945, Congress authorized the construction of a lateral canal and locks at the Chain of Rocks. The Chain of Rocks Reach extending along the northern boundary of St. Louis and St. Louis County, has been a hazard to river traffic since the earliest days of navigation on the Mississippi. At two locations in this reach, ledges of rock extend from the east bank under the river channel. These ledges act as submerged dams, causing a sharp increase in slope of the river, which in turn increases the velocity of the water. The high velocities produced in the Chain of Rocks Reach made this section exceedingly dangerous and difficult to navigate, and even the most powerful towboats were forced to divide their tows and take smaller groups of barges through the reach.

The approved project allowed for the bypassing of this hazardous reach of the river and included a lateral canal on the east bank (Illinois side) of the Mississippi River between river miles 184.0 and 194.5, with a 1,200-foot main and 600-foot auxiliary lock at the downstream end of the canal approximately due west of Granite City, Illinois, and levees on both sides of the canal. Construction of these facilities began in 1945 and the project was completed in 1953.

Immediately above the locks the canal was widened for a distance of 6,750 feet to a bottom width of 700 feet, in order to procure material required for levees and to provide harbor facilities for industries in Alton, Wood River, Granite City and other cities in the area.

Initial development of the Granite City Harbor was started by the Bi-State Development Agency in 1953. Bi-State now owns the lower half of the harbor and Tri-City Regional Port District the upper half of the harbor.

1.4.5 LOW WATER DAM (DAM NO. 27)

In 1958 Congress authorized the construction of rock fill dam across the Mississippi River at Mile 190.4, about 900 feet downstream from the Chain of Rocks Bridge. This dam was built to insure a minimum depth of nine feet at low water over the lower miter sill of Locks No. 26 at Alton, Illinois. This structure (Dam No. 27) has a fixed-crest elevation of 395 feet m.s.l. and a 700-foot fixed spillway section with crest elevation of 391 m.s.l. to facilitate passage of ice and silt. The dam raises the low water to elevation 395 m.s.l. extending the pool at this elevation to the locks at Alton.

1.5 SUMMARY OF PROJECT BENEFITS AND COSTS

The derivation of project benefits has been shown above. Total project Federal cost as of 25 August 1975 is $207,053,000 (Appendix A-1). The average annual benefits and costs are $45,937,000 and $11,736,000, respectively, thus yielding a benefit/cost ratio of 3.9 to 1.

1.6 RELATED STUDIES

1.6.1 TWELVE-FOOT CHANNEL STUDY

There is an authorized Corps of Engineers study of the feasibility of providing a 12-foot navigation channel on the Mississippi River from the mouth of the Ohio River to Minneapolis, Minnesota, and on the Illinois River from its mouth to the Great Lakes. The Phase I Report on this study indicated that it is not economically feasible to achieve a 12-foot project on the Mississippi River upstream of the Illinois River at this time, but that continued study from the Ohio River to the Illinois River and thence to Chicago is justified, but at this time has been suspended.

The key to the entire 12-foot project is the open river reach extending from the Ohio River to the lower end of the Chain of Rocks Canal at mile 184. Preliminary analysis has been made of three basic alternate means of obtaining and maintaining a 12-foot channel in this reach. These were (a) dredging, assuming regulating work for the 9-foot project were in place and being maintained; (b) regulating works with residual maintenance dredging; and (c) creation of a slackwater system (dams).

Of three alternatives studied, dredging would appear to be the most desirable upon casual observation. However, the preliminary cost estimate for this alternative did not include (a) the cost of "Planned" dredged material disposal sites; (b) of additional dredging equipment and maintenance of the same; or (c) the costs to navigation interests due to temporary stoppage when rapidly falling stages result in shoal water at many crossings simultaneously. Recognition of the fact that dredging as a solution is never ending, and that a realistic look into the future does not indicate any reason for optimism so far as supplemented flows for navigation is concerned, gives further reason to be wary of this alternative. The continuing heavy maintenance dredging also presents an ever-increasing problem of spoil disposal.

Regulating works, consisting of stone dikes and bank revetment, ranks next in cost. The increase from a 9-foot to 12-foot depth would require additional dikes as well as the extension of existing dikes, resulting in a greater contraction of the channel under low flow conditions. Close coordination and cooperation between the Corps on one hand and pertinent State and Federal agencies on the other, would be required in order to make this an environmentally acceptable alternative.

The creation of a slackwater system by the construction of low-head navigation dams and locks is the most positive means of providing the 12-foot channel dimensions under all river flow conditions. Even though location of such dams would be carefully made so as to create the least possible interference with river bottom drainage, and also so that the pool at the dam under full pool conditions would remain within high banks, the cost of this alternative makes it most unlikely as a chosen approach. This alternative could probably be justified only as a last resort should flow depletions, primarily from the Missouri River, become intolerable in the future.

1.7 PLANS OF OTHER FEDERAL, STATE, AND LOCAL AGENCIES

Plans of other local, State, and Federal agencies that are related or were developed in conjunction with the project, as presented by the Corps of Engineers, are presented below.

1.7.1 FEDERAL AGENCY PLANNING PROPOSALS

1.7.1.1 St. Louis Harbor Study

A multi-agency study on the feasibility of a St. Louis harbor facility is presently ongoing. The St. Louis District has been authorized to determine the advisability of providing improved commercial harbor facilities at and in the vicinity of St. Louis, Missouri. This authorization offers the opportunity for a comprehensive study of solutions to identified sedimentation problems, and should, in cooperation with local municipal governments and other Federal agencies, permit in-depth study of both sides of the river; need of improved harbor facilities; and need for the possible creation of a completely new off-channel harbor, which, in conjunction with truck, rail, and air transportation, could provide a truly integrated transportation capability. The harbor study was at one time considered as only the area between miles 172 and 191 or between River Des Peres and Watkins Creek. This area has successively been extended (1) from Jefferson Barracks Bridge, mile 169 to Watkins Creek, mile 196.2, (2) lower limit of Jefferson County, mile 138.8, to upper limit of Madison County, mile 208.8, (3) and presently a request to extend the area upstream to uppermost limit of St. Charles County, mile 236.4, is in the Office, Chief of Engineers for approval. In addition, funding in the harbor study is such that completion date continues to be pushed back and is now set as FY 1980. In addressing the District's operation and maintenance actions as they pertain to this portion of the River, it is important to note that no formal channel contraction plan exists for the harbor, with the exception of the Mosenthien Island reach from miles 184 to 190. After the Spring 1973 flood, the main channel reverted to the left bank chute along Cabaret Island, precluding any further harbor development in Sawyer Bend, as well as increasing current attack and erosion on Cabaret Island. Between November 1967 and April 1975, more than 130 acres have been lost from Cabaret and Mosenthien Islands, compounding the dredging problem at the lower Chain of Rocks canal access. With the aid of WES model studies, the St. Louis District anticipates two phases of construction. The first phase (which has been completed) will control the erosion and also return the channel to Sawyer Bend.

Locks 27 and the Chain of Rocks canal also lie within this reach, and erosion from wave wash due to passing tows will be controlled with revetment as necessary.

1.7.2.1 Missouri Department of Conservation

The Missouri Department of Conservation has indicated an interest in the project and possible alternatives. This agency's meetings with the Corps of Engineers concerning the regulation works are detailed in Sections 9.1 and 9.2. The Missouri Department of Conservation has no plans for the area which conflict with the project.

1.7.2.2 Illinois Department of Conservation

The Illinois Department of Conservation has no formal plans which would affect the project. This agency has also been included in meetings with the Corps of Engineers concerning the regulating works and possible alternatives.

1.7.3 LOCAL AGENCY PLANS

No plans for the project by local agencies are known at this time.

PART 2

2. EXISTING ENVIRONMENTAL SETTING

2.1 PHYSICAL ELEMENTS

2.1.1 RIVER CHANNEL CONFIGURATION AND STAGES

Although hydraulic data were presented for the segment of Mississippi River under study in the previous portion of the environmental statement, a presentation is appropriate regarding the existing physical configuration of the river and its associated side channels. At present, the Mississippi River has a width of approximately 3,200 feet between high banks. Extending riverward from these high banks are dikes which have a width of approximately 1,800 feet between their opposite riverward ends and/or opposite high bankline for the purpose of confining the flows to provide adequate navigation depths.

A by-product of these successive dike contractions has been the creation of numerous side channels adjacent to the main channel. These side channels were formed by the subsequent vegetation of sandbars which were created by the slackwater conditions between adjacent dikes. The mechanics of formation of these sandbars was generally such that an open water area existed between the island and the riverbank (see Figure 1-3). Quite often, adjacent sandbars (or islands) joined together; thus forming a side channel of considerable length.

Due to reduced flow velocities through the dike fields and the natural processes of the river, the side channels, which are formed by high dikes tend to become filled with sediment, and often disappear because of the passage of sediment-laden flows entering from the main channel. As new dikes are being built, and the subsequent formation of sidechannels takes place, older side channels are being filled with sediment. Many of the existing side channels may eventually fill up and new ones may or may not form. This would be true even if all dike construction were to cease.

It should be mentioned that some side channels are of a particular configuration which enables them to exist for a relatively long period of time. For example, a cutoff channel on the inside of a point bar will pass significant flow, particularly during high stages, due to its shorter path on the inside of a river bend which enables it to be somewhat self-scouring. Also, the entrances of some side channels are located on the outside of a river bend which allows for a smaller portion of the sediment to be carried into the side channel and subsequently deposited.

In addition, the main channel border areas between adjacent dikes in the main channel are reported to be valuable habitat areas. In the past, the ultimate effect of the dike fields has been to fill these areas.

In describing the existing river, mention should be made of the changes in stage for past similar flows, although this topic will be discussed in the "impacts" portion of this statement. The deepening of the riverbed by the scouring action of the dikes causes a lowering of river stages for past similar low flows; thus, in effect, reducing the amount of water available for the relatively shallow side channels. In contrast, flood stages are now higher, due to the net effects of levees and utilization of the floodplain by man.

In summary, the existing Middle Mississippi River system from St. Louis south to Cairo consists of essentially a single channel stream with an average width of about 3,200 feet between high banks with an adjacent series of connected side channels, which for the most part, were created as a result of successive dike constructions.

2.1.2 REGIONAL GEOLOGIC ELEMENTS

2.1.2.1 Physiography

The United States has been divided into a number of physiographic divisions called provinces. Boundaries, in some cases, are quite sharp in nature; in other instances, these dividing lines represent broad generalizations. Fenneman's (1938) divisions havebeen used in this report, and parts of the following provinces occur in or near the study area: (a) Coastal Plain, (b) Ozark Plateaus, (c) Central Lowland (east and west of the Mississippi), and (d) Interior Low Plateau. Plate 2-1 depicts the boundaries of these physiographic provinces in the Middle Mississippi River flood plain.

a. Coastal Plain. The Coastal Plain is a topographic feature, the surface of which dips generally seaward. Significant inward deviations occur in the vicinity of (a) the Mississippi River, (b) northeast Texas, and (c) the Rio Grande.

The southern part of the study area to the latitude of Cape Girardeau, Missouri, is included in the Coastal Plain (see Plate 2-1). Specifically this part of the Coastal Plain Province is known as the Mississippi embayment, a broad structural trough between the Appalachian uplift to the east and the Ozark highlands to the west, submerged during a large part of its history. When this embayment emerged, the Mississippi River followed its axis to the Gulf of Mexico. Despite the fact that aggradation does occur, the trough between the bluffs is due largely to excess erosion.

An important divide in the Mississippi embayment is Crowley's Ridge, a remnant of the higher nearly level plain in which the present alluvial trough was carved. It extends from Thebes, Illinois, southwestward to Helena, Arkansas, and is assumed to have served as a divide

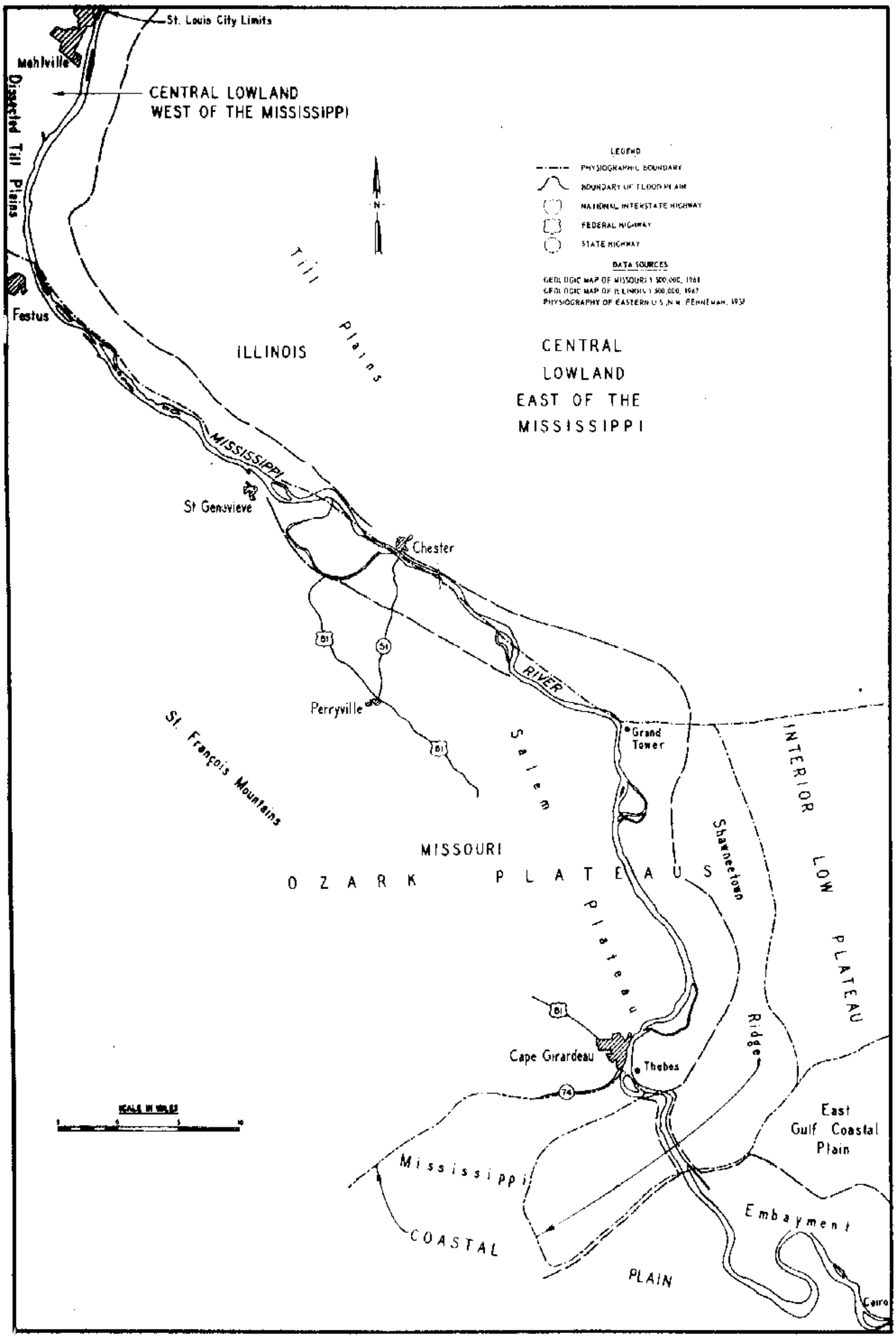


Plate 2-1. Physiography of the Middle Mississippi River Region

between the ancient Mississippi and Ohio Rivers. Presumably during the Pleistocene epoch the Mississippi broke through this ridge and joined the Ohio at its present location, Cairo, Illinois. From Cape Girardeau to Commerce, Missouri, the Mississippi flows through high bluffs in a gap of a ridge of hard, massive limestone and shale of Ordovician age.

b. Ozark Plateaus. The Ozark Plateaus is an area of 40,000 square miles mostly west of the Mississippi River and south of the Missouri River. Although the majority of this physiographic province is in central and southern Missouri, portions of it do extend into southwestern Kansas, northeastern Oklahoma, northwestern Arkansas, and eastern Illinois. Fenneman (1938) describes the form of the Ozark Plateaus as ". . .that of an asymmetrical dome steeper on the east than on the west and breaking off rather abruptly on the south." The entire region, which is one of strong rocks and submature dissection, is too steep for agricultural even to the west. The province is unglaciated, and the bedrock topography has been modified by deposition of loess over the entire area and alluvium in stream valleys.

Major subdivisions of the Ozark Plateaus are the Boston Mountains, Springfield Plateau, St. Francois Mountains and the Salem Plateau. That portion of the study area falling within the Ozark Plateaus is wholly within the Salem Plateau. The Salem Plateau consists of remnants of a maturely dissected rolling upland surface, preserved largely on Cambrian and Ordovician rocks, even though some rocks of later Paleozoic age remain on the north and northeast flanks. Much of the surface of the Salem Plateau has been destroyed by stream action (Missouri Geological Survey and Water Resources, 1967).

The Ozark Plateaus ranges on both sides of the Mississippi River from Cape Girardeau to Grand Tower, Illinois, and from Grand Tower north to Festus, Missouri, on only the Missouri side of the river (see Plate 2-1).

In the Missouri portion of the Ozark Plateaus beds dip steeply westward, and a series of cuestas is well developed. The most important of these are the eastward facing Crystal and Burlington escarpments. The Crystal escarpment owes its existence to the friable St. Peter sandstone (Ordovician) outcropping under the edge of strong middle Ordovician sandstones. The less resistent St. Peter sandstone erodes and leaves the overlying rocks unsupported causing them to break loose. This cyclic mechanism maintains the prominent escarpment. The Burlington escarpment, the most persistent of all escarpments in this province because of the cherty and resistant Burlington limestone (lower Mississippian), follows the Missouri River to its mouth, crosses to the Illinois side of the Mississippi and again returns to the west side of the Mississippi at Ste. Genevieve, Missouri. In the Illinois portion of the Ozark Plateaus, the Ozark dome extends in a more linear uplift and is referred to as the Shawneetown Ridge. The Illinois rocks in ascending order from Ordovician to Mississippian are strong limestones. Beds dip northward toward the syncline of central Illinois. The steep bluffs of the Mississippi River reach a height of 400 feet as it flows through the Ozark Plateaus province.

c. Central Lowland. Fenneman (1938) considers the Central Lowland east of the Mississippi River and that to the west of this river as major subdivisions of the Central Lowland physiographic province, and he devotes a single chapter to each subdivision.

d. Central Lowland East of the Mississippi River. The Central Lowland east of the Mississippi ranges from east of Lake Ontario to the Mississippi River. The boundary from northern Ohio to around St. Louis is approximately at the edge of the glacial drift, and according to Fenneman (1938)"Glaciation dominates most of the landscape, but it probably created as much variety as it destroyed." In the portion of the central lowland physiographic province east of the Mississippi River there are three subdivisions: (a) Great Lake section, (b) Driftless section, and (c) Till Plains.

The study area falls entirely within the Till Plains (see Figure 2-1a). The character of this subdivision, now one of little relief, was due to complete burial of preglacial features. It is difficult to differentiate between the Till Plains and the Great Lake section to the north of it. Fenneman(1938) states that "If justification of the two sections be attempted on geologic terms, the Till Plains section may be distinguished as that portion of the glaciated area east of the Mississippi River wherein the movement of ice was less controlled and diverted by deep valleys." Cuestas and lowlands are more dominant in the Great Lake section.

In the Till Plains the main preglacial structural features are the northern part of the Cincinnati anticline, which brings Ordovician rocks to the surface and the southern Illinois syncline which ". . .retains its carboniferous coal measures even where the surface is very low."(Fenneman 1938) On the west side, these lowlands of southeastern Illinois border the trench of the Mississippi River.

The Illinoian ice sheet covered all of the Till Plains including the southern section, but the Wisconsin sheet did not reach western or southern Illinois. Below St. Louis ice climbed the dip slope of the Mississippian cuesta to the west. Where the Illinoian drift was not covered by the Wisconsin, it is covered with loess. The origin of this loess is believed to be "glacial flour," distributed first by water, then by wind lifting it from the flood plain. Along the Mississippi this material may reach a thickness of 50 feet.

GENERALIZED GEOLOGICAL COLUMN FOR THE MIDDLE MISSISSIPPI RIVER FLOODPLAIN AND VICINITY

ERA*	SYSTEM	SERIES	STAGE	GROUP	FORMATION	YEARS BEFORE PRESENT	
CENOZOIC	QUATERNARY	PLEISTOCENE "ICE AGE"	RECENT			7,000 TO PRESENT	"AGE OF MAMMALS"
			WISCONSINAN (Glacial)			75,000	
			SANGAMONIAN (Interglacial)				
			ILLINOIAN (Glacial)				
			YARMOUTHIAN (Interglacial)				
			KANSAN (Glacial)				
			AFTONIAN (Interglacial)				
			NEBRASKAN (Glacial)			1,000,000	
	TERTIARY					63,000,000	
MESOZOIC	CRETACEOUS	GULFIAN				135,000,000	"AGE OF REPTILES"
PALEOZOIC	PENNSYLVANIAN	DES MOINESIAN		KEWANEE (ILLINOIS)	SPOON (ILLINOIS)		"AGE OF AMPHIBIANS AND EARLY PLANTS"
		ATOKAN			CARBONDALE (ILLINOIS)		
					ABBOTT (ILLINOIS)		
		MORROWAN		McCORMICK (ILLINOIS)	CASEYVILLE (ILLINOIS)	310,000,000	
	MISSISSIPPIAN	CHESTERIAN (MISSOURI); UPPER CHESTERIAN (ILLINOIS)					
		LOWER CHESTERIAN (ILLINOIS)					
		MERAMECIAN (MISSOURI); UPPER VALMEYERAN (ILLINOIS)					
		MIDDLE VALMEYERAN (ILLINOIS)					
		LOWER VALMEYERAN (ILLINOIS)					
		OSAGEAN (MISSOURI)					
		KINDERHOOKIAN				345,000,000	
	DEVONIAN	MIDDLE DEVONIAN (ILLINOIS)					"AGE OF FISHES"
		LOWER DEVONIAN (ILLINOIS)				405,000,000	
	SILURIAN					425,000,000	
	ORDOVICIAN	CINCINNATIAN	RICHMONDIAN (MISSOURI)	MAQUOKETA (ILLINOIS)	MAQUOKETA (MISSOURI)		"AGE OF INVERTEBRATES"
		CHAMPLANIAN	MOHAWKIAN (MISSOURI)	GALENA (ILLINOIS)	DECORAH (MISSOURI)		
				PLATTEVILLE (ILLINOIS)	PLATTIN (MISSOURI) (SUBGROUP IN ILLINOIS)		
			CHAZYAN (MISSOURI)	ANCELL (ILLINOIS)	JOACHIM (MISSOURI)		
					DUTCHTOWN (MISSOURI)		
					ST. PETERS (MISSOURI)		
					EVERTON (MISSOURI)		
		CANADIAN			SMITHVILLE (MISSOURI)		
					POWELL (MISSOURI)		
					COTTER (MISSOURI)		
					JEFFERSON CITY (MISSOURI)	500,000,000	
	CAMBRIAN					600,000,000	
	PRECAMBRIAN						

*THERE IS NO UNIVERSALLY ACCEPTED TIME-STRATIGRAPHIC EQUIVALENT FOR THE GEOLOGICAL TIME UNIT "ERA". THE EUROPEANS, HOWEVER, USE "ERATHEM."

SOURCES: THE STRATIGRAPHIC SUCCESSION IN MISSOURI, MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES, 1971
GEOLOGICAL MAP OF MISSOURI, MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES, SCALE 1:500,000, 1961
GEOLOGICAL MAP OF ILLINOIS GEOLOGICAL SURVEY, SCALE 1:500,000, 1967
GEOLOGICAL TIMETABLE, F.W.B. VAN EYSINGA, 1972

Fig. 2-1a Generalized geological column for the Middle Mississippi River Region

The rocks in the Till Plains section have been worn down many hundreds of feet. Fenneman (1938) believes that "...the Till Plains section was reduced to a peneplain at least once, and parts of it several times. The Mississippi in this area flows through a trench 400-500 feet deep. Much of this 400-500 foot deep trench is now filled with sand and gravel and finer alluvium, on which the Mississippi now flows. The young trench south of Thebes was not eroded that deep, and at places the river flows on bedrock.

e. Central Lowland West of the Mississippi River. This portion of the Central Lowland province lies, as the name implies, to the west of the Mississippi River and extends across the Great Plains of the central United States and Canada. The same general descriptors apply to this portion as to the eastern portion of the province. The three subdivisions are (a) the Western Young Drift section, (b) the Osage section, and (c) the Dissected Till Plains. The study area is located in the Dissected Till Plains.

In general this section is a flat till plain in a sub-mature to mature erosion cycle with a relief being 100-300 ft. It is covered by loess, varying in depth from a few feet to a maximum of 90 feet adjacent to the large rivers. Fenneman (1938) states that, "This section is distinguished from the Till Plains on the east and from the (western) Young Drift section on the north by the stage it has reached in the post-glacial erosional cycle." Older Paleozoic rocks beneath the Mississippian are found in only the narrow valleys of the two rivers. The land surface seems continuous with a peneplain east of the river (Till Plains section). There are two glacial stages recognized in the Dissected Till Plains: (a) Kansan and (b) Nebraskan. Eighty percent of this area now, however, has an erosional surface, hence the name Dissected Till Plains.

Specifically the study area is located within the southeastern portion of the Dissected Till Plains and ranges on the Missouri side to the Mississippi River from Festus, in the Ozark Plateaus to the northern terminus of the Middle Mississippi River flood plain at St. Louis. The Dissected Till Plains are located across the Mississippi from the Till Plains section of Illinois. Thickness of loess on the bluffs (average 40-50 feet) has obscured older relief. The river flows through a 400-500-foot deep trough on the east boundary of this province.

f. Interior Low Plateau. This province falls completely outside the Middle Mississippi River flood plain. The interior low plateau is contiguous with the Ozark Plateaus in south Illinois some ten miles east of the Mississippi River (see Plate 2-1). The terms "low" and "plateau" seem to be contradictory, but they refer to relative elevations, since they describe an area situated between the Till Plains, the Coastal Plain, the Ozark Plateaus, and the Appalachian Plateau. The sections making up this province are (a) the Highland Rim, (b) Nashville Basin, (c) Bluegrass section, and (d) Shawnee section.

It is the Shawnee section that is of interest because of its proximity to the study area, specifically the Shawneetown section of the Ozark Plateau. In this section according to Fenneman(1938) the rock succession is ". . . depressed in a syncline pitching northwestward . . . ." The stratigraphic sequence ". . . beveled by an old surface now dissected is accountable for the major features of relief." Two prominent cuestas form a wide area of rugged topography.

In the eastern part of the section a thin and porous sandstone cover has allowed access of surface waters to the underlying soluble limestone, and as a result, there are numerous sinkholes and caves, including Mammoth Cave. In the western part of the Shawnee section, which is located near the study area, the two cuestas continue almost to the Ozark uplift of southern Illinois. There are numerous faults south of the two cuestas in this area, but Fenneman(1938) states that ". . . since the faults antedated that last peneplain they do not affect the landscape, except where the rocks on opposite sides (of small streams which follow their faults)differ in hardness." This portion of the Shawnee section is equal to that of the nearby cuestas. In this area is the great flnorite district of the United States.

2.1.2.2 Historical Geology

The oldest rocks in the Mississippi Valley region are not exposed within the project area. Precambrian metasediments and gneissic granites are exposed to the west in the St. Francois Mountains of Missouri. These rocks range in age from 1.2 to 1.45 billion years.

The widespread extrusive and intrusive igneous activity of the Precambrian in Missouri ended approximately 1.2 billion years ago. This was followed by an extremely long period of erosion during which a barren, rugged landscape of hills and valleys was etched into the igneous terrain. The geologic record is not resumed until about 540 million years ago when the initial deposits of transgressing Late Cambrian seas began to mantle the eroded Precambrian granites and felsites.

The Paleozoic era encompassed nearly 350 million years. In the Mississippi Valley, and throughout the central United States, it was a time of alternate inundation and regression of semi-tropical or tropical epeiric seas. The marine phases were the most persistent. Between the marine phases, subaerial erosion produced low-lying landscapes and succeeded in removing parts of the stratigraphic section that had accumulated in the earlier periods of deposition.

Paleozoic history began with the deposition of clastic sediments. They were the initial strand line deposits of a transgressing sea. As the marine transgression continued, finer clastics and eventually carbonate rocks were deposited. This interval of time is represented by Cambrian formations, which are not exposed in the Mississippi Valley, as well as the Lower Ordovician, Roubidoux, Cotter, Powell, and Smithville units.

Near the close of Early Ordovician time, the sea regressed producing a well-known regional unconformity that marks the top of the Canadian Series. This regression was apparently synchronous with the uplift of the Ozark area to the west. Once again, the record resumes with deposition of a clastic unit, this time the Ordovician Everton and St. Peter Sandstones. Their deposition is followed as before with calcareous sediments (the Dutchtown, Joachim, Plattin, Decorah, and Kimmswick Formations).

Following a post-Kimmswick regression, inundation resumed and the fine clastics of the Maquoketa and other Cincinnatian Formations were deposited. This was followed by a minor regression of the sea. Alternate transgressing and regressing of the Silurian Sea produced the Alexandrian limestones. Finally the sea deeply submerged the entire region and the Bainbridge limestone was deposited. Strata of these systems are occasionally thinner, often missing because of erosion, somewhat more clastic, and less extensive than previous deposits. Following a minor regression of the sea marking the close of the Silurian period, a great thickness of Devonian limestones was deposited. Devonian rocks rest unconformably on formations as old as Ordovician, reflecting a major erosional hiatus during which Early Devonian and some Silurian and Ordovician strata were stripped away. Near the end of the Devonian limestone depositional period, there was major faulting and uplift followed by a long period of erosion during which much of the Devonian limestone was removed.

Renewed subsidence during the Mississippian Period brought initial deposition of fine clastics and variably cherty, often crinoidal limestones, Chouteau, Burlington, and Keokuk Formations. This was followed by a period of deep water deposition of Meramecian and Chesterian sediments. The Mississippian throughout the central U.S. is characterized by these widespread deposits of carbonates.

Near the end of the Mississippian, the seas regressed on a vast scale producing one of the most extensive regional erosional unconformities of the North American Continent. The reason for this great regression is usually attributed to crustal uplift or possibly tilting.

The post-Mississippian pre-Pennsylvanian unconformity represents a lengthy period of subaerial erosion and landscape evolution. In many parts of Missouri, Karst topography developed on the Paleozoic limestones, particularly the Burlington Formation. Subsequently, many of the sinkhole and other solution features were filled with younger Pennsylvanian sediments of the Atokan.

By the time the sea advanced again over the Mississippi Valley, erosion had reduced the landscape to a relatively low-lying plain. Continually regressing and transgressing seas produced cyclic deposits of shale, limestone, sandstone, and coal which are particularly thick to the east in the Illinois Basin. In Late Cretaceous and early Tertiary times, the sea invaded the Mississippi Valley for the last time. The rock record of these marine incursion is in the extreme southern part of the project area.

Cenozoic sediments mantle much of the upland and flood plain areas of the Mississippi Valley. They are composed primarily of glacial, alluvial, and aeolian (loess) deposits. Most of northern Missouri and Illinois was covered by glacial ice during the Kansan, Nebraskan, and Illinoian Pleistocene stages which filled depressions and valleys and left a mantle of glacial drift in the uplands. Ice age mastodons, sloths, pecarries, bears, and wolves roamed the landscape. During the Nebraskan advance, the ice reached an arc somewhat north of the present course of the Missouri River. The second or Kansan invasion moved southward over the present course of the Missouri River. A third advance, the Illinoian, may have penetrated the extremem eastern edge of Missouri and covered most of Illinois. Although the Wisconsinan glaciers did not advance so far south as the project area, deposits of Wisconsinan Age form most of the valley sill and terraces along the Middle Mississippi River, as well as large amounts of loess on the bluffs, especially on the east side of the valley.

In addition to the coarse glacial drift deposits, the silt-sized wind-blown deposit known as loess was widely deposited throughout the state during the Pleistocene interglacial stages.

The Pleistocene was followed by the Recent Epoch, during which running water has been the dominant force shaping the landscape of the Mississippi Valley. Recent deposits consist predominantly of alluvium deposited by the Mississippi River and its tributaries.

2.1.2.3 Stratigraphy

a. General. The age of the rocks exposed at the surface of the study area ranges from Quaternary down through lower Ordovician. Figure 2-1 is a generalized geological column for the Middle Mississippi Valley showing the geological ages, and Plate 2-2 is a map of the regional geology of the study area. Names of geologic units are not always the same in Missouri and Illinois as mapping was done by different agencies at different times. Below is a brief description of mapped units in the Middle Mississippi Valley (Havre and Koenig, 1961; McCraken, 1961; Willman,1967).

b. Paleozoic Era.

(1) Ordovician System.

(a) **Canadian Series.**

(.1) Roubidoux Formation. The Roubidoux Formation consists of sandstone, dolomitic sandstone, and cherty dolomite. In eastern Missouri, 10 percent of the formation contains sandstone and most of the rock is cherty dolomite. The sandstone is composed of fine-to-medium-grained quartz sand which characteristically is subrounded and frosted. Gray and brown colors are predominant on weathered surfaces, but the color of the fresh sandstone is commonly light yellow, tan, or red at the surface and white in the subsurface. The dolomite in the Roubidoux is finely crystalline, light gray to brown in color, and thinly to thickly bedded. Individual beds contain brown to gray, banded oolitic, sandy chert.

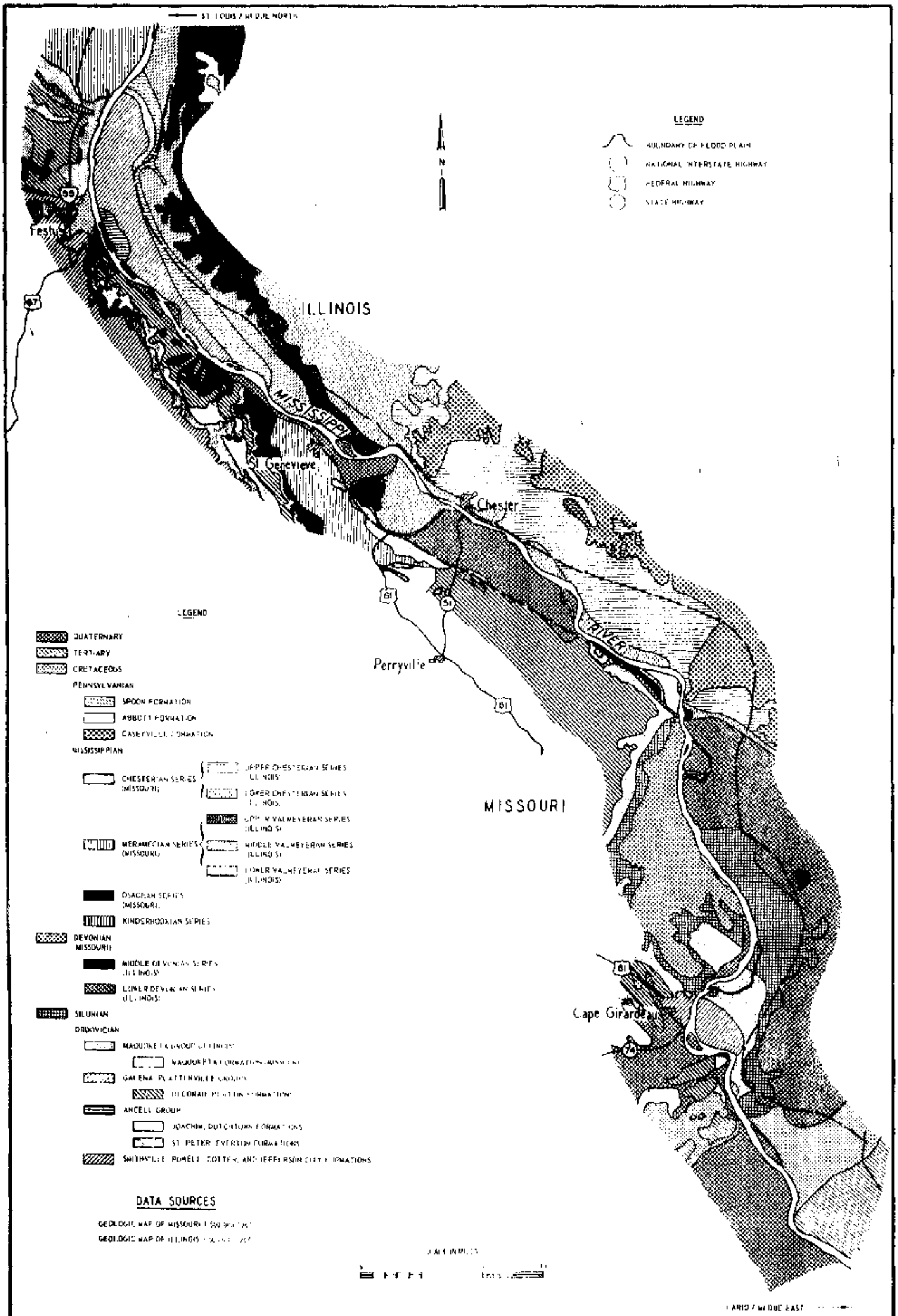


Plate 2-2. Regional geology of the Middle Mississippi River

The Roubidoux normally is sparingly fossiliferous, but some of the chert locally contains numerous fossils, chiefly mollusks. In many places the sandstone is characterized by exceptionally well-preserved ripple marks, mud cracks, and crossbedding. In the western part of the state, the formation contains three distinct sandstone units; one near the base, one near the middle, and one near the top. The sandstone units are quarried for building stone at many places in Missouri.

The outcrop area of the Roubidoux occupies a large part of southern Missouri, and the formation is present throughout the subsurface of the state downdip from the outcrop area.

The thickness of the Roubidoux ranges from 100 to 250 feet. The formation's greatest thickness is at the southwestern part of the Ozarks, and its least thickness is along the northeastern part of the area.

(.2) Jefferson City Formation. The Jefferson City Formation is composed principally of light brown to brown, medium to finely crystalline dolomite and argillaceous dolomite. Lenses of orthoquartzite, conglomerate, and shale are locally present in the formation. A stratigraphic succession of the Jefferson City Formation in one locality is rarely duplicated in another locality, although there is a similarity. Finely crystalline, argillaceous dolomite called "cotton rock" is characteristic of the formation. An equally important rock type found in many exposures is thickly bedded, massive, brown, medium crystalline dolomite that weathers with a coarsely pitted surface. This is the informally designated "Quarry Ledge" of the Ozark region that is present 35 to 40 feet above the base of the formation. In the past, rock obtained from this unit was very popular as a dimension stone.

The Jefferson City is exposed around the periphery of the Ozarks and is recognized in the subsurface in all of northern and western Missouri by its characteristic type of oolitic chert. Several insoluble residue zones within the formation contain siliceous spicules which are commonly referred to as "spines." The thickness of the Jefferson City ranges from 125 to 350 feet; its average thickness is 300 feet.

(.3) Cotter Formation. The major part of the Cotter Formation is composed of light gray to light brown, medium to finely crystalline, cherty dolomite. It is normally medium to thinly bedded and contains thin interrelated beds of green shale and sandstone.

The lower part of the Cotter Formation is relatively noncherty and contains echinoderm fragments, the middle part is characterized by oolitic chert and large siliceous ooliths, and the upper part is shaly and contains small quartz masses and brown quartzose oolitic chert.

The Cotter is conformatble on the underlying Jefferson City, and because it is difficult to differentiate the two formations, they are often designated as a combined unit, as Jefferson City-Cotter. The Cotter crops out along the northern and western edges of the Ozark uplift and is present in the subsurface except where it has been removed by pre-St. Peter erosion in west-central and northwestern Missouri. The average thickness of the Cotter is 200 feet, but its maximum thickness is in the subsurface of southeastern Missouri where it is 450 feet thick.

(.4) Powell Formation. The Powell Formation is composed of medium to finely crystalline dolomite and thin beds of green shale and fine-grained sandstone. In Ste. Genevieve County it is divisible into lower and upper parts. The lower part contains several sandstone beds and is typically dark brown. The upper part is composed of finely crystalline, argillaceous dolomite or "cotton rock" and many thin beds of green shale. Soft, ferruginous and "rotten" chert is characteristic of the residues in its outcrop areas.

The Powell crops out in eastern Missouri from Cape Girardeau County northward to St. Charles County and is also present in extreme southwestern Missouri. It is present in the subsurface except in the west-central and northwestern parts of the state. Its thickness in Ste. Genevieve County ranges from 150 to 175 feet.

(.5) Smithville Formation. The Smithville Formation is composed of dolomite which contains a small amount of chert. One of the distinguishing characteristics of the formation is the presence of Bryozoa. Smithville fossils have been collected from residual chert over a large area in Bollinger County and from a quarry near Delta in Cape Girardeau County.

The formation is present in the subsurface south and east of Cape Girardeau, and in some areas it is at least 150 feet thick. Because the formation is lithologically similar to the underlying Powell Formation, it is most often distinguished from the Powell by the characteristics of its insoluble residue.

(b) Champlainian Series.

(.1) Everton Formation. The Everton is the basal formation of the Champlainian Series and rests unconformably on Canadian strata. It consists mostly of sandy dolomite, but it also contains interbedded sandstone, limestone, and chert. The dolomite is both light and dark gray and commonly contains scattered grains of quartz sand. The sandstone is fine to very fine grained and frequently contains silt. The grains of sand are rounded and are commonly pitted or frosted. The sandstone of the Everton resembles the overlying St. Peter sandstone, but its average grain size is generally smaller. Where the sandstones of the two formations are in contact, they cannot be readily distinguished one from the other. Medium gray to white chert in thin beds, lenses, and nodules is sporadically distributed throughout most of the formation. Poorly preserved fossils are sparsely present in some of the upper limy dolomite beds.

The Everton crops out in Missouri from Scott County northward to Jefferson County. It has not been definitely recognized elsewhere in the state. It is approximately 400 feet thick in Scott County but thins rapidly northward and is probably absent north of Jefferson County.

(.2) St. Peter Formation. The St. Peter is typically a well-sorted, quartzose sandstone but locally is an orthoquartzite. The sand grains are fine to medium in size, rounded, spherical, and characteristically frosted. The formation's silica content is as high as 99 percent. A freshly exposed surface of the formation is commonly white with shades of pink and green. Weathered surfaces are a dirty gray or brown and are case-hardened at many localities. Bedding is indistinct, and the formation appears massive throughout. The rock is cross bedded and ripple marked locally. The formation is generally porous and permeable except where it is an orthoquartzite. The St. Peter appears to be unfossiliferous in Missouri, but locally there are elongate, cylindrical structures in the formation that have been interpreted as reed molds.

In southeastern Missouri, the St. Peter is conformable with the Everton. North of Jefferson County, the formation is disconformable on the eroded surface of the Canadian Series.

The St. Peter Formation is continuous throughout the Champlainian outcrop belt in Missouri and is present in the subsurface of the northern and west-central part of the state. It has the greatest distribution of any Champlainian or Cincinnatian formation in the state. The St. Peter is mined in eastern Missouri for glass sand and abrasive and is an aquifer in parts of central and eastern Missouri.

The thickness of the formation is variable, ranging from less than 10 to more than 100 feet. Its approximate thickness in the outcrop area is between 60 to 80 feet.

(.3) Dutchtown Formation. The Dutchtown formation is composed dominantly of medium to thinly bedded limestone and dolomite and contains varying amounts of dolomitic sandstone, siltstone, shale, and clay. The color of the rock is dark blue, gray, or black. The carbonate rocks contain finely disseminated particles of organic matter and hydrocarbons in the form of asphaltic-filled vugs. Both the limestone and dolomite give off a petroliferous odor when struck with a hammer. The limestone, dolomite, and sandstone are all fossiliferous, though well-preserved fossils are scarce. Pelecypods and gastropods are the most abundant fossils. Masses of Cryptozoon are present in the lower part of the formation at a few localities.

The Dutchtown Formation is best developed in Scott, Cape Girardeau, and Perry Counties, Missouri, and in southwestern Illinois. Outcrops are few, and information on the distribution and lithology of the formation is based largely on subsurface data. The Dutchtown has been divided into three units on the basis of distinctive insoluble residues.

The formation attains a maximum thickness of approximately 170 feet in southern Cape Girardeau County. It thins rapidly northward and is only 20 feet thick in southern Perry County. It is apparently absent from Perryville northward. South of Cape Girardeau County, the Dutchtown is present only in northeastern Scott County.

The relationship of the Dutchtown to underlying formations has been determined from subsurface information. These data indicate that pre-Dutchtown erosion has removed part or all of the St. Peter Formation in some places, and that the Dutchtown thus overlaps the older St. Peter and Everton Formations.

(.4) Joachim Formation. The Joachim is predominantly a yellowish-brown, argillaceous dolomite which contains interbedded limestone and shale in its lower part. Scattered quartz sand grains are prominent in the lower beds of dolomite, shale, and limestone. Mud cracks are common. Chert is absent throughout the unit except for a thin but persistent, nodular chert bed at the top. Fossils are scarce in the Joachim in Missouri.

The Joachim extends throughout the Champlainian outcrop belt of Missouri but pinches out in the subsurface westward and northwestward of Lincoln and Montgomery Counties. It thins from south to north, ranging from an average thickness of about 175 feet in Cape Girardeau and Scott Counties to less than 50 feet in Ralls and Montgomery Counties.

In Scott, Cape Girardeau, and Perry Counties, the Joachim unconformably overlies the Dutchtown Formation. North of this area, the Dutchtown is absent, and the Joachim unconformably lies on the St. Peter Formation.

(.5) Rock Levee Formation. The Rock Levee includes beds that were formerly assigned to the upper part of the Joachim and to the lower part of the Plattin. Thus, the formation contains a succession of rock units which lie below an oolitic pebble conglomerate at the base of the redefined Plattin and above a very thin but persistent zone of chert at the top of the Joachim as it is now defined. The chert zone is a recognizable subsurface marker, but it is not at all conspicuous in surface exposures; therefore, in field mapping the Rock Levee is usually grouped with the Joachim Formation.

In southeastern Missouri, the Rock Levee is predominantly a limestone which contains interbedded dolomite. In east-central and northeastern Missouri, the formation is composed mostly of dolomite and has thin limestone beds near the top. Thin green and tan shale beds are frequently intercalated with the limestone and dolomite. Megafossils are sparse in the Rock Levee Formation, but casts of ostracodes are common. A marker zone of silicified echinoderm ossicles is used as an aid in subsurface correlation work.

The thickness of the Rock Levee Formation ranges from a few feet in southern Ralls and eastern Callaway Counties to approximately 70 feet in Cape Girardeau County. The Rock Levee appears to be conformable with the underlying Joachim.

(.6) Plattin Formation. The Plattin consists of evenly bedded, dark gray, finely crystalline to sublithographic limestone which contains minor amounts of intercalated shale. The basal unit is easily recognized because it is composed of a pebble conglomerate and oolite and contains shale and ostracodes. Tubular or fucoidal structures, which are commonly filled with light brown, saccharoidal dolomite or white calcite, are minor but distinctive features of the formation. Thin metabentonite beds are present in the upper part of the Plattin. Brown, dark gray, and white chert nodules and layers are present throughout most of the formation. Locally, some beds within the formation are dolomite, but in parts of east-central Missouri, all of the formation is composed of dolomite. The formation is fossiliferous and contains an abundance of dallmanellid, strophomenid, and orthid brachiopods. Recently, it has been proposed that the Plattin in Missouri and Illinois be subdivided into a number of formational units. These proposals have not as yet been formally adopted by the Missouri Geological Survey.

Northward and westward from Cape Girardeau County, the Plattin is approximately 450 feet thick. It lies on the Rock Levee Formation in northeastern Missouri where there appears to be a slight disconformity at its base.

(.7) Decorah Formation. The Decorah consists of green or brown shales and has numerous, thin, interbedded limestone layers in its lower part that grade upward into a medium to thinly bedded, fossiliferous limestone which contains thin, fossiliferous shale partings. Beds of metabentonite lie in the basal part of the formation. The brachiopods Pionodema subaequata and Rafinesquina are the most common fossils.

The Decorah varies in thickness from a few feet to more than 40 feet. The relationship of the Decorah to the Plattin in eastern Missouri appears to be unconformable.

(.8) Kimmswick Formation. The Kimmswick is typically a coarsely crystalline, white to light gray, medium bedded to massive limestone. The weathered surface of the rock is distinctive in that it is notably pitted or "honeycombed." Chert is nodular and irregularly scattered locally in the upper part of the formation. Invertebrate fossils, predominantly brachiopods and bryozoans, are common throughout the formation. The "sunflower coral," Receptaculites oweni, characterizes the Kimmswick in Missouri. Regionally, the Kimmswick is unconformable on underlying units.

In much of the subsurface of north-central and northwestern Missouri, the Kimmswick is a dolomite which contains interbedded limestone. This is especially true in the Forest City basin in northwestern Missouri. The Kimmswick is also a dolomite in the faulted areas of Perry and Ste. Genevieve Counties, where it is commonly gray to grayish brown, coarsely to medium crystalline and contains chert.

Where the Kimmswick is a limestone, it has a content of 95 to 99 percent calcium carbonate. It is quarried throughout its outcropbelt from northern Scott County to Pike County.

The Kimmswick is 50 to 150 feet thick in eastern Missouri.

(c) Cincinnatian Series.

(.1) Cape Formation. The formation is composed of a coarsely crystalline, argillaceous limestone. The color of the limestone is gray, and fresh exposures have a distinctive purplish or brown tinge. The beds are thin to medium in thickness, wavy, and irregular. Thin beds of shale are present in the lower part of the formation which becomes massive toward the top. Weathered exposures of the limestone crumble readily. Fossils, particularly brachiopods and barrel-shaped crinoid columnals, are abundant but poorly preserved. The brachiopod Lepidocyclus is commonly present in the formation in Missouri.

Outcrops of the formation are intermittently distributed, with exposures being present in Cape Girardeau, Perry, Ste. Genevieve, and Jefferson Counties. The Cape lies unconformably upon the Kimmswick Formation.

In its outcrop area in southeastern Missouri, the formation ranges from a maximum thickness of about 15 feet in Cape Girardeau County to less than a foot in Ste. Genevieve and Jefferson Counties.

(.2) Maquoketa Formation. The Maquoketa Formation is typically a thinly laminated, silty, calcareous or dolomitic shale which locally contains nodular and shaly lenses of limestone. The color of the shale ranges through various shades of dull green, dark gray, and brown. The limestone is commonly light brown or gray. The formation is locally fossiliferous, especially where the shale is calcareous and thin beds of limestone are present. Mollusks, corals, and brachiopods are the most common fossils. Graptolites are commonly regarded as an index of the Maquoketa in subsurface work. Quartz sand grains and quartzose sandstone lentils are present locally in the upper part of the formation.

The Maquoketa Formation disconformably overlies the Kimmswick Formation throughout most of its extent in Missouri. In southeastern Missouri, however, it locally overlies the Cape Formation. An extensive erosional disconformity exists at the base of the Maquoketa.

The Maquoketa crops out in Missouri in most of the counties which border the Mississippi River from Scott County northward to southern Marion County. The thickness of the Maquoketa in southeastern Missouri ranges from 10 to 60 feet.

(.3) Thebes Formation. The Thebes Formation is typically a fine-grained quartzose sandstone which contains variable amounts of silt and mica. The sandstone is gray to bluish-gray and weathers to a yellowish-brown. The beds of the formation are very thin or thin to medium in thickness. At fresh exposures, the formation appears massive, but it soon weathers into shaly layers. Two prominent sets of nearly vertical joints are present in the sandstone and weathering along these joints causes the rock to break into large rectangular slabs.

The Thebes has been traced from Alexander County, Illinois, into southeastern Missouri and is recognized in northern Scott, eastern Cape Girardeau, Perry, and Ste. Genevieve Counties. The thickness of the formation ranges from less than 5 feet to as much as 20 or 25 feet in Missouri. The sandstone thins in the Ste. Genevieve County area and apparently feathers out in that county.

The Thebes Formation is generally considered to be Richmond in age, and it has been correlated by some geologists with the lower part of the Maquoketa Formation that is present in northern Illinois and Iowa. In the subsurface of southeastern Missouri, several sandstone units are present in a shale unit which lies between the Cape and Girardeau Formations, and it is questionable as to which of these units is the Thebes. Thus, there is some reason to believe that the exposed sandstone which in Missouri is regarded as the Thebes may be only a southern facies of the Maquoketa Formation of Illinois and Iowa.

(.4) Orchard Creek Formation. The shale unit which lies above the Thebes Formation and below the Girardeau Formation in Missouri and which is herein questionably regarded as equivalent to the Orchard

Creek Formation of Illinois is composed of olive green to bluish-gray shale and intercalated beds of limestone. The shale is platy, calcareous, and generally weathers brown. The limestone beds are argillaceous and thin in the lower part of the unit but become less so upward where they resemble the limestone of the overlying Girardeau Formation. Fossils are presentin both the limestone and shale but are not abundant. The contact of the Orchard Creek with the underlying Thebes Formation is generally gradational, but locally it is sharp and distinct. The average thickness of the formation is 50 feet. The formation's contact with the overlying Girardeau appears transitional. The unit is present in Cape Girardeau, Perry and Ste. Genevieve Counties.

In Illinois, because of the similarity of Orchard Creek fauna with the Girardeau fauna, Savage (1917) placed the Orchard Creek Formation in the Silurian System.

(2) Silurian System.

(a) Alexandrian Series.

(.1) Girardeau Formation. The Girardeau is a dark to medium gray limestone which weathers to a light bluish gray. The texture of the limestone is dense to sublithographic, and the rock breaks with a conchoidal fracture. Bedding is thin and irregular with individual beds pinching out in short distances. Black and dark brown chert nodules are irregularly scattered throughout the upper part of the formation. Intercalated with the limestone beds, especially in the lower part, are yellowish-brown and olive, calcareous shale partings. Fossils are generally sparse in the limestone beds but are fairly abundant in many of the shale partings. The thickness of the formation ranges from a few feet to a maximum of 40 feet. The upper boundary of the Girardeau is marked by an erosional unconformity. The Girardeau Formation in Missouri is restricted mainly to Cape Girardeau County.

(.2) Edgewood Formation (Cyrene member). In southeastern Missouri, the Cyrene member is typically a gray, thin-bedded, argillaceous limestone in which yellowish-brown chert locally forms thin beds, lenses, and nodules.

The thickness of the Cyrene member does not exceed 20 feet, and throughout its extent it lies unconformably on older strata.

(.3) Sexton Creek Formation. In southeastern Missouri, the Sexton Creek Formation is an olive gray, medium to finely crystalline, cherty limestone. The bedding is thin, irregular, and commonly lenticular but may appear massive on weathered surfaces. Chert in the form of layers and lenses is especially abundant in the lower part of the formation where the chert is intercalated with the limestone. Upon weathering, the limestone forms re-entrants between protruding knobs and layers of the more resistant chert, thus giving the formation a very characteristic appearance. Green shale is also interbedded with the limestone. The thickness of the formation ranges from 20 to 60 feet in this area. An erosional unconformity is present at its base.

(b) Niagran Series.

(.1) Bainbridge Formation. The Bainbridge is typically a dark red, argillaceous limestone and is probably one of the most easily recognized formations in southeastern Missouri. Light to medium gray limestone beds which are mottled with purple and green colors are common in the dominantly reddish limestone. The basal part of the formation contains beds of argillaceous and slightly silty limestone that becomes increasingly more shaley upward. Glauconite is common in the basal part of the formation. The bedding is thin and irregular, and the formation's thickness ranges from 30 to about 160 feet. The formation is unconformably overlain by the Baily Formation (Devonian) and lies disconformably upon the Sexton Creek Formation.

(.2) St. Clair Limestone. The St. Clair Limestone is a coarsely crystalline, granular, fossiliferous, light gray, pink and chocolate brown limestone. In Illinois these strata were considered the lower part of the Bainbridge Formation until differentiated by Lowenstam (1949, p. 13).

In the Thebes Quadrangle the St. Clair is exposed in only a few scattered outcrops along the Mississippi River bluffs. Its contact with the underlying Sexton Creek Limestone is not well exposed although, along the Mississippi River at low water just southwest of the mouth of Orchard Creek (NW1/4SW1/4 sec. 21, T. 15 S., R. 3 W.) 4 feet of Sexton Creek Limestone is exposed about 8 feet below red and pink limestone of the St. Clair (Figure 3). In this exposure the St. Clair consists of 6- to 8-inch beds of red-brown silty limestone intertongued with more massive 12- to 18-inch beds of pink limestone that have abundant fossil fragments and appear to local bioherms. In the Missouri Pacific Railway cut at the north side of Powder Mill Hollow (SW 1/4 NE 1/4 SE 1/4 Sec. 28, T. 15 S., R. 3 W.) 6 to 7 feet of St. Clair are exposed in steeply dipping beds. Between the road and the upper railway (Missouri Pacific) at the south line of sec. 21, T. 15 S., R. 3 W., scattered outcrops of St. Clair are exposed in a shallow syncline.

Neither the top nor the base of the St. Clair is exposed in the area but its thickness is estimated as being between 10 and 20 feet.

(.3) Moccasin Springs Formation. The Moccasin Springs Formation was named for red and mottled red and gray to greenish gray, very fine grained, silty, argillaceous limestone and calcareous siltstone, exposed about three-quarters of a mile south of Moccasin Springs, Missouri, along the bluffs of the Mississippi River.

The entire Moccasin Springs Formation is not exposed in the Thebes Quadrangle, but incomplete sequences are exposed in the banks of Salamans Creek, north branch of Miller Creek, and in the Mississippi River bluffs to the south in the SW 1/4 sec. 21 and N 1/2 sec. 28, T. 15 S., R. 3 W.

About 100 feet of the Moccasin Springs Formation is exposed along the south side of Salamans Creek, and represents the upper part of the Moccasin Springs Formation and the basal beds of the Bailey Formation. The contact between the two formations is gradational through 8 to 10 feet, and the first occurence of ledge-forming chert and siliceous siltstone is arbitrarily taken as the base of the Bailey Formation.

The lower beds in the Moccasin Springs Formation are discontinuously exposed beneath Cretaceous sediments in the bed of Orchard Creek in Rock Springs Hollow (sec. 21, 22, and 23, T. 15 S., R. 3 W.). About 30 feet of mottled red-brown to green limestone is exposed in the bed of the creek in the SE 1/4 SW 1/4 sec. 22, where the beds weather into 1- to 3-foot blocks and contain abundant megafossils and microfossils. Farther west in the SE 1/4 SE 1/4 sec. 21, a 4-foot block of massive, medium gray to pink, very fine-grained limestone with brown-red spots and many Formainifera and Ostracoda dips 8 degrees to the northwest and may be faulted to its present position. Closely similar limestone occurs about 80 feet above the base of the formation north of Cape Girardeau, Missouri. In the SW 1/4 SE 1/4 sec. 28 nearly 40 feet of the Moccasin Springs is exposed in a gully between the upper railway (Missouri Pacific) and the road (SE 1/4 SE 1/4 NW 1/4 sec. 28) just north of Powder Mill Hollow. Along the axis of the Thebes anticline in sec. 19, T. 15 S., R. 3 W., the upper 15 feet of the Moccasin Springs Formation are exposed in several road cuts.

The Moccasin Springs Formation is estimated to be 120 to 130 feet thick throughout most of the Thebes Quadrangle.

(3) Devonian System.

(a) Lower Devonian Series.

(.1) Bailey Formation. Three characteristic but gradational lithologies can be recognized in exposures of the Bailey Formation. The lower part of the formation consists of grayish-tan and light brown, dense, thinly bedded limestone which is intercalated with blue, green, and pink shale. The middle part is characterized by thick beds of argillaceous limestone which is pale blue and mottled with tan colored streaks and blotches. The upper part is a tan colored, thinly and evenly bedded limestone with interbedded chert and shale. Light gray chert is present throughout the formation in the form of nodules and layers. In some places, the chert may amount to as much as one-half of the formation. The thickness of the Bailey, which covers much of the eastern third of Cape Girardeau County and is exposed in the fault areas of Ste. Genevieve and Perry Counties, is about 300 feet. Because of the lithologic similarities of the adjacent parts of the Bailey and the underlying Bainbridge Formation (Silurian), there is some question as to the position and character of the contact. Although an unconformity is assumed to be present, it is not readily apparent.

(.2) Little Saline Formation. The Little Saline Formation is a white, coarsely crystalline, thickly bedded limestone. The lower part is abundantly fossiliferous, and crinoidal beds are present near the top. The formation is approximatley 100 feet thick at its type locality near the Little Saline fault area in Ste. Genevieve County, and it thins to 25 feet within a short distance. It rests unconformably on the Bailey Formation and is unconformably overlain by the Grand Tower Formation.

(b) Middle Devonian Series.

(.1) Clear Creek Formation. The Clear Creek Formation is a white to tan to chrome yellow, thinly bedded chert with brown to reddish ferruginous bands and some concretionary limonitic masses. The estimated thickness of the formation is about 300 feet in its restricted outcrop area in eastern Perry County. Here, it lies unconformably on the underlying Bailey Formation, indicating the local absence of the Little Saline Formation, the equivalent of which is present a few miles to the east in Illinois. Where the Little Saline is absent, the Clear Creek is not differentiated from the Bailey in the subsurface of Missouri because of its close similarity to the Bailey.

(.2) Grand Tower Formation. The Grand Tower in Missouri is a limestone, the upper part of which is arenaceous. In the area of the Little Saline fault zone in Ste. Genevieve County, the limestone is light gray to almost white, dense to coarsely crystalline, and regularly bedded. In the few limited exposures of the formation in Perry County, it is purplish gray or grayish tan in color and is finely crystalline in texture but varies locally from dense to coarsely crystalline. The upper part of the formation is marked by an abundance of the brachiopod Schizophoria, and the lower part is predominantly coralline. In some places, coral remains are so numerous that they form biostromes, with the coral Favosites being the most abundantly represented. In Ste. Genevieve County, the formation is approximately 250 feet thick, but in Perry County, it thins to about 100 feet. It lies unconformably on the Clear Creek Formation in eastern Perry County and apparently is unconformable on the Little Saline in Ste. Genevieve County. It merges with no observable sedimentary break with the overlying Beauvais Formation.

(.3) Beauvais Formation. The Beauvais is nearly white to yellowish brown quartzose sandstone which is remarkably similar to the sandstone of the St. Peter Formation (Ordovician). It is about 80 feet thick and restricted to an area of less than one square mile within the Little Saline fault complex in Ste. Genevieve County. It is conformable with the underlying Grand Tower and the overlying St. Laurent. The Beauvais occurs sporadically in the subsurface of southwestern Illinois several miles east of St. Louis where it is considered to be the basal member of the Lingle Formation.

(.4) St. Laurent Formation. Limestone is the dominant constituent of the St. Laurent. It is gray or bluish gray, dense, brittle, and thinly bedded. Most of it is arenaceous with local concentrations of sandstone. At one locality, an intraformational limestone conglomerate has been noted. Although all of the known exposures of the formation in the faulted outcrop areas of Ste. Genevieve and Perry Counties are incomplete, its thickness is estimated as being 275 feet. Its relationship with the underlying Beauvais Formation is believed to be conformable. It is unconformably overlain by the Fern Glen Formation (Mississippian) and by sandstone blocks suggestive of the Bushberg Formation.

(.5) Lingle Limestone and Alto Formation. A series of strata that crop out at only a few places and whose detailed character and variations are imperfectly known overlie the Grand Tower Limestone in Union and Alexander Counties. Early work suggested that the beds included a shale unit at the base, overlain by the Lingle Limestone, above which was the Alto Formation. The latter formation consisted of shale and limestone, with the limestone in the upper part of the formation. More recent investigations raise a question regarding the feasibility of attempting to recognize the three units in the outcrops.

One of the best outcrops of the Lingle Limestone occurred in the south bank of Clear Creek in the NE 1/4 sec. 34, T. 11 S., R. 2 W. The exposure is now inferior to what it was earlier when it showed 43 feet of mostly impure, dark-colored limestone. Some of the limestone was cherty and a 7-inch bed of chert was present. Other less extensive outcrops were of the same general character. The maximum thickness of the Lingle Limestone may be 90 feet.

The limestone of the Alto Formation is believed to be of roughly the same nature as that of the Lingle Limestone. One of the better outcrops of the formation occurred along a creek in the SE 1/4 sec. 10 T. 12 S., R. 2 W., where 35 feet of impure limestone is reported. The thickness of the Alto is not known but is probably between 0 to 100 feet or more. Well records suggest that some of the limestone of the Alto Formation may be dolomitic.

(4) Mississippian System.

(a) Kinderhookian Series.

(.1) Chouteau Group. The Chouteau limestone is the most widely distributed and most important of the Lower Mississippian formations in Missouri. The formation is mainly made up of thin-bedded limestone although some beds range up to two feet or more in thickness. In some places a dolomite occupies the top 15 to 20 feet.

The Chouteau limestone ranges through various shades of gray, mouse-gray being the commonest color. Many shale partings and scattered chert nodules are present. Irregular streaks of dark gray then mouse-gray are common. Dark gray irregular markings are present near the bottom and a dark mouse-gray nodular limestone is prominent about eight feet from the bottom.

In many places the Chouteau may be recognized by its weathered surface being hackly. The formation is very irregular in thickness and in many places it is not present between the Bushberg and the Burlington. Along the Missouri River at Easley it is 60 feet thick, but 15 miles southeast of there, at New Bloomfield, none is present.

(b) Osagean Series.

(.1) Fern Glen Formation. Although the Fern Glen Formation and the southwestern extension of the Pierson Formation are closely similar in lithology and age, they are separated by almost the entire width of the state. The Fern Glen is recognized only in east-central and southeastern Missouri, from eastern Franklin County east through St. Louis County and south through Jefferson and Ste. Genevieve Counties to northern Perry County.

Throughout this area, the formation consists of gray, grayish-green, and red limestone, and green and red calcareous shale. At most exposures, the lower part is noncherty while the upper part contains small nodules and layers of grayish-green to gray chert. Over much of the area, the formation has three types of lithologies; a lower, noncherty, brown, thickly bedded, crinoidal limestone 4 to 15 feet thick, which contains a few quartz geodes in places; a middle, distinctively red and (or) green, fossiliferous, calcareous shale 10- to 20-feet thick and an upper, nodular, cherty crinoidal limestone 12 to 30 feet thick which contains some quartz geodes. The total thickness of the formation ranges from 20 to 45 feet. Because the limestone in the upper part is crinoidal, there is a suggestion that it is transitional with the overlying Burlington. At the type area in central St. Louis County, the prevailing color of the formation is red, but in southwestern St. Louis County and in Jersey County, Illinois, the formation is predominantly light greenish gray or yellowish gray.

The lower, non-cherty limestone unit of the Fern Glen in western St. Louis County is interpreted by some geologists as the eastward extension of the undifferentiated Chouteau unit of central Missouri, but opinions concerning this problem are about equally divided, and no satisfactory solution has yet been reached.

The Fern Glen Formation is very fossiliferous and contains many brachiopods, corals, and crinoids. The hryozoan, Evactinopora sexradiata, and the brachiopods, Spirifer vernonensis, S. rowleyi, Athyris lamellosa, and Cleiothyridina, as well as the coral Cyathaxonia arcuatas are common. Many species are restricted to the formation.

The formation usually crops out at the base of bluffs formed by the overlying Burlington-Keokuk Formations. Where the upper part of the formatiou is very cherty, it is ledge forming. From the type area, the upper cherty limestone thickens southward toward Jefferson County. The lithology of this part of the formation resembles that of the Reeds Spring Formation of southeastern Missouri, and because of this and faunal similarities, the two are considered correlative at least in part. Toward the northern limits of its occurrence, the formation overlies truncated undifferentiated Chouteau or sandstones which have been regarded as Bushberg (Devonian-Mississippian). In Ste. Genevieve County, the formation overlies Ordovician and Devonian rocks. Residual boulders containing a Fern Glen fauna have been found as far west as Phelps County in central Missouri.

(.2) Burlington Formation. The Burlington in Missouri is a widespread formation of uniform lithology. It is present in nearly all the major Mississippian outcrop areas of the state and also occurs in the subsurface of northwestern Missouri. Throughout this entire area, it consists of white to light buff, very coarsely crystalline, fossiliferous, crinoidal limestone. Layers of chert nodules are common, especially in the upper part.

One of the difficulties in estimating the thickness of either the Burlington or the overlying Keokuk is that the boundary between the two formations is obscure, and in most reports the two are combined as one unit and their total thickness is recorded. However, the thickness of the Burlington Formation is believed to be fairly uniform throughout the state, seldom exceeding 100 feet. In central, east-central, and southeastern Missouri, it ranges from 75 to 100 feet.

The contact of the Burlington with underlying formations varies considerably. In east-central and southeastern Missouri, it is conformable on the Fern Glen; in central Missouri, it is unconformable on both undifferentiated Chouteau and Northview. Its contact with the overlying Keokuk is obscure and not easily distinguished either on the outcrop or in drill cuttings, but it is considered to be conformable.

(.3) Keokuk Formation. The Keokuk Formation is widespread throughout the state and like the Burlington Formation is of fairly uniform lithology. It is present in all the major Mississippian outcrop areas of the state and is also present in the subsurface of northwestern Missouri. The formation is characteristically a bluish-gray, medium to coarsely crystalline, medium bedded limestone which contains an abundant amount of light gray chert in the form of layers and nodules. Some beds of the formation in the southwestern part of the state are finely crystalline, and some parts of the formation in the same area are extremely crinoidal. In the northeastern part of the state, thin shale beds separate the limestone strata. Stylolites are common and are especially pronounced at the contact of coarsely and finely crystalline beds.

The chert in the Keokuk is irregularly distributed throughout the formation but appears to be more concentrated in the lower and upper parts. It is dense, light gray, and has tripolitic borders. It weathers to buff aud reddish brown.

Fossils are common in the formation but are not readily removed from the limestone. The productid brachiopods Buxtonia, Dictyoclostus, Linoproductus, and Marginirugus are common, as well as the following species of brachiopods: Orthotetes keokuk, Cleiothyridina obmaxima, Echinoconchus alternatus, Spirifer logani, and Tetracamera spp. Horn corals and bryozoans, especially the distinctive bryozoan genus Archimedes, are relatively abundant in the formation.

As previously stated in the discussion of the Burlington Formation, thickness determinations for either the Burlington or Keokuk are difficult to make because of the obscure boundary between them. This is especially true in east-central and southeastern Missouri where the two formations together have a thickness of about 125 feet. Of this amount, about 50 feet belongs to the Keokuk. In central and southwestern Missouri, it is about 100 feet thick.

Throughout most of its extent, the Keokuk appears to be conformably overlain by the Warsaw Formation. The Keokuk overlies the Burlington in all areas of the state except in the Tri-State district and in parts of Barry County where it lies directly on the Grand Falls or Reeds Spring-Grand Falls unit.

The Keokuk is used for road metal and occasionally for building stone. Agstone quarry operators utilize the less cherty parts of the formation which includes the Short Creek member. Tripoli is mined from weathered Keokuk chert in western Newton County. Fossils consist mostly of brachiopods such as Orthotetes keokuk, Rhipidomella spp., and Chonetes illinoisensis.

(c) Meramecian (Valmeyeran) Series.

(.1) Warsaw Formation. Exposures of the Warsaw Formation are widely but discontinuously distributed throughout Missouri. From northeastern Missouri, the Warsaw can be traced southeastward in the subsurface down along the southwestern flank of the Lincoln fold to St. Charles and St. Louis Counties where it again crops out. The formation also is exposed in Ste. Genevieve County and in the extreme eastern part of Perry County. In these areas, the Warsaw is about 80 to 100 feet thick and is very shaly. The lower half is composed of finely crystalline shaly, very fossiliferous, dolomitic limestone, and the upper half is a dark, fissile shale.

(.2) Salem Formation. The most complete and thickest exposures of the Salem Formation in Missouri are present in the east-central and southeastern parts of the state in St. Louis, Ste. Genevieve, and eastern Perry Counties. Throughout this area, the formation is 100 to 160 feet thick. In Ste. Genevieve County, the lower part of the Salem is a light gray to white, fragmentally fossiliferous, argillaceous, locally oolitic limestone, and the upper part is a bluish-gray, argillaceous, oolitic, dolomitic limestone in which the oolitic content varies considerably. The formation is commonly cross bedded. In the St. Louis area it becomes more dolomitic. The upper part of the Salem is fossiliferous and contains blastoid, crinoid, echinoid, and bryozoan debris, as well as the coral Syringopora. The top of the formation grades upward into the St. Louis formation, and the intermediate beds contain the coral Lithostrotion. The insoluble residue from the upper 50 feet of the Salem in the St. Louis area contains a high percentage of speckled gray and tan chert. The residue from the Salem also contains the Foraminifera Endothyra, and echinoderm fragments. In Ste. Genevieve County, an exceptionally pure white oolitic limestone in the middle of the formation is used for making lime. Other parts of the formation in the same area have heen used for riprap, agricultural limestone, and road metal.

The Salem thins northward from St. Louis County, aud in the northeastern part of the state it ranges from 20 to 40 feet in thickness. It is composed of buff weathering limestone, dolomitic limestone, and shale in this part of the state, and its contact with the underlying Warsaw is obscure because the lithologies of the two formations intergrade.

(.3) St. Louis Formation. The St. Louis Formation attains its fullest expression within Missouri in its type area in St. Louis County and in adjacent parts of east-central and southeastern Missouri. Here, the formation is a gray lithographic to finely crystalline, medium to massively bedded limestone which is more than 100 feet thick. Limestone breccia is common in the lower part of the formation but is not necessarily confined to this part. Shale occurs as a matrix between the blocks of breccia. Blue and bluish-gray shale also forms thin beds throughout the formation and increases in abundance toward the northeastern part of the state. Chert is not common. Where it is present, it is uaually brown and in the form of small angular fragments. Parts of the formation are locally dolomitic. The compound corals Lithostrotionella castelnaui and Lithostrotion proliferum are considered to be diagnostic, and the coral Syringopora is common. The percentage of insoluble residue that can be extracted from the St. Louis is generally low. The residue from the lower part of the formation normally contains small (less than 1 mm.) euhedral quartz crystals. Gray or tan quartzose chert rosettes are also common residue constitutents. The contact between the St. Louis and Salem Formation appears to be conformable.

The limestone from the St. Louis Formation is quarried in the St. Louis area for cement manufacture and aggregate. In northeastern and southwestern Missouri, the limestone is used for agstone and road metal.

(.4) Ste. Genevieve Formation. The Ste. Genevieve Formation is typically developed in the east-central and southeastern parts of Missouri in Ste. Genevieve and St. Louis Counties and in eastern Perry County. It is also present in adjacent parts of Illinois and Kentucky where it has been subdivided into members. Within the Missonri area, the formation is a white, massively bedded, sandy, elastic limestone. It is generally coarsely crystalline and oolitic but does contain a few beds of finely crystalline limestone. The lower part of the formation is sandy, white to light tan or light olive gray in color, and is prominently cross bedded and ripple marked. Lenses and clusters of algal material are present in this part of the formation in regularly-bedded strata. Above the cross-bedded unit and near the middle of the formation, there are some layers of red and gray chert, as well as some lenses and beds of sandstone that occur locally. The lithology of the formation changes laterally, making it difficult to trace individual units. Certain beds contain notable amounts of limonite which lines small cavities in the rock. In the upper part of the formation, various shades of yellow, green, and purple have been noted. The percentage of insoluble residue that can be extracted from the Ste. Genevieve in this area is usually low. The residue contains a proportionately large amount of pink or bluish-gray chert, some quartz sand and crystals, and silicified ooliths.

Fossils are irregularly distributed throughout the Ste. Genevieve in the east-central and southeastern parts of Missouri. The best preserved forms are present above the cross-bedded part of the formation. The brachiopod Pugnoides ottumwa, the small crinoid Platycrinites penicillus, and the very large gastropod Bellerophon are commonly present in the formation in this area.

The average thickness of the Ste. Genevieve in southeastern Missouri is 85 feet with the maximum being less than 100 feet. The formation's thickness in St. Louis County is 30 feet. There is a disconformable contact between the Ste. Genevieve and the underlying St. Louis Formation, with a basal conglomerate being present in numerous places. A significant pre-Chester erosional surface marks the top of the formation. In the St. Louis area, the formation is overlain either by beds of the Pennsylvania system or by Pleistocene deposits.

(d) Chesterian Series

(.1) Aux Vases Formation. The Aux Vases Formation is composed principally of straw- to tan-colored sandstone and interbedded green to variegated shale which contains sandstone stringers in the lower and upper parts. The sandstone is finely grained and even textured. Its coarser portions occur in Perry County where it superficially resembles but differs from the St. Peter sandstone by being finer grained and by containing a considerably greater variety of minerals. The middle part of the formation is bluff forming and contains massive, cross-bedded sandstone which has been used for building stone. The sandstone is locally cemented by silica and is sparingly fossiliferous, containing mostly broken crinoid and brachiopod remains. The formation has about the same areal extent as the underlying Ste. Genevieve Formation upon which it lies unconformably. Complete sections are not exposed in any one locality. In Ste. Genevieve County, the thickness of the formation ranges from 40 to 60 feet and in Perry County, from 56 to 105 feet.

(.2) Renault Formation. The Renault Formation includes a variety of rock types and is not very well exposed. The lower part contains shale and sandy limestone which is conglomeratic near the Aux Vases contact; the conglomerate is composed of limestone, chert, and sandstone fragments. The sandstone is fine grained and commonly contains worm borings. In the upper part, thin, bluish-gray to light gray limestone is interbedded with red, gray, or green, fissile shale. The formation's contact with the underlying Aux Vases is generally covered; thus, the relationship between the two formations is believed to be unconformable. The formation varies in thickness from 46 to 90 feet and is exposed in and near the Mississippi River bluffs from the Aux Vases River in Ste. Genevieve County to a point a few miles south of the Perry County line.

Fragments of the plant Lepidodendron are commonly present in the lower sandy beds. In the upper limestone beds, crinoids and bryozoans are common, and the crinoid Talarocrinus and the bryozoan Lyropora are widespread markers.

(.3) Yankeetown Formation. Throughout most of its outcrop area, the Yankeetown Formation is a fine-grained, light to reddish-brown, calcarceus sandstone. The sandstone is irregularly bedded and cross-bedded, shows rib and furrow structure, and in many places is cemented with silica. The irregularity of some of the bedding and cross-bedding may be caused by the leaching of the calcareous cement. At many places, the formation contains gray or red shale. The contact between the Yankeetown and Renault Formations is transitional. If most of the sandstone that lies below the Paint Creek Formation in Missouri is assigned to the Yankeetown, the thickness of the formation in Perry County will be 60 feet, and in Ste. Genevieve County it will be somewhat less.

(.4) Paint Creek Formation. The Paint Creek Formation is poorly exposed in Missouri and is presently only in northeastern Perry County. The basal part of the formation consists of limestone and interbedded shale. The limestone is light gray, coarsely to finely crystalline, and contains distinctively pink crinoid and blastoid ossicles. This lower limestone unit varies in thickness from 8 to 20 feet. The middle part of the formation consists of shale that has a few limestone beds in the upper part and noncalcareous, red claystone in the lower part. It is from 15 to 30 feet thick. The upper part of the Paint Creek contains light buff oolitic, cross-bedded limestone and very little shale. Crinoid and blastoid debris is common, and the crinoid Pterotocrinus is distinctive. This part of the Paint Creek is 40 to 70 feet thick. The total thickness of the formation varies from 80 to 100 feet.

(.5) Cypress Formation. The Cypress Formation is composed of gray shale and mudstone and contains some red shale layers and a few thin limestone stringers. The limited exposures in east-central Perry County are poor, and the contacts of the formation with the overlying Golconda and underlying Paint Creek Formations are concealed. The Cypress Formation becomes silty and sandy and extends eastward into Illinois where it rapidly thickens so that 10 miles east of the Mississippi River bluffs it consists of 70 to 80 feet of sandstone which may be a channel deposit. Because this facies relationship was not noted in the past, the formations have not been previously recognized in Missouri where the thickness of the unit probably does not exceed 30 feet.

(.6) Golconda Formation. The Golconda Formation is a limestone and shale succession that can be divided into three parts. The basal part is a dark gray to brown limestone 5 to 20 feet thick which contains an abundance of Foraminifera, small gastropods, and pelecypods. The middle part is 70 to 90 feet thick and is composed of shale which contains beds of darkly colored crinoidal limestone, and the upper part is a very light gray, oolitic, cross-bedded limestone 50 feet thick. Outcrops of the formation are confined to northern Perry County where the limestone beds in the Golconda are massive and form steep bluffs and ledges along the Mississippi River and its tributaries. Because the typical sandstone of the Cypress Formation is absent in Missouri, there is a suggestion that an unconformity is present at the base of the Golconda.

(.7) Hardinsburg Formation. The Hardinsburg Formation consists of dark gray shale or plastic clay which contains quartzose sandstone streaks in the upper part. A thin coal streak has been noted to be present within the unit in one Missouri exposure. This shaly succession between the Glen Dean and the Golconda limestones apparently represents the westward extension of a more typical, thicker, sandy shale and sandstone of western Illinois. This shale has not been differentiated as Hardinsburg in older reports of the Missouri Geological Survey. Limited and poor exposures of the formation are present in east-central Perry County near the Mississippi River bluffs. Its thickness ranges between 13 and 20 feet but may reach 30 feet, a thickness which is comparable to that observed in wells across the river in Illinois.

(.8) Glen Dean Formation. The Glen Dean Formation consists of limestone and numerous interbedded layers of shale. The limestone is light gray and coarsely to finely crustalline or oolitic. Stratisication is very irregular. The bedding planes undulate, and cross-bedding is common. The formation weathers buff to gray. Both the shale and limestone are fossiliferous. The large blastoid Pentremites spicatus is characteristic but not common, and the bryozoan Prismopora serratula is commonly present in the upper part of the formation. Brachiopods, horn corals, and crinoids also occur. The formation's contact with the underlying Hardinsburg appears to be conformable. Its outcrop belt is confined to a band along the Mississippi River bluff in east-central Perry County. The Glen Dean is 65 to 80 feet thick and contains numerous local disconformities.

(.9) Menard Limestone. This formation attains a thickness of 70 to 85 feet and crops out east of Kaskaskia River from Little Plum Creek four miles south of Baldwin to Fort Gage and thence along the Mississippi bluff to a point 4-1/2 miles below Cora. An inlier of considerable size occurs in the basin of Gravel Creek just north of Chester.

The Menard succeeds the Baldwin Formation conformably, and consists of beds of limestone rarely more than one foot thick separated by shaly partings or variable thicknesses of shale. The limestones of the Menard Formation are commonly darker colored and finer grained than the Okaw and lower limestones, are more or less cherty in certain parts, and no oolitic beds have been observed. The bedding planes are characteristically uneven and hummocky. Near the top in the vicinity of Chester there is a ledge of crystalline, crinoidal limestone. Good exposures occur in old quarries in the face of the Mississippi bluff between Chester and the mouth of Marys River.

(.10) Palestine Sandstone. This formation crops out from the upper valley of Nine-mile Creek five miles southeast of Evansville to a point less than two miles northeast of Reily Lake. Northeast of

Fort Gage it seems to be overlapped by the Pennsylvania system which locally rests upon the Menard. It reappears at the top of the Chester section in the Mississippi bluff two miles to the southeast, however, and is present throughout a considerable area extending to Marys River and northeastward six miles from Chester. It continues in the lower part of the Mississippi bluff from Marys River to six miles below Cora.

The Palestine sandstone attains a thickness of 40 to 60 feet, and probably succeeds the Menard limestone with a slight unconformity. It is somewhat variable in lithology but is generally a thin-bedded, flaggy, shaly sandstone locally including a considerable percentage of arenaceous shale. At some localities it includes more massive beds that were formerly quarried for building stone. Shaly Palestine sandstone is exposed below the W.P.A. quarry near Ford, four miles southeast of Chester, and massive beds project prominently from the hillside at Rockwood.

(.11) Clore Formation. This formation crops out on Little Marys River seven miles northeast of Chester and extends to Welge and thence to the Mississippi bluff which it follows to a point eight miles below Cora. A large outlier caps the hill upon which Chester is situated, and several other smaller outliers occur between Chester and Marys River. It succeeds the Palestine sandstone conformably.

The Clore Formation, generally from 40 to 60 feet thick, contains much shale in which variable amounts of limestone are interbedded. Most of the Clore limestone occurs in the upper part of the formation and is similar to that in the Menard Formation, but the bedding is more regular and lacks the hummocky surfaces so characteristic of the latter. Nearly black limestone is present locally, and chert has not been noted in this formation. The Clore is almost completely exposed at the W.P.A. quarry near Ford Station just below the mouth of Marys River.

(.12) Degonia Sandstone. This formation varies in thickness from 75 to 150 feet and crops out from the vicinity of Breman down Marys River and along the Mississippi bluff to within two or three miles to Grimsby. It probably overlies the Clore Formation unconformably.

The lower half of the Degonia is more or less thin-bedded and locally shaly, but the upper half includes massive, cliff forming beds up to 50 feet or more in thickness. These strata are so similar to some of the lower Pennsylvanian sandstones that they cannot be recognized with certainty where the overlying Kinkaid limestone was entirely removed by pre-Pennsylvanian erosion. The Degonia, however, does not contain the quartz-pebble conglomerates so characteristic of some of the Pennsylvanian sandstones. The formation crops out extensively in many of the small valleys that intersect the Mississippi River bluffs in the Campbell Hill quadrangle.

(.13) Kinkaid Limestone. The Kinkaid Formation is present only east of Marys River and extends along the bluff eastward nearby to Big Muddy River. Particularly good exposures occur on Kinkaid Creek in the NW. 1/4 sec. 6, T. 8 S., R. 4 W. where a large quarry is in operation. It overlies the Degonia sandstone conformably. Because of Pre-Pennsylvanian erosion the thickness of the Kinkaid formation is quite variable; 90 feet in the greatest thickness that has been observed in this area.

The Kinkaid is dominantly a limestone formation but shale beds a few feet back occur at several horizons. The limestone is commonly gray and fine-grained and occurs in beds a foot or less in thickness separated by shaly partings. Cherty bands occur particularly in the upper part.

(5) Pennsylvanian System.

(a) Caseyville Formation. The Caseyville Formation is characterized by dominance of sandstone and prominent development of sandy shale and siltstone. Sandstone members are not uncommonly of the order of 100 feet thick, and the two sandstone members that have been named, Pounds and Battery Rock, form prominent bluffs along the Pennsylvanian escarpment of southern Illinois.

The Caseyville sandstones are composed of clean quartz sands and have little clay or mica. The sandstones contain well rounded white quartz pebbles commonly about 1/4 to 1/2 inch in diameter, although pebbles about 1-1/2 inches in diameter have been reported. In some areas the quartz pebbles are distributed throughout the sandstone bodies, but more commonly they are concentrated along bedding planes or in conglomeratic lenses. In many exposures the quartz pebbles are scarce and are found only by careful search. Secondary enlargement of quartz grains is common and gives sparkle to the rock. The character of the sandstones is the most useful feature for distinguishing the Caseyville from overlying formations.

The shaly and silty strata below the principal sandstones are characteristically sandy. Sandstone benches up to at least 25 feet and similar to the principal sandstone members occur in the Lusk Shale, the lowest member.

Two or more coal beds have been recognized within each of the more shaly parts of the Caseyville Formation throughout much of the southern Illinois outcrop belt. The coals, however, generally are very thin and not widely traceable. Only one coal, the Gentry Coal Member, has been widely correlated, but even this is not continuously traceable.

In genral, limestones have not been observed in Caseyville strata, but fossiliferous sandy beds occur in a few places. Some of the fossils are reworked from Mississippian and older rocks.

(b) Abbott Formation. Like the Caseyville Formation, the Abbott Formation is characterized by the dominance of sandstone, sandy shale, and siltstone. The massive sandstone members generally do not attain a maximum thickness as great as do those of the Caseyville. The sandstones of this formation may be considered transitional from the relatively pure quartz sandstones of the Caseyville Formation to the argillaceous and micaceous sandstones of higher Pennsylvanian Formations. The lowermost sandstone is a relatively clean quartz sandstone, and the highest sandstone member is more argillaceous and micaceous.

Sandstones of the Caseyville and Abbott Formations can best be differentiated by the general absence of quartz pebbles and the greater prominence of clay matrix in the Abbott sandstones. A few quartz pebbles have been reported in sandstone members of the Abbott Formation, but they are rare.

Sandstones and siltstones constitute more than 50 percent of the Abbott Formation.

Although the shales of the Abbot are commonly sandy and silty, like those in the underlying Caseyville, there are more nonsandy, clayey shales than in underlying strata.

Coals in the Abbott Formation generally are thicker and much more widely traceable than coals of the Caseyville. However, the coals are rarely more than 24 inches thick and have much less continuity than the higher coals.

Limestones are generally absent in this formation but relatively thin, discontinuous, sandy limestones or fossiliferous sandstones are associated with at least two of the sandstone members. In Indiana Ferdinand and Fulda Limestones occur in strata equivalent to the Abbott Formation.

The Abbott Formation has a maximum thicknes-s of 300 to 350 feet in southern Illinois, but it thins westward and northward. The Abbott probably is never more than 100 feet thick in western Illinois and is generally much thinner.

(c) Spoon Formation. The Spoon Formation contains much less sandstone and correpondingly more shale than the underlying formation (fig. 4). The sandstones are generally more argillaceous and micaceous than sandstones of the Abbott Formation, although this change is a gradational one. They do not differ markedly from sandstones of overlying formations.

The shales of the Spoon Formation are commonly less sandy than those in underlying strata, and underclays beneath the coals and black shales above the coals are generally better developed.

Coal members, for the most part, are thicker and much more widely traceable than coals encountered in lower formations. They lack the uniform thickness, and most of them lack the very wide continuity, of coals in the overlying Carbondale Formation.

Although limestones are relatively minor in the Spoon Formation several limestones of appreciable continuity occur and have been correlated widely. The limestones are not as continuous as those in the overlying Carbondale Formation.

The Spoon Formation has a maximum thickness of about 350 feet in southern Illinois but is thinner in most places. It ranges from a few feet to nearly 100 feet thick in western Illinois.

(d) Carbondale Formation. The Carbondale Formation is dominantly gray shale, but sandstones are prominent locally and have a maximum thickness of about 100 feet. The sand bodies are generally linear in their maximum development and are interpreted as filled channels. The formation is characterized by wide distribution of coals and limestones. Many of the coals are relatively thick, commonly ranging from 2 to 7 feet and in some areas up to 15 feet. The formation includes the principal coals that have been most extensively mined in Illinois. Several limestone members are nearly as extensive as some of the coals. The limestones are usually about 1 to 5 feet thick, but some are locally thicker. They usually are relatively argillaceous. A few are locally highly dolomitic. Black fissile shales are particularly well developed over most of the coals, and underclays are uniformly present. Cyclic sequences have a wider variety of lithologic units than occur in lower formations.

The Carbondale Formation is commonly 225 to 300 feet thick, but in parts of northern, western, and southwestern Illinois the formation thins to about 125 feet, locally even less. In part of southeastern Illinois, the formation is nearly 400 feet thick.

c. Mezezoic Era.

(1) Cretaceous System.

(a) McNairy Formation. In its outcrop area in Scott and Stoddard Counties, the McNairy Formation is composed of a succession of non-marine sand, sandy clay, and clay. Southeastward in the deeper parts of the Embayment, the formation becomes more marine in character and contains calcareous material, glauconite, and fossil fragments. At the surface, the formation is roughly divisible into a lower and upper part. The lower part contains in ascending order: 1) a basal gravel;

2) a clay that is thinly bedded, light gray in color and interbedded with thin layers of fine- to medium-grained orange sand; and 3) a sandstone composed of light yellow to orange, medium- to coarse-grained, subangular sand with little or no mica. The upper part of this sandstone is usually silicified and is locally named the "Commerce quartzite." The upper part of the McNairy is made up of a succession of five alternating beds of sandstone and clay which can be traced throughout the outcrop area but which cannot be differentiated in the subsurface. They are in ascending order: 1) a yellow to brown clayey sandstone; 2) a white to yellow fine-grained micaceous sandstone; 3) a light gray to brownish-black lignitic clay locally known as the "Zodoc clay" and mined for ceramic clay; 4) an interbedded orange sandstone and gray to brown clay; and 5) a brown, lignite, sandy clay. The McNairy is an important acquifer in the Embayment area and is also a source of sand. Its thickness ranges from 100 to 250 feet.

(b) Owl Creek Formation. The Owl Creek Formation consists of a massive sandy, micaceous, fossiliferous, marine clay which is commonly glauconitic. On fresh exposures, the formation has a dark bluish-gray color but upon weathering alters to a yellowish brown. The Owl Creek is exposed along Crowley's Ridge in Scott and Stoddard Counties and dips southeastward into the subsurface of the Embayment where it consists of brown, calcareous, sandy clay with pyritized fossils and glauconite. The thickness of the formation is variable, ranging from a few inches to 11 feet in the outcrop area to as much as 100 feet in the subsurface. The Owl Creek is unconformably overlain by Teritary rocks.

d. Cenezoic Era.

(1) Tertiary System.

(a) Paleocene Series.

(.1) Clayton Formation. The Clayton Formation in its outcrop area is a fossiliferous, calcareous, glauconitic sand or clay which contains varying amounts of limonite. The formation has a distinctive green color which makes it noticeable and easy to recognize in the outcrop area. In the subsurface, the formation becomes increasingly calcareous, and in the deeper parts of the Mississippi Embayment within Missouri it becomes a fossiliferous, glauconitic limestone. It also is a very distinctive unit in the subsurface and is frequently used as a datum for mapping purposes. The thickness of the formation varies from a few inches to 10 feet in the outcrop area to as much as 20 feet in the subsurface.

(.2) Porters Creek Formation. The Porters Creek Formation is a massive, homogenous, dark gray clay which is almost black when wet. When dry, it spalls with a characteristic conchoidal fracture and is white to very light gray. The formation is remarkably uniform in lithologic character and maintains its diagnostic features throughout its extent. In its thicker parts, large boulders of iron carbonate are scattered erratically in the clay. Small quantities of mica and gypsum are disseminated throughout the formation, and in the outcrop area where the clay is bedded, fine-grained, white sand and mica are concentrated along some of the parting planes. In several parts of Stoddard County, bauxitic clay has been noted at the top of the formation. Petrographic studies indicate that the clays of the Porters Creek are bentonite and are commercially valuable as a bleaching clay. The Porters Creek varies in thickness in the outcrop area and is more than 200 feet thick in some places. Southeastward, in the subsurface, it thickens to 650 feet or more. In the subsurface, the formation lacks sand, and its lower 50 feet commonly contains Foraminifera and small pelecypods.

(b) Eocene Series.

(.1) Wilcox Group. In Missouri, the formations of the Wilcox group are widely distributed along Crowley's Ridge in Stoddard County and are present in a limited area in Scott County southwest of Commerce. The group includes beds of sand and clay that lie between the Midway group (Paleocene) and the base of "Lafayette" Formation (Pliocene?). The Wilcox group has a thickness in the outcrop area that varies from 0 to more than 300 feet because over much of the area, with the exception of loess and patches of gravel, it forms the uppermost rock succession on Crowley's Ridge. It thickens southeastward, and in the subsurface in the extreme southeastern corner of the state it is more than 1,300 feet thick. The group lies unconformably above the Midway group and unconformably below the gravels of the "Lafayette" Formation.

(c) Pliocene Series.

(.1) "Lafayette" Formation. Descriptions of the various occurrences of the "Lafayette" Formation throughout eastern Missouri indicate that in this area there is little variation in its composition. In most exposures, the formation is composed of irregularly bedded gravel with minor amounts of coarse sand and clay. The gravel consists dominantly of pale brown, polished, and rounded pebbles of chert which make up as much as 80 to 90 percent of the formation. Pebbles of quartz and quartzite are present in lesser amounts. Most of the pebbles are between 1-1/2 and 3 inches in diameter; however, large cobbles and a few boulders are not uncommon. The chert pebbles vary considerably in color and texture. Some are oolitic and some are fossiliferous and contain Paleozoic fossils. The quartzite pebbles are commonly pinkish or purplish in color, whereas the quartz pebbles are predominantly white or pale gray. Slight compositional variations exist between the gravels in the St. Louis County area and those in the Embayment area in that in the former locality subangular to rounded fragments or conglomerate occur in which well-rounded quartz pebbles are set in a matrix of dark brown ferruginous sandstone. Pebbles composed of other rock types are rare. Feldspathic igneous rocks and carbonate sedimentary rocks appear to be absent.

The sand which is associated with the gravel is medium- to coarse-grained, subangular to angular in shape, and heavily stained with iron oxide. This staining gives the formation a distinctive dark red color at most exposures. The clay in the formation is erradically distributed as thin lenses, or else it forms a matrix for the gravel. In this very sandy, plastic, noncalcareous, and varies in color from white, gray, yellow, purple to deep red.

The formation is usually cross-bedded, and the gravels and sand are poorly sorted. In the St. Louis area, the formation is approximately 30 feet thick. In southeastern Missouri where the formation caps most of the hills it is estimated to be as much as 60 feet thick along the southeastern margin of Crowley's Ridge and only a thin veneer on the flanks of the Ozark uplift adjacent to the Mississippi Embayment. The formation lies unconformably upon a very uneven and eroded surface which truncates Paleozoic, Cretaceous, Paleocene, and Eocene rocks. In much of its area of exposure in Missouri, the formation either forms the surface rock or is overlain by Pleistocene loess.

2.1.2.4. Structural Geology

a. General. Structural features within the limits of the study area are confined to monoclines, domes, folds, anticlines and faults (see Plate 2-3). Some of these features are associated with the Ozark Uplift.

McCracken (1961) states that "At least six episodes of deformation have occurred in Missouri beginning with intense faulting and volcanic activity in the Precambrian followed by intermittent but persistent uplift of the Ozark region during the Paleozoic and Mesozoic. Sharp rejuvenation of the Mississippi Embayment took place in post Paleocene-pre Pliocene time. Pleistocene stream terraces, entrenched meanders, and seismic activity all indicate that uplift is continuing." (Figure 2-1 contains a geological time scale.)

b. Structural Features. Within the study area, the following significant structural features can be found: (1) Valmeyer anticline, which crosses the river midway between Festus and St. Louis; (2) Crystal City anticline at Festus; (3) Plattin Creek anticline, trending northeastward to Crystal City (east of Festus); (4) Ste. Genevieve fault system, a series of several folds and faults downthrown to the north and east which extends from Franklin Gounty, Missouri, (approximately 50 miles southeast of St. Louis) along the river crossing at Perry County (see Plate 2-3) and into Illinois, where it is called the Rattlesnake fault; (5) Brooks dome, located in Cape Girardeau County, Missouri, four miles north-northeast of Cape Girardeau; (6) Cape Girardeau fault, a minor fault in Cape Girardeau County, Missouri; (7) Thebes anticline and associated faults and folds; (8) Jackson fault, located in Cape Girardeau County, Missouri; (9) Albright Creek fault, located in Scott County, Missouri, (see Plate 2-3) and exposed at the mouth of Albright Creek; and (10) English Hill Fault, located in Scott County, Missouri, where loess has been faulted. The fact that the loess (Plieistocene) is affected by this fault shows late movement in the area. This remains an active seismic area.

2.1.2.5. Seismic Activity

Cairo, at the southern end of the study area, is located 34 miles northeast of New Madrid, Missouri. This is near the epicenter of one of the most devastating earthquakes to be felt on the North American Continent. Actually a series of three earthquakes which occurred between December 1811 and February 1812 comprise what is commonly though of as the New Madrid Earthquake. Since 1816 over one hundred earthquakes have been felt in this area, several of which were moderate tremors. The southern half of the Middle Mississippi Valley is given a seismic risk classification of "3" (as is California), while the northern half is classified as "2" on a seismic risk scale of 0-3.

Earthquakes in the Madrid trend are responsible for sand blows, fissures, and related phenomena caused by liquefaction of shallow subsurface sand and its extrusion to the surface.

2.1.2.6. Groundwater Geology

Large underdeveloped groundwater resources occur within the glacial deposits filling major bedrock valleys through Missouri and Illinois and the thickest and most continous aquifers are within the present Mississippi Valley which in large part coincide with preglacial valleys. Valley fill ranges in thickness from 120-175 feet and is composed mainly of sand and gravel. In the St. Louis-East St. Louis area, significant withdrawals of groundwater have taken place. In the study area south of St. Louis only minor amounts of groundwater have been withdrawn, so the entire middle Mississippi Valley, with the possible exception of the narrows between Alexander County, Illinois, and Scott County, Missouri,has large undeveloped groundwater reserves (Horberg, 1950).

Water well yield from representative deep and/or high yield water wells in Missouri indicate most wells have a yield of 50 or fewer gallons per minute (gpm); a few wells have yeilds in the range of 50-200 gpm, and one well in Scott County, Missouri, has a yield of 500-1,000 gpm.

The groundwater geology of the East St. Louis area has been extensively studied. The first significant withdrawal of groundwater in the East St. Louis area started in the late 1890's. Prior to 1900 groundwater was primarily used for domestic and farm supply; since 1900 pumpage has been mostly for industrial use. Only the Valley fill material (i.e., bulk alluvium and glacial outwash) aquifers are suited for large quantity production, as the bedrock aquifers are likely to contain highly mineralized water. Aquifers are recharged by rainfall, floods, and percolation from the Mississippi River.

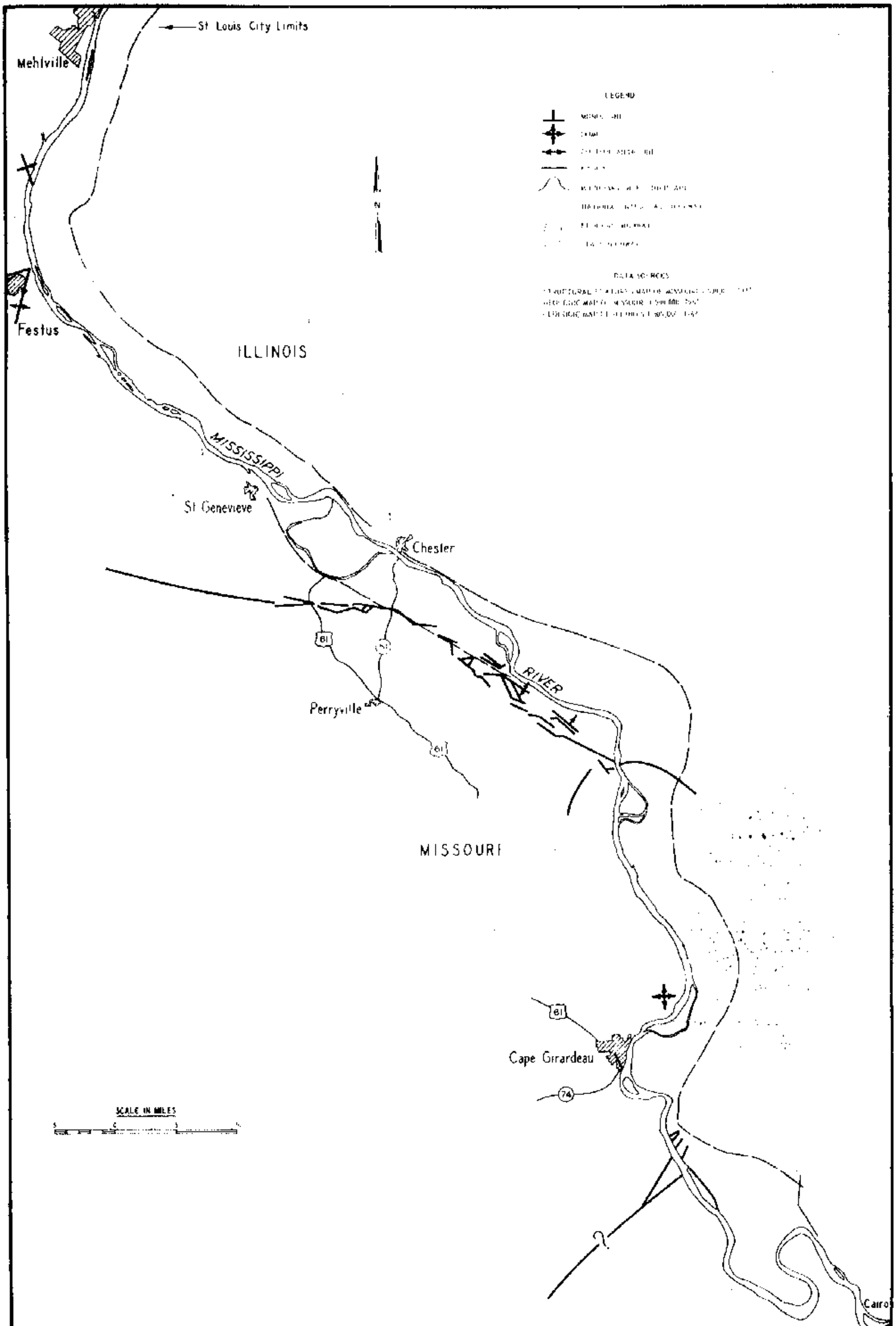


Plate 2-3. Structural geology of the Middle Mississippi River Region

The available groundwater data are inadequate to assure supplies at specific locations. For this reason, and because of the sudden lateral variations in the permeability of most glacial deposits, electrical-resistivity surveys and test borings are usually required in order to discover the most favorable locations within an area.

2.1.2.7. Economic Geology

a. General. The States of Illinois and Missouri receive millions of dollars annually in revenue from their economically important minerals. Some minerals are distributed throughout the state, while others are confined to specific locations. Figure 2-5 shows the distribution of important mines, quarries, mining operations, and plants in the study area. In the following paragraphs some of the more important economic resources that occur within the study area are discussed.

b. Cement. The development of the cement industry began in 1901 and has continuted to prosper with the future looking even brighter. The use of cement in modern-day construction has placed a burden upon the suppliers. However, large quantities of limestone, Mississippian and Ordovician in age, located in or near the bluff line provide one of the main raw materials for cement. This, along with access to the Mississippi River for transportation, should balance the supply and demand theory.

c. Stone. Quarries are very active within the study area. The availablility, plus the reserve of raw material, coupled with water transportation, can supply unlimited tonnage of crushed stone for road surfacing, agricultural limestone, aggregate used in concrete and bituminous roads, revetments, and related river works. Most quarries are the permanent type yet some contractors utilize portable crushers, theus using local raw materials with each job. Dimension stone, including marble, accounts only for a small percentage of the total tonnage but has a higher unit price and is used for interior and exterior architectural building, rough construction, flagging, and rubble.

d. Clay. The availability of clay is small, yet is important in the total economic development. Some of the finished products include drain tile building block, various types of brick, and sewer pipe.

e. Silica Sand. Of the total silica sand produced in the United States, 33 percent is used by the glass industry. Other uses are abrasives, flux in metallurgy, refractory material, and in the manufacture of ceramic ware. Sources for this type sand, include sandstone, quartzite, and sand, all of course being of a good quality. The Missouri Geological Survey indicates that the future of silica sand and its products looks very promising.

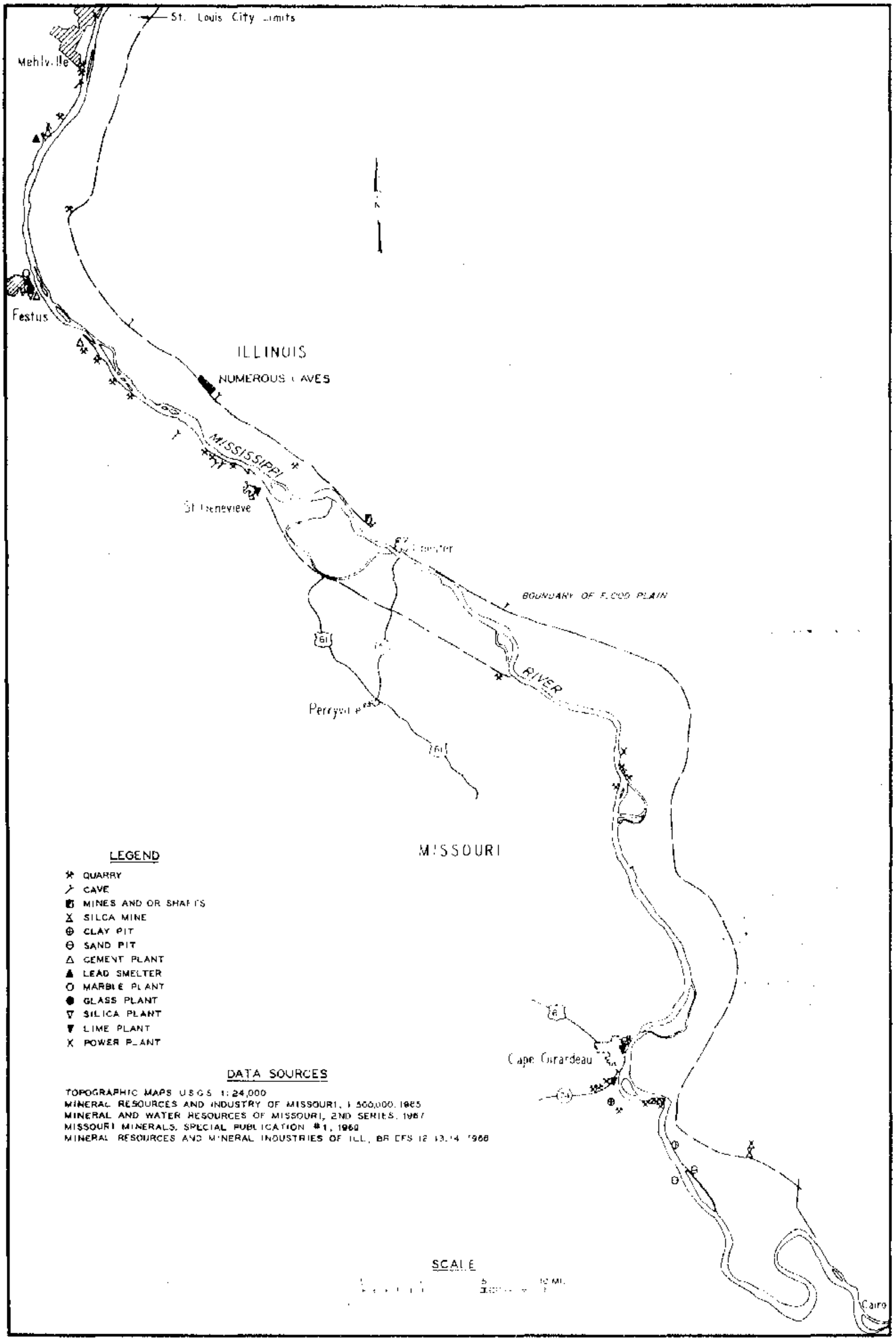


Plate 2-4. Economic geology of the Middle Mississippi River Valley

f. Lead. A smelter is located in Herculaneaum, Missouri, with the raw material being shipped in from outside the study area.

g. Sand and Gravel. Enormous quantities of sand and gravel occur at many places along the Mississippi River, the gravel principally near the deeper channels of the river and the sand in bars both in and along the river. Although used principally as aggregate, these Mississippi River deposits contain an unusually high concentration of feldspar and thus constitute a potential source for this mineral resource. Sand and gravel is also commercially mined from on-land deposits in the uplands.

h. Others. Within the States of Illinois and Missouri are other economic minerals and metals, but their occurrence lies outside the study area. Some of these are barite, coal, copper, iron ore, silver, zinc, oil, and gas.

2.1.2.8. Caves

A total of 54 caves are known to be located within the 13 Missouri and Illinois counties bordering the project area. Of these, 13 are located in or near the bluffs overlooking the Mississippi flood plain. They are: Rice Cave, Cliff Cave, and 3 unnamed caves in Missouri, and Filled Cave, Mine Cave, Statz Cave, Fish Cave, Kock's Cave, Falling Spring Cave, and Saltpeter Cave in Illinois.

2.1.3. SOILS

2.1.3.1. General

Surficial soils within the study area are entirely of recent alluvial origin, geologically classified as flood plain deposits. As typified by soils of similar genesis, these surface soils are of a highly hetrogeneous nature in both vertical and lateral extents. Properties such as soil texture, color, plasticity and other physical characteristics may be expected to vary widely over relatively short distances. Textural classifications range from sands to highly plastic clays and some organic deposits, depending on the detailed depositional history at the particular location. Soils having a preponderance of sand sizes are found at depth and, in general, gradations become coarser with depth.

Flood plain deposits within the study area may be of four land form or morphological types: 1) point-bar (meander-bar) deposits; 2) abandoned channel fillings; 3) natural levee deposits; or 4) backswamp deposits (U.S. Army Engineer District, St. Louis, 1972). Each type deposit has its own characteristic topographic expression and associated soil type.

Point-bar (meander bar) deposits (Thornbury, 1969) mark former or present courses of the principal channel. Well-defined point-bar deposits exhibit a low ridge and swale topography and soil types vary from sand to silt. Poorly defined point-bars exhibit similar depositional heterogeneity but have no discernible topography expression.

Cannel fillings (Thornbury, 1969) are deposits made in abandoned stream channels. Cut-off channels are formed when the stream abandons a portion of its circuitous channel for a more direct route. Abandoned channels may generally be recognized as topographic lows with definite directional characteristics. Soils found in an abandoned channel are typically clays of moderate to high plasticity; organic content may also be high. The thickness of the clay depends on the size of the abandoned channel and the degree to which that channel has been filled in. Thicknesses of up to 20 feet may be expected to occur in this area of the Mississippi River.

Natural levee deposits (Thornbury, 1969) are formed during times of flood when water spills out over the banks, losing velocity and depositing silt and sand. Natural levees are low ridges that parallel a river course, either present or former. They are highest near the river course and slope gradually away from it.

Backswamp deposits (Thornbury, 1969) are those that were laid down in the flood plain landward of natural levees. They consist of interlayered deposits of silt and clay. Areas of backswamp deposits are usually marked by very flat relief and by drainage networks that reflect the position of older drainage lines.

2.1.3.2. Surficial Soils - Soil Features Affecting Use

No comprehensive system of soil classification for the lands bordering the Mississippi River between St. Louis, Missouri, and Cairo, Illinois, exists. Much of the work done in this area was accomplished many years ago before the development of more comprehensive nation-wide classification system and invariably reflects both a local and agricultural bias. Consequently, some of the information is general and some is more detailed, depending upon when the area was mapped and classified. Available information has been compiled and discussed, by counties, in a report entitled, "Inventory of Physical and Cultural Elements- Middle Mississippi River Floodplain (River Reach - St. Louis, Missouri, to Cairo, Illinois)." This inventory was made by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, under the sponsorship of the U.S. Army Engineer District, St. Louis.

2.1.3.3. Riverbed Soils

Numerous borings have been taken by the St. Louis District both overwater and adjacent to the Mississippi River in connection with design of various Civil Works projects. For the Locks and Dam No. 26 (Replacement) project near Alton, Illinois, approximately 200 overwater borings were taken between 1967 and 1973. For the Alton to Gale Levee project, paralleling most of the Middle Mississippi River, several thousand borings were drilled in the early to mid 1950's. With certain exceptions, the river generally flows in a sand-filled bedrock through averaging about 70 feet deep as measured below the river bottom.

Sand samples from the Locks and Dam No. 26 (Replacement) project were analyzed in detail by the Corps of Engineers and the Illinois State Geological Survey. Based on grain size, shape, mineralogy, carbonate content, etc., three major depositional origins were established: Recent Alluvium, Wisconsinan outwash at 20 to 50 feet; and the Illinoian Ice Contact material below 40 feet. Typical gradation curves for bag samples of these materials are shown in figure 2-2b. In general, split spoon samples showed finer, more uniform gradation curves due to the sampler not picking up gravel size particles. River bottom materials at commonly dredged depths are generally Recent Alluvium and possibly some Wisconsinan outwash. The material may be characterized as fine to medium sand with occasional gravel.

No comprehensive mathematical analysis has been made of the thousands of grain size analyses made for the Alton to Gale project, but several trends are apparent upon detailed examination of the logs: (1) Material near the river bottom elevation are typically fine or fine to medium sand; (2) At a given location, the sands tend to become coarser with depth; (3) Going downstream from Alton to Cape Girardeau, sand sizes tend to become finer. This last phenomenon is likely related to glacial melting as smaller particles were transported longer distances.

Dredged sand from the Mississippi River is sold by a number of commercial sand plants, and has been used for a number of major construction projects. The Wood River levee near Alton, Illinois, was constructed of dredged sand, and Turnbull and Mansur (1973) discuss the dredged sand fill at the Rush Island power plant south of Festus, Missouri. Typical gradation curves for these two projects are shown in figure 2-2c. It will be noted that these curves generally agree with the curves for river bottom materials in the preceding figure.

Turnbull, W.S., and C.J. Mansur, "Compaction of Hydraulically Placed Fills." Soil Mechanics and Foundations Division, ASCE, vol. 99, No. SM11, Nov. 1973.

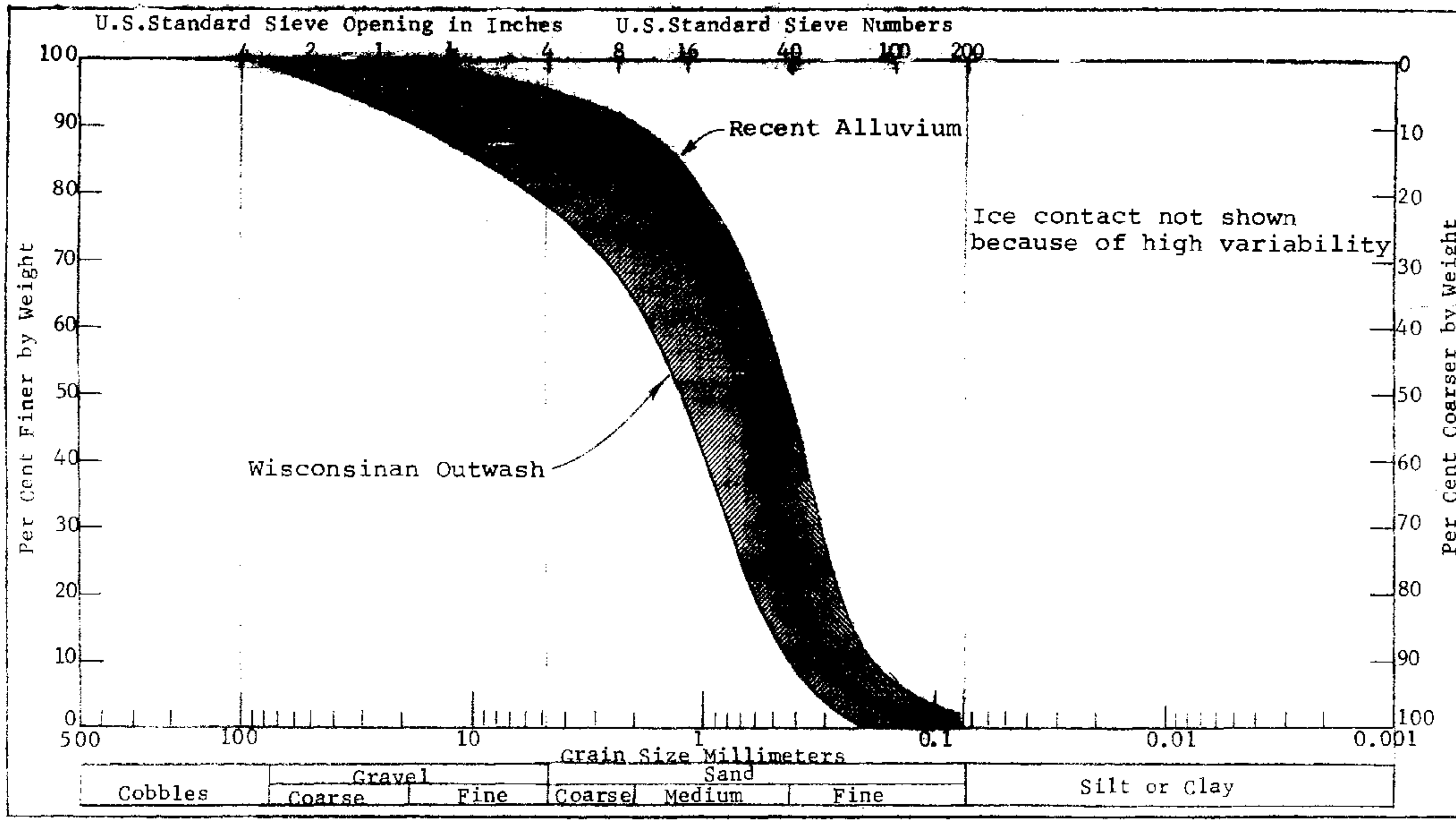
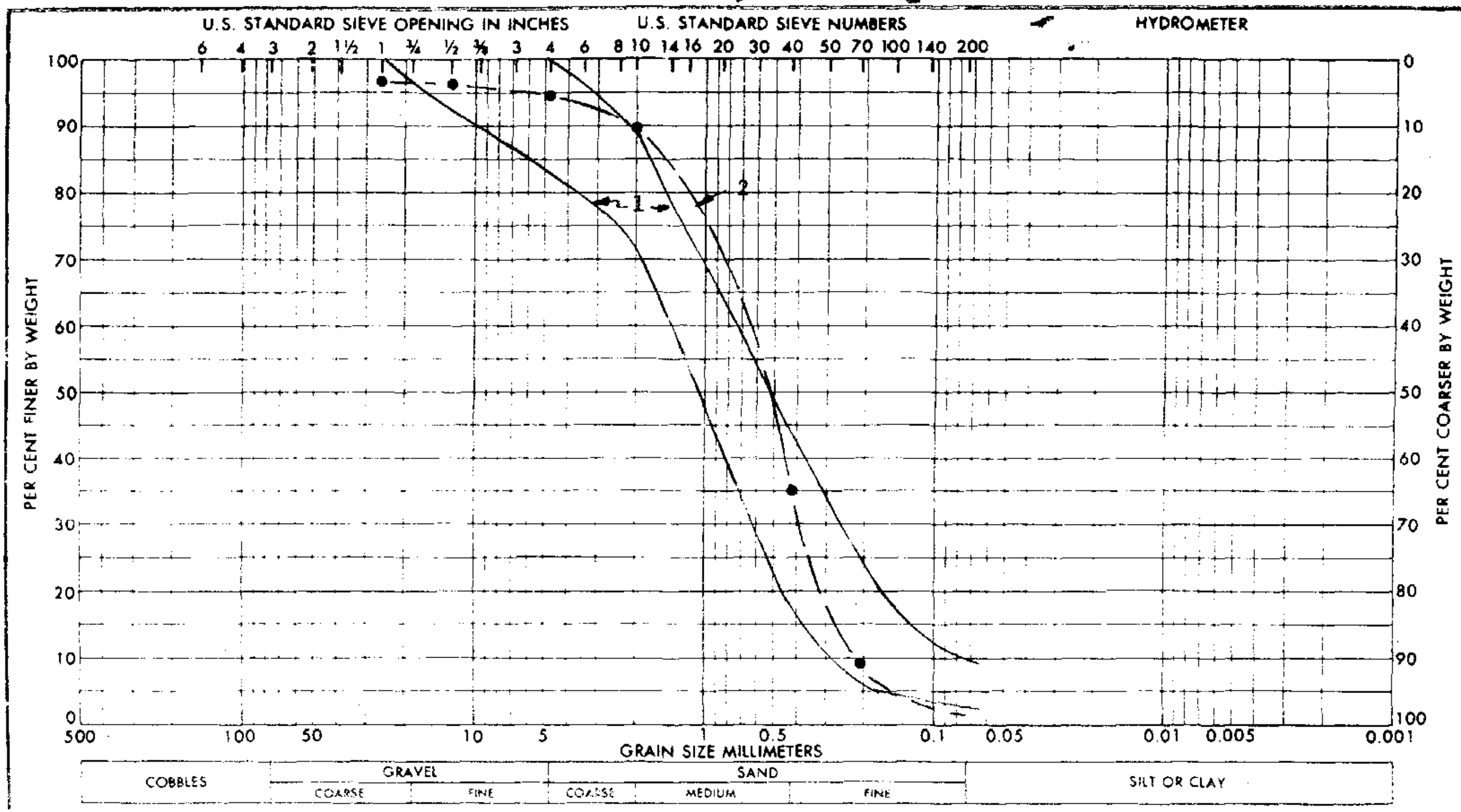


Figure 2 - 1b Typical gradation curves for river bottom soils, Locks and Dam No. 26 (Repl.) Alton,Ill.



1. Range of dredged sand fill - Wood River Levee, Alton Ill.
2. Typical gradation of dredged sand - Rush Island Power Plant (from Turnbull and Mansur)

Figure 2 - 1c Typical gradation curves for dredged fill materials

2.1.4 WATER QUALITY

Measurement of the quality of both water and sediments, as well as analysis of aquatic biota, were obtained throughout the Middle Mississippi River reaches by the U.S. Army Engineer Waterways Experiment Station personnel during the periods 19 June - 1 July 1972, 21 August - 11 September 1972, 10-18 July 1973, and 10-16 September 1973. During the first three sampling periods, data were gathered for comparison of side channels with river border areas (Emge, et al., 1974). During the fourth period, information for comparison of dredged sites was collected (Solomon, et al., 1974). These data were used as baseline information to describe the water quality of the Middle Mississippi River. These data were compared with data previously collected by the U.S. Geological Survey (1972). Data also were used from a comparison of side channels with main channel border areas by the Missouri Department of Conservation (Ragland, 1974). The data from the various studies are summarized in Appendix G_1 through Appendix P.

In large rivers such as the Mississippi River, the volume of water, the velocity of flow, and the generally shifting nature of bottom sediments often combine to yield instantaneous variations in water quality parameters and make the acquisition of meaningful samples extremely difficult. The data collected both by Emge, et al., (1974), and Ragland (1974) likely reflected the extremely high river stages that occurred during some of the sampling periods. An evaluation and comparison could be made of the general conditions within the different environments of the study area at a single point in time. However, considerably more data collected over a much longer period of time would be necessary for an in-depth evaluation of meaningful temporal and spatial changes in the water quality of the Middle Mississippi River.

2.1.4.1. Temperature. Characteristically, the temperatures of large rivers like the Mississippi vary much more rapidly than those of lakes, and quite often this variation is over a much smaller range, (Hynes, 1972). To understand the temperature regime of a certain habitat, one must consider the factors peculiar to that habitat that influence temperature. In other words, the temperature of a body of water like a river or lake is a reflection of the actions and interactions of a wide variety of factors. Variations in velocity, volume, depth, substrate, cover, water source as well as seasonal and local meteorological conditions are some of the factors which govern and define the temperature of any particular water body.

Based on data collected from river border areas during July 1973 (Emge, et al., 1974), there was no evidence of thermal stratification of the water column. In contrast to lentic environments, rivers like the

Middle Mississippi usually show little thermal stratification because of their turbulent flow (Hynes, 1972). Conversely, in side channels which characteristically are isolated from the river proper during certain times of the year, warming of the surface waters will eventually lead to stratification of the water column. Comparison of mean surface and bottom temperatures for June and September 1972 and July 1973 indicate that most of the side channels sampled in the Middle Mississippi River do exhibit thermal stratification. High river stages, which connect side channels with the river proper, thus allowing water to flow through them, usually destroy any stratification.

The major factor causing the warming of rivers and associated habitats like side channels is direct solar radiation. Seasonal warming and cooling of surface waters in side channels is demonstrated by the data presented in Appendix G_1, Table 2. Mean surface temperature recorded in June was 26.2°C, in July 29.9°C, and in September 27.7°C. Although these data were not collected during consecutive seasons, the warming and cooling effects, dependent upon increasing and decreasing ambient air temperature, are shown.

Temperature comparisons between river border areas and side channels by Johnson, et al.,(1974), are of limited value because few observations were made in river border areas. However, Ragland's (1974) data does demonstrate that water temperature is higher in side channels than in river border areas, except during the winter and spring seasons when high river stages generally occur and result in mixing. Also, at no time during the annual cycle does thermal stratification develop in river border areas.

2.1.4.2. Dissolved Oxygen. Because of the large surface area exposed to the air and the constant motion of the river, the oxygen content of rivers is normally near, or above, saturation and adequate for the aquatic biota. For this reason, aquatic organisms of rivers generally have a narrow tolerance and are especially sensitive to reduced oxygen levels.

The Illinois Pollution Control Board and the Missouri Clean Water Commission have set the minimum concentration of dissolved oxygen for streams in Illinois and Missouri at 5.0 mg/l (Illinois E.P.A., 1972; Missouri Clean Water Commission, 1973). This concentration is generally accepted as the lower limit for maintaining a desirable warm water fish fauna in rivers such as the Mississippi. It is recognized that this standard is periodically exceeded during rising river stages or flooding. For example, from October 1971 to September 1972, the monthly average dissolved oxygen concentration at East St. Louis, Illinois, ranged from 0.06 - 11.1 mg/l with a mean of 7.0 mg/l (U.S. Geological Survey, 1972). The range at Cape Girardeau, Missouri, was from 4.8 - 13.3 mg/l with an average of 8.1 mg/l.

Dissolved oxygen data collected from side channels and river border areas in the Middle Mississippi River (Emge, et al., 1974) are summarized in Appendix G_1, Tables 1 and 2. Based on the overall means, higher dissolved oxygen concentrations were observed among side channels (surface = 7.3 mg/l, bottom = 5.2 mg/l) than among river border areas (surface = 4.6 mg/l, bottom 4.7 mg/l), although fewer samples were collected from river border areas.

Ragland (1974), who collected oxygen data from side channels and river border areas for one year, observed slightly higher concentrations in surface waters of side channels than in river border areas. Side channels with reduced or no flow provide a more hospitable environment for the primary producers which are an important source of oxygen.

The annual cycle of oxygen in rivers is closely correlated with temperature conditions. Studies of large rivers in warm southern regions have shown that the oxygen content of flowing waters is generally highest in the winter and lowest in late summer (Reid, 1961). Emge's et al. (1974) data collected from side channels similarly show that mean surface oxygen concentrations decreased during the summer (from June to July) and increased during the fall (September). (Appendix G_1, Table 2). Ragland (1974) also observed highest concentrations in the winter but reported that lowest concentrations occurred in the fall. Generally, both studies demonstrated that surface oxygen concentrations were higher than bottom concentrations in side channels. Oxygen stratification of the water column was not observed for river border areas.

In a September 1973 study by Solomon, et al. (1974), surface dissolved oxygen concentration varied from 4.6 - 8.4 mg/l in dredged sites (main channel) and from 4.6 - 7.9 at the disposal areas. Mean surface dissolved oxygen concentration for these sites were similar, 6.5 and 6.6 mg/l, respectively. The oxygen saturation values for both dredged sites and disposal sites ranged from a minimum of 55 percent to a maximum of 100 percent and averaged 79 percent.

In large rivers like the Mississippi, very often the overriding factor that influences dissolved oxygen concentration is discharge (Dorris, et al., 1963). The influence of river discharges on dissolved oxygen concentration is clearly evident in the study by Solomon, et al. (1974). Increasing river stage was accompanied by a corresponding decrease in dissolved oxygen, probably brought about by the oxygen demand of washed-in organic matter. Conversely, decreased river stages with lower flow was accompanied by increased dissolved oxygen concentrations.

2.1.4.3. Turbidity. One of the most noticeable characteristics of the Middle Mississippi River is its generally turbid nature. The soil particles which comprise most of this turbidity affect the biotic communities of rivers by decreasing light penetration which limits photosynthetic activity of aquatic plants, altering temperature patterns, interfering with the gills of fish, causing abrasion of benthic organisms in the more turbulent areas of the river, and smothering of benthic organisms and fish spawning beds in areas of high sedimentation.

In Ragland's (1974) study during 1972 and 1973, turbidity (measured by the platinum wire method) ranged from 75.0 to 800.0 mg/l with an average of 304.0 mg/l in the side channels. In the river border areas it ranged from 140.0 to 700.0 mg/l with a mean of 340.0 mg/l.

Turbidity measurements were made in side channels and river border areas during a study by Emge, et al. (1974). Among river border areas, mean turbidity values (measured in Jackson Turbidity Units) of surface and bottom strata were 312 and 394, JTU's, respectively. Side channels were less turbid with mean surface and bottom values of 128 and 164 JTU's, respectively. Both Ragland and Emge generally found turbidity to be less in side channels than in river border areas. Continuous flow and turbulence associated with river border areas is not a characteristic feature of side channels except during flooding.

In September 1973, surface turbidity varied from 80 to 180 JTU's and averaged 132.5 JTU's in the main channel and river border areas (Solomon, et al., 1974). The variation of bottom measurements was greater, ranging from 72.0 to 240.0 JTU's; the mean was 183.3 JTU's. In general, bottom turbidity measurements were slightly greater than that at the surface. Increased turbulence nearer the bottom of the channel bed most likely accounted for the higher bottom values. The variation of turbidity along the length of the river appears to be influenced by changing river stages, although the relationship is not strong. Average monthly turbidity values recorded by the U.S. Geological Survey (1972) varied from 54.0 to 290.0 JTU's at East St. Louis, Illinois and from 80.0 to 325.0 JTU's at Cape Girardeau, Missouri, for the period October 1971 to September 1972.

2.1.4.4. Settleable Solids. The measurement of settleable solids gives an indication of the amount of material that will settle out of the water column with reduced velocity. Such a measure is important in assessing the carrying capacity of flowing water and its relationship to the deposition of material. High concentrations of settleable solids is an important biological consideration since excessive concentrations may interfere with filter-feeding organisms such as certain pelecypodes and aquatic dipterans. Additionally, settleable solids contribute to the turbidity of water and may interfere with light penetration and subsequently could affect photosynthetic activity of the primary producers.

Settleable solids were determined volumetrically from water samples taken just below the surface from both dredged and disposal sites in a study by Solomon, et. al. (1974). Mean settleable solids were higher in the dredged sites (0.42 ml/l) than in the disposal sites is due to increased velocities and turbulence associated with these areas. It was determined that the relationship between settleable solids and river stage was stronger than the relationship between turbidity and river stage. A direct correlation was found between river stage measurements and concentrations of settleable solids. Generally, when the river stage increased, the concentration of settleable solids showed a similar increase, and vice versa. This is a fairly general phenomenon and has been observed elsewhere (Dorris, et. al., 1963).

2.1.4.5. Total Alkalinity. Total alkalinity is a measure of the buffering capacity of the water which may affect the toxicity of various compounds in the water. Measurements of total alkalinity were made in side channels and river border areas during June and September 1972 and in July 1973. (Emge, et. al., 1974). Overall mean surface and bottom alkalinity measurements were higher in side channels (175.8 and 189.3 mg/l) than in river border areas (156.2 and 158.5 mg/l). During every sampling period, bottom alkalinities were higher than surface alkalinities. Ragland (1974) observed lower total alkalinity values in the side channels and river boder areas than were recorded by Emge, et al., (1974). The overall mean for side channels was 84 mg/l; and 71 mg/l for river border areas. Alkalinity recorded by the U.S. Geological Survey varied from 144.0-192.0 mg/l at East St. Louis, Illinois, and from 138.0-185.0 mg/l at Cape Girardeau, Missouri.

Solomon, et al. (1974) reported slightly higher values in a study conducted in September 1973. Mean surface and bottom alkalinity at river border areas were 184.8 and 187.6 mg/l, respectively. In the main channel, mean surface and bottom alkalinities were slightly higher (194.4 and 194.0 mg/l, respectively). The influence of changing river stages on total alkalinity measurements was evident. In every case, increased river stages were accompanied by increased alkalinity values. Presumably, the range of total alkalinity served to buffer or prevent sudden changes in pH values which, as the data indicate, were fairly constant at all locations during the study period.

2.1.4.6. Nutrients (Water and Sediments). The chemical characteristics of waters relate closely to the soil characteristics of the drainage basins and the soils themselves reflect geological, climatological, and topographical conditions. The wastes entering waters from agricultural areas are highly dependent upon local circumstances such as irrigation and fertilization practices, crop types, and animal populations. Soil and water conservation work on the watershed also influences the quantity and quality of run-off water.

Nutrients originating from man's activities and those transported into a river ecosystem from all sources become part of the "nutrient pools." They may be classified as available or unavailable relative to their chemical state and the requirements of the organisms. As specific nutrients or pollutants are added to the system, those organisms directly or indirectly stimulated will increase in number, whereas other species unable to compete or adapt may disappear completely. In cases where the materials are toxic, all biological life may be suppressed. Pollutants stress the system, disrupting the normal flow of energy and materials, and generally produce less desirable systems (Oglesby, et al., 1972).

For the Middle Mississippi River, few studies have described nutrient concentrations in water and sediment. Solomon, et al. (1974), sampled five main channel stations for nutrient analysis of water samples and four stations for sediment analysis. Nitrate ranged from 0.1 to 2.9 mg/l and averaged 1.3 mg/l. Insignificant concentrations of nitrite and ammonia nitrogen were reported. Total phosphorus ranged from 0.1 to 3.5 mg/l and averaged 1.2 mg/l. Oglesby, et al. (1972), cited ranges of reported values for phosphorus in rivers of the United States of 0.002 to 5.040 mg/l.

Reported nitrate and nitrite concentrations in sediments samples were below 1.0 mg/kg (Solomon, et al., 1974). Total phosphorus in sediments from the main channel ranged from 2.0 to 8.0 mg/kg and averaged 4.7 mg/kg.

The U.S. Geological Survey (1972) found that the average monthly nitrogen concentrations were highly variable over the period from October 1971 to September 1972. At river mile 192.1 near East St. Louis, Illinois, organic nitrogen ranged from 0.25 - 1.70 mg/l, with a mean of 0.68 mg/l; ammonia nitrogen ranged from 0.00 - 0.92 mg/l, with a mean of 0.19 mg/l; and nitrates ranged from 0.50 - 5.00 mg/l, with an average of 3.02 mg/l. Monthly averages for total phosphorus was from 0.15 - 0.76 mg/l and averaged 0.34, while dissolved phosphorus was from 0.10 - 0.30 mg/l and averaged 0.17.1 mg/l. At river mile 54.3, monthly average organic nitrogen concentrations ranged from 0.02 - 1.50 mg/l, with an average of 0.77 mg/l; ammonia nitrogen from 0.00 - 0.47 mg/l, with a mean of 0.09; and nitrates from 0.14 - 3.20 mg/l, averaging 1.37 mg/l. Total phosphorus at this location varied from 0.11 - 0.82 mg/l, with an average of 0.36 mg/l; and dissolved phosphates from 0.00 - 0.25 mg/l, averaging 0.12 mg/l.

Total Kieldahl nitrogen, recorded from sediment samples by Emge, et al., (1974), was found to exceed EPA criteria (Lee and Plumb, 1974), (Appendix M) in 6 side channels during the August and September 1972 period and 4 side channels during July 1973.

Turbidity analyses indicated that light is the factor limiting algal and other aquatic plant activity in the Mid-Mississippi River and as such these elevated plant nutrient concentrations are not of apparent consequence in this area of the river.

2.1.4.7. Metals (Water and Sediments). Metal analyses were performed on water and sediment samples taken from river border areas and side channels during period of 21 August - 11 September 1972 and 10-28 July 1973 (Emge, et al., 1974), and from dredge sites in the main channel and disposal sites along main channel border areas during September 1973. (Solomon, et al., 1974). Results are shown in Appendix H, Appendix I, Appendix L, and Appendix M.

Zinc exceeded the U.S. Environmental Protection Agency criteria (Lee and Plumb, 1974) (Appendix M)in the sediments of 6 side channels during the first sample period. Mercury and zinc exceeded the criteria for sediment in 5 side channels during the second sampling period. The criteria for mercury was also exceeded at 4 dredge sites during the third sampling period.

The Illinois Criteria for water quality was exceeded by mercury in 2 side channels during the first sampling period, 5 side channels during the second, and 5 dredge sites during the third. Total iron also exceeded the criteria at 4 dredge sites during the third sampling period.

2.1.4.8. Pesticides. There were no detectable concentrations of organo-chloride pesticides in any of the bottom sediments.

2.1.4.9. Chemical oxygen demand. Chemical oxygen demand (COD) is a measure of the organic content of water and bottom sediments. In side channels, COD values of the water varied from 12.2 - 17.8 mg/l, and had an average of 15.6 mg/l; whereas in the main channel COD values ranged from 6.9 - 8.7 mg/l, and averaged 7.7 mg/l. COD was also found to be higher in the sediments of the side channels, as would be expected from greater deposition of organic material in these areas. In side channels, COD ranged from 17,417 - 41,312 mg/kg, and averaged 29,969 mg/kg; as compared to a range of from 983 - 3,280 mg/kg in the main channel, with an average of 1,892 mg/kg. COD was found to exceed EPA criteria (Lee and Plumb, 1974), in sediments from 3 side channels during the August and September 1972 sampling period.

2.1.5 CLIMATOLOGICAL ELEMENTS

2.1.5.1. Introduction

The movement of large masses of air into the Lower Mississippi River Region is an important climate control. Dry, cold air covers the area at times, but a large percentage of total precipitation occurs when warm, moist air from the Gulf of Mexico dominates. The alternate invasion of the region by air masses from these sources and the conflict along the frontal zones when they come together produce a variety of weather conditions, none of which are likely to persist to the point of monotony. The climate of the region is continental, but extremes vary from north to south. Missouri and southern Illinois have warm temperate, rainy climates with hot summers and comparatively mild winters.

2.1.5.2. Precipitation

a. Historical Record. Average monthly precipitation based on records from 1900-1972 is given in Table 2-1 for St. Louis, Chester, and Cairo. Normal annual precipitation for the region, based on the average for the period is a little over 35 inches. At St. Louis, a maximum of 68.83 was recorded in 1858, while a minimum of 20.59 inches occurred in 1953.

b. Snowfall. Mean average snowfall, based on 1931-1951 data, runs from about 14 in/yr at St. Louis to 8 in/yr at Cairo, varying linearly for points in between. This amounts to about 5 percent of the total precipitation at St. Louis and a decreasing proportion further south. St. Louis receives a snowfall of one inch or more between 5 to 10 days in most winters.

c. Runoff, Infiltration, and Evaporation. The average annual runoff ranges from about 10 inches at St. Louis to slightly more than 15 inches at Cairo. This results in annual flow at St. Louis on the Mississippi River as follows (Table 2-2):

Table 2-2. Annual Runoff - St. Louis, Missouri

	Annual Runoff (10^6 acre-feet)
Minimum	49.01
Average	126.42
Maximum	248.78

(Note: Maximum and minimum values are based on any 12 continuous months, not limited to calendar, water, or climatic years.)

Source: 1861-1965 recorded data.

Infiltration rates are particularly important for storm rainfall runoff and snowmelt-runoff studies. Infiltration rates are important for flood planning purposes and are usually conservative. They range from 0.03 in/hr to 0.15 in/hr within the entire Upper Mississippi River Basin, but are only about 0.03 in/hr within that part of the basin between St. Louis and Cairo. (Rates are those at which saturated soil can absorb and transmit additional moisture to lower strata).

Evaporation may become important in sizing storage reservoirs, particularly when reservoirs have large surface areas coupled with limited storage capacity. Annual lake evaporation for the St. Louis to Cairo area is about 36 in/yr. North of St. Louis, values decrease to 24 in/yr.

2.1.5.3. Temperature

a. Historical Record. The average annual temperature for the region ranges from 55 degrees Fahrenheit at St. Louis to 58 degrees Fahrenheit at Cairo. Table 2-3 gives additional temperature tabulations.

Table 2-3. Temperature Parameters, Lower Mississippi River

Temperature Descriptions	St. Louis	Cairo
Average annual temperature	55	58
Mean annual number of days within maximum temperature 90 degrees Fahrenheit and above	45	60
Mean annual number of days with miminum temperature 32 degrees Fahrenheit and below	90	60

b. Average Monthly Temperature. Average monthly and record temperature information for St. Louis and Cairo, based on 72 years of record from 1900 to 1972 are given in Table 2-1. While no reliable temperature information is available for intermediate points, interpolation may be used since temperature changes at a fairly constant rate when moving north to south along the river valley.

2.1.5.4. Severe Weather

a. Tornadoes. Data for the St. Louis to Cairo study are are most complete for the period 1916-present. Because the St. Louis to Cairo study area lies within the so-called "tornado belt," the tornado threat is ever-present. There is a high incidence of tornadoes during the spring season. The tabulation below of all observed tornadoes for a 35-year period (1916-1950) reported within the counties bordering the Mississippi River, St. Louis to Cairo, illustrates this trend.

Table 2-4. Tornado occurrence and frequency

Month	Number of Occurrences
January	3
February	0
March	17
April	2
May	8
June	1
July	1
August	2
September	2
October	0
November	0
December	1

$\frac{37}{35}$ = 1.06 tornadoes per year

Approximately 60 percent of the tornadoes in the Mid-West move from the southwest to the northeast, with 34 percent from other westerly directions; only 6 percent occur from the north and northeast. The 3 p.m. to 7 p.m. period is the most common time of occurrence during the day. This area should therefore expect a "typical" tornado to come out of the southwest on a spring afternoon about once a year. Any given tornado may, however, come from any direction, travel any course whether straight or highly irregular, and occur at any time.

b. Other Severe Weather. Thunderstorms, accompanied by lightning and thunder, usually with strong gusts of wind, heavy rain, and occasional hail, are common to the study area. There are about 60 thunderstorm days annually, with the greatest activity in the summer and least in the winter. Thunderstorm damage is most often caused by lightning, but hail and flash floods also account for some. Hail occurs in 5 percent of the thunderstorms. Other types of severe weather in the study area are droughts and floods. Severe droughts still occur from time to time in the study area, such as in 1954 and 1964. Flooding, the other extreme, is occasionally a problem when snowmelt and certain other hydrologic factors combine, such as in 1973.

2.1.6. AIR QUALITY

Air quality in the Middle Mississippi River region is relatively good due to its predominantly rural character. Power generation plants, limestone quarries, and animal feed lots, all create significant smoke, airborne dusts, and/or odors and thus, are potential point sources of air pollution. However, the relatively sparse population, and the remoteness of these point sources, and their few numbers, join to dissipate any air pollution problem.

2.2. BIOLOGICAL ELEMENTS

2.2.1. AQUATIC COMMUNITIES

2.2.1.1. General

A comprehensive study of the physical, chemical, and biological characteristics of the Middle Mississippi River aquatic system was made by personnel of the Waterways Experiment Station (Emge, et al., 1974). The three principal types of aquatic habitat described were (1) main channel; (2) main channel border; and (3) side channels.

(1) The main channel habitat of the river includes the navigation channel which has a minimum depth of 9 feet and a minimum bottom width of 300 feet. The main channel will generally be contracted to 1,500 feet between riverward ends of dikes throughout the study area in order to maintain the 9-foot depth during periods of low flow. A current always exists in the main channel, varying in velocity with the river stages. Sand, silt over sand, and occasional patches of gravel are the main types of bed material. The navigation channel is subject to scouring action at low stages by passage of towboats and the entire main channel to aggradation and degradation during changes in river stages. No rooted aquatic vegetation is present in the main channel. Approximately 80 percent (42,500 acres) of the available aquatic habitat is represented by main channel area.

(2) The main channel border habitat is that zone between the main channel and the river bank and is usually within a dike field. Where there are no dike fields on the main channel, a narrow border still occurs, and often the banks have been covered with revetment. The bottom generally consists of silt or sand. Little or no rooted aquatic vegetation is present. Approximately 8 percent (4,300 acres) of the available aquatic habitat is represented by main channel border areas.

(3) Side channels, as defined in this study, are channels that parallel the main channel or cut across a bendway. The various forms of habitat in this category are many, ranging from swift-flowing watercourses to those that vary in current velocity with stage, depending upon the height of the internal dikes. The banks of side channels are usually not protected by revetment, sandbars are common near the head and mouth, and the bottom substrate varies from sand to silt. There is no rooted aquatic vegetation in areas of swift current, but vegetation is common in the shallower areas which have silt bottoms and slight to moderate current. Approximately 12 percent (6,300 acres) of the total available aquatic habitat is represented by side channel areas.

The nature of these aquatic habitats will be affected by efforts to obtain and maintain the 9-foot navigation channel. The objective of the study by Emge, et al., (1974) was to provide a data base of the physical, chemical, and biological characteristics of the Middle Mississippi River aquatic system. Concurrent with the Waterways Experiment Station study, personnel of the Missouri Department of Conservation attempted to evaluate and document the value of side channels and the main channel border of the Middle Mississippi River as fish habitat (Ragland, 1974). Personnel of the Waterways Experiment Station summarized the results of these two studies as well as other studies and attempted to assess the environmental impact of the 9-foot channel on the aquatic ecosystem of the Middle Mississippi River (Johnson, et al., 1974). The efforts in both studies were concentrated in side channels and main channel border areas, since these areas are considered higher quality biotic habitat and as such, are likely to be more effected by the 9-foot channel project.

2.2.1.2. Community Characteristics

a. Phytoplankton. Phytoplankton forms the base of aquatic food chains, and its role in primary production is essential to the system. Large, turbid rivers usually do not support much true phytoplankton, and what does exist is derived primarily from headwater lakes or ponds, and quiet backwaters.

Both main channel border areas and side channels are subject to fluctuating water levels, and turbidity levels are characteristically high. These conditions prevent the growth of rooted aquatic macrophytes within the river proper and most areas within the side channels. As a result, photyplankton assemblages probably account for most of the primary production that occurs.

A total of 71 genera of phytoplankton representing five taxonomic divisions were collected in the various habitats of the Middle Mississippi River by the Waterways Experiment Station and the Missouri Department of Conservation (Appendix A_1). Chrysophyta (yellow-green algae and diatoms) were found to be the dominant phytoplankton group in most of the 23 side channels and four main channel border areas (Figures 2-2a through 2-2d) (Johnson, et al., 1974). This trend has been observed for other large turbid rivers (Hynes, 1970). Turbidity is usually less in the side channels and since primary production is a function of available light energy,

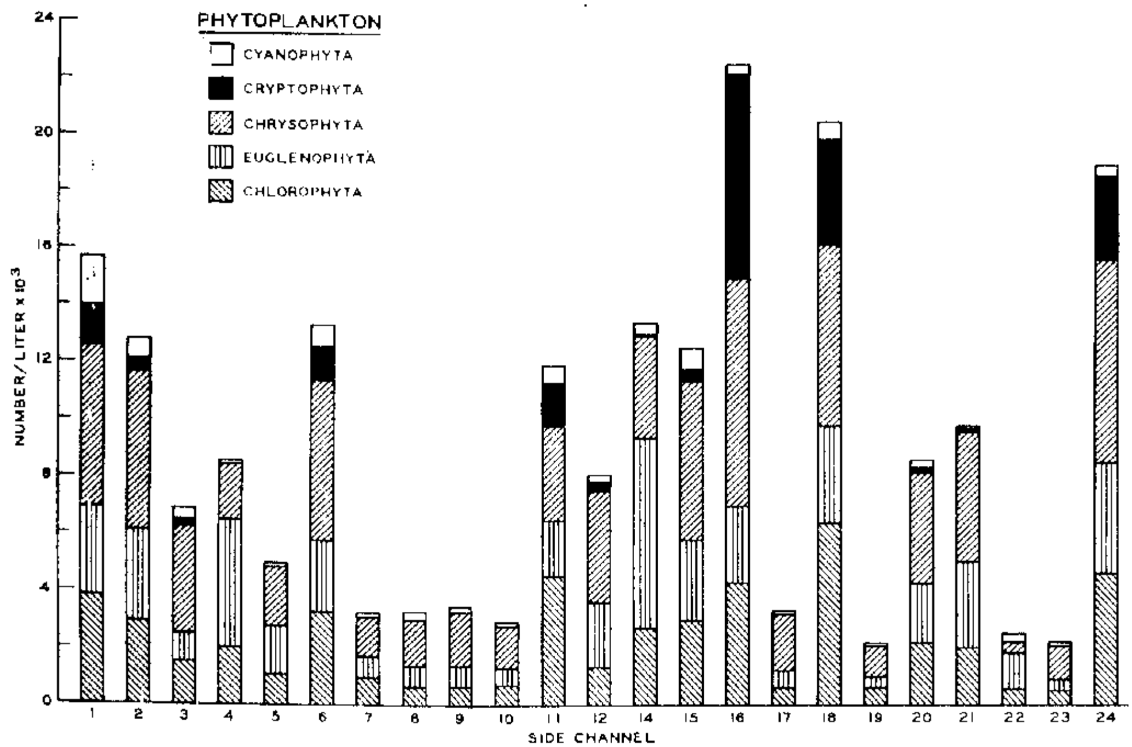


Figure 2-2a. Phytoplankton collected during sampling period I (19 June-1 July 1972), in side channel areas

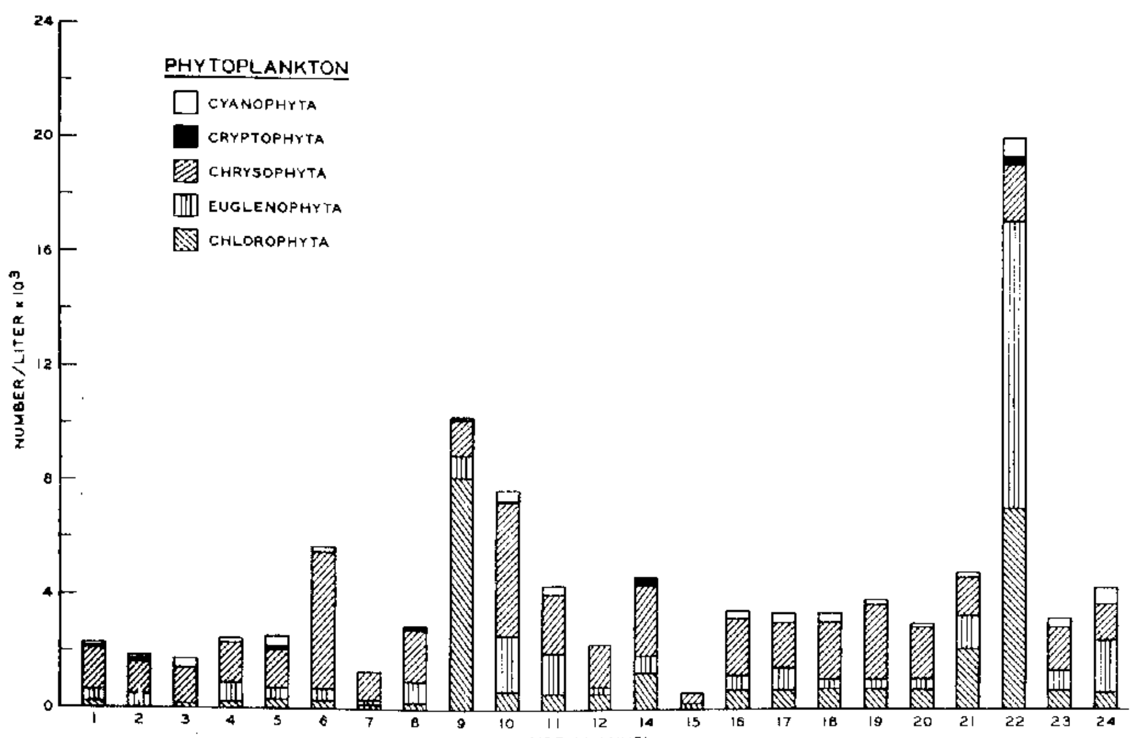


Figure 2-2b. Phytoplankton collected during sampling period II (21 August-11 September 1972), in side channel areas

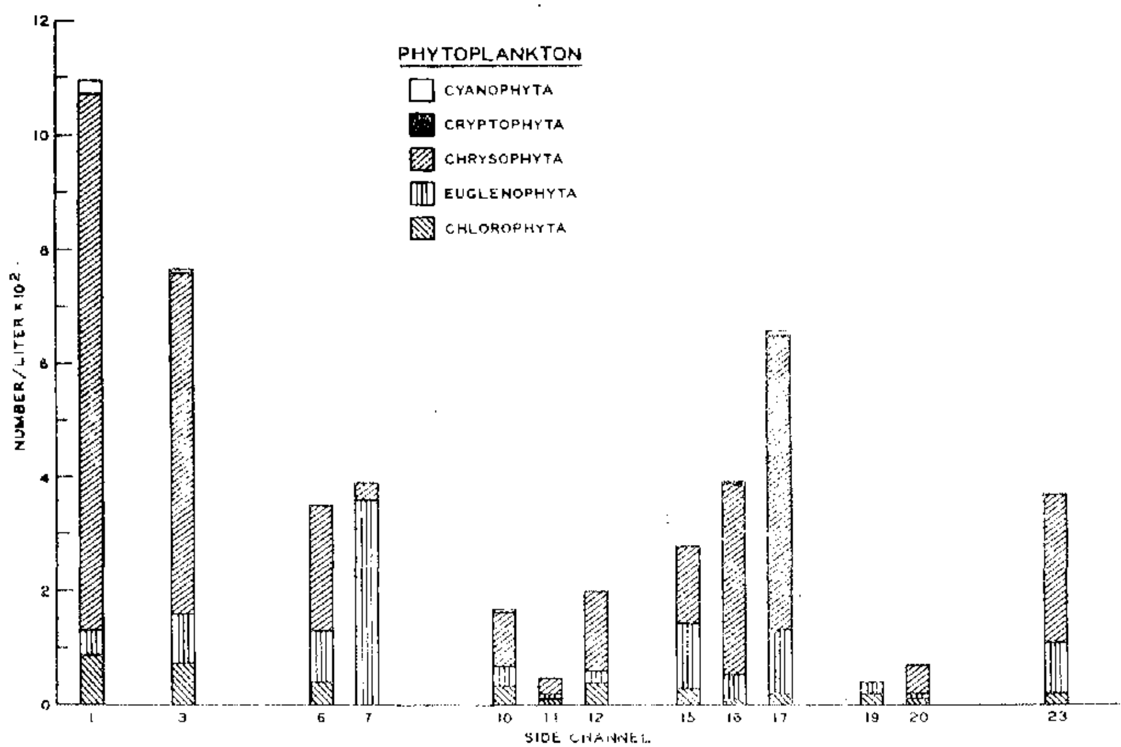


Figure 2-2c. Phytoplankton collected during sampling period III (10-28 July 1973), in side channel areas

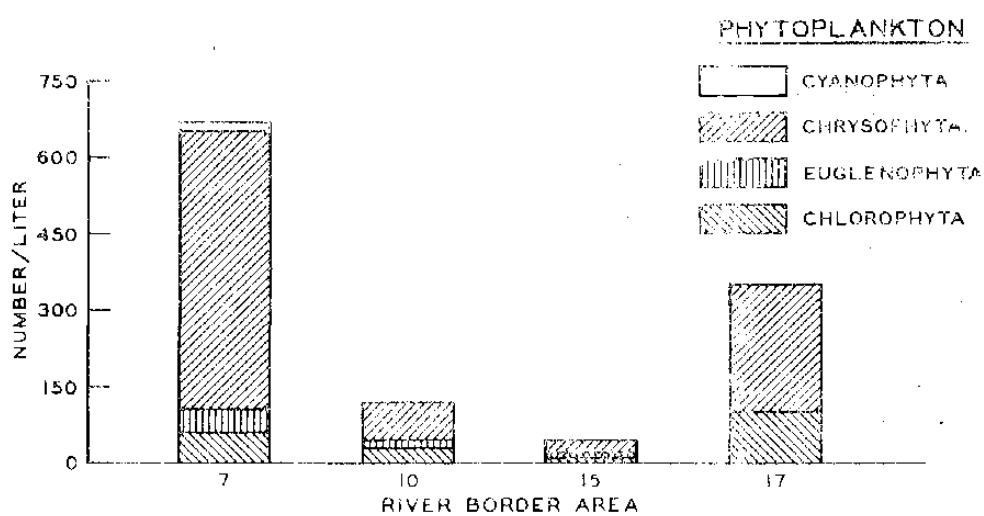


Figure 2-2d. Phytoplankton collected during sampling period III (10-28 July 1973), in river border areas

greater numbers of phytoplankton were expected in the side channels. However, no significant difference in numbers were detected by Ragland or the Waterways Experiment Station.

b. Zooplankton. Zooplankton is essential to the aquatic food web because it serves as a link between the primary producers (plants and phytoplankton) and the higher level consumers (macroinvertebrates and small fish). Twenty-six genera of zooplankton representing four phyla were collected from various habitat types in the Middle Mississippi River (Appendix B). Ragland (1974), in his study of the river, found that zooplankton occurred in greater numbers in side channels than in adjacent main channel borders. Rotifers were found to be dominant in side channels, whereas copepods were dominant in river border areas. When all side channels were considered in the study performed by the Waterways Experiment Station, rotifers were found to be the dominant zooplankton groups (Figures 2-2e through 2-2h) (Johnson, et al., 1974). This is in agreement with Hynes (1970), who noted that the typical zooplankton of large rivers is nearly always dominated by rotifers. Copepods and protozoa were next in abundance.

It is generally recognized that lentic environments provide conditions more suitable for plankton reproduction and growth than lotic environments. Plankton that originates in the pools above St. Louis very likely are swept down river into the upper portion of the Middle Mississippi River. In this reach of the river those backwater areas that most nearly approximate the lentic conditions found in pools are side channels. These areas probably contribute significantly to the plankton populations occurring in the river.

c. Benthos. A greater variety of kind and number is probably exhibited by benthic macroinvertebrates than any other group of aquatic organisms. They are an integral component of the riverine food web. Since the benthic invertebrate community remains in place and is subject to the instantaneous changes which occur in the water mass flowing over it, the type and abundance of these bottom organisms can be used to reflect conditions in a stream, and the species diversity of these communities has been considered one of the best indicators of environmental alterations.

A total of 100 taxonomic groupings of benthic organisms were collected from the Middle Mississippi River by the Waterways Experiment Station and the Missouri Department of Conservation (Appendix C). Aquatic insects contributed 96 percent of the total benthos in the study by Ragland (1974), with oligochaetes representing only 3 percent. The Waterways Experiment Station study showed that oligochaetes comprised a much larger percent of the total benthos (Figures 2-2i through 2-2k) (Johnson, et al., 1974). Ragland found that total benthos were more abundant in the main channel border than in the side channels. The study by Waterways Experiment Station found the opposite to be true.

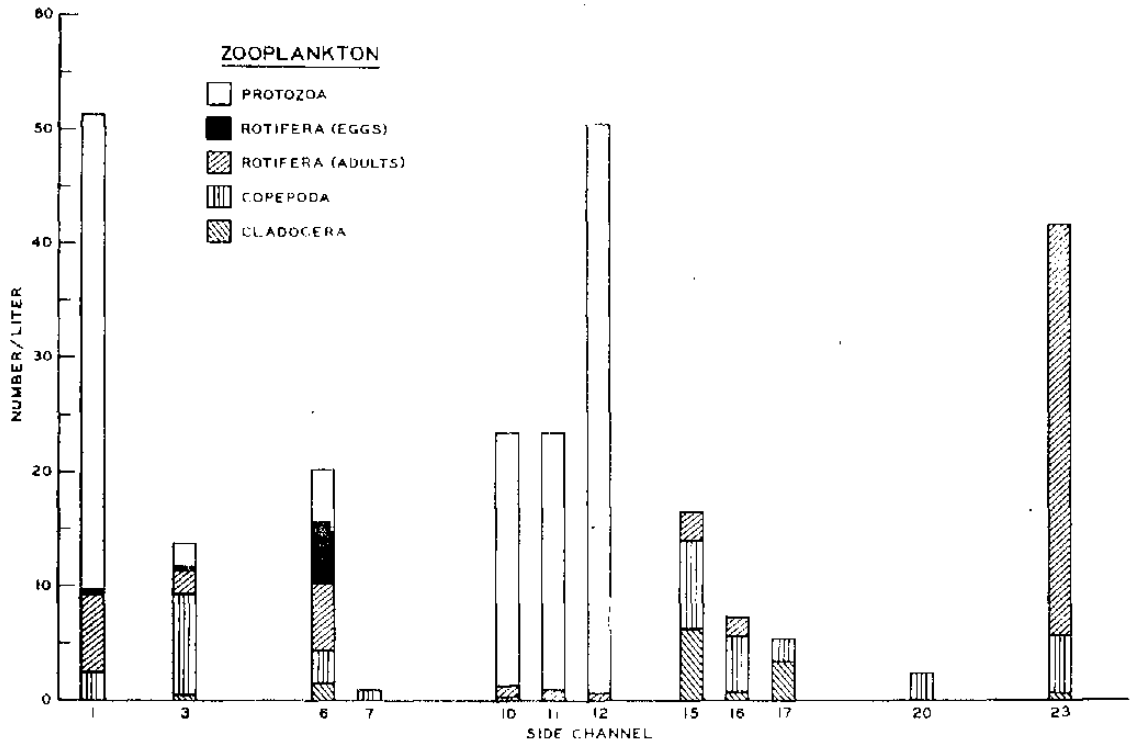


Figure 2-2g Zooplankton collected during sampling period III (10-28 July 1973), in side channel areas

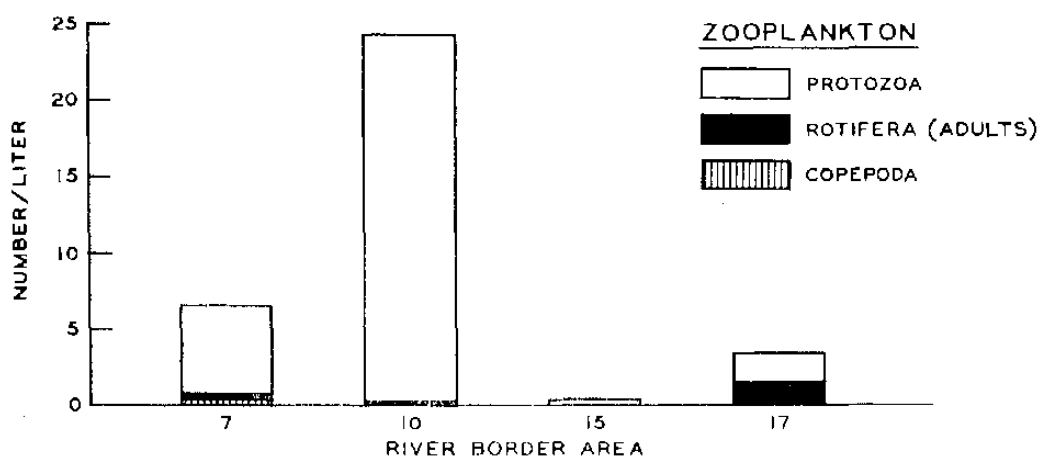


Figure 2-2h Zooplankton collected during sampling period III (10-28 July 1973), in river border areas

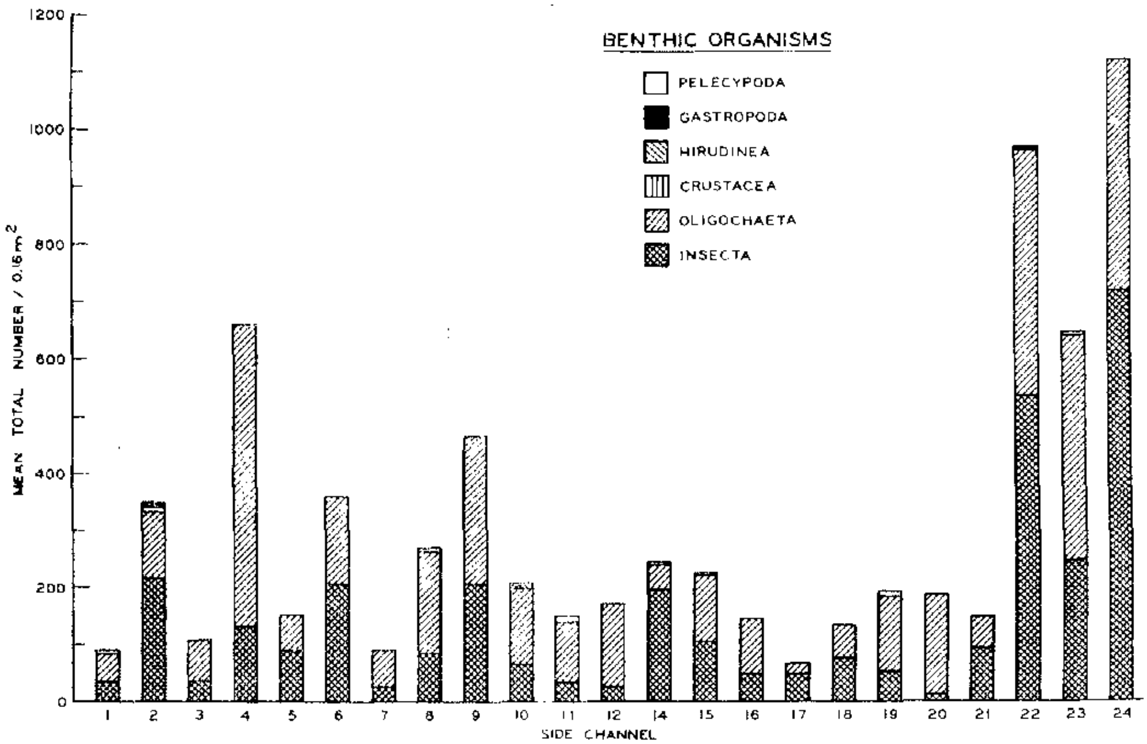


Figure 2-2i. Benthic invertebrates collected during sampling period II (21 August-11 September 1972), in side channel areas

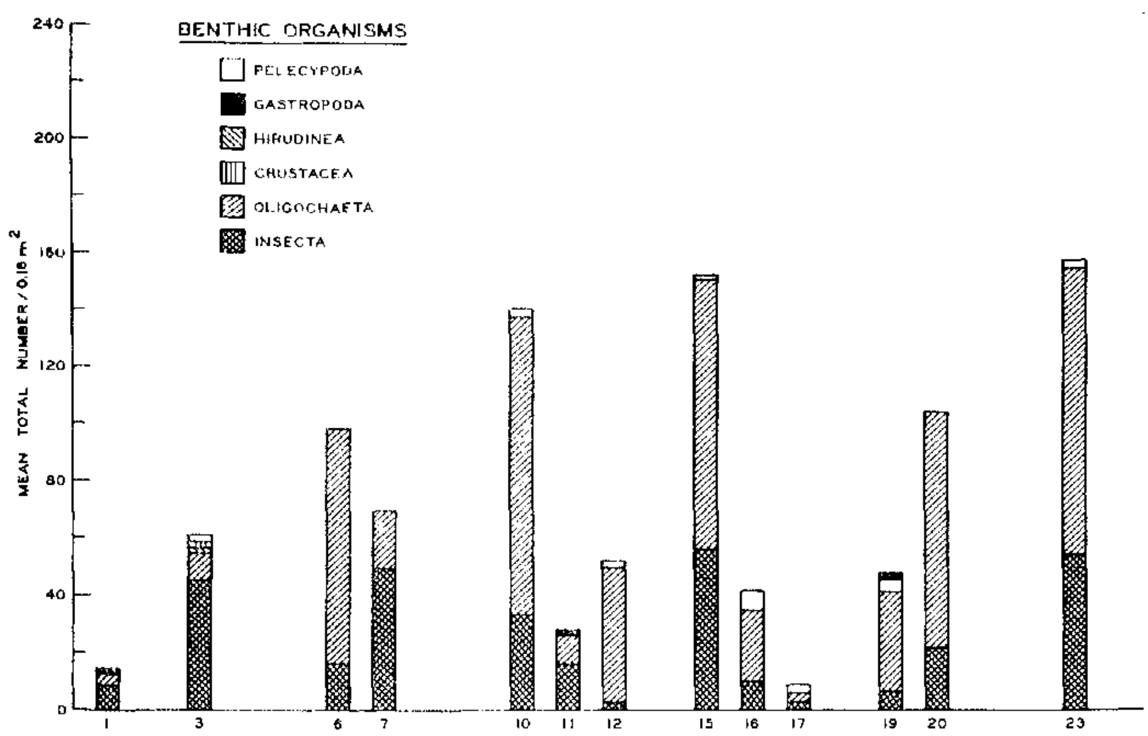


Figure 2-2j. Benthic invertebrates collected during sampling period III (10-28 July 1973), in side channel areas

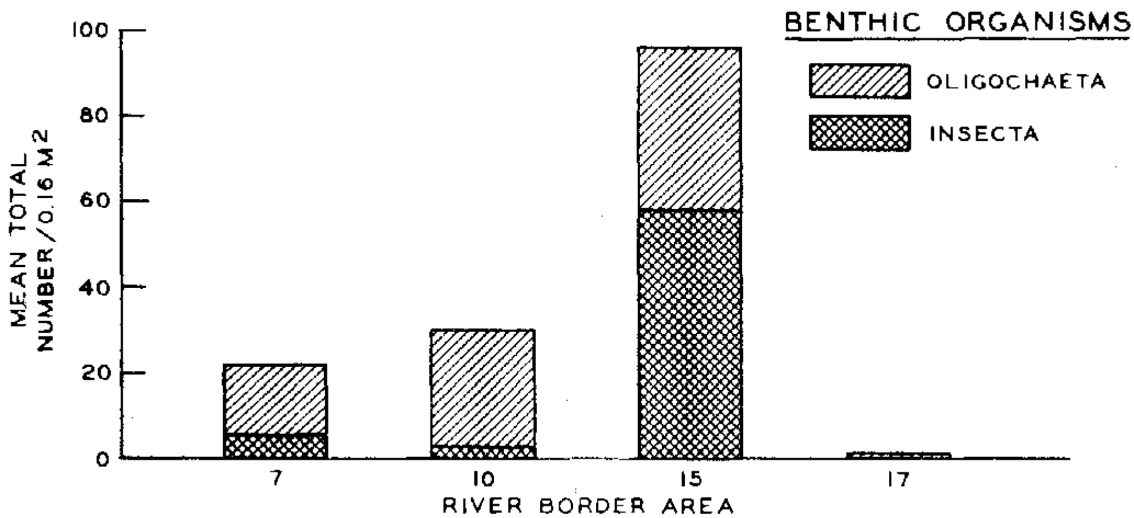


Figure 2-2k. Benthic invertebrates collected during sampling period III (10-28 July 1973), in river border areas

and also showed that of a total of 60 taxa collected, only eight taxa were found solely in the main channel border areas; 29 taxa were found only in the side channels; and 23 taxa were common in both main channel border areas and side channels. The differences observed in the two studies were due to the fact that different side channels were compared and that different sampling methods were used.

d. Fish. A fish may occupy one or more niches in the riverine food web throughout its life history. Many species feed on phytoplankton or zooplankton as fry, but feed on aquatic insects or other fish as adults. Adult fish may act as primary consumers, feeding on phytoplankton or aquatic macrophytes; secondary consumers, feeding on zooplankton or benthic organisms; or tertiary consumers, feeding strictly on many other species of fish. All fish species, interacting with other component organisms, are important in maintaining a balanced natural ecosystem.

The fishes inhabiting the Middle Mississippi River reaches have been well documented. An extensive literature review and research program carried out by various member agencies of the Upper Mississippi River Conservation Committee revealed a total of 82 fish species that were indigenous to the Middle Mississippi River (Appendix D) (Smith, Lopinot, and Pflieger, 1971). Twenty species were cited as common to moderately common near the mouth of the Ohio River but relatively rare upstream from there. Eleven species were considered rare to extremely rare throughout the Middle Mississippi River. The majority of the fishes (46 species) were of widespread or sporadic distribution with intermediate levels of abundance.

The Middle Mississippi River supports a diverse fish fauna, with most of its native species represented. A total of 21 fish species that may be classified as sport fishes and 26 species classified as commercial fishes inhabit the area. The classification of sport fishes is admittedly arbitrary and possibly incomplete, as some species are included which are not legally defined as game fish by Illinois or Missouri, whereas some fishermen would be inclined to add a number of species to the list. The gars certainly have a reputation as a sport fish by both anglers and archers, while the goldeye and mooneye are sought after by anglers using artificial lures in more northern waters (Funk, 1973; Schram and Lewis, 1973). The classification of fish species as commercial species is generally based on commercial fishing harvest records (Upper Mississippi River Conservation Committee, 1948 - 1974).

The sport and commercial fishing potential of the Middle Mississippi River is relatively untouched. The Mississippi River forms the entire eastern border of Missouri, a distance of approximately 500 miles. The 208-mile reach of the Mississippi River bordering St. Louis County to Scott County (the approximate boundary of the Middle Mississippi River nine-foot channel project) represents approximately 42 percent of the border, yet only 22 percent of the licensed commercial fishermen resided in that area and only 13 percent of the reported commercial harvest occurred in that area in 1972 (Robinson, 1972; Robinson, personal communication). A part of this disparity in use of the river can be explained by the widespread reports of municipal and industrial pollution of the river in the St. Louis area (Ryck, 1974). Robinson also attributed a portion of the disparity to a less diverse habitat (therefore, fewer good netting sites and fewer fish) in the Middle Mississippi River than in the Lower and Upper Mississippi River reaches, due to channelization and constriction that has taken place to date. Also the lack of public access to this section of the river limits its use. The demand for both sport and commercial fishing is present, but the resource is not being utilized to its potential in the Middle Mississippi River.

The environmental requirements of fish populations vary tremendously. To consider the importance of various environmental factors to fish, one must consider all species individually, throughout their life cycles. The requirements for current, oxygen, light, and food are often very different for young fry and adults. Seasonal, and even daily, requirements might vary for an individual fish or fish species. Throughout the day, a fish might need a swift-water area below a shallow riffle or shoal to feed, a brush-pile or vegetated area in which to avoid being eaten, and a deep quiet-water area or hole in the bank in which to rest. Seasonally, a number of fish species are known to migrate from generally swift-water habitats into quiet-water areas to spawn. Many others make spawning runs upstream from reservoirs or lakes into swift-flowing tributary streams.

The Waterways Experiment Station, in an attempt to evaluate the importance of side channels as fish nursery areas, made fish collections from 23 side channels and 4 main channel border areas of the Middle Mississippi River (Johnson, et al., 1974). A total of 52 fish species were collected, using a 3/16-inch mesh minnow seine (Appendix E). All of the species occurred in the side channels, but only 29 species occurred in the main channel border areas. Johnson, et al. (1974) felt that this was probably the result of the inefficiency of the seining method in the main channel border areas, rather than the normal species distribution. Ragland (1974) made fish collections in three side channels and three adjacent main channel border areas, using a variety of sampling gear. He collected a total of 53 fish species. Of this total, six species were found exclusively in the side channels and nine species were found exclusively in the main channel border areas.

Johnson, et al. (1974) made an attempt to compare the abundance of fish collected from the four main channel border areas studied and four adjacent side channels. Based on total numbers per seine haul, more fish were collected from all four side channels than from adjacent main channel border areas during their summer 1972 sampling period. Total numbers per seine haul were similar at all four side channels and adjacent main channel border areas during their spring 1973 sampling period. These similarities were attributed to the homogenizing effect of high river water levels at the time of sampling.

Ragland (1974) made two types of comparisons of fish collected in his study of three side channels and adjacent main channel border areas. He compared the species composition and relative abundance of fish collected using minnow seines. In a separate comparison, the results of collecting fish using various types of nets and electrofishing gear was compared. In the first comparison, he found that minnows and small fish were nearly 6.0 times more abundant in sein collections from the side channels than in main channel borders. For the more abundant fish species, electrofishing and netting captured significantly more carp, bluegill, shortnose gar, black crappie, bigmouth buffalo, white crappie, and bowfin in the side channels than in adjacent main channel borders. Largemonth bass were found only in the side channels. Significantly greater numbers of freshwater drum were observed in main channel borders.

2.2.1.3. Species Diversity Indices

It is generally conceded that the main channel of the Middle Mississippi River is poor habitat for aquatic fauna, as a result of the relatively high turbidity levels and the unstable bottom substrate. This has probably been true throughout the history of the river.

The Waterways Experiment Station calculated two types of indices, species diversity index ($\bar{d}$) and evenness index (e), as an indication of the quality of the aquatic habitat in side channels and main channel border areas. Indices were calculated using both benthos and fish species (Emge, et al., 1974). Average $\bar{d}$ values were relatively low for both side channels and main channel border areas, indicating that these areas are of moderate to poor quality aquatic habitat (Appendix C_1). Average e values for benthos were relatively high for both side channels and main channel borders, indicating that these areas are moderate to high quality aquatic habitat. Most values for both indices were of a medium range, indicating moderate quality habitat for aquatic organisms both in the side channels and in the main channel border areas of the Middle Mississippi River.

2.2.2. TERRESTRIAL COMMUNITIES

2.2.2.1. Flora and Fauna

The flora and fauna of the unprotected portion of the Mississippi River flood plain (i.e., the land between the River and the levees) located between St. Louis, Missouri, and Cairo, Illinois, have been recently described on the basis of cover types (Terpening, et al., 1974). Based on this work, nine separate cover types were delineated in the unprotected flood plain: older stand, younger stand, early secondary succession, young bar, sand and mud flat, water, old field, cultivated field, and developed land. The acreage and percent of total acreage for each cover type is shown in Table 2-5. The term "cover type" can be equated with the term "community." However, young bar, younger stand, and older stand are not communities in the strict sense of the term due to intergradations; water and developed land refer to physical aspects.

A total of 302 plant species were recorded in the unprotected flood plain during the environmental inventory (Terpening, et al., 1974). A total of 313 terrestrial vertebrate species were also observed or expected to occur in the project area. The more significant and/or characteristic plant and animal species of each cover type are discussed in part 2.2.2.2. Exemplary species of many of the major insect orders, as well as the moninsect groups such as spiders, ticks, and mites, also inhabitat the general region of the unprotected flood plain.

Table 2-5. Acreage and percent of each cover type in the unprotected flood plain

Cover Type		Acres	Percent
Older Stand		381	0.5
Younger Stand		23,260	29.9
Early Secondary Succession		2,751	3.5
Young Bar		9,272	11.9
Sand and Mud Flat		1,701	2.1
Water		4,279	5.5
Old Field		679	0.9
Cultivated Field		34,628	44.5
Developed Land		923	1.2
	TOTAL	77,874	100.0

2.2.2.2. Cover Types

a. Sand Mud Flat (Annual Grass-Forb). A sand/mud flat is newly-formed land or land uncovered by the recession of water. Although often referred to as a littoral zone, this area does not fit the textbook definition of that term. The plants that grow here are for the most part non-aquatic, as the swift nature of the water flow inhibits growth of aquatic plants. Plant growth begins in early fall with the recession of water and continues until the first killing frost. Because of the low-lying position, the vegetation is subject to frequent inundations for various lengths of time. These flats support more than 200 species of vascular plants, most of which are common and somewhat weedy species; about 20 percent of the vascular plants are non-native elements (Evans, 1971). Plants are abundant on the mud flats, but are often lacking in sandy areas with little water-holding capacity. Annual grasses are best represented, followed by composites and sedges. Common herbaceous species are lovegrass, pony grass, feather grass, panic grass, water hemp, yellow cress, and carpetweed. Plants of these sand and mud flats that are rare or uncommon elsewhere in Illinois and Missouri include yellow cress (*Rorippa islandica* var *islandica*), sedge (*Cyprus diandrus*), spurge (*Chamaesyce geyeri*), and cinquefoil (*Potentilla paradoxa* and *P. Millegrana*). There is some representation by seedlings of the woody species, including those of cottonwood, sandbar willow, and black willow. Older specimens of these species form the first line of permanent vegetation.

This habitat offers little permanent cover, but is important as a foraging area. The white-footed mouse, deer mouse, and house mouse utilize the sand and mud flats, apparently attracted to the logs and debris which often harbor invertebrates. Mice may also eat seeds washed up on shore. Beaver and muskrat also utilize the area. Foods present for muskrat include panic grass, fish, mussels, crayfish, and insects. Tracks of the opossum, raccoon, long-tailed weasel, and striped skunk are commonly observed. In this habitat the opossum finds crayfish, insects, and carrion. The raccoon, an omnivore, will take almost any animal food encountered, plus grasses and sedges. Weasels prey primarily on mice; striped skunks eat mice, insects, carrion, amphibians, reptiles, and reptile eggs. Mink in this habitat prey on mice, muskrats, rabbits, frogs, fish, crayfish, and invertebrates. The swamp rabbit (rare in Missouri, uncommon in Illinois), which usually uses water as a means of escape, eats grasses, sedges, and forbs. It rests and deposits droppings on logs or objects projecting from the water. Free-ranging dogs may forage on the flats, and deer come to drink.

Ring-billed gulls and herring gulls, less common to Illinois and Missouri, utilize sand and mud flats as resting sites, from which they search for fish and mollusks. Great blue herons, common egrets, and cattle egrets forage for fish, frogs, lizards, insects, crayfish, and tadpoles on mud flats and in water areas. Common crows, fish crows, and bald eagles have been reported foraging for dead fish and other carrion along the edges of the flats.

Migrating waterfowl such as Canada geese, mallards, lesser scaup, common mergansers, and others use sand and mud flats for loafing. Shorebirds use sand bars for resting areas as well as sources of crustaceans, insects, and other food items. The golden plover, spotted sandpiper, dunlin, buff-breasted sandpiper, and pectoral sandpiper are known from mud flats in the Mississippi River (Anderson and Bauer, 1968).

The spotted sandpiper and the least tern have been recorded as breeding on sand bars and mud flats in the Mississippi River (Anderson and Bauer, 1968). Availability of stable sand bars as nesting sites is a limiting factor for the rare interior least tern (Sterna albifrons althalassos). Competition for nesting sites is probably minimal when sandbars are available, and heavy predation occurs only if the bar is connected to the mainland, in which case other animals may prey on the eggs and nestlings.

Fowler's toad is a characteristic species of sandy areas along the water's edge. Standing water is assumed necessary for breeding, egg deposition, and tadpole transformation, and the shallows of permanent water can be used. Fowler's toad is insectivorous. The rare Illinois chorus frog is thought to utilize sand prairies and sandy flood plains as its non-breeding habitat. Abandoned crayfish burrows may harbor the northern crayfish frog during most of the year.

Several river turtles, although highly aquatic, may utilize the sand/mud interface of piles of driftwood for basking. They are the Missouri slider, slider, hieroglyphic turtle (a hybrid of the first two species), map turtle, false map turtle, and Mississippi map turtle. Sliders and Mississippi map turtles appear to be omnivorous, but juveniles tend to be carnivores and adults to be vegetarians. The diet of the hieroglyphic turtle is not well known. Plants, crustaceans, insects, ampbibians, and fish have been reported in its stomach contents. Map turtles eat mollusks; false map turtles eat mollusks, insects, and vegetation. All of the above turtles come on land to dig a nest and lay their eggs; it is not known if a sandy substrate is utilized. Smooth softshell turtles, eastern spiny softshells, and western spiny softshells utilize flats and islands as basking and egg-laying sites. The first two species prefer a sand substrate, the third prefers mud. All three are carnivorous, eating such items as mollusks, crustaceans (crayfish especially), aquatic insects, amphibians, and fish.

The dusty hognose snake is associated with sandy areas and often adjacent woodlands. This species is more omnivorous than the eastern hognose, eating toads, frogs, other snakes, birds, shrews, and mice. Six-lined racerunners occur on the prairies and major sand areas of Illinois and Missouri, and may occur along the Mississippi River on the larger flats. Racerunners feed mainly on arthropods.

b. Water. This category refers to water that is not a part of the river's main channel. Included are free-flowing and stagnant chutes, sloughs, and various depressions with standing water. Many of these aquatic areas are intermittent or only occur in wet weather, and thus do not support extensive aquatic plant communities. Only duckweed, a true aquatic, has been observed in these waters. Other plants associated with these areas are the typical sand and mud flat species.

Several species of bats forage for insects over water at twilight, including the little brown, southeastern, gray, Keen's, Indiana, silver-haired, big brown, red, hoary, evening, eastern and western big-eared bats, and the eastern pipistrelle. As a rule, forest edges and openings are preferred for hunting; sloughs and quiet side channels are ideal. Beaver, muskrat, and river otter depend on the relatively still water areas of some side channels and bay-like areas below rock dikes. Water is used for escape by all three animals; it provides food for the otter (crayfish and aquatic insects), and to some extent, the muskrat. Sloughs, side channels, and the river's edge are a source of drinking water for many mammals.

Side channels and sloughs attract migrating waterfowl which rest in the relatively quiet waters. Ring-billed and herring gulls also rest in these areas, and search for fish and carrion. Mallards, Canada geese, and lesser scaup utilize these sloughs throughout their migration. Food items such as duckweed and invertebrates are more available in sloughs than in the side channels.

Temporary, semi-permanent, or permanent water is necessary for the survival of amphibians and many reptiles. Water-filled ditches contain bullfrogs, southern leopard frogs, stinkpot turtles, and diamond-back water snakes. The northern spring peeper, southern leopard frog, painted turtle, red-eared turtle, map turtle, smooth softshell turtle, Graham's water snake, and diamond-backed water snake are also associated with these sloughs.

Four salamanders are totally aquatic, the hellbender, three-toed amphiuma, mudpuppy, and western lesser siren. The hellbender is limited to fast-flowing water, the mudpuppy occurs in slower, deep water, and the siren and amphiuma in sloughs and ditches. All four species prey on fish, mollusks, crustaceans, and various other arthropods. They lay eggs on the bed of the slough or river except for the amphiuma, which nests in a moist area on land. The mature central newt is aquatic, occupying ponds and water-filled ditches. It prefers mollusks, but also eats insects, frog eggs, and young amphibians. Spotted, mole, and eastern tiger salamanders deposit their eggs in shallow ponds. Permanent ponds are necessary for the spotted and the eastern tiger salamanders as breeding sites. Both species are fossorial, eating the invertebrates they find in their burrows and shelters. Little is known of the mile salamander's habitat requirements except its need for moisture. Apparently it feeds on invertebrates.

The eastern spadefoot toad, American and dwarf toads, upland, western, and Illinois chorus frogs, and northern crayfish frogs utilize temporary water such as flooded fields and shallow ditches for reproduction. The eastern gray tree frog and Blanchard's cricket frog use nearly any type of water. The cricket frog lives in water with good vegetative cover. Semi-permenent or temporary ponds accommodate the northern spring peeper; ponds, sloughs, and semi-permanent water are used by the southern leopard frog; and ditches and shallows of permanent waters by Fowler's toad. The rare western bird-voiced tree frog is known to occur only in swampy areas. Its eggs are laid in water. The green tree frog, also considered rare in Illinois, lives in swamps or sloughs intimately associated with vegetation. It preys on small arthropods. Most permanent water harbors the bullfrog, which lays its eggs on top of the water. Its food includes crustaceans and insects primarily, plus small frogs and an occasional snake. An intergrade population of the green and bronze frogs (Rana clamitans melanota x clamitans) occupies permanent water of swampy areas. A southern race of the pickerel frog prefers oxbows, swamps, and marsh areas. It eats arthropods and mollusks. Apparently the eastern narrow-mouthed toad breeds at the edges of ponds, streams, and swamps.

Most turtles are at least semi-aquatic in their habits. The river species are also seen in the larger sloughs. Snapping turtles and alligator snapping turtles are bottom dwellers and seldom seen, although they lay their eggs on land. Both are basically sedentary, catching prey as it moves by. The alligator snapper is piscivorous, the common snapper is omnivorous and a scavenger. Three more active bottom dwellers are the stinkpot, Mississippi mud turtle, and mud turtle (K. s. subrubrum x hippocrepis). They forage, eating primarily fish, mollusks, and aquatic arthropods. Mud turtles apparently are scavengers also. The habitat of the three turtles is backwater sloughs or swampy areas, but the Mississippi mud turtle prefers shallower waters. In Missouri, the western chicken turtle has been noted in ponds and temporary water-filled ditches. Its natural diet is uncertain, but the turtle may be omnivorous. Midland painted, western painted, and southern painted turtles, and red-eared turtles are all inhabitants of the quiet waters and are often seen basking on banks and debris. Their diet may include plants, fish, amphibians, mollusks, crustaceans, and insects. Western ribbon snakes, especially, and eastern garter snakes are often found associated with standing water, either along the edge or searching for prey on dense stands of duckweed. The western mud snake is aquatic and very secretive, being found under and near logs and vegetation in sloughs, swampy areas, and shallow ponds. It reportedly eats amphibians, especially salamanders. Water snakes are the most conspicuous snakes associated with this cover type. The rare green, the yellow-bellied, and northern copperbelly water snakes are common in sluggish waters such as swamps. Their food items include fish, frogs, and salamanders. Graham's water snake also prefers quiet water. It uses burrows of other animals and rocks for shelter. It eats crayfish extensively; also frogs, salamanders, and small fish. Diamond-backed water snakes are reported to utilize the shallows of sloughs and ponds.

Fish comprise most of their diet. The rare broad-banded water snake is associated with mud bottoms of sloughs, ditches, and other slow-moving water. It eats fish, crayfish, and frogs. The western cottonmouth is a common inhabitant of swamps, weedy sloughs, and drainage ditches. Its diet includes fish, frogs, turtles, other snakes, rodents, and birds.

c. Young Bar (Sandbar Willow-Black Willow-Cottonwood). The young sand and mud bars are elevated slightly above the adjacent sand and mud flats. The vegetation here is permanent, and, of necessity, water-tolerant and fast-growing, since it is subject to frequent inundations during periods of normal high water. Young, and often even-aged, sandbar willow, black willow, and cottonwood dominate the canopy. These three species occur in pure and mixed stands and range from finger-sized saplings near the sand and mud flats to medium-aged trees on the higher sites. Sandbar willow reaches maximum age and size on these sites, consequently dead and dying stands of these species are often seen. Driftwood and river debris are common and inhibit plant growth in places. Seedlings of box elder and silver maple are abundant; sycamore seedlings are less common. Seedlings of the dominant tree species are mostly found at the young bar-sand/mud flat interface where light is sufficient for reproduction. Nettle, false nettle, poison ivy, skullcap, and aster are the most abundant ground cover species on the young bar.

The additional vegetation on young bars allows a greater number of individuals and species to coexist, since escape and nesting cover is present. The white-footed mouse, house mouse, and deer mouse are commonly found in this cover type. All three may nest under roots and debris. Rabbit, beaver, muskrat, raccoon, mink, dog, and deer are also common. Food and nest sites (hollow logs, depressions, herbaceous vegetation) are available. The banks of young bars provide den areas for beaver, muskrat, and otter; mink may use abandoned muskrat dens for homes. The opossum and striped skunk will forage in this habitat. The solitary bobcat, finds sufficient cover on most young bars, and preys on rabbits, squirrels, mice, deer, opossums, and a variety of birds.

Bird species associated with this cover type include the cardinal, blue jay, song sparrow, Carolina chickadee, Americal goldfinch, dark-eyed junco, rufous-sided towhee, swamp sparrow, and ruby-crowned kinglet. Bald eagles are occasionally seen roosting in trees along the river. The rufous-sided towhee is marginal in this type and is usually found in a more secluded and protected environment. The swamp sparrow was not recorded from any other habitat type. A winter resident, it shows an affinity for yound bars. R. Graber (Unpublished data, 24 May 1973, Mississippi River Heron Census, Illinois Natural History Survey, Urbana) found great blue herons and great egrets nesting in this habitat type.

Use of this cover type by amphibians and reptiles is similar to their use of sand and mud flats. Southern leopard frogs, Fowler's toads, Illinois chorus frogs, northern crayfish frogs, sliders, map turtles, false map turtles, soft-shells, and dusty hognose snakes are present; only the southern leopard frog would be expected to occur here with any regularity. The flats are possibly more favored by softshells than the bars for basking and egg-laying, as the lack of cover would aid in spotting intruders.

The rough green snake may be seen in vegetation overhanging water, and is seldom seen on the ground. Its diet includes insects, spiders, and other arthropods.

d. Younger Stand (Cottonwood-Black Willow-Silver Maple-Box Elder). Age, species composition, and the presence of ridges and flats indicate that flooding of younger stands is common. Many small channels and drainage ditches are not yet overgrown with trees but support such weedy herbaceous species as tall pigweed, nettle, and false nettle. Cottonwood and black willow share a dominant or co-dominant role in most cases. Reproduction of these dominants is low or non-existent in this old-growth timber. Medium-aged silver maple may occur in almost pure stands, as may boxelder; seedlings and saplings of these species are frequently encountered in most younger stands. Occasionally sugarberry, green ash, American elm, red mulberry, and old-growth sandbar willow are also present. Poison ivy and grape are important elements and often climb into the canopy of the smaller trees. The most common ground cover species include nettle, bedstraw, southern dewberry, and aster.

Because of its diversity and great number of available niches, the younger stand supports a wide variety of mammals. Loose bark and tree cavities harbor the rare southeastern and hoary bats, the endangered Indiana bat, and the little brown, silver-haired, big brown, red, and evening bats, although the little brown and Indiana bats will be found in caves in winter. Fox and gray squirrels build nests in tree cavities or forks of branches. Foods of both species include various parts of elm and mulberry trees, fruits, field corn, and some invertebrates. Diversity of available foods is vital to the squirrel; pure river-bottom stands of willow, maple, or elm are an insufficient food source (Schwartz and Schwartz, 1959). Tree cavities, stumps, hollow logs, and depressions next to logs provide shelter and dens for the opossum, cottontail, swamp rabbit, raccoon, mink, fox, and bobcat. In addition to their water-related foods, opossoms eat pokeberry, mulberry, grape, persimmon, corn, mice, small birds, amphibians, reptiles, and invertebrates. Although the cottontail and swamp rabbit both occupy woodlands, the cottontail is more often found near the edge and away from water, while the swamp rabbit is found in the deeper part of the woods and usually near water (Lowe 1958; Toll et al., 1960). Cottontails feed on various parts of woody species in winter, but prefer herbaceous material such as bluegrass, sedges, goldenrod, clover, wheat, alfalfa, and soybeans. Swamp rabbits eat various grasses, sedges, and herbs, as well as deciduous holly, sugarberry, and elm. Food items available for the raccoon in younger stands include persimmon, grape, insects, frogs, snakes, ground-nesting birds, mice, and eggs of reptiles and birds. The mink eats animal foods similar to those of the raccoon. Both the gray and red fox are omnivorous and opportunistic, although the bulk of their diet consists of rodents. Bears eat grass, fruits, seeds, and inner bark of several species of trees, plus a variety of animal foods.

Many small mammals such as white-footed, house,and deer mice inhabit the forest floor. They live in leaf litter, under and in logs and stumps, and iu burrows, eating seeds and invertebrates. Insects and worms compose the diet of the rare southeastern shrew, which nests in shallow depressious liued with grass or leaves. The short-tailed shrew inhabits runways of other animals or digs its own burrows. It eats insects, a variety of other invertebrates, salamanders, snakes, birds, mice, and other shrews. Other burrowers present in younger stands are the eastern mole, pine vole, and southern bog lemming. Moles are usually found in more open areas, but if the soil is loose, they will burrow in woodlands. They eat worms, grubs, and insect larvae found in the soil. Pine voles and lemmings prefer loose soil and thick leaf litter. Voles feed on all parts of available vegetation and some invertebrates. Grass, fuugus, moss, bark, and beetles make up the southern bog lemming's diet.

Several species of mammals are found at the margin between woods and some other habitat type, usually a cultivated field or an old field. The white-footed mouse is often trapped at the edge of woods and fields; the cottontail rabbit and the red fox are edge species. In the winter, the woodchuck utilizes the forest edge for hibernation. The eastern chipmunk lives in burrows or brush piles and forages for seeds, berries, mushrooms, corn, wheat, and invertebrates. The rare meadow jumping mouse, an edge species, hibernates underground, usually under a log or rock. Grass seed is its preferred food, but it also eats fruits, roots, insects, and other arthropods. The long-tailed weasel preys on mice, squirrels, chipmunks, voles, shrews, moles, rabbits, small birds, and eggs. Coyotes den in woodlands at least during the breeding season, and hunt the edge for rabbits, mice, other small rodents, birds, and carrion. The white-tailed deer, an important game animal, browses on leaves, twigs, and fruits of trees and shrubs, herbs, and cultivated crops. It prefers open timber stands and the edges.

Blue jays and cardinals nest in the tree foliage or in the understory of younger stands; their heavy beaks are well-adapted for cracking seeds. The white-breasted nuthatch, red-bellied woodpecker, and prothonotary warbler, are hole-nesting species and feed on tree insects. Hooded mergansers and wood ducks build nests in hollow trees or stumps in wooded swamps or forests near water.

Edge habitat is the most productive, providing not only extensive cover but an adequate food supply and usually water. In the winter, woodland edges shelter flocks of the ruby-crowned kinglet, golden-crowned kinglet, American goldfinch, yellow-rumped warbler, and tufted titmouse. The Carolina wren and the mockingbird, inhabitants of thick, brush areas, remain through all seasons. Yellow-billed cuckoos, mourning doves, yellowthroats, and indigo buntings utilize edge for nesting.

Breeding species include the scarlet tanager, cardinal, brown-headed cowbird, Baltimore oriole, brown thrasher, white-breasted nuthatch, Carolina chickadee, common crow, tree swallow, pileated and red-bellied woodpeckers, belted kingfisher, and wood duck.

The downy woodpecker, song sparrow, white-throated sparrow, dark-eyed junco, and rusty blackbird appear to be more common here than in older stands, possibly due to a higher availability of food and cover. Broad-winged hawks and screech owls are the most prevalent species of raptors using the younger stands for food and nesting. Great blue herons, common egrets, and cattle egrets may nest here, but use mud flats and water areas for foraging.

Upland species are expected to utilize this cover type, as it is one of the driest habitats in the flood plain. Marbled salamanders and small-mouthed salamanders tolerate the dryness and may be found under rocks, logs, and leaf litter most of the year. Marbled salamanders breed in the fall in places damp from autumn rains. Small-mouthed salamanders breed in late winter, and require standing water. Both species eat arthropods and other invertebrates found in the soil and leaf litter. Spotted salamanders, mole salamanders, and eastern tiger salamanders may be found. The land form of the central newt, known as an eft, may occur in moist woodlands. The ubiquitous American toad and the dwarf toad, a woodland animal, may be found in the younger stand. Both are insectivorous. Upland chorus frogs and eastern gray tree frogs are forest animals which feed on small arthropods. In hot weather the frogs take shelter under tree bark or in moist logs. The northern spring peeper is most often found on vegetation. It feeds on arthropods.

Land turtles, the eastern box in Illinois, and the three-toed box in Missouri, are primarily upland species. Both are omnivorous, eating invertebrates, fruits, fungi, and other plant and animal matter. Mating, egg-laying, and hibernation may all occur in woodlands. Three lizards, the five-lined skink, the broad-headed skink, and the ground skink, prefer mesic woodlands. They may be found in younger stands and prey on insects and other arthropods. The broad-headed skink appears to be more arboreal than the five-lined skink, while the ground skink finds shelter in woodland debris and litter. The northern fence lizard is arboreal and prefers dry wooded areas. It eats insects and other arthropods. Females lay eggs in moist sheltered spots.

Several species of snakes are associated with the younger stand. The midland brown snake eats earthworms, and may be found under cover at the edge of this cover type. Also expected to occur at the edge of the woods is the eastern hognose snake, which seems to prefer soils with low organic content. Food items are primarily toads, although frogs and tree frogs may be eaten. The black rat snake is commonly seen in woods, where it feeds on mice, rats, voles, small rabbits, and birds. It is a good climber. Eggs of this species have been found in rotting logs and stumps. The gray rat snake is apparently similar in habits and habitat. Two kingsnakes, the black kingsnake and an intergrade of the black and speckled kingsnake, occur in woodlands in rough terrain. They eat birds, mice, voles, and other snakes. Also a kingsnake, the red milk snake is more secretive, seldom seen by day. It is most often collected from rotten logs or stumps and from under rocks, and feeds on mice, lizards, and other small snakes. Like the hognose, the eastern garter snake prefers the edge of a forest. A variety of food items are taken, including frogs, salamanders, small birds, fish, and invertebrates. The northern red-bellied snake is semi-fossorial, seeking shelter in leaf litter and under wood. Earthworms are its primary food. Copperheads are primarily snakes of hillsides and uplands, but the southern copperhead, which occurs in the Middle Mississippi, shows a propensity for lowland woods. Lizards, frogs, toads, cotton rats, mice, voles, birds, and insects all have been recorded on its diet. Eastern massasauga rattlesnakes prefer marshy or old field situations but may occur in open, moist woodlands. Small mammals and birds are eaten. The canebrake rattlesnake also is a bottomland subspecies. It prefers rabbits, mice, and other rodents. Both copperheads and canebrakes normally migrate to rock dens in the fall to hibernate until warm weather.

e. Older Stand (Black Willow-Cottonwood-Silver Maple-Box Elder). Vegetation of these areas is older and more stable than other vegetation in the unprotected flood plain. Older stands occur at elevations not subject to flooding except during periods of unusually high water. Consequently, soils of this cover type are more developed. Flats, ridges, and drainage ditches created by previous high water now support timber of substantial size and age. These subtle changes in relief result in differences in soil composition and moisture levels, and, thus, species diversity and frequency. Cottonwood and black willow are the oldest components of this cover type and are non-reproducing for the most part. Cottonwood, due to its size and frequency, is often logged. Silver maple and box elder, along with cottonwood and black willow, share the dominant and co-dominant role. Sycamore is not uncommon and is most often associated with high, well-drained sandy substrates. Less frequent trees include sugarberry, American elm, slippery elm, red mulberry, green ash, and rarely, pecan and sassafras. Seedlings of box elder, sugarberry, elms, and silver maple are frequently encountered, indicating a potentially more important role for these species in the future. Among the more common ground cover species are nettle, false nettle, poison ivy, chervil, bedstraw, aud aster. Species that are apparently restricted to this cover type and indicate a stable flood plain woodland include sedge, catbrier, and lizard-tail. Sandbar willow, characteristic of less stable environs, is absent from this cover type. Euonymous (*Euonymus fortinei*), rare in Illinois and unknown from Missouri, occurs in an older stand of timber on Devil's Island at river mile 64 (Terpening, *et al*., 1974).

Vegetation in this cover type shows enough similarity to that of younger stands that mammalian species composition is probably similar. Species preferring a more upland or a disturbed situation such as the fox squirrel and red fox, may be slightly more abundant.

Most observations of birds in younger stands are valid for older stands. The interior of an older stand offers little food except for insectivorous upper strata birds such as the cerulean warbler, the various Empidonax flycatchers, and vireos. The pileated woodpecker is restricted to this environment because it depends upon mature trees for nesting sites and for woodboring insects. The rare Mississippi kite is also dependent upon old age timber for nesting, but it searches brushland and water areas for large insects, frogs, lizards, and mice.

Marginal breeders are those species utilizing a specific cover type for breeding only if there is a lack of preferred habitat. In older stands the rufous-sided towhee, indigo bunting, orchard oriole, eastern bluebird, and downy woodpecker are marginal breeders.

Although the abundant edge cover provides protection for rodents and small birds, the broad-winged hawk and the red-shouldered hawk do hunt along the margins of older stands. Rodents, insects, small hirds, and reptiles make up their diet. These hawks migrate to warmer latitudes during the winter, but the barred and screech owls find sufficient food in the form of small animals and birds to stay.

This cover type harbors many of the same species of amphibians and reptiles as the younger stand.

f. Early Secondary Succession (Perenniel Weed-Shrub-Sapling-Vine). Early secondary succession vegetation results from three factors: (1) extended periods of flooding and standing water which produces dead and damaged canopy vegetation; (2) logging operations which leave slash and undesirable trees and open the canopy to shrub-vine vegetation; and (3) land clearing operations which produce slash, rubble and soil erosion. Early secondary succession sites occur frequently in the unprotected flood plain but are usually small in area. An array of erect and climbing herbs, woody vines, small trees, and shrubs often make these areas almost impenetrable. Common tree saplings and shrubs of wetter areas include sandbar willow, black willow, swamp-privet, and boxelder). Drier sites support red mulberry, rough-leaved dogwood, and sugarberry. Common woody vines of both wet and dry sites include riverbank grape and poison ivy. Among the more common weedy herbs are tall pigweed, pokeberry, climbing buckwheat, and giant ragweed.

Small mammals are abundant in this habitat. In addition to providing cover for permanent residence, early secondary succession may provide a protected travel route between two other habitat types. The prairie vole, and white-footed, deer, house, and the rare meadow jumping mice, as well as several other rodents, are expected to occur here. Rice rats nest on the ground in dense cover, moist areas being preferred. They build runways through the vegetation and feed on grasses, sedges, fruits, and berries. They may enter water to escape predators. The cotton mouse also requires dense cover but nests in drier areas. Though categorized as rare in Illinois and uncommon in Missouri, the golden mouse should be locally abundant in the unprotected flood plain. Many of its favored food plants, including poison ivy, bedstraw, blackberry, and grape are present. It nests in catbrier, grape, honeysuckle, and other brushy situations, either arboreally or on the ground. Another small mammal, the least shrew, nests under logs and stumps, and in deep depressions. Its diet includes a large variety of arthropods, frogs, and carrion. The short-tailed shrew may also be present. Opossum, rabbit, dog, red fox, weasel, and striped skunk may be seen foraging for food. The striped skunk is mainly insectivorous, but also eats mice, shrews, moles, rabbits, eggs, and carrion. It requires permanent water nearby, but nests in almost any situation with sufficient cover.

Vegetative cover, seeds, and insects are ample in early secondary succession habitat, making it one of the most important habitats for birds. Frequently seen were seed-eating birds, including the cardinal, song sparrow, American goldfinch, white-throated sparrow, field sparrow, dark-eyed junco, rufous-sided towhee, Oregon junco, and tree sparrow. Other species common to this type were the blue jay, Carolina chickadee, tufted titmouse, mockingbird, Carolina wren, rusty hlackbird, and yellow-shafted flicker.

The following permanent residents are expected to breed in this cover type: cardinal, song sparrow, Carolina chickadee, American goldfinch, field sparrow, tufted titmouse, mockingbird, Carolina wren, mourning dove, and rufous-sided towhee.

Ground nesting, or low nesting, species are probably common in this area during years of normal river levels. Species likely to breed in early secondary succession vegetation include the rare Bewick's wren, white-eyed vireo, brown thrasher, and yellow-breasted chat.

Both the small-mouthed and the eastern tiger salamanders can persist in disturbed regions such as early secondary succession. The American toad and its main predator, the eastern hognose snake, may be present. Other species mentioned before and possibly occurring here are the black and gray rat snakes and the eastern garter snake. The yellow-bellied racer, formerly known as the blue racer, and the southern black racer occur in several habitats, including brushy areas. They consume insects, mice, voles, frogs, salamanders, other reptiles, and birds in their variable diet. In the winter, racers normally migrate to rock dens to hibernate, but they may utilize the burrows of small mammals. The prairie kingsnake prefers areas with brushy cover, tolerating some disturbance by man. Mice are its primary food item, but it eats shrews, moles, rats, ground squirrels, gophers, birds, amphibians, reptiles, and insects.

g. Cultivated Field. This type includes fields with harvestable crops, pastures, most levees, fallow ground, and fields that show some sign of recent cultivation. These cultivated areas are located on the oldest, highest, and driest parts of the unprotected flood plain. The most common crops grown are corn, soybeans, and wheat. Alfalfa cotton, and grain sorghum are also present.

This habitat type is an important food source for many of the mammals previously discussed. Common species include the short-tailed shrew, deer mouse, white-footed mouse, prairie vole, house mouse, opossum, eastern mole, rabbit, woodchuck, raccoon, long-tailed weasel, striped skunk, and white-tailed deer. Several other species are expected to utilize this habitat, including the plains pocket gopher, cotton rat, pine vole, Norway rat, meadow jumping mouse, coyote, and spotted skunk. Gophers may become pests because of their burrowing habit. They often choose levees, railroad rights-of-way, and loose soils of fields for den sites. Their food consists of roots and underground stems of grasses, legumes, and alfalfa. The woodchuck is a summer resident whose habits are similar to those of the gopher. The Norway rat is a serious pest usually found near human habitation; in warm weather it may migrate to fields. It is omnivorous.

This cover type is more important as a foraging area than a nesting area, although there is some nesting at the edges of fields. The following species are commonly found associated with this cover type during the winter: common crow, field sparrow, mourning dove, rock dove, dark-eyed junco, red-tailed hawk, sparrow hawk, Harlan's hawk, rusty blackbird, eastern meadowlark, western meadowlark, starling, house sparrow, white-crowned sparrow, savannah sparrow, vesper sparrow, horned lark, Lapland longspur, and Le Conte's sparrow. The eastern meadowlark, field sparrow, red-winged blackbird, and horned lark are expected to nest at the edges of cultivated fields.

Species which may be expected to utilize this cover type include the American, dwarf, and Fowler's toads, Blanchard's cricket frog, bullfrog, southern leopard frog, three-toed box turtle, eastern yellow-bellied racer, black rat snake, black kingsnake, western ribbon snake, eastern garter snake, diamond-backed water snake, the western chorus frog, and Snapping, stinkpot, painted, and red-eared turtles. In addition, the southern black racer, prairie kingsnake, midland brown snake, northern red-bellied snake, and eastern massasauga rattlesnake are expected to occur here.

h. Old Field. Old fields support a type of early secondary succession vegetation that results from abandoned farming operations. Frequent flooding is the usual reason for abandonment of small areas in cultivated fields. These areas occur infrequently. Although old field vegetation may look much like the early secondary succession vegetation, the two types are of different origins, and only a few species are common to both. Perennial weeds, woody vines, shrubs, and young trees are growth forms most often found in old fields. Most common perennial weeds are

Pennsylvania smartweed, climbing buckwheat, southern dewberry, and morning glory. Woody vines, including trumpet creeper, poison ivy, and riverbank grape often form dense thickets along with shrubs of white mulberry and rough-leaved dogwood. Saplings of winged elm and silver maple are frequently encountered. Railroad rights-of-way support an old field type of vegetation.

The vegetative character of an old field is similar to that of early secondary succession, and presumably the animals are similar. Common species include rabbit, deer mouse, white-footed mouse, prairie and pine vole, house mouse, meadow jumping mouse, and white-tailed deer. The southeastern shrew, woodchuck, cotton rat, coyote, spotted skunk, and deer are also expected to occur here.

The most common wintering birds in old fields are the vesper sparrow, common crow, brown-headed cowbird, and bobwhite quail. Also expected is the cardinal, song sparrow, field sparrow, mourning dove, dark-eyed junco, yellow-shafted flicker, red-tailed hawk, marsh hawk, rusty blackbird, eastern and western meadowlarks, house sparrow, and eastern bluebird.

Old field vegetation, especially foxtail, is the primary roosting site of the rare short-eared owl. Light-colored grasses such as foxtail help conceal this ground-roosting owl. The vesper sparrow, savannah sparrow, Le Conte's sparrow, western meadowlark, lapland longspur, and rough-legged hawk were recorded during the environmental inventory (Terpening, et al., 1974). These species are uncommon in Illinois and Missouri.

Breeding birds present include field sparrow, horned lark, eastern meadowlark, and bobwhite. During the winter, bobwhite gather into coveys. In the spring, they disperse and set up breeding territories on dry grassland. Bobwhite forage on the ground for seeds and insects.

The northern fence lizard and black rat snake have been noted in this habitat, which is similar in form to early secondary succession. The American toad, southern leopard frog, eastern hognose snake, eastern yellow-bellied racer, southern black racer, black and gray rat snakes, prairie kingsnake, eastern garter snake, and western ribbon snake are also expected.

i. Developed Land. Included in this cover type are industrial structures and those environs which are greatly influenced by industrial development. Common industries are grain elevator operations, light and power companies, and barge docking and loading sites that are associated with nearby towns. The occasional farm houses and outbuildings that occur on the unprotected flood plain are not included in this cover type.

No mammals depend primarily on developed land for habitat. The Norway rat and house mouse may be locally abundant, and free-ranging dogs and cats may be visitors.

Species expected to utilize this type include the house sparrow, starling, chimney swift, rock dove, and barn swallow. The nighthawk, which has a habit of nesting on the gravel roofs of buildings, may also occur here.

The American toad is attracted by insects found at night in lighted areas. Fence rows, shrubs, piles of debris, and other objects provide shelter during the day. The northern lined snake is considered an urban species, found in vacant lots and under rocks, trash, or leaf piles. Only earthworms are listed as food. The midland brown snake could also be expected in this cover type. Several species might occur as visitors, attracted to food at night but elsewhere during the day. These include the terrestrial salamanders, skinks, black rat snake, eastern hognose snake, and the king snake.

2.2.2.3. Successional Trends in Terrestrial Communities

In the unprotected flood plain, floodwater is probably the most important factor in establishing and limiting vegetation. Primary plant succession begins in most cases on the sand and mud flats adjacent to the water's edge and proceeds toward higher and less frequently inundated areas. The sand and mud flats are formed where the water velocity decreases, and soil particles of sand, silt, and clay, respectively, settle out. During periods of high water, velocity is less where the river can widen. Here the flats are extensive and form an important part of the flood plain ecosystem. In areas where the river is confined by revetments or by natural levees, the flats are small or nonexistent. The flats become available for plant habitation and growth as the river recedes in the latter part of the year. Seeds float or are wind-blown onto exposed flats where they become established if the flats are not inundated for a growing season. Most vegetation develops on mud where moisture is held during the hot and dry periods of late summer. Annual grasses and forbs are most common; first year seedlings of sandbar willow, black willow, and cottonwood are also common. Few of the pioneering plants survive for more than a single growing season on sand and mud flats.

Sand and mud flats may also be associated with water that is not a part of the main channel, such as sloughs, chutes, and impounded water. Here, with less frequent flooding, succession proceeds rapidly to a more stable vegetation type characterized by the presence of willows and cottonwood as dominants, and boxelder and silver maple in subdominant numbers.

Should the flats be inundated only intermittently for two or more growing seasons, seedlings of black willow, sandbar willow, and cottonwood become established. These species usually grow along the high side of the flats and form the first permanent line of vegetation. Once established, the front-line vegetation begins to catch drift and soil and provides a more suitable habitat for other tree seedlings and herbaceous species. Many willow-cottonwood stands adjacent to the river are even-aged, suggesting that all were established during a single favorable period. Fortuitous seeding and the amount of subsequent moisture probably determine dominance in the willow-cottonwood stands. Generally, the wetter areas favor sandbar and black willow over cottonwood, as willows are more tolerant to saturated soil conditions (Yeager,1949; Hall and Smith,1955). In addition, if inundated during early establishment, willows can survive longer than cottonwood (Hosner,1960). Cottonwood competes more successfully with willow on dry sites (Hosner and Minckler, 1963). The relatively coarse soils associated with newly-formed land have less water-holding capacity, which favors cottonwood. Although black willow initially grows faster than cottonwood, the latter does not seem to be affected by the slight shading. The initial dominance of the willow over cottonwood generally lasts approximately 15 to 20 years on the better drained sites, and 25 to 30 years in more poorly drained areas (Hosner and Minckler,1963). Both cottonwood and the willows require abundant light for germination and effective initial growth (Shelford,1954; Fowles, 1965). As light in these stands is reduced by the developing canopy, sandbar willows, black willow, and cottonwood reproduction is inhibited, and shade-tolerant silver maple, boxelder, and sycamore become established. Through all these processes the vegetation of young bars is determined. Seedlings of silver maple, boxelder, and sycamore are common understory components of young bars. Saplings of these species, and occasionally mulberry and slippery elm, are evident on infrequently flooded sites in this cover type. Vines, both woody and herbaceous, begin to take hold, clinging to the timber. Riverbank grape becomes an important canopy element. Flooding is common in this cover type during periods of annual high water. The frequency, intensity, and duration of these inundations are strong controlling factors in the succession that occurs there.

With time and without unusual disturbances, young bars grade into younger stands. The difference between the two types is primarily a function of age. As stands of sandbar willow reach maturity and die, room for developing silver maple, boxelder, sugarberry, sycamore, slippery elm, and American elm is available. Logging of cottonwood, not uncommon in younger stands, also favors the growth of these more mesic species. Many herbs common on the flats are apparently absent from younger stands; these include some grasses and members of the sunflower family which are possibly limited by increased shade and litter. Silver maple and boxelder increase in size and frequency and become subdominants in more advanced stands. On the better drained sites, medium-aged silver maple occurs in almost pure stands. Woody vines, especially riverbank grape, gain importance with time.

Black willow and cottonwood mature in about 45 to 55 years (Fowles, 1965). Following death or logging, silver maple and boxelder replace them and assume a co-dominant role in older stands. Hosner and Minckler (1963) also concluded that the frequency of silver maple and boxelder seedlings in cottonwood-willow stands suggested that the future stand will consist predominantly of these two species. Sycamore gains dominance in areas with a well-drained sandy substrate. Reproduction in these stands indicates that American elm, slippery elm, sugarberry, and green ash have a potentially more important role later as canopy trees. Herbaceous species indicative of greater habitat stability include sedge, catbrier, and lizard-tail.

Succession beyond older stands is presently indistinct. Tree and herb species common to nearby woodlands in the protected flood plain are not present in the unprotected areas. Conspicuously absent are pin oak, swamp white oak, swamp chestnut oak, and sweetgum. Swamp species such as swamp cottonwood, baldcypress, and pumpkin ash, are also unknown in the unprotected flood plain. The forest communities in many protected areas are on heavy, clay loam soils which are characterized as being slow to drain (Norton, et al.,1933). However, soils in the unprotected areas are mostly fine sandy and silty loams which are moderately to readily water permeable (Parks and Fehrenbacher, 1968). Sloughs and flats are higher in clay. The coarse and permeable soils, the periodic flooding during the growing season, and the scouring action of flood water probably explain the absence of many common protected flood plain trees in the unprotected areas. Succession toward these protected flood plain types will progress extremely slowly if at all. More likely, succession will continue, excepting catastrophic floods, to a silver maple-boxelder disclimax and be held in check by natural disturbances at this stage. Light-tolerant American elm, sugarberry, and green ash which are present now in small numbers, will be more important elements in this semi-stable stage.

Should the water table be significantly lowered and flooding occur only rarely, succession will progress further. The bottomland forests at Horseshoe Lake Wildlife Refuge, Alexander County, Illinois, may be an example of this advanced succession. This former Mississippi River island has well-drained, sandy loam soils on the highest elevations and increasing amounts of clay at lower elevations (Cavanaugh, et al.,1973). The highest and sandiest soils support dominant trees of beech, sugar maple, bitternut hickory, and basswood. The lower clay soils support sweetgum, American elm, red maple, boxelder, and red ash as dominants, with bald cypress and water-tupelo dominant in standing water (Weaver and Robertson, 1973). Hosner and Minckler (1963) suggested that progression of these unprotected stands to a drier oak-hickory climax is dependent upon long-term geologic changes such as major soil depositions or changes in stream course.

Succession is often disrupted in the unprotected flood plain. Standing water often may damage vegetation of young bars, younger stands, or older stands. If the damage is sufficient to kill trees and shrubs, secondary succession occurs. Logging, common in older stands, causes the establishment of the early secondary succession type. Cultivated fields, if abandoned, will proceed to old fields, then to younger stands, and finally to older stands. Abandoned fields lose most signs of management after 3 to 5 years. Saplings of silver maple and white mulberry, as well as riverbank grape, suggest that succession in old fields progresses toward younger stand vegetation.

As succession advances or is disrupted, the animals dependent on a community for food, shelter, or reproduction must move to another area or adapt to the new successional stage. Those animals incapable of moving or adapting will eventually die. In discussing animal succession, one must remember that many animals depend upon more than one community and move freely among them.

Sand and mud flats are utilized by fish crows, gulls, terns, scavengers like the raccoon, opossum, and skunk, some toads, and soft-shell turtles. The adjacent side channels and the sloughs support beaver, muskrat, migrating waterfowl, herons, egrets, frogs, water snakes, mud and snapping turtles, and aquatic salamanders. As the area becomes drier, aquatic animals gradually disappear, and terrestrial vertebrates enter. A few vertebrates occur in all terrestrial habitats; these include some small rodents such as the white-footed mouse, house mouse, and deer mouse, birds of prey, and seed-eating birds such as cardinals and dark-eyed juncos.

In addition to those animals found in all terrestrial habitats, rabbits, opossums, rodents, some carnivores, insect- and seed-eating birds, certain frogs, and turtles also utilize young bars. The drier and more mature younger stands favor deer, carnivores, hole-nesting birds, small insectivorous birds, land turtles, terrestrial salamanders, and some snakes. Although older stands are similar in animal composition to younger stands, a few of the tree-nesting birds and the more solitary carnivores prefer the more mature stands.

Early secondary succession favors those species preferring tangled, brushy habitats, especially small rodents, seed-eating birds, and snakes. Levees, pastures, and cultivated fields attract animals preferring more open spaces; the woodchuck, pocket gopher, killdeer, horned lark, meadowlark, toads, and snakes are typically found there. If flooded, animals associated with water, such as shorebirds, waterfowl, water snakes, and frogs move into the area. Old fields harbor species similar to those in early secondary succession and cultivated fields.

Capture data of small mammals exemplifies the concept of animal succession. In a 16-year study on a disturbed flood plain in central Illinois, Wetzel (1958) found that the deer mouse was the first invader. The prairie vole followed after sufficient grass cover had developed. With the establishment of trees and a humus layer, the deer mouse was replaced by the white-footed mouse. A similar trend was found in the unprotected flood plain of the Mississippi River (S.I.U., 1973).

2.2.2.4. Pestiferous Plants and Animals

a. Plants. Several plant species are found in the unprotected flood plain which may cause allergic reactions or skin irritation. Most common of these is poison ivy (*Rhus radicans*). It is found in nearly all cover types throughout the flood plain. Individual reactions vary but it causes severe discomfort to some people. Horseweed (Ambrosia trifida), also known as giant ragweed, is locally abundant in the flood plain. The pollen causes allergic reactions in many individuals and is the principal "hayfever" species. Various species of nettle occur in the flood plain and are the cause of concern and nuisance to those which come in contact with them. The "stinging" hairs break off in the skin, causing an intense itching or burning sensation.

b. Animals. Some aspects of public health involving animals of the unprotected flood plain are discussed below. Although records are not available for any diseases or some animal species from the flood plain specifically, information presented is pertinent to our study area.

(1) Mammals. Rabies is an infectious disease that affects the nervous system, including the brain and spinal cord, of animals including man. The disease is caused by a virus present in the saliva of infected animals and usually transmitted by the bite of a rabid animal. Dogs, foxes, coyotes, wolves, beaver, cats, skunks, raccoons, and bats are known carriers; several other mammals are suspect. Skunks and foxes are the major carriers of the disease in wild animals (McLean, 1970). In 1961, no cases of fox or bat rabies were reported in the river counties of Illinois or Missouri (U. S. Department of Health, Education, and Welfare, 1961); but dog rabies was reported in St. Louis County, and skunk rabies in Jefferson County, Missouri. Except for the wolf, all the known carriers occur in the unprotected flood plain; hunters, fishermen, and other users of the area could be exposed to this disease.

Tularemia, an infection of ticks, rabbits, man, rodents, and other animals, is caused by the bacterium Francisella tularensis (U. S. Department of Health, Education, and Welfare, 1964). Illinois, Missouri, and five other states reported 56 percent of all cases in the United States. From 1959 to 1963, 7.20 percent of the cases reported per year in 43 states were from Missouri, 8.41 percent from Illinois. In 1963, the incidence of tularemia in Illinois declined to 3.61 percent, while in Missouri it increased to 10.11 percent of the cases per year. Man is infected primarily by skinning infected rabbits, but also by receiving bites from infected ticks and deer flies, skinning small rodents, muskrats, or beaver, drinking water contaminated by muskrat or beaver, or by eating insufficiently cooked infected meat. The incidence of tularemia in man is highest in the summer in Illinois and Missouri.

Leptospirosis disease is a bacterial (Leptospira interrogans) carried by livestock, dogs, cats, foxes, opossums, skunks, raccoons, bobcats, rats, mice, voles, and bats (U. S. Department of Health, Education, and Welfare, 1963). Bacteria infect the kidneys and are shed in urine, then enter the body through breaks in the skin or through the nose, mouth, or eyes. A highly contagious disease, leptospirosis is causing the death of cattle in Missouri (Anonymous, 1973). The flooding of lowlands has made contaminated water available to livestock.

(2) Reptiles. No deaths from snake bite have been reported recently in Illinois (Smith, 1961), and none were mentioned in Missouri (Anderson, 1965). An average of 14 people die in the United States each year (Parish, 1963, in Burkett, 1966) out of 5,000 bitten (Burkett, 1966). Timber and canebrake rattlesnakes cause the most serious bites, followed in order by the cottonmoutn and copperhead. More people are bitten by copperheads than by any other poisonous snake in this area, but the fatality rate is less than 1 percent (Anderson, 1965). As poisonous snakes are found in the unprotected flood plain, hunters, trappers, fishermen, mushroom hunters, and others may come in contact with them.

(3) Invertebrates. The following annotated list discusses only the major groups and public health concerns:

Class Arachnida

Order Araneida (Spiders)

Family Loxoscelidae

Loxosceles reclusa Gertsch and Mulaire, hrown recluse spider. Poisonous. Bite serious, necrotic and ulcerative. Lives in buildings, wood piles, cracks in the ground (Baerg, 1959).

Family Theridiidae

Latrodectus mactans (Fab.), black widow spider. Poisonous. Neurotoxic and systemic reaction. Found under stones, in brush piles, and vacant animal burrows (Baerg, 1959).

Order Acarida (Mites, Ticks, Chiggers)

Family Ixodidae

Dermacentor variabilis (Say), wood tick. Transmits causative agent of Rocky Mountain spotted fever; causes tick paralysis (Stannard, 1967). Field mice host immature stages. Most mammals except rabbits attacked by adults. Woodland and brushy habitat.

Amblyomma americanum (Linn), lone star tick. Bite extremely irritating to human skin. Possibly transmits Rocky Mountain spotted fever and tularemia. Attacks rabbits especially. Woodland and brushy habitat (Stannard, 1967).

Ixodes scapularis Say, black-legged tick. Causes dermatosis. Attacks mammals and birds (Herms and James, 1961).

Family Dermanyssidae

Dermanyssus gallinae (DeGreer), chicken mite. Bite in man results in dermatitis. Transmits St. Louis and equine encephalitis. Primarily a chicken parasite (Baker, 1956).

Ornithonyssus sylvarium (Cane and Fan.), northern fowl mite. Transmits St. Louis and western equine encephalitis. Parasitizes domestic or wild fowl.

O. bursa (Berlese). Fowl parasite. Bite in man causes dermatitis.

Echinolaelaps enchidnus (Berlese), spiny rat mite. Reservoir of causative agent of tularemia.

Haemolaelaps glasgowi (Ewing), common rodent mite. Reservoir or causative agent of tularemia.

Family Pyemotidae

Pyemotes ventricosus (Newport), hay itch mite. Causes severe dermatitis and secondary infections. Parasitizes insect larvae which are pests of grains and hay (Baker, 1956).

Family Demodicidae

Demodox spp., follicle mites. Implicated in skin disorders and dermatitis. Several different mammals attacked by species in this genus (Baker, 1956).

Family Trombiculidae

Trombicula alfreddugesi (Oudemans), chigger. Bites result in dermatitis and an allergic reaction. Many vertebrates parasitized; man is an accidental host (Baker, 1956).

Family Sarcoptidae

Sarcoptes scabei (DeGreer), itch mite. Burrows into skin and causes severe irritation which may lead to secondary infection. Man and domestic animals affected (Baker, 1956).

Class Insecta

Order Orthoptera (Grasshoppers and Allies)

Family Blattidae (Cockroaches)

Parcoblatta spp., wood cockroaches. Six species recorded in the unprotected flood plain, younger stand. Roaches in general transmit viral, bacterial, fungal, and protozoan diseases (Roth and Willis, 1957).

Order Hemiptera (True Bugs)

Family Reduviidae (Assassin Bugs)

Reduvius spp., assassin bugs. Can inflict painful bite; local inflammation and swelling may follow (Horsfall, 1962).

Arilus cristatus (Linn.), wheel bug. Can inflict painful bite; local inflammation and swelling may occur (Herms and James, 1961). This and the previous species prey on other invertebrates.

Order Coleoptera (Beetles)

Family Staphylinidae (Rove Beetles)

Occur around decaying plant and animal material. Some species found in the Mississippi flood plain may transmit anthrax (Herms and James, 1961).

Paederus spp. Cause painful blisters upon contact with human skin (Faust, et al., 1968)

Family Silphidae (Carrion Beetles)

Silpha spp. and Nicrophorus spp. Both collected in a mammal can trap in the unprotected flood plain. Transmit anthrax (Horsfall, 1962).

Family Dermestidae (Skin Beetles)

Various life stages transmit anthrax (Herms and James, 1961); invade the auditory canal of man; cause an allergic reaction, possibly asthma (Faust, et al., 1968).

Family Scarabaeidae (Scarab or Lamellicorn Beetles)

Implicated in disease transmission. Scavengers, some carrion and dung feeders (Horsfall, 1962).

Family Oedemeridae (False Blister Beetles)

Implicated in disease transmission. Larvae thrive in moist decaying wood, especially driftwood (Faust, et al., 1968).

Family Ptinidae (Spider Beetles)

Implicated in disease transmission (Faust, et al., 1968).

Family Melodidae (Blister Beetles)

Causes blisters upon contact with human skin (Herms and James, 1961).

Family Curculionidae (Weevils)

Some species cause allergic reactions similar to that of the skin beetles (Faust, et al, 1968)

Order Lepidoptera (Moths and Butterflies)

Family Noctuidae

With urticating hairs. Contact with skin causes inflammation and possible systemic disturbance (Matheson, 1950).

Catocala spp., underwings. Taken in unprotected flood plain on levee and in younger stand.

Order Diptera (Flies)

Family Culicidae (Mosquitoes)

Includes the flood water mosquitoes who lay eggs in soil which is seasonally flooded; eggs hatch under the stimulus of moisture. 55 species in Illinois, 51 in Missouri. Some of the most important species are listed (Ross and Horsfall, 1965; Smith, 1955).

Aedes spp. Eggs laid in woodland depressions, ditches, borrow pits, and artificial containers.

A. aegyptii (Linnaeus). Probably eastern, western, and St. Louis encephalitis. Prefers human blood to blood of other animals.

A. dorsalis (Meigen). Western equine encephalitis and St. Louis encephalitis.

A. thibaulti Dyar and Knab. Painful biter. Locally abundant in southeast Missouri.

Anopheles spp. Transmit tularemia, malaria, and encephalitis. Eggs laid around pools and marshy areas with vegetation.

A. crucians Wiedermann. Transmits malaria.

A. quadrimaculatus Say. Most important malarial vector in southeastern United States. Abundant around suitable breeding areas.

Culex pipiens Linnaeus, northern house mosquito. Western equine and St. Louis encephalitis, possibly tularemia. Breeds in ditches and artificial containers. Persistent biter.

Culiseta spp. All strains of equine and St. Louis encephalitis.

Family Simuliidae (Black Flies, Gnats)

Bite can be severe and serious, causing extreme pain, itching, and swelling. Larvae attach to rocks or vegetation in running water. Floods may wash in large numbers of eggs; with subsequent flooding they hatch, the larvae develop, and huge swarms of adults may result. Livestock, man, and presumably wild animals are attached (Herms and James, 1961).

Family Chloropidae (Fruit Flies, Eye Gnats)

Hippelates spp., eye gnats. Involved in mechanical transmission of pinkeye (Graham-Smith, 1930). Eggs laid on freshly disturbed ground with high moisture content. Larvae found in decaying material (Stone, *et al.*, 1965).

Family Tabanidae (Horse Flies, Deer Flies)

Swarm annoyingly, cause painful bites, act as mechanical and cyclic disease vectors. Harrassment of livestock can lead to weakened condition. Eggs deposited on aquatic vegetation or vegetation overhanging water. Larvae found in moist soil, humus, and mud of flood plains and ditches (Anthony, 1962).

Tabanus spp., horse flies. Transmit anthrax and causative agent of tularemia. Pests around sand areas.

Chrysops spp., deer flies. Transmit anthrax and causative agent of tularemia, and possibly other diseases. Swarm around the head persistently.

Family Muscidae (Miscid Flies)

Responsible or partly responsible for transmission of typhoid, paratyphoid, cholera, dysentery, salmonella enteris, anthrax, conjunctivitis, poliomyelitis, and tuberculosis (Herms and James, 1961; West, 1951). Transmit eggs of several parasitic worms. Produce traumatic myiasis and pseudomyiasis (James, 1947). Larvae and adults feed on excreta and carrion, adults associate freely with man. Transmission is mechanical or due to regurgitation during feeding (Matheson, 1950). Many species in this family are found in the unprotected flood plain, all of which can bring about one or more of the above problems. Includes *Musca domestica* Linn., the common housefly (West, 1951).

Culex pipiens Linnaeus, northern house mosquito. Western equine and St. Louis encephalitis, possibly tularemia. Breeds in ditches and artificial containers. Persistent biter.

Culiseta spp. All strains of equine and St. Louis encephalitis.

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Family Vespidae (Vespoid Wasps)

Vespula spp., bald-faced hornets, yellow jackets. Venomous and agressive. Most build nests underground (Horsfall, 1962).

Polistes spp., paper wasps. Venomous. Build nests in buildings (Horsfall, 1962).

Family Sphecidae (Sphecid Wasps)

Potent stings. Nest in wood, often found on flowers (Horsfall, 1962).

Family Apidae (Bees)

Bombus spp., bumble bee. Venomous. Ground nester (Faust, *et al.*, 1968).

Apis mellifera (Linn.), honey bee. Venomous. Partially domesticated, also nests in trees (Faust, *et al.*, 1968).

2.2.3 RARE AND ENDANGERED SPECIES

2.2.3.1. United States List

Information on the status of fauna recognized nationally as endangered has been taken from the "United States List of Endangered Fauna" (U. S. Department of the Interior, 1974). These lists include those biotic species which are in danger of extinction through out all or a significant portion of their range. Protection has been established for these species and their habitat, in accordance with the Endangered Species Act of 1973 (Public Law 93-205; 87 Stat. 884). Three species ff fauna with this classification, the peregrine falcon, southern bald eagle, and Indiana bat, occur within the Middle Mississippi River project area (Table 2-5a). All three species are extermely uncommon within the project area as well as other portions of their range.

Table 2-5a. Endangered Fauna of the Middle Mississippi River.

Common Name	Scientific Name
Peregrine Falcon	Falco peregrinus anatum (Bonaparte)
Southern Bald Eagel	Haliaeetus leucocephalus leucocephalus (Linnaeus)
Indiana Bat	Myotis sodalis Miller and Allen

2.2.3.2. State Lists

a. General. Information on the status of flora and fauna recognized by the states of Illinois and Missouri as rare or endangered has been taken primarily from three lists: (1) Rare and Endangered Vertebrates of Illinois, Preliminary Draft (Illinois Nature Preserves Commission, 1971), (2) Rare and Endangered Fish of Illinois (Lopinot and Smith, 1973), and (3) Rare and Endangered Species of Missouri (Missouri Department of Conservation and Soil Conservation Service, 1974).

b. Plants. The identification of rare and endangered plant species is presently limited to recognition on a state by state basis only. The State of Missouri has published such a listing (Rare and Endangered Species of Missouri), but no similar publication is available for the State of Illinois at this time.

A literature search for rare and endangered plant species which occur in the seven Missouri counties adjoining the Mississippi River revealed that there are 64 such species which may occur on the unprotected flood plain (Appendix F).

c. Aquatic Invertebrates. The status of rare and endangered invertebrates is very fragmentary. The State of Illinois has not adopted such a list to date. Missouri included a number of invertebrates on its list of rare and endangered species, but no attempt was made to assign a status to any species. None of the benthic organisms collected by Emge, et al. (1974) or Ragland (1974) was included on Missouri's rare and endangered list.

d. Aquatic Vertebrates. Six species of fish which inhabit the reaches of the Middle Mississippi River are recognized as "rare" or "endangered" either by the States of Ill nois or Missouri (Appendix G). The alligator gar has been given protection from harvest by commercial fishing in Illinois, and the pallid sturgeon has been given the same protection in Missouri (Illinois Fishing Information, 1974-1975; Missouri Conservation Commission, 1975).

e. Terrestrial Invertebrates. Although the list of rare and endangered species of Missouri includes invertebrates, the State of Illinois has not yet adopted such a listing. Because of the complexity of this group, and the lack of information pertaining to individual species diversity and distribution, no attempt has been made to identify rare and endangered invertebrates for the purpose of this report.

f. Terrestrial Vertebrates. A total of 67 terrestrial vertebrate species which occur in the project area are recognized under either or both of Illinois' and Missouri's, "Rare and Endangered Species Program" (Appendix G).

2.3. CULTURAL ELEMENTS

2.3.1. DEMOGRAPHY

2.3.1.1. Population

In 1970 the population of the counties bordering the stretch of river considered in this environmental statement was 1,584,941. The vast majority of this population was confined to Jefferson, St. Louis, and St. Clair Counties which are part of the St. Louis Standard Metropolitan Statistical Area (SMSA). The population of these metropolitan counties accounts for almost 85 percent of the total population of the study area. The rest of the study area is relatively sparsely settled, with the exception of Cape Girardeau County, Missouri, and Jackson County, Illinois, which contains the cities of Cape Girardeau and Carbondale, respectively.

Population fluctuations in the study area in recent decades have mirrored trends occurring on a national scale. Metropolitan counties or counties with ready access to metropolitan areas have grown, while counties with a rural based economy or which were inaccessible to urban areas have been bypassed by growth and in many instances have experienced declining populations. This trend can be seen in Table 2-6 below, which compares population rates of change in study area counties from 1950 to 1970.

Table 2-6. Rate of population change by percent, 1950-1970.

County	Percent Change
St. Louis	173.7
Jefferson	176.9
Ste. Genevieve	14.5
Perry	-3.3
Cape Girardeau	28.5
Scott	1.2
St. Clair	38.4
Monroe	41.8
Randolph	-.9
Jackson	44.3
Union	-21.6
Alexander	-40.9

Source: U. S. Census of Population, 1950-1970.

As can be seen in Table 2-6, the metropolitan counties identified above experienced substantial growth over the two decades, as did Cape Girardeau and Jackson Counties. Monroe County's location in the zone of the St. Louis SMSA also placed it in a formable position for growth. The other counties in the study area have grown at a slower rate, or have experienced substantial losses in their population base.

Again, this is a national phenomenon caused, in part, by the centralization of business and, therefore, job opportunities in urban areas. With the corresponding reduction in the amount of agricultural employment opportunities due to farm mechanization, rural-based populations have been forced to relocate in or near urban areas. Unless factors which alter these centralization processes occur, it can be expected that future population growth will largely accrue to the metropolitan portion of the study area, and the more urban counties of Cape Girardeau and Jackson. Population projections prepared by the offices of the Missouri and Illinois State Governments predict that population in the metropolitan counties of Jefferson, St. Louis, and St. Clair will increase 41 percent between 1970 and 1990, while for other counties the increase should total about 18 percent.

2.3.1.2. Spatial Distribution

Within each county interval redistribution of population can occur. Since this environmental statement is most concerned with the interface of river and land, those townships of counties fronting on the river are important. In general, the trend over the past decade concerning population distribution, has been a proportional reduction in riverward township's share of study area population. Of the 24 townships fronting the river, 20 (83 percent) grew at a slower rate or lost proportionately more of their population between 1960 and 1970 than did their respective counties. This fact tends to indicate that on the whole, population movement in the study area counties has occurred away from the river.

In addition to differences in proportional distribution of population, counties vary as to the type of residences of their population. Almost 87 percent of the population of metropolitan counties reside in urban areas compared with 53 percent of the population living in the rest of the study area counties. Similar differences, shown in Table 2-7 are present in rural farm and rural non-farm places of residences.

Table 2-7. Place of residences.

Place	Percent Urban	Percent Rural Farm	Percent Rural Non-Farm
Metropolitan Counties	86.9	.8	12.3
Non-metropolitan counties	52.8	11.7	35.5

Source: U. S. Census of Population, 1970.

The figures in Table 2-7 above have been aggregated, and there is wide variation within both groups. For example, in Jefferson County, part of the metropolitan group, 81 percent of the population is classified as rural non-farm; while in the non-metropolitan counties of Cape Girardeau and Jackson a higher proportion of urban residential distribution is found than Table 2-7 indicates. Nevertheless, the general picture that emerges from considering rural-urban data, is of two distinct types of areas having different patterns of residential distribution.

2.3.1.3. Migration

Net migration figures for 1970 substantiate the conclusion that differential rates of population growth among counties in the study area correspond to the relative attractiveness of metropolitan and urban areas as growth and job opportunity centers. In viewing migration totals, it is metropolitan counties and those counties with expanding industries that have attracted new residents while other counties have lost part of their population to these growth centers (Table 2-8).

Table 2-8. Net migration 1960 to 1970.

County	Net Migration (percent)
St. Louis	21.7
Jefferson	37.6
Ste. Genevieve	-3.1
Perry	-9.2
Cape Girardeau	9.6
Scott	-10.6
St. Clair	-3.3
Monroe	12.8
Randolph	.4
Jackson	19.8
Union	-10.4
Alexander	-2.1

Source: U. S. Census of Population, 1970.

2.3.2. ECONOMIC CHARACTERISTICS

2.3.2.1. The Mississippi River System

The Mississippi River plays a vital part in the national economy, providing low-cost water transportation to the eastern, southern, and central United States, and to the west by way of intermodal transfer. The Mississippi River system consists of the main channels and all navigable tributaries of the Mississippi, Illinois, Missouri, and Ohio Rivers.

For navigation purposes, the Mississippi River itself is divided into upper and lower reaches. The lower Mississippi extends from the Gulf of Mexico 100 miles south of New Orleans north to Cairo, Illinois, a distance of 984 miles. On the lower reach, a nine-foot channel for river commerce is maintained through dredging. The upper Mississippi River extends north from Cairo, Illinois, to Minneapolis, Minnesota, a distance of 853 miles. From St. Louis northward, a series of 29 dams has been constructed on the Mississippi River to maintain the necessary depth. The project area, from St. Louis to Cairo, is open river, and is also maintained by dredging.

On the Mississippi River system, tonnages of commodities shipped has increased continually over the past decade. Table 2-9 details the increases over the entire system, and in the areas with which the study is concerned.

Table 2-9. Inland waterborne commerce, 1962 and 1972.

	Million Tons (short tons)		
	1962	1972	Percent Increase
Mississippi River System	200.0	326.6	63
Minneapolis to Gulf	92.0	178.8	94
St. Louis to Cairo	35.1	67.5	92

Source: U. S. Army Engineer Division, Lower Mississippi Valley, 1972.

Major commodities transported on the system are grain, coal, petroleum products, cement, sand and gravel, industrial and agricultural chemicals, iron ore, steel, and metal products. Table 2-10 provides information on the relative amounts of the major kinds of products shipped on the system in 1971.

Table 2-10. Commodity distribution, 1971.

Commodity	Million Tons	Percentage of Total
Grains	23.1	7.6
Coal	96.7	31.9
Petroleum Products	77.6	25.6
Others	105.8	34.9
	303.2	100.0

Source: U. S. Army Engineer Division, Lower Mississippi Valley, 1972.

The project reach is a key link in the inland waterways system. It ties together the Upper Mississippi, Illinois, and Missouri Rivers to the north and the Ohio River system and the Lower Mississippi River and their tributary waterways to the south.

The importance of this link is demonstrated in the fact that, despite the presence of the largest port (St. Louis) in the system in the reach, in 1972 approximately two thirds of the tonnage passing through the reach neither originated nor ended there.

Table 2-11 presents a breakdown of tonnage moving in the reach between the mouth of the Missouri and the mouth of the Ohio by commodity type and origin-destination-direction categories. A breakdown for the project area alone is not available.

Major commodities transported in the reach are the same as those on the system. A total of 47,007,337 tons, or nearly 70 percent of the total tonnage in 1972, consisted of just three commodities: grain, coal, and petroleum. Thirty-seven percent of total tonnage was in grain alone.

2.3.2.2. Regional Economy

The project area includes two district economic regions. Bordering the northernmost portion of the reach is the St. Louis metropolitan area, characterized by a 1970 population of 2.4 million people, a large and diversified manufacturing base and the largest port in the inland waterways. South of St. Louis, by contrast, the river flows through a largely rural area, with few towns or ports, until it reaches Cairo. Because of the diverse nature of the two areas, it is appropriate to consider them separately.

a. St. Louis Area.

(1) Industries and Employment. The economy of the St. Louis region is quite diverse with a rather broad manufacturing base. Manufacturing makes up about 25 percent of employment, commerce 25 percent,

Table 2-11. Internal Commodity Tonnage by Commodity and Direction, Mouth of Missouri to Mouth of Ohio, 1972

Commodity	Total	Upbound	Inbound Upbound	Outbound Upbound	Through Upbound	Downbound	Inbound Downbound	Outbound Downbound	Through Downbound
Grain	24,958,048	--	--	4,515	3,255	1,427	492,680	1,707,158	22,749,013
Coal	11,752,901	1,286,678	370,108	5,743,842	2,206,808	19,195	--	2,123,602	2,668
Petro	10,296,388	24,293	1,853,360	921,138	4,860,438	118,826	656,695	303,401	1,558,237
CS&G	2,711,019	781,050	--	232,786	9,550	211,725	211,566	665,567	598,775
I & S	2,259,335	--	278,366	32,843	799,607	--	171,726	94,410	882,383
Ind. Chem.	[illegible]	--	305,603	226,239	[illegible]	[illegible]	[illegible]	154,099	312,76[illegible]
[illegible]	[illegible]	--	263,576	158,895	2,341,399	--	1,467	8,291	94,53[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	67,204,552	2,734,829	3,840,089	7,835,431	16,698,687	466,623	1,736,929	6,003,156	27,888,80

services and government 30 percent, and the remaining 20 percent is miscellaneous employment categories (see Table 2-12).

Major manufacturing industries of both durable and non-durable goods are located in the region. The largest industrial groups are the transportation equipment industries, automotive manufacturing industry, aircraft and electronics industries, the chemical industry, the food processing industries, and metal processing and metal products industries (see Table 2-13).

Regional employment was 980,000 persons in 1968 and has decreased since that time to a 1972 figure of 961,000. The loss of employment has been concentrated in the manufacturing segment which declined from 292,000 to 257,000 in the same period (U. S. Department of Labor, 1969 and 1972).

The regional economy, as measured by employment, has not compared favorably with either the national economy or other metropolitan areas in recent years. Since 1969, St. Louis regional employment has declined an average of 1.2 percent per year, compared to a national increase of 2.2 percent per year, and an average of 0.1 percent per year increase for selected metropolitan area (East-West Gateway Coordinating Council, 1973).

Intra-regional employment shifts within the St. Louis region over the 1956-1971 period have consisted of sizable declines of employment in the City of St. Louis - particularly in the area of manufacturing employment and wholesale trade - and an overall decline in the city's share of employment from 62.9 percent in 1956 to 48.0 percent in 1971. At the same time, St. Louis County's share of regional employment increased from 15.1 percent in 1956 to 31.4 percent in 1971 (see Table 2-14).

(2) Unemployment. From 1968 to 1971, unemployment grew steadily in the St. Louis region, reaching a high of 6.2 percent in 1971. Since 1971, the unemployment rate has remained higher than during the periods of peak employment of 1968 and 1969, however, the rate has dropped somewhat (see Table 2-15).

The three outlying Missouri counties (St. Charles, Jefferson, and Franklin) still have a small share of the employment, but are growing significantly. The two major Illinois counties (Madison and St. Clair) have a declining share of the regional employment, while Monroe County has remained at its 1956 percentage level (East-West Gateway Coordinating Council, 1973).

Table 2-12. St. Louis area employment.

	Annual Average Employment (000)			Percent of Total Employment	Percent Change
	1964	1968	1972	1972	1964-72
Civilian Work Force	918	1,019	1,024		+ 11.5
Unemployment	37	35	62		+ 67.6
Employment - Total	879	980	961	100.0	+ 9.3
Manufacturing	269	293	257	26.8	- 4.5
Durable Goods	161	184	163		+ 1.2
Non-Durable Goods	108	109	94		- 13.0
Non-Manufacturing	514	601	624	64.9	+ 21.4
Mining	3	2	3	0.3	
Construction	40	42	32	3.3	- 20.0
Transportation Communication, Public Utilities	63	68	64	6.7	- 1.5
Commerce	160	183	192	20.0	+ 20.0
Finance, Insurance, Real Estate	40	45	47	4.9	+ 17.5
Services	117	142	156	16.2	+ 33.3
Government	91	120	130	13.5	+ 45.0
Other Non-Agricultural	83	76	70	7.3	- 15.7
Agricultural	14	11	10	1.0	- 28.6

NOTE: Numbers may not total due to rounding.

Source: U. S. Department of Labor, 1973.

Table 2-13. Employment by industry group, St. Louis Region

	Annual Average Employment (000)		
	1964	1968	1972
Manufacturing	268.6	292.6	256.7
Durable Goods	161.0	183.6	162.7
Primary Metal Industries	25.9	23.7	21.4
Fabricated Metal Products	18.3	21.5	19.9
Machinery, Except Electrical	18.2	20.8	20.5
Electrical Equipment and Supplies	14.2	19.3	17.2
Transportation Equipment	56.7	66.7	58.6
Other	27.7	31.6	25.1
Non-Durable Goods	107.6	109.0	94.0
Food and Kindred Products	29.1	27.8	23.0
Printing and Publishing	14.3	15.1	15.2
Chemicals and Allied Products	21.5	24.1	20.5
Textiles and Apparel	14.9	13.5	11.5
Others	27.8	28.5	22.9

Source: U. S. Department of Labor, 1973

Table 2-14. Shares of regional employment, St. Louis Region.

	1956	1971
City of St. Louis, Mo.	62.9%	48.0%
St. Louis County Mo.	15.1%	31.4%
St. Charles County, Mo.	1.1%	2.2%
Franklin County, Mo.	1.4%	1.7%
Jefferson County, Mo.	1.2%	1.5%
Madison County, Ill.	9.9%	8.3%
Monroe County, Ill.	0.2%	0.2%
St. Clair County, Ill.	8.0%	6.7%

Table 2-15. Annual average unemployment - St. Louis Region.

1968	3.4%
1969	3.5%
1970	5.4%
1971	6.2%
1972	6.0%
1973 (first 9 mos.)	5.2%

Source: Missouri Division of Employment Security, Clayton Office, 1973.

Compared to other metropolitan regions (data for March only) the St. Louis regional unemployment rate of 6.0 percent for 1972 compared to a median rate of 4.7 percent for other selected metropolitan regions (East-West Gateway Coordinating Council, 1973).

(3) Personal income. Figures citing personal income for the region on a year-by-year basis are not generally available; however, effective buying income, which normally represents 80 to 85 percent of total income, illustrates the changes that have occurred in the region.

Effective buying income for the St. Louis region is estimated at $9.4 billion for 1972, up an average of 37.5 percent since 1967 (See Table 2-16). Effective buying income has increased at a rate greater than the consumer price index for the area and represents an actual gain in income.

Table 2-16. Effective buying income - St. Louis Region.

	Consumer [1] Price Index St. Louis	Established[2] Buying Income St. Louis Region	Effective[3] Buying Income in 1967 Dollars
1967	100.8	$6.9 Billion	$6.9 Billion
1970	116.6	8.2 Billion	7.1 Billion
1971	120.5	8.7 Billion	7.3 Billion
1972	123.6	9.4 Billion	7.7 Billion

Sources: 1. Sales Management, 1973.
2. U. S. Department of Labor Statistics, 1973.
3. Estimated by Harland, Bartholomew and Associates, 1974.

b. Economic Conditions.

(1) General. Tables 2-17 and 2-18 present county-level information for Missouri and Illinois on both a rural farm and rural non-farm basis. Since few cities exist on or near the Mississippi River flood plain between St. Louis and Cairo, these figures reflect typical incomes of people living on the flood plain in rural environments. Particular note should be made of the large percentage of families whose incomes fall below the poverty level, noting the general increase in this figure with distance from the St. Louis Metropolitan Area. These levels range up to a high of 40.9 percent for Mississippi County, Missouri. Tables 2-19 and 2-20 contain income data on an overall county and state basis to include urban areas, and a noticeable decrease in poverty level percentages is apparent. Ste. Genevieve and Cape Girardeau Counties in Missouri and all listed Illinois counties have significant flood plain areas and the generally low incomes noted in county summaries are necessarily important factors for consideration.

Table 2-17

Personal Income Characteristics of Missouri Counties, Bordering the Middle Mississippi River Floodplain, 1970 Census

	Rural Nonfarm					
	Jefferson	Ste. Genevieve	Perry	Cape Giradeau	Scott	Mississippi
			1969 Incomes			
Median income of families, in dollars	9,899	7,916	6,467	7,191	6,666	4,497
Mean income of families, in dollars	10,251	8,333	7,294	7,788	7,340	5,603
			Income < Poverty Level			
Number of families	1,339	192	252	278	650	573
Percent of families	6.6	15.0	19.0	15.0	19.3	40.9
Number of unrelated individuals	1,160	144	270	258	379	235
Percent of unrelated individuals	44.0	56.0	70.5	54.0	57.1	71.6

Table 2-17 (Concluded)

	Rural Farm					
	Jefferson	Ste. Genevieve	Perry	Cape Giradeau	Scott	Mississippi
			1969 Incomes			
Median income of families, in dollars	8,950	7,129	5,574	6,180	7,802	5,671
Mean income of families, in dollars	9,730	8,372	6,372	7,489	10,332	6,564
			Income < Poverty Level			
Number of families	215	92	181	299	113	167
Percent of families	11.4	13.3	17.2	18.3	14.8	26.1
Number of unrelated individuals	128	28	40	85	57	46
Percent of unrelated individuals	45.6	--	--	43.4	51.8	41.8

Table 2-18

Personal Income Characterisitcs of Illinois Bordering the Middle Mississippi River Floodplain, 1970 Census

	Monroe	Randolph	Jackson	Union	Alexander
		Rural Nonfarm			
1969 Incomes					
Median Income of families ($)	8,503	8,952	7,739	6,535	5,608
Mean Incomes of families ($)	9,162	9,350	8,653	7,758	6,263
Incomes < Poverty Level					
Number of families	118	274	579	439	328
Percent of families	6.1	8.5	14.5	19.8	32.6
Number of Unrelated Individuals	137	547	1,326	345	202
Percent of Unrelated Individuals	55.2	61.0	60.8	60.4	72.4
		Rural Farm			
1969 Incomes					
Mediam Incomes of families ($)	9,338	7,753	7,972	7,168	3,717
Mean Incomes of families ($)	10,130	8,467	9,628	8,607	4,888
Incomes < Poverty Level					
Number of Families	102	158	122	86	183
Percent of Families	9.0	11.6	13.7	11.2	31.4
Number of Unrelated Individuals	[illegible]	63	83	37	69
Percent of Unrelated Individuals	[illegible].6	39.6	44.1	--	56.1

Table 2-19

Employment Characteristics for Missouri Counties Bordering the Middle Mississippi River Floodplain, 1970 Census

Area	Nonworker-Worker Ratio	Percent in Labor Force: Female, 16 Years and Over	Percent in Labor Force: Married Women, Husband Present: Total	Percent in Labor Force: Married Women, Husband Present: With Own Children Under 6 Years	Percent in Labor Force: Male: 18 to 24 Years	Percent in Labor Force: Male: 65 Years and Over	Civilian Labor Force-Percent Unemployed	Employed Persons: Percent in Manufacturing Industries	Employed Persons: Percent in White-collar Occupations	Employed Persons: Percent Government Workers	During Census Week-Percent Working Outside County of Residence	Persons Who Worked in 1969-Percent Worked 50 to 52 Weeks	Families: Median Income (Dollars)	Families: Percent with Income of-Less than Poverty Level	Families: Percent with Income of-$15,000 or More
Missouri	1.46	[illegible]	39.4	30.9	75.8	25.1	4.2	24.1	[illegible]	14.8	[illegible]	[illegible]	8,914	11.5	17.1
Counties															
St. Louis	1.30	42.6	38.6	[illegible]	74.6	32.5	3.4	27.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.6	33.3
Jefferson	1.62	37.3	35.7	28.1	84.2	21.0	5.4	35.0	36.3	9.5	55.7	60.2	9,742	7.2	14.3
Ste. Genevieve	1.91	32.4	32.6	30.4	85.3	14.6	2.3	36.2	25.8	9.1	22.0	64.1	8,020	13.6	[illegible]
Perry	1.69	34.4	36.3	35.4	73.6	35.7	3.0	31.7	25.7	8.5	17.5	57.9	6,518	16.9	6.7
Cape Girardeau	1.39	41.5	41.4	38.1	60.5	25.8	4.1	19.9	44.4	15.2	10.3	54.2	8,155	11.3	12.5
Scott	1.68	39.8	41.0	39.2	75.1	18.3	3.8	21.2	37.9	13.0	17.8	60.3	7,288	16.1	11.0
Mississippi	2.17	33.7	37.5	29.7	70.8	10.0	7.3	18.2	30.8	14.2	15.3	49.0	4,933	33.4	5.8

Table 2-20

Employment Characteristics for Illinois Counties Bordering the Middle Mississippi River Floodplain, 1970 Census

		Percent in Labor Force						Employed Persons					Families		
			Married Women, Husband Present		Male						During Census Week-Percent Working Outside County of Residence	Persons Who Worked in 1969-Percent Worked 50 to 52 Weeks		Percent Income of-	
State	Nonworker-Worker Ratio	Female, 16 Years and Over	Total	With Own Children Under 6 Years	18 to 24 Years	65 Years and Over	Civilian Labor Force-Percent Unemployed	Percent in Manufacturing Industries	Percent in White-collar Occupations	Percent Government Workers			Median Income (Dollars)	Less than Poverty Level	$15,000 or More
Illinois	1.37	43.3	39.8	25.5	74.4	27.9	3.7	30.3	49.1	13.1	13.1	56.6	10,959	7.7	26.4
Counties															
St. Clair	1.62	38.9	37.0	27.0	78.8	24.2	6.1	24.1	45.0	25.8	33.3	59.8	9,547	12.4	17.7
Monroe	1.61	33.5	33.3	23.0	85.9	29.0	2.8	20.3	35.5	11.9	46.9	67.7	9,332	7.4	14.5
Randolph	1.66	36.1	34.8	27.4	55.1	31.1	3.2	28.8	29.1	13.5	10.9	66.1	8,918	9.0	13.5
Jackson	1.64	38.6	40.2	34.0	39.1	23.3	4.9	12.0	53.6	38.9	8.4	39.2	7,915	14.1	14.8
Union	1.61	35.1	38.3	34.1	72.2	25.3	4.7	18.2	33.6	29.5	15.1	60.5	7,115	16.2	9.4
Alexander	1.86	35.5	34.4	26.8	77.9	23.8	8.3	15.9	37.6	17.9	13.2	53.5	5,471	31.2	8.3

The Upper Mississippi River Comprehensive Basin Study (UMRCBS) estimates personal income through 2020 according to plan areas. The St. Louis-to-Cairo region falls within three plan areas with indexes of personal income given in Table 2-21 below.

Table 2-21.. Personal income index.

	Index, based on 1960 = 100					
Plan Area	1970	1980	1990	2000	2010	2020
6 - Kaskaskia	134	176	226	300	389	482
7 - Big Muddy	137	182	234	308	400	488
8 - Meramec	134	173	215	273	246	423

(2) Occupation - Employment. Tables 2-22 and 2-23 list 1970 census information on occupations within those counties bordering the Mississippi River between St. Louis and Cairo. Manufacturing is the major occupational grouping in all counties, but is particularly significant in the St. Louis Metropolitan Area and nearby counties. Employment in the Agricultural, Forestry, and Fisheries occupations is significant in the case of several counties and data for this are shown in Table 2-23a below.

Table 2-23a. Agricultural, forestry, and fisheries occupation index

Missouri		Illinois	
St. Louis	0.62%	St. Clair	1.76%
Jefferson	1.55%	Monroe	12.94%
Ste. Genevieve	8.01%	Randolph	9.46%
Perry	15.34%	Jackson	3.67%
Cape Girardeau	6.94%	Union	10.21%
Scott	7.09%	Alexander	5.61%
Mississippi	20.39%		

The highest percentages (10 percent) are generally associated with comparatively low values for total employment and median earnings except in the case of Monroe County. The higher employment and earnings data for Monroe County reflect the influence of the nearby St. Louis urban area.

Projected employment indexes, based on UMRCBS plan areas, are given as follows (Table 2-24):

Table 2-22

Occupation and Earnings Data Summary for Missouri Counties Bordering the Middle Mississippi River Floodplain, 1970 Census

Counties	St. Louis City	St. Louis	Jefferson	Ste. Genevieve	Perry	Cape Girardeau	Scott	Mississippi
OCCUPATION								
Total employed, 16 years old and over	231,765	384,409	37,563	4,243	5,110	19,572	11,820	4,781
Professional, technical, and kindred workers	25,413	76,618	3,571	314	323	2,586	1,138	435
Managers and administrators, except farm	10,444	41,473	3,329	264	266	1,819	1,122	308
Sales workers	11,730	39,127	1,776	159	280	1,681	742	263
Clerical and kindred workers	50,086	81,032	5,946	338	445	2,605	1,483	467
Craftsmen, foremen, and kindred workers	24,121	52,485	8,195	735	681	2,691	1,715	568
Operatives, except transport	40,153	33,486	7,468	969	1,146	2,671	1,936	825
Transport equipment operatives	9,970	12,019	2,234	301	320	391	788	148
Laborers, except farm	13,066	11,282	1,977	290	241	770	436	191
Farmers and farm managers	171	594	299	288	645	981	522	411
Farm laborers and farm foremen	514	541	[illegible]	37	[illegible]	274	246	512
Service workers, except private household[1]	39,839	33,097	3,407	476	572	2,261	1,491	455
Private household workers	6,258	2,655	209	52	57	342	201	198
MEDIAN EARNINGS IN 1969 OF PERSONS IN EXPERIENCED CIVILIAN LABOR FORCE FOR SELECTED OCCUPATION GROUPS								
Male, 16 years old and over with earnings[2]	$6,791	$9,480	$8,211	$6,655	$5,340	$6,288	$6,142	$4,369
Professional, managerial, and kindred workers	8,716	12,552	9,719	8,659	7,677	8,871	8,357	6,886
Craftsmen, foremen, and kindred workers	7,856	9,781	9,185	7,758	6,400	7,130	6,571	5,099
Operatives, including transport	6,646	7,942	7,836	6,720	5,548	5,347	5,579	4,202
Laborers, except farm	5,517	5,627	6,588	5,329	3,625	4,393	4,404	3,050
Farmers and farm managers	6,100	5,138	3,167	5,286	2,957	2,977	6,882	5,517
Farm laborers, except unpaid, and farm foremen	2,385	2,833	--	--	2,636	2,340	2,533	2,884
Female, 16 years old and over with earnings[2]	$3,829	$4,014	$3,586	$2,799	$2,901	$3,106	$3,200	$2,736
Clerical and kindred workers	4,425	4,381	4,036	3,113	3213	3,167	3,435	3,658
Operatives, including transport	3,836	4,325	3,843	3,448	3,250	3,475	3,462	2,961

1 Includes allocated cases, not shown separately.
2 Includes persons in other occupation groups, not shown separately.

Table 2-23

Occupation and Earnings for Illinois Counties Bordering the Middle Mississippi River Floodplain, 1970 Census

Counties	St. Clair	Monroe	Randolph	Jackson	Union	Alexander
OCCUPATION						
Total employed, 16 years old and over	96,020	6,869	11,232	19,651	5,796	3,800
Professional, technical, and kindred workers	11,546	580	863	4,312	602	358
Managers and administrators, except farm	5,768	393	681	1,558	495	367
Sales workers	6,328	396	475	975	298	216
Clerical and kindred workers	19,527	1,072	1,249	3,681	550	489
Craftsmen, foremen, and kindred workers	14,254	1,303	2,173	1,875	797	383
Operatives, except transport	13,313	856	1,849	2,045	839	538
Transport equipment operatives	5,539	390	520	590	319	190
Laborers, except farm	5,234	350	641	701	334	219
Farmers and farm managers	1,061	613	801	460	322	98
Farm laborers and farm foremen	428	233	215	186	210	95
Service workers, except private household[1]	11,996	627	1,670	3,030	961	766
Private household workers	1,026	56	95	238	69	81
MEDIAN EARNINGS IN 1969 OF PERSONS OF EXPERIENCED CIVILIAN LABOR FORCE FOR SELECTED OCCUPATION GROUPS						
Male, 16 years old and over with earnings[2]	$7,890	$7,998	$7,347	$5,819	$5,949	$5,406
Professional, managerial and kindred workers	10,462	10,023	9,409	8,645	8,904	8,721
Craftsmen, foremen, and kindred workers	8,826	8,740	8,983	7,443	6,765	6,160
Operatives, including transport	7,487	7,997	7,055	5,112	5,438	5,179
Laborers, except farm	5,629	5,708	5,873	3,771	4,262	2,722
Farmers and farm managers	5,175	6,378	5,034	5,191	4,433	2,409
Farm laborers, except unpaid, and farm foremen	1,135	2,650	1,745	2,444	2,292	—
Female, 16 years old and over with earnings[2]	$3,684	$3,498	$3,196	$2,855	$3,549	$2,791
Clerical and kindred workers	4,232	4,224	3,658	2,516	3,757	3,554
Operatives, including transport	3,752	2,705	3,608	3,639	3,598	2,795

1 Includes allocated cases, not shown separately.
2 Includes persons in other occupation groups, not shown separately.

Table 2-24. Projected employment index.

Plan Area	Index, based on 1960 = 100		
	1980	2000	2020
6 - Kaskaskia	127	160	209
7 - Big Muddy	127	161	204
8 - Meramec	140	192	259

Additional 1970 census data is available in Tables 2-19 and 2-20. For example, Table 2-20 indicates that Jackson County, Illinois, has a high 54.6 percent in white-collar occupations and 38.9 percent in Government employment. Similarly, Alexander County's poor economic health is evidenced by a median income of $5,471, 31.2 percent of families on a poverty level, and a high nonworker-worker ratio of 1.86.

UMRCBS employment projections based on specific industries are given in Table 2-25.

(3) Business patterns. Tables 2-26 and 2-27 portray the nature and size of business activities for counties along the Middle Mississippi River for 1971. It should be noted that these tables exclude Government employees, railroad employees, and self-employed persons. The tables are useful in evaluating size and relative importance of specific industries likely to be affected by flood plain modification.

The UMRCBS projects near-time growth starting with 1960, on a plan area basis, for selected industries. These data are given in Table 2-28.

(4) Conclusions. The flood plain bordering the Mississippi River between St. Louis and Cairo are economically depressed, particularly those counties some distance from St. Louis. Median incomes are low and many families subsist at poverty levels. Most employment is in industry although a higher than average number of people farm for a living. Projections indicate that personal income and industrial output will increase significantly in the next few decades but generally will remain below national levels.

2.3.2.3. The Mississippi River and the Regional Economy

a. St. Louis Region.

(1) The Port of Metropolitan St. Louis. The Port of Metropolitan St. Louis includes the northernmost 57 miles of the project reach, and extends along both banks of the Mississippi River from river mile 138.8, past the mouth of the Missouri, at mile 195, to mile 208.8.

Table 2-25

Projected Employment for Selected Manufacturing Industries by Standard Industrial Classification (SIC)

Year	20-Food	28-Chem.	29-Petrol. Prod.	23-Stone Clay, Glass	33-Primary Metals	34, 35-Fabr. Met. & Nonelec. Mach.	Total
			Plan Area #6: Kaskaskia River				
1960	9*	5	6	5	17	5	47
1980	9	6	4	5	19	6	49
2000	9	8	3	5	21	8	54
			Plan Area #7: Big Muddy River				
1960	1	1	--	(c)	(c)	(c)	2
1980	1	1	--	(c)	(c)	(c)	2
2000	1	1	--	(c)	(c)	(c)	2
			Plan Area #8: Meramec River				
1960	26	16	(c)	8	6	35	91
1980	27	20	(c)	8	6	44	105
2000	27	27	(c)	8	7	58	127

* All numbers are in thousands of dollars.
(c) Less than 500 employees.

Table 2-26

Business Patterns for Illinois Counties Bordering the Middle Mississippi River Floodplain, 1971 Data

Industry	Number of Employees, mid-Mar Pay Period	Taxable Payrolls, Jan-Mar ($1,000)	Total Reporting Units
Monroe County			
Agricultural services, forestry, fisheries	3	3	3
Mining	(D)	(D)	1
Contract construction	317	673	35
Manufacturing	90	126	12
Transportation and other public utilities	102	160	11
Wholesale trade	63	105	10
Retail trade	603	640	108
Finance, insurance, and real estate	154	203	25
Services	362	273	76
Unclassified establishments	(D)	(D)	4
Total	1820	2,380	285
Randolph County			
Agricultural services, forestry, fisheries	(D)	(D)	2
Mining	783	2,647	10
Contract construction	294	528	45
Manufacturing	3141	5,866	28
Transportation and other public utilities	595	1,489	37
Wholesale trade	273	647	29
Retail trade	1590	1,519	256
Finance, insurance, and real estate	239	320	39
Services	776	662	136
Unclassified establishments	(D)	(D)	6
Total	7729	13,729	588
Jackson County			
Agricultural services, forestry, fisheries	18	9	5
Mining	(D)	(D)	3
Contract construction	607	1,105	67
Manufacturing	1579	2,411	30
Transportation and other public utilities	639	1,147	39
Wholesale trade	374	585	41
Retail trade	3314	3,033	311
Finance, insurance, and real estate	736	974	86
Services	1833	1,889	259
Unclassified establishments	(D)	(D)	19
Total	9206	11,285	860

(Continued)

Note: "D" denotes figures withheld to avoid disclosure of operations of individual reporting units.

Table 2-26 (Concluded)

Industry	Number of Employees, mid-Mar Pay Period	Taxable Payrolls, Jan-Mar ($1,000)	Total Reporting Units
Union County			
Agricultural services, forestry, fisheries	(D)	(D)	1
Mining	(D)	(D)	1
Contract construction	113	260	20
Manufacturing	1021	1594	18
Transportation and other public utilities	213	378	23
Wholesale trade	149	196	19
Retail trade	538	547	124
Finance, insurance, and real estate	122	168	27
Services	396	381	89
Unclassified establishments	(D)	(D)	5
Total	2621	3622	327
Alexander County			
Agricultural services, forestry, fisheries	(D)	(D)	1
Contract construction	115	212	16
Manufacturing	900	943	11
Transportation and other public utilities	160	252	17
Wholesale trade	287	433	29
Retail trade	906	781	135
Finance, insurance, and real estate	131	183	16
Services	395	276	69
Unclassified establishments	(D)	(D)	2
Total	2906	3087	296

Note: "D" denotes figures withheld to avoid disclosure of operations of individual reporting units.

Table 2-27

Business Patterns for Missouri Counties Bordering the

Middle Mississippi River Floodplain, 1971 Data

Industry	Number of Employees, Mid-March Pay Period	Taxable Payrolls, Jan-Mar ($1,000)	Total Reporting Units
Cape Girardeau County			
Total	14,244	20,348	1,152
Agricultural Services, Forestry, Fisheries	24	20	7
Mining	80	123	4
Contract Construction	1,043	2,110	113
Manufacturing	4,175	6,598	82
Transportation and Other Public Utilities	1,014	2,236	46
Wholesale Trade	1,092	1,883	118
Retail Trade	3,545	3,627	379
Finance, Insurance, and Real Estate	693	1,172	97
Services	2,524	2,517	296
Unclassified Establishments	54	62	10
Scott County			
Total	6,604	8,217	678
Agricultural Services, Forestry, Fisheries	62	24	7
Mining	(D)	(D)	1
Contract Construction	464	798	64
Manufacturing	2,004	2,290	35
Transportation and Other Public Utilities	372	550	32
Wholesale Trade	674	1,117	54
Retail Trade	1,487	1,599	264
Finance, Insurance, and Real Estate	406	600	50
Services	1,105	1,104	164
Unclassified Establishments	(D)	(D)	7
Mississippi County			
Total	2,108	2,318	302
Agricultural Services, Forestry, Fisheries	(D)	(D)	3
Contract Construction	62	54	19
Manufacturing	633	649	14
Transportation and Other Public Utilities	237	457	24
Wholesale Trade	98	128	21
Retail Trade	662	647	131
Finance, Insurance, and Real Estate	83	101	25
Services	289	247	58
Unclassified Establishments	(D)	(D)	7

(Continued)

"D" denotes figures withheld to avoid disclosure of operations of individual reporting units.

Table 2-27 (Concluded)

Industry	Number of Employees, Mid-March Pay Period	Taxable Payrolls, Jan-Mar ($1,000)	Total Reporting Units
Jefferson County			
Total	10,742	16,786	1,072
Agricultural Services, Forestry, Fisheries	43	75	8
Mining	126	283	8
Contract Construction	656	1,247	152
Manufacturing	3,817	8,069	60
Transportation and Other Public Utilities	624	1,184	49
Wholesale Trade	367	667	56
Retail Trade	2,588	2,684	381
Finance, Insurance, and Real Estate	626	833	83
Services	1,799	1,636	257
Unclassified Establishments	96	108	18
Ste. Genevieve County			
Total	2,869	4,059	199
Agricultural Services, Forestry, Fisheries	(D)	(D)	1
Mining	17	16	4
Contract Construction	165	344	11
Manufacturing	1,694	1,587	16
Transportation and Other Public Utilities	170	278	8
Wholesale Trade	25	46	9
Retail Trade	471	466	82
Finance, Insurance, and Real Estate	94	160	18
Services	224	178	48
Unclassified Establishments	(D)	(D)	2
Perry County			
Total	2,886	3,284	282
Agricultural Services, Forestry, Fisheries	8	13	3
Mining	(D)	(D)	1
Contract Construction	353	767	27
Manufacturing	1,085	1,242	27
Transportation and Other Public Utilities	83	80	11
Wholesale Trade	66	82	16
Retail Trade	792	690	119
Finance, Insurance, and Real Estate	93	109	15
Services	379	272	59
Unclassified Establishments	(D)	(D)	4

"D" denotes figures withheld to avoid disclosure of operations of individual reporting units.

Table 2-28

Projected Output (Value Added) for Selected Manufacturing Industries by Standard Industrial Classification (SIC)

Year	20-Food	28-Chem.	291-Petrol. Ref.	324-Hyd. Cemt.	33-Primary Metals	34, 35-Fabr. Met. & Nonelec. Mach.	Total
			Plan Area #6: Kaskaskia River				
1960	119*	90	104	--	220	59	593
1980	284	328	207	--	462	140	1,421
			Plan Area #7: Big Muddy River				
1960	15	9	--	--	2	3	29
1980	43	25	--	--	6	8	82
			Plan Area #8: Meramac River				
1960	408	317	--	19	63	369	1,176
1980	1,211	1,122	--	43	135	1,295	3,806

* All numbers are in millions of dollars.

That part of the harbor within the project reach handles a significant portion of reach traffic. In 1972, 16,269,959 tons were handled, accounting for 24 percent of total traffic in the reach, and 72 percent of the traffic with origin and/or destination in the reach.

The port serves as a major transshipment point on the Mississippi River waterway. The port has four major terminals and at least 70 specialized private terminals. The four terminals are: (1) St. Louis Terminals Corporation (operates St. Louis Municipal Dock and Bi-State Dock-Granite City under contract); (2) Valley Barge Line Terminal Company, private terminal; (3) Cooper Terminal Company, Alton Slough Railroad-Fox Terminal at Sauget, Illinois; (4) Tri-State Regional Port Authority Granite City (East-West Gateway Coordinating Council, 1973).

Freight traffic statistics for the St. Louis Port for 1972 are shown on Table 2-29.

Table 2-29. Freight traffic - 1972 - Port of Metropolitan St. Louis

	Short Tons
Local	1,246,782
Internal Receipts	7,396,507
Internal Shipments	13,335,731
Coastwise Receipts	10,563
Coastwise Shipments	18,568
TOTAL	22,008,151

Source: U. S. Army Engineer District, St. Louis, 1973.

(2) Waterborne commerce employment patterns. In 1972, in the St. Louis region, 2,104 persons were employed in the water transportation sector of the economy (See Table 2-30). These were employed in such fields as barging and towing, fleeting, and other similar operations. Employment has increased approximately 50 percent since 1964, yet remains small in relation to employment in other transportation modes such as trucking and rail.

Table 2-30. Employees in water transportation industries

1964	1,417
1967	1,770
1972	2,104

Source: U. S. Department of Commerce, 1972.

Employment in those industries using water transportation in 1972 represented 17 percent of total manufacturing (see Table 2-31). Major industries, in terms of employment using river transportation, included the chemical industry, primary metal products, and electrical equipment and supplies.

Table 2-31. Employment in industries using water transportation, St. Louis Region

	Employment In Industries Using Water Transportation-1972 (000)	Annual Average Manufacturing Employment-1972 (000)
Primary Metal Products	7.95	21.4
Chemicals & Allied Products	10.70	20.5
Fabricated Metal Products	4.70	19.9
Electrical Equipment & Supplies	9.75	17.2
Machinery (Except Electrical)	0.90	20.5
Petroleum & Coal Products	4.20	3.5
Food and Kindred Products	3.40	23.9
Stone, Clay and Glass	0.65	7.7
Transportation Equipment	0.15	58.6
Other Manufacturing	1.00	63.5
TOTAL	43.40	256.7

Source: Kearney, A. T., Inc., 1973.

In the St. Louis region, the ratio of manufacturing to total employment has varied from 2.9:1 in 1966 to 3.3:1 in 1972, as the manufacturing sector has declined and the retail and services sectors increased (U. S. Department of Labor, 1966 and 1972). Based on a conservative ratio of 3.0:1, employment in water transportation-oriented manufacturing has a broad economic impact expressed in total regional employment figures of 130,000 employees, just under 15 percent of total employment.

b. <u>The Rural River Counties</u>. In contrast to the St. Louis area, river navigation appears to have little impact on the rural counties bordering the lower 139 miles of the project area. At some point on this stretch of river in 1972, 8,733,457 tons of cargo had origin, destination, or both. This amounted to 13 percent of the total traffic, or 39 percent of the total tonnage with origin and/or destination in the reach.

Slightly more than half of the tonnage with origin and/or destination in the rural counties in 1972 was Illinois coal. In the near future, additional coal tonnage ought to enter the lower part of the reach from the presently incomplete Kaskaskia River Navigation project (although some of this tonnage may be diverted from Mississippi River docks).

There are approximately 30 docks in the project reach. Ten are in the Cape Girardeau area, six in or near Ste. Genevieve, and three near Chester, with the remainder at various other locations in the reach.

Figures on the employment in the water transportation sector of the economy are unavailable due to the small number of firms involved. However, given the small number of terminals, and the comparatively little tonnage originating or arriving in the reach, it appears that such employment might be rather small, but absolutely and in relationship to total employment in the rural project counties.

2.3.3. LAND USE

2.3.3.1 St. Louis Metropolitan Area

The Mississippi River in the St. Louis metropolitan area is a combination of a "pooled" and an "open" river. This reach begins at Locks and Dam No. 26 (river mile 202.9) extends south to the Jefferson Barracks Bridge (river mile 168.5). The "pooled" section of the River is created by a "low dam", Dam 27 near the northern limit of St. Louis. Pool 27 is not as large as the pools upriver and is for the purpose of maintaining a navigable water level over the lower sill at Locks No. 26 during periods of low flow. Past Pool 27, the river flows in an "open" condition, having no dams or locks. In the northern extreme of this reach, the river is bordered by flood plains on both sides. Portage des Sioux and the Columbia Bottoms on the west, and the beginning of the American Bottoms on the east. Going south, the western flood plains give way to uplands, with the river flowing against the western bluffs. On the east, the American Bottoms develop into an expansive lense-shaped flood plain, having a maximum width of twelve miles. In the southern extreme of this reach, the west remains uplands, while the eastern American Bottoms narrow to about a three mile width.

Land use in this reach of the river is primarily dense urbanization with interspersions of open space - agriculture. The west side of the river, holds St. Louis City and its suburban sprawl. This side is almost totally developed with commercial, residential, industrial and recreational uses integrated along the riverfront. Almost all development on the west side is located on the upland.

Urban development on the Missouri side proceeded in a semicircular pattern into St. Louis County, usually staying on the uplands. In recent years, development has occurred in a corridor fashion along the main radial highways of I-70, I-55, and I-44, and into the exterior reaches of St. Louis County, as well as into St. Charles, Franklin, and Jefferson Counties.

The urban pattern on the Illinois side of the river is neither as extensive nor as concentrated as that on the Missouri side. Rather, development occurs almost entirely on the protected flood plain and tends to form urban units around well separated medium size cities of Alton, Granite City, Belleville, and East St. Louis. Except for the upland community of Belleville, the urban units have extensive complexes of heavy manufacturing located on the flood plain. Probes of development branch out from the urban centers along the major highways of Illinois Route 3, U. S. 460, and Interstates 55, and 70.

Open space in the St. Louis region is mostly agricultural and is found in either peripheral areas which development has not yet reached or in areas of physical limitations such as flood plains and severe slopes. The extensive protected and unprotected flood plains of the Mississippi and Missouri Rivers and their tributaries are heavily farmed, as are the uplands outside the urban development. Much of the Jefferson and Franklin Counties have steep slopes of 16 percent and greater and these limit not only urban development, but also the extent and type of farming.

Three interstate highways, I-70, I-55, and I-44, converge in the St. Louis region and make up the principal elements of the thoroughfare system. A circumferential route, I-270, serves the Missouri side of the region and a similar highway is planned for the Illinois side. There are a number of Mississippi River crossings in the region, the major ones being U.S. 67 at Alton, I-270 north of St. Louis, I-55-70 at downtown St. Louis City, Bypass 50 in south St. Louis County, and others such as Eads and McKinley, Veterans and MacArthur Bridges in St. Louis City.

A multitude of railroads and their goods enter the St. Louis region from all directions. Running north and south are such railroads as Illinois Central Gulf, Missouri Pacific, and St. Louis-San Francisco, which Chicago-Rock Island and Pacific, Missouri-Kansas-Texas, Burlington Northern, Baltimore and Ohio, and Penn Central run in a general east-west direction.

2.3.3.2 Middle Mississippi Region River Mile 170.0 to 0.0

a. Past Land Use

Land use in the Middle Mississippi River flood plain has evolved through four distinct stages. Prior to the late 1700's, the flood plain was swamp and forested land. From the late 18th century through the 19th century, settlers began to clear the ridges and upland areas for substinence frontier farms. Most of the flood plain, however, remained relatively untouched due to annual flooding and inadequate surface drainage. With the coming of the railroads in the late 19th century, the land was open to more intensive settlement. This new settlement resulted in the expansion of agriculture and timber production due to the harvest of the bottomland hardwood forest. As the forests were cleared for farming, farmers began to erect small levees to protect their crops (Terpening, et al., 1974). The first period may be said to have begun in the 1930's with the first federal program of levee building. Due to the present flood protection and surface drainage, land use is a complex pattern of agricultural, transportational, industrial, and residential needs.

b. <u>Present Land Use</u>

As cited above, present land use on the flood plain is carried on despite its wet origin and history of flooding. Of the nearly 78,000 acres of unprotected flood plain, agriculture is the dominant land use with 34,800 acres. Other major land use categories include lake and backswamp (4,279), woodland, urban, and industrial. Plates 2-5a through 2-5k show the distribution of land use types for the entire flood plain.

Agriculture is located on both the flood plain proper as well as the larger islands, supplanting woodland at the higher, more favorable sites. Woodland, in turn, has been relegated to the lower areas which are susceptible to periodic flooding, and thus too wet to farm. Woodland occurs along streams, lakes, backswamps, side channels, and the river, on both the flood plain and the islands. Backswamps and lakes on the flood plain are widely scattered and most occur in the long, linear bodies, indicating an origin as a meander scar. Lakes also occur at side channels or chutes which have been puuposely closed by dikes, thus forming a lake. Backswamps occur at low areas which have only been partially drained or at eutrophic lakes.

Ubban land use is located at the small farm towns which regularly occur on the flood plain. These communities, such as Dupo, Valmeyer, Prairie du Rocher, and Grand Tower, make up most of the urban land on the flood plain. However, as a land use type, urban land makes up only a small percentage of the flood plain. The same is true of industrial land which is found near communities or adjacent to the Mississippi River. Industrial types on the flood plain include electric power plants, quarries, manufacturing, and terminal transport facilities.

Recreation is a flood plain land use although not shown on the maps. Other than city parks, Lewis and Clark and Fort Defiance State Parks and Shawnee National Forest in Illinois and Trail of Tears State Park in Missouri are formally set aside for public recreation purposes. Other sources of recreation include the river. Its islands and its side channels are utilized for duck and goose hunting, small game hunting, and fishing and trapping. However, much of this takes place on privately owned land. Also, private hunting clubs are located near Ware and Wolf lake, Illinois, offering duck, goose, and deer hunting.

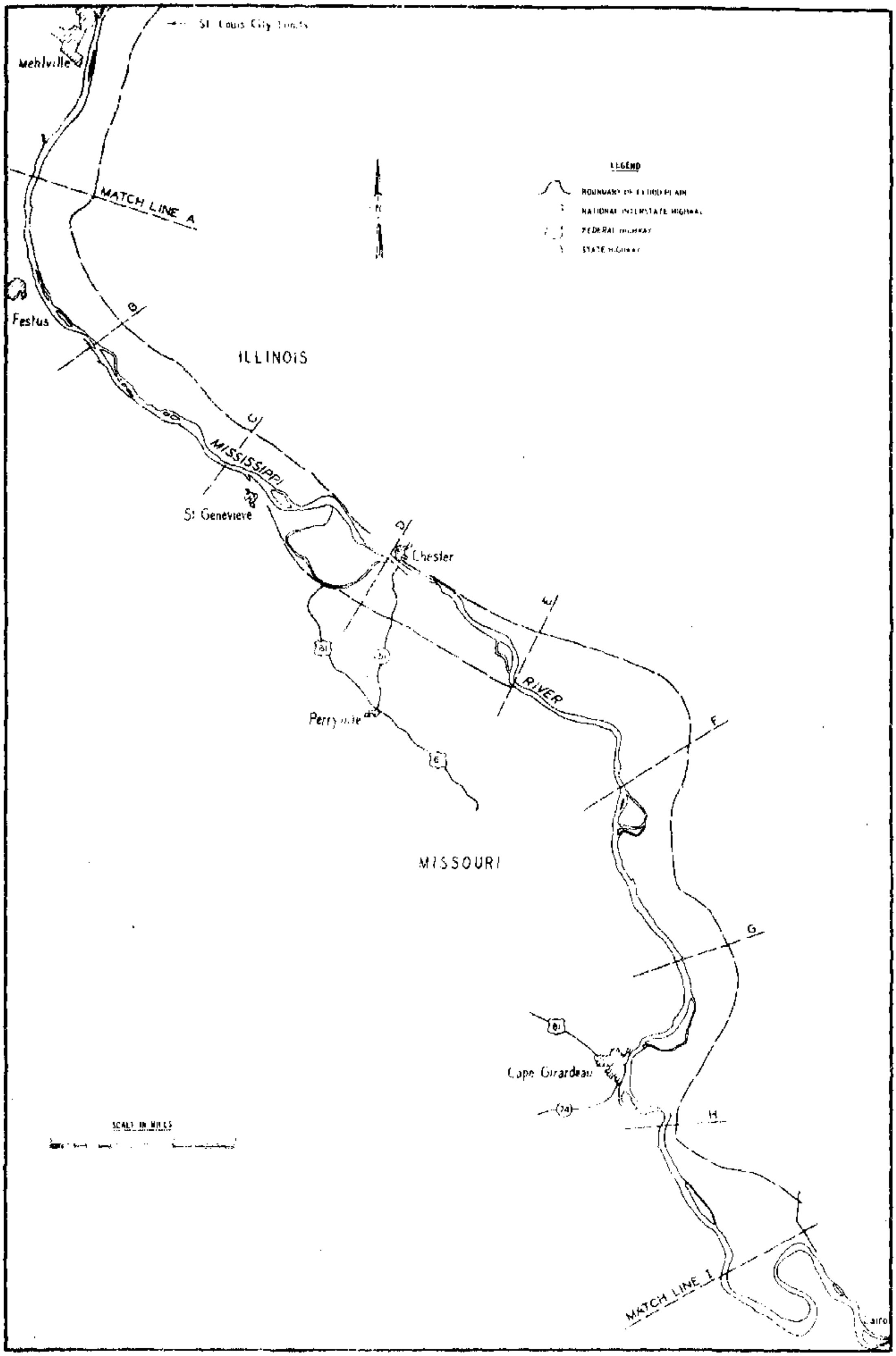


Plate 2-5a. Index sheet for land use maps, Middle Mississippi River, 1969

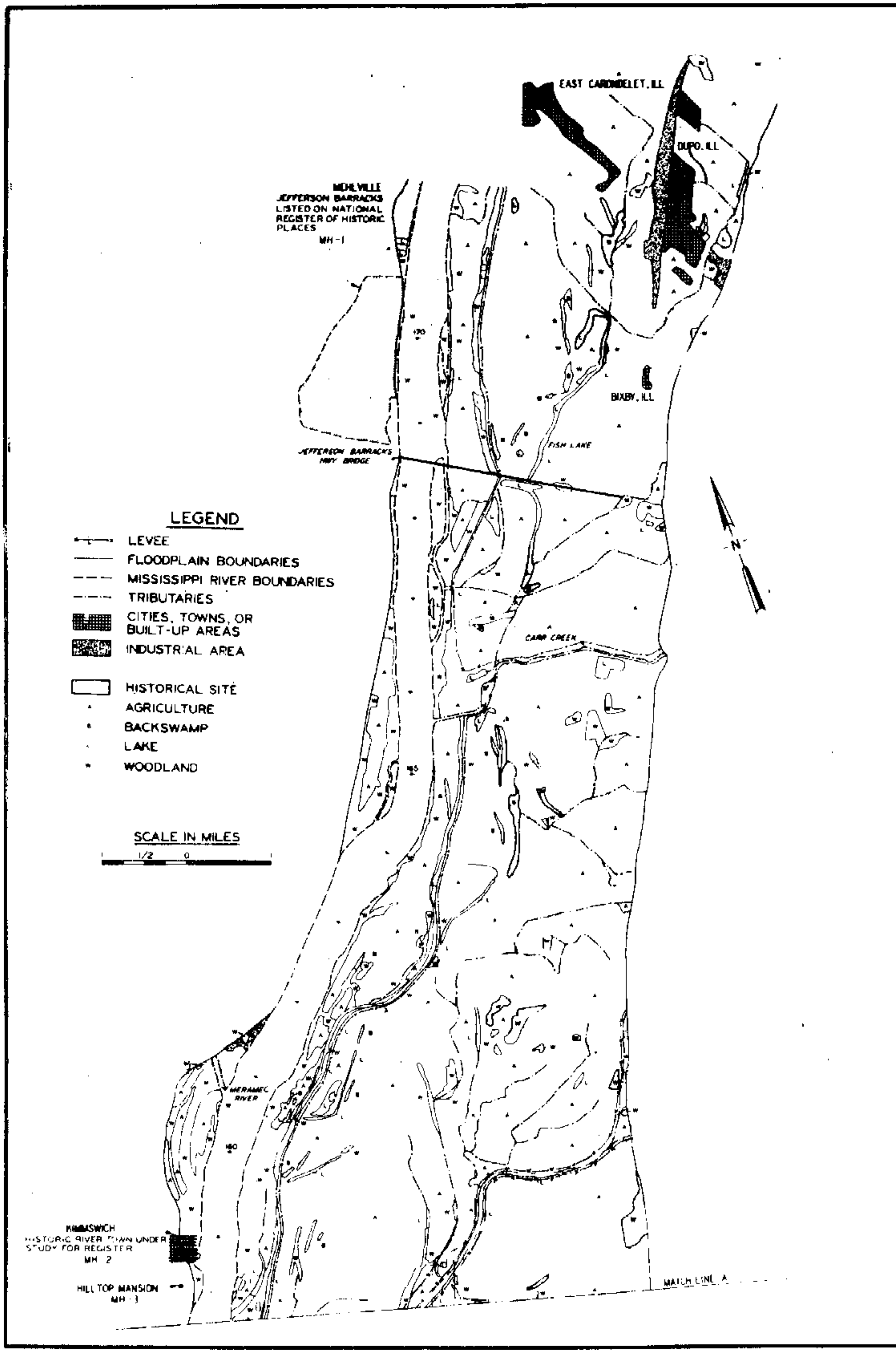


Plate 2-5b. Middle Mississippi River floodplain land use - sheet 1

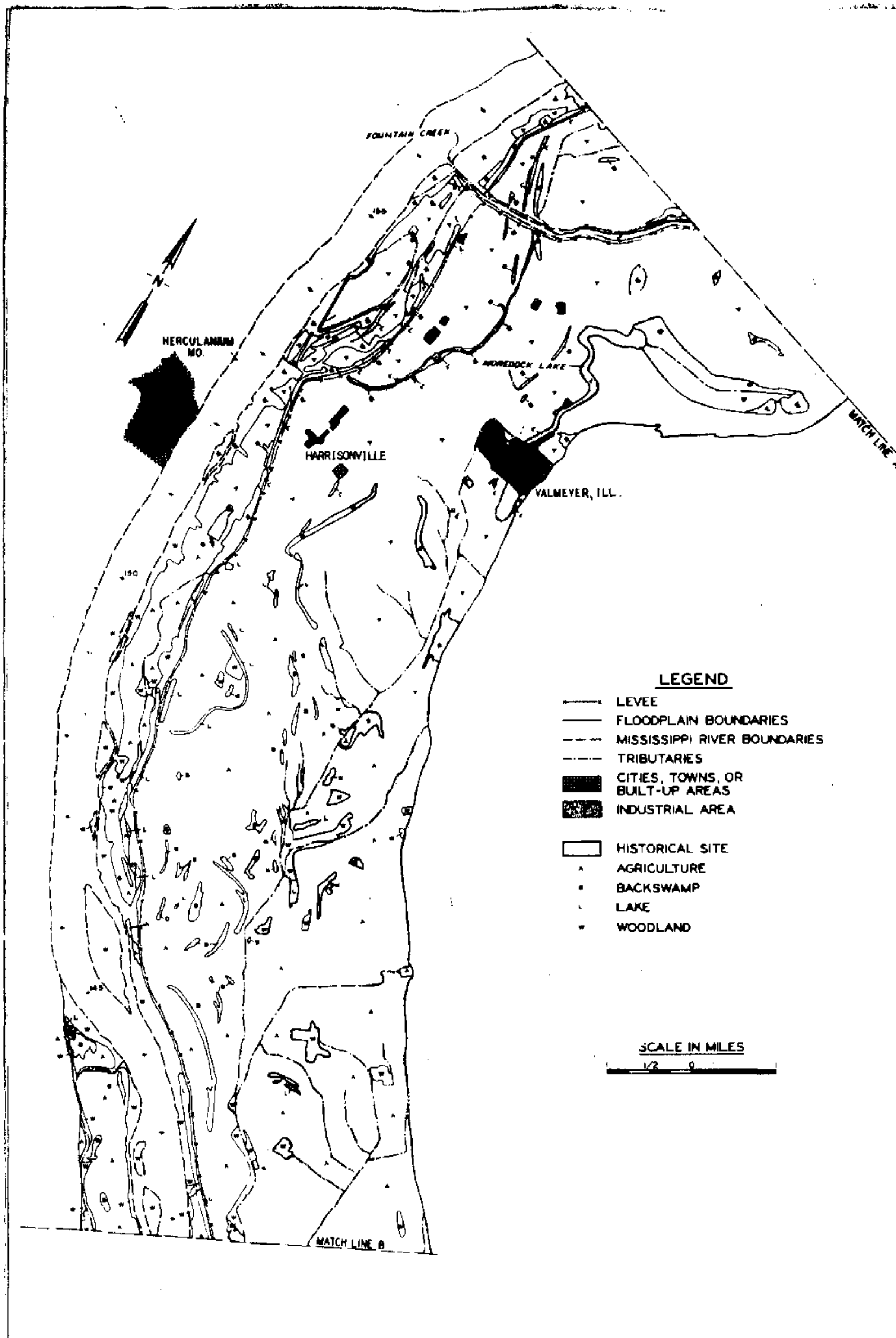


Plate 2-5c. Middle Mississippi River floodplain land use - sheet 2

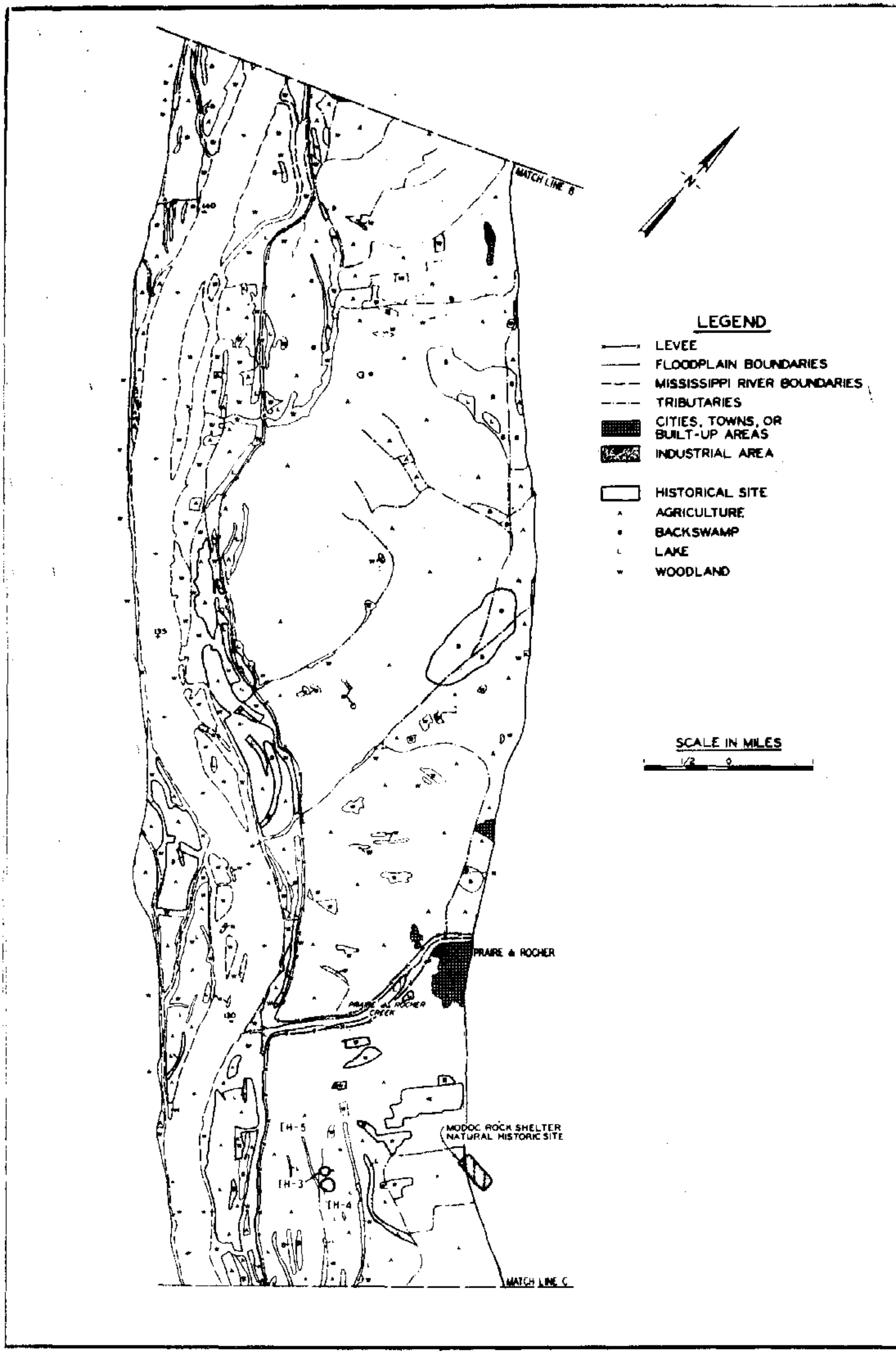


Plate 2-5d. Middle Mississippi River floodplain land use - sheet 3

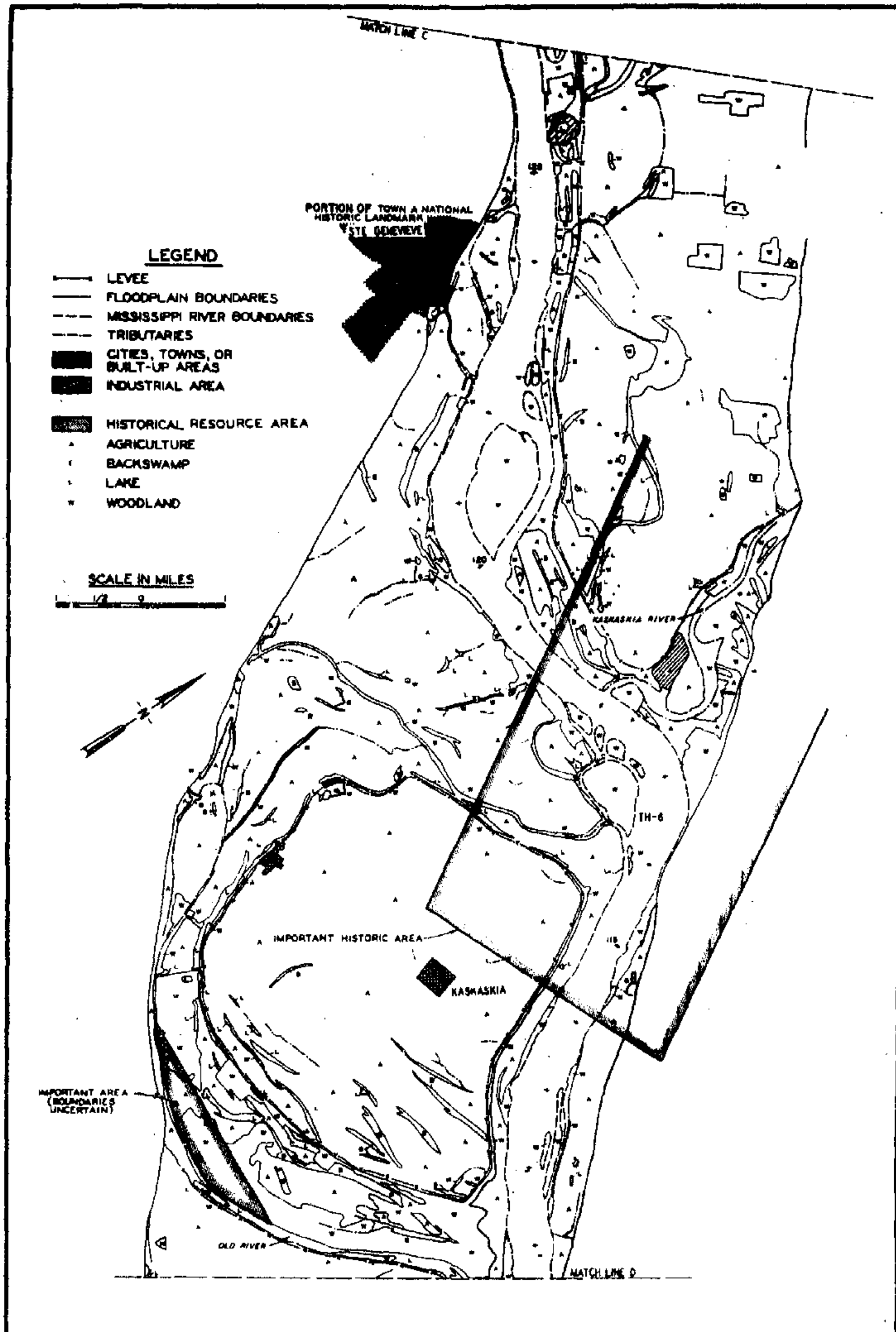


Plate 2-5e. Middle Mississippi River floodplain land use - sheet 4

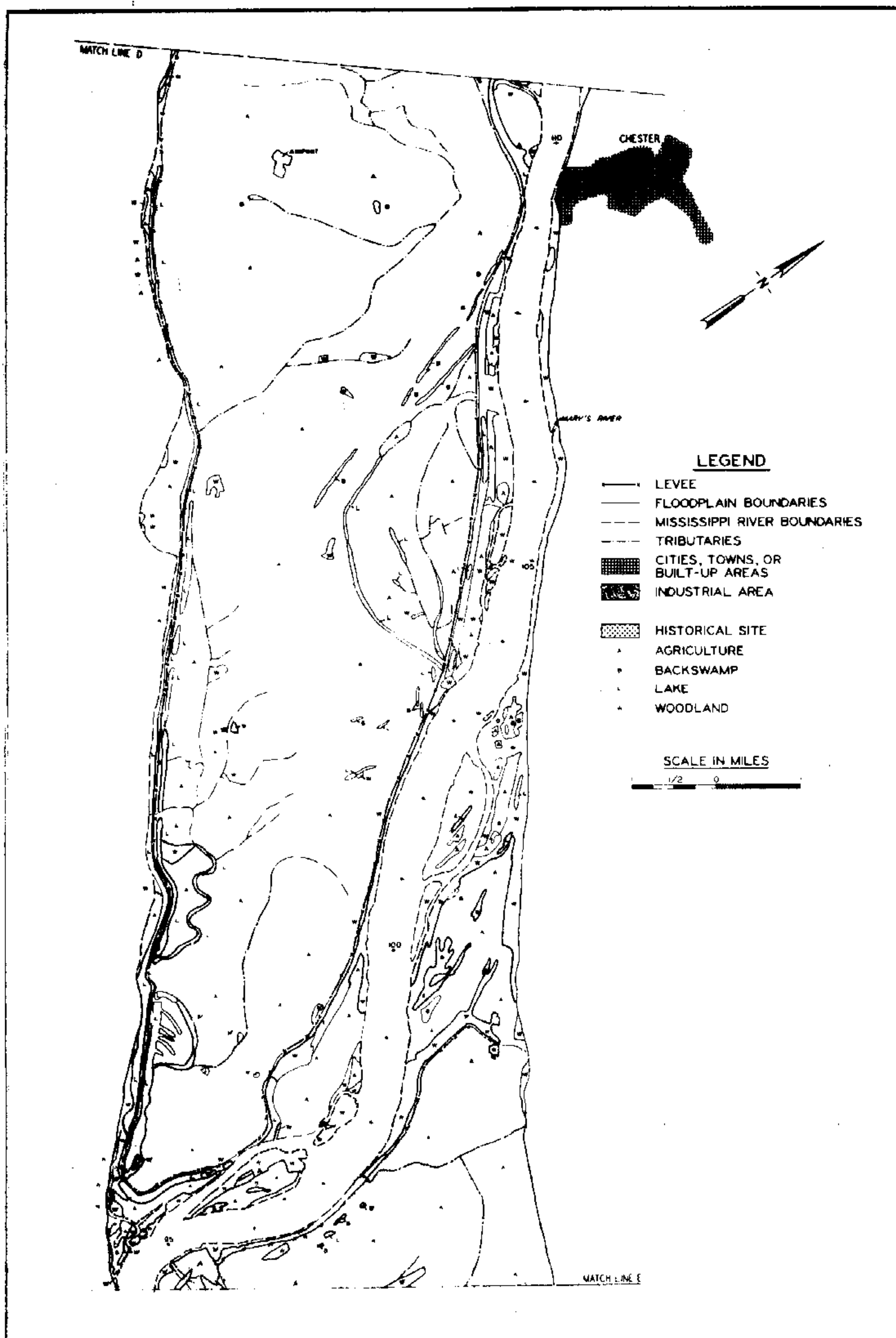


Plate 2-5f. Middle Mississippi River floodplain land use - sheet 5

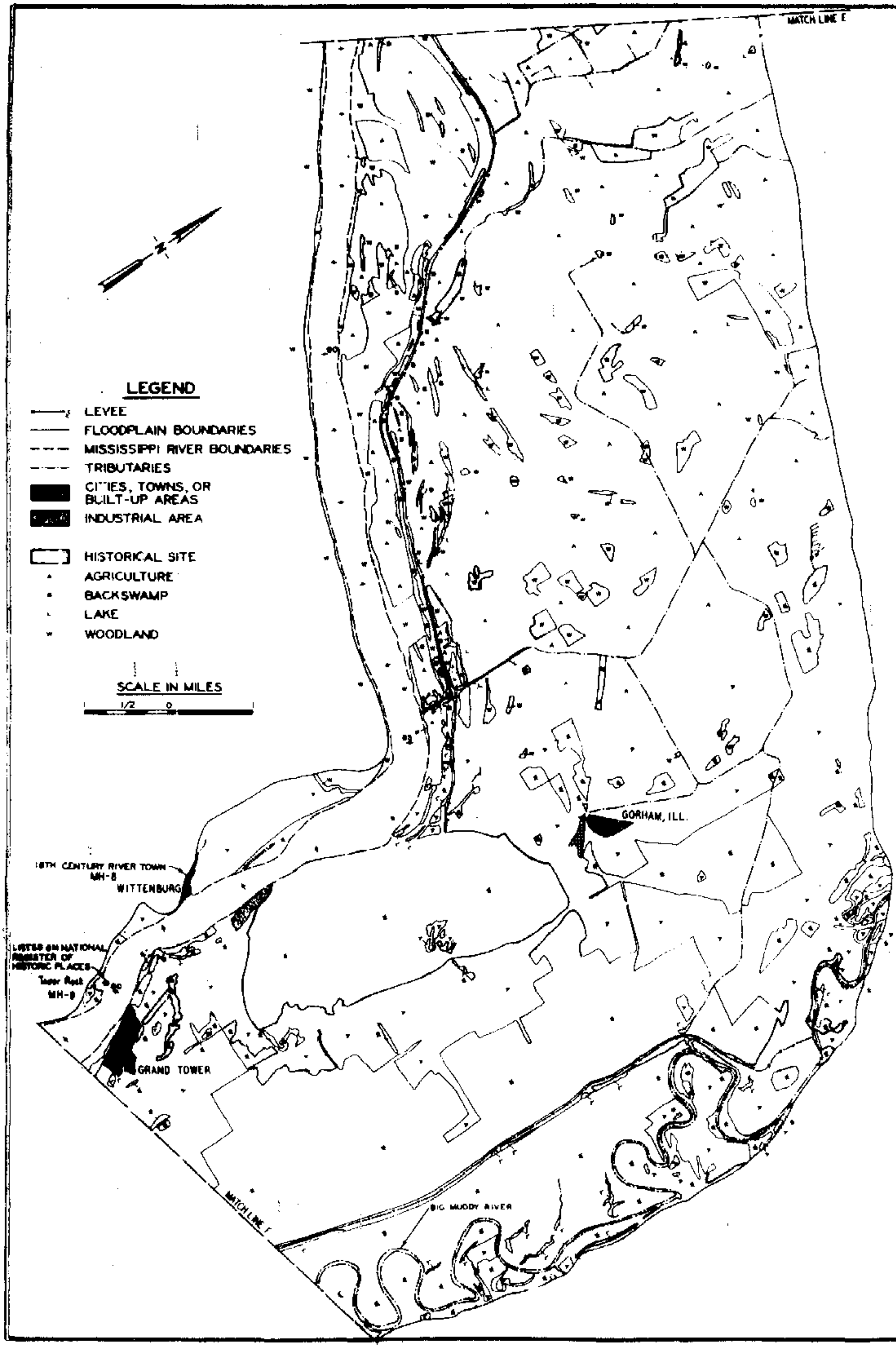


Plate 2-5g. Middle Mississippi River floodplain land use - sheet 6

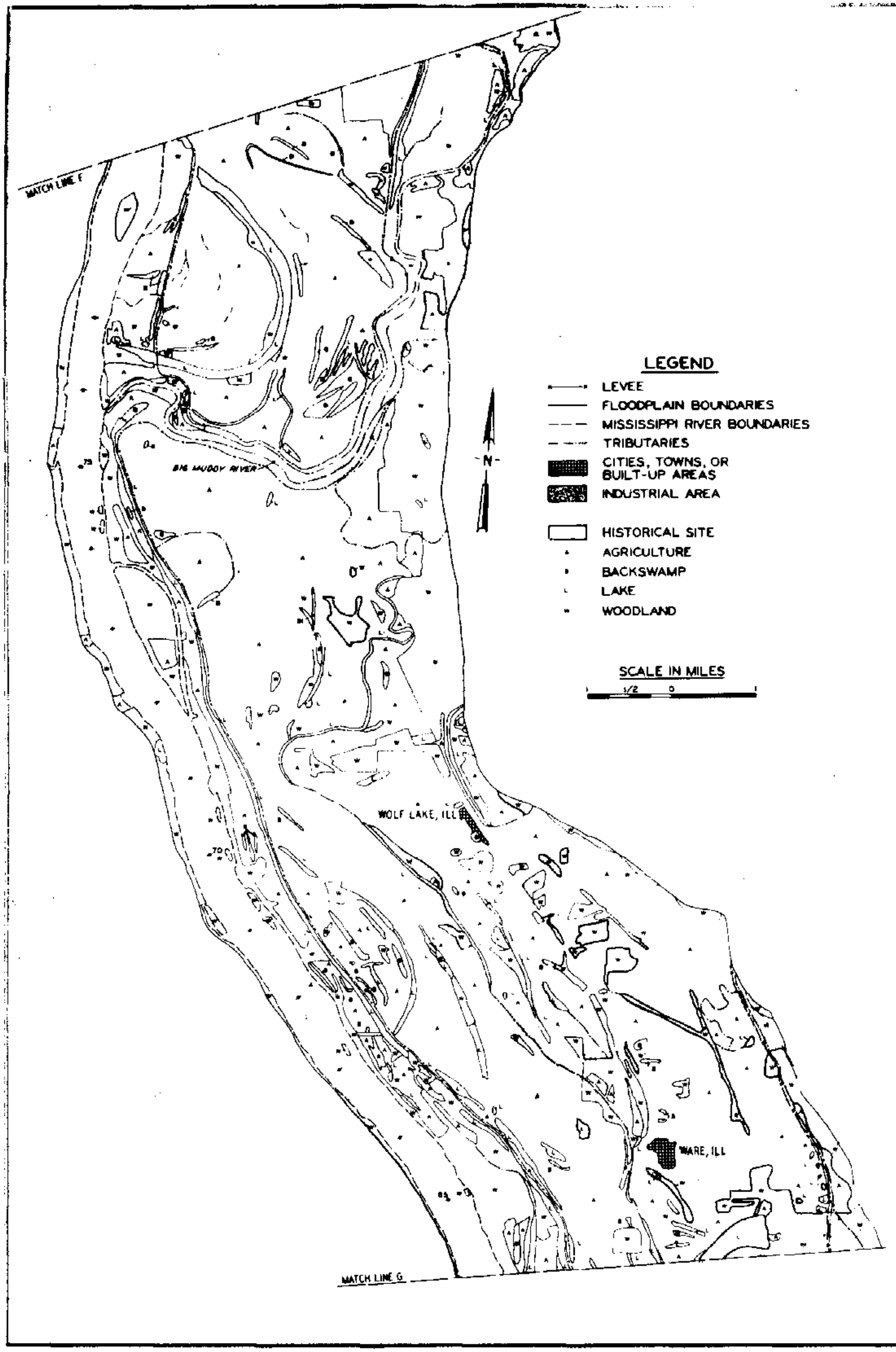


Plate 2-5h. Middle Mississippi River floodplain land use - sheet 7

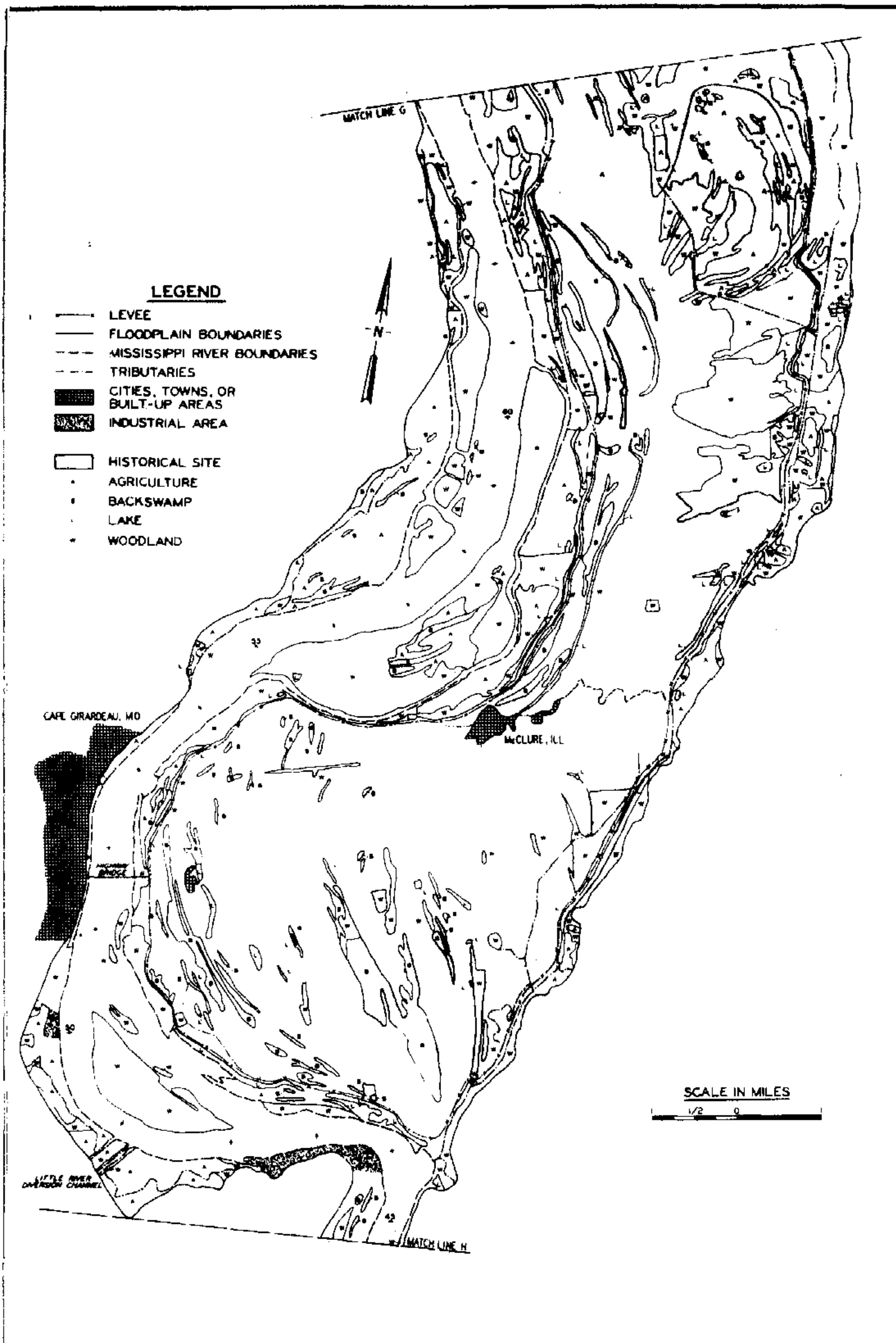


Plate 2-5i. Middle Mississippi River floodplain land use - sheet 8

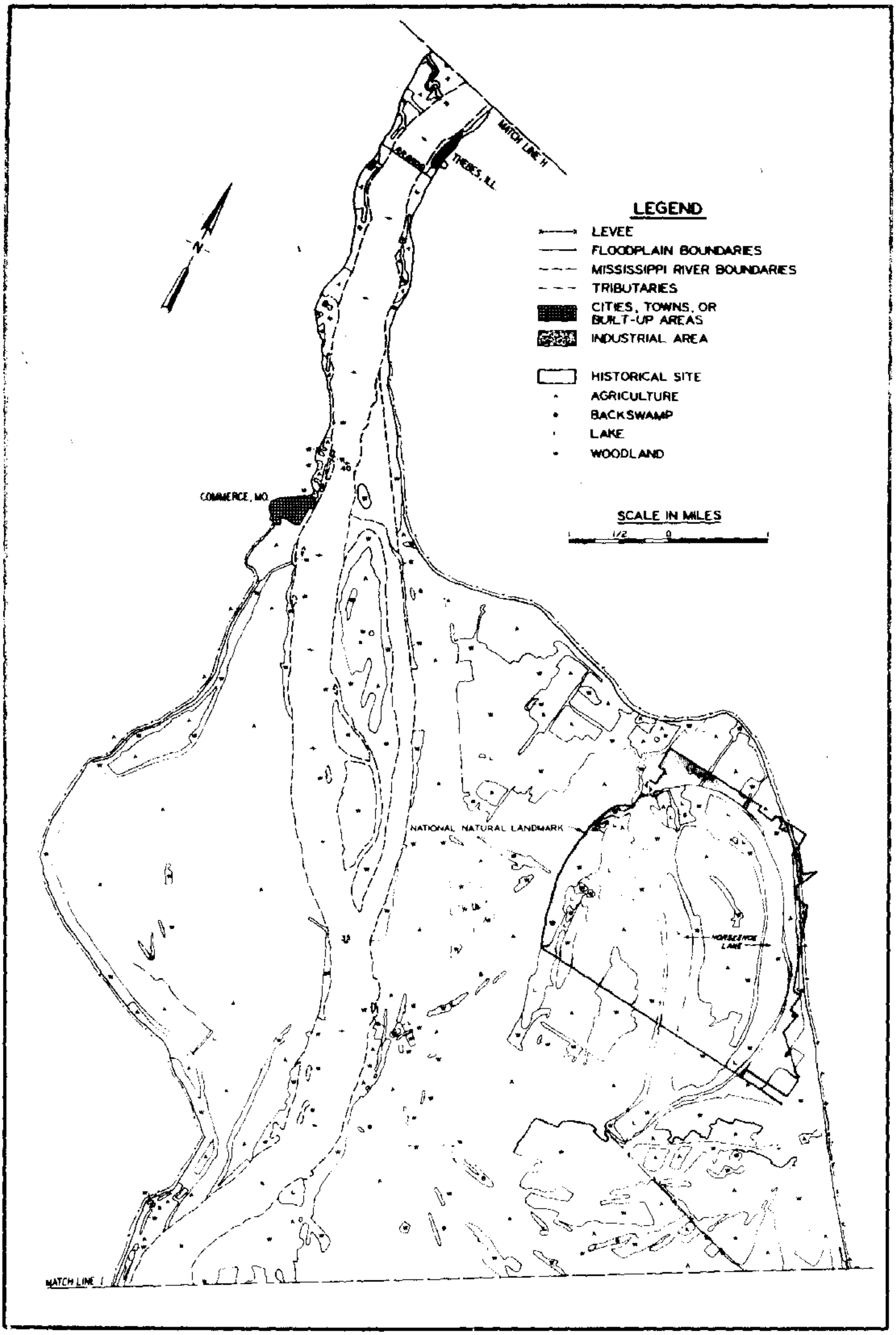


Plate 2-5j. Middle Mississippi River floodplain land use - sheet 9

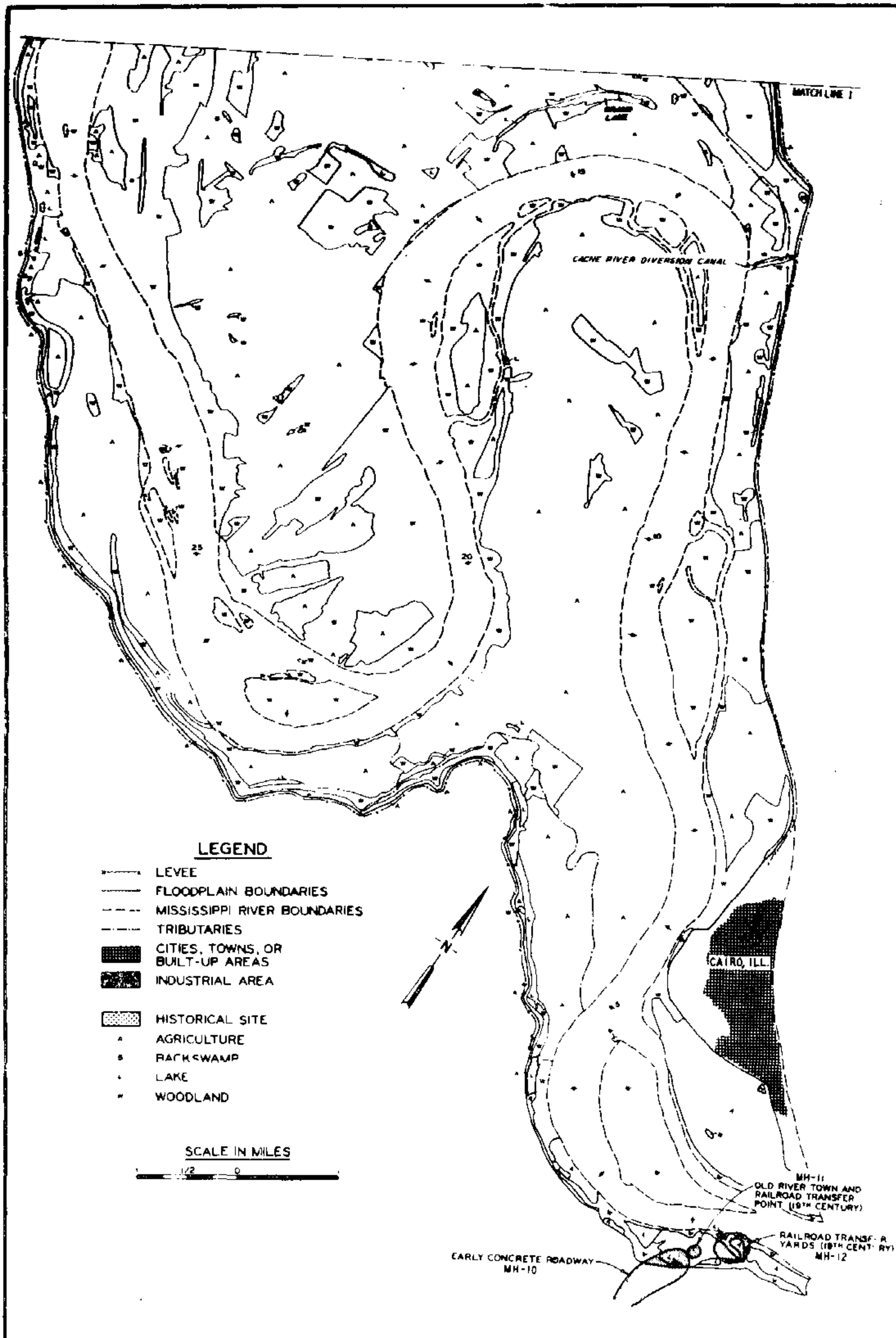


Plate 2-5k. Middle Mississippi River floodplain land use - sheet 10

c. **Future Land Use**

Land use on the flood plain cannot be expected to change drastically in the future. Aside from the natural conversion of lakes to backswamps or backswamps to a grassland, the only possible change may come from agriculture. Stimulated by rising prices, farmers may drain some backswamps or clear some islands for the purpose of cultivation. Such a change, however, is by no means a certainty. Also, some changes may come from the urban and industrial sectors, but this would be small in relative magnitude.

2.3.4. OUTDOOR RECREATION

Developed recreation space in the Lower Mississippi Region totals approximately 23,770 acres. Nearly all of this acreage is located in state parks and state conservation areas. Roadside parks, points of interest, and city parks comprise a small amount of the total acres. Table 2-32 presents a complete inventory of recreation facilities of the state parks in the study area, listing activities available for each site. This information indicates that the region's major recreation facilities not only give a wide range of available activities, but are also well-distributed in spatial terms.

Despite adequate facilities and good spatial distribution of these facilities, the recreation resources of the region have several shortcomings. The region lacks good accessibility from the St. Louis metropolitan area. Major highways into the area from St. Louis are Interstate Highway 55 and Illinois Highway 3. While Interstate 55 is an excellent multi-laned highway, it does not penetrate the region. Illinois 3 is a scenic route, and does run the length of the region, but suffers in that it is only two-laned. A second deficiency is found in the fact that, notwithstanding the presence of the Mississippi River, the only state park which makes active use of the river, except for scenic purposes, is the Trail of Tears State Park. In fact, relatively few public access facilities to the river are available. Thus, the Mississippi, a great natural feature, is limited to a passive role in recreation. However, it should be noted that river areas north of St. Louis are more favorable than those areas to the south in many cases, since navigation impoundments lend themselves more readily to boating activities.

Table 2-32 Recreational facilities of the lower Mississippi region.

		Major Activities						
	Acreages	Fishing	Hunting	Camping	Picnicking	Hiking	Boating	Historical
<u>Illinois</u>								
<u>State Parks</u>								
1. Fort Chartres	1,104				X			X
2. Fort Defiance	38	X			X		X	X
3. Fort Kaskaskia	236			X	X	X		X
4. Lewis and Clark	-				X			
5. Randolph County	1,031	X	X	X	X	X	X	
6. Horseshoe Lake	7,901	X		X	X	X	X	
<u>State Forests</u>								
7. Trail of Tears	3,990				X			
<u>Conservation Areas</u>								
8. Union County	6,202	X		X				
<u>Missouri</u>								
<u>State Parks</u>								
9. Trail of Tears	3,268	X		X			X	

Sources: State of Illinois, <u>Outdoor Recreation in Illinois</u>, 1965.
State of Illinois, <u>Illinois Highway Map</u>, 1975.
State of Missouri, <u>Outdoor Recreation Plan</u> Vols. I and II, 1970.

2.3.5. CULTURAL RESOURCES

2.3.5.1. Archeology

In Illinois study area counties, about 400 archeological sites have been located on the flood plain; while on the Missouri side, 22 sites have been located on the flood plain. Actual locations of sites are not presented in this statement in order to preserve their integrity; however, qualified individuals may obtain their location from the Illinois Archeological Survey or the Missouri Archeological Society.

Several archeological sites along the river are currently on the National Register of Historic Places. These include the Common Field Site, the Saltpan Kreilich Site in Ste. Genevieve County, and a site in Cape Girardeau County.

2.3.5.2. Historic Sites

A total of 21 historic sites and structures were located on the Missouri and Illinois flood plains. National Register sites include: (1) Modoc Rock Shelter, Randolph County, Illinois; (2) Ste. Genevieve (entire town), Ste. Genevieve County, Missouri; and (3) Tower Rock, Perry County, Missouri.

PART 3

3. RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS

3.1 STATE OF PLANNING

Land use planning has progressed slowly in the Middle Mississippi River Region and is presently in a mixed state. Most of the counties in the region have comprehensive plans, but the majority of these plans are in a proposed status, rather than adopted. Only four counties have adopted land use plans. These counties are Ste. Genevieve and Cape Girardeau Counties in Missouri, and St. Clair and Randolph Counties in Illinois.

3.2 COMPREHENSIVE PLANS

As stated above, most of the counties have comprehensive plans, i.e., land use plans, though the overall status of adoption is mixed. As mentioned in Section 2.3.3, the region presently has a predominantly rural character and the plans seek to perpetuate this situation. The majority of the land will remain in agriculture. Future urban/commercial development will take place at presently existing urban centers. Some corridor or strip commercial development is planned along major highways. Planned greenbelts, conservation and recreation areas follow this conservative theme of preserving the existing land use pattern by planning uses for areas which already have the use or have natural features for the use. Such is the case with Shawnee National Forest and the expansion of it. Large areas planned for industrial use are generally situated on a navigable waterway, either the Mississippi or Kaskaskia Rivers, with adjacent road facilities, and near an urban center.

Looking more closely at the flood plain, the future land uses planned for the flood plain are again conservative, seeking to preserve the status quo. Planned land uses on the flood plain are public and conservation areas, agriculture and intensive agriculture, and small amounts of urban and industry. Again, each future use is planned for an area at which it already exists.

3.3 COMPARISON OF THE ACTION TO LAND USE PLANS

A comparison of the above land use plans to the location and description of the proposed project shows no direct contradiction in future land use types or the location of a land use. Nor do the impacts of the project conflict with the plans. Rather, the plans have taken into account the channelization of the Mississippi River, regardless of method, and have planned with it in mind. Barge facilities and general industrial uses along the river are planned with the assumption of continued navigation. Other uses planned along the river are conservation and recreation areas, and agriculture.

PART 4

4. IMPACT OF THE ACTION ON THE ENVIRONMENT

4.1 PHYSICAL IMPACTS

4.1.1 IMPACT TO RIVER REGIME

4.1.1.1 Early Alterations to the River

To properly delineate the effects of channel stabilization works, i.e., dike and revetment construction, and maintenance dredging upon the river's physcial configuration as a result of such continuing action, a presentation of past efforts is necessary.

The earliest available maps of the Middle Mississippi River, before any significant alteration by man, in which sufficient flood plain details are shown are those which were made under the direction of General Victor Collot in about 1796. As can be seen in Plate 4-1, that portion of river from St. Louis, Missouri, to Chester, Illinois, is depicted as a relatively straight reach with numerous islands, thus perhaps giving it the appearance of a bifurcated (divided) channel in many places. The map depicts the river as impinging against the west valley wall for the majority of its path.

Prior to 1881, no comprehensive plan had been devised for the systematic regulation and stabilization of the Middle Mississippi River. The earliest major work on the river was federally sponsored projects for the removal of snags. These snags consisted of trees which were embedded in the river bottom. Such obstructions proved to be a hazard to navigation, especially if they were submerged just below water level. In addition to removing snags from the river, trees were cleared from the high bank as necessary to preclude the formation of new snags in the navigation channel.

In 1837, Lt. Robert E. Lee, of the Corps of Engineers, was assigned the task of removing a large sandbar, called Bloody Island, which was threatening the St. Louis harbor area. Data from historic maps reveal that the Mississippi River at Vine Street in St. Louis was 3,100 feet wide in 1803. Due to shifting currents, flood events which attacked the banklines, and the creation of a major secondary channel to the east of the newly formed Bloody Island, the river gradually enlarged to 3,700 feet in 1837. Using a system of dikes, Lt. Lee joined the island with the Illinois shore, thus deepening and narrowing the channel adjacent to St. Louis.

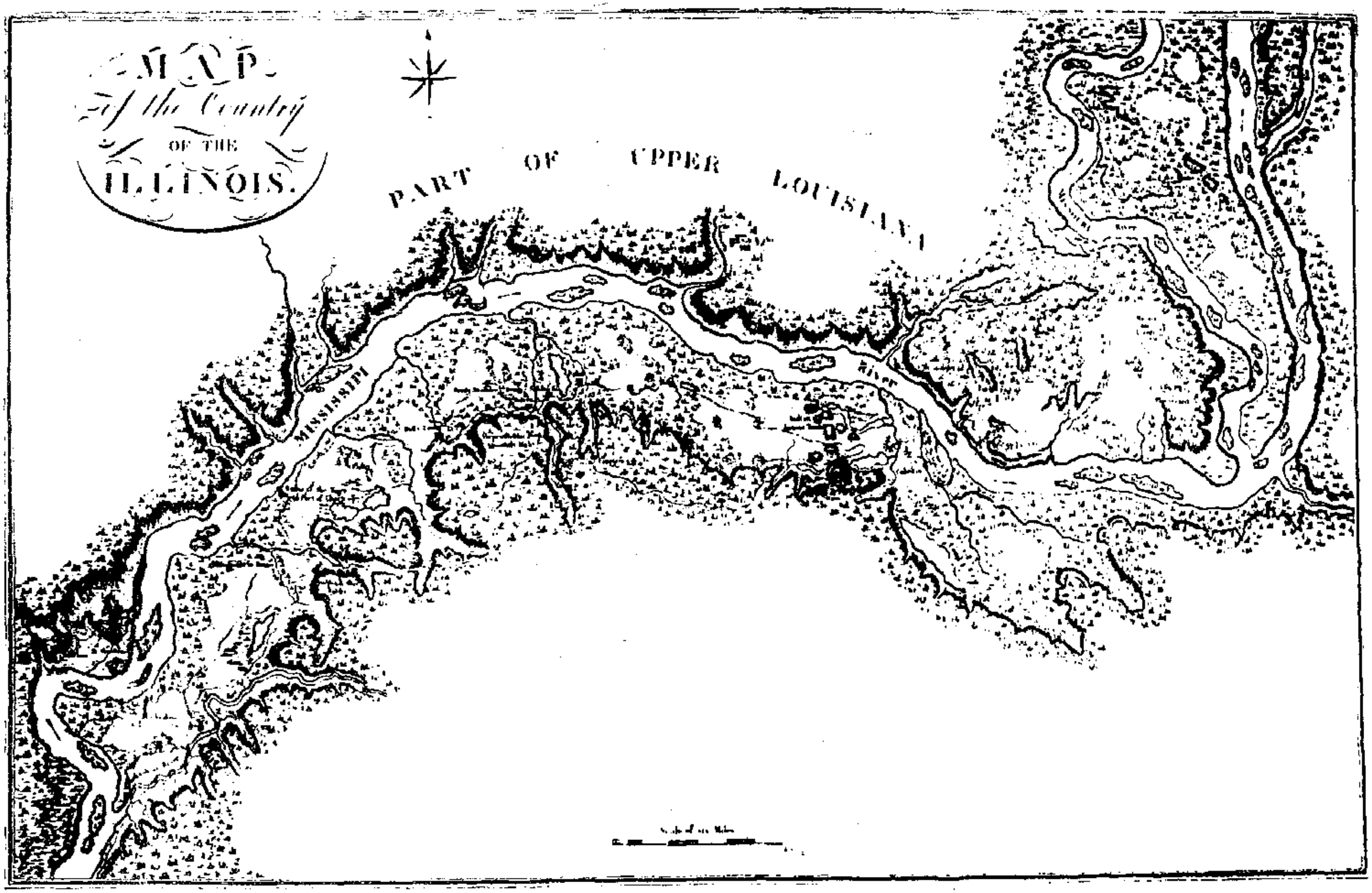


PLATE 4-1. 1796 Map of Mississippi River, miles 225 to 110

After the above-mentioned work was performed by Lt. Lee, federal expenditures ceased until 1872, except for snagging operations, although unrelated, isolated channel improvement work was performed by local interest groups near St. Louis until this time. A comprehensive plan for regulation of the Middle Mississippi River was approved by Congress in 1881, which provided for channel improvements utilizing dikes and revetments.

Although dike fields are now being constructed with solid dikes, experience has shown that permeable dikes, composed of timber hurdles or screens, would produce a more rapid rate of sedimentation. Most dikes which were constructed during this early channel stabilization era were built to elevations equivalent to 20 to 25 feet on the St. Louis gage.

The suspended sediment load of the Missouri River has been substantially reduced subsequent to the construction and operation of impoundment dams in the Upper Missouri River Basin. While the suspended sediment load entering the Middle Mississippi River by way of the Missouri River was high, permeable dike fields were efficient in trapping suspended materials between dikes. Under present conditions of reduced sediment transport, solid stone-filled dikes are more efficient in trapping material between dikes than permeable pile dike structures.

Remnants of these now buried pile dikes are sometimes found in cultivated fields a considerable distance from the present river bank, and the adjoining ground elevation corresponds somewhat to the original height of these old dikes. In most cases, the ground is somewhat higher due to the additional fill that is trapped by trees and vegetation which grew on the newly formed sandbars.

An example of the effects of these dikes on the narrowing of the river is shown in Plate 4-2, when in 1873, a severe shoaling condition occurred at Horsetail Bar in the vicinity of Jefferson Barracks Bridge, just south of St. Louis. The river at this locality was over 5,000 feet wide and average channel depths were only 3 to 4 feet. Dikes were constructed in this area in 1881 and as can be seen, a considerable fill with vegetative growth had been accumulated by 1888. By 1946 the former sandbars between dike fields were in an advanced state of cultivation.

The CSU report entitled "Geomorphology of the Middle Mississippi River" states, "The cross-sectional area at bank-full stage is approximately 80,000 square feet in 1973 whereas the area was 120,000 square feet in 1837. The narrowing of the channel at St. Louis has reduced the bank-full channel area by about one-third. A similar decrease in the bank-full cross-sectional area has occurred throughout the Middle Mississippi River wherever the river channel has been contracted."

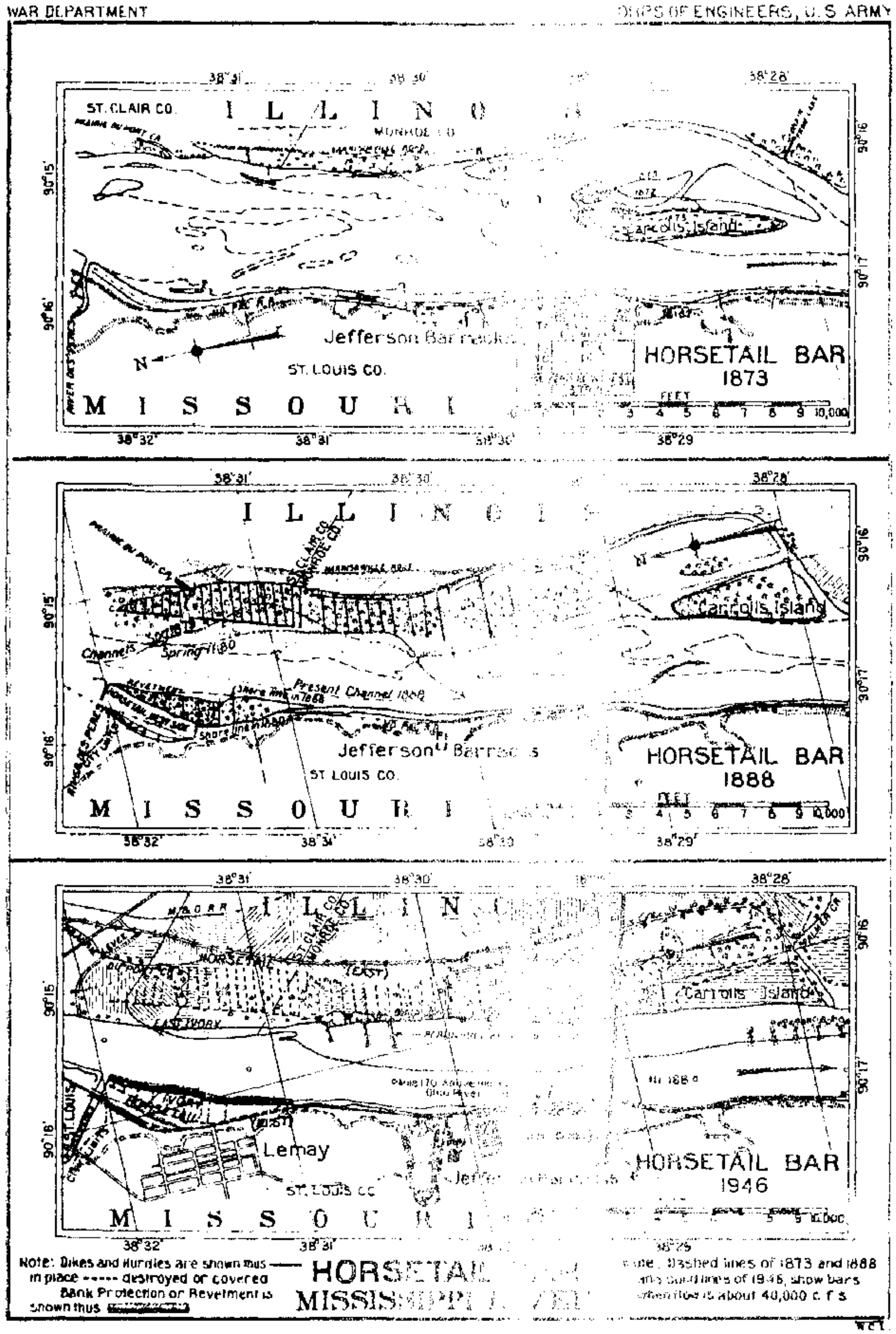


PLATE 4-2. Channel configuration maps ... setail Bar Area

Another example of low water channel change is shown on Plate 4-3 which gives a pictorial description of the changes which occurred during the 18 year period from 1889 to 1907 in a typical reach of river below St. Louis (river miles 154 - 138). It should be noted that exposed portions of the river bed without appreciable growth of vegetation, i.e., sand bars are not shown, since even a minor change in river stage could alter the size and extent of these sand bars significantly. The approximate dates of initial dike construction are also shown.

The growth of willows and other vegetation is quite fast due to either frequent inundation and/or a high water table. The uniform height of willow trees, sometimes in several distinct rows on low terraces, is very striking. If river stages are not high for long periods of time, the seedlings of a particular year will become tall enough to stand above the next high water, thus surviving, while their younger, shorter counterparts are submerged and die. The stabilizing influence of vegetation is important and islands are known to form in just a matter of a few years (Shull, 1922).

Once vegetation such as willows is established, sediment deposition can be very rapid due to increased surface roughness when the area is submerged. Deposits of several feet thick within a single flood period are not uncommon. Needless to say, the angle of current attack and many other factors affect the rates of sediment deposition.

4.1.1.2 Existing Channel Configuration

The change to impermeable stone dikes reduced the rate of deposition between dikes and the subsequent creation of new lands, due to the fact that deposition could only occur when fine sediemnts were brought in by eddy action when the water surface was lower than the dike crest or by the deposition of coarse particles when the dike was submerged. Imrpoved bank protection measures also helped reduce the rate and extent of bankline erosion and hence less sediment was introduced.

The St. Louis District has recently lowered the design elevation of dike fields in an effort to preserve and possibly enhance fish habitat as per the request of conservation agencies. Some of these dike fields contain notched dikes which were intended to improve fish

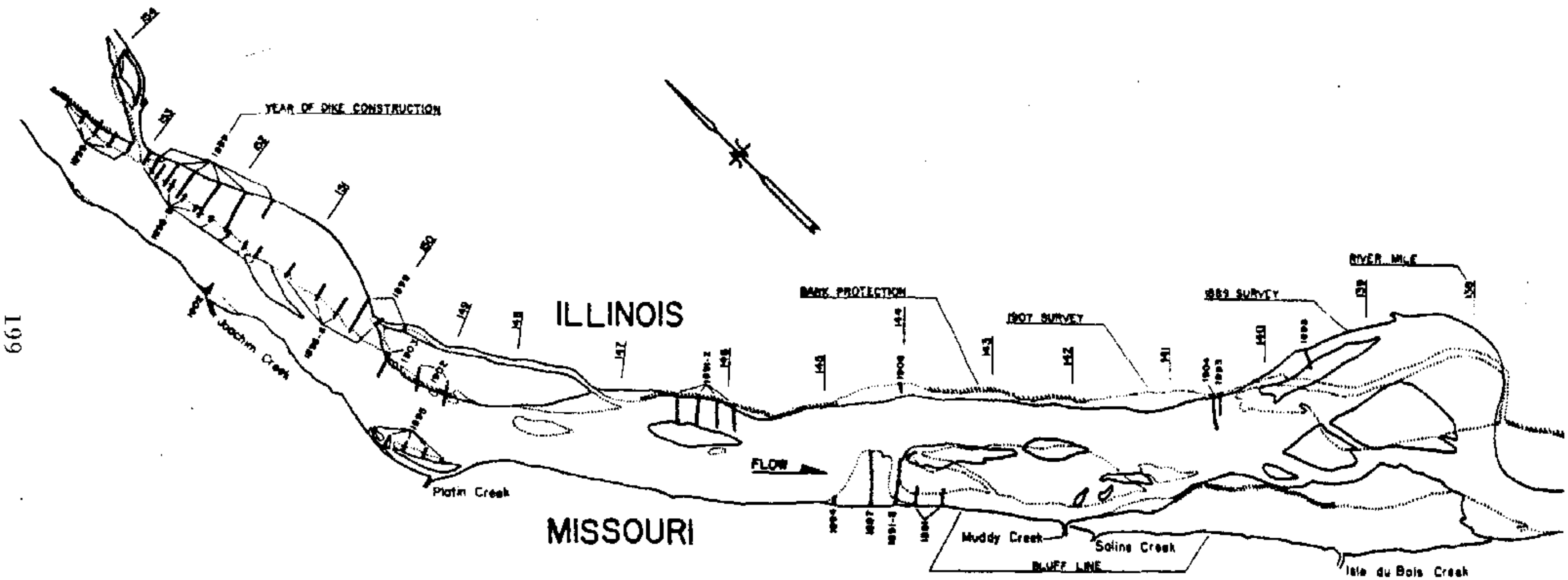


PLATE 4-3. Channel change map, 1889 to 1907, miles 154 to 138

habitat; however, observations to date indicate that notched dikes tend to draw more material into the dike field at a faster rate than unnotched dikes. Since the side opposite a dike field is now usually revetted, the possibility of any major or rapid change of the channel boundary in the near future is precluded.

With reference to the reach of river between miles 154 to 138 as shown on Plate 4-3, 1889 river conditions are compared with 1970 river conditions on Plate 4-4. Also shown are all the dikes which were constructed from 1882 to date. Plate 4-4 indicates how channel improvement works have been utilized to improve the navigation channel. In 1889 the river was very wide and shallow. By 1970 dike construction had reduced the width of the river and improved the navigation channel both in depth and alinement for waterborne commerce. Due to the decrease in sediment load of the Middle Mississippi River the rate of siltation between dike fields has been diminished. Future changes in channel cross-sectional area for improvement of the navigation channel will not occur as rapidly in the future as they did during the period from 1889 to 1970 as shown on Plate 4-3.

From 1889 to 1907 dike construction was primarily located from St. Louis downstream for about 70 miles. The remaining 100 miles of river downstream to the mouth of the Ohio River experienced little or no dike construction. It is of interest to note that with the exception of further narrowing of the river in some localities and the reduction of flows through certain side channels, the changes in width were generally not as great during the 63-year period from 1907 to 1970 as compared to the previous 18-year period (1889 to 1907), due to the fact that recent dike construction has consisted primarily of gradual extensions of existing dikes rather than relatively long new dikes as shown for the previous period, and the relatively slow rate of deposition between stone dikes as compared to the earlier permeable pile dikes.

4.1.1.3 Effect of Channel Maintenance Dredging

Approximately 4 to 5 million cubic yards of material is dredged each year from the Mississippi River at troublesome channel crossings in the reach from St. Louis to Cairo. This material is either placed between dike fields or adjacent to the main channel. Throughout the past year, coordination has been maintained with the respective state and federal conservation agencies so as to place the material in locations which are suspected to have the least adverse impact. In particular, efforts are made to avoid placement of this material in localities where it could enter or block openings to the previously mentioned side channels. Insufficient equipment exists at this time to enable the dredged material to be placed at elevations higher than the adjacent river level.

Although no significant changes in the bankline configuration have taken place, the question as to the relative permanency and stability of the dredged material is, for the most part, unanswered. When placed between dike fields, it seems as if the material is more stable than when placed adjacent to the main channel within the river

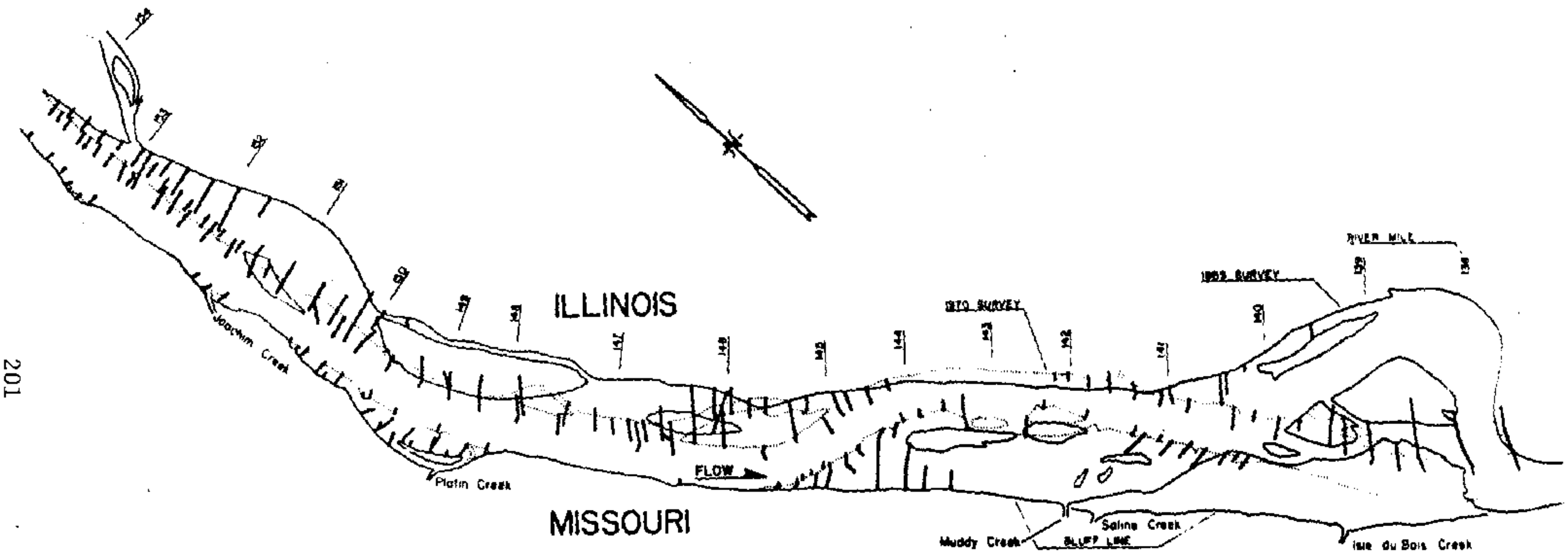


PLATE 4-4. Channel change map, 1889 to 1970, miles 154 to 138

where a succeeding high water event could transport the material to some unknown locality downstream, possibly to have the coarser portion of the material reappear at another future dredging. It should be mentioned, however, that the 4 or 5 million cubic yards to be dredged constitutes only about 3 or 4 percent of the total sediment load being transported, and possibly a fraction thereof being deposited elsewhere.

4.1.1.4 Narrowing of River Width and Decrease in Surface Area

The CSU report defines the width of the river as follows: "The river width is the distance from tree line to tree line irrespective of the bank height taken normal to the general direction of the flow in the river."

Table 4-1, also from the CSU report, shows the surface area of the Middle Mississippi River between Jefferson Barracks, Missouri, and Cairo, Illinois, as compiled from available maps. A comparison of these surface areas is most interesting. It is not certain what events and/or factors caused the increase in surface area, island area, and riverbed area between 1821 and 1888; however, it is probable that the large floods which occurred between 1844 and 1888 and land use practices increased the surface and riverbed areas of the river due to natural processes. During the period between 1888 and 1968 the river surface area was reduced by approximately one-third, the island area by one-half, and the riverbed area by one-fourth. The aforementioned reductions were brought about for the main part by channel improvement works and partially due to natural processes; however, the river surface area today is not too different from what it was back in 1821.

Table 4-1. River Surface Areas

Year	Surface Area (Sq.Mi.)	Average Width (Ft.)	Island Areas (Sq.Mi.)	Riverbed Areas (Sq.Mi.)
1821	109	3,620	14	95
1888	163	5,310	35	128
1968	100	3,160	17	83

4.1.1.5 Lowering of Riverbed Elevation

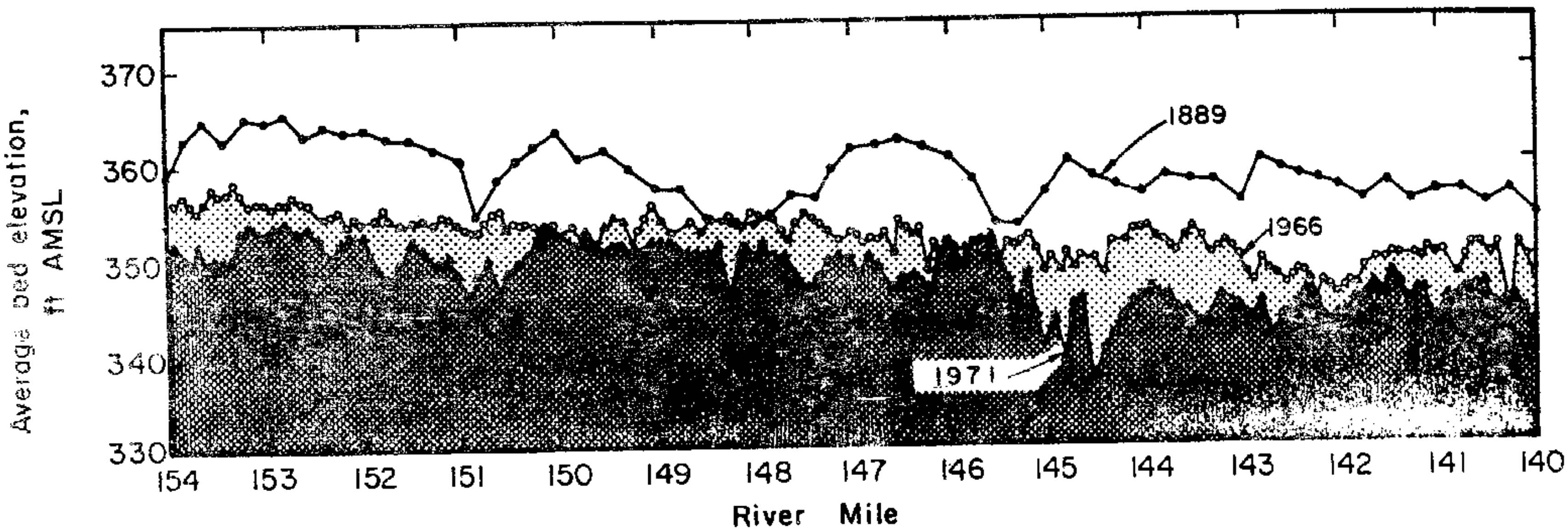
The basic engineering concept for development of a navigable waterway is to redirect the river's energy to the task of scouring out a suitable navigation channel. This is accomplished by contracting the width of the river on some prearranged navigation alinement so that a temporary increase in current velocities will develop a channel having the minium desired dimensions. The temporary increase in average current velocities begins to scour out the river bottom during low stages as soon as the river width has been reduced by contraction works. As the depths of the river increases, the temporary increases in current velocities begin to decrease and approach their original values prior to contraction, although they may be somewhat higher due to the fact that improved channel conditions offer less resistance to flow. A portion of the riverbed elevations in the 16-mile reach of river shown in Plate 4-4 are shown in Figure 4-1. The average bed elevation shown is the mean elevation of the riverbed in the low-water channel. The average bed elevation was determined as the average of between 10 and 20 riverbed elevations at a cross section. The riverbed elevation is not necessarily related to depth of flow but is the indicator of degradation or aggradation (scour or fill) in the river.

In 1889, riverbed elevations were taken after there had been a substantial increase in river surface areas from 1821 to 1888. The river at that point in time was about 4,800 feet in width. The elevation of the river bottom may have been influenced by the high water condition which prevailed during the early 1880's. The river was wide, shallow, and was not under the influence of extensive channel improvement works. Between 1889 and 1907 there was a substantial decrease in river width as previously mentioned. By 1966 the bank to bank width of the river had been reduced to approximately 3,200 feet, and the river had been contracted by a number of pile dikes to a low water width of 1,800 feet. The riverbed had lowered about 8 feet between 1889 and 1966. In July 1967, the Corps of Engineers selected this reach as a test reach (the previously mentioned prototype reach) to develop design criteria for obtaining and maintaining a dependable 9-foot deep navigation channel. Between 1967 and 1968, this test reach narrowed from 1,800 feet to 1,200 feet in width at low flow. In 1971, the riverbed was resurveyed. The 1971 bed profile is shown in Figure 4-1. The contraction from 1,800 feet to 1,200 feet at low flow had resulted in a 3-foot lowering of the riverbed. In 1971 the low-water riverbed in the reach between mile 140 and mile 154 was on the average 11 feet lower than in 1889.

It should be mentioned that between 1821 and 1889 the width of the river increased drastically with an attendant decrease in the average depth of the river. Therefore part of the riverbed degradation depicted in Figure 4-1 between 1889 and 1971 includes whatever increase in riverbed elevation that occurred between 1821 and 1889. The 1881 Navigation Act was passed by Congress because the riverbed elevations had increased between 1821 and 1880 to the point where the river was no longer suitable for navigation during low river stages. The amount of riverbed degradation compared to 1821 conditions and 1971 conditions is not known.

4.1.1.6 Effect on Flows

Using recorded discharge information the CSU report contains the following data. The water flows in the Middle Mississippi River have been measured at St. Louis intermittently from 1843 to 1861, and continuously since 1861. The flood peak discharge of record at St. Louis was 1,300,000 cfs, as recorded in 1844; with the Missouri River contributing 900,000 cfs, the flood of record in the lower Missouri. The largest recorded flood in the Upper Mississippi was 565,000 cfs at Alton, Illinois, which occurred in 1851 and again in 1858. The minimum discharge at St. Louis was 18,000 cfs which occurred in 1863.



To be comparable, riverbed elevations should be compared at similar discharges and river stages. The 1966 and 1971 bed profiles were determined for approximately the same river stage. The 1889 discharge and river stage may or may not be quite different from those of 1966 and 1971.

FIGURE 4-1. Bed Elevations Miles 140 to 154

The construction of levees along the flood plain was one of man's first influences to affect natural flows in the Middle Mississippi. The flood plain was a storage area for flood waters when the river rose above the bank-full stage. Also the flood plain provided some channel capacity to carry water downstream. Hence, levees, by protecting most of the flood plain from inundation, increase flood stages on unprotected areas for discharges greater than bank-full stage.

Because the flood plain was not protected by levees in 1844, the estimated peak discharge of 1,300,000 cfs during the flood that year passed St. Louis at a 41.3-foot stage. Now, mainly due to the construction of levee systems, the same discharge would pass St. Louis at approximately a 52.0-foot stage (Figure 4-2). While the peak discharge stage is now some 10 feet higher under developed conditions, as opposed to natural conditions, rural and urbanized areas suffer less flood damage, with the flood protection provided by levees, than without levees.

In about 1907, levee construction in the Middle Mississippi began in earnest because the financing of levees was shifted from private landowners to the Government. Until this time, levees were not effective because of inadequate engineering capabilities and inadequate financial resources.

The next dominant factor to affect flows was the construction of storage dams on the Missouri River, but the first was not completed until 1940. The larger dams are Yellow Tail on the Yellowstone River and Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point on the Missouri, The effects of these reservoirs on the flows depend on the method of operation. In general, the reservoirs have the effect of decreasing the maximum flows and increasing the minimum flows.

Other factors which could influence the natural flows are changes in conditions that affect runoff from the drainage basin, These factors could be changes in the amount of precipitation and changes in the land uses. Watershed Protection and Flood Prevention projects under Public Law 566 along with soil and water conservation work on individual farms affects run-off from drainage basin. Also consumptive uses for irrigation and domestic use are other factors.

The CSU report states the net effects of upstream developments on the flows in the Middle Mississippi River at St. Louis are:

1. The average annual peak flood discharge has not changed much in 110 years. On the average, the present-day peak floods are only slightly lower than previously.

2. Large flood flows are not occurring as frequently now as in the past. In the decade between 1850 and 1860 there were three flood peaks greater than 1,000,000 cfs. Flood flows in excess of 1,000,000 cfs have not occurred since 1903.

3. The mean annual discharge has not changed in 130 years.

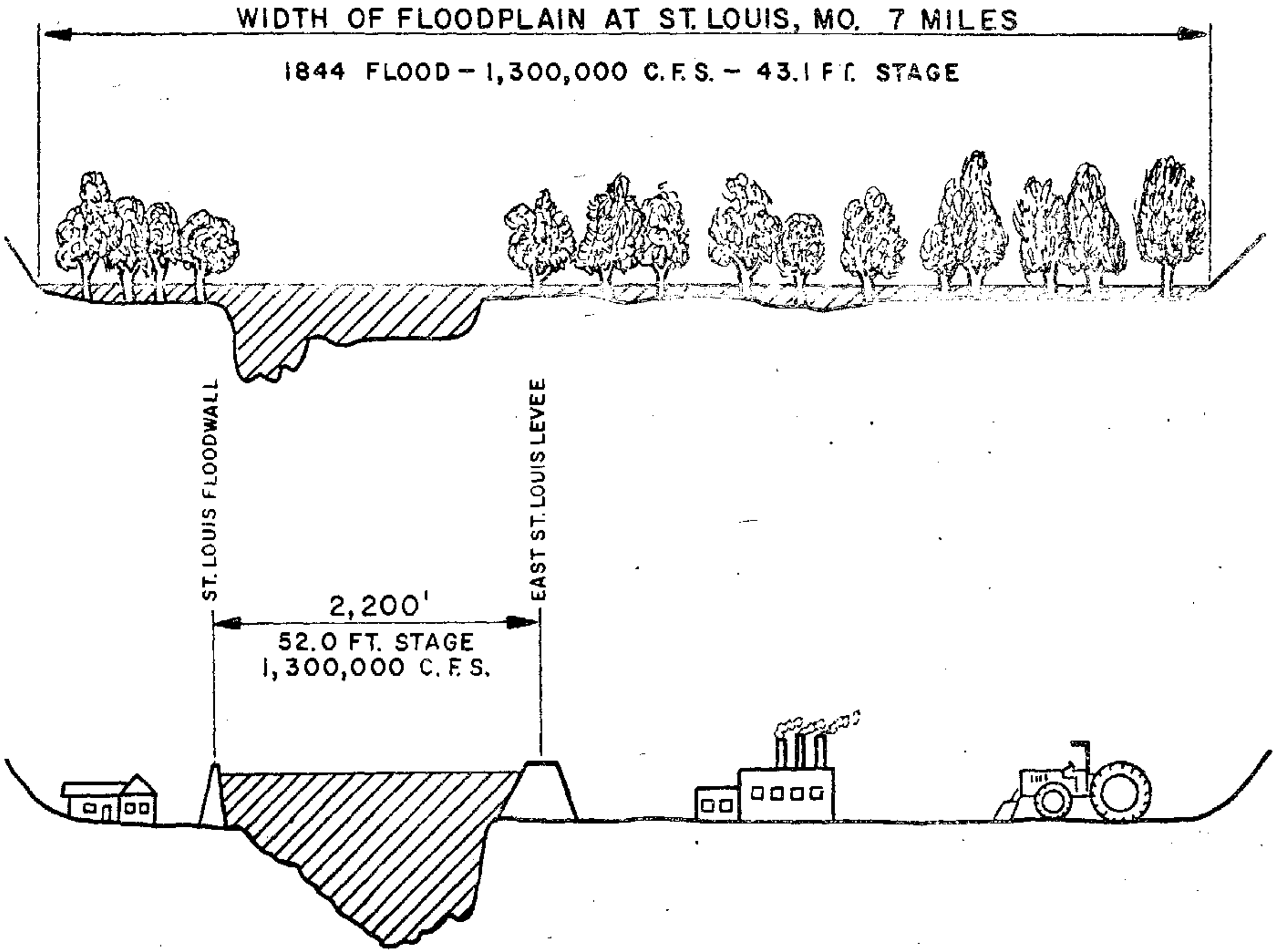


FIGURE 4-2. APPROXIMATE FLOODPLAIN CROSS SECTION FOR 1,300,000 C.F.S.

6. The annual minimum flow has been increasing slightly during the 130 years of records.

In general, the conclusion is that storage reservoirs, levees, dikes, land use changes, and any climatic changes have, in aggregate, not significantly changed the average annual flow in the Middle Mississippi. In terms of flood control the effect is that very large and very small discharges were more common in the natural river than in the river today.

4.1.1.7 Changes in Sediment Discharge

In is the water flows delivered to the Middle Mississippi River by its tributaries and the Upper Mississippi River which sculpture the river form. The sediment flow is the supply of material which interacts with the erodable bed and bank material to determine the form of the river. Subsequent to the construction of upstream reservoirs in the Missouri River Basin there has been a substantial reduction of the sediment load entering the Middle Mississippi River from the Missouri River. Extensive revetment works constructed on the Middle Mississippi River to date also cause a reduction in the sediment load of the river.

Most of the sediment load delivered to the Middle Mississippi River comes from the Missouri River (Jordan, 1965). That sediment carried in suspension is about 50 percent clay, 35 percent silt, and 15 percent sand. In general, the sediment moving along the bed of the river is find sand.

Since the delivery of sediment to the Middle Mississippi River is being decreased by upstream storage reservoirs or other development, such as soil and water conservation work,it is anticipated that the river channel will "naturally" deepen slightly because of degradation induced by upstream storage of sediment.

4.1.1.8 Effect on River Stages

Contractive works for the channel improvement project are designed to be effective in maintaining minimum authorized channel dimensions between a discharge of 54,000 cfs up to and including 300,000cfs. When discharges are lower than 54,000 cfs, the channel must maintained by dredging because it is more economical to utilize maintenance dredging to maintain the channel than to attempt to do so with additional contractive effort. Discharges below 54,000 cfs occur on the average of 3 percent of the time based on a 114 year period of record. Following periods of high flow when discharges are above 300,000 cfs, a rapid fall in river stage may deposit excessive amounts of material in the navigation channel so that the contractive effort may not have time to flush out this excess material prior to the next low water season. When this occurs, it is also more economical to maintain the channel by dredging than to do so via the construction of additional contractive effort. Discharges above 300,000 cfs occur on the average of 14 percent of the time based on 114-year period of records.

Figure 4-3 (a) shows that the stage-discharge relationship at a discharge of 54,000 cfs has been lowered by 11 feet between 1837 and 1946. This is due to past and current efforts to develop a dependable navigation channel.

Based on published discharge data, the CSU report concludes that there has been no change in the stage-discharge relationship at 290,000 cfs between 1837 and 1946 as shown in Figure 4-3(b).

Based on published discharge data, the CSU report concludes that the stage-discharge relationship at a discharge of 500,000 cfs, i.e., bankfull stage, has increased 2.5 feet between 1837 and 1946. The increase of 2.5 feet in present-day river stage above the former natural river stage is attributed by CSU solely to dike construction as indicated in figure 4-3(c).

At discharges above 500,000 cfs river, stages begin to overtop the natural high bank of the Middle Mississippi River. (Bank-full stage at St. Louis is 30 feet on the gage). As discharges continue to increase above 500,000 cfs, the effect of the 2.5 foot increase in the stage-discharge relationship, graphically illustrated by Figure 4-3 (c), begins to diminish and levees begin to have a more pronounced effect on the substantial increase in the stage-discharge relationship, graphically illustrated by Figure 4-2.

Although the effect of the channel improvement project on flood stages is small in comparison to the effect of levees, there is some effect caused by the channel improvement project which must be addressed in this Environmental Impact Statement.

Opinions differ as to the exact amount of increases in flood stages caused by the channel improvement works constructed to date. As previously mentioned, the increase in present-day river stages attributed to dike construction by CSU is based on published stage-discharge data. This subject is currently under review because stage-discharge data published prior to 1934 is known to be less accurate than stage-discharge data published after 1934. Channel improvement works constructed to date may or may not have some influence on flood stages; however, it is generally agreed that the major cause for the increase in flood stages during the past 100 years is due mainly to the extensive flood protective works constructed within the floodplain. It should be pointed out that the Corps of Engineers become involved in flood protection under the terms of the 1928 Flood Control Act following the disastrous flood which occurred on the Mississippi River in 1927. It should also be pointed out that the act which authorized the navigation project does not contain any provisions for the construction of flood protective works, which are covered by other Congressional authorizations. The St. Louis District took the increase in flood stages into account at the time the flood protective works were designed as attested by the fact that the major flood of 1973 passed St. Louis within allowable tolerances of the rating curve for that discharge. In addition, 2 feet of freeboard above the design flood crest elevation is included for all levees and floodwalls constructed by the St. Louis District.

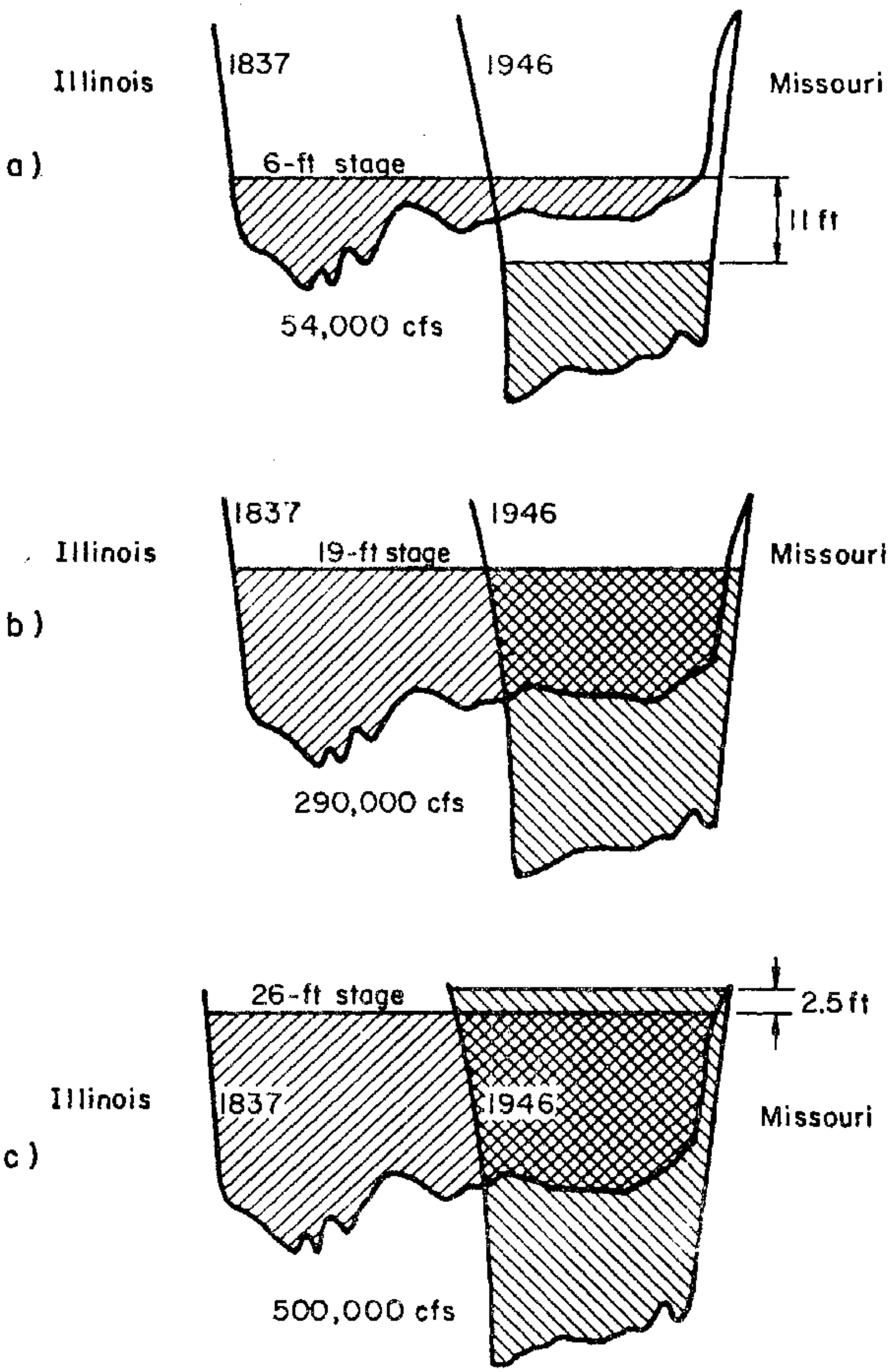


FIGURE 4-3. Channel cross section areas at St. Louis. Discharges based on published discharge data

Based upon published discharge data, CSU prepared Table 4-2 which contains a tabulation of flood stages for similar discharges at St. Louis. This table indicates that similar discharges are now about ten (10) feet higher in elevation than they were in 1881. This relationship coincides with the difference in the stage-discharge relationship shown on Figure 4-2, and is consistent with design expectations. The most significant fact relating to the tabulation in Table 4-2 is that the 1927 flood passed St. Louis at 36.1 feet, causing catastrophic damages within the flood plain. The 1973 flood passed St. Louis at 43.3 feet, and no Government levee failed, with the exception of Kaskaskia Island, which was overtopped. The Kaskaskia levee was not built to provide the same degree of protection as other Government levees in the St. Louis District.

Table 4-2. Flood Stages for Similar Discharge at St. Louis

Year	Maximum Stage (Ft.)	Discharge (cfs)
1881	33.6	822,000
1883	34.8	863,000
1908	35.0	850,000
1909	35.2	861,000
1927	36.1	889,000
1943	38.9	840,000
1944	39.0	844,000
1973	43.3	855,000

The CSU report indicates the following: for discharges greater than approximately 290,000 cfs but less than 500,000 cfs, the increase in present-day river stage above the former natural river stage is due solely to the dikes. Because the channel below bank-full stage is much narrower in the contracted river, the state for a flow of 500,000 cfs is greater than in the natural river. For a flow of 500,000 cfs (bank-full flow), the cross-sectional areas occupied by the flow are shown in Figure 4-3(c). At 500,000 cfs, the 1946 stage was 2.5 feet higher than the 1837 stage.

Once the river flows spill overbank, the levees and developments upon the flood plain, and possibly dikes, influence high water stages. For discharges slightly greater than bankfull, the effect of levees on river stage is small. The former flood plain (now protected by levees) was not efficient at carrying shallow flows. For larger floods, the former flood plain provided more storage area than the present flood plain, consequently, flood stages are now higher for similar discharges than in the past.

The effect of dike construction on river stages above bank full stage is still under review as prevsiously mentioned. If dike construction does influence river stage above bank full stage, as stated in the CSU report, there is some flood discharge greater than bank full for which the increase in stage caused by levees is equal to the increase in stage possibly caused by dike construction. For floods greater than this flood, the effect of levees on the peak stage is much greater than the possible effect of dike construction peak stage.

4.1.1.9 Existing Side Channels and Future Configurations of the River

To adequately define the processes of formation of the previously mentioned side channels and the effects of dikes upon the main channel itself, studies were made by Colorado State University to investigate this particular phenomenon (Simons, et al., 1974). As stated previously, the manmade side channels were created as a result of subsequent vegetation of sandbars which were formed between the slack-water areas of adjacent dikes and the creation of side channels between the newly-formed islands and the river bank. However, these side channel areas, although their rate of deposition may be slower than that of the island area itself, will ultimately fill with sediment, thus making the island a part of the floodplain proper. It should be remembered that natural side channels existed before man-induced changes began due to the shifting of the river channel. Since the position of the river within the floodplain is now controlled, the opportunity for new side channels to form is minimal.

As part of the Corps policy of cooperating with Federal and state conservation agencies, notches were built into numerous dikes. several years ago, at the agencies suggestion, in an effort to reduce the rate of sedimentation between them. The notch consisted of a 4-foot low gap near the middle of the dike 50 to 200 feet in length. Generally speaking, it has been found that the notches are ineffective in achieving their purpose, and can actually increase the rate of sedimentation between them.

Model tests and investigations of existing side channels were performed by Colorado State University in an effort to find ways to alleviate this siltation problem. To present their findings in the most expeditious manner, their conclusions are herewith presented:

> "From our (Colorado State University) analysis of the historical changes in the river and from our geomorphic model studies, we have come to the following conclusions concerning the planned channel contractions by extending existing dikes and building new dikes to achieve a 9-foot deep low-water navigation channel in the Middle Mississippi River. It is assumed that future dike construction will be to the same specifications that have been used in the last decade and that vegetation will form on the bars in the dike fields. Below, the anticipated river behavior is compared to the behavior of the river as it is in 1973. In this way, the comparison can be made without considering levees. The levees were completed prior to 1973.
>
> 1. The natural backwater channels are a product of the natural, uncontrolled, shifting river. Any river subject to development will experience a deterioration of the natural backwater channels unless these channels are maintained artificially.
>
> 2. Future channel contractions will result in an increase in the depth of flow at all river stages.

3. Future channel contractions may decrease the river channel capacity at flood stage. The result may be higher flood stages for a given flood discharge.

4. Future channel contractions will lower the riverbed level and the low and intermediate water stages in the river. Stages will be lower on a greater number of days in the year. Lower stages affect groundwater levels in the acquifers connected to the river and affect tributary channels.

5. In the past, the construction of the dike fields has eliminated many natural side channels but these natural side channels were replaced by side channels resulting from the dike fields.

6. In the most part, future channel contractions by extensions of dikes will produce no new side channels.

7. Unless steps are taken to prevent it, ultimately nearly all natural and man-induced side channels should completely fill with sediment and become undistinguishable from the flood plain.

8. Small natural and man-made chute channels fill at a rate of up to three feet per year. Backwater channels fill at rates between one and five inches per year. Those few large natural chute channels in existence today will remain open for a long period of time.

9. Generally speaking, it is very difficult to design dike fields so that the resulting side channels will be self-maintaining. Dike fields are usually located in depositional areas of the river channel and suitable side channel intake positions are not available unless the flow is realigned upstream of the dike fields.

10. The life of a side channel can be increased greatly if the side channel can be isolated on the upper end from the main channel. When the side channel is isolated in this manner, the side channel is a backwater channel and the rate of sedimentation is very small.

11. Blocking an unsuitable upstream intake to a side channel will extend the life of that side channel. With the upstream intake blocked, the sediment supply to the side channel is reduced. Short side channels can be supplied with water during low stages from the lower end.

12. The notched dike may help in extending the life of a very few side channels. In general, the notched dike cannot be located in the proper position. Also, bankline instability will result where large scour holes occur next to the bankline."

It should be noted that the above findings are based on future dike construction being the same specification that was used during the last decade. However, it is now the current practice of the St. Louis District to construct dikes to a lower elevation than previously used. It is anticipated that the lower dike elevations will cause numerous channels to be perpetually maintained along and between these structures because of regime changes in the channel between low and high flow and the associated scouring effect over and around the low dikes.

Environmentalists fear that the life of all natural and man made side channels is limited and may eventually fill with sediment, thus transforming the Middle Mississippi River into a single channel stream. However, it should be mentioned that even if dike construction were to cease at this time, the end result would still be the same, thus precluding the action of cessation of dike and revetment construction as a means to significantly alleviate the physical impacts to the river's regime.

4.1.2 IMPACTS ON GEOLOGIC ELEMENTS

4.1.2.1 Impact of Construction of Economic Geology

No adverse impact on bedrock mineral resources is anticipated. Construction of stone-fill dikes and bankline revetments associated with the project would create an increased demand for quarry or paving stone. Numerous quarries which can supply adequate limestone are adjacent to the river the entire length of the project.

4.1.2.2 Impact on Seismic Activity

Although the lower half of the project area occurs in a high risk seismic region, the nature of the project precludes its having any effect on seismic activity.

4.1.2.3 Impact on Groundwater

There will be no impact on the quality of the groundwater in the project area. There may be an insignificant lowering of groundwater levels immediately adjacent to the Middle Mississippi River and the mouths of tributary streams.

4.1.2.4 Impact on Economic Geology

The construction of dikes and the resulting siltation will cover over the sand and gravel deposits which occur immediately behind each dike thus eliminating these mineral resources from economic exploitation. In addition, commercial dredging operations for sand and gravel deposits will be restricted in areas immediately adjacent to dikes to prevent undermining of the structures. Numerous sand and gravel deposits occur along the river; however, only a very few deposits would be affected by this project.

4.1.3. IMPACTS ON SOILS

4.1.3.1. Alteration of Topography

To operate and maintain the nine-foot channel in this study area with a minimum amount of dredging, a system of dikes and revetted shoreline is necessary. Dredging alters the depositional gradation and density of the dredged materials in addition to altering the topography. The system of dikes and revetment alters the transportation of sediments downstream. The dikes slow the velocity of the water in areas behind them, causing an increase of material deposition, and increase the velocity of the water in the channel, causing a decrease of material deposition and possibly removal of additional material. The revetment is for protection from erosion caused by the higher velocities.

4.1.3.2. Alteration of Drainage

The alterations of topography will cause minor alterations in the drainage in local areas where materials have been deposited.

4.1.4 IMPACT OF OPERATION AND MAINTENANCE OF PRESENT NAVIGATION CHANNEL ON WATER QUALITY

4.1.4.1 Dikes and Revetments

Dikes and revetments serve to constrict the main channel in order to maintain the 9-foot navigation channel. Constriction of the river has generally caused the reduction of river surface area, island area, riverbed area, river width, and corresponding bankful channel and cross-sectional area. Dikes also shut off side channels to low flow, keeping more water in the main channel.

The reduced width causes increased depth per unit of width, which results in increased transport capability of the water. Turbidity, which serves to limit oxygen production by photosynthesis, is greater because of this capability of the water to carry more suspended material. The river bottom is further degraded by scour due to the increased transport capacity, which put into and keep in suspension such pollutants as heavy metals and pesticides if present along with sediments that would normally settle out. Also, organic material in the sediments are resuspended in the water column, which may elevate the chemical oxygen demand, resulting in the reduction of dissolved oxygen concentrations.

The new dikes and extension of old dikes to increase constriction of the river from 1,800 feet to 1,500 feet will cause increased flow velocities resulting in further scouring of the bottom of the channel. More sediment will be carried by the river,causing and increase in turbidity in the channel, as well as pollutants resuspended from the sediments. Greater deposition of sediments will also take place behind dikes and in dike fields, which will speed closures of side channels by sedimentation.

Short-term increases in turbidity will probably result during bank proparation and dike and revetment placement activities, Once river bank areas stabilized by revement, rates of erosion diminish and these areas will contribute less turbidity than unprotected banklines.

4.1.4.2 Maintenance Dredging and Disposal

A factor of major concern is the adverse effect of dredging and disposal of dredged material on water quality. Increased turbidity along with increased siltation are probably the most detrimental factors associated with the project. Turbidity reduced light penetration and, therefore, may interfere with primary production, flocculate planktonic organisms, decrease food availability, and produce effects that may be aesthetically displeasing. Also, increased sedimentation could result in the smothering of benthic organisms, destruction of spawning areas for fish, reduce habitat diversity, and reduce vegetation cover. Also, pesticides, metals, sulfides, methane, or other toxins, if present in bottom deposits, can be released to the water column by resuspension of the sediments which could have an adverse effect on the use of the water for municipal water supplies, if it causes existing water quality criterius to be exceeded. The resuspension of organic matter from the sediments causes increased chemical oxygen demand, and the resulting decomposition could cause reduction of dissolved oxygen concentrations.

4.1.4.3 Barge Traffic

Barge traffic on the river and the resulting impact of propeller wash during low stages, causing a temporary increase in turbidity and the repositioning of bottom sediments, the results of which have been discussed earlier. Below St. Louis the Middle Mississippi River has no locks and dams. For this reason the current is faster, resulting in the river's ability to carry a greater load of suspended solids, with the major source of the load being the Missouri River, entering the Mississippi River just north of St. Louis. Because of this, ambient turbidities in this section of the river are comparatively high, and the aquatic biota is characteristic of such conditions. Also, sediments are mainly sand, which settles out very quickly after being resuspended. Consequently, these impacts are expected to be confined primarily to the main channel, which is generally poor habitat for aquatic biota.

Barge traffic increased by 92 percent on the Middle Mississippi during the period 1962 to 1972 (see paragraph 2.3.2.1). Such increases in traffic increase the risk of accidental spillage of pollutants into the river. Federal and State regulations prohibit the purposeful discharge of wastes into the river, and such regulations greatly reduce the amount of waste entering the waterway.

4.1.4.4 Chain of Rocks Canal and Locks

The operation and maintenance of the Chain of Rocks canal and locks is a vital function for navigation on the Upper Mississippi River System. These facilities permit the safe and efficient passage of river traffic around the navigational hazards associated with the Chain of Rocks Reach as described in Part 1.4.4, page 47a. In addition to this function, the harbor facilities which were developed with this project provide St. Louis a terminal port location for navigational purposes.

4.1.4.5 Low Water Dam (Dam No. 27)

Since its completion, Dam No. 27 has required minimal maintenance and because of its structural features is self operating. This structure is responsible for insuring a minimum depth of nine feet at low water over the lower miter sill of Locks and Dam No. 26 at Alton, Illinois. Dam No. 27 blocks navigation of the hazardous Chain of Rocks Reach for commercial interests as well as for most pleasure boats except during extreme high water periods. The artificial rapids and pool areas created by this structure are utilized by local canoeists and fishermen, respectively.

4.2 BIOLOGICAL IMPACTS

4.2.1 AQUATIC COMMUNITIES

4.2.1.1 Dikes and Revetment

Between 1888 and 1968, the effects of river contractions by dike fields and bank revetment in the Middle Mississippi River reaches between St. Louis, Missouri, and Cairo, Illinois, reduced the bank-to bank river surface area by one-third, the island area by one-half, and the water surface area by one-half (Simons, et al, 1974). A total of 91 miles of functional dikes and 122 miles of revetment were constructed.

The natural consequences of reducing the river's width include an increased transport capability of the river, resulting in degradation of the riverbed. The effects of riverbed degradation on aquatic organisms in the Middle Mississippi River are not yet fully understood; it is probable that adverse impacts occur directly by abrasion and suffocation and indirectly through alteration of their habitats.

Increased variations in annual maximum river stages and decreases in annual minimum and daily river stages have occurred since man-made modification of the Middle Mississippi River bagan. The net result has been greater fluctuation of water levels than in the past. Fluctuating water levels have occurred throughout the history of the river, and biota living in the river are characteristic of these conditions. Nevertheless, it has been demonstrated that a considerable amount of movement and displacement of fish and invertebrates takes place during periods of high water (Maitland, 1964, and Sprules, 1947, as cited by Hynes, 1970; Fajen, 1959). Differential rates of survival of and recovery from flooding have also been recorded for different families of invertebrates (Deacon, 1961). The increase in water level fluctuations could have the effect of changing the species composition and abundance of organisms that occur in the various aquatic habitats within the Middle Mississippi River reaches.

Perhaps the most serious adverse impact resulting from the 9-foot channel project on the Middle Mississippi River is reduction in size and diversity of the aquatic habitat. The water surface area has been reduced by 9 square miles since 1821 and by 63 square miles with respect to the 1888 area. Based on Colorado State University studies of man-induced changes in the Middle Mississippi River, most of the side channel and main channel border habitat will eventually become filled with sediment (Simons, Schumm, and Stevens, 1974), unless artificial means, i.e., dredging, are employed to maintain side channels. It should be noted that reduced sediment loads in the Mississippi River have had a tendency to prolong the life of existing side channels. ✓

Reduced numbers of Plankton, benthos, and fish species have been cited as the effect of channelization projects on smaller rivers and streams (Little, 1973; Schneberger and Funk, editors, 1971). Reductions as great as 90% in the standing crop of fish and invertebrates have been reported. In the Missouri River in the 93 years between 1879 and 1972 the water surface area between Rulo, Nebraska and the mouth has been reduced by 50%. The commercial fish harvest declined in the Missouri River by 80% in the 16 years between 1947 and 1963 (Funk and Robinson, 1974)

The cumulative effect of channelization efforts in the Middle Mississippi River to date has not been adequately assessed. The loss of habitat due to reduction in surface area must be viewed together with the newly established 91 miles of dikes and 122 miles of revetment and the possible habitat they provide for aquatic organisms. Field surveys by Waterways Experiment Station personnel of dikes and revetments at various locations along the river indicated that these rock-strewn areas provided excellent habitat for benthic organisms. ✓ Large numbers of nonburrowing mayflies and caddisflies, along with other aquatic invertebrates, were observed in these areas.

4.2.1.2 Maintenance Dredging and Disposal of Dredged Material

The direct effects of dredging on benthic communities appear harmful; yet definitive information allowing the predication and assessment of the extent, duration, and significance of these effects has not been documented. In general, the potential for the direct destruction of benthic communities is greater in areas which have not previously been dredged than in areas where dredging has occurred, which characteristically have shifting substrates that may limit successful benthic colonization. Direct destruction of commercially valuable species such as mussels is another concern.

Among the physical alterations as a result of dredging are changes in bottom geometry and bottom substrate that cause temporary alterations in current patterns, and possible nutrient exchange or toxic chemical exchange between sediments and the overlying water. These physical alterations may work individually or synergistically to initiate different responses within aquatic communities.

Most of the concern associated with the disposal of dredged material in the Middle Mississippi River involves the effects of open-water disposal on water quality and aquatic organisms and the closure of side channels. Open-water disposal results in the resuspension of large volumes of sediment within a very short time and in a limited area. The resuspended sediments may contain toxic chemicals and nutrients that may enter into solution and adversely affect biological communities. The increased turbidity that results from the disposal of dredged material temporarily reduces light penetration and therefore, may interfere with primary production, flocculate planktonic organisms, decrease food availability, and produce effects that may be aesthetically displeasing. Also, increased sedimentation could result in the smothering of benthic organisms, destruction of spawning areas for fish, reduction of habitat diversity, and reduction of vegetative cover. The decomposition of resuspended organic matter from the sediments could cause the reduction of dissolved oxygen concentrations, thereby causing the suffocation of stress of organisms in the immediate vicinity and/or the release of noxious materials, such as sulfides and methane into the water column.

It is well established that, within the Mississippi River, bottom sediments are continually being resuspended naturally, and to a degree, open-water disposal of dredged material can be thought of as an extension of these natural processes. The impacts of open-water disposal would be short-term and minor, because of the concentration of such impacts primarily in the main channel, which is generally poor habitat for aquatic biota. It should be also noted that samples of dredge material obtained from the navigation channel by the St. Louis District sampling program conducted in conjunction with the preparation of this report, and routine water quality analyses, all indicate that the water quality of the Middle Mississippi River generally meets the minimum standards established by the Environmental Protection Agency. However certain heavy metals were found to exceed Illinois water quality standards.

Dredged material is not disposed of in critical areas, such as near the entrance or exits of side channels, because it could block the flow of water through the side channels and thereby prevent the movement of fish and other aquatic organisms between side channels and the river, and could also result in the alteration of existing physicochemical characteristics.

4.2.1.3 Tow Boat Operations

The primary purpose of the 9-foot channel project on the Middle Mississippi River is to construct and maintain a navigation channel for barge traffic. Operation of the tow-boats, while not a part of the construction or maintenance activities, is intricately involved in the channelization project. As such, the effect of tow-boat operations on the riverine ecosystem must be considered.

The primary effect of tow-boat operations on the riverine ecosystem during extreme low-water periods, which occur on the average less than 5 percent of the time, is to sometimes increase turbidity levels by the temporary resuspension of sediments. The effects previously cited as being associated with higher trubidity levels and the resuspension of sediments include the interference with photosynthetic activities and the abrasion and suffocation of aquatic organisms. These impacts are expected to be confined primarily to the main channel, which is generally poor habitat for aquatic biota.

A second concern relating to tow-boat operations is the adverse impact resulting from toxic materials introduced into the river by accidental spillage; however, the Missouri Department of Conservation has indicated that it knows of no major fish kill on the Middle Mississippi River being caused by accidental spillage from barges.

4.2.2 TERRESTRIAL COMMUNITIES

4.2.2.1 Impact on Vegetation

Disturbance by flooding is a characteristic of all unprotected flood plains, and it is largely this property that makes them unique habitats. Flooding plays a significant role in plant establishment and dispersal.

Although there are other river environments, the same set of ecological conditions that is present in the project area is not found elsewhere. Consequently, any increase in agricultural, timber harvesting, and public utilization activities will be detrimental to the uniqueness of this area.

4.2.2.2 Impact on Wildlife

Efforts to develop the river from the standpoint of flood control and navigation have been vast and effective. Over the past years, many low areas which were once swamps have been cut off from the river by an extensive system of levees and drained. These areas are now inhabited and farmed, and are now not as suitable for wildlife habitat as they formerly were prior to the improvements made to benefit man.

Control of the river for flood control and navigation purposes has resulted in the increased efficiency of the hydraulics system,but slowly reduced the river surface area. Most of the time the river flows between levees. What wildlife values are remaining, exist on this unprotected flood plain which is bounded on each side by levees. Further development and control of the river for flood control and navigation will diminish the remaining wildlife values,which are extremely valuable even at this reduced status. As an example, the closure of side channels may have adverse impacts on wildlife species. The presence of these channels offers four benefits to wildlife in general: (1) the extent of sand and mud flats in that area would be maintained, favoring several organisms, (2) they serve as a barrier between the mainland and the islands, hence access to the islands by man and many predators is limited, (3) with a lack of access, the islands are less likely to be modified by logging and clearing, and (4) since loss of any one environmental type puts stress on remaining aspects of the system, maintenance of chutes and their diversity is important to the ecosystem. It should be noted that during the past five years the St. Louis District has been cooperating with conservationists in an effort to preserve these side channels.

Land ownership in the unprotected flood plain rests in the hands of the private citizens and it is no coincidence that much of this valuable wildlife habitat is also valued for its timber and agricultural potential. Consequently, during years of low flow,this land is under the threat of being cleared and utilized for cropland.

4.2.3 IMPACT ON RARE AND ENDANGERED SPECIES

4.2.3.1 United States List

The Indiana bat, southern bald eagle, and peregrine falcon are endangered nationwide (U. S. Department of the Interior, 1974). Construction and operation and maintenance of the nine-foot channel in the Middle Mississippi River would probably have an insignificant impact on these species. The endangered status of the southern bald eagle and peregrine falcon is thought to be the result of insecticides, encroachment on nesting areas, and illegal shooting. It is believed at this time that the limiting factor for Indiana bats is the lack of undisturbed hibernation areas, such as caves and mines, which do not occur near the navigation channel.

4.2.3.2 State Lists

Eleven species of fish are considered rare to extremely rare in abundance within the reaches of the Middle Mississippi River (Appendix D). Six of these species, the alligator gar, Alabama shad, sickefin chub, sturgeon chub, pallid sturgeon, and blue sucker, have been listed as being rare or endangered statewide by the states of Illinois or Missouri (Appendix G). It is thought that none of these 11 species have ever been abundant in the Middle Mississippi River reaches. Man's activities to date, including construction and maintenance of the nine-foot channel, have probably been a minor factor in the critical abundance of these species. However, continuation of the operation and maintenance activities could result in a further decline or the elimination of most of these species from this section of the Mississippi River, unless artificial means are employed to enhance or maintain the fish habitat.

A total of 64 plants, 17 mammals, 25 birds, and 19 reptiles or amphibians, which are rare, endangered, or status unknown in Illinois or Missouri or both, occur or may be expected to occur in the unprotected floodplain (Appendices F and G). The Indiana bat, southern bald eagle, and peregrine falcon are endangered nationwide.

Reasons for the decline of many rare or endangered species aee not known. Several birds and mammals have historically been over-exploited for sport or commerce; indiscriminate hunting of rattlesnakes and other unprotected species continues today. Use of pesticides and herbicides is thought to have a great effect on biotic populations expecially birds. Pollution in general is detrimental to all species.

Habitat destruction, especially loss of woodlands and wet lowlands to clearing and drainage, has caused the status of about half of the species concerned. Several terrestrial vertebrates use this habitat almost exclusively. Woodlands in the unprotected flood plain are significant because they comprise 30.4 percent of the vegetation and presently have limited human use. Animals intolerant of man's activities, such as the bobcat, bear, otter, pileated woodpecker, anhinga, and timber rattlesnake, exist here. Thus, increased agriculture, timber harvesting, and public utilization could be deterimental to many of the rare or endangered species.

Several species, such as the southeastern bat, cotton mouse, black bulture, fish crow, green treefrog, and green water snake, exist in the Middle Mississippi at the periphery of their range. The vegetative homogeneity between latitudes of the unprotected flood plain is an asset in allowing range expansion.

4.3 CULTURAL IMPACTS

4.3.1 DEMOGRAPHY

The continued regulation of the 9-foot channel involves the activities of revetments, dikes, and dredging. The construction and/or institution of these measures have no direct impact on the population. However, the product of the regulating works, i.e., the 9-foot navigable channel, does have an effect on the settlement pattern. This impact takes place at transportation termini, such as St. Louis and Cairo, and river towns, such as Ste. Genevieve, Chester, and Cape Girardeau. Not only were each of these towns founded because of river access, but they continue to prosper, in part, because of the comparative advantage afforded to them by river transportation. Because of this advantage, these settlements attract economic activities, i.e., manufacturing, which, without river transportation, might have located at other points, perhaps inland.

Linked to the above idea is the role of St. Louis as a regional center and its linkages to the Mississippi River. Though academic at this time, a change in the status of river navigation could effectively alter St. Louis' role as a regional center. In time, such a change would give rise to a more regular horizontal arrangemnt of settlements and centers based upon land distance and cost of land transportation. Such an evolution would serve to deemphasize St. Louis as a regional center.

4.3.2 ECONOMY

4.3.2.1 Project Future

a. National Economy. Maintenance of the 9-foot channel in the project reach would allow for continued use of the river for inland navigation. The project will not alter the existing cost structure of waterborne transportation, and thus should have no effect on the existing modal split, i.e., water, rail, pipeline, truck .

b. Regional Economy. The main impact of continued maintenance of the 9-foot channel on the regional economy will be to (1) maintain the current level of shipping, and (2) allow for future growth of the waterborne commerce industry, and industries using the water for shipping.

Maintenance of the channel will not in itself result in economic growth in the project area. On the whole, the port of St. Louis (portions both within and outside of the project area) are much more likely to benefit from maintenance of the channel than the rural counties at the southern end of the reach. The metropolitan area has the other transportation facilities to act as a transshipment point, the market and industries to consume commodities moving on the water, and the industries to produce bulk commodities unacceptable to waterborne carriage.

The rural areas, by contrast, lack manufacturing facilities, a large market, and an extensive transportation network, and they might be expected to benefit less from maintenance of the channel. Raw materials, especially coal (with the opening of the Kaskaskia River navigation project), and to a much lesser extent, grain, should continue to be shipped from these rural areas.

4.3.2.2 Future Without the Project

a. National Economy. Non-maintenance of a 9-foot channel in the project reach would have substantial adverse impacts on the national economy. As has been noted above, this stretch of the river serves as a vital link between the Upper Mississippi, Illinois, and Missouri Rivers to the north, and the Ohio and Lower Mississippi River to the south, with more than 88 percent of the total tonnage through the reach neither originating nor ending there. Breakage of this link would vastly change the current modal split. The very substantial tonnage moving between the two systems via this part of the river would have to be diverted to other modes of transportation.

Other major commodity flows would also be expected to be disrupted; for example, the movement of coal and chemicals from the Ohio to the Upper River.

While short run traffic for the railroads, and other modes of transport would exceed the ability of those modes to handle it, substantial excess capacity might be expected to develop on other portions of the inland water system. Due to cleavage of the system into two smaller systems, both federally maintained navigation facilities and privately owned tows and barges would be underutilized, resulting in considerable economic waste.

b. Regional Economy. Discontinuation of operation and maintenance of this portion of the river would have varying impacts on different parts of the region.

It is likely that this alternative would have a comparatively small impact on the rural portion of the project area, since, as noted above, the river presently has comparatively little impact on their economics.

More seriously affected would be the port of St. Louis. As noted previously, the upper thirty miles of the project area are also the lower thirty miles of the newly defined harbor, and 14 of the 74 docks in the harbors are in this area. More importantly, in excess of 7,000,000 tons of commodities that passed through the project reach either originated or were destined for St. Louis Harbor in 1972, accounting for nearly half of the harbor's total tonnage.

Elimination of this tonnage would result in substantial losses to the waterborne commerce industry in the city. Shippers would suffer various degrees of losses, depending on (1) the extent of their use of the waterway, (2) the cost competitiveness of other modes of transport, and (3) especially in the short run, the ability of other modes of transport to handle their commodities. Of course, some of this loss to the waterborne commerce industry would be regained by the rail and truck industries. On the whole, especially in the short run, it can be expected that the St. Louis region would receive a major setback to economic growth if the 9-foot channel were not maintained.

It should be mentioned that limitations to the growth of the regional and national economy are not always necessarily undesirable. Consideration should be given to the fact that use by the United States accounts for about one-third of total world energy and non-renewable resource consumption, yet our population is only 6 percent of the world population (Ehrlich and Ehrlich, 1970). Our high rates of consumption require extensive importation of raw materials, and eventually our world economic and political situation, combined with increasing scarcity of goods, may force drastic changes in our present dependence on a growth economy. Such economic changes could occur within the lifetime of the proposed project. Other reasons for limiting economic growth include energy shortages, cumulative effects of pollution, and decreasing rates of population growth.

4.3.3 LAND USE

Present land use on the flood plain is the joint result of flood protection, interior drainage works, and the stabilization of the river channel. However, stabilization of the channel alone has had an impact on land use. In the past, without the project, the river meandered about the flood plain, frequently changing its channel, and eroding and inundating land. In this situation, land use on the flood plain was in a more natural state, the hazards of the river making many areas of the plain economically unfeasible to develop. Yet, with the stabilization of the river channel, the flood plain is no longer vulnerable to river meanders. Thus, development, particularly intensive agriculture, occurs on the flood plain, even adjacent to the river, without danger of being supplanted or eroded by the river.

A second impact on land use stems from the maintenance of a navigable channel. As mentioned in Section 4.3.1, certain economic activities, such as manufacturing, will locate near a navigable channel due to the possibility of water transportation. The navigable river channel has served as a major location factor for that industry adjacent to the river.

4.3.4 OUTDOOR RECREATION

The regulating works will have no impact on the existing recreational resources nor on the use of these sites. However, recreation on the river proper, particularly sport fishing, will suffer adverse impacts. Section 4.2.1 holds a detailed discussion of the expected impacts on sport fishing.

4.3.5 IMPACTS ON CULTURAL RESOURCES

The continued maintenance of the 9-foot waterway involves the activities of dredging and dike revetment construction. All these activities take place on the river and do not touch the land. Dredge spoil is not placed upon the banks of the river, but is placed back in the river, outside the navigation channel. Construction of dikes and revetments takes place from boats, and land is not disturbed by these activities. In some instances of revetment construction, small amounts of river bank are sloped to prevent bank erosion.

In view of the fact that O&M activities do not have an impact on the floodplain, there will be no impact on any archeological or historical sites or structures located there. In those instances where portions of the river bank are contoured, archeological sites that might be present in these locations could be adversely affected by the surface disruption. In view of this fact, prior to any O&M work that will involve contouring or otherwise disturbing the ground surface of the riverbank an archeological reconnaissance survey of the affected areas utilizing both surface and subsurface investigative techniques will be performed. If archeological resources are encountered plans to preserve the site of information from the site will be coordinated with the appropriate State Historic Preservation Offices and the Advisory Council on Historic Preservation.

No sites on the National Register of Historic Places will be affected by the continued operation and maintenance of the 9-foot channel.

PART 5

5. ADVERSE ENVIRONMENTAL EFFECTS WHICH ARE NOT AVOIDABLE

5.1 GENERAL

The primary impact which may or may not be avoidable could be the eventual destruction of side channels. The adverse impacts associated with channelization as related to the destruction of side channels are discussed below. It is noted that the term adverse is broadly defined, recognizing that conditions which are adverse to one man's environment may not be adverse to another's.

5.2 ADVERSE IMPACTS RESULTING FROM THE PROJECT

5.2.1 IMPACT TO RIVER REGIME

With the exception of the attainment of a dependable 9-foot navigation channel and the protection of levees and flood plain farmlands via confinement of the once-meandering alluvial channel, almost all the impacts discussed in Section 4.1.1 can, for the most part, be considered adverse and unavoidable. This is based on the findings of the Corps of Engineers and the studies which were specifically performed for this environmental statement which found that the side channels and river border areas between dikes in the main channel are important habitat areas. It is difficult to see how these impacts can be lessened to any great degree if strict compliance to the 1927 Congressional authorization is maintained which delineated the attainment of a dependable 9-foot deep navigation channel as its sole purpose.

To avoid needless redundance, the unavoidable adverse impacts are summarized here in lieu of a full-scale duplicate presentation:

(1) Future Channel contractions will continue to scour out some troublesome channel crossings. This scouring action may cause some additional lowering of low water discharge stages, thus reducing the amount of water available for adjacent side channels. There may be an insignificant temporary lowering of ground water levels, during extreme low flow conditions, immediately adjacent to the river and the mouth of tributaries.

(2) The narrowing of the river channel via the eventual creation of additional flood plain lands, may, in addition to narrowing the river slightly decrease the channel capacity for flood flows. (Simons, et al, 1974). The result may be higher flood stages for a certain range of flood discharges. Any increased river stages in the Mississippi River will create increased stages near the lower reaches of the tributary streams via the usual backwater effects.

(3) The creation of new natural side channels via the shifting of the alluvial river channel is virtually precluded due to its confinement by dikes and bankline revetments. It should be mentioned that the side channels which consist of cutoff chutes on the inside of river bends could remain open for quite some time, if not indefinitely, due to the scouring action of flood flows when this shorter travel path is taken.

(4) Many of the existing side channels may eventually fill up with sediment and new ones may or may not form.

(5) Future channel contractions by the extension of dikes (to achieve a general 1,500 foot contraction from the existing 1,800 foot contraction) may or may not result in the creation of some new side channels.

5.2.2 ECONOMIC GEOLOGY

The project would eliminate a very small percentage of the present sand and gravel deposits along this portion of the river.

5.2.3 WATER QUALITY

Maintenance dredging, disposal of dredged material, increased barge traffic, and further constriction of the river by dikes and revetments have the effect of resuspending sediments, which increases turbidity in the main channel and sedimentation in slack water areas along main channel border areas and side channels. It should be noted that turbidity and suspended sediments have a natural tendency to increase with rising river stages so that during high river stages, natural turbidity and suspended sediments exceed those temporary increases brought about by the works of man. Pollutants such as pesticides, metals, sulfides, methane, or other toxins, if present in bottom deposits, can be released to the water column by resuspension of the sediments. The resuspention of organic matter causes increased chemical oxygen demand and the resulting decomposition could cause reduction in dissolved oxygen concentrations.

More barge traffic on the river will increase the risk of accidental spillage of pollutants. Federal and state regulations prohibit the purposeful discharge of wastes into the river, and such regulations greatly reduce the amount of waste entering the waterway.

5.2.4 AQUATIC COMMUNITIES

Thirty-five percent of the water surface area was converted from aquatic to terrestrial habitat on the unprotected flood plain of the Middle Mississippi River during the period 1888 to 1968. (Simons, et al, 1974). Most of the remaining side channels and main channel border habitat will be converted from aquatic to terrestrial habitat over a long-term period, unless these areas can be maintained by dredging. A slightly smaller loss would be involved if no further dike extension were involved. Reduced sediment loads in the Middle Mississippi River will have a tendency to prolong the life of existing side channels and those which might form in the future.

Most of the adverse impacts associated with the operation and maintenance of the project are felt most acutely within the main channel habitat. These effects include dredging, disposal of dredge material, constriction of the river by dikes and revetments, and increased barge traffic. All of these activities temporarily resuspend bottom sediments, thereby increasing turbidity and reducing light penetration, with the ultimate consequences being interference with primary production, flocculation of planktonic organisms, a decrease in food availability for fish, interference with the gills of fish, abrasion of benthic organisms in turbulent areas, and production of some effects that may be aesthetically displeasing. Pollutants such as pesticides, metals, sulfides, methane, and other toxins, if present in bottom deposits, can be released to the water column by resuspension of the sediments. The resuspension of organic matter causes increased chemical oxygen demand, and the resulting decomposition could cause reduction of dissolved oxygen concentrations. These impacts are compounded by physical alterations, such as changes in bottom geometry and bottom substrate that cause subsequent alterations in current patterns.

Deposition of sediments in slack water areas such as side channels and dike fields could result in the smothering of benthic organisms, destruction of spawning areas for fish, reduction of habitat diversity, and reduction of vegetative cover. Disposal of dredged material is now being carefully monitored so as not to be destructive of the remaining side channel areas. As previously mentioned in paragraph 5.2.3. (Water Quality), natural turbidity and suspended sediment during high river stages may have a more pronounced effect on aquatic communities than increased turbidity and suspended sediments associated with the works of man.

5.2.5 TERRESTRIAL COMMUNITIES

The original flora and fauna of the unprotected flood plain has been reduced and altered through man's attempt to control the river. The species found on the flood plain today are a result of these activities. Future attempts to develop the river for flood control and navigation purposes would continue to reduce this resource. Many of the adverse impacts witnessed today could be avoided, if not corrected, in the future by developing an increased sensitivity to the significance of these unique biological systems. The post-authorization change, as described in part 6.4, would provide the Corps of Engineers with the authority to pursue this need by including a fish and wildlife project purpose.

PART 6

6. ALTERNATIVES

Each of the alternative plans of action addressed in this part are discussed on the basis of their potential to provide the public with a valid and reasonable method for fulfilling the authorized purpose of maintaining a nine-foot navigation channel in the portion of the Mississippi River which lies between the confluences of the Missouri and Ohio Rivers. As required under regulations formulated in response to the National Environmental Policy Act of 1969, the alternative of no action is also addressed. Each alternative considered is discussed in the sections which follow.

6.1 MAINTAIN EXISTING ACTIONS

This alternative involves continuing with established procedures, reflecting no changes or alterations in the present operation and maintenance policies. The existing dredge plant capability would remain unchanged. Placement of dikes and revetment would not be appreciably decreased or increased. All work would still be primarily based on the immediate need to resolve the navigational barriers or continuing troublesome areas. Other activities, including coordination with other interests would continue as in the past.

Physical impacts would continue much as they are at the present time. This would result in the continuing development of the main channel area for navigation purposes with some fish and wildlife enhancement efforts being made on localized basis. Existing side channels will continue to fill with sediment, although at a lesser rate due to reduced sediment loads in the river, and new side channels may or may not be formed. Levee systems would not be appreciably affected, the same being applicable to air quality and noise levels.

The biological impacts associated with continuing the present operation and maintenance program may result in a further degradation of fish and wildlife habitat. Degradation of fish and wildlife habitat attributable to the channelizatoon project may be partially offset and possibly more than compensated for by current pollution abatement programs.

The cultural impacts resulting from this alternative would be classified as minor as the present operation and maintenance program has been developed to facilitate the requirements of this cultural environment.

6.2 CEASE ALL OPERATION AND MAINTENANCE ACTIVITIES (NO ACTION)

This no action alternative would involve the cessation of all the operation and maintenance activities described in Part 1 of this environmental statement. The annual budget for this work would be discontinued and all remaining structures would be left as is. All dredging would be stopped.

Table 6-1: Summary of Impacts Associated With Alternative Actions

The above table has been deleted from the final environmental statement.

Under this alternative the main channel area would become impassable to commercial river traffic, especially during low flow periods of the year. Side channels areas would eventually silt in as the river sought to revert back to its natural state. To what degree this would be possible within the confines of the existing levee system is speculative, however, eventually some new side channel areas would again be formed. Water quality would be moderately improved as river navigation decreased. Noise levels would also decrease along with the decrease in river traffic. Levee systems would be more susceptible to these river flow conditions than they were and would require various degrees of structural modification in order to maintain their function. The net effect of this alternative on fish and wildlife resources would be of a beneficial nature.

Cultural impacts would be of a major proportion as commercial navigation would be greatly reduced on the river. Attempts to maintain this use of the river would probably be limited to periods of high flow, and even then an uncertain depth would limit the profitability of such use. The potential for increased river navigation accidents would exist, as would the potential for an increase in spills of oil and other hazardous substances due to these accidents. If commercial navigation were to cease, the potential accidents would also cease. As barge traffic declined on the river, various modes of surface transportation would begin to receive the responsibility of transporting additional commodities. It is reasonable to believe that there would be an immediate lack of surface transportation facilities to accomodate the large amount of freight now being transported by this waterway; however, these shortages would be eliminated as these modes of transportation increased their capabilities. There would no longer be the need for an annual operation and maintenance expense of approximately $4,000,000.00 Several private firms and companies would suffer severe economic setbacks as they have based their business locations and delivery schedules on the availability of the waterway. Additional costs would be required for them to relocate and/or establish new operating procedures based on other modes of transportation.

The major impact of the no action alternative would be that the main stem of the Mississippi River would no longer be under control and would be free to migrate. In so doing, it would eventually destroy all of the flood protective works constructed to date. Although the flood protection and navigation projects are separate authorizations, the bank protective works of the navigation project are absolutely essential to preclude the eventual destruction of the flood protection works.

6.3 LOCKS AND DAMS

The most commonly thought of alternative for achieving a nine-foot navigation channel other than by present methods is that of a series of locks and dams extending from the mouth of the Ohio River upstream to the mouth of the Missouri River. Although this alternative method is precluded by the 1927 Congressional Authorization which states specifically the methods which shall be utilized, it is appropriate to consider this alternative.

Under this alternative the existing configuration of the main channel and its associated side channels would be lost to inundation. All levee systems would be affected by this alternative in that they would either have to be raised or setback, or both. Air quality and noise levels in the surrounding area would be moderately increased due to an increase in the time required to navigate this portion of the river.

Biological impacts associated with this alternative include those which are normally associated with creating reservoir pools in a flowing stream environment. Much of the existing terrestrial wildlife habitat would be inundated, waterfowl habitat conditions would be enhanced to some degree, fish populations would be altered as well as the benthos and plankton populations. The most significant impact would be the loss of the side channel areas which possess a unique set of biological conditions which make them invaluable to the maintenance and enhancement of the few remaining "natural" areas along this portion of the Mississippi River.

Impacts to the cultural environment would be significant. A system of locks and dams on this portion of the Mississippi River would result in increased water borne transportation time which would impact favorably on other modes of transportation. Settlement and land-use patterns would be influenced as a result of this action and its "ripple effect". The economic impact of this action would be of major proportions from the construction costs as well as from the functional costs and influences. Conflicts with historical and archeological resources would increase with the increased utilization of lands for project purposes.

6.4 POST-AUTHORIZATION CHANGE

As indicated in the previous sections of this environmental statement, the overall effects of the attainment of a nine-foot navigation channel upon the riverine ecosystem has not been beneficial. A significant amount of fish and wildlife habitat has been affected.

Part 1 of this environmental statement describes in detail the Corps of Engineers recognition of this fact and the past coordination with federal and state conservation agencies to alleviate these undesirable effects. In summation, the result of all joint efforts with respective conservation agencies over the past years has been the realization that the 1927 authorizing Congressional document will have to be modified if it is to provide for environmental protection and enhancement little can be accomplished within the purview of the existing authorization.

As a result of meetings held on this subject in coordination with the Fish and Wildlife Service, Upper Mississippi River Conservation Committee, Missouri Department of Conservation, and the Illinois Department of Conservation, the groundwork for a viable post-authorization change to the project document as authorized in 1927 has been established. This post authorization change, once formulated and formalized, will be submitted to higher authority for appropriate action. The changes being considered in this effort are presented below, along with a discussion of their associated impacts.

a. Dredging. Under a post authorization change dredging side channel areas would be initiated in an attempt to prolong and enhance the fish and wildlife attributes they possess. The placement of dredged material in accordance with planned fish and wildlife management programs (not yet formulated) would be carried out to the fullest extent possible.

b. Dike and Revetment Work. Work under these two categories includes the maintenance and construction of pile dikes to enhance fish habitat; notching and/or lowering dikes, if considered feasible and desirable; and altering stone dikes which provide access to islands.

c. Impacts. The impacts of these actions would be directed to preserving and enhancing fish and wildlife habitat associated with this riverine system, while at the same time continuing to utilize the river for navigational purposes. If authorized to do so, the U.S. Army Corps of Engineers District, St. Louis, Missouri, would increase their budget for operating and maintaining this portion of the Mississippi River. Some land use patterns, particularly agricultural use, would be moderately affected, due to alteration and loss of access lanes to islands provided by existing dikes.

6.5 ALTERNATE USES OF DREDGED MATERIAL

Although the alternate uses of dredged material in itself does not constitute a viable alternative for maintaining a 9-foot navigation channel, a discussion of these uses is deemed appropriate in this part, due to the environmental consequences associated with such uses. Three general categories of use were considered as being applicable to this project.

a. Commercial. The utilization of dredging for commercial purposes such as fill material, mortar sand, aggregate, concrete, or other such uses depends on many factors. Included in these factors are such things as the physical suitability of the material, the economics of handling it, including the location from where it is being dredged compared to its eventual point of use and the demand for its use.

Such commercial use offers the benefit of reducing the extent in which the aquatic and terrestrial ecosystems are disrupted and at the same time provides a benefit use for the material being disposed of. Disposal of dredged material for commercial purposes would require quite different dredged material placement practices. As such, many of the adverse impacts associated with current practices could probably be reduced.

Economic processes could be disrupted by providing material to areas which do not normally have this material available, as well as market values for the uses employed may suffer declines. This economic impact would probably be felt primarily by private dredge contractors and sand and gravel companies which might lose business because of a change in market conditions.

b. Recreation. The use of dredged material for recreational purposes has a potential for providing high quality campsites and beaches for intense recreational use along the river. Dredged material would be deposited in areas identified for development based on need and available access.

Recreation development of this kind would require the acquisition and commitment of land for this purpose. The commitment of these areas for that purpose would not be entirely irretrievable because the type of developments placed on them would be of a primitive nature requiring little construction and minimal modifications to the original disposal area. Therefore, any future decision to convert these recreation areas to another use such as wildlife habitat or intense recreation development could be easily implemented.

This potential use would have unavoidable biological impacts in terms of preventing the natural succession on those areas developed. However, landscape planting associated with recreation development could provide some wildlife value.

The social impacts of this method for handling dredged material would be to increase the recreation opportunity along the river and enhance the available recreational experience. The provision of sanitary facilities and the improved trash and litter disposal would remove a source of water pollution and improve the overall aesthetic setting. Sanitary facilities and water supply would have to be constructed consistent with public health codes and State regulations. Special provisions would be needed in areas subject to inundation by high water levels.

The economic impacts of the recreational uses for dredged material would be realized in terms of money expended by recreation users. Part-time seasonal jobs would be reated in order to provide operation, maintenance, and repair of the site. Land aquisition costs would also be of pertinent consideration.

c. Wildlife Habitat. It is possible to utilize dredged material for enhancement of terrestrial wildlife habitat. Under proper utilization and management of these areas, wildlife habitat could be increased. Therefore, increases in value should be realized in terms of aesthetics, most forms of recreational uses, and economics. Deposition of dredged materials as a result of present operational and maintenance activities accomplishes very little in terms of creating wildlife habitat. The availability of funds to provide such habitat would also be necessary.

d. Agricultural Uses. The use of dredged material for agricultural purposes provides another alternative for consideration and further investigation. Depending on the quality of the dredged material and the economics involved in making it available for agricultural purposes, such uses as creating new farmland or providing topsoil mixtures for existing farmland are within the realm of consideration.

PART 7

7. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

In the preceding sections, it has been shown how the river is being developed to provide a dependable 9-foot navigation channel. Because the river is dynamic, the navigation channel must be considered as being transitory in nature in much the same manner as side channels. The economic cost of perpetuating a dependable navigation channel also involves some environmental costs. In order to reduce the environmental costs it may entail some long term economic cost to make the navigation project more compatible with its riverine environment. Maintenance of existing side channels by artificial means is at best a short term, temporary solution. The life span of side channels may be enhanced by further reduction in the suspended sediment load of the river brought about by existing and future reservoirs, bank stabilization, soil conservation, reforestation, better land use practices, and many other programs which may be put into effect to improve the quality of our streams in the future. Side channels are known to provide valuable fish, wildlife, and waterfowl habitat areas. Many of the side channels are held in private ownership and the maintenance and possible improvement of side channel areas is largely dependent upon the cooperation of local interests under the present Congressional Authorization for the Navigation Project. Insofar as many local land owners are concerned, they would prefer that many of the existing side channels become filled with accretions so that these areas could be utilized for agricultural purposes. In essence, the preservation of existing side channels by short term artificial means and long term future programs to reduce the siltation process is academic until ways and means are developed to enlist local cooperation so that these areas may be somehow supervised and controlled by state conservation agencies.

A long term economic commitment to maintain the 9-foot navigation project will contribute to the continued economic development of the nation by facilitating low cost shipment of commodities to national and international markets. Hopefully that same long term economic commitment will include some means to make the navigation project compatible with the riverine environment. Cessation of the project would entail drastic short term and long term economic losses. This alternative would allow the Middle Mississippi River to meander freely within its flood plain and to eventually destroy all of the improvements made by man to date.

PART 8

8. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH ARE INVOLVED IN THE CONTINUING ACTION

The previously discussed Post-Authorization Change provides the most viable alternative for implementing adequate environmental considerations to make the navigation project more compatible with its riverine environment. The additional funds required to implement such environmental considerations, under a Post-Authorization Change, are not know at this time. The major natural resource which is endangered by continuing action to develop the authorized navigation channel are the existing side channels and any new side channels which may be formed in the future. As previously discussed, artificial means can be employed to preclude the irreversible tendency of a river system to deposit accretions in slack-water areas. Furthermore, past losses of side channel areas cannot be construed as being irretrievable because artificial means can also be employed to create new side channel areas. Destruction of side channels need not be an irreversible and irretrievable commitment of this project. A viable Post-Authorization Change can be utilized to preserve those resources which presently exist and those which may naturally develop in the future. With regards to whatever past losses have occurred in this resource, appropriate action to provide for a necessary land acquisition within the flood plain of the Middle Mississippi River would make it possible to restore and maintain past resource losses so that the total resource under developed conditions could equal or possibly exceed those which existed under natural conditions. In summary, the question of the irreversible depletion of this natural resource and the irretrievability of past losses of this resource is dependent upon two separate and distinct actions. One requires the preservation of existing side channel areas and the other requires appropriate authority to engage in land acquisition to restore past losses in side channel areas.

PART 9

9. [illegible] ON [illegible]

9.1. GOVERNMENTAL AGENCIES

The combined efforts of state and federal agencies were utilized, and their views were given careful consideration in the preparation of this environmental statement and the formulation of the associated studies which were undertaken for the statement. The federal agencies which participated are:

U. S. Army Engineer Division, Lower Mississippi Valley
Vicksburg, Mississippi
U. S. Army Engineer District, St. Louis,
St. Louis, Missouri
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi
U. S. Department of the Interior
Fish and Wildlife Service Regional Office,
Twin Cities, Minnesota Area Office,
Rock Island, Illinois

The state agencies which participated are:

The Illinois Department of Conservation
The Missouri Department of Conservation

In addition, Southern Illinois University at Carbondale, Illinois, Illinois Natural History Survey, and Colorado State University, Fort Collins, Colorado, participated in this study program under separate contracts let by the Waterways Experiment Station (WES), Vicksburg, Mississippi, on behalf of the U. S. Army Engineer District, St. Louis, Missouri.

9.2. COORDINATION LEADING TO THE SUBSEQUENT PREPARATION OF THIS ENVIRONMENTAL IMPACT STATEMENT

In order to fully understand the following comments which pertain to past coordination efforts, it is necessary that one be apprised of the events and circumstances leading up to the original coordination efforts and the subsequent negotiations which have now culminated in the preparation of this environmental statement.

The original plan for the attainment of a navigation channel having a minimum depth of nine feet and a minimum width of 300 feet, with additional width in bends, has not changed since it was first authorized in 1927. The basic engineering premise called for the construction of bank protective works, i.e., revetment; contractive works, i.e., dikes; and dredging where necessary, to attain project objectives.

Because the natural river had a tendency to erode its banklines and to meander within its alluvial flood plain, bank protective works were required to prevent further migration of the river bed which would adversely affect the alinement of the navigation channel. Bank protective works were generally constructed on the outside of bends and opposite dike fields because the banklines at those particular locations were subject to stronger current attack.

Contractive works were designed to reduce the low water width of the river, thereby temporarily increasing current velocities a sufficient amount to degrade the bed of the river to provide a minimum nine-foot by 300-foot channel measured with respect to a specified low-water datum plane. Contractive works were designed to utilize the river's own energy to assist in development and maintenance of the authorized navigation channel.

Due to the vagaries of the Middle Mississippi River system (Ohio to Missouri River), it is not possible to design contractive works which will eliminate all dredging. The original plan, as authorized for the attainment of the nine-foot by 300-foot navigation channel, recognized this fact and made provision to maintain the channel by dredging when necessary.

As can be seen from the information contained above, the authorizing document provided for the attainment of a nine-foot deep by 300-foot wide navigation channel and did not contain any provisions for the enhancement of the environment nor the prevention of any potential environmental deterioration. The revetment works constructed to date have prevented river migration which would have created new channels by natural forces. Dike construction designed to develop the authorized channel dimensions often accelerates the rate of deposition. These accretions sometimes develop vegetative growths which further accelerates the rate of deposition, so that the major portion of the river bottom within the dike fields may be converted to terrestrial vegetation, and results in a loss of water surface area at low stages suitable for aquatic vegetation and fish habitat. Dredge spoil is sometimes placed within dike fields, which contributes to the reduction of water surface area at low river stages suitable for fish habitat.

Efforts to develop a dependable channel have been continuous since 1927. In 1964 an extreme low-water period occurred on the Middle Mississippi River in the vicinity of St. Louis, Missouri. The duration of the low-water period was so prolonged so as to have a major economic impact on the shipping industry as a whole, and created a localized economic problem for the shipping industry whose facilities were located in St. Louis Harbor. Accordingly, a special study was authorized to investigate ways and means of eliminating the shoal water problem in the St. Louis Harbor area.

Since the low-water period mentioned in the above paragraph had a major impact on the shipping industry as a whole, the U. S. Army Engineer District, St. Louis, recommended that another plan be adopted to provide a minimum nine-foot deep by 300-foot wide channel. As a result of this recommendation, the U. S. Army Engineer District, St. Louis, was authorized to construct a prototype reach between Mississippi River miles 140.0 to 154.0 above the mouth of the Ohio River to evaluate hydraulic engineering studies which indicated that a 1200-foot contraction was required to develop a nine-foot channel at a low-water flow. Prototype reach construction was initiated in 1967 and completed in 1969.

On 9 December 1968, the U. S. Army Engineer District, St. Louis established a River Stabilization Branch within the Engineering Division whose primary function was to design engineering works for the development and maintenance of the nine-foot channel project. The first plan of improvement designed by the newly formed River Stabilization Branch called for the construction of a number of new stone-fill dikes between Mississippi River miles 55.0 to 68.0. This reach of river is commonly referred to as the Devil's Island reach, and is one of the most difficult reaches of river in which to obtain and maintain the authorized channel dimensions. Accordingly, a determination was made to conduct a model study of this problem area at the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Authorization to conduct said model tests was obtained from the Chief, Engineering Division, Civil Works, Office of the Chief of Engineers, Washington, D. C. on 29 July 1969.

Although no record is available of the first direct request for assistance by a Conservation Agency, it is known that this request was forthcoming from Mr. John W. Robinson, Biologist, Missouri Department of Conservation, and that this request was made shortly after the model test mentioned in the paragraph above was approved.

Mr. Robinson was concerned about the possibility that the St. Louis District was already constructing a 12-foot waterway, and cited the prototype reach construction between Mississippi River miles 140.0 to 154.0 to substantiate his contention. Mr. Robiuson was given assurances that the prototype reach was constructed to evaluate the validity of hydraulic engineering data relative to the development of a nine-foot waterway. He was also informed that prototype reach study data would, of course, be utilized by the U. S. Army Engineer District, St. Louis, to determine the feasibility of developing a 12-foot waterway as a part of the authorized 12-foot waterway study, but the prototype reach per se was not, in fact, the initial construction start of the 12-foot waterway. He was informed that the 12-foot waterway study had not yet been completed, and the finalized report had not beeu forwarded to higher authority for their review and comments.

After Mr. Robinson understood the intent and the purpose of the prototype reach study program, he was invited to express his views and concern over the possible environmental deterioration being caused as a result of construction activities performed under the authorized navigation project. Mr. Robinson presented what appeared to be valid and persuasive arguments in behalf of the need to incorporate environmental considerations into the design of future engineering works for the development of the authorized navigation channel. He was advised that the project document, as authorized, did not contain any provisions for the enhancement of fish habitat, nor the prevention of fish habitat deterioration, but that the U. S. Army Engineer District, St. Louis, was most willing to cooperate with his agency (Missouri Department of Conservation) to study ways and means of reducing adverse environmental impacts caused through construction of the project, and, if possible, studies would be conducted to investigate ways and means of enhancing fish habitat through future construction activities on the authorized project. Mr. Robinson was invited to prepare environmental input which he felt would be of benefit to the environment, and which could be accomplished within the purview of the authorizing act.

Subsequent meetings were held with Mr. John W. Robinson and Mr. Charles E. Hooker of the Missouri Department of Conservation pursuant to the incorporation of all environmental considerations which could conceivably be accomplished under the project, as authorized. The primary concern of Mr. Robinson and Mr. Hooker was the fact that many side channels had already been closed off at low flows to divert more flow into the main stem of the Mississippi River for navigation purposes. They were informed that many of the secondary side channels which had been closed off had no inflow of water at stages less than mid-bankful, but that they did receive considerable inflow of water when stages are above mid-bank stages. This occurs approximately 50 percent of the time. They were also reminded that many of the secondary channels which were already closed off provided some of the best fishing on the Middle Mississippi River. They agreed, but were concerned that these side channels might be completely destroyed in the event the Corps of Engineers pursued its policy of closing off these side channels in the future as they had done in the past. Accordingly, Messrs. Robinson and Hooker were given assurances that no further chute closures would be constructed unless some unforeseen emergency made it necessary to do so to maintain the navigation channel, and that if such structures were required, they would be fully apprised of the need to do so before any construction was initiated.

As a result of these environmental conferences, the Missouri Department of Conservation was invited to participate in the model testing program of the Devil's Island reach soon to be conducted at the Waterways Experiment Station in Vicksburg, Mississippi. This proposal was accepted, and necessary arrangements were made for the Missouri Department of Conservation to participate in the model study program as soon as the initial model studies were completed for the development of a suitable navigation channel. The purpose of this arrangement was to study the feasibility of reducing the impact on fish habitat and possibly enhancing fish habitat through specialized stone dike configurations after the initial model test runs had indicated that the desired channel improvements could be accomplished. The basic premise of this plan of action was to modify structures placed in the model for the development of the nine-foot channel in such a way so as to create and maintain desirable fish habitat.

On 3 October 1969, Mr. Carl R. Noren, Director, Missouri Department of Conservation, forwarded a letter to the St. Louis District indicating he had recently become aware of proposed construction activities at Mississippi River mile 24.8 by way of a navigation notice sent out to navigation interests to inform them of the impending construction at this locality. Mr. Noren was concerned about the apparent lack of communication concerning items of mutual interest, and requested that his office be apprised of future construction activities prior to the advertisement and award of contracts so that his staff could submit suggestions which would lessen the impact of closure structures on fish habitat. Members of Mr. Noren's staff were informed that the closure structure in question had been designed and programmed for construction prior to our agreement to keep them informed of such construction, as previously agreed to in a preceding paragraph.

As a result of the communique from Mr. Noren mentioned above, informal meetings were held for the purpose of informing the Missouri Department of Conservation personnel relative to the Corps plan for future construction, and they were advised that their suggestions on ways and means of lessening the impact on fish and wildlife habitat would be given serious consideration on all future contract work.

It is significant to note that all of the foregoing coordination efforts between the Missouri Department of Conservation and the St. Louis District were accomplished prior to enactment of the National Environmental Policy Act of 1969.

On 24 February 1970, Mr. Charles E. Hooker, an engineer with the Missouri Department of Conservation, prepared a memo which contained a rough sketch of a scheme to promote fish and wildlife habitat with the use of stone-fill dikes. The scheme envisioned leaving a notch in the dikes, i.e., a low spot, that would allow one-in-six-months flood frequency to flow through and, therein, <u>maybe</u> create sloughs and potholes in the silt trap pools. This information was brought to the attention of the St. Louis District, and it was agreed that the Corps of Engineers would test this proposal during its Devil's Island reach testing program.

On 19 March 1970, Mr. Carl R. Noren, Director, Missouri Department of Conservation, wrote a letter to the St. Louis District indicating that his agency was very interested in participating and was preparing input for the model study program. On 27 March 1970, the St. Louis District responded by saying it would be pleased to test such input in conjunction with its normal testing program. Mr. Noren was also advised that it would be necessary for members of his staff to journey to Vicksburg, Mississippi, for the purpose of discussing their environmental input with U. S. Army Waterways Experiment Station (WES) personnel.

On 25 April 1970, the Missouri Department of Conservation advised the St. Louis District that they had conducted the necessary field investigations of the Mississippi River between Mississippi River miles 55.0 and 68.0, and they were now ready to discuss their environmental input to the pending model study program.

On 6 July 1970, the Missouri Department of Conservation expressed concern because they had not yet been invited to present their environmental input to Waterways Experiment Station personnel. On 10 July 1970, they were advised that the model was still in the process of being verified, and they were given assurances that their input would be given consideration at a meeting tentatively scheduled to be held at WES during September 1970.

On 6 and 7 October 1970, the aforementioned conservation conference was held at WES. The following personnel were in attendance:

John J. Franco, Chief, Waterways Branch, WES
Thomas Murphy, Chief, Structures Branch, WES
Norbert C. Long, Chief, River Stabilization Branch, SLD
Claude N. Strauser, Civil Engineer, River Stabilization Branch, SLD
David B. Mathis, Biologist, Hydraulics Division, WES
Carl W. Stephan, Chief, Hydraulics Branch, BSWF, Federal Building, Ft. Snelling, Twin Cities, Minnesota
Larry L. Dunham, Mississippi River Biologist, Illinois Department of Conservation, Box 164, Aledo, Illinois
Raymond C. Hubley, Jr., UMRCC Coordinator, Davenport, Iowa
C. E. Hooker, Chief Engineer, Missouri Department of Conservation
D. E. Norman, Biologist, Missouri Department of Conservation
Gordon B. Farabee, Biologist, Missouri Department of Conservation
James P. Fry, Biologist, Missouri Department of Conservation
John W. Robinson, Biologist, Missouri Department of Conservation

The meeting was opened with a welcome from LTC Frederick M. Anklam, Deputy Director of WES. This was followed by a movie entitled "The WES Story," after which the conferees were given a tour of the hydraulic section of the experiment station. After the preliminary business had been concluded, the discussion was concentrated upon the topic of river regulating works and its effects on fish and wildlife habitat. Conservationists generally outlined their environmental input to the model testing program and Mr. John J. Franco, Chief, Waterways Branch, WES, was of the opinion that WES could develop guidelines whereby existing backwater areas along the Middle Mississippi River could receive the necessary inflow of water required for the preservation of fish habitat without unduly affecting the navigation channel. Each recommendation presented by the conservationists was discussed in detail to formulate a model testing program to investigate ways and means of enhancing the fish habitat. Conservationists expressed concern that more emphasis should be placed upon the environmental testing program, and that perhaps a model testing program could be conducted exclusively for environmental enhancement. They were informed that although funds were limited, the Corps of Engineers would attempt to conduct tests of all environmental input data discussed at the meeting. Mr. Norbert C. Long, Chief, River Stabilization Branch, St. Louis, mentioned that it might be possible for the conservationists to utilize the model exclusively for environmental testing after the St. Louis District had completed it model testing program. Mr. Franco stated that the average monthly cost for WES to conduct model tests was approximately $6,000. Conservationists were of the opinion that the aforementioned monthly charges for model testing should be paid for in some manner by the Corps of Engineers. Mr. Long stated that although funds had not been programmed for such model testing by the Corps of Engineers, he would investigate the possibility of obtaining such funds. He further stated that since the engineering and construction costs of the model exceeded $80,000 that perhaps the conservationists might program some of their funds for the proposed model testing program for environmental enhancement. Conservation personnel indicated they would submit this proposal to their respective agencies to ascertain whether or not they could allocate the necessary funds to conduct their own model testing program. The Missouri Department of Conservation personnel requested that St. Louis District forward a letter to Mr. Carl R. Noren, Director, Missouri Department of Conservation, to inform him of the type of environmental information WES could obtain from the model testing program with funds already allocated under the authorized navigation project.

On 26 October 1970, St. Louis District advised the Missouri Department of Conservation of the following:

a. Model tests would be run for the purpose of improving the design of chute closures which would obtain the required nine-foot navigation depth, and at the same time preserve fish and wildlife habitat in backwater channels to the maximum possible degree.

b. Additional tests would be conducted to ascertain the feasibility of constructing low-profile (elevation) dikes to obtain a nine-foot navigation channel on the main stem of the Mississippi River, and at the same time preserve fish and wildlife habitat in that area to the maximum possible degree.

c. They were further advised that the St. Louis District would be pleased to make the model available to conservation agencies after the Corps had completed its testing program for the nine-foot channel project. The construction cost of the model, amounting to approximately $80,000, was to be borne by the St. Louis District, and the cost of performing environmental testing in the amount of approximately $6,000 a month was to be borne by the conservation agencies.

On 7 December 1970, the Missouri Department of Conservation expressed appreciation for the opportunity to work with the St. Louis District personnel on problems of mutual interest, but reserved the right to base their decision on whether or not to conduct environmental testing at their expense until after the St. Louis District had completed its study program for the navigation project.

On 1-2 June 1971, another conservation conference was held at the Waterways Experiment Station. The following personnel were in attendance:

John J. Franco, Chief, Waterways Branch, WES
Norbert C. Long, Chief, River Stabilization Branch, SLD
David B. Mathis, Biologist, Hydraulics Division, WES
Hanley K. Smith, Ecologist, Environmental Resources Section, SLD
C. E. Hooker, Chief Engineer, Missouri Department of Conservation
John W. Robinson, Biologist, Missouri Department of Conservation

This meeting resulted in a decision to perform additional environmental testing on behalf of the conservation agencies.

On 30 September 1971, the St. Louis District was presented with one of four awards presented under the Chief of Engineers Design Award Program, for the design and construction of the prototype reach, Mississippi River miles 140.0 to 154.0. The awards are presented as a part of the annual Chief of Engineers program designed to encourage Corps and Architectural-Engineering firms in their pursuit of superiority in providing an efficient, economical, and sound engineering design.

The receipt of this award is mentioned here for the purpose of emphasizing that the St. Louis District possessed the necessary engineering expertise to assist and guide the conservation agencies in the pursuit of their environmental objectives under the Devil's Island model testing program and future studies to be conducted in conjunction with the preparation of this environmental statement.

On 6 October 1971, a letter was received from Mr. Charles J. Kulp, Coordinator, Upper Mississippi River Conservation Committee, expressing concern over a proposed repair program for dikes and revetment between Mississippi River miles 50.1 and 98.6. In a letter dated 13 October 1971, the St. Louis District advised Mr. Kulp that the contract did not call for any new dike construction, or the construction of any additional chute closures. The contract was let for the purpose of making minor repairs to existing dikes and revetment. He was also furnished a description of repairs to be made under that contract.

On 21 October 1971, the St. Louis District received a letter from the Missouri Department of Conservation indicating that they did not wish to conduct any additional environmental testing at their own expense in the Devil's Island model at the Waterways Experiment Station. Their reason for doing so was because they did not feel they would obtain additional significant information over and above the environmental data being generated as a result of the St. Louis District's model testing program.

On 8 November 1971, a conservation conference was held at the St. Louis District. The following were in attendance:

Corps of Engineers Personnel

Mr. N. C. Long, Chief, River Stabilization Branch
Mr. J. A. Petersen, Asst. Chief, Operations Division
Mr. J. E. Baker, Asst. Chief, Construction Division
Mr. G. A. Clapp, Head, Navigation Studies Section
Mr. C. E. Barron, Head, Channel Maintenance Section
Mr. Dale Beard, Head, Office Engineering Section
Mr. E. A Degenhardt, Potamologist, River Stabilization Branch
Mr. H. K. Smith, Environmental Resources Section
Mr. C. N. Strauser, Civil Engineer, River Stabilization Branch

Conservation Personnel

Mr. Charles Kulp, Coordinator, Upper Mississippi River Conservation Committee
Mr. L. L. Dunham, Illinois Department of Conservation
Mr. B. A. Bertrand, Illinois Department of Conservation
Mr. J. W. Robinson, Missouri Department of Conservation
Mr. L. C. Redmond, Missouri Department of Conservation
Mr. W. H. Dieffenbach, Missouri Department of Conservation
Mr. Salty Daniel, Missouri Department of Conservation
Mr. Don Henson, Missouri Department of Conservation

The conference objectives were as follows:

a. Review of recent river regulating structures construction activities with regard to the preservation of fish habitat.

b. Review of pending river regulating construction program with regard to the enhancement of fish habitat.

c. Formation of a joint committee to review all proposed river regulating contract work for the purpose of implementing environmental considerations prior to the preparation of finalized plans and specifications. The following topics were discussed during the conference:

(1) Proposed dike construction from river miles 116.3 to 124.9.

(2) Proposed repair work from river miles 50.1 to 98.6. During this discussion conservationists agreed to permit the Corps to perform emergency repair work at chute closure Number 51.0-L.

(3) A general discussion was held concerning the environmental data generated as a result of the Devil's Island model testing program. Agreements were reached whereby the St. Louis District would construct a number of prototype structures under future construction programs for the purpose of trying to enhance the environment.

After the meeting, conservation agencies were provided with the most recent hydrographic survey maps of the Middle Mississippi River, and were also provided information pertaining to the Corps maintenance dredging program.

On 11 November 1971, St. Louis District received a letter from the Missouri Department of Conservation confirming the agreements made during the conservation conference in St. Louis, 8 November 1971. A similar letter, dated 19 November 1971, was received from Mr. Travis S. Roberts, Regional Director, Fish and Wildlife Service, Twin Cities, Minnesota.

On 29 November 1971, the St. Louis District forwarded plans for the repair of pile and stone-fill dikes, Mississippi River miles 98.9 - 105.9, for review and comments to the following agencies:

Missouri Department of Conservation
Illinois Department of Conservation
Upper Mississippi River Conservation Committee

On 30 November 1971, Mr. Henry N. Barkhausen, Director, Department of conservation, State of Illinois, expressed his appreciation for the river inspection trip, conducted for conservation personnel, between St. Louis, Missouri, and Cairo, Illinois. The letter also contained requests for additional joint conferences to discuss environmental issues. In a separate letter, dated 30 November 1971, Mr. Barkhausen confirmed the agreements which had been made during the environmental conference held in St. Louis, Missouri, on 8 November 1971.

On 1 December 1971, St. Louis District forwarded plans for repair of revetment, pile and stone dikes, Mississippi River miles 0.0 to 50.0 for review and comments to the following agencies:

Missouri Department of Conservation
Illinois Department of Conservation
Upper Mississippi River Conservation Committee

On 1 December 1971, St. Louis District received a letter from Mr. Charles J. Kulp, Coordinator, Upper Mississippi River Conservation Committee, confirming the agreements made during the environmental conference held in St. Louis on 8 November 1971.

On 17 December 1971, the Illinois Department of Conservation submitted their comments relative to proposed contract repair work, Mississippi River miles 0.0 to 50.0. These comments were also given careful consideration and, wherever possible, were incorporated into finalized contract plans.

On 20 December 1971, the Waterways Experiment Station informed the St. Louis District that all model testing for the navigation project, and all model testing requested for environmental purposes had been completed, and requested authority to dismantle the model. The River Stabilization Branch, St. Louis District, checked with all concerned environmental agencies to learn whether or not they wished to conduct any further model testing at their expense because all Federal funds allocated for the program had been expended. Negative replies were received from all conservation agencies, and on 28 December 1971, WES was given authority to dismantle the model as per their request.

On 22 December 1971, the Missouri Department of Conservation requested more information on proposed contract repairs, Mississippi River miles 0.0 to 50.0. This information was forwarded to their office as per their request.

In January of 1972, the St. Louis District was having difficulty in resolving all of the environmental recommendations submitted by the various conservation agencies. Some agencies failed to submit their comments within the specified 30-day time period. The main problem encountered by the St. Louis District was that the environmental review resulted in conflicting and divergent recommendations being submitted by the conservation agencies involved for all contract plans submitted to them for review. It was evident that imporved coordination efforts were required to resolve these conflicts of opinion. Accordingly , the St. Louis District held a three-day environmental coordination conference from 7-9 February 1972 to discuss its entire construction program with the concerned environmental agencies. During this particular conference, each item of work for all proposed contract activities was discussed in detail. As a result, the St. Louis District eliminated, for the time being, [illegible] which were considered by the conservationists to be deleterious [illegible]. Numerous other dikes were lowered in elevation to satisfy [illegible] requests of the conservationists, and at the same time, accomplish [illegible] improvement to the navigation channel. During this conference, [illegible] agencies requested that many dikes be constructed with [illegible], low spot, in an effort to construct a number of prototype structures for the purpose of obtaining environmental data relative to the performance of these structures under actual flow conditions. Model test data [illegible] from the Devil's Island model study at WES indicated a [illegible] would tend to draw materials into the dike field rather than create [illegible] fish habitat. The St Louis District agreed to construct these [illegible] structures out of the spirit of cooperation and through a sincere [illegible] to be of service to the conservationists in their efforts [illegible] the environment in the Middle Mississippi River. Since these structures [illegible] prove hazardous to small boats, or children playing along the [illegible], they were located in isolated reaches of the river which were not [illegible] to children, nor easily accessilbe to small floating craft

On [illegible] Mr. Clifford L. Summers, Acting Executive Director, Water [illegible] Board, State of Missouri, forwarded a letter to the St. Louis [illegible] indicating his concern over the proposed construction of notched [illegible]. It was his opinion that the notched dikes might be detrimental to [illegible] portion of the waterway, and might accelerate deposition [illegible] dike fields rather than improve fish habitat. On 8 March 1972, the St. Louis District advised Mr. Summers that the Corps of Engineers had [illegible] the right to take corrective action, if necessary, in the event that [illegible] prototype structures did not perform as intended by the conservationists.

On 8 March [illegible] a letter was received from Mr. Travis S. Roberts, Regional Director, Fish and Wildlife Service, requesting that all future contracts [illegible] discussed during the conference in St. Louis on 7-9 February 1972 [illegible] separate Environmental Impact Statements prepared for each new item of work. This proposal had not been mentioned during the conference. Accordingly, the St. Louis District requested guidance from higher authority [illegible] the intent of the National Environmental Policy Act of 1969 relative to the preparation of separate Environmental Impact Statements on an individual contract basis. On 19 June 1972, guidance was received indicating that the preparation of Environmental Impact Statements on an individual contract basis would relegate such statements to a narrow and limited [illegible] of environmental impact The view of the Council on Environmental Quality was that ways be found to consolidate numbers of impact statements [illegible] fewer but broader and more meaningful reviews.

This information was forwarded to Mr. Travis S. Roberts.

On 20 March 1972, St. Louis District forwarded revised plans and specifications for contract work, Mississippi River miles 116.3 to 124.9; 98.9 to 105.6; 240.4 to 255.0; and 0.0 to 53.0, as agreed to during the joint environmental meeting in St. Louis on 7-9 February 1972. Copies of these plans and specifications were forwarded to:

Upper Mississippi River Conservation Committee
Missouri Department of Conservation
Illinois Department of Conservation
Bureau of Sport Fisheries and Wildlife

On 12 June 1972, the first work order in the amount of $8,000 was forwarded to the Waterways Experiment Station to initiate preliminary environmental assessment studies required for preparation of this Environmental Impact Statement.

On 16 June 1972, a preliminary report was forwarded to the St. Louis District by WES concerning the results of the Devil's Island model study program. The report contained a discussion and conclusion on five plans of improvement. Plans A, B, and C indicated that preliminary design assumptions prepared by St. Louis District were valid, although additional model testing was conducted to obtain a plan of improvement at the least cost to the Federal Government. Plan C was modified for environmental considerations in accordance with prior agreements with conservation agencies. This model run indicated a satisfactory channel would be developed, and it included the environmental input suggested by conservation agencies with the exception of constructing L-head dikes for the purpose of improving fish habitat within dike fields. After model testing of Plan D was complete, it was modified to form Plan E, which included L-head dike construction as requested by conservationists. This plan of improvement indicated that L-head dike configurations would provide a minor amount of suitable fish habitat within dike fields. The cost analysis indicated that this plan of improvement would cost an additional $1 million, yet only provide the conservationists with a few acres of suitable fish habitat. When this was brought to the attention of conservation agencies, they agreed that the increased cost was prohibitive, and the St. Louis District should proceed with the plan of improvement developed under Plan D. Plan D included low profile dikes, provisions to maintain discharges through backwater areas, and included the construction of notched dikes.

On 30 June 1972, the Waterways Experiment Station forwarded a letter to the St. Louis District requesting further allocation of funds for the purpose of providing field data on physical, chemical, and biological parameters, literature survey data and subsequent analysis, all of which were to be incorporated into the overall plan of action for the preparation of this report. Contracts were to be negotiated with each of the following subcontractors:

Missouri Department of Conservation
Southern Illinois University
Illinois Natural History Survey

As of 22 August 1974, $484,500 has been allocated for the comprehensive studies leading to the preparation of this Environmental Statement.

On 2 August 1972, the St. Louis District received a letter from the Missouri Department of Conservation making recommendations concerning a proposed dredging operation in the vicinity of Cape Bend Towhead, Mississippi River miles 49.7 to 50.9. On 8 August 1972, St. Louis District informed Missouri Department of Conservation, Illinois Department of Conservation, Bureau of Sport Fisheries and Wildlife, and Upper Mississippi River Conservation Committee that dredge spoil would be disposed of in accordance with agreements made between conservation agencies and the St. Louis District at the dredge spoil conference in St. Louis on 11 June 1972.

On 3 November 1972, the U. S. Department of Interior requested the St. Louis District to furnish copies of the Congressional documents authorizing the construction of the nine-foot channel project on the Middle Mississippi River, and requested information pertaining to the overall plan of improvement. On 20 November 1972, the St. Louis District informed the Department of the Interior that they had no spare copies of these documents authorizing the projects, but cited the applicable Congressional authorization so the Department of the Interior could obtain copies from the Library of Congress. They were also informed that the documents cited did not, as yet, contain any provision for the purpose of maintaining or improving fish and wildlife habitat. With regard to the overall plan of improvement, they were informed that the St. Louis District had conducted an extensive study program which included prototype reach construction and the Devil's Island model testing program in order to develop a plan of improvement to obtain authorized channel dimensions at the least cost to the Federal Government.

On 9 January 1973, Mr. Norbert C. Long, Chief, River Stabilization Branch, Engineering Division, St. Louis District, Corps of Engineers, was presented with one of two conservation awards given by the Upper Mississippi River Conservation Committee during 1973 for his efforts and cooperation in attempting to enhance the environment along the Middle Mississippi River.

During the first half of 1973, collection and development of environmental data continued under the supervision of the Waterways Experiment Station in cooperation with concerned conservation agencies. It was determined that a specialized model study should be conducted by experts in the field of river mechanics, in order to explore all possible means of environmental enhancement through the construction of regulating works intended to develop a navigable waterway on the Middle Mississippi River. This problem was discussed at great length with personnel at the Waterways Experiment Station, and it was determined that model testing facilities would not be soon available at WES in order to conduct the necessary testing. Accordingly, a decision was made by the St. Louis District to let a sub-contract to Colorado State University, Fort Collins, Colorado, which has world-wide recognition for their expertise in the field of river mechanics; this was for the purpose of conducting a thorough investigation of the channel improvement program on the Middle Mississippi River, and to conduct a specialized model test to determine ways and means of maintaining and improving fish habitat. In August 1973, Colorado State University submitted a preliminary draft of their study entitled, "Geomorphology of the Middle Mississippi River," for review and comments. This report indicated the following: The life of existing side channels in the Middle Mississippi River could be prolonged, but unless artificial means were utilized, i.e., dredging, side channels would eventually fill in. With regard to the improvement of fish habitat on the main stem of the Mississippi River, the report indicated that specialized dike field configuration would be of little value to the overall enhancement. The report also indicated that specialized dike field configuration would be of little value to the overall enhancement. The report also indicated that low-profile dikes were beneficial in that the accretions deposited would be lower and hence submerged under normal river stage conditions for a sufficient period of time so as to minimize the growth of willow trees, which are thought to be the primary cause of aquatic habitat being converted to terrestrial habitat. Model tests conducted relative to the utilization of notched dikes again substantiated information previously compiled at Waterways Experiment Station, in that notched dikes had a tendency to draw material into a dike field system, and did not improve fish habitat as hoped for by the conservationists.

Between August 1973 and July 1974, the St. Louis District continued to incorporate environmental considerations into its design for regulating structures in an effort to lessen the impact of its construction program upon fish habitat until the results of the finalized environmental studies were complete. All the study data generated as a result of the environmental studies have been made available to concerned agencies. The prototype structures, consisting of notched dikes, did not perform as anticipated by conservationists, but confirmed the results of the two previous model tests, which indicated notched dikes would tend to draw more material (sediment) into a dike field than un-notched conventional dikes. Thus, the results of all joint efforts to enhance fish habitat, under the authorizing Congressional document, indicated that the document would have to be modified to provide for environmental enhancement because little could be accomplished within the purview of the existing authorization.

In July 1974, a meeting was held in the St. Louis District between members of the Fish and Wildlife Service, Upper Mississippi River Conservation Committee, Missouri Department of Conservation, and Illinois Department of Conservation, and members of the St. Louis District, including the District Engineer, to discuss ways and means of enhancing the environment under a study program designed to prepare a viable post-authorization change to the project document as authorized in 1927. An agreement was reached whereby all concerned conservation agencies would work with St. Louis District to prepare a post-authorization change to the project which would best suit the needs of the environment and continue with the development of the authorized nine-foot navigation channel.

By means of coordination meetings held on 7 November and 12 December 1974, the St. Louis District implemented the necessary efforts aimed at submitting the aforementioned post-authorization change to higher authority for necessary action by July 1975. Subsequent meetings scheduled early in 1975 were postponed at the request of representatives of the Fish and Wildlife Service, and it now appears that the report cannot be submitted as originally scheduled.

9.3 PUBLIC MEETING ON CHANNEL MAINTENANCE DREDGING ON THE MISSISSIPPI RIVER BETWEEN CAIRO, ILLINOIS, AND THE MOUTH OF THE MISSOURI RIVER

On 16 September 1974, the St. Louis District circulated a public notice to over 700 individuals, agencies, and groups who were selected on the basis of probable interest in dredging and disposal activities on the river. Charts indicating prospective dredge and disposal sites were distributed with the public notice (Appendix Q). In response to the notice, the Water Commissioner, City of St. Louis, and the Chairman, Great Lakes Chapter of the Sierra Club, requested a public meeting. A notice of public meeting was issued by the St. Louis District on 8 November 1974 (Appendix R).

On 12 December 1974, a public meeting was held at St. Louis, Missouri, to obtain the views of all interested parties with respect to proposed disposal sites. The meeting was attended by 96 people, representing a wide range of backgrounds. The total transcript of this public meeting is included in this environmental statement as Appendix S. The findings of this public meeting in the form of a Statement of Findings, dated 4 February 1975 is also presented in Appendix T.

9.4 COORDINATION OF THE ENVIRONMENTAL STATEMENT

The Draft Environmental Statement for the Mississippi River between the Ohio and Missouri Rivers Regulating Works was coordinated with appropriate federal and state agencies, local communities, organizations, and interested individuals in May 1975 for review purposes in compliance with the National Environmental Policy Act of 1969. The Draft Environmental Statement was filed with the Council on Environmental Quality and subsequently a notice of this action was published in the Federal Register on 13 June 1975. The comments which were received as a result of this review are addressed in this part. Copies of the letters of coordination are continued in Appendix U.

a. U.S. Senator Thomas F. Eagleton

Comment 1: Thank you very much for sending me a copy of the Draft Environmental Statement for the Middle Mississippi River Between the Ohio and Missouri Rivers, Regulating Works. I found it to be quite interesting and I am sure my staff will find it to be very helpful.

Response: Comment noted.

b. <u>The Honorable Mrs. Leonor K. Sullivan - Member of Congress</u>

<u>Comment 1</u>: Just a note to let you know that I am in receipt of the Draft of the Environmental Statement.

Thank you for sending it along and when time permits I shall study it carefully.

<u>Response</u>: Comment noted.

c. United States Department of Housing and Urban Development

Comment 1: Your office's EIS on the Middle Mississippi Regulating Works presented a great deal of useful information describing the Corps extensive work in providing a nine foot navigation channel for Mississippi water commerce and the relationship of this work to the Middle Mississippi ecosystem. The Corps deserves credit for maintaining this channel for, as the EIS states, non-maintenance would have substantial adverse impacts on the national economy. The Corps also deserves recognition for its recent attempts to maintain the viability of side channel areas and we at HUD would like to encourage the expansion of this effort by the Corps.

Response: Comment noted.

Comment 2: The Alternatives Section of the EIS discussed the possibility of "Post-Authorization Change" which would expand the Congressional mandate to include provision for environmental protection and enhancement and action by the Corps. The EIS points out the need for and advantages of such a change and we at the Chicago Area Office of HUD would like to support your actions towards achieving this end.

Response: Comment noted.

Comment 3: We thought the EIS was well prepared in most areas but we would like to see one change in the Final. The Draft EIS makes reference to insufficient equipment to place dredged materials at elevations higher than the adjacent river level. We would appreciate a discussion of the reasons for this condition and the cost and benefits relative to a change which would enable dredging disposal at higher elevations.

Response: The statement referring to insufficient equipment to place dredged materials at elevations higher than adjacent river level has been removed from the environmental statement. The ability does exist to place material above water level.

d. <u>United States Department of Commerce</u>

Comment 1: Geodetic control survey monuments are located in the immediate vicinity of the proposed project area. If there is any planned activity which will disturb or destroy these monuments, National Ocean Survey (NOS) required not less than 90 days notification in advance of such activity in order to plan for their relocation. NOS recommends that funding for this project include the cost of any relocation required for NOS monuments.

Response: This office envisions no activities which will require a relocation of any existing geodetic control survey monuments.

e. United States Department of Agriculture Forest Service

Comment 1: The dredging will have little effect on woodland. If possible, the final statement could include an estimate of the area of wildlife habitat that is lost due to maintenance of the channel.

Response: Because of the unknown amount of maintenance required to maintain the 9-foot channel, due to the unpredictable nature of the river, it is very difficult to place numbers on the amount of wildlife habitat that will be lost.

f. United States Department of Agriculture Soil Conservation Service

Comment 1: The draft environmental impact statement for the Mississippi River Between the Ohio and Missouri Rivers (Regulating Works) appears to adequately display the effects and alternatives of maintaining a nine-foot navigation channel.

Response: Comment noted.

Comment 2: Soils - Section 2.1.3 (page 94)
Section 2.1.3.2. on surficial soils states "no comprehensive system of soil classification for the lands bordering the Mississippi River between St. Louis, Missouri, and Cairo, Illinois exists." There is a nationwide system of soil classification through the National Cooperative Soil Survey under the leadership of the Soil Conservation Service. There is soil survey information based on this system for counties along the Mississippi River in Illinois. Both detailed and general soil maps exist for Alexander, Union, Jackson and St. Clair Counties. General maps exist for Madison, Monroe and Randolph Counties. The soils have been interpreted for their behavior related to a number of uses, agricultural as well as engineering. Representatives of the Soil Conservation Service in Illinois would be happy to discuss the soil survey information available with representatives of the U.S. Army Engineer District, St. Louis, Missiouri.

Response: This office is aware of the nationwide system of soil classification. The basis for the above statement was the fact that many of the soil surveys in counties bordering the river were published prior to national correlation of soil types; similar soils may vary in name from county to county; and, as such, the existing set of surveys are not "comprehensive." Information and maps from soil surveys of all the above counties, except Madison, are included in the "Inventory of Physical and Cultural Elements - Middle Mississippi River," referenced in the EIS. This information was obtained by contact with SCS personnel by Waterways Experiment Station personnel, who prepared the inventory. The SCS "Status of Soil Surveys Map, dated July 1974, places Madison County in a category described by "no modern soil survey being conducted and no old published survey available."

Comment 3: Land Use and Conservation Treatment in the Watershed - We recognize this statement covers only the middle section of the Mississippi River which has a total drainage area of approximately 700,000 square miles. However since the control and removal of sediment is one of the major phases or causes for the regulating works covered by this statement we suggest attention be given to the need for improved land use and additional conservation treatment in the watershed. We note on page 9 the fact that suspended sediment discharges taken at St. Louis average approximately 500,000 tons per day.

It may be beneficial to include the acres needing soil and water conservation treatment for Kaskaskia and Big Muddy Rivers watersheds. The Soil Conservation Service has information from the Conservation Needs

Inventory for these watersheds.

You may wish to add a statement such as "The Corps of U.S. Army Engineers will work closely with Federal, State and Local agencies and with local Soil and Water Conservation Districts in promoting an accelerated land treatment program throughout the watershed to reduce erosion, sedimentation and subsequent water pollution."

Response: Comment noted. The St. Louis District has begun coordination with the concerned local Soil and Water Conservation Districts and State, Federal and Local agencies.

Comment 4: Nutrients (Water and Sediment)- 2.1.4.6 (page 99)- Soil and water conservation work on the watershed could be added as one of the factors influencing the quantity and quality of runoff water.

Response: This change has been made.

Comment 5: Air Quality 2.1.6 (page 106)- We question the validity of the statement which indicates animal feedlots create significant smoke. You may wish to make a separate reference to feedlots and delete this portion.

Response: The statment did not intentionally site animal feedlots as creating significant smoke, but rather dust and odors. The wording has been changed to enhance clarity.

Comment 6: Cover Types 2.2.2.2 (page 128) "g. Cultivated Field" - Suggest this be changed to read "Cropland Fields."

Response: The District fails to see the difference.

Comment 7: Cover Types 2.2.2.2 (page 128) "h. Old Field" - These areas could be called "open land."

Response: The use of the term "Old Field" identifies a specific cover type or habitat that is not readily identifiable when speaking of "open land."

Comment 8: Past Land Use 2.3.3.1 (page 171) - Suggest eliminating the wording "due to exploitation of bottomland hardwood forests." The harvest of hardwood timber from bottomland is not necessary exploitation.

Response: The term "exploitation" was used in the context of the utilization of a natural resource (Websters Seventh New Collegiate Dictionary) such as a harvest of hardwood timber from the bottomland. However, due to the fact that "exploitation" may imply improper use or unjust profit, the wording has been changed.

Comment 9: Suggested change: Narrowing of River Width 4.1.1.4 (page 196) - Suggest eliminating the word "poor" in describing the land use practices between 1821 and 1888. The land use decision makers of that period may have acted in the best interests of their country.

Response: Concur. The word "poor" will be deleted.

Comment 10: Suggested change: Effect on Flows 4.1.1.6. (page 199), fifth paragraph - Watershed Protection and Flood Prevention projects under Public Law 566 along with soil and water conservation work on individual farms could be mentioned as a factor affecting run-off from the drainage basin.

Response: Concur. The efforts of the U.S. Department of Agriculture should be recognized in this area.

Comment 11: Suggested change: Changes in Sediment Discharge 4.1.1.7. (page 201), Paragraph 5 - You may wish to include the influence soil and water conservation work has and can have on decreasing erosion and sediment in the river.

Response: Concur. The efforts of the U.S. Department of Agriculture should be recognized in this area.

Comment 12: Impact on Widdlife 4.2.2.2. (page 214) - Suggest eliminating the last sentence in this section. Increased production from farms, timber production, and public land use does not have to be detrimental to all wildlife and wildlife habitat as stated. Soil and water conservation management practices on these lands can be beneficial to wildlife.

Response: This change has been made.

Comment 13: Impact on Threatened, Rare or Endangered Species 4.2.3 (page 215) In the next to last paragraph suggest it be changed to read from "will be" to "can be detrimental." Land management practices can be planned and followed which will protect and enhance the habitat for rare and endangered species.

Response: This change has been made.

Comment 14: Coordination of the Environmental Statement 9.4 (pages 249 through 251) - For coordination purposes you may wish to add the local Soil and Water Conservation Districts to your list. Each county in Illinois is in a Soil and Water Conservation District with responsibilities for the conservation of soil and water resources and for the control and prevention of soil erosion, floodwater and sediment damages within the district.

Response: The respective Soil and Water Conservation Districts have been added to the coordination list for the final environmental statement.

g. United States Department of the Interior

Comment 1: In most instances the statement identifies and acknowledges the extreme modification and distruction of fish and wildlife habitat that has, and is continuing, to occur on the Middle Mississippi River as a result of the 9-Foot Navigation Project. This admission and the movement toward a post-authorization change document to include fish and wildlife conservation as a project purpose are hopeful signs of an improved future for a much abused resource.

Response: Comment noted.

Comment 2: 1. PROJECT DESCRIPTION AND HISTORY - 1.2 HISTORY AND AUTHORIZATION OF THE PROJECT - Page 7: We believe that this statement should deal with the entire project area from the mouth of the Ohio River to the mouth of the Missouri River, including the St. Louis Harbor. St. Louis, the largest port on the inland waterway system, is an important and integral part of the river. Its segmentation from the rest of the river is not appropriate since dredging and other channel maintenance activities are performed there and barge traffic and use of the river shoreline is particularly intense in the harbor area.

Response: Comment noted. This is a valid point in which the District concurs. This final environmental statement has been amended to include a more detailed discussion of the St. Louis Harbor area (see pages 50-51, Part 1.7.1.1) and the paragraph on page 7 has been omitted.

Comment 3: Page 48. It is our understanding that the St. Louis Corps District has generally dredged to a depth of about 13 feet below the low water reference plane elevation, not 9 feet as indicated in this section.

Response: The St. Louis District is currently dredging to a depth of approximately 11 feet below the low water reference plane. The 2 foot over depth is required to minimize the total volume of material to be dredged over a period of time and is the least costly method of maintaining the authorized project.

Comment 4: Page 51. This section should state that the formation of new side channels is unlikely (see page 205 and 207) due to the constriction and confinement of the river within its present channel by dikes and bank revetment. In fact, this feature of the project is later considered a benefit in the statement since farm fields are not being eroded into the river. Any side channels formed in new dike fields will be the result of land accretion at the river end of the dikes. This means that in order for the new side channel to be formed, the river will be filled and further constricted by the formation of the new island. The width of the river already has been severely reduced (5,000 feet to 2,200 feet) by navigation dikes and levee construction. The formation of temporary side channels does not justify continuation of this damaging process of compensate for fish and wildlife losses resulting from the project.

Response: Section 2 is only a description of the existing environment in the project area. Impacts of the project, such as preventing new side channel formation, is discussed in Section 4, Impact of the Action on the Environment.

Comment 5: Page 52: Dike construction has created side channels but the total river contraction process has destroyed many more. This destruction has not been fully studied or compensated for as intended by the Fish and Wildlife Coordination Act. (P.L. 85-624).

Response: The St. Louis District is in the process of preparing a Post Authorization Change, which will include the preservation and enhancement of fish and wildlife as a project purpose.

Comment 6: 2.2 BIOLOGICAL ELEMENTS - Page 110: Figures 2-2e through 2-2h illustrating zooplankton occurrence are missing.

Response: These figures have been added.

Comment 7: Page 114: The lack of public access to the river and the adverse effects of channelization on fish and wildlife habitat also should be included as causes for the low level of sport fishing use of the river.

Response: Lack of public access has been added as a cause for the low level of use of this section of the river. Channelization and constriction were mentioned in the first paragraph of Page 114.

Comment 8: Page 123: The brown creeper is only a rare breeder in the subject area. During migration periods, it is quite common and also occurs as a fairly common winter resident.

Response: Comment noted. The final environmental statement has omitted such inference.

Comment 9: Table 2-5a. The endangered bald eagle should be correctly listed to subspecies, Haliaeetus leucocephalus leucocephalus.

Response: This change has been made.

Comment 10: Page 143: An updated list of rare and endangered vertebrates of Illinois was published by the Illinois Nature Preserves Commission in 1973. This more recent list should be used instead of the 1971 Preliminary Draft.

Response: Contact with the Illinois Nature Preserves Commission has indicated that the 1971 list is the most recent list from that organization. However, a 1975 list of rare and endangered vertebrates of Illinois, prepared by the Illinois Department of Transportation, has been used to update the Environmental Statement.

Comment 11: 2.3 Cultural Elements - Page 172: The data presented on land use in the flood plain is misleading. It appears that the acreage figures were taken from Table 1 of the publication by Terpening et al., prepared under Corps contract. This table gives data only for the unprotected flood plain but the statement represents this as data for the entire flood plain. The reference Plates 2-5a through 2-5k show land use for the entire flood plain. Acreage for lake and backswamp should be 4,279 and not 4,729.

Response: The land use data presented on page 172 of the draft environmental statement should indeed be labeled as that for the unprotected flood plain. The misrepresentation was unintentional and corrections have been made in the final environmental statement. Also, the acreage for lake and backswamp has been corrected to read 4,279.

Comment 12: The Shawnee National Forest and city parks are not the only areas on the river formally dedicated to recreation. In Illinois there are Lewis and Clark and Fort Defiance State Parks and in Missouri there is Trail of Tears State Park.

Response: The discussion of recreation facilities on page 172 of the draft environmental statement referred only to those located on the flood plain. The expansion of the study area to include the St. Louis metropolitan area brings in Lewis and Clark State Park in Illinois, directly opposite of the mouth of the Missouri River.

Comment 13: Page 184: Through the Land and Water Conservation Fund, the Bureau of Outdoor Recreation is assisting Grand Tower, Illinois, in expanding Devils Backbone Park by 8.5 acres (project 17 - 00215). When developed it is planned that this park will provide camping and picnicking facilities and boat access to the Mississippi River. Trail of Tears State Park also makes use of the river through a recently developed marina and boat ramp. We suggest this section and Table 2-32 be expanded to recognize those major city parks which contribute to the public's enjoyment of the flood plain's natural resources and the Mississippi River.

Response: Concur, this information has been added.

Comment 14: The statement that the region lacks good accessibility from the St. Louis area seems based on the premise that the only good access consists of an interstate highway going to or near the point in question. I-55, U. S. 61 and Ill. 3 with their associated secondary roads provide travel at near maximum speed limits (55 mph) to almost the entire area.

Response: Concur, these changes have been made.

Comment 15: Page 188: The statement comparing the relative diversity of side channels in 1796 with today is speculative. Unless supported by further documentation, it should be removed.

Response: Concur. Relative diversity of side channels in 1796 is speculative just as much as the 1888 conditions were, as cited by Colorado State University.

Comment 16: Page 196: The 4 or 5 million cubic yards of material dredged annually also should be described in terms of percent of the river's bedload.

Response: The percentage of bedload to the total transport capacity of the river is very difficult to measure. The Corps estimates that it ranges between 15 and 25 percent. Part of the 4 to 5 million cubic yards of dredged material includes suspended particles not transported as bedload. Furthermore, it is possible that some dredge material must be handled more than once. The dredging requirements also are influenced by extreme low stages (low discharges) and by rapid fluctuation in river stages for all other discharges. The Corps does not have information to give a definite or exact answer to this comment.

Comment 17: Page 199: We agree that a levee provides flood protection when it does not break or is not overtopped, but because of increased construction on and use of both the protected and unprotected flood plain, the amount of damage caused by floods apparently has been increasing. The statement leaves the impression that flood damages are less now than in the past, which is not necessarily true.

Response: It is true that dollar damages caused by floods has been increasing over time, for the same level flood. However, this problem is directly traceable to increased damageable development in unprotected areas. The levee, floodwall, channel improvement and flood control reservoir system for reducing damages has been in general, an outstanding success for the area's protected. Obviously, flood damage reduction does not take place, and is not intended to take place, in areas outside the limit's of the protected area. It is the increased use of and development of unprotected areas that has caused the Nation's flood damages to continue to increase.

Comment 18: Page 204: In the 1973 flood, no government levees failed, but what was the level of flood related damages compared to 1927? When speaking of the 1927 flood, the statement mentions only "catastrophic damages", yet no mention is made of damages caused by the 1973 floods. The damages from the 1973 flood should be stated.

Response: Due to a lack of Federal flood protection, the 1926 and 1927 flood events the flood stage was exceeded for a total of 273 days from 5 September 1926 through 8 July 1927. Damages suffered within the St. Louis District Corps of Engineers, at that time, amounted to $14,093,000. Damages in the Missouri portion of the St. Louis Corps District were $4,228,000 and in the Illinois portion $9,865,000. Obviously a dollar was worth much more in 1927 than in 1973. Additionally, the length of the flood period in 1927 plus the fact that commerce and industry were more river oriented and dependent in 1927, than 1973, made the 1927 flood more of a catastrophy than the 1973 flood. In 1973 the flood damages were in general restricted to areas not afforded Federal flood protective works. The 1973 flood damages were $302,250,000 within the St. Louis District areas. Damage in the Missouri portion of the St. Louis Corps District were $62,754,000 and in the Illinois portion $220,496,000. However, equally important in understanding the 1973 flood situation versus the 1927 flood, is the realization that Federal flood protective improvements currently in place prevented the occurrance of an additional $908,639,000 in flood damages with the St. Louis Corps District. Flood damage prevented by Federal flood protective works in the Missouri portion of the St. Louis Corps District were $182,100,000, and in the Illinois portion $726,529,000 in flood damages was prevented.

Comment 19: Page 210: Section 4.1.4.3 generally dismisses the effects of increased barge traffic as being comparatively insignificant, but does not provide a basis for comparison. Since the 9-foot navigation channel sustains and in fact, encourages river traffic, the total effect of navigation on the riverine environment should be defined in addition to effects generated by an increase in traffic. The latter only aggravates an already bad situation which itself deserves description in this statement.

Response: This section has been expanded; however, this portion of the river is naturally turbid and has evidently been this way for quite some time. For this reason turbidity resulting from barge traffic will be insignificant when compared to ambient turbidities.

Comment 20: 4.2 BIOLOGICAL IMPACTS - Page 212: A survey of the location and composition of the freshwater mussel population of the Middle Mississippi River is needed. It generally is believed that very few mussels are able to survive the poor quality water, but no clear picture of the actual situation exists.

Response: Over the past decade an improvement in water quality has been noted, probably due to more stringent water quality standards. An example of this has been the increase of the fingernail clam population in the Illinois River.

Comment 21: Page 217: The philosophy and realistic attitude expressed in the last paragraph is commendable. It is becoming increasingly important that we view our growth efforts with a critical eye toward their impacts on the global ecosystem.

Response: Comment noted.

Comment 22: Page 218: It is stated that the regulating works will have no impact on the existing recreational resources. However, we believe, as noted in paragraph 4.2.1.1, "The effects of river contractions by dike fields and bank revetment . . . reduced the bank-to-bank river surface area by one-third, the island area by one-half, and the water surface area by one-half . . ." have discouraged the development of riverside recreational resources and boat marinas. Further contraction of the river will result in even less water surface, the need for more powerful boats in the faster current, and increased possibility of conflict and collision between pleasure boats and commercial barges. Greater contraction of the river also will probably continue to inhibit the development of riverside recreational resources and marinas.

Response: Theoretically the comment would appear correct regarding loss of water surface area. However, boat registration statistics, regarding need for or justification of marinas for boat storage and services do not substantiate lack of recreation development to accomodate such. Most registered boats are of the trailered type used by fishermen, and to some extent by recreation boaters for boating or water skiing purposes. These are usually of a utility type with outboard motors and a limited number of inboard-outboards. Pleasure crafts, as represented in the comment, are limited primarily to larger boats, including house boats, which are transients moving up or down river and are not normally boats based in the region. There are locations where boat access facilities such as boat launching ramps, parking, and public access are needed or need to be expanded. Joint efforts during the past ten years has failed to produce an acceptable cost-sharing arrangement between the Corps of Engineers and a non-federal local sponsor for the provision of such facilities. Greatest need along this Middle Mississippi River reach has been for marine services, primarily fuel. The portion of the comment regarding boat safety is well taken. Navigation interests are constantly on the alert to avoid boating accidents. Recreation boaters too, through boat registration and boating law enforcement, have improved in their practice of boat safety.

Comment 23: 4.3.5 IMPACTS ON CULTURAL RESOURCES - The statement does not clearly confirm consultation with the State Historic Preservation Officers for Illinois and Missouri. The statement should reflect that they were consulted to determine whether the proposal will affect any cultural site which may be eligible for inclusion in the National Register of Historic Places.

Response: Discussions on an informal basis concerning the potential effects of operation and maintenance artisties took place on several occassions with staff of the Missouri Department of Natural Resources, State Historical Survey and Planning Office; and with persons in the Illinois Archeological Society. Views on the effects of the project of these agencies are contained in this statement.

Comment 24: The statement also should present the views of the Illinois Archeological Survey (137 Davenport Hall, University of Illinois, Urbana, Illinois 61801) and the Missouri Archeological Survey (Mr. David R. Evans, Director, 15 Switzler Hall, University of Missouri, Columbia, Missouri 65201) regarding project effect upon cultural resources.

Response: Comments of the Illinois Archeological Survey as well as responses to these views are contained in this volume. Coordination with the Archeological Survey of Missouri has taken place in the form of requests for information on archeological sites on the floodplain of the Mississippi River. Comments of the Archeological Survey of Missouri appear in this statement.

Comment 25: 6. ALTERNATIVES 6.4 POST-AUTHORIZATION CHANGE - We support the joint efforts of conservation agencies to seek modification of the 1927 authorizing Congressional document to provide for environmental protection and enhancement.

Response: Comment noted.

Comment 26: APPENDIX G - A notation should be included in this table indicating that the inclusion and status of some of the listed species is based on judgments made by the preparers of the statement and not on any published lists of rare, threatened, and endangered species.

Response: The sources of information used in preparation of this appendix have been added.

Comment 27: The following species should be added and the bald eagle listed as two sub-species:

Common Name	Scientific Name	IL	MO	U.S.
Bigeye Shiner	Notropis boops	R	-	-
Mississippi Silverside	Menidia audens	-	R	-
Snowy Egret	Egretta thula	R	-	-
Pintail	Anas acuta	R	-	-
Northern Shoveler	Anas clypeata	R	-	-
Canvasback	Aythya valisineria	R	-	-
Southern Bald Eagle	Haliaeetus leucocephalus leucocephalus	E	-	E
Northern Bald Eagle	Haliaeetus leucocephalus alascensis	E	R	-

Response: These additions have been made.

Comment 28: APPENDIX Q: The only reference to grain-size of typical dredged sediment that was noted in the statement is in Appendix Q (p. 2, par. #4), where the sediment is described as 5 percent coarse gravel, 10 percent pea gravel, and 85 percent sand and silt. Since the alternative of using dredge spoils for such commercial purposes as fill material, mortar sand, aggregate and concrete is under consideration (p. 228, par. 6.5), it would be helpful to provide any available data on grain-size distribution and other physical properties typical of the spoils.

Response: Each dredging location within the reach addressed within this statement contains material of different properties; thus each dredging site should be studied on its own merit with respect to alternate use.

Comment 29: (a) Maps provided in the main body of the statement show the location of only about 40 disposal sites, all of these being within the Mississippi River immediately adjacent to the dredging areas (Plates 1-4a to 1-4j). It has not been mentioned until Appendix Q that about 125 disposal sites are under consideration.

Response: (a) The maps in the main body of the statement, by the legend indicate dredging accomplished from 1969 through 1974 while Appendix Q is to indicate all known and anticipated dredging sites as well as proposed dredged disposal areas.

Comment 29: (b) It had been stated in the main body of the statement that "insufficient equipment exists at this time to enable the dredged material to be placed at elevations higher than the adjacent river level" (p. 194, par. 4.1.1.3). However, the public notice published as recently as September 16, 1974 refers to disposal sites on land, and accompanying maps show elevations of some disposal sites as high as 12 feet above L.W.R.P. (App. Q, map for river miles 25.8 to 42.7).

Response: (b) No disposal sites on land are indicated in the 16 Sep 74 Public Notice as stated on page 2, paragraph 3.b. "Dredging Practices". The maps indicating elevations of disposal sites up to 12 feet above LWRP have no relationship to placing material higher than the adjacent river level since LWRP is the calculated low water reference plane.

Comment 29: (c) On the map covering river mile 63.9 to 80.9 Appendix Q, the area of prospective dredging in the vicinity of river mile 75.0 to 75.5 appears to have been omitted.

Response: (c) Concur.

h. <u>United States Department of Health, Education, and Welfare</u>

<u>Comment 1</u>: Review of the above referenced document indicates that there is no apparent impact on programs of the Department of Health, Education, and Welfare. It would appear that the impacts of the proposed action and the reasonable alternatives have been adequately addressed.

<u>Response</u>: Comment noted.

i. United States Department of Transportation Regional Representative Of The Secretary

Comment 1: Our review of the Corps of Engineers' Draft Environmental Statement for the Mississippi River Between the Ohio and Missouri Rivers Regulating Works indicates that the Statement adequately considers the effects the project may have on areas within the jurisdiction of the Department of Transportation.

Response: Comment noted.

j. United States Department of Transportation United States Coast Guard

Comment 1: The concerned operating administrations and staff of the Department of Transportation have reviewed the material submitted. We have no comments to offer nor do we have any objection to this project.

Response: Comment noted.

k. United States Department of Transportation Federal Highway Administration

Comment 1: The statement acknowledges the potential for scour and channel deepening that can result from continuing maintenance. Since modification of existing dikes and construction of new dikes may be needed to help maintain the 9-foot channel, we believe some assurances should be provided that the substructures of existing bridges will be adequately protected during the construction and maintenance operations.

Response: The purpose of the channel improvement program is to develop the authorized 9-foot channel with respect to a low water datum plane delineated by a low water discharge of 54,000 cubic feet per second. It has been our experience that channel improvement structures have not created a scour problem in the vicinity of substructures on existing bridges. As a matter of fact, these substructures are subject to scour when dike fields are overtopped and the velocity of the river increases due to natural processes. If these substructures are designed to withstand scouring action which occurs under the aforementioned conditions, the channel improvement project will in no way affect the stability of thowe structures.

Please be informed that ice gorges can create severe scouring conditions when the river is virtually blocked by ice. Under these conditions a considerable hydraulic head can develop upstream of an ice gorge and produce severe scouring action as the water passes under the ice pack. Unfortunately, little data are available on this subject. This office brought that phenomena to the attention of the State and Federal agencies involved with the construction of new bridge I-57 at Cairo, Illinois. It is our understanding that the substructures for the I-57 bridge have been redesigned to preclue the possibility of scour damage created by an ice gorge.

It would be beneficial if all substructures for existing bridges on the Middle Mississippi River were equipped with automatic sounding devices so that our respective agencies could obtain more data on the scour problem for all river conditions.

1. United States Environmental Protection Agency

Comment 1: We have reviewed the Draft Environmental Impact Statement (EIS) for the operation and maintenance program referenced above. The program and statement are rated ER-2 meaning the Environmental Protection Agency (EPA) has environmental reservations with the project because of the historic and predicted degradation of wetlands and the probable violation of water quality standards due to resuspension of heavy metals into the water. In addition, we believe the final statement should be modified to include information on the subjects discussed in this letter.

Response: Comment noted. Specific responses are applied to the comments which follow.

Comment 2: The draft statement indicates that, through the use of regulating works, the surface area of the Middle Mississippi River has been reduced by one-third and the total island area by one-half. The unintentional act of destroying wetlands without mitigation is in conflict with both the EPA and Corps of Engineers wetland policies. Therefore, the Corps should take any or all means available to curtail further wetland destruction and provide a program of enhancement or restoration of the remaining wetland ecosystem consistent with the existing 1927 navigation mandate.

Response: Comment noted. The reader is referred to the Statement of Findings accompaning the final environment statement which deals with a post authorization change for the purpose of maintaining side channels.

Comment 3: The backwater and side channel areas make up the adjacent wetland areas of the Middle Mississippi River. Major wetland reduction has taken place as a result of the present 1800-foot main channel contraction program. The further isolation of side channels from the main channel, which will result from the proposes 1500-foot contraction program, should be evaluated for its additional reduction in wetland areas.

Response: Comment noted. The reader is referred to the Statement of Findings accompaning the final environmental statement.

Comment 4: In addition, the anticipated reintroduction of nutrients and toxicants into the remaining wetland ecosystem, due to the main channel scour under a 1500-foot contraction program, should be assessed.

Response: In the main channel, where this scour will occur, the sediments are continually resuspended and deposited under natural conditions, allowing very little build-up of pollutants. For this reason, resuspension of main channel sediments should have little affect on water quality.

Comment 5: Water Quality Information included in Appendices H through P indicate coliform bacteria concerntrations, chemical oxygen demand levels and heavy metals concentrations often exceed the EPA and Illinois Water Quality Standards. We believe the final statement should also provide data on organophophate and chloro-hydrocarbon pesticides concentrations.

Response: No information was available from this section of the Mississippi River on organophosphates; however, values of total phosphorus and dissolved phosphates were presented. In a study by Emge, et al (1974) no detectable concentrations of organo-chloride pesticides were detected in any of the bottom sediments.

Comment 6: The draft statement indicates the bottom sediments at selected sites contain high concentrations of COD and heavy metals. In addition, these sediments may contain high concentrations of pesticides. Reintroduction of these materials through dredging or riverbed scour, due to confinement of the main channel, would severely degrade the downstream water quality. We believe any spoil material, which constitutes a pollution source, should be removed from the river regime, confined and the supernatant return flow monitored to minimize adverse impacts.

Response: Comment noted. Additional studies and/or site investigations prior to dredging would be necessary in order to ascertain the magnitude of the potential problem identified Corrective action would follow accordingly. The St. Louis District realizes the significance of this potential problem. The reader is referred to the recommendations made in the Statement of Findings which accompanies this final environmental statement.

Comment 7: The statement indicates side channels exhibit thermal stratification. Anaerobic conditions may occur at the lower depths in these channels. Many pollutants which are insoluble under aerobic conditions become soluable under anaerobic conditions and subject to downstream release during high flows through the side channel. The final statement should provide an assessment of the anticipated impacts of the project on the aquatic environment of the side channels and the downstream water quality with respect to stratification.

Response: Most of the side channels studies where found to exhibit thermal stratification to some degree during the summer, and surface dissolved oxygen concentrations were higher in side channels than bottom concentrations; however, no anarobic conditions were observed. In fact, bottom dissolved oxygen concentrations were higher in side channels than in river border areas.

Comment 8: The resuspension and deposition of pollutant laden sediments may cause a severe impact on the quality of public water supplies downstream. These may contain heavy metals, pesticides, and carcinogenic pollutants. The final statement should assess the anticipated impacts on municipal water supplies from the operation and maintenance program.

Response: Section 4.1.4 has been expanded to address this possibility; however, as was mentioned in the response to comment 4, most resuspension of riverbed sediments, whether from scour, dredging, or turbulance from towboats, will cccur from the main channel where the sediments are continually resuspended and deposited under natural conditions. For this reason, resuspension of main channel sediments should have little affect on water quality. It was found, however, that mercury did exceed EPA criteria at 4 sites in the main channel.

Comment 9: General Comments: The draft statement has provided an appraisal of the present program of 1800-foot main channel contraction. The final statement should include an appraisal of the environmental impacts of the proposed program of 1500-foot contraction.

Response: The Draft Environmental Statement addresses and appraises the environmental impacts of obtaining the navigation channel by use of 1,800; 1,500; and 1,200-foot contraction plans. Results of hydraulic investigations have indicated that it is not necessary to utilize a 1,200-foot contraction plan to develop the navigation channel under present low flow conditions. In addition, some reaches of the river may not require a 1,500-foot contraction plan since the 1,800-foot contraction may provide a dependable navigation channel at present low-flow conditions.

The St. Louis District recognizes the intent of the 1969 NEPA Act. Requests will be made under a Post Authorization Change to include fish and wildlife considerations as a project purpose to the Navigation Act, and necessary funds will be requested to accomplish that objective. To date, approximately $600,000 has been expended from project funds to conduct necessary studies for the preparation of the Environmental Statement aimed at making the navigation project more compatible with its riverine environment. A substantial amount of funds have been expended in order to place dredge material at locations acceptable to concerned conservation agencies. Considerable engineering effort has been expended in an effort to cooperate with conservation agencies in order to modify contract plans for regulating works to comply with their recommendations. Since 1969, approximately $40,000,000 in contract plans have been so modified as a result of environmental review.

The cooperative efforts between the St. Louis District and concerned conservation agencies was undertaken prior to the enactment of the 1969 NEPA Act.

Comment 10: The final environmental statement should identify any impacts of this particular operation and maintenance program which may affect other sections of the Mississippi River System.

Response: Other Corps of Engineer districts along the Mississippi River have prepared or are preparing environmental impact statements dealing with the impacts of navigation on the river within their district.

Comment 11: The maps showing the locations of possible dredging sites and proposed disposal sites are not adequate. In some areas it appears the disposal sites depicted could close backwater areas, but as stated in the draft, this practice is no longer followed. Better maps indicating locations of disposal sites would clear up this confusion.

Response: It is assumed that this comment is in reference to the maps presented in Appendix Q. Although the adequacy of these maps may be questionable the District's position is that they are of value to the report and are adequate when used along with the maps presented in pages 35 - 44 (Plates 1-4, a-j).

m. Advisory Council On Historic Preservation

Comment 1: This is in response to your request of June 4, 1975, for comments on the draft environmental statement for the Middle Mississippi River Between the Ohio and Missouri Rivers Regulating Works, Missouri and Illinois. Pursuant to its responsibilities under Section 102 (2) (C) of the National Environmental Policy Act of 1969 and the Council's "Procedures for the Protection of Historic and Cultural Properties" (36 C.F.R. Part 800), the Advisory Council has determined that your draft environmental statement is inadequate because it does not contain sufficient information on archeological resources to enable us to comment on your compliance with Executive Order 11593 "Protection and Enhancement of the Cultural Environment" of May 13, 1971, and the Council's prodedures.

Under Section 1 (3) and 2 (b) of the Executive Order and Section 800.4(a) of the Council's procedures, Federal agencies are required to identify all Federal and non-federally owned properties within the area of their undertaking's potential environmental impact that may be eligible for inclusion in the National Register of Historic Places.

Although extensive archeological surveys have been conducted in the flood plain area, the environmental statement indicates that the proposed operation and maintenance activities will be confined to the river and river bank, an area which has apparently not been surveyed for potential National Register properties.

Without a survey to determine the nature and extent of archeological resources in the project area, Nation Register eligible sites may be inadvertently demolished or substantially altered. This possibility is mentioned by the Corps on page 219 of the environmental statement:

> In those instances where portions of the river bank are contoured, if an archeological site were to be present at that location, it might be adversely affected by the surface disruption.

Response: Operation and maintenance activities are of such a nature that long range planning for revetments or dike construction is generally not feasible. Given this situation it is impossible to define a project area for archeological survey other than the specific localized action that is to take place. In those instances where operation and maintenance activities such as revetment placement or dike construction will take place which will involve disturbing the riverbank, an archeological survey of the area to be affected will be accomplished. The survey will follow the spirit and intent of EO11593 and if appropriate the Council's procedures (36 CFR, part 800) will be followed in determining the significance of sites, and in reaching decisions as to their disposition. The environmental statement has been changed in sections 2.3.5.1 and 4.3.5 to reflect this information.

Comment 2: In order to reduce the likelihood of such an occurance, the Advisory Council suggests that an archeological survey be undertaken by the Corps in those areas of the river bank where surface disruption is proposed. In addition, we support the June 17, 1975, position of the Missouri State Historic Preservation Officer (SHPO) concerning protection of unknown underwater archeological resources that may be affected by the proposed undertaking. A copy of the Missouri SHPO's letter is attached.

Response: Concur. See response 1 above. In the event underwater archeological resources are encountered during dredging operations, relevant information will be transmitted to the appropriate state historical authorities.

Comment 3: Until archeological resources in the project area have been identified and the need for further compliance with the Council's procedures has been ascertained, the Council cannot comment favorably with respect to your environmental statement.

Response: We feel that the changes that have been made in the environmental statement regarding the inclusion of archeological survey and appropriate follow-up actions in standard operation and maintenance procedures satisfy laws covering the preservation of cultural resources.

n. Federal Power Commission

Comment 1: Our principal concern with proposals affecting land and water resources is the possible effect of such proposals on bulk electric power facilities, including potential hydroelectric development, and on natural gas pipeline facilities.

Response: In preparing plans and specifications for channel improvement works, due consideration is given to existing electric power facilities and all types of submarine crossings. Whenever proposed hydroelectric development in being considered along the Middle Mississippi River, the St. Louis District renders all necessary technical services requested by the developers. For example, numerous meetings and technical data was afforded to Union Electric Company at the time they were formulating plans tc construct an electric power plant at Rush Island, Mississippi River mile 140.

Comment 2: Review of the draft environmental statement by the Commission's staff indicates that the proposed project would not have any significant effect on matters of concern to the Federal Power Commission. We note that there are several steam-electric power plants which depend on this reach of the Mississippi River as the source of cooling water supply. Care should be taken to protect the water intake and discharge works of these power plants from the proposed activities of dredging and dredged material disposal.

Response: As alluded to in the response to Comment 1, great care is taken to protect water intakes and discharge works under our channel improvement program and our maintenance dredging program. This not only applies to any facility along the river constructed at the expense of municipal, industrial, or private interests.

n_1. Illinois Department of Conservation

Comment 1: The Illinois Department of Conservation has completed its review of the draft environmental statement "Mississippi River Betwee; the Ohio and Missouri Rivers Regulating Works."

We wish to compliment your office for the prepration of this document. The document properly addresses the issues caused by maintenance of the 9-foot channel and does not belittle the importance of the issues.

Response: Comment noted.

Comment 2: We do suggest that the document could be improved through a study designed to document the occurrence of mussels in this section of the river.

Response: Concur. The District is considering such a study effort, particularly as it relates to those species of mussels which may be classified as rare and endangered by the United States Department of Interior.

Comment 3: In our opinion, the study points out that, without a post-authorization change to include environmental work in the project, the continuance of current procedures can only result in continued degradation and loss of aquatic habitat.

As you are aware the Illinois Department of Conservation supports the post-authorization change. It is our belief that this document will help our joint efforts to secure these changes.

Thank you for the opportunity to comment.

Response: Comment noted.

o. Illinois Natural History Survey

Comment 1: Although information from the Illinois Natural History Survey is incorporated in the statement, I am disappointed that a copy of the draft was not sent to the Natural History Survey for comment.

Response: Copies of the environmental statement were sent to the Illinois State Clearinghouse which distributes them to state agencies, which was assumed to include the Illinois Natural History Survey. A copy of this final environmental statement will be mailed directly to the Illinois Natural History Survey.

Comment 2: The losses of fish and wildlife habitat due to this project appear to be of considerable magnitude. Therefore, I urge your continued cooperation with the Illinois Natural History Survey, the Fish and Wildlife Service, and other natural resource agencies and organizations, to minimize the adverse effects of such projects on fish and wildlife.

Response: Comment noted, such cooperation will continue to be carried out.

p. Illinois State Geological Survey

Comment 1: p. 52/2.1.2.1a: The Coastal Plain is a topographic feature, not a geosyncline.

Response: Concur. The Coastal Plain Section will be corrected to show it as a topographic feature, not a geosyncline.

Comment 2: p. 57, last sentence - part d: Much of this 400-500 foot deep trench is now filled with sand and gravel and finer alluvium, in which the Mississippi now flows. The young trench south of Thebes was not eroded that deep.

Response: Concur. The last part of this paragraph will be changes as follows: "The Mississippi in this area flowed through a trench 400 to 500 feet deep. Much of the 400-500-foot deep trench is not filled with sand and gravel and finer alluvium, on which the Mississippi now flows. The young trench south of Thebes was not eroded that deep, and at places the river flows on bedrock."

Comment 3: p. 58 - part f. If features such as Mammoth Cave and the fluorite district are going to be mentioned, the physiographic map should include their locations.

Response: Do not concur. Mammoth Cave and the fluorite district are not physiographic features. Their general location is adequately described in the text.

Comment 4: p. 59, paragraph 3: Chesterian Series is a cyclic sequence of shallow water limestones and clastics. The alternating beds consist of about one-half shale, one-fourth limestone, and one-fourth sandstone.

Response: Concur. The word "limestone" in line 5 of this paragraph will be changed to "sediments."

Comment 5: p. 59 - last paragraph: The youngest marine sediments are both Cretaceous and early Tertiary (Paleocene and Eocene) in age in southernmost Illinois.

Response: Concur. The penultimate sentence of this paragraph will be changed to read as follows: "In late Cretaceous and Tertiary times, the sea invaded the Mississippi Valley for the last times."

In the last sentence, "this marine incursion" will be changed to: "these marine incursions."

Comment 6: p. 60 - first paragraph: Replace Cenozoic with Pliocene-Pleistocene fluvial chert gravels and Pleistocene sediments of glacial origin. 3rd sentence - Kansan, Nebraskan, and Illinoin are glacial stages of the Pleistocene (list in order of age). Last sentence - Wisconsinan is the age of most valley fill and terraces along the Middle Mississippi River, also of large amounts of loess on the bluffs, especially on the east side of the valley, and should be noted.

Response: p. 60, paragraph 1, sentence 1 - Sentence 1: The Pliocene and Pleistocene epochs are in the Cenozoic Era. It is not felt that this additional detail is necessary.

Sentence 3 will be changed as follows: The word "ages" to read "stages" and the stages listed in order of age, i.e., Kansan, Nebraskan, and Illinoin.

The last sentence will be changed to read: "Although the Wisconsinan glaciers did not advance as far south as the project area, deposits of Wisconsinan Age form most of the valley fill and terraces along the Middle Mississippi River, as well as large amounts of loess on the bluffs, especially on the east side of the valley.

Comment 7: p. 60 - paragraph 3: Recent flood plain deposits are important enough to get more thorough treatment. Alluvium is deposited by the Mississippi and all its tributaries, not just the Salt River. Some types of river deposits are described under soils in 2.1.3.1, p. 93.

Response: Treatment of recent flood plain deposits is considered adequate for a section dealing with geologic history. Page 60, paragraph 3, last sentence - change the word "Salt" to "Mississippi."

Comment 8: p. 60: The reference to Harve and Koenig, 1961, is not listed in the Bibliography.

Response: Concur. The complete reference is: Howe, W.B. and Koenig, J.W., 1961. The stratigraphic succession in Missouri, Missouri Geological Survey, Ser. 2, Vol. 70, 185 p. This will be added to the Bibliography.

Comment 9: p. 74: The Upper Devonian is not discussed.

Response: Comment noted. Upper Devonian deposits are not present in the project area. See FIG. 2-1.

Comment 10: p. 85: The Carbondale Formation is not shown on the Generalized Geological Column of the Middle Mississippi River Region (FIG. 2-1, p. 56).

Response: Comment noted. The Carbondale Formation will be added to the geological column, FIG. 2-1.

Comment 11: p. 88/2.1.2.4: Structural Geology; additional information on Illinois may be found in the following:

Ross, C.A., 1963, Structural Framework of Southernmost Illinois, Illinois Geological Survey, Circular 351, 27 pages.

Response: Comment noted. This reference will be added to the Bibliography.

Comment 12: p. 90/2.1.2.5 - Seismic Activity: Even if the 1811-1812 Series had not occurred, this area would have to classified as something more than a "minor" seismic region - perhaps "moderate" seismicity would be more appropriate. There have been a couple of magnitude 6 quakes along what is referred to as "the New Madrid Fault Zone." A magnitude of 6.0 occurred on 4 January 1843 at 35.5 degrees N 90.5 degrees W, and a magnitude of 6.2 occurred on 31 October 1895 at 37.0 degrees N 89.4 degrees W near Charleston, Mo. This together with other seismic and structural evidence seems to indicate "minor" is improper. Charleston, Missouri, is about 20 miles due west of Cairo, Illinois, and St. Louis University's latest microearthquake studies extend the line of epicenters associated with "the New Madrid Fault Zone" well into Illinois to about Ullin in Pulaski County.

Response: Concur. Sentence 4, paragraph 1, will be changed to read: "Since 1816, over 100 earthquakes have been felt in this area, several of which were moderate tremors."

In paragraph 2, sentence 1: "These earthquakes" will be changed to "Earthquakes in the New Madrid trend."

The last two sentences of paragraph 2 will be deleted.

Comment 13: p. 228 - Alternate Uses of Dredged Material: Data are needed on the particle size distribution and mineralogy of the dredged material. This would highlight some possible uses while eliminating others.

Refer to: Ehrlinger and Jackman, 1970, Lower Mississippi River Terrace Sands as a Commercial Source of Feldspar, Illinois Geological Survey, Illinois.

Response: Section 2.1.3.3, discussing physical characteristics of riverbed soils, has been added to the EIS. This section also discusses instances in which dredged material has been used directly as fill. With minimal screening, this material could also be used as concrete or mortar sand. The river sands also contain a high percentage of feldspar (see page 93) which for various reasons has not yet been developed. However, the economic utilization of dredged material depends more on its location relative to point of use than on any physical parameters of the deposit itself.

Comment 14: The principal comment received from nearly all our reviewers has to do with the large volume of extraneous geological information included in your statement. Our reviewers believe that only geologic information relevant to the project should be included. We suggest that the detailed discussion of bedrock geology, structural geology, and other topics not directly related to the maintenance of a 9-foot-deep, 300-foot-wide channel in the Mississippi Flood plain be deleted and replaced with brief references to the bibliography as to where additional information is available.

Response: Comment noted. There are two philosophies regarding content of an inventory: one, that the total environmental setting be established;

two, that the inventory be concentrated on those items with an apparently close relationship to the physical features of the project. A balanced approach is, of course, the best.

Comment 15: The draft needs to emphasize the geological aspects of the disposition of Pleistocene and Holocene materials in the bedrock valley. Particular attention should be given to the deposition of Wisconsinan materials and the reworking of these materials to form the present river bottomland. As is indicated above, the grain size distribution, mineralogy, and other characteristics of the dredged materials should be included in the impact to suggest concepts for disposition of these materials.

Response: Comment noted. Section 2.1.3.3, discussing physical characteristics of river bottom soils, has been added to the EIS. This section also discusses some uses which have been made of dredged sand. Economic utilization of dredged material depends more on its location relative to point of use than on any physical parameter of the deposit itself.

Comment 16: If the information is not available, this should be stated in the report so that research may be directed toward acquiring it.

Response: Comment noted. See reply to comment above.

q. Illinois Archaeological Survey

Comment 1: Sometime ago we provided the Waterways Experiment Station in Vicksburg with generalized areas on the Mississippi River floodplain where archaeological sites would be present. These are indicated in your report in Plates 2-5a through 2-5k, pages 173-183. Although these archaeological areas are of a general nature, please delete them from the final draft, particularly because your office contends that no archeological resources will be impacted or affected by your project.

Response: Per your request generalized archeological areas have been removed from subject maps.

Comment 2: I do not concur with this reasoning of non-impact as indicated in paragraph 4.3.5 on pages 218-219 of the Draft. In the first place, there is a strong possibility that archaeological sites may be buried in select areas of the floodplain through years of continual silting and flooding, and the only way that this can be confirmed or denied would be through a site survey coring project. Moreover, you indicate on page 218 that in revetment construction river bank areas will be sloped or (page 219) contoured. Since these areas throughout the project area may contain archaeological sites, they would be consequently directly impacted or, in effect, destroyed by your project. I suggest therefore that in any type of action undertaken by this project involving dredging, filling, construction, or whatever, that affects the floodplain or banks or bluffs in any way that an impact on the archaeological resource base is not only possible but very likely will take place. I therefore recommend a detailed archaeological reconnaissance survey of the entire project area, in order to obtain specific data on the archaeological resource base from those locations where any type of dredging, construction, or alteration of land surface or even submerged land surface will take place. Without this survey, we will have no idea what the effect on the archaeological resource base may be by your project. I therefore find the Draft Environmental Statement totally inadequate with its assessment of this particular cultural resource.

Response: That archeological resources may in fact be present along the riverbank buried under layers of silt has little bearing on the present discussion. Since as described in this statement, Operation and Maintenance activities will not disturb the vast majority of riverbank areas the existence of such buried sites is outside the scope of federal protection laws and funding mandates. You are quite correct in maintaining that localized O&M activities which require a disruption of the riverbank may adversely effect archeological resources that may be present. Thus, in order to prevent losses of archeological information, archeological survey of riverbank areas scheduled to be disturbed through O&M activities will be performed as a matter of standard procedure.

r. MISSOURI STATE HIGHWAY COMMISSION

Comment 1: The Draft Environmental Statement covering regulating works along the Mississippi River between the Ohio and Missouri River by the U.S. Army Engineer District, St. Louis, does not conflict with state highway crossings of the river. However, any plans covering the location of dikes which could alter current and cause scour at bridge piers, similar to the proposed alteration of the channel in Mississippi County, should be reviewed by this office to aviod any possible damage to existing bridges.

Response. Comment noted. The Missouri State Highway Commission will be contacted prior to any alteration that may affect existing bridges.

s. Missouri Department of Conservation

Comment 1: We have completed our review of the draft environmental statement for the Mississippi River between the Ohio and Missouri Rivers. The factual material presented in the statement generally depicts the changes that have occured in the Middle Mississippi River.

Response: Comment noted.

Comment 2: The Corps of Engineers takes credit for creating numerous side channels.

Response: It was not our intention to take any credit for creating new side channels. Natural processes result in the formation of some new side channels within dike fields. We have constructed a number of prototype structures which contain a notch to ascertain whether or not it is possible to preserve or improve side channels which develop as a result of our dike construction.

Comment 3: The "natural process of the river filled the side channels with sediment". Data presented in the form of maps and references indicate a tremendous permanent loss of side channel habitat has occurred due in large measure to dikes and revetments. The dynamic processes of a natural river system forming, then filling, and reforming side channels are ignored. Certainly natural fluvial rivers gradually fill side channels, and isolate chutes, but while one channel is eliminated other channels are formed.

Response: Newly formed side channels often form within dike fields due to a natural process which is influenced by our initial construction. These same natural processes eventually fill in newly created side channels when dike fields are overtopped. It was not our intention to ignore the dynamic processes of a natural river system forming, then filling,and reforming new side channels. Our intent was to describe how dike fields influence natural processes which intially form new side channels which are eventually destroyed by the same process, recognizing the fact that this process does not reform any new side channels.

Comment 4: Dike work may in some cases create limited side channel habitat, but the same dike work has over the years eliminated thousands of acres of habitat. Once dikes are constructed the permanent loss of water seems to be imminent.

Response: This question is also addressed in our response to your comments on table 4-1, page 196. If the riverbed area, based upon 1821 conditions, represents natural conditions there has been a loss of approximately 12 square miles in riverbed area between 1821 and 1968. However, that loss does not necessarily reflect a loss of desirable fish habitat. It is reasonable to assume that two-thirds of that loss occurred in the main channel of the river which at best provides rather harsh habitat for fish. Based upon that assumption, there has been a loss in desirable fish habitat of approximately four square miles or 2,560 acres. It has been determined that approximately 10,600 acres of desirable fish habitat remain, in the form of side channels and main channel border habitat.

It is our desire to use the portion of the river which possesses the most harsh habitat for fish for navigation. We are prepared to work with you in preserving and improving our best fish habitat, in order to make navigation compatible with its riverine environment.

Comment 5; Summary Sheet- Item 3, Lines 9 throught 19. The statement fails to accept any responsibility for the loss of side channel habitat. Page 206, Item 5 the Colorado State University does indicate that the natural side channels were eliminated by the construction of dike fields.

Response: The Summary Sheet has been expanded to take in the consideration of the effects of dikes on the closure of side channels.

Comment 6;In addition, there is no recognition of the fact that the river would create new channels if it were not for the regulating works. The third paragraph of Section 1.2 (Page 1) gives slight indication of the river's natural condition.

Response: The effect of banklines revetments on controling the formation of side channels by stabilizing the meandering river channel has been added to the Summary Sheet.

Comment 7: The interests demanding the deeper channel should be identified. Consideration should also be given to some form of cost sharing by these interests in the project.

Response: The reviewer may have misconstrued the meaning of the word "demand" as used in the text. "Demand" as used is in relation to "supply". Cost sharing is a decision made by the United States Congress. If instructed, by Congress, to consider the ramifications of cost sharing, the Corps of Engineers would of course do so.

Comment 8: Page 5 - Second Complete Paragraph-What the costs of developing a minimum channel depth of 9 feet as opposed to a channel 9 feet deep 90 percent of the time? Seventy-five percent? Such information should be presented to Congress.

Response: The comment is an interesting comment, but one which cannot be answered in a simple response. No study of costs for these types of project alterations are known to the St. Louis District. Studies of the physical mechanics of the river, the savings through dredging, the added burden to consumers, and the ability of a alternate modes to carry the displaced traffic. As it exists today, the river navigation system is designed to carry traffic all year. Thus, producers who ship via the waterway are geared to do so for all 12 months of the year. Any savings which might accrue to the Government by lessening costs through decreased dredging would not be true savings. Added costs to producers and industries who ship on the waterway as well as the added costs passed on to consumers would dissipate any such savings. For the project to bear its greatest benefits, it must provide a dependable year round mode of transportation, rather than a sporadic one.

in the river bends.

Comment 9: Does this include the work being performed on Mosenthien Island?

Response: Yes, subject to the following revision of this paragraph: No formal channel contraction plan exists for the harbor, with the exception of the Mosenthien Island reach from miles 184.0 to 190.0. After the Spring 1973 flood, the main channel reverted to the left bank chute along Cabaret Island, precluding any further harbor development in Sawyer Bend, as well as increasing current attack and erosion on Cabaret Island. Between November 1967 and April 1975, more than 130 acres have been lost from Cabaret and Mosenthien Islands, compounding the dredging problem at the lower Chain of Rocks canal access. With the aid of WES model studies, SLD anticipates two phases of construction. The first phase (which has been completed) will control the erosion and also return the channel to Sawyer Bend. Locks 27 and the Chain of Rocks canal also lie within this reach, and erosion from wave wash due to passong tows will be controlled with revetment as necessary.

Comment 10: Page 12 - Paragraph 3 - The loss due to dike work is quite permanent. On the natural river, new side channels would be formed.

Response: The best fish habitat along the Middle Mississippi River is presently located in side channels. The St. Louis District has given special consideration to the preservation of these side channels in all designs for regulating structures and is all of our dredging operations. In addition, the St. Louis District is actively prusuing a Post Authorization Change which will enable the Corps to preserve and improve existing side channels for fish habitat. At the present time the St. Louis District has no plans to create new side channels by artificial means. After side channels, river border areas afford the next best fish habitat. This District has modified its design for regulating works to lessen the impact of these structures on the environment. In addition, the placement of dredge material is carefully monitored so as not to harm fish habitat along border areas. Under natural conditions new side channels would be formed as stated. However, the purpose of our present environmental program is to maintain fish habitat in existing side channels under the present state of developed conditions.

Comment 11: Dredging in November of 1970 was omitted from Plate 1-4a.

Response: This error has been corrected.

Comment 12: Plate 1-4d - Mile 122.2 - Dredging in September 1970 was omitted. Mile 117.1 - Dredging in December 1969 was omitted. Mile 117.0 - Dredging in October - 1970 was omitted. Mile 117.0 - Dredging in August 1971 was omitted.

Response: This error has been corrected.

Comment 13: Plate 1-4a - Mile 11.5 - Dredging in December 1970 was omitted. Mile 110.4 - Dredging in December 1972 was omitted. There are no notations for years when sites were frequently dredged. For example: 1973 - Mile 96.0 was dredged on two occasions. 1970 - Mile 96.7, 96.5, 95.3 were all dredged. 1973 - Mile 103.6 was dredged and 103.5 was dredged on two occasions.

Response: This District has no record of dredging at RM 11.5 in December, 1970. Dredging at RM 110.4 in December, 1972 has been added to plate 1-4a. The number of times dredged per location is not notated as on several occasions dredging had to be stopped and the dredge moved to a more critical location only to later return to the original site to complete project dimensions.

Comment 14: Plate 1-4j - 1969 - Mile 27.0 - Dredging in November 1969 was omitted.

Response: This error has been corrected.

Comment 15: The Dredge Kennedy has limited capabilities and is often unable with its 1,000 feet of pipeline to reach the least damaging spoil site.

Response: The description of the Dredge KENNEDY contained on page 45 accurately describes the physical plant.

Comment 16: The study should also include costs due to flooding as well as fish and wildlife recreation.

Response: Any increase in flood stages attributable to the project were taken into account in design of flood control works. The St. Louis District in cooperation with the United States Fish and Wildlife Service, the Missouri Department of Conservation, and the Illinois Department of Conservation, is currently studying ways to affect a Post Authorization change to the project. These efforts, if successful, would make fish and wildlife a project purpose.

Comment 17: Third paragraph - The do nothing alternative is not discussed

Response: This is only a discussion of the Twelve-foot Channel Study. The no action alternative is discussed under Section 6, Alternatives.

Comment 18: Page 51-a. Credit is taken for creating side channel (Paragraph 2) while blame is given the river for filling them with sediment. (Paragraph3).

Response: The effect of reduced flow velocities through dike fields has been added as a factor in the filling of side channels with sediments.

Comment 19: There is no discussion of the dynamics of a natural river.

Response: Section 2 of the environmental statement is a description of the existing environmental setting which, in the case of the section of the Mississippi River covered by this report, is a river that has been considerably modified for the purpose of navigation.

Comment 20: b. Paragraph 5 - How has the effect of dike fields changed if: "In the past....the dike fields reduced the width of the river"?

Response: The width of the natural river was reduced in the past by dikes, but now dikes are only used to maintain the existing width - to which the river has been reduced. Any further reduction in width would require extension of dikes.

Comment 21: Page 97 - Paragraph 1 - Appendix C is a listing of benthic organisms.

Response: This has been corrected.

Comment 22: Pages 133-141 - An imblance seems to exist in that more than eight pages are dedicated to a detailed discussion of "Pestiferous Plants and Animals" while two pages and a table constitute a very general discussion of Threatened, Rare and Endangered Species.

Response: Comment noted. The imbalance referred to is a reflection of the amount of available data existing on each subject area.

Comment 23: It is noted that approximately one-third of the tonnage originates or terminates at St. Louis. A seemingly favorable situation when considering that St. Louis is competing with Minneapolis, Chicago, and New Orleans.

Response: The text should read, "The importance of this like. . .neither originated or ended in the reach".

Comment 24 : Is the intent of the discussion to indicate that the economic conditions of families is due to their living in the flood plain?

Response: No, Althought some may live in the flood plain because of their economic condition.

Comment 25: Industries using water transportation also typically use other modes of transportation. Percentages of waterway use vs. truck or rail should be tabulated for comparison purposes.

Response: Data of this type is virtually non-existent. To gather it where available would be beyond the funds of this office and also not significantly add to, or subtract from this statement.

Comment 26: Is the project area considered a part of the Upper Mississippi River Basin or the Lower Mississippi River for outdoor recreation purposes?

Response: The project area referred to is considered a part of the Upper Mississippi River Basin. The reaches addressed in the Environmental Impact Statement are usually referred to as the Middle Mississippi River portion.

Comment 27: Trail of Tears State Park is located on the Mississippi River and makes active use of the river

Response: Concur. Statement referring to no state park makes active use of the river, except for scenic purposes, has been modified to include the active use of Trail of Tears State Park.

Comment 28: Page 188 - Paragraph 2 - Data or a more complete discussion of facts that form the basis for the statement "nor as diverse" in reference to early side channels would be of interest to our staff.

Response: This statement has been deleted.

Comment 29: Page 190 - Paragraph 2 and 3 - What data supports the statement that wooden pile dikes or screens produce a more rapid rate of sedimentation than stone filled dikes?

Response: During construction of pile dikes, the sediment load of the Mississippi River was substantially higher than the present. This high load enabled pile dike structures and screens to produce a rapid rate of sedimentation. In the past 15 years the Corps has constructed stone fill dikes to reduce maintenance costs while during this same period sediment load decreased. Based on field observation and model tests, high profile dikes have been found to catch and fill more rapidly than low profile dikes. Since more pile dikes were built to 20 to 25 feet on the St. Louis gage, they would have greater ability to catch material at more stages thatn the present-day low profiles dikes, most of which are constructed to 5 feet on the St. Louis gage.

Comment 30: Page 194 - a - line 1 -Field observation indicate notched dikes are performing well in some areas. The notches in deposition areas may allow sediments to move over the dike more readily but we doubt that notches "draw more material into dike fields." Observations in the miles 140 to 154 reach indicate no diversity without notches.

Response: Model studies indicate that notches draw material more rapidly than ~~regular profile dikes. Some field~~ observations give supporting data to modle studies while others are non-conclusive. The St. Louis District is continuing to study the effects of notched dikes on dike fields and their possibility of improving fish habitat. If notched dikes are conclusively found to provide diversity for fish habitat, then the St. Louis District would consider creating notches in the Miles 140 to 154 reach and in any other reach deemed feasible.

Comment 31: b. Last paragraph of Section 4.1.12. The paragraph ingnores the impact of floods such as 1881, 1883, 1908, 1909, 1927, 1943. 1944. and 1973 on the river. With regulating works the river is unable to create new habitat. If it is true that there has been relatively little change in river width since 1907, then it might be inferred that the change has been toward a narrow canalized river with less and less diversity and flood carrying capacity.

Response: Under developed conditions floods have much less impact on the river than they did under natural conditions. Critical banklines of the river are now protected to precent river migration which could adversely affect the alimement of the navigation channel and possibly endanger mainline levee systems. Since the river is no longer able to migrate within its flood plain the possibilities for creating new habitat over and above that which presently exists are rather remote. The St. Louis District is investigating ways and means of preserving existing fish habitat but has not considered the creation of new habitat on privately owned lands. The change in river width and its attendant influence on riverbed area is more fully discussed in our reply pertaining to your comments on Table 4-1, Page 196. Under developed conditions the width of the river has been reduced to provide a navigation channel but that does not necessarily mean there has been a substantial decrease in the carrying capacity of the river at bankfull stage. The flood carrying capacity of the Middle Mississippi River is capable of passing the discharge of record but at a higher stage-discharge relationship. With reference to the diversity of the Middle Mississippi River this question is also addressed in your comment pertaining to Table 3-1, Page 196.

Comment 32: Page 196 - Table 4-1 - Once again the loss of river area is apparent. The fact that the loss is permanent due to the regulating works should be discussed. Would the flood of 1973 have increased the river area if it were unregulated? This discussion seems to indicate that the river was dynamic.

Response: Data contained in Table 4-1 does not necessarily reflect a loss of riverbed area due solely to the works of man. Records indicate there was a substantial increase in riverbed area between 1821 and 1888, which was most likely caused by a series of major floods. It appears reasonable to assume thataafter 1888 the river would attempt to readjust itself to its former reiverbed area in the absence of the works of man. The increase in riverbed area between 1821 and 1888 was undoubtedly influenced by early efforts to remove snags from the river. It was found that trees were constantly falling into the river which compounded the problem of snag removal. In an effort to reduce the cost of snagging operation, the Government appropriated funds to cut down standing timber as far back as 400 feet from the high bankline erosion. The major floods which occurred between 1821 and 1888 undoubtedly caused an abnormal amount of bankline erosion which resulted in a substantial increase of the riverbed area. Based on the above, it can be stated that although the 1888 conditions were natural, they were not necessarily normal. If that hypothesis is correct, then today's riverbed area is not far different from what it was in 1821. The loss of riverbed area does not necessarily reflect a loss of desirable fish habitat. Even under natural conditions the main stem of the Mississippi River provided relatively poor fish habitat. Since the length of the Middle Mississippi River has been relatively stable for the past 200 years; it follows that the length of river border areas has also been relatively stable and that the main loss of riverbed area has occurred uin the main stem of the river. The loss of riverbed area between 1821 and 1968 amounts to 12 square miles. If the major loss of fish habitat occurred in the main stem of the river then Table 4-1 most certainly does not indicate a loss of desirable fish habitat.

The loss of riverbed area which is due to regulating works is not necessarily permanent. There remains many miles of unprotected banklines which can erode and bring about an increase in riverbed area. The St. Louis District is now constructing very low profile dikes in an effort to preserve the riverbed area which exists at the present time.

With reference to the comment pertaining to the 1973 flood and its effects on the river area if it were unregulated, it can reasonably be assumed that a flood of that magnitude could have brought about a temporary increase in riverbed area under natural conditions.

With reference to the comment pertaining to the dynamic nature of the river, it can be stated that under natural flow conditions the regimen of the river would constantly be readjusting itself to accommodate prevailing discharges. Under developed coditions the dynamic nature tof the river is utilized to maintain the navigation channel during low discharges. During high river stages, bank protective works prevent the erosion of critical banklines adjacent to the navigation channel many of which also front mainline levee systems. The river is still dynamic but the works of man utilizes its energy at low river stages for purpose of maintaining a navigation channel, and harness its energy at high river stages to prevent flood damage within the Middle Mississippi River flood plain.

Comment 33: Page 199 - Paragraph 1 - Second sentence should be changed to: "The flood plain was a storage area." Since levees have been built, it has in a large part been lost for flood storage.

Response: Concur.

Comment 34: Page 202 - a - Line 9 - Are these statistics to indicate where the sediments are flushed to? Is this flushing of sediment considered to be part of the deposition problem in the downstream navigation channel?

Response: High and low water surveys for each year always indicate that materials is flushed from the navigation channel when stages fall. No statistics are available to indicate the percentages of where the material is flushed to. Some material is trapped in dike fields, in the absence of a property located chute closure, some is trappped in side channels, and some is passed through the system. That material which is not effectively transported through the system due to vagaries of the river regime is part of the problem in the downstream navigation channel.

Comment 35: b. Next to last paragraph - Is it possible that levees are built close to the channel because the channel is "pinned down"?

Response: Levee alinement was chosen so as to provide maximum flood protection and to pass project flood discharge.

Comment 36: Are there techniques for assessing the synergistic effect on a narrow pinned down channel with levees close to the river bank?

Response: The width of the Middle Mississippi River is not far different from what it was in 1821. We assume your reference to a pinned down channel refers to the fact that banklines have now been stabilized to maintain the alinement of the navigation channel. Mainline levees are not built in close proximity to the high bankline because to do so would endanger the stability of the structures. Levees have been set back a sufficient distance to pass project flood discharge.

Comment 37: c. Last paragraph - Data should be presented on the impacts of levees and channelization on flood heights along the entire reach of the Middle Mississippi River.

Response: When Congress authorized the construction of various levee projects along the Middle Mississippi River it was known that this construction would result in an unavoidable increase in the stage-discharge relationship for the project flood. The project flood under developed conditions is now approximately 10 feet higher than it was under natural conditions. The increase in the stage-discharge relationship was fully taken into account at the same time the Alton to Gale levee system was designed. The accuracy of the design is attested by the fact that the major flood of 1973 passed St. Louis within allowable tolerances of the rating curve for that discharge.

Comment 38: Page 206 - Our understanding is that bedload has easy access to notches in the Colorado State University model study. Are there actual stream data that indicate means to salvage side channels?

Response: The Colorado State University study indicated that notched dikes had a tendency to draw more material into a dike field than an unnotched dike. Model studies conducted at Waterways Experiment Station obtained similar results. Many prototype structures in the Middle Mississippi River have indicated that notches can create a more rapid deposition within dikefields. Some prototype structures have not reponded in this manner. The St. Louis District is continuing the process of evaluating the performance of these prototype structures in an effort to obtain design criteria which will lessen the impact of dike fields upon fish habitat. Model studies indicate that closure structures at the upper end of a side channel will prolong the life of a side channel; however, dredging will be required to maintain these side channels in order to preserve the existing riverine environment for future generations to enjoy.

Comment 39: Page 207 - Last Paragraph - We strongly disagree with the sentence beginning with "However". Althought it may be unrealistic under present circumstance, the river would revert to a pre-1900 condition if dike and revetment work were to cease. This was observed on the Missouri River during 1973 floods.

Response: The comment beginning with "However" in the last paragraph on page 207, refers to new construction and does not pertain to the maintenance of existing regulating works. The comment was intended to show that if we adopted a status quo attitude and maintained the structures which presently exist natural processes would eventually destroy all existing side channels. The maintenance of existing works would tend to prevent the river form reverting to its pre-1900 condition. Your observation pertaining to conditions on the Missouri River during the 1973 flood does not apply to the Middle Mississippi River. The flood of 1973 did very little damage to existing regulating works.

Comment 40: Page 208 - A discussion of the impacts that have occurred due to material being flushed downstream through the river system should be included.

Response: It is presumed the commentator is referring to the increased transport capability of the river due to its contracted width and resulting higher velocities. Material being carried downstream is either deposited at the delta of the Mississippi River or in side channels or dikes fields. The relative amount of such deposited materials cannot be determined. The specific impact of this action on water quality is discussed in paragraph 4.1.4.1; the specific impact on biological communities is discussed in paragraph 4.2.1.1

Comment 41: Page 212 - Paragraph 4 - Dredge spoil disposal is very slightly similar to natural processes. However, dredge spoil disposal is an unnatural process that depostis thousands of cubic yards of sand at a single site at low water stages.

Response: The statement that "to a degree , open-water disposal of dredged material can be though of as an extension of these natural processes" was qualified by the statement in the following sentence that "However, open-water disposal usually results in the resuspension of large volumes of sediment within a very short time and in a limited area".

Comment 42: Page 213 - Paragraph 1 - With equipment limitations as described on page 45, it is difficult to understand how disposal in critical areas is avoided.

Response: Even with the mentioned limitations of the equipment, specific placement of dredged material in or near the entrance and exit of side channels can be avoided. However, an increase in equipment capabilities would facilitate such disposal.

Comment 43: Page 214 - Paragraph 2 - Is the increased efficiency of the hydraulic system for flood control, navigation, recreation, fish and wildlife, sediment transport or what?

Response : Increased efficiency of the hydraulic system is for navigation which is the project purpose. But in accomplishing the project purpose sediment transport capabilities have been increased.

Comment 44: b. - Line 1 and Paragraph 3 - The Middle Mississippi River and its riparian land could tolerate a tremendous increase in use before the uniqueness would be damaged. Timber harvesting and public utilization are not necessarily detrimental to wildlife habitat. However, conversion of the remaining forest to cleared cropland in many cases would be deterimental.

Response: This paragraph has been changed so it does not indicate that all agriculture, timber harvesting, and public utilization is detrimental to wildlife.

Comment 45: Page 218 - Section 4.3.3 - a. - Land Use - In practice the pattern of land use along the Middle Mississippi River has been (1) stabilized; (2) clear; (3) protect;and (4) drain.

Response: Comment noted.

Comment 46: b. 4.3.4 - Outdoor Recreation - The public, especially recreationists, have lost tremendous acreages of public water due to the canalization of the Middle Mississippi River.

Response: Comment noted.

Comment 47: Page 222 - a. Paragraph 2 - If all channel maintenance activities ceased, the river would revert to a more natural state. filling would continue, but new habitat in the form of side channels and chutes would be formed. One recent example of the river trying to revert is Cape Bend Towhead where the river threatened to seek a new course.

Response: Comment noted.

Comment 48: b. - Last paragraph - On what basis is deposition in dike fields considered to be natural? Man induces the change for a purpose.

Response: The word natural has been deleted.

Comment 49: Page 226 - Paragraph 2 - New habitat would be formed if channel maintenance ceased. Old side channels would fill, but new channels and chutes would be formed.

Response: Comment noted. It is mentioned in the same paragraph that the side channels lost would eventually be replaced by new ones.

Comment 50: Species living in and along the Mississippi River evolved with the dynamic, natural river. What data is available that indicated which plants and animals "could be eliminated" by allowing the river to revert?

Response: The species presented in this environmental statement are of those species now present along the Mississippi River in the project area. Very little information is available on the species present in this area before navigation on the river, making it very difficult to accurately predict what species would be lost if maintenance of the navigation channel ceased.

Comment 51: c. How would the hypothetical condition of clearing during the low flows differ from what is occurring with the present project?

Response: Land clearing pratices during low flow would probably be similar tc what they are today. This indicates that even with the no action alternative wildlife habitat would still be lost to clearing.

Comment 52: d. Paragraph 3 - If the waterway was phased out over a ten or twenty year period, the impacts would be less traumatic.

Response: Comment noted.

Comment 53: Paragraph 4 - This paragraph seems to disagree with paragraph 2 and tends in part to support the idea that the river would revert.

Response: The river would revert to a certain degree; however, the flood protection projects (levees) which are under a separate authorization from the navigation project, would prevent a complete return to the natural state.

Comment 54: Page 227 - Paragraph 3 - Data on anticipated loss of side channel habitat due to locks and dams should be presented. Our observations indicate more permanent habitat would likely be formed.

Response: More permanent aquatic habitat would be formed. However, side channels, as defined by the Upper Mississippi River Conservation Committee as being departures form the main channel in which current is present to some degree, would be converted into more nearly slough habitats where there is very little if any current. Habitat would be gained but it would be of a different type than is now present. Whether this is a favorable or adverse impact would depend on individual preference.

Comment 55: The canalization of the river has destroyed much of its appeal for camping and beach type recreation.

Response: Do not concur. Statement in text is complimentary to existing resource. Dredging of the river has not caused a loss of appeal for camping and beach type recreation. This middle river portion does have appeal for such uses. Several factors that deter such uses include low population density, public indifference to the river, and limited road access for such uses. Where access does exist there does not appear to be any unmet needs for these recreation pursuits. The public that wishes to avail themselves of camping and beach type recreation do so.

Comment 56: It is doubtful that landscaping in the floodway would be practial.

Response: Do not concur. Landscape planting referred to in the text would be of indigeonous plant materials specifically selected for aesthetic purposes as well as beneficial to wildlife. Such planting would help to provide some protection from erosion actions and provide valuable wildlife habitat, cover, and food.

Comment 57:Page 230 - Wildlife Habitat - Gives specific example of where dredge spoil would be utlized to "enhance" aquatic habitat along the Middle Mississippi River.

Response: The reference to aquatic habitat in this paragraph has been deleted.

Comment 58: Numerous references were omitted from the Bibliography (pages 252-258). Several of those noted by page of citation are as follows:

b. Page 95 - Hynes, 1972
c. Page 134 - Kingsbury, 1964
d. Page 100 - Lee and Plumb, 1974
e. Page 107 - Kearney, 1973
f. Page 113 - Schram and Lewis, 1973
h. Page 143 - Stansbery , 1968
j. Page 113 - UMRCC, 1972

Response: These reference have been added to the Bibliography or deleted from the text.

t. <u>University of Missouri - Columbia, Missouri Archeological Survey</u>

<u>Comment 1</u>: In reference to correspondence LMSED-BA of 4 June 1975, on the Draft Environmental Statement of the Mississippi River between the Ohio and Missouri River Regulating Works, I have noted that you reference archaeological resources and indicate that there will be no impact through the operation and management of the river on the flood plain. So long as this statement remains true then the environmental statement on archaeology seems adequate.

<u>Response</u>: Comment noted.

<u>Comment 2</u>: The actual in-the-field survey for archaeological resources in Missouri has not, to the best of my knowledge, been done by professional archaeologists and, should impact on the flood plain take place, a professional archaeological survey should be conducted.

<u>Response</u>: Concur. The environmental statement has elaborated on this point in greater detail in sections 2.3.5.1 and 4.3.5.

u. Missouri Department of Natural Resources

Comment 1: My staff at the Historical Survey and Planning Office has determined that it is unlikely the project will affect any known archaeological sites as long as the project is contained within the river channel. I should point out, however, that dredging activities can destroy underwater archaeological sites such as sunken boats, steamboat wrecks, or boats involved in Military operations during the Civil War. Hence, if such a wreck is found during dredging projects, the Corps or its subcontractors should cease operations and notify this office.

Response: Comment noted. In the event submerged wreck are located during dredging operations, such information will be converged to your office.

V. Missouri Chapter of the American Fisheries Society

Comment 1: This statement is reasonably well written with little of the jargon and redundance which frequently mar such documents. It purports to be an environmental impact statement and many of the impacts of the agency's activities on the environment are discussed. A great deal of time, however, is taken up discussing economic and sociological problems in the area and there is the distinct feeling that it is these things the writer wants to be sure the reader has in mind. It is refreshing to have the Corps of Engineers admit to having altered the environment to the extent that they have. However, here they not only admit to having altered the Mississippi River, they seem to be claiming to have created it. At any rate, they make it sound sacrilegious to suggest that they cease altering it.

Response: Comment noted. The economic and social situations discussed in the environmental statement are just as much a part of the environment as are the biological concerns. The America Fisheries Society is correct in stating that the Corps of Engineers wants the reviewers of this environmental statement to be cognizant of these situations. All aspects of the environment must be considered before any meaningful decisions can be made and implemented.

Comment 2: Although much space is used discussing economic considerations, much of this seems rather irrelevant. Is the relative importance of the fishery in the river and the barge traffic on it to be determined on the basis of the number of people employed in each? If we are going to discuss economics, should we not talk about the relative cost of alternative methods of transportation and the effects on them of an annual federal subsidy of $11,500,000, the equivalent of the annual expenditure to maintain a nine foot navigation channel in the river?

Response: The comment alludes to a conclusion which is not drawn or intimated. The fishery in the river is as important in the free enterprise system providing food as is the barge traffic in providing transportation of the particular tonnages conducive to waterway movement.

Relative costs of alternative methods of transportation are indeed an important consideration. Available information provides enough data so as to show that for the type commodities presently transported on the waterway plus the length of haul involved, barge transportation is, in the majority of cases, the least cost method. It is also interesting to note that the $11,500,000 annual expenditure provided for movement through the project of 67,545,404 tons in 1972 at a cost of approximately $0.17 per ton. This would not significantly change the existing relative cost position between modes.

Comment 3: Side channels received considerable attention in the statement. These portions of the river habitat have been demonstrated to be especially productive of fish and provide fishing sites favored by fishermen, removed from the treacherous current and dangerous traffic of the main channel. The Corps admits its structures often cause side channels to silt full and thus be obliterated. It also claims that side channels are created by its structures, although specific examples are not cited. Notches in dikes were suggested by conservation agencies as a means of prolonging the life of side channels. Experimental notches were placed in several dikes, a comment on the cooperation between the Corps and the conservation agencies. The effects of the notched dikes were evaluated in a model study conducted by Colorado State University and the results of this study are quoted in the statement. The report points out that ultimately all side channels will fill with sediment, which certainly is recognized. No one expects a particular side channel to last forever. The important factor is the element of time; there is a great deal of difference between a geologic and a human-oriented time scale. While neighter makes any definite statement of the time scale under discussion, in general the CSU report is more encouraging than the statement as to the "life expectancy" of side channels. Why in the statement are the most negative aspects of the CSU report emphasized, the more positive aspects ignored?

Response: The St. Louis District possesses sufficient expertise and has the means available by which it could bring about rapid siltation in side channels to confine river discharges to the navigation channel as provided for in the authorizing Navigation Act. At the request of representatives from the Missouri Department of Conservation, all additional efforts to reduce the flow carrying capacity of side channels were suspended in 1968. This was done pending completion of environmental studies required to make navigation compatible with its riverine environment. The Corps is now pursuing a Post Authorization Change to accomplish that objective by including fish and wildlife considerations as a project purpose. The intent of the Colorado State University report was to indicate that the suspension of all future efforts to reduce flow carrying capacity of side channels would not in itself preserve these side channels for an indefinite period of time. In recognition of that fact, the St. Louis District is pursuing means of preserving and enhancing existing side channels by artificial means.

The negative aspects of the CSU report were emphasized in order to show that some form of corrective action should be taken in the near future to preserve side channel areas before they are completely filled in by sediments and are then utilized by private interests for agricultural purposes under the rights of riparian ownership.

Comment 4: In the statement fishery of the Mississippi River is said to be underused and the implication seems to be that for this reason the fishery resource is not worthy of much consideration. In the past, the fish caught from much of the section of river under consideration had an unappetizing flavor, attributed to pollution from the St. Louis metropolitan area. With improved sewage treatment in recent years, the fish should be more desirable and fishing use should increase. This is only part of the cause of limited use, however, and much of the rest is directly attributable to the Corps of Engineers and the navigation project.

Response: The fishery resource of this area of the Mississippi River is relatively untouched, but this does not imply that such an important resource should be ignored. There are reports, generally from sport fishermen, that fishing and the flavor of the fish caught has improved in recent years, probably due to improved water quality. However, there are also conflicting reports from commercial fishermen that the fish still have an unpleasant flavor which results in the inability of selling their catch.

Comment 5: Favored fishing places on the river are the side channels where bass, bluegills, crappies, and other sport fish are abundant and can be readily caught. The quiet water of the side channels is safe for small boats. According to the statement, many side channels have been eliminated in the navigation project and the few remaining will be eliminated eventually. The main channel has been made narrower and deeper, with a swifter current, as a result of the navigation project. This channel is hazardous for fishermen in small boats and the hazards are increased enormously when a tow of barges goes by, as happens quite frequently. Finally, access to the river is limited. There are few places where a fisherman can launch his boat. Lack of access is cited in the statement as a reason for limited recreational use of the river. Certainly, all these things tend to inhibit use by fishermen.

Response: Comment noted.

Comment 6: Much is made in the statement of the finding by a research team that many invertebrates are produced on the rock dikes and revetments. This is not a surprising discovery. Aquatic biologists have long known that rock rubble is a more productive substrate for benthic organisms than shifting sand. Much more pertinent would have been for the research team to determine how much of the 90 miles of dike and 140 miles of revetment was available for production of invertebrates and how much has been silted in. Then they might have demonstrated what relationship, if any, there is in the Mississippi River between production of invertebrates and fish production.

Response: Comment noted.

Comment 7: The main thrust of the statement is that the project and its structures must be maintained. It is also stated that the dikes must be extended and the width of the main channel reduced from 1,500 to 1,200 feet. Why is it necessary to extend the dikes? Who made this decision? Nowhere in the statement are these questions discussed.

Response: Regulating works must be maintained to assure continuous navigation with a minimum amount of dredging. Reference made to increasing the contraction from 1,500 feet to 1,200 feet is an error. Please be informed that the three feet of additional scouring which occurred during the period from 1967 through 1971, between Mississippi River miles 140 to 154, is not typical of the current rate of riverbed degradation. The average depth increased as a result of a prototype study program designed to investigate the desireability of utilizing a 1,200 foot low-water contraction plan to develop the authorized 9-foot navigation channel with respect to a low water datum plan delineated by a low water flow of 40,000 cubic feet per second (c.f.s.), however, the increase in average depth does not mean that the entire study reach was degraded by three feet.

Field investigations indicated that it was feasible to develop a 9-foot navigation channel at a low-water flow of 40,000 c.f.s., because the study reach had degraded approximately three feet, as mentioned in your comment, in a relatively short period of time.

Hydraulic investigations made as a part of this prototype reach study program indicated the low-water datum plane based on a low water discharge of 54,000 c.f.s. very closely approximated the average 10-and 20-year low-water discharges. Accordingly, a decision was made to develop the authorized navigation project with respect to a low-water discharge of 54,000 c.f.s. and not 40,000 c.f.s. The results of these hydraulic investigations therefore indicated it was not necessary to utilize a 1,200 foot contraction to develop the navigation channel under present low flow conditions.

Model study data obtained from the Waterways Experiment Station, Vicksburg, Mississippi, indicated the authorized navigation project could be developed with respect to a low water discharge of 54,000 c.f.s. with a 1,500 foot low water contraction plan. To date, approximately 50 miles of river have been contracted to be a 1,500 foot low water width. Observations made to date indicate the 1,500 foot contraction plan is generally capable of improving shoal water navigation crossings without causing a general degradation of the average riverbed elevation.

Comment 8: There is an extensive list of "pestiferous" plants and animals in the statement. Each species is listed and its undesirable qualities are discussed but little effort is made to relate these species to the Mississippi River or put the dangers from them in a suitable frame of reference. Will the project increase or decrease the nuisance effects of these organisms? Can this be an attempt to frighten those whose knowledge of the outdoors was gleaned from reading "Peter Rabbit"?

Response: The extensive list of "pestiferous" species referred to is appropriately presented in Part 2 of the environmental statement which deals with describing the existing environment. Inasmuch as the population and distribution data for many of these species is of a general nature, it was reported accordingly. It is not anticipated that the project would either increase, or decrease, the nuisance effects of these organisms, therefore no mention of this was made in Part 4, "Impact of the Action on the Environment". This information has not been presented in an attempt to frighten anyone.

Comment 9: The treatment of rare and endangered species in the statement is very superficial. The species known to occur in the Mississippi River are given but nothing is said about the possible effects of the project on them. No mention is made of any effort to minimize such effects. The alligator gar, Alabama shad, sicklefin chub, sturgeon chub, pallid sturgeon and blue sucker have all declined in abundance during the past 80 years, the period in which the Corps has been manipulating the channel of the middle Mississippi River. Can they prove there is no relationship between the changes in the river channel and the changes in the fish population?

Response: Comment noted. The discussion of rare and endangered species as presented in the environmental statement is consistent with the information available on these species. The Corps is aware of the need for further evaluations and studies in this area of concern and the reader is referred to the Corps of Engineers recommendations made in the Statement of Findings accompanying this final environmental statement.

Comment 10: The Corps of Engineers admits in the statement that in the 80 years between 1888 and 1968, the period when they were most active on the middle Mississippi River, the surface area of the river was reduced about one-third, the island area one-half, the river bed area by one-fourth. The river has been deepened an average of about 11 feet due to contraction of the main channel. This is serious alternation of a great natural resource, comparable to the cutting of a great forest, the draining of an extensive marshland, or the damming of a great river. Is the Corps contention that, having done so much to the Mississippi River, they should be permitted to continue to have their way with it a tenable argument? What do you do with a natural resource which has been changed almost beyond recognition?

Response: As a Federal Agency the Corps of Engineers has the responsibility of carrying out the will of the public as expressed by Congressional direction via Public Laws. In carrying out this responsibility over a period of years, these charges are added to as new legislative acts are signed into laws. Subsequently, conflicts in methodology arise, that operational procedure which satisfied one requirement may not be as appropriately applicable to other newer requirements. The Corps of Engineers recognizes these difficulties and is striving to eliminate these types of conflicts. The reader is referred to the recommendations made in the Statement of Findings which accompanies this final environmental statement.

Comment 11: The Mississippi River will never again be the same as it was when Joliet and Marquette sailed their canoes on it or even when Mark Twain piloted steamboats. It must be recognized that navigation is only one of several major uses of the Middle Mississippi. Extension of the dikes should not be continued unless it can be conclusively shown that other valuable habitat, such as side channels, will not be damaged.

Response: All plans for the future construction of regulating works along with proposed maintenance dredging activities are currently being reviewed by concerned conservation agencies to reduce and possibly eliminate the adverse impact of these activities on side channels. As previously mentioned in our response to Comment 3, this procedure will not preclude the eventual destruction of existing side channel areas. The St. Louis District and concerned conservation agencies are currently negotiating to formulate and implement a plan of action which will do so by artificial means.

Comment 12: The Corps has made much of their cooperation with the Conservation Departments of Illinois and Missouri. This relationship has been good and unusually productive. It has been a one-sided game, however, in which the Corps claimed all the trump cards because of their insistence that they had no funds for any purpose not directly related to navigation. The Environmental Quality Act should have made it clear that when the Federal Government engages in an activity which has an impact on the environment, funds appropriated for the activity must be used to reduce the impact. When will the Corps of Engineers recognize that the Environmental Quality Act is as much the law of the land as the Rivers and Harbors bill?

Response: The St. Louis District recognizes the intent of the 1969 NEPA Act. Requests will be made under a Post Authorization Change to include fish and wildlife considerations as a project purpose to the navigation act, and necessary funds will be requested to accomplish that objective. Submission of the Post Authorization Change has been delayed due to the fact that the St. Louis District has not received the necessary input from conservation agencies. To date, approximately $600,000 has been expended from project funds to conduct necessary studies for the preparation of the Environmental Statement aimed at making the navigation project more compatible with its riverine environment. A substantial amount of funds have been expended, although the exact figure is not known, in order to place dredge material at locations acceptable to concerned conservation agencies. Considerable engineering effort has been expended in an effort to cooperate with conservation agencies in order to modify contract plans for regulating works to comply with their recommendations. Since 1969, approximately $40,000,000 in contract plans have been so modified as a result of environmental review.

Many of these cooperative efforts between the St. Louis District and concerned conservation agencies have taken place prior to the enactment of the 1969 NEPA Act.

w. Waterways Journal

Comment 1: We should like to take this opportunity to commend the St. Louis District on the thoroughness of the preparations for this environmental impact statement, and the wide scope of interests of organizations and individuals who were contacted by the District prior to the publication of this environmental statement.

Response: Comment noted.

Comment 2: In evaluating this statement, we believe it is imperative to remember that in the National Environmental Policy Act, as passed by Congress, language therein is explicit that a balance should be maintained in the consideration of environmental features between the welfare of nature and man. Nowhere do we read in NEPA that Congress has given governmental agencies the authority to place the human race in "second place" when environmental consideration are made.

In reading this environmental statement, we feel that the proper balance has indeed been kept, and that the statement demonstrated a need for the continued construction and maintenance of regulating works between the mouths of the Missouri and Ohio Rivers.

Response: Comment noted.

Comment 3: We conclude that the continued construction and maintenance of these regulating works is necessary for the well-being of the human environment. The Mississippi River between Cairo and the mouth of the Missouri carries a large and important volume of traffic which unites industry and agriculture in all sections of the United States through the inland waterways system. Some of the most important items moving through this stretch of river are energy materials such as coal, fuel oil, gasoline, and other petroleum products needed to keep industry and commerce active. In addition, much of the grain products which will be moving to the Gulf of Mexico for export will move on this stretch of river, and any delay of these wheat, corn, and other grain products will have an adverse effect on the balance of payments of the United States. Other shipments are destined for domestic consumption, and any delay in these shipments would result in higher cost for the American consumer and, therefore, added inflation.

Response: Comment noted.

Comment 4: It should be pointed out that a recent study done for the United States Maritime Commission by the consulting firm of A.T. Kearney, of Chicago, predicts that inland waterways transportation will double by the year 2000. To move this volume of water-borne commerce effeciently and safely, it will make it necessary for the channel between Cairo and the mouth of the Missouri River to be kept at the project width and depth at all times.

Response: Comment noted.

Comment 5: We would not like to address the environmental impact of these regulating works. As we pointed out in the statement presented to you during the hearings in St. Louis in December, 1974, at the Gateway Hotel, we emphasize the fact that the river between Cairo and the mouth of the Missouri has been traditionally used for commerce for hundreds of years; first by the Indians, then by the French and Spanish settlers, and finally by Americans. Even if all the fish and wildlife were forced off this stretch of river -- which could not be the case -- we feel that the need of this channel for the betterment of the human environment would outweigh the bad effects on the natural environment.

Response: Comment noted.

Comment 6: We also pointed out in our statement to you during the previous hearing that the states of Illinois and Missouri have adequate water, through other streams and through impoundments, to offset any loss (if there really is any) from navigation projects between Cairo and the mouth of the Missouri. As we said at that time, these water resources are:

1. In the state of Illinois there are impounded water areas (lakes and reservoirs) covering 428 square miles of 273,796 acres, and 134 square miles or 85,771 acres covering inland stream water areas. Boundary water areas cover 1,745 square miles of 1,118, 397 acres. (1972 Illinois Surface Water Inventory -- Illinois Department of Conservation.)

2. In the state of Missouri the figures are not as complete, but they show that there are 315,000 acres of impounded water in lakes and reservoirs and 11,500 miles of inland streams. (Missouri Conservation Department).

Response: The Mississippi River, being such a large river, is unique and any alteration of such a system would be difficult to offset by any other stream or impoundment.

Comment 7: If environmental groups wish to provide more area for fish and wildlife on the Mississippi River between Cairo and the mouth of the Missouri, we suggest that the Bureau of Fish and Wildlife provide these areas through its own budget, with financial assistance from the Sierra Club, Izaak Walton League, and other environmental groups. It must be made sure, however, that these areas do not in any way hinder navigation.

Response: Comment noted.

Comment 8: Statements have been made by certain environmentalists concerning the bad effects that would result from these navigation improvements for commerce on the Mississippi River. We believe these should be answered as follows:

Dredge Spoil Disposal -- Any change in bank and channel material is going to cause effects on vegetation and organisms. This has been going on for centuries through floods, bank cave-ins, and other natural forces. True, there is a temporary change in what has been coined the "ecosystems," but apparently this has not been too devastating to wildlife inasmuch as there are muskrats, beavers, and amphibians around in 1975, and many fish. Nature takes care of itself.

Response: Studies for this environmental statement along with other studies have shown that improvements to the river on behalf of navigation have had many effects on the river ecosystem. The Mississippi River is very important to wildlife today as it was in the past, even though there has been a change in numbers and species composition over the years.

Comment 9: Noise Pollution--There have been comments about protecting animals and birds from noise pollution through the elimination of construction of ports and terminals on the waterways. This would have a devastating effect on the future development of river traffic. Cargos moved by river must be loaded and unloaded, or there would be no river commerce at all. There are many examples of wildlife living close to industrial facilities, especially on the Gulf Coast. They have adjusted to the noise, just as humans do.

Response: At present, the effects of noise on wildlife are virtually unknown. However the placement of a terminal in a critical habitat of a sensitive species such as a heron rookery would have detrimental effects on this species. An inventory of possible sensitive areas along the river should be made and new development should be precluded from critical wildlife areas.

Comment 10: Wave Wash--Various reports that we have seen about the effect of wave wash on animals and fish that nest and breed along the river would indicate that they are intelligent enough to stay out of main channels, and that the wave wash from vessels does not generally reach the sloughs and chutes where these animals would naturally gravitate. Although recreational craft are generally omitted from these reports, indications are that the wave wash from these vessels has more velocity and height than that from commercial vessels.

Response: Comment noted.

Comment 11: Food Chain--Through natural floods and run-offs, the food chain is continually changing on the river bottom and, once again, since this turibidity has been going on for centuries, it would appear the turbidity caused by towboats, operating in the main channels, would have very little effect on the food chain necessary for wildlife. Food necessary for fish and wildlife is in the sloughs, not in the main channels of the river.

Response: Comment noted. The Mississippi River has always been a turbid river, however turbidity has increased on the Illinois River and also on the Mississippi River due to runoff from areas of increased agricultural activities.

Response: Comment noted. The Mississippi River has always been a turbid river. However turbidity has possibly increased to some minor extent on the Mississipii River due to runoff from areas of increased agricultural activities. Nevertheless, it is thought that such increases are more than offset by decreases in turbidity on the Mississippi River resulting from the effect of headwater reservoirs on the Missouri River.

Comment 12: Accidents and Spillages--it should be pointed out that the pollution in the water of the Mississippi is due primarily to sewage and chemical wastes from shore, not from boats and barges. If there is one thing we are sure of, it is that the Coast Guard has been most diligent in its efforts to stop pollution on the waterways and that anyone responsible is liabel to fines and even imprisonment.

Response: Comment noted.

Comment 13: In conclusion, we wish to emphasize that the continued and improved maintenance of regulating works on the "Middle Mississippi" between the mouths of the Ohio and the Missouri Rivers is necessary for the maintenance of the human environment and the welfare of the human race. We also wish to point out that even with the zero population that is now advocated by certain organizations and individuals, there will be millions of young persons growing up who will need homes, fuel, and food. Much of this material is moved by river at a low rate of cost and with the use of less energy than by other modes. The river between Cairo and the mouth of the Missouri is a key link in the chain of waterways that carry these vital materials.

Response: Comment noted.

x. Sierra Club

Comment 1: A. Goals - The Corps of Engineers as a Federal Agency has had particular problems in responding to this redirection of goals or agency missions in response to the 1969 NEPA Act. This critique is made with the idea of encouraging the acceleration of that response. It is intended as an institutional critique rather than directed against any particular level of command with the Corps.

Response: Comment noted.

Comment 2: We see the M.M. EIS, the Corps contract research assignments, the research itself, the operation and maintenance procedures, and the Corps' relations with the public all as a reflection, although in different degrees, of the Corps' unfortunate "biased" or "ideologically motivated" commitment to the original missions of navigation expansion and flood plain development rather than a broader spectrum of goals and values. These would included in general mitigation of enviornmental damage and more particularly preservation of existing rivering ecological systems, preservation of water quality standards within the river system, enchancement of recreation uses of the river, protection of fish and wildlife habitat, maintenance of the flood storage capacity of the river, and the maintenance and preservation of the long term uses of the river flood plain for agriculture.

Response: Comment noted.

Comment 3: B. EIS Methodology - In order to satisfy the purpose of the EIS as intended by Congress, the first methodological requirement is that the EIS show the long term trends or the dynamic relation of the particular technology being imposed on the ecosystem to the key indicators of river systems stability. These indicators might be considered as the first-order impacts of a technology on our environment.

Response: Comment noted.

Comment 4: The technologies are twofold. First is the technology of river modification in order to make the river navigable for waterborne commerce. This technology itself has been in a constant state of change, influenced by expansion of barge transportation technology, such as larger towboats, longer tows and deeper barge drafts. The second basic technological change is that of urbanization of the flood plain; that is, modifying flood plain use from agricultural, wildlife and wilderness purposes to urban purposes such as port facilities, manufacturing, power plant installations, commercial use and housing and land transport systems. The first-order environmental impacts of these two advancing technologies are as follows:

1. loss of the backwaters of the Middle Mississippi River
2. loss of the flood storage capacity of the river
3. loss of the water quality rejuvenation potential of the river.

Response: Comment noted.

Comment 5: These first-order impacts can all be operationally defined. For instance, the backwater area of the river may be measured as the difference between the total river surface area at low water discharge less the "target channel area" of the river. As Simons, Schumm, Stevens (1974:12) notes, this target channel width can best be defined in an open river as the "distance between ends of wing-dikes on opposite sides of the river." Except for the test section between mile 138 and mile 154, the target channel width is 1,500 feet (cf. Simons, Schumm, Stevens, 1974:12).

Response: Comment noted. The aquatic communities discussed in this environmental statement have been broken down into similar habitats in Section 2.2.1 with main channel border habitat and side channels corresponding to backwater areas as referred to in this comment.

Comment 6: The flood storage capacity of the river can be measured by comparing the flood discharge at a certain gauge reading with subsequent and previous flood discharges at that same gauge reading. For instance, on the Middle Mississippi, according to Simons, Schumm, Stevens (1974:28), the gauge reading at the Eads Bridge in St. Louis for the 1973 flood was 43.3 feet. The gauge reading for the maximum flood of record which was in 1844, was 41.3 feet. The actual discharge for the 1973 flood was 855,000 CFS, whereas the discharge for the 1844 flood was 1,300,000 CFS. Assuming the maximum stage gauge readings to be equal for these two floods, which would be a very conservative assumption, and assuming the flood storage capacity at the site of the Eads Bridge in 1844 was 1.0, then the flood storage capacity in 1973 is 855,000 divided by 1,300,000 or .658, a reduction of some 24% in the flood storage capacity.

Response: We concur; however, Eads Bridge is not a representative section of the Mississippi River because of the constriction due to heavy urbanization and urban flood protection in the area.

Comment 7: The third first-order impact, the loss of water rejuvenating capacity of the river, is more difficult to define, but it is, to say the least, some function of the backwater area of the river as opposed to the navigation channel. The backwater is relatively rich in biological organisms as opposed to the main channel which has a sand bottom and is sterile. Fremling (1972) explains the positive role of the backwaters in achieving water quality rejuvenation. The relationship of advancing technology to water quality requires considerably more study than it has received so far. There could very well be other major first-order impacts of advancing technologies on the river system, but these are the ones of major concern on the Middle Mississippi.

Response: Comment noted. Under the Nine Foot Channel Post Authorization Change, plans have been considered for studying the backwater areas with the idea of maintaining and possibly managing for fish and wildlife. Results of the change will depend on further coordination among the Corps of Engineers, Fish and Wildlife Service, Missouri Department of Conservation, and Illinois Department of Conservation.

Comment 8: The methodology of adverse environmental impact assessment which the M.M. EIS uses does focus on the loss of the backwaters and the loss of flood storage capacity of the Middle Mississippi, but displays some rather significant departures from objective methodological analysis which are as follows:

1. It avoids any quantification of adverse environmental impacts, either in physical quantities or in dollars.

2. It extolls the virtues of developmental values and minimizes the adverse effects of operations and maintenance on the environment.

3. It segments its statement in such a way as to externalize or place outside of the EIS, Corps operations that adversely effect the environment. These externalized adverse effects on the environment are often explained as "natural processes of the river" or other euphemisms that tend to depict them as other than man-induced or Corps-induced. The result of such a methodology produces significant departures between the EIS descriptions of the dynamics of adverse environmental impacts and the descriptions contained in Corps-funded scientific technical reports and other scientific and objective discussions of the processes involved.

Response: Because of the changing amount of maintenance required from year to year to maintain a nine-foot channel in such a dynamic and changing river as the Mississippi, it is difficult to make accurate quantitative predictions. The project does have adverse impacts on the environment resulting from Corps of Engineer activities; however, the benefits of navigation on the river are such to justify its existences. This does not mean that maintenance of a navigation channel justifies a complete disregard of the natural environment. At present there is a post authorization change being considered that should aid in alleviating some of the adverse impacts.

Comment 9: The Corps interprets this charge of Congress as one not only to "attain and maintain a dependable 9 foot navigation channel" but, furthermore, projects its role beyond this to that of one that will "facilitate the normal economic expansion of waterborne commerce and stimulate industry dependent upon this mode of transportation." Such language seems to imply a charge from Congress that navigation be expanded in perpetuity. Such language would overstate the precise mandate which the Corps has from Congress. There is considerable scientific evidence to indicate that the Mississippi River system is indeed a finite resource and does not have unlimited navigation expansion capabilities.

Response: Operations performed by the St. Louis District have only been of the nature to attain a dependable 9-foot channel.

Comment 10: Furthermore, focusing exclusively on the virtues of taxpayer-subsidized stimulation of industries dependent upon this mode of transportation ignores the adverse economic impact which such artificial stimulation has on other industries not so stimulated and the adverse economic impact on alternate modes of transportation. The Corps exceeds its authority from Congress if it presupposes that it is charged with stimulation of unlimited flood plain urbanization. It is just this type of mindless, unplanned development that the 1969 NEPA Act speaks out against.

Response: Comment noted.

Comment 11: 2. Levees and Other Flood Protection Structures - This statement does not distinguish between the agricultural levees designed to protect farmland and the 150 year flood frequency protection required by urbanized area. The two contrasting levee systems have entirely difference impacts on the flood storage capacity of the river, particularly at the higher flood stages. The land protected by agricultural levees retains its potentiality for further deposition of alluviam and thus the potentiality for increasing land elevation to keep pace with increasing flood stages; whereas urban land fixes forever the elevation of the terrain in the flood plain. Overtopping of the first type of levee results in minimal damage whereas overtopping of the second type of levee can result in catastrophic damages.

Response: Comment noted. In addition, it should be stated that agricultural levees are built at the expense of the private landowner to protect his farmland. These levees are usually overtopped and breached more easily than mainline levees and as a result the farmland is periodically covered with sand since the clays and silts remain in suspension to be carried downstream by the swift moving current.

Mainline levees are designed so as to provide maximum flood protection and to pass the project flood discharge. When Congress authorized the construction of various mainline levee projects along the Middle Mississippi River it was known that an unavoidable increase in the stage-discharge relationship would result for the project flood and this increase was fully taken into account in the design.

Comment 12: 3. Contraction of the Channel - Here the Corps concludes that the area of the river other than the navigation channel "will eventually fill with sediment". There seems to be complete agreement then, that on the Middle Mississippi the total backwater area will completely disappear over time and all that will remain will be the navigation channel. Considering that the Corps' present target channel width is 1,500 feet, this would mean that the Mississippi River from St. Louis to Cairo would be approximately 1,500 feet wide for the entire length of this reach of the river. In addition, the Middle Mississippi EIS implies that further contractions may be necessary to maintain even a 9-foot channel. What the Middle Mississippi EIS is trying to convey, however, in their conclusional paragraph, is that this resultant navigation channel is due to "natural processes of the river:" in addition to their channel narrowing effort. What is actually happening is that the Corps' operations are an overriding process. As noted by Simons, Schumm, Stevens (1974:57), the river in its natural state is one where the main channel grows and recedes in size and where the side channels sometimes deteriorate in size and at other times increase. The Corps-induced changes in the hydrology and geomorphology of the river pre-empt the enlargement of side channels and the main channels through wind-diking and closing chutes, whereas side channels that are filling up naturally are allowed to continue to do so. This is explained in a number of sections of Simons, Schumm, Stevens, but we particularly call your attention to Simons, Schumm, Stevens, 1974:46 wherein they state:

> The features of side channel formation in both the Power's Island reach and in the laboratory model discussed above were the same as those described by Shull. A straight reach of the channel will divide if we have the right depositional environment and a trigger mechanism to start the deposition. The development of vegetation on the deposition enhances the deposition processes and makes the bar more permanent. In Shull's case, the side channels filled naturally. In the Power's Island reach, most of the side channels were closed with the help of the engineering works.

In general, the Middle Mississippi EIS mental model of the Middle Mississippi is quite different than that displayed by Simons, Schumm, Stevens (1974:9). In the Middle Mississippi EIS model there is a river that is in part influenced by "natural processes" and part influenced by man-made decisions. The Simons, Schumm, Stevens vies of the river considers the river "natural" river up until about the beginning of the 20th century, and from there on it became a "developed" river. In the developed river, more and more the processes that control the hydrology and the geomorphology of the river are dictated by man's decisions. It would be too narrow a view to think of the entire siltation process of the Middle Mississippi as being controlled completely by the design and operation of the regulating works within this reach of the river. There are other important factors: such as the discharge regulating effects of the mainstem dams on the upper Missouri and channel contraction works on the Missouri River; channelization of other tributaries coming into the Middle Mississippi; and urbanization of the flood plain. But these too are all man-induced impacts on the hydrology and geomorphology of the Middle Mississippi. As Ogburn (1966) once noted, as man comes to invade more and more a natural environment through the process of urbanization, his technology itself becomes the environment. The Corps, or any Federal agency, cannot claim the direct intended benefits of their development programs on the one hand and on the other hand claim the unintended consequences of those very same development programs are "acts of nature" or external to their studies. This is a form of system segmentation. The Corps further states in their conclusional paragraph the following:

> Cessation of the ongoing efforts to obtain and maintain the authorized 9-foot navigation channel would not significantly reduce the above siltation processes.

This statement is misleading in that it simply picks out one of the many man-induced changes of the Middle Mississippi and states if that one change were eliminated, siltation would still continue. What is gremane is that if all man-induced changes were discontinued, then the river would revert back to its natural state.

The statement is misleading in another way in that it implies the only policy choices are continuation of the 9-foot navigation channel by using present operation and maintenance procedures or complete cessation of the 9-foot channel. In view of the economic considerations on the one hand and the 1969 NEPA Act on the other, neither of the above two alternatives is realistic. The only logical choice would be change in O & M procedures that would protect the integrity in the backwaters.

Response: The entire comment may be summarized by stating that it is not economically feasible to abandon the 9-foot channel project nor to continue construction of the project in a manner which disregards environmental considerations. The back to nature concept would be completely unacceptable to those persons now living within the Middle Mississippi River flood plain. At the same time the St. Louis District recognizes the fact that it must implement some plan of action which will make navigation compatible with the riverine environment. This has been our position for the past several years because the Corps is charged with the responsibility of expanding the economic base of our economy and to do so in a manner which is not harmful to the environment. Positive steps have already been taken to accomplish that objective on this particular project. The ultimate success of this endeavor will in large measure depend upon some overriding issues pertaining to economic and the environment. In this respect it may be necessary to accept some trade-offs which will benefit both navigation and the environment. This will require a complete understanding of the issues involved and a cooperative attitude on the part of all concerned to assure that the best interests of the public and the environment are served during future efforts to develop the authorized 9-foot navigation project.

Comment 13: 4. Dredging. The statement on dredging appears to be in agreement with the supporting scientific technical literature. We comment further that if for some reason procedures were changed so that all dredging was diverted from the backwaters to the higher land areas in the flood plain, the backwaters would continue to silt up because of wing-diking and closure diking.

Response: All of the St. Louis District dredging programs and disposal sites are reviewed by conservation agencies. The Corps has discontinued the practice of randomly placing dredged material in open water. All efforts are being made to preserve the most valuable fish habitat by avoiding dumping of dredged material in or near side channels. Supporting data indicates that best disposal is disposal in open river into deep water pool areas.
The St. Louis District has not built any chute closure structures since 1968 at the request of the Illinois and Missouri Dept. of Conservation. All contract work for regulating works is reviewed by conservationists and the Corps eliminates dikes at their request if the dikes would directly cause premature silting in of valuable backwater areas. Work already in place will not preserve backwater areas due to the natural processes of the river. Since the river is controlled, no new side channels will be formed. The St. Louis District is in the process of preparing a Post Authorization Change for the Middle Mississippi River to include fish and wildlife preservation and enhancement as a project purpose. It was scheduled to be submitted to higher authority in early July 1975. To date, this District has not received the necessary information to all the Corps to proceed with the required documents for the Post Authorization Change. If the Post Authorization Change is approved, this District is prepared to work with conservationists to develop plans to maintain and enhance side channels and backwater areas by artificial means.

Comment 14: 5. Loss of Flood Storage Capacity of the River. The Corps' comment on this adverse environmental impact is as follows:

> Similarly, the construction of flood protective works to protect urban areas and thousands of acres of productive farmland from floods has caused a significant increase for flood flows as compared to the past.

This statement clearly shows the counter-productive nature of Corps policies which are originally intended to protect areas in the flood plain but in actual practice cause unintended consequences of increasing flood flows as compared to the past. The program in itself is counter-productive to the Corps' stated intentions. Thus, for example, farmers who may have been induced in some previous time to build an agricultural levee that would withstand a 20-year flood probability, now find the same levee depreciated in value to where it is good for only a five year probably flood. In effect, the flood storage capacity of the Middle Mississippi is in a state of disequilibrium due to urbanization of the flood plain, continuing placement of new levee systems and channel.

Response: Increasing flood stages is not a Corps policy. When Congress authorized the construction of various levee projects along the Middle Mississippi River it was known that this construction would result in an unavoidable increase in the stage-discharge relationship for the project flood. The project flood under developed conditions is now approximately 10 feet higher than it was under natural conditions. This increase in the stage-discharge relationship was fully taken into account at the time the Alton to Gale levee system was designed. The accuracy of the design is attested by the fact that the major flood of 1973 passed St. Louis within allowable tolerances of the rating curve for that discharge.

Your statement that flood protective works have increased flood flows as compared to the past is incorrect. What was meant to be stated was that flood stages are now higher for a given discharge as compared to the past; which is far different from increasing the amount of discharge. We are directed by Congress to provide flood protective works and in so doing brought about a change in the stage-discharge relationship.

Increases in the stage-discharge relationship increases the probability of floods within the unprotected flood plain. The Corps has no control over local flood zoning ordinances. People live there at their own risk. Information about problems of flooding in the unprotected flood plain is available if people would only inquire. The Corps of Engineers does not induce anyone to build agricultural levees in the flood plain. Private persons do so at their own volition and risk. However, if levees are damaged by floods the Corps does have a program to repair those private levees at Federal expense. The Corps is not authorized to increase flood protection to private interests by increasing the height of the agricultural levees, but the Corps will repair and restore the levees to their original height and design if damaged. It is important to note that construction of other levees in the flood plain could reduce the degree of protection provided at any given locality.

Comment 15: Again, there is a rather striking disparity between the Corps' description of the causes of this increased flooding and those contained in Simons, Schumm, Stevens (1974). The Corps attributes all loss of flood storage capacity to flood protective works whereas Simons, Schumm, Stevens attributes this loss to both flood protective works and navigation contraction work. For instance, Simons, Schumm, Stevens (1974:34) states:

> The increase in river stage for any particular flood is the result of the combined effects of levees on the flood plain, dikes in the river channel, and alterations of the flood plain between the levees and the river channel due to land use changes.

While they do not try to distinguish one casual change from the other, they clearly suggest that the channel modification works have a significant effect on flooding in the Middle Mississippi. The effect of navigation works on the loss of flood storage capacity on the Middle Mississippi was first discussed by Belt (1973). He notes particularly the high stages reached during the 1973 flood at Chester, Illinois, at mile 100. These stages were accomplished even though the low agricultural levees in the surrounding vicinity were generally overtopped, thus opening up the entire flood plain in this reach of the river to the flood flow. (cf. BELT 1975)

Response: The flood storage capacity of the Mississippi River flood plain has primarily been reduced by the construction of flood protective works and to a much lesser degree by the construction of channel improvement works. No information is available to indicate that channel improvement works have a significant effect on flood stages. This problem is presently being fully investigated throughout the entire Lower Mississippi Valley Division.

The record flood stage of 1973 passed St. Louis within one foot of the rating curve for that discharge. The one foot difference was on the high side of the rating curve and the St. Louis District has conclusive documentation that the discrepancy was probably due to a loop effect. To be specific, three major flood crests occurred during the 1973 flood. The discharge at the first crest passed St. Louis at a lower stage than the same discharge did during the following two crests. This was due to the fact that flood water was carrying a large amount of material during rising river stages on the first crest and part of that material was deposited on the river bottom after the first crest passed. Thus, the flow carrying capacity of the river was very slightly reduced. The same phenomenon occurred for the second crest, and again for the third crest. The purpose of our contractive works is to remove deposited material from the navigation channel as river stages fall within the upper limits of its contractive effort.

Comment 16: C. Correction of Methodologies Deficiencies - The Middle Mississippi EIS contains a number of conclusatory statements which are not correlated with the basic scientific and technical reports. These dificiencies could be overcome by a tighter methodological format that would include the following:

1. Referencing statements made to documents in the bibliography

Response: Attempts have now been made to reference all statement to the appropriate entry in the bibliography.

Comment 17: 2. Citing only references that are contained in the bibliography.

Response: Attempts have now been made to make additions to the bibliography of all material cited in the text.

Comment 18: 3. Using baseline data for comparing of facts displayed. Many statements are made in the EIS that lose their significance as they are not compared to meaningful baseline data.

Response: Comment noted.

Comment 19: 4. Quantitative analysis of the dynamic characteristics of the river - adverse environmental impacts particularly are handled on a qualitative rather than a quantitative basis. Many of the scientific technical reports cited in the bibliography do contain more quantitative analysis. Loss of the backwaters and loss of the flood storage capacity of a river do lead directly to economic losses that could be quantified first in operational physical terms and next in dollars.

Response: Quantitative information is available on the past and present condition of the Mississippi River allowing changes from the past to the present to be quantified. However, future changes to such a complex system as the river, while possibly similar to past changes, are very difficult to quantify.

Comment 20: 5. Lack of legislative history -- we're referring particularly here to pages 4 and 5 which would appear to be a series of representations to Congress from the Corps of Engineers of what it would take to achieve first the 8-foot channel in 1881 and later the 9-foot channel starting in 1927. Actual achievement of a stable, dependable 9 foot channel in this reach of the river always seems to be something that will be achieved upon the next program of channel contraction. This starts with a 2,500 foot channel target width in 1881, 1,800 feet in 1927, and now 1,500 feet. The record suggests that continuing contractions of the channel are necessary in order to keep dredge quantities from moving exponentially out of sight.

Response: The 1927 Act authorizing the navigation projects directed the Corps to develop a 9-foot channel utilizing contractive works, revetment, and dredging. The navigation channel was to be developed with respect to a datum plan delineated by a low water discharge of 40,000 cubic feet per second (c.f.s.). Investigations and past experience indicated an 1,800 foot contraction plan could not develop authorized channel dimensions. A prototype reach study program conducted between miles 140-154 proved to our satisfaction that a 1,200 foot contraction plan was necessary to develop authorized channel dimensions with respect to a low water discharge of 40,000 c.f.s. Hydraulic computations made during the prototype reach study program, indicated that the low water datum plane for navigation projects should be based on a discharge of 54,000 c.f.s. and not 40,000 c.f.s. The reason for this decision was because the combination of dike construction and contractive works to develop the authorized channel at a discharge of 54,000 c.f.s. was more economical than the same combination at a flow of 40,000 c.f.s. Therefore a decision was made to reduce the contractive effort from 1,200 feet to 1,500 feet and to develop the channel with respect to a discharge of 54,000 c.f.s. It was recognized that the economics of this decision would also result in less environmental impact upon the riverine environment.

With regards to the dredging requirements mentioned in the basic comment, over 10 dredges were required to maintain the channel in the Middle Mississippi River after the enactment of the 1927 Navigation Act. Today, only two dredges are required on a part-time basis to maintain navigation dimensions on the Middle Mississippi River. Dredging is only a temporary solution which is repetitive on an annual basis while contractive works have proven their worth in reducing the amount of dredging to maintain the channel.

Comment 21: 6. Lack of public disclosure of planning alternatives. The Middle Mississippi EIS considers basically three alternatives, the first being continuation of the present O&M practices, the second being complete cessation of navigation on the Middle Mississippi and the third being a post-authorization change which simply amounts to alloting a very small proportion of the present O&M budget for experiment with methods to decrease environmental damage. It would seem that an extensive discussion of the alternatives offered by a present technology for complete mitigation of environmental damage should be in order, including the costs involved.

Response: The alternatives identified and discussed in this environmental statement are those which are considered as being applicable at this point in time. The District is aware of the limited value of these alternatives and the reader is referred to the recommendations made in the Statement of Findings which accompanies this environmental statement.

Comment 22: Planning alternatives relative to the 12-foot channel are particularly vague. (cf. Middle Mississippi EIS 1975:48-49). This section states the cost deficiency in the original phase one 12-foot channel study. The section also implies a serious shortage in water availability on the Middle Mississippi in the more distant future. Will there be enough low water discharge available for navigation at that time?

Response: 1.6.1 Twelve-Foot Channel Study. The use of the word "Ongoing" in the first sentence should be deleted. When this paragraph was first written, this was probably a true statement, but before the EIS went to press in May 1975, all work on 12-foot study had ceased.

If the "planning alternatives relative to the 12-foot channel are particularly vague" it is simply because the in-depth engineering, economic, and environmental studies necessary to clearly establish which alternatives would survive, were not a part of the Phase I report. The basic comment refers to long range projections relating to flow depletions from the Missouri River Basin. The effect of flow depletions upon the 9-foot channel project are problematical at this time. Dependent upon the magnitude of flow depletions if they should occur, a decision will have to be made at some future date as to the best means of resolving this problem area. Additional dredging would be one alternative, additional contractive effort another alternative, and reducing the length of the navigation season would be another alternative which would not require a structural or maintenance solution to this problem.

Comment 23: In conclusion, it is our understanding of the law that navigation on the Middle Mississippi should proceed only if there is a concurrent program of environmental mitigation, a program to protect the integrity of the backwaters. Flood plain development must also proceed in such a way as to protect the flood storage capacity of the river.

The notion that economic development can and must proceed at a cost of continuing environmental degradation, will in the end bankrupt the environment.

Response: Comment noted.

y. Bootheel Regional Planning Commission and Economic Development Council

Comment 1: Both the Bootheel's A-95 PNRS Committee and the Bootheel Regional Planning Commission have reviewed and approved the Draft Environmental Statement on the Mississippi River Between the Ohio and Missouri Rivers Regulating Works.

Response: Comment noted.

z. Union Electric Company

Comment 1: Section 4.1.1.5 Lowering of Riverbed Elevation (Page 196) As discussed in the report, the engineering concept of channel development is to redirect the river's energy to the task of scouring out a suitable navigation channel by contracting the river width with a corresponding increase in current velocity. As the report indicates, the riverbed elevation is reduced through degradation or scouring. As a result, the riverbed has been lowered by about 8 feet between the years 1889 and 1966. The 15-mile long test or prototype section between miles 140 and 154 was lowered an additional 3 feet during the period from 1967 to 1971.

Response: Comment noted.

Comment 2: Section 4.1.1.8 Effect on River Stages (Page 201) The reduction in river stage at low flows is discussed, and figure 4-3 (a) shows that the stage-discharge relationship at a discharge of 54,000 cfs. has been lowered by 11 feet between 1837 and 1946 due to degradation of the riverbed brought about as a result of the channel improvement project. At higher discharges, the reduction in river stage is less marked reaching a no-change condition between 1837 and 1946 at a flow of 290,000 cfs. At 500,000 cfs. flow the stage is 2-1/2 feet higher for 1946 than was recorded for an equivalent flow in 1837.

Response: Comment noted.

Comment 3: Our concern is the reduction in elevation of the river surface at low flows of 54,000 cfs. and below. As noted in Section 4.1.1.6, Effect on Flows (page 197), a minimum discharge at St. Louis of 18,000 cfs. occurred in 1863. We became concerned over lowering of the river surface elevation at low flows at our various steam electric generating plants along the Mississippi River in the St. Louis area during the mid-to-late 1950's. As a result, we adopted a program of setting the water inlet sill of new circulating water intake facilities at a lower elevation than had been used based on earlier design criteria, since it appeared that this reduction in river level due to bottom scouring would continue.

Response: Comment noted.

Comment 4: The need to employ the mechanism of bottom scouring to maintain the 9-foot channel through use of contracting dikes is recognized, and indeed Union Electric is dependent on availability of the 9-foot river channel for the receipt of barge coal at Meramec Plant and for delivery of oil to our plants and to our suppliers. Therefore, we are not specifically objecting to the use of this mechanism in maintaining the channel.

Response: Comment noted.

Comment 5: Impact of river degradation and low-water discharges on the availability of water for industrial, commercial, and municipal intakes.

Response: The concern Union Electric Company has expressed about the availability of a continued water supply to meet the needs of industrial commercial, and municipal water intakes is shared by the Corps of Engineers. With regard to Section 4.1.1.5, Lowering of Riverbed Elevation, contained on Page 196, please be informed that the three feet of additional scouring which occurred during the period from 1967 through 1971, between Miles 140 to 154 is not typical of the current rate of riverbed degradation. The average depth increased as a result of a prototype study program designed to investigate the desirability of utilizing a 1,200 foot low-water contraction plan to develop the authorized 9-foot navigation channel with respect to a low water datum plane delineated by a low water flow of 40,000 cubic feet per second (c.f.s.). Accordingly, the study reach was contracted from a low water width of 1,800 feet to a low water width of 1,200 feet. Field investigations indicated that it was feasible to develop a 9-foot navigation channel at a low-water flow of 40,000 c.f.s. because the average depth had increased by approximately three feet, as mentioned in your comment, but this does not mean the entire reach was increased by three feet. Hydraulic investigations made as a part of this prototype reach study program indicated the low-water datum plane based on a low water discharge of 54,000 c.f.s. very closely approximated the average 10 and 20-year low-water discharges. Accordingly, a decision was made to develop the authorized navigation project with respect to a low-water discharge of 54,000 c.f.s. and not 40,000 c.f.s. The results of these hydraulic investigations therefore indicated it was not necessary to utilize a 1,200 foot contraction to develop the navigation channel under present low flow conditions. Model study data obtained from the Waterways Experiment Station, Vicksburg, Mississippi, indicated the authorized navigation project could be developed with respect to a low water discharge of 54,000 c.f.s. with a 1,500 foot low water contraction plan. To date, approximately 50 miles of river have been contracted to a 1,500 foot contraction plan is generally capable of improving shoal water navigation crossings without causing a general lowering of the average riverbed elevation.

With regard to Section 4.1.1.8, Effect on River Stages, contained on Page 201, please be informed that in 1956 the projected elevation of the low water datum plane for a discharge of 54,000 c.f.s. was estimated to be -3.5 feet on the St. Louis gage. Recent hydraulic computations indicate the low water datum plane for that discharge is presently located at about -2.8 feet on the St. Louis gage. The rate of riverbed change has been noticeably slowing down during the past 20 years. Based upon our present plan of improvement, we do not envision that low water surface elevation will be a major problem in the future.

Discharges are higher than 54,000 c.f.s. approximately 97 percent of the time based upon present flow conditions. A discharge of 18,000 c.f.s. similar to that which occurred in 1863 is very rare. In addition to the discharge from the Upper Mississippi River, Middle Mississippi River discharges are now augmented by releases from Lake Michigan and reservoirs in the Missouri River Basin.

With regard to your comments concerning the use of contractive works to develop the authorized channel, we are pleased that you interpose no objections to this procedure. You may rest assured that our plan of improvement will utilize the minimum contractive effort necessary to develop the authorized navigation channel which may require that maintenance dredging be performed at some troublesome channel crossings.

All of the aforementioned information has been presented to show that future changes in the low water elevation should not post a serious problem to water intakes based upon present low flow conditions. This does not mean, however, that low water discharges less than 54,000 c.f.s. will not be experienced in the future. Very long range projections indicate some flow depletions may occur in the Missouri River Basin which will affect Middle Mississippi River discharges and lower the low water surface elevation by as much as 2.5 feet. You may wish to review the elevation of your present water intakes to learn what effects this long range projection may have on your operations.

Comment 6: We are not concerned with the effect of regulating works on river stages at high flows, as our plants are built to appropriate design criteria for protection against flows of the greater-than-500 year-flood magnitude.

Response: With regard to your comment pertaining to higher flood stages under the present state of development, we are pleased to know that your facilities along the Middle Mississippi River are designed to withstand a 500-year flood which far exceeds the degree of flood protection afforded the Middle Mississippi River flood plain.

a.a. The American Waterways Operators, Inc.

Comment 1: The membership of AWO fully supports the channel maintenance work of the Corps of Engineers. The Congressionally-authroized 9-foot channel on this segment of the river has brought to the public a wealth of economic benefits through the availability and reliability of low-cost water transportation. These benefits, while chiefly transmitted through water rates, have also been felt through reduced rail charges along water competitive routes.

Response: Comment noted.

Comment 2: The Mississippi segment detailed in this draft, the portion between the Missouri and Ohio, is an extremely critical link to the entire inland waterway system. While the maintenance of the 9-foot channel has direct implications for the immediate area, secondary effects are seen as far as such points as Pittsburgh, Chicago, Minneapolis, New Orleans, and a host of other major river ports located along the nation's inland waterway system.

Response: Comment noted.

Comment 3: In this era of energy shortages, it is important to note that nearly 60 percent of total tonnage moved on the nation's waterways consists of "fuel for others," such as coal, oil, and refined petroleum products. Products moved on the Mississipiip River between the Ohio and Missouri Rivers Regulating Works are, in large part, the same "fuel for others."

Response: Comment noted.

Comment 4: Current transportation and economic trends dictate the maintenance of a 9-foot channel in this strategically located area. AWO urges the St. Louis District of the Corps of Engineers to expedite the channel maintenance program in this area as a significant means supporting urgent economic, social, and energy needs.

Response: Comment noted.

b.b. Mrs. Marty Nelson

Comment 1: Consideration of threatened species gives rise to conjecture--is not the American taxpayer ("status undetermined") entitled to the protection--species, habitat and livelihood--of the government and agencies he supports? This was the intent of NEPA and this Environmental Statement, prepared in compliance with that law, fails as a procedural safeguard against environmental, economic and social damage. This Statement is at an incomplete, deficient and often inaccurate stage. Much more research, sincere effort, and expertise is needed to produce the January, 1976 EIS to be submitted to the CEQ, Congress and the general public.

Response: Comment noted.

Comment 2: Validity of the benefit/cost ratio of 4.01 to 1 questionable; figures, estimates, and items used in the calculation are, inaccurate, incomplete, or non-existent.

Response: The benefit/cost ratio is calculated under Corps of Engineers regulations as prescribed by the Congress of the United States.

Comment 3: No inclusion is made of the discount rate utilized in the B/C ratio calculation.

Response: The discount rate used in the B/C ratio calculation 2.50%.

Comment 4: Statement excludes cost and maintenance of disposal sites as well as costs to navigation resulting from adverse channel conditions.

Response: The Corps does not maintain disposal sites thus there is no cost for this effort. Detailed studies are planned which would identify all costs to towing firms and shippers resultant from either a complete channel blockage or a reduction in depth.

Comment 5: (3) Numerous references in the Draft indicate that dredging is "never eliminated", "always needed", "Never ending", and that annual amounts of dredge material are merely estimated because of deviations due to uncontrollable river conditions. Such deviations or increased dredging necessary could impose an additional annual cost. Yet the "average annual" of $11,428,000 is represented as a fixed annual amount in arriving at the B/C without noted concern for annual charges arising from river conditions, economic pressures, labor demands or technological changes.

Response: Annual cost to dredge is dependent on the amount of material which accumulates in the navigable channel any given year. Average annual costs base on a historical record are used as reflective of what may be reasonably expected in the future.

Comment 6: The benefit/cost summary uses terms "cost" for the project, and "charges" for the annual average. In reality, navigation interests have river experienced "charges" for use or abuse of either national waterway or revenue.

Response: The document does not state, imply, criticize, or attempt to further the fact that there is no "cost" to navigation interests for use of national waterways.

Comment 7: The derivation of project benefits is cloudy at best and no adjustment in B/C ratio is exhibited compiled from figures reflecting federal subsidies to offset handicaps to competing transportation modes due to lack of Corps development and maintenance or decrease in navigation benefits if charges were imposed to offset Corps services rendered.

Response: Comment noted. See response to comment 2.

Comment 8: No benefit/cost ratio type comparison for energy efficiency is reported. Comparative studies of the energy utilization of establishing and maintaining the channel as well as utilization by the various existing modes of transportation are conspicuous by their absence.

Response: Comparative studies of establishing and maintaining right-of-ways become difficult if not impossible under existing conditions. In some cases, maintenance outlays are impossible to determine because of deferred charges. At this point, the question becomes, "What level of maintenance is to be compared"?

In regard to the direct energy efficiency of competing modes, there are numerous studies and reports that provide equally numerous findings. The commentator is possibly aware of many of these reports. Most recently the Battelle Memorial Institute in Washington, D.C., has been retained to study relative energy intensity by mode, by commodity carried. Results of this work may provide a more in-depth look at the question.

Comment 9: III. I find it embarrassing to point out that the statement on page 219 "O&M activities do not have an impact on the flood plain" manifests an unbelievable ignorance of elementary sand box physics! Flood waters unable to occupy filled spoil sites will occupy wetlands and/or flood plain. This resulting creation of flood-prone land may involve federally subsidized flood insurance, local qualifying ordinances, flood plain zoning, and jeopardize recreational sites, cultural resources and the environmental quality of natural resources. Little or no evidence is presented to indicate an understanding of these involvements. In fact a total disregard is apparent from the statement on page 231 summarizing environmental cost as the disappearance of side channels and loss of water surface with no mention of water or air quality. These oversights take on even greater significance considering the imminent commercial expansion based upon project completion. One navigation company quotes in the Draft a planned a planned 113% expansion program.

Response: The statement on page 219 that O&M activities will not have an impact on the flood plain is in reference to any impact on archeological or historical sites or structures located there. Other social and economic impacts are dealt with in this same section (Section 4.3, Cultural Impacts).

Comment 10: Clarification needed as to site selection guidelines, permit issuance, compliance inspection and reporting.

Response: Permit activities have not been addressed in this Environmental Statement.

Comment 11: Table 1-1 omits documentation of the 1966 authorization for the prototype reach used to develop design criteria to implement the 9-foot channel project.

Response: This was mentioned in the text preceeding the table.

Comment 12: Clarification needed as to the issue of transportation efficiency vs. survival of river transportation industry as raised by a December, 1974, hearing participant.

Response: The hearing participant was evidently a representative of Agri-Trans. Corp. A copy of the transcript of the December, 1974, hearing is available for review at the St. Louis District, Corps of Engineers, 210 N. 12th St., St. Louis, Missouri 63101.

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Appendices

Appendix A. Benefit-Cost Summary. Economic Data are Based on an Updating of Information Contained in LMV Form 23 Prepared 25 August 1975. Documentation is Available at U. S. Army Engineer District, 210 N. 12th Street, St. Louis, Missouri.

Project Cost	$207,053,000
Average Annual Benefits	
Navigation	45,937,000
Total Annual Benefits	45,937,000
Average Annual Charges	11,736,000
Benefit-to-Cost Ratio	3.9 to 1.0

Appendix A1. Summary of Phytoplankton Collected from Side Channels, Main Channel Border, and Disposal Sites from the Mississippi River Between St. Louis, Missouri and Cairo, Illinois. (Source: Emge, et al., 1974; Ragland, 1974; and Solomon, et al., 1974).

Classification	Side Channel	Main Channel Border	Disposal Sites
Phylum (Division) Chlorophyta			
Class Chlorophyceae			
Order Chlorococcales			
Family Characeae			
Characium sp.	X*	--	--
Family Chlorococcaceae			
Golenkinia sp.	X	--	--
Family Coelastraceae			
Coelastrum sp.	X	X	X
Family Hydrodictyaceae			
Hydrodictyon sp.	X	--	--
Pediastrum boryanum	X	X	X
P. duplex	X	X	--
P. simplex	X	X	--
Family Oocystaceae			
Ankistrodesmus sp.	X	X	--
Chlorella sp.	X	--	--
Chodatella sp.	X	--	--
Closteriopsis sp.	X	X	--
Dictyosphaerium sp.	X	--	--
Dimorphococcus sp.	X	--	--
Kirchneriella sp.	X	--	--
Oocystis sp.	X	X	--
Quadrigula sp.	X	--	--
Schroederia sp.	X	X	--
Selenastrum sp.	X	--	--
Tetraedron sp.	X	--	--
Family Scenedesmaceae			
Actinastrum sp.	X	--	--
Crucigenia sp.	X	--	--
Micractinium sp.	X	--	--
Scenedesmus sp.	X	X	X
Tetrastrum sp.	X	--	--
Order Cladophorales			
Family Cladophoraceae			
Cladophora sp.	X	X	--
Order Oedogoniales			
Family Oedogoniaceae			
Oedogonium sp.	--	X	X
Order Volvocales			
Family Chlamydomonadaceae			
Chlamydomonas sp.	X	X	--
Family Phacotaceae			
Pteromones sp.	X	--	--
Family Volvocaceae			
Eudorina sp.	X	--	--
Pandorina sp.	X	--	--
Order Tetrasporales			
Family Palmellaceae			
Gloeocystis sp.	X	X	--
Sphaerocystis sp.	X	--	--
Order Zygnematales			
Family Desmidiaceae			
Closterium sp.	X	--	--
Cosmarium sp.	X	X	X
Pleurotaenium sp.	--	X	--
Staurastrum sp.	X	--	--
Family Zygnemataceae			
Spirogyra sp.	X	X	--
Phylum (Division) Cryptophyta			
Class Cryptophyceae			
Order Cryptomonadales			
Family Cryptomonadaceae			
Cryptomonas sp.	X	--	--

Appendix A_1. Continued

Classification	Side Channel	Main Channel Border	Disposal Sites
Phylum (Division) Chrysophyta			
Class Bacillariophyceae			
Order Centrales			
Family Coscinodiscaceae			
Cyclotella sp.	X	X	X
C. bodanica	X	X	--
C. meneghiniana	X	X	--
Melosira sp.	X	X	X
M. italica	X	X	--
M. varians	X	X	--
Stephanodiscus sp.	X	X	--
Order Pennales			
Family Achnanthaceae			
Rhoicosphenia curvata	--	X	--
Family Cymbellaceace			
Cymbella sp.	X	X	--
Family Diatomaceae			
Diatoma sp.	--	X	--
Family Fragilariaceae			
Asterionella sp.	X	X	--
Fragilaria sp.	X	X	X
Synedra sp.	X	X	X
Family Gomphonemataceae			
Gomphonema sp.	X	X	--
Family Naviculaceae			
Gyrosigma sp.	X	X	X
Navicula sp.	X	X	X
Pennularia sp.	X	--	--
Family Nitzschiaceae			
Nitzschia sp.	X	X	X
Family Surirellaceae			
Surirella sp.	X	X	--
Family Tabellariaceae			
Tabellaria sp.	X	X	--
Class Chrysophyceae			
Order Chrysomonadales			
Family Mallomonadaceae			
Mallomonas sp.	X	--	--
Family Tabellariaceae			
Tabellaria sp.	X	--	--
Class Chrysophyceae			
Order Chrysomonadales			
Family Mallomonadaceae			
Mallomonas sp.	X	--	--
Family Ochromonadaceae			
Dinobryon sp.	X	--	--
Ochromonas sp.	X	--	--
Phylum (Division) Cyanophyta			
Class Cyanophyceae			
Order Chroococcales			
Family Chroococcaceae			
Aphanocapas sp.	X	X	X
Chroococcus sp.	X	X	X
Coelosphaerium sp.	X	X	--
Gloeocapsa sp.	X	X	X
Gomphosphaeria sp.	X	--	--
Microcystis sp.	X	X	X
Merismopedia sp.	X	--	--
Order Hormogonales			
Family Nostocaceae			
Anabaena sp.	X	X	--
Family Oscillatoriaceae			
Oscillatoria sp.	X	X	X
Spirulina sp.	X	--	--
Phylum (Division) Euglenophyta			
Class Euglenophyceae			
Order Euglenales			
Family Euglenaceae			
Euglena sp.	X	X	X
Lepocinclis sp.	X	--	--

Classification	Side Channel	Main Channel Border	Disposal Sites
Phacus sp.	X	--	--
Trachelomonas sp.	X	X	X

* An X signifies capture in side channels, the main channel border, or dredged material disposal sites.

Appendix B. Summary of Zooplankton Collected from Side Channels, Main Channel Border, and Disposal Sites from the Mississippi River Between St. Louis, Missouri and Cairo, Illinois. (Source: Emge, et al, Ragland, 1974; and Solomon, et al., 1974).

Classification	Side Channels	Main Channel Border	Disposal Sites
Phylum Protozoa			
Class Ciliata			
Family Vorticellidae			
Vorticella sp.	X *	--	X
Class Euglenophyceae			
Order Euglenales			
Family Englenaceae			
Phacus sp.	X	--	--
Class Heliozea			
Order Actinophydia			
Family Actinophidae			
Actinosphaerium sp.	X	X	--
Class Lobosa			
Order Testacealobosa			
Family Difflugiidae			
Difflugia sp.	X	X	X
Phylum Arthropoda			
Class Crustacea			
Order Cladocera			
Adult Cladocera	X	X	X
Immature Cladocera	X	X	X
Family Bosminidae			
Bosmina coregoni	X	X	--
B. longirostris	--	X	--
Family Chydoridae			
Acroperus harpae	X	X	--
Chydorus sphaericus	X	X	--
Pleuroxus hamulatus	X	X	--
Family Daphnidae			
Ceriodaphnia sp.	--	X	--
Daphnia parvula	X	X	--
Moina micrura	X	X	--
Simocephalus vetulus	X	--	--
Family Macrothricidae			
Illyocryptus sordidus	X	--	--
I. spinifer	X	--	--
Family			
Diaphanosoma leuchtenbergianum	X	X	--
Subclass Copepoda			
Order Branchiura			
Family Argulidae			
Argulus sp.	X	X	--
Order Eucopepoda			
Suborder Calanoida	X	X	X
Family Diaptomidae			
Diaptomus siciloides	X	X	--
Suborder Cyclopoida	X	X	X
Family Cyclopidae			
Cyclops bicuspidatus thomasi	X	X	--
C. vernalis	--	X	--
Eucyclops agilis	X	X	--
Suborder Harpacticoida	X	X	--
Subclass Ostracoda			
Order Podocopa			
Family Cypridae			
Cypria mediana	X	--	--
Class Insecta			
Order Diptera			
Family Culicidae			
Chaoborus sp.	X	--	--

Appendix B. Concluded

Classification	Side Channels	Main Channel Border	Disposal Sites
Phylum Gastrotricha	X	--	--
Phylum Rotifera			
Eggs	X	X	X
Class Monogonata			
Order Flosculariaceae			
Family Branchionidae			
Brachionus angularis	X	X	X
B. budapestinensis	X	X	X
B. calyciflorus	X	X	X
B. furculatus	X	X	X
B. havanaensis	X	X	X
B. urceolaris	X	X	X
Keratella sp.	X	X	X
Platysias patulus	X	X	--
Family Lecanidae			
Monostyla sp.	X	--	--
Family Synchaetidae			
Polyarthra sp.	X	--	--
Family Testudinellidae			
Filinia sp.	X	--	--

* An X indicates collection in the side channels, main channel border, or dredged material disposal sites.

Appendix C. Summary of Benthic Organisms Collected from Side Channels, Main Channel Border, Disposal Sites, and Dredged Sites from the Mississippi River Between St. Louis, Missouri and Cairo, Illinois

Classification	Side Channel	Main Channel Border	Disposal Sites	Dredged Sites
Phylum Annelida				
Class Hirudinea				
Order Arhynchobdellida	--	X	--	--
Order Rhynchobdellida	X*	--	--	--
Class Oligochaeta				
Order Plesiopora				
Family Enchytraeidae				
Enchytraeus sp.	--	X	--	--
Family Naididae				
Aulophorus sp.	X	--	--	--
Pristina longiseta leidyi	X	X	--	--
Family Tubificidae				
Limnodrilus sp.	X	X	--	--
Branchiura sowerbyi	X	X	X	--
Tubifex tubifex	X	--	--	--
Order Prosopora				
Family Lumbriculidae	X	--	--	--
Phylum Arthropoda				
Class Crustacea				
Order Amphipoda				
Family Gammaridae				
Crangonx sp.	X	X	--	--
Gammarus fasciatus	X	--	--	--
Family Talitridae				
Hyalella azteca	X	X	--	--
Order Isopoda				
Family Asellidae				
Asellus brevicaudus	--	X	--	--
A. militaris	X	--	--	--
Lirceus frontinalis	--	X	--	--
Order Decapoda				
Family Astacidae				
Camberellu sp.	X	--	--	--
Class Insecta				
Order Coleoptera				
Family Dytiscidae				
Acilius sp.	--	X	--	--
Family Dryopidae				
Dryops sp.	X	--	--	--
Helichus sp.	--	X	--	--
Family Elmidae				
Stenelmis sp.	X	X	X	--
Family Heteroceridae				
Heterocerus sp.	--	X	--	--
Order Collembola				
Family Isotomidae				
Isotoma sp.	X	--	--	--
Family Sminthuridae	X	--	--	--
Order Diptera				
Family Anthomyiidae				
Limnophora sp.	X	--	--	--
Family Ceratopogonidae				
Palpomyia sp.	X	--	--	--
Bezzia/Probezzia sp.	X	X	--	--
Family Chironomidae				
Ablabesmyia sp.	X	--	--	--
Chironomus sp.	X	X	X	X
Coelotanypus sp.	X	X	X	--
Cryptochironomus sp.	X	X	X	--
Microtendipes sp.	--	X	X	X
Orthocladius sp.	--	X	--	--
Paracladopelma sp.	X	X	--	--
Polypedilum sp.	X	X	X	--
Procladius sp.	X	--	X	--
Stenochironomus sp.	X	--	--	--
Xenochironomus				
Tribe Pentaneurini	X	X	--	--
Tribe Tanytarsini	X	--	--	--

Appendix C. Continued

Classification	Side Channel	Main Channel Border	Disposal Sites	Dredged Sites
Family Culicidae				
Chaoborus punctipennis	X	X	X	--
Family Empididae	X	X	--	--
Family Ephydridae				
Notiphila sp.	X	--	--	--
Family Maidae	X	X	--	--
Family Psychodidae	X	--	--	--
Family Rhagionidae				
Atherix variegata	X	--	--	--
Family Simuliidae	--	X	--	--
Family Tipulidae	--	X	--	--
Order Ephemeroptera				
Family Baetidae				
Baetis sp.	X	X	X	--
Baetisca sp.	X	--	--	--
Neocloeon sp.	--	X	--	--
Siphlonurus quebecensis	--	X	--	--
Family Caenidae				
Brachycerus sp.	X	--	--	--
Caenis sp.	X	X	--	--
Trycorythodes sp.	X	X	--	--
Family Ephemeridae				
Ephron sp.	X	--	--	--
Hexagenia limbata	X	X	X	--
H. rigida	X	--	--	--
Pentagenia vittigera	X	X	X	--
P. sp.	X	X	--	--
Tortopus sp.	X	--	--	--
Family Heptageniidae				
Heptagenia sp.	X	X	X	--
Stenonema canadense	X	X	X	--
S. guilderslecvei	X	X		
S. pulchellum	X	--	--	--
Family Potamanthidae				
Potomanthus sp.	--	X	--	--
Family Siphlonuridae				
Isonychia sp.	--	X	--	--
Order Hemiptera				
Family Corixidae				
Trichocorixa sp.	X	X	--	--
Family Notonectidae				
Notonecta sp.	X	--	--	--
Family Ochteridae				
Ochterus sp.	X	--	--	--
Order Lepidoptera				
Family Pyralididae				
Eloplia sp.	X	--	--	--
Order Neroptera(=Megaloptera)				
Family Corydalidae				
Corydalus cornutus	X	--	--	--
Order Odonata				
Family Coenagrionidae				
Argia/Hyponeura	X	X	--	--
Nehallenia sp.	X	X	--	--
Family Gomphidae				
Dromogomphus sp.	X	--	--	--
Gomphus sp.	X	--	--	--
Hagenius brevistylus	X	--	--	--
Family Libellulidae				
Perithemis sp.	X	--	--	--
Order Plecoptera				
Family Nemouridae				
Brachyptera sp.	X	--	--	--
Order Trichoprera				
Family Hydropsychidae				
Cheumatopsyche sp.	X	X	--	--
Hydropsyche frisoni	X	X	--	--
H. orris	X	X	--	--
H. simulans	--	X	X	X
Potamyia flava	X	X	X	X

Classification	Side Channel	Main Channel Border	Disposal Sites	Dredged Sites
Family Hydroptilidae	--	X	--	--
Family Leptoceridae				
Athripsodes sp.	--	X	--	--
Leptocella candida	X	X	--	--
L. pavida	--	X	--	--
Mystacides sp.	X	--	--	--
Family Molannidae	X	--	--	--
Family Psychomyiidae				
Neureclipsis sp.	X	X	X	--
Polycentropus centralis	X	X	--	--
P. interruptus	--	X	--	--
Psychomyiid Genus A/Cyrnellus sp.	X	X	--	--
Phylum Mollusca				
Class Gastropoda				
Order Basommatropha				
Family Physidae				
Physa sp.	X	X	X	--
Family Planorbidae				
Helisoma sp.	--	X	--	--
Planorbula sp.	X	--	--	--
Family Lymnaeidae				
Lymnaea sp.	X	--	--	--
Order Mesogastropoda				
Family Bulimidae				
Pyrgulopsis sp.	--	X	--	--
Family Pleuroceridae				
Pleurocera sp.	--	X	--	--
Class Pelecypoda				
Order Heterodonta				
Family Corbiculidae				
Corbicula sp.	X	X	X	--
Family Sphaeriidae				
Sphaerium sp.	--	X	X	--
Phylum Nematoda	X	X	--	--
Phylum Nematomorpha				
Class Gordioidea				
Order Gordiida				
Family Gordiidae				
Gordius sp.	X	--	--	--
Phylum Platyhelminthes				
Class Turbellaria				
Order Tricladida				
Family Planariidae				
Dugesia sp.	--	X	--	--

* An X signifies capture in a particular location.

Appendix C_1. Average species diversity indices ($\bar{d}$) and evenness indices (e) calculated for benthos and fish species collected from Middle Mississippi River side channels and main channel border areas (Emge, *et al.*, 1974).

	Average calculated index for sampling periods II/III			
	Benthos		Fish	
Side channel	$\bar{d}$	e	$\bar{d}$	e
1	2.10/2.53	0.62/0.92	2.63/2.22	0.69/0.71
2	2.18/——	0.60/——	1.70/0.92	0.57/0.39
3	1.66/1.93	0.58/0.62	1.10/1.92	0.37/0.56
4	1.21/——	0.38/——	1.95/2.66	0.60/0.68
5	1.61/——	0.62/——	2.21/1.98	0.73/0.62
6	1.00/1.11	0.35/0.60	1.64/1.46	0.54/0.39
7	1.01/1.42	0.65/0.64	2.42/1.84	0.73/0.58
8	1.32/——	0.52/——	1.72/2.53	3.76/0.74
9	1.41/——	0.54/——	1.45/1.85	0.55/0.60
10	1.40/0.95	0.48/0.32	2.08/2.27	0.71/0.66
11	1.39/2.43	0.46/0.80	1.76/1.93	0.65/0.72
12	0.97/1.24	0.44/0.47	1.76/1.93	0.52/0.70
14	1.49/——	0.66/——	1.91/1.49	0.74/0.41
15	1.52/0.86	0.52/0.36	2.02/1.81	0.79/0.58
16	1.22/1.50	0.45/0.58	1.74/2.63	0.62/0.81
17	2.16/0.92	0.67/0.87	0.92/2.36	0.50/0.75
18	1.75/——	0.73/——	1.41/2.13	0.64/0.59
19	1.16/1.44	0.38/0.54	1.31/2.04	0.72/0.67
20	0.44/0.80	0.19/0.39	2.28/2.00	0.74/0.67
21	1.78/——	0.67/——	1.72/2.32	0.60/0.69
22	1.44/——	0.58/——	1.62/2.48	0.54/0.67
23	1.54/1.73	0.51/0.53	2.43/1.82	0.77/0.54
24	1.41/——	0.56/——	1.60/2.31	0.52/0.64
Main channel border				
7	——/1.39	——/0.83	0.41/1.20	0.41/0.43
10	——/1.28	——/0.63	0.00/2.24	0.00/0.75
15	——/1.33	——/0.51	0.70/2.14	0.44/0.68
17	——/0.00	——/0.00	1.03/1.70	0.52/0.66
Frequency of occurrence of calculated measurements in selected ranges*:				
Side channels:				
$\bar{d}$: (1) 0.00-1.00	7		2	
(2) 1.01-2.99	29		44	
(3) 3.00+	0		0	
e: (1) 0.00-0.29		1		0
(2) 0.30-0.59		21		15
(3) 0.60+		14		31
Main channel borders:				
$\bar{d}$: (1) 0.00-1.00	1		3	
(2) 1.01-2.99	3		5	
(3) 3.00+	0		0	
e: (1) 0.00-0.29		1		1
(2) 0.30-0.59		1		4
(3) 0.60+		2		3

* Ranges: (1) Polluted waters of poor quality.
(2) Slight to moderately polluted waters of moderate quality.
(3) Nonpolluted waters of high quality.

Appendix D. Fishes of the Middle Mississippi River (Smith, Lopinot, and Pflieger, 1971).

Species*	Distribution and abundance	Importance as sport or commercial species
Bowfin family		
Bowfin	Widely distributed	Commercial
Drum family		
Freshwater drum	Widely distributed; common	Sport, commercial
Freshwater catfish family		
Black bullhead	Widely distributed, but not common	Sport, commercial
Yellow bullhead	Widely distributed, but not common	Sport, commercial
Blue catfish	Sporadically distributed	Sport, commercial
Channel catfish	Widely distributed; common	Sport, commercial
Flathead catfish	Widely distributed; common	Sport, commercial
Stonecat	Sporadically distributed	--
Tadpole madtom	Widely distributed, but not common	--
Freshwater eel family		
American eel	Sporadically distributed	Sport, commercial
Gar family		
Alligator gar	Rare	Commercial
Longnose gar	Widely distributed, but not common	Commercial
Shortnose gar	Widely distributed; common	Commercial
Herring family		
Alabama shad	Extremely rare	--
Gizzard shad	Widely distributed; common	--
Threadfin shad	Moderately common near the mouth of the Ohio River	--
Skipjack herring	Widely distributed; moderately common near the mouth of the Ohio River	--

Appendix D. Continued

Species*	Distribution and abundance	Importance as s or commercial s
Killifish family		
Blackstripe topminnow	Sporadically distributed	--
Lamprey family		
Chestnut lamprey	Widely distributed, but not common	--
Silver lamprey	Sporadically distributed	--
Livebearer family		
Mosquitofish	Widely distributed, but not common	--
Minnow and carp family		
Carp	Widely distributed; common	Sport, comme
Flathead chub	Widely distributed; common	--
Gravel chub	Sporadically distributed; rare	--
Sicklefin chub	Sporadically distributed	--
Silver chub	Widely distributed; common	--
Speckled chub	Widely distributed	--
Sturgeon chub	Sporadically distributed; rare	--
Bluntnose minnow	Widely distributed, but not common	--
Bullhead minnow	Widely distributed, but not common	--
Fathead minnow	Widely distributed, but not common	--
Plains minnow	Widely distributed; moderately common	--
Silverjaw minnow	Sporadically distributed	--
Silvery minnow	Widely distributed; common	--
Suckermouth minnow	Widely distributed, but not common	--
Western silvery minnow	Widely distributed, but not common	--
Bigmouth shiner	Sporadically distributed	--
Emerald shiner	Widely distributed; common	--
Ghost shiner	Widely distributed; common	--
Golden shiner	Widely distributed, but not common	--
Mimic shiner	Widely distributed; most common near the mouth of the Ohio River	--
Red shiner	Widely distributed; moderately common	--

Appendix D . Continued

Species*	Distribution and abundance	Importance as sport or commercial specie
River shiner	Widely distributed; common	--
Sand shiner	Widely distributed, but not common	--
Silverband shiner	Widely distributed; most common near the mouth of the Ohio River	--
Spotfin shiner	Rare	--
Spottail shiner	Sporadically distributed	--
Mooneye family		
Goldeye	Widely distributed; common	Commercial
Mooneye	Sporadically distributed	Commercial
Paddlefish family		
Paddlefish	Widely distributed, but not common	Commercial
Perch family		
Bluntnose darter	Sporadically distributed	--
Johnny darter	Sporadically distributed	--
Mud darter	Sporadically distributed	--
River darter	Widely distributed, but not common	--
Slenderhead darter	Rare	--
Logperch	Sporadically distributed	--
Sauger	Widely distributed; common	Sport
Walleye	Widely distributed, but not common	Sport
Silverside family		
Brook silverside	Widely distributed, but not common	--
Sturgeon family		
Pallid sturgeon	Extremely rare	Commercial
Shovelnose sturgeon	Widely distributed, but not common	Commercial
Sucker family		
Bigmouth buffalo	Widely distributed; moderately common	Commercial

Appendix D. Concluded

Species*	Distribution and abundance	Importance as sport or commercial species
Black buffalo	Widely distributed; moderately common	Commercial
Smallmouth buffalo	Widely distributed; moderately common	Commercial
Golden redhorse	Rare	Commercial
Shorthead redhorse	Widely distributed, but not common	Commercial
Silver redhorse	Rare	Commercial
Blue sucker	Sporadically distributed	Commercial
Quillback	Sporadically distributed	Commercial
River carpsucker	Widely distributed; common	Commercial
Sunfish family		
Largemouth bass	Widely distributed; common	Sport
Smallmouth bass	Rare	Sport
Black crappie	Widely distributed; common	Sport
White crappie	Widely distributed; common	Sport
Bluegill	Widely distributed; common	Sport
Green sunfish	Widely distributed, but not common	Sport
Longear sunfish	Moderately common near the mouth of the Ohio River	Sport
Orangespotted sunfish	Widely distributed; common	Sport
Warmouth	Widely distributed, but not common	Sport
Temperate bass family		
White bass	Widely distributed; common	Sport
Yellow bass	Sporadically distributed	Sport
Trout-perch family		
Trout-perch	Rare	--

*The common names correspond with the scientific names shown in Pflieger's (1971) text "A Distributional Study of Missouri Fishes."

Appendix E Fishes collected from the Middle Mississippi River (Johnson, et al., 1974; Ragland, 1974).

Species*	Waterways Experiment Station study: Side Channels	Waterways Experiment Station study: Main Channel Borders	Missouri Conservation Department study: Side Channels	Missouri Conservation Department study: Main Channel Borders
Bowfin	--	--	X	X
Freshwater drum	X**	X	X	X
Black bullhead	X	--	--	X
Yellow bullhead	X	--	X	--
Blue catfish	--	--	X	X
Channel catfish	X	X	X	X
Flathead catfish	--	--	X	X
American eel	--	--	X	X
Longnose gar	X	--	X	X
Shortnose gar	X	X	X	X
Spotted gar	X	--	--	--
Gizzard shad	X	X	X	X
Threadfin shad	X	X	--	--
Skipjack herring	X	X	X	X
Blackstripe topminnow	X	--	--	--
Northern studfish	X	--	--	--
Chestnut lamprey	--	--	X	X
Silver lamprey	--	--	X	--
Mosquitofish	X	X	X	X
Carp	X	X	X	X
Flathead chub	X	X	--	X
River chub	--	--	X	--
Silver chub	X	X	X	X
Speckled chub	--	--	--	X
Bluntnose minnow	--	--	X	--
Bullhead minnow	X	X	X	X
Fathead minnow	X	--	X	X
Plains minnow	X	X	X	X
Silvery minnow	X	X	--	X

Appendix E. Continued.

Species*	Waterways Experiment Station study: Side Channels	Waterways Experiment Station study: Main Channel Borders	Missouri Conservation Department study: Side Channels	Missouri Conservation Department study: Main Channel Borders
Suckermouth minnow	X	--	--	--
Western silvery minnow	X	X	--	--
Blacktail shiner	X	--	--	--
Emerald shiner	X	X	X	X
Ghost shiner	--	--	--	X
Golden shiner	X	X	--	--
Mimic shiner	X	--	--	--
Red shiner	X	X	X	X
River shiner	X	X	X	X
Sand shiner	X	X	--	--
Silverband shiner	X	--	X	X
Spotfin shiner	--	--	--	X
Spottail shiner	X	--	--	--
Goldeye	X	X	X	X
Mooneye	--	--	X	X
Paddlefish	--	--	X	X
Johnny darter	X	--	--	--
Logperch	X	--	--	--
Sauger	X	X	X	X
Walleye	X	--	X	X
Brook silverside	X	X	X	X
Shovelnose sturgeon	--	--	X	X
Bigmouth buffalo	X	--	X	X
Black buffalo	--	--	X	X
Smallmouth buffalo	X	X	X	X
Shorthead redhorse	--	--	X	X
River carpsucker	X	--	X	X
Largemouth bass	X	--	X	--
Smallmouth bass	X	--	--	--
Spotted bass	X	--	--	X

Appendix E. Concluded.

Species*	Waterways Experiment Station study		Missouri Conservation Department study	
	Side Channels	Main Channel Borders	Side Channels	Main Channel Borders
Black crappie	X	X	X	X
White crappie	X	X	X	X
Bluegill	X	X	X	X
Green sunfish	X	X	--	X
Longear sunfish	X	X	X	--
Orangespotted sunfish	X	--	X	X
Warmouth	X	--	--	X
White bass	X	X	X	X
Yellow bass	X	--	--	--

*The common names shown correspond to the scientific names cited in Pflieger's (1971) text "A Distributional Study of Missouri Fishes" and the American Fisheries Society's publication "A List of Common and Scientific Names of Fishes from the United States and Canada" (Bailey, 1970).

**An X signifies collection in the side channels or the main channel border habitat.

Appendix F. Rare and Endangered Plants of the Middle Mississippi River.

Common Name		Scientific Name	Status*
Liverworts			
1.	-	Microlepidozia sylvatica (Evans) Joerg.	E
2.	-	Bassania trilobata (L.) S. F. Gray	E
3.	-	Marsupella sullivantii (De Not) Evans	E
Mosses			
4.	Sword Moss	Bryoziphium norvegicum (Brid.) Mitt.	E
5.	-	Rhabdoweisia denticulata (Brid.) B.S.G.	E
6.	-	Syrrhopodon texanus Sull	E
7.	-	Philonotus capillaris Lindb.	E
8.	-	Isopterygium dischaceum (Mitt.) Jaeg. & Sauerb.	E
9.	-	Isopterygium muellerianum (Schimp) Jaeg. & Sauerb.	E
10.	-	Thamnobryum alleghaniense (C. Mull.) Nieuwl.	E
11.	-	Fontinalis disticha Hook. & Wils. ex Drumm	E
12.	-	Sphagnum capillaceum (Weiss) Schrank. var. tenerum (Sull. & Lesq. ex Sull.) Crum	E
Clubmosses			
13.	Fir Clubmoss	Lycopodium selago L. var. patens (Beauv.) Desv.	R
14.	Shining Clubmoss	Lycopodium lucidulum Michx. var. lucidulum	R
15.	Round-branched Ground Pine	Lycopodium obscurum L. var. dendroideum (Michx) D. C. Eatan	E
16.	Ground Cedar	Lycopodium tristachyum Pursh	SU
Adders-tongue			
17.	Cut-leaved Grape Fern	Botrychium dissectum Spreng. var. dissectum	R
Ferns			
18.	Hay Scented Fern	Dennstaedtia punctilobula (Michx.) Moore	R
19.	Spinulose Shield Fern	Dryopteris austriaca (Jacq.) Waynar var. spinulosa	R
Cypress			
20.	Fed cedar (Frogbit)	Juniperus virginiana var. crebra Fern. & Frisc.	R
21.	American Frogbit	Limnobium spongia (Bosc) Steud.	R
Grasses			
22.	Pale Manna Grass	Glyceria pallida (Torr.) Trin.	R
23.	Inland Salt Grass	Distichlis stricta (Torr.) Rydb.	R
24.	Creeping Brachiaria	Brachiaria platyphylla (Griseb.) Nash	R
25.	Joint Grass	Manisnris cylindrica (Michx.) Ktze	R
26.	Love Grass	Eragrostis reptans (Michx.) Nees	R
Sedges			
27.	Teasel-like Cyperus	Cyperus dipsaciformis Fern.	SU
28.	Shining Nutrush	Scleria nitida Willd.	R
29.	Slender Sedge	Carex praegracilis Boott	R
30.	Douglas' Sedge	Carex douglasii Boott	E
31.	Bellows-beaked Sedge	Carex physorphyncha Liebm.	E
32.	Graceful Sedge	Carex gracillima Schwein.	SU
33.	Schweinitz Sedge	Carex Schweinitzii Dewey	E
Arum			
34.	Arrow Arum	Peltandra virginica (L.) Schott & Endl.	R
Arrowroot			
35.	Thalia	Thalia dealbata Roscoe	R

Appendix F. (continued)

Common Name		Scientific Name	Status*
Orchids			
36.	Large Whorled Pogonia	Isotria verticillata (Willd.) Ra.	R
37.	Ladies Tresses	Spiranthes ovalis Lindl.	R
38.	Rattlesnake Plantain	Goodyera pubescens (Willd.) R. Br.	R
39.	Green Adder's Mouth	Malaxis unifolia Michx f. unifolia	R
Elms			
40.	Elms	Ulmus spp.	E*
Nettles			
41.	Nettle	Urtica chamaedryoides Pursh	SU
Buckwheats			
42.	Knotweed, Smartweed	Polygonum densiflorum Meisn	R
43.	Knotweed, Smartweed	Polygonum bicorne Raf	R
44.	Jointweed	Polygonella americana (Fisch. & Mey.) Small	R
Magnolia			
45.	Cucumber Tree	Magnolia acuminata L. var. acuminata	E
Fumitory			
46.	Corydalis	Corydalis halei (Small) Fern. & Schub.	E
Cashew			
47.	Poison Oak	Rhus toxicodendron L.	R
Holly			
48.	American Holly	Ilex opaca Ait.	E
Mallow			
49.	Clustered Poppy Mallow	Callirhoe triangulata (Leaven w.) Gray	R
50.	Sida	Sida elliotti T. & G.	E
Evening Primrose			
51.	Primrose Willow	Jussiaea leptocarpa Nutt.	SU
Ginseng			
52.	Wild Sarsaparilla	Aralia nudicaulis L.	SU
Heath			
53.	Azalea	Rhododendron roseum (Loisel.) Rehd. f. albidum Steyermark	R
Styrax			
54.	Snowbell	Styrax americana Lam. var. americana	R
Logania			
55.	Polypremum	Polypremum procumbens L.	SU
Phlox			
56.	Wild Sweet William	Phlox maculata L. var. pyramidalis (Smith)	R
Mints			
57.	Hedge Nettle	Stachys hyssopifolia Michx. var. ambigua Gray	SU
Figwort			
58.	Water Hyssop	Bacopa acuminata (Walt.) Robinson	SU
Broom-rape			
59.	Broom-rape	Orobanche ludoviciana Nutt.	E
Gourds			
60.	Silva Manso	Cayaponia grandifolia (T.& G.) Small	SU
Asters			
61.	White Prairie Aster	Aster commutatus (T. & G.) Gray	R
62.	Seashore Chamomile	Matricaria maritima L. var. agrestis (Knaf) Wilmott	SU
63.	Field Sow Thistle	Sonchus arvensis L.	SU
64.	Rattlesnake Root	Prenanthes racemosa Michx.	E

*The status of each species is indicated by the following symbols:
(1) R - rare, (2) E - endangered, or (3) SU - status undetermined

Appendix G. Rare and Endangered Vertebrates of the Middle Mississippi River.

Common Name	Scientific Name	Status* Illinois	Missouri	United States
Fish				
1. Alligator gar	Lepisosteus spatula Lacepede	R	R	-
2. Alabama shad	Alosa alabamae Jordan and Evermann	R	R	-
3. Sicklefin chub	Hybopsis meeki Jordan and Evermann	R	E	-
4. Sturgeon chub	Hybopsis gelida (Girard)	R	E	-
5. Pallid sturgeon	Scaphirhynchus albus (Forbes and Richardson)	R	E	-
6. Blue sucker	Cycleptus elongatus (Lesueur)	-	R	-
Amphibians & Reptiles				
7. Dark-sided Salamander	Eurycea longicauda melanopleura	R	-	-
8. Mole Salamander	Ambystoma talpoideum (Holbrook)	R	-	-
9. Eastern Spade foot Toad	Scaphiopus holbrooki (Harlan)	R	-	-
10. Illinois Chorus Frog	Pseudacris streckeri illinoensis Smith	R	SU	-
11. Western Bird-voiced Treefrog	Hyla avivoca avivoca Viosca	R	-	-
12. Green Treefrog	Hyla cinerea (Schneider)	R	-	-
13. Eastern Narrow Mouthed Toad	Gastrophryne carolinensis carolinensis (Holbrook)	R	-	-
14. Mud Turtle	Kinosternon subrubrum subrubrum (Lacepede) x hippocrepis Gray	R	-	-
15. Western Chicken Turtle	Deirochelys reticularia miaria Schwartz	-	R	-
16. Hieroglyphic Turtle	Pseudemys concinna hieroglyphica (Holbrook) x floridana hoyi (Agassiz)	R	-	-
17. Western Slender Glass Lizard	Ophisaurus attenuatus attenuatus Cope	R	R	-
18. Green Water Snake	Natrix cyclopion cyclopion (Dumeril, Bibron, and Dumeril)	R	R	-
19. Broad-banded Water Snake	Natrix fasciata confluens Blanchard	R	R	-
20. Northern Flathead	Tantilla gracilis hallowelli	R	-	-
21. Timber Rattlesnake	Crotalus horridus horridus	R	-	-
22. Eastern Massasauga Rattlesnake	Sistrurus catenatus catenatus (Rafinesque)	-	R	-
23. Canebrake Rattlesnake	Crotalus horridus atricaudatus Latreille	-	R	-
24. Hellbender	Cryptobranchus alleganiensis alleganiensis (Daudin)	E	SU	-
25. Alligator Snapping Turtle	Macroclemys temmincki (Troost)	E	R	-
26. Plains Hognose Snake	Heterodon nasicus Baird and Girard	R	E	-
27. Scarlet Snake	Cemophora coccinea (Blumenbach)	E	R	-
28. Northern Lined Snake	Tropidoclonion lineatum lineatum (Hallowell)	E	-	-
Birds				
29. Ruddy Duck	Oxyura jamaicensis	R	-	-
30. Hooded Mergaser	Lophodytes cucullatus (Linngeus)	R	-	-
31. Black Duck	Anas rubripes Brewster	R	-	-
32. Pintail	Anas acuta	R	-	-
33. Northern Shoveler	Anas clypeuta	R	-	-
34. Canvasback	Aythya valisinerig	R	-	-
35. Black Vulture	Coragyps atratus (Bechstein)	-	R	-
36. Marsh Hawk	Circus cyaneus hudsonius (Linnaeus)	R	-	-
37. Mississippi Kite	Ictinia mississippiensis (Wilson)	-	R	-
38. Snowy Egret	Egretta Thula	R	-	-

Common Name	Scientific Name	Status* Illinois	Missouri	United States
Birds (Continued)				
39. Little Blue Heron	Florida caerulea caerulea (Linnaeus)	R	-	-
40. Black-crowned Night Heron	Nycticorax nycticorax hoactli (Gmelin)	R	-	-
41. Wood Ibis or Wood Stork	Mycteria americana Linnaeus	R	-	-
42. Interior Least Tern	Sterna albifrons athalassos (Burleigh and Lowery)	R	R	-
43. Short-eared Owl	Asio flammeus flammeus (Pontoppidan)	R	-	-
44. Yellow-bellied Sapsucker	Sphyrapicus varius varius (Linnaeus)	R	-	-
45. Fish Crow	Corvus ossifragus Wilson	-	R	-
46. Brown Creeper	Certhia familiaris Linnaeus	R	-	-
47. Bewick's Wren	Thryomanes bewickii bewickii (Audubon)	R	-	-
48. Loggerhead Shrike	Lanius ludovicianus migrans Palmer	R	-	-
49. Swainson's Warbler	Limnothlypis swainsonii (Audubon)	R	R	-
50. Double-crested Cormorant	Phalacrocorax auritus auritus (Lesson)	E	E	-
51. Cooper's Hawk	Accipiter cooperii (Bonaparte)	E	E	-
52. Red-shouldered Hawk	Buteo lineatus lineatus (Gmelin)	E	R	-
53. Osprey	Pandion haliaetus carolinensis (Gmelin)	E	E	-
54. Peregrine Falcon	Falco peregrinus anatum (Bonaparte)	E	E	E
55. Southern Bald Eagle	Haliaeetus leucocephalus leucocephalus	E	-	E
56. Northern Bald Eagle	Haliaeetus leucocephalus leucocephalus	E	R	-
57. Anhinga or Water Turkey	Anhinga anhinga leucogaster (Vieillot)	E	E	-
58. Cliff Swallow	Petrochelidon pyrrhonota phrrhonota (Vieillot)	SU	-	-
59. Bank Swallow	Riparia riparia riparia (Linnaeus)	SU	-	-
Mammals				
60. Southeastern Shrew	Sorex longirostris Bachman	R	R	-
61. Southeastern Bat	Myotis austroriparius (Rhoads)	R	-	-
62. Keens Bat	Myotis Keenii (Merriam)	-	R	-
63. Hoary Bat	Lasiurus cinereus (Beauvois)	R	R	-
64. Swamp Rabbit	Sylvilagus acquaticus Bachman	-	R	-
65. Rice Rat	Oryzomys palustris (Harlan)	R	-	-
66. Eastern Woodrat	Neotoma floridana	R	-	-
67. Golden Mouse	Peromyscus nuttallii aureolus Audubon and Bachman	R	-	-
68. Meadow Jumping Mouse	Zapus hudsonius (Zimmerman)	R	-	-
69. Long-tailed Weasel	Mustela frenata Lichtenstein	-	R	-
70. Gray Bat	Myotis grisescens Howell	R	E	-
71. Indiana Bat	Myotis sodalis Miller and Allen	E	E	E
72. Eastern Big-eared Bat	Plecotus rafinesquii (Le Conte)	R	E	-
73. Western Big-eared Bat	Plecotus townsendi Cooper	-	E	-
74. Cotton Mouse	Peromyscus gossypinus (Le Conte)	E	-	-
75. Black Bear	Ursus americanus Pallus	-	E	-

Common Name			Status* Illinois	Missouri	United States
	Mammals (Continued)				
76.	River Otter	Lutra canadensis (Schreber)	R	E	-
77.	Bobcat	Lynx rufus (Schreber)	E	-	-

*The status of each species is indicated by the following symbols:
(1) R - rare, (2) E - endangered, or
(3) SU - status undetermined.

Source: United States Listed Endangered Fauna (U.S. Department of the Interior, 1974); Rare and Endangered Vertebrates of Illinois, Preliminary Draft (Illinois Nature Preserve Commission, 1971); Rare and Endangered Vertebrates of Illinois (Illinois Department of Transportation, 1975); Rare and Endangered Fish of Illinois (Lopinot and Smith, 1973); Rare and Endangered Species of Missouri (Missouri Department of Conservation and Soil Conservation Service, 1974); and A Survey of the Fauna and Flora Occuring in the Mississippi River Floodplain Between St. Louis, Missouri and Cairo, Illinois (U.S. Army Engineer Waterways Experiment Station, 1974).

Appendix G_1

Table 1.

Statistical Analysis of 1972-1973 Physiochemical and Biological Data from Side Channels in Middle Mississippi River

	Sampling Period											
	June 1972			September 1972			July 1973			Over Periods		
Variable	$\bar{X}$	SD	No. Obs.	$\bar{X}$	SD	No. Obs	$\bar{X}$	SD	No. Obs	$\bar{X}$	SD	Obs
Physiochemical (Surface):												
Temperature, °C	26.2	1.3	69	27.7	1.9	69	29.9	1.5	39	27.6	2.2	177
Dissolved Oxygen (DO), mg/ℓ	6.6	0.9	69	8.3	2.6	69	6.7	2.2	39	7.3	2.2	177
Turbidity, JTU	145.8	103.6	69	67.2	34.6	69	207.7	206.3	39	128.8	129.5	177
pH	7.7	0.3	69	7.8	0.3	69	7.9	0.3	39	7.8	0.3	177
Total Alkalinity, mg/ℓ	164.8	45.5	69	171.8	55.3	69	202.5	17.5	39	175.8	47.5	177
Physiochemical (Bottom):												
Temperature, °C	25.1	1.7	69	26.2	2.2	68	28.4	1.7	39	26.2	2.3	176
Dissolved Oxygen (DO), mg/ℓ	5.1	1.7	69	5.4	2.2	68	4.7	2.1	39	5.2	1.9	176
Turbidity, JTU	190.0	112.5	69	94.6	45.9	68	240.8	209.8	39	164.4	136.9	176
pH	7.6	0.4	69	7.6	0.3	68	7.7	0.3	39	7.6	0.3	176
Total Alkalinity, mg/ℓ	183.9	106.8	69	182.0	95.6	68	211.7	32.6	39	189.3	91.1	176
Benthos (no./m^2):												
Insecta	-	-	-	853.1	1068.8	69	151.9	225.0	38	603.8	929.4	107
Oligochaeta	-	-	-	1087.5	1240.6	69	286.9	369.4	38	803.1	1088.1	107
Crustacea	-	-	-	0.3	1.3	69	0.6	2.4	38	0.6	1.9	107
Pelecypoda	-	-	-	11.3	28.8	69	9.4	18.1	38	10.6	25.6	107
Hirudinea	-	-	-	0.4	1.6	69	0.1	1.0	38	0.6	1.3	107
Gastropoda	-	-	-	1.3	4.4	69	1.3	3.1	38	1.3	3.8	107
Total Density	-	-	-	1948.8	2048.1	69	451.3	407.5	38	1416.9	1807.5	107
Species Diversity, $\bar{d}$	-	-	-	1.44	0.58	69	1.44	0.78	38	1.44	0.65	107
Evenness Index, e	-	-	-	0.53	0.18	69	0.58	0.24	35	0.55	0.20	104
Number of Taxa	-	-	-	43.8	18.8	69	40.6	24.4	38	43.1	21.3	107
Phytoplankton (no./ℓ):												
Chlorophyta	2257.7	1889.9	69	1212.3	3301.6	64	32.6	29.7	23	1500.7	2570.4	156
Euglenophyta	2139.9	2054.5	69	1093.8	2692.1	65	67.4	77.9	23	1403.2	2314.5	157
Chrysophyta	3556.9	2481.4	69	1882.5	1545.5	64	276.7	290.9	23	2386.4	2249.3	156
Cyanophyta	419.2	501.1	69	227.5	266.5	66	0.0	0.0	23	278.1	399.1	158
Cryptophyta	843.5	2119.1	69	32.1	94.7	65	5.4	9.2	23	384.8	1458.5	157
Total Density	9217.2	6881.2	69	4471.7	5544.5	64	382.2	332.3	23	5967.7	6598.2	156
Species Diversity, $\bar{d}$	2.97	0.50	69	2.80	0.60	63	1.82	0.67	22	2.74	0.68	154
Evenness Index, e	0.79	0.10	69	0.80	0.12	63	0.78	0.21	22	0.79	0.13	154
Zooplankton (no./ℓ):												
Cladocera	5.1	5.4	69	7.7	11.1	64	1.0	2.3	22	5.63	8.31	155
Copepoda	11.2	8.9	69	10.1	8.5	64	3.4	3.7	22	9.67	8.58	155
Rotifera (adults)	22.1	39.4	69	26.9	32.1	64	3.7	7.6	22	21.4	34.2	155
Rotifera (eggs)	17.3	25.7	69	9.8	17.9	64	0.5	1.6	22	11.8	21.3	155
Protozoa	13.8	15.7	69	16.8	18.8	64	10.9	18.9	22	14.6	17.5	155
Total Density	69.5	67.5	69	71.3	60.2	64	19.5	19.5	22	63.2	62.1	155
Species Diversity, $\bar{d}$	2.30	0.51	69	2.11	0.55	64	0.91	0.76	22	2.02	0.73	155
Evenness Index, e	0.76	0.13	69	0.78	0.15	64	0.43	0.33	22	0.72	0.21	155
Fish (per six seine hauls):												
Total Fish	-	-	-	113.5	110.4	65	134.6	135.3	67	124.3	123.7	132
Total Young-of-Year (YOY)	-	-	-	81.1	97.3	65	128.9	135.4	67	105.3	120.1	132
Total Adult/Juvenile (A/J)	-	-	-	32.5	43.9	65	5.8	7.6	67	18.9	33.9	132
Forage Fish (YOY)	-	-	-	57.5	88.0	65	89.7	129.1	67	73.8	111.6	132
Commercial Fish (YOY)	-	-	-	1.81	3.0	65	19.5	23.9	67	10.8	19.2	132
Predator Fish (YOY)	-	-	-	0.0	0.0	65	0.3	0.6	67	0.2	0.4	132
Sport Fish (YOY)	-	-	-	22.5	38.2	65	19.9	27.1	67	21.2	32.9	132
Forage Fish (A/J)	-	-	-	31.2	43.9	65	3.8	5.0	66	17.4	33.9	131
Commercial Fish (A/J)	-	-	-	0.6	2.2	65	0.1	0.6	67	0.4	1.6	132
Predator Fish (A/J)	-	-	-	0.1	0.3	65	0.1	0.2	67	0.1	0.2	132
Sport Fish (A/J)	-	-	-	0.5	1.2	65	1.1	2.1	67	0.8	1.6	132
Species Diversity, $\bar{d}$	-	-	-	1.72	0.57	63	2.0	0.74	67	1.89	0.68	130
Evenness Index, e	-	-	-	0.62	0.17	63	0.63	0.20	67	0.62	0.18	130
Number of Taxa	-	-	-	7.3	2.5	65	10.2	3.2	67	8.8	3.3	132

NOTE: $\bar{X}$ = mean value
SD = standard deviation
No. obs = number of observations
- = indicates no sample taken

Appendix G_1

Table 2.

Statistical Analysis of 1972-1973 Physiochemical and Biological Data from River Border Areas in Middle Mississippi River

Variable	June 1972 $\bar{X}$	June 1972 SD	June 1972 No. Obs.	September 1972 $\bar{X}$	September 1972 SD	September 1972 No. Obs	July 1973 $\bar{X}$	July 1973 SD	July 1973 No. Obs	Over Periods $\bar{X}$	Over Periods SD	Over Periods No. Obs
Physiochemical (Surface):												
Temperature, °C	-	-	-	-	-	-	28.8	0.9	11	28.8	0.9	11
Dissolved Oxygen (DO), mg/ℓ	-	-	-	-	-	-	4.6	1.0	11	4.6	1.0	11
Turbidity, JTU	-	-	-	-	-	-	312.5	187.1	11	312.5	187.1	11
pH	-	-	-	-	-	-	7.8	0.2	11	7.8	0.2	11
Total Alkalinity, mg/ℓ	-	-	-	-	-	-	156.2	35.3	11	156.2	35.3	11
Physiochemical (Bottom):												
Temperature, °C	-	-	-	-	-	-	28.7	0.8	11	28.7	0.8	11
Dissolved Oxygen (DO), mg/ℓ	-	-	-	-	-	-	4.7	1.1	11	4.7	1.1	11
Turbidity, JTU	-	-	-	-	-	-	394.5	169.7	11	394.5	169.7	11
pH	-	-	-	-	-	-	7.8	0.2	11	7.8	0.2	11
Total Alkalinity, mg/ℓ	-	-	-	-	-	-	158.5	32.5	11	158.5	32.5	11
Benthos (no./m^2):												
Insecta	-	-	-	-	-	-	105.0	213.8	12	105.0	213.8	12
Oligochaeta	-	-	-	-	-	-	123.1	138.8	12	123.1	138.8	12
Crustacea	-	-	-	-	-	-	0.0	0.0	12	0.0	0.0	12
Pelecypoda	-	-	-	-	-	-	3.1	6.3	12	3.1	6.3	12
Hirudinea	-	-	-	-	-	-	0.0	0.0	12	0.0	0.0	12
Gastropoda	-	-	-	-	-	-	0.0	0.0	12	0.0	0.0	12
Total Density	-	-	-	-	-	-	231.3	295.0	12	231.3	295.0	12
Species Diversity, $\bar{d}$	-	-	-	-	-	-	1.00	0.75	12	1.00	0.75	12
Evenness Index, e	-	-	-	-	-	-	0.49	0.35	12	0.49	0.35	12
Number of Taxa	-	-	-	-	-	-	23.8	15.6	12	23.8	15.6	12
Phytoplankton no./ℓ):												
Chlorophyta	-	-	-	-	-	-	42.9	33.0	7	42.9	33.0	7
Euglenophyta	-	-	-	-	-	-	18.6	24.1	7	18.6	24.1	7
Chrysophyta	-	-	-	-	-	-	223.6	237.5	7	223.6	237.5	7
Cyanophyta	-	-	-	-	-	-	0.0	0.0	7	0.0	0.0	7
Cryptophyta	-	-	-	-	-	-	4.3	7.9	7	4.29	7.87	7
Total Density	-	-	-	-	-	-	289.3	282.3	7	289.3	282.3	7
Species Diversity, $\bar{d}$	-	-	-	-	-	-	2.30	0.50	7	2.30	0.50	7
Evenness Index, e	-	-	-	-	-	-	0.88	0.10	7	0.88	0.10	7
Zooplankton (no./ℓ):												
Cladocera	-	-	-	-	-	-	0.0	0.0	10	0.0	0.0	10
Copepoda	-	-	-	-	-	-	0.1	0.4	10	0.13	0.41	10
Rotifera (adults)	-	-	-	-	-	-	0.3	0.6	10	0.34	0.65	10
Rotifera (eggs)	-	-	-	-	-	-	0.0	0.0	10	0.0	0.0	10
Protozoa	-	-	-	-	-	-	9.3	20.7	10	9.3	20.7	10
Total Density	-	-	-	-	-	-	9.8	20.6	10	9.8	20.6	10
Species Diversity, $\bar{d}$	-	-	-	-	-	-	0.28	0.43	10	0.28	0.43	10
Evenness Index, e	-	-	-	-	-	-	0.23	0.34	10	0.23	0.34	10
Fish (per six seine hauls):												
Total Fish	-	-	-	36.2	28.0	19	63.7	37.5	6	42.8	32.1	25
Total Young-of-Year (YOY)	-	-	-	7.1	8.9	19	60.7	37.8	6	19.9	30.1	25
Total Adult/Juvenile (A/J)	-	-	-	29.0	25.9	19	3.0	2.0	6	22.8	25.2	25
Forage Fish (YOY)	-	-	-	7.0	8.9	19	38.0	33.4	6	14.4	21.8	25
Commercial Fish (YOY)	-	-	-	0.5	0.2	19	8.8	11.5	6	2.2	6.5	25
Predator Fish (YOY)	-	-	-	0.0	0.0	18	0.0	0.0	6	0.0	0.0	24
Sport Fish (YOY)	-	-	-	0.1	0.2	19	13.8	15.4	6	3.4	9.3	25
Forage Fish (A/J)	-	-	-	29.1	25.9	19	2.0	1.8	6	22.6	22.4	25
Commercial Fish (A/J)	-	-	-	0.0	0.0	19	0.0	0.0	6	0.0	0.0	25
Predator Fish (A/J)	-	-	-	0.0	0.0	18	0.2	0.4	6	0.1	0.2	24
Sport Fish (A/J)	-	-	-	0.0	0.0	19	0.8	1.6	6	0.2	0.8	25
Species Diversity, $\bar{d}$	-	-	-	0.84	0.5	19	1.78	0.40	6	1.06	0.64	25
Evenness Index, e	-	-	-	0.47	0.2	19	0.64	0.12	6	0.51	0.22	25
Number of Taxa	-	-	-	3.5	1.5	19	7.0	1.7	6	4.3	2.1	25

NOTE: $\bar{X}$ = mean value
SD = standard deviation
No. obs = number of observations
- = indicates no sample taken

Appendix H. CHEMICAL ANALYSIS OF SEDIMENTS AND WATER - SAMPLING PERIOD II
(Emge, et al., 1974)

Sediments

Concentration, % (Dry Weight Basis)

Side Channel Station No.	Volatile Solids	COD	Total Kjeldahl Nitrogen	Ammonia Nitrogen	Mercury	Zinc	Lead
3-2	6.27	6.05	0.182	0.017	<0.00001	0.0098	0.0021
3-3	5.91	5.44	0.151	0.010	0.00001	0.0132	0.0018
4-1	4.72	2.39	0.106	0.009	0.00001	0.0089	0.0020
4-2	2.80	1.41	0.069	0.006	<0.00001	0.0047	0.0016
4-3	5.62	4.99	0.126	0.011	<0.00001	0.0092	0.0015
5-1	3.36	3.13	0.086	0.008	<0.00001	0.0060	0.0018
5-2	6.26	6.19	0.183	0.011	0.00001	0.0097	0.0025
5-3	4.81	4.78	0.146	0.005	0.00001	0.0092	0.0029

Water

Side Channel Station No.	Volatile Solids mg/1	COD mg/1	Total Kjeldahl Nitrogen mg/1	Ammonia Nitrogen mg/1	Mercury µg/1	Zinc mg/1	Lead mg/1
3-2	96	35.0	0.8	0.0	1.8	0.03	0.01
3-3	74	25.3	1.0	0.0	0.8	0.03	0.01

Appendix I. **CHEMICAL ANALYSIS OF SEDIMENTS AND WATER - SAMPLING PERIOD III** (Emge, et al., 1974)

SEDIMENTS

S/C-Sta. #	COD mg/kg	NO_3 mg/kg	NO_2 mg/kg	TKN mg/kg	Total Phos mg/kg	Total Fe mg/kg	Sol FeO mg/kg	As mg/kg	Hg mg/kg	Pb mg/kg	Zn mg/kg	Cd mg/kg	Mn mg/kg	Volatiles 600°C mg/kg
3-3	31,911	<1.0	<1.0	1382	25	4,310	34	2.18	25.7	32	114	1.0	871	44,081
6-2	17,417	<1.0	<1.0	597	14	13,902	33	0.87	32.0	16	62	0.6	345	25,415
7-3	39,292	<1.0	<1.0	2242	37	4,860	45	2.56	42.5	49	193	1.6	1 038	56,764
15-3	41,312	<1.0	<1.0	1889	41	30,265	28	6.53	32.1	38	131	0.9	1213	59,470
20-3	19,914	<1.0	<1.0	1230	77	12,124	30	<0.02	25.2	15	50	0.4	417	27,798

WATER

S/C-Sta. #	COD mg/l	NO_3, N mg/l	NO_2, N mg/l	NH_4, N mg/l	TKN mg/l	Ferrous Iron mg/l	Total Iron mg/l	As mg/l	Hg mg/l	Pb mg/l	Zn mg/l	Cd mg/l	Mn mg/l	Total Phos mg/l
3-3	16.5	7.4	<0.001	0.1	1.0	<0.1	0.1	<0.02	1.9	<0.01	<0.001	<0.001	<0.1	1.7
7-3	17.8	4.2	0.049	<0.1	1.3	<0.1	<0.1	<0.02	1.5	<0.01	0.006	<0.001	<0.1	0.8
15-3	12.2	4.2	0.012	0.5	1.2	<0.1	0.4	<0.02	0.7	<0.01	<0.001	<0.001	0.8	1.5
20-3	15.7	3.5	<0.001	<0.1	0.8	<0.1	0.2	<0.02	1.2	<0.01	<0.001	<0.001	<0.1	1.2

Appendix J. MEAN VALUES AND NUMBER OF OBSERVATIONS OF PHYSICAL-CHEMICAL VARIABLES FOR DREDGED AND DISPOSAL SITES
MIDDLE MISSISSIPPI RIVER
SEPTEMBER 1973
(Solomon, *et al.*, 1974)

	Temperature, °C				Dissolved Oxygen, mg/l				pH			
	Surface		Bottom		Surface		Bottom		Surface		Bottom	
River Mile	Dredged Site	Disposal Site	Dredged Site	Disposal Site	Dredged Site	Disposal Site	Dredged Site	Disposal Site	Dredged Site	Disposal Site	Dredged Site	Disposal Site
49	24.8 (1)	24.6 (2)	25 (1)	24.5 (2)	5.3 (1)	5.6 (2)	5.6 (1)	5.5 (2)	7.5 (1)	7.3 (2)	7.3 (1)	7.4 (2)
57		25.0 (1)		25.0 (1)		6.2 (1)		6.2 (1)		7.4 (1)		7.4 (1)
61		25.2 (1)		25.2 (1)		6.2 (1)		6.0 (1)		7.4 (1)		7.6 (1)
65	25.0 (1)	25.0 (1)	25.0 (1)	25.0 (1)	6.3 (1)	6.3 (1)	6.4 (1)	6.2 (1)	7.4 (1)	7.5 (1)	7.4 (1)	7.4 (1)
90	25.0 (1)	25.0 (2)	25.0 (1)	25.0 (2)	5.8 (1)	5.8 (2)	5.7 (1)	5.8 (2)	7.3 (1)	7.2 (2)	7.4 (1)	7.3 (2)
97	25.0 (1)	25.5 (1)	25.0 (1)	25.0 (1)	6.6 (1)	6.8 (1)	6.6 (1)	6.5 (1)	7.4 (1)	7.4 (1)	7.4 (1)	7.4 (1)
102		26.0 (1)		25.9 (1)		6.8 (1)		6.9 (1)		7.3 (1)		7.6 (1)
107	24.0 (1)		24.0 (1)						7.3 (1)	7.4 (1)	7.4 (1)	7.6 (1)
110	24.0 (1)	25.0 (1)	24.0 (1)	25.0 (1)		7.4 (1)		6.8 (1)	7.3 (1)	7.5 (1)	7.4 (1)	7.5 (1)
116	26.6 (1)	26.7 (1)	26.4 (1)	26.5 (1)	7.9 (1)	8.1 (1)	7.6 (1)	7.8 (1)	7.6 (1)	7.6 (1)	7.6 (1)	7.5 (1)
122	26.5 (1)	25.8 (2)	25.9 (1)	25.8 (2)	8.4 (1)	7.6 (2)	7.9 (1)	7.8 (2)	7.4 (1)	7.4 (2)	7.5 (1)	7.4 (2)
125	25.0 (1)	26.0 (1)	24.8 (1)	26.0 (1)	4.6 (1)	6.2 (1)	6.1 (1)	6.2 (1)	7.4 (1)	7.5 (1)	7.3 (1)	7.5 (1)
135		26.3 (1)		26.3 (1)		6.3 (1)		6.2 (1)	7.4 (1)	7.6 (1)	7.5 (1)	7.5 (1)
155		25.9 (1)		26.0 (1)		6.4 (1)		6.2 (1)	7.3 (1)	7.6 (1)	7.4 (1)	7.8 (1)
179	25.8 (1)	26.2 (2)	26.0 (1)	26.6 (2)	7.2 (1)	6.8 (2)	7.0 (1)	6.6 (2)	7.5 (1)	7.6 (2)	7.2 (1)	7.4 (2)
Minimum	24.0	24.6	24.0	24.5	4.6	5.6	5.6	5.5	7.3	7.2	7.2	7.3
Maximum	26.6	26.7	26.4	26.6	8.4	8.1	7.9	7.8	7.6	7.6	7.6	7.8
Grand Mean	25.2	25.5	25.1	25.5	6.5	6.6	6.6	6.5	7.4	7.4	7.4	7.5

Note: Entries are mean value (number of observations).

Appendix J. Concluded

River Mile	Total Alkalinity, mg/ℓ: Surface, Dredged Site	Total Alkalinity, mg/ℓ: Surface, Disposal Site	Total Alkalinity, mg/ℓ: Bottom, Dredged Site	Total Alkalinity, mg/ℓ: Bottom, Disposal Site	Settleable Solids, mg/ℓ: Mid-Depth, Dredged Site	Settleable Solids, mg/ℓ: Mid-Depth, Disposal Site	Turbidity, JTU: Surface, Dredged Site	Turbidity, JTU: Surface, Disposal Site	Turbidity, JTU: Bottom, Dredged Site	Turbidity, JTU: Bottom, Disposal Site
49		192 (2)		195 (2)	0.5 (1)	0.6 (1)		145 (2)		162 (2)
57		194 (1)		194 (1)		0.5 (1)		170 (1)		185 (1)
61		195 (1)		194 (1)		0.4 (1)		80 (1)		110 (1)
65	192 (1)	191 (1)	192 (1)	191 (1)	0.2 (1)	0.3 (1)	95 (1)	95 (1)	95 (1)	105 (1)
90	186 (1)	185 (2)	189 (1)	186 (2)	0.3 (1)	0.5 (2)		172 (2)		180 (2)
97	183 (1)	185 (1)	190 (1)	189 (1)	0.2 (1)	0.1 (1)	104 (1)	88 (1)	102 (1)	109 (1)
102		175 (1)		177 (1)		0.4 (1)		160 (1)		240 (1)
107	169 (1)	186 (1)	170 (1)	178 (1)	0.4 (1)	0.4 (1)	190 (1)	170 (1)	185 (1)	150 (1)
110	178 (1)	183 (1)	182 (1)	178 (1)	0.2 (1)	0.3 (1)		152 (1)		140 (1)
116	201 (1)		203 (1)		0.6 (1)	0.4 (1)		180 (1)		185 (1)
122		203 (2)		200 (2)	0.3 (1)	0.3 (1)		113 (2)		164 (2)
125		208 (1)		211 (1)	0.8 (1)	0.5 (1)		180 (1)		72 (1)
135		211 (1)		203 (1)	1.0 (1)	0.3 (1)		92 (1)		92 (1)
155		211 (1)		212 (1)	0.2 (1)	0.2 (1)		101 (1)		87 (1)
179		210 (2)		208 (2)		0.5 (1)		90 (2)		94 (2)
Minimum	169	175	170	177	0.2	0.1	95	80	95	72
Maximum	201	211	203	212	1.0	0.6	190	180	185	240
Grand Mean	184.8	194.9	187.6	194.0	0.42	0.38	129.6	132.5	127.3	138.3

Note: Entries are mean value (number of observations).

Appendix K. MEAN VALUES, NUMBER OF OBSERVATIONS, AND STANDARD DEVIATIONS OF PHYSICAL-CHEMICAL VARIABLES FOR THREE RIVER BORDER AREAS
MIDDLE MISSISSIPPI RIVER
SEPTEMBER 1973
(Solomon, et al., 1974)

River Border Areas - River Mile	Temperature, °C						Dissolved Oxygen, mg/ℓ						pH					
	Surface			Bottom			Surface			Bottom			Surface			Bottom		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
65	24.7	9	0.3	24.7	9	0.2	6.5	9	0.5	6.5	9	0.5	7.4	3	0.1	7.5	3	0.1
100	25.3	8	0.4	25.4	8	0.1	5.9	8	0.1	5.8	8	0.4	7.4	3	0.1	7.4	3	0.1
129	26.0	9	0.0	25.9	9	0.2	6.3	9	0.3	6.2	9	0.2	7.4	3	0.1	7.4	3	0.1
Minimum	24.7			24.7			5.9			5.8			7.4			7.4		
Maximum	26.0			25.9			6.5			6.5			7.4			7.5		
Grand Mean	25.3	8.7	0.2	25.3	8.7	0.2	6.2	8.7	0.3	6.2	8.7	0.4	7.4	3	0.1	7.4	3	0.1

Note: Column 1 = mean value
Column 2 = number of observations
Column 3 = standard deviation

Appendix K. Concluded

River Border Areas - River Mile	Total Alkalinity, mg/ℓ						Settleable Solids, mg/ℓ			Turbidity, JTU					
	Surface			Bottom			Mid-Depth			Surface			Bottom		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
65	195.7	3	0.6	196.3	3	3.2	0.2	1		87.7	7	8.5	93.3	3	12.6
100	178.7	3	8.1	180.7	3	8.1	0.5	1		72.1	7	11.9	107.0	3	30.4
129	192.3	3	1.4	195.7	3	5.0	0.5	1		124.2	9	12.9	147.3	3	6.4
Minimum	178.7			180.7			0.2			72.1			93.3		
Maximum	195.7			196.3			0.4			124.2			147.3		
Grand Mean	188.9	3	3.4	190.9	3	5.4	0.4	1		94.7	7.7	11.1	115.9	3	16.5

Note: Column 1 = mean value

Column 2 = number of observations

Column 3 = standard deviation

Appendix L.

CHEMICAL ANALYSIS OF WATER SAMPLES COLLECTED FROM SELECTED DREDGED SITES MIDDLE MISSISSIPPI RIVER, SEPTEMBER 1973

(Solomon, et al., 1974)

River Mile	Water Analysis, mg/ℓ																	
	COD	NO_3,N	NO_2,N	NH_4,N	TKN	Arsenic	Total P	Total Fe	Ferrous Fe	Mn	Hg*	Pb	Cd	Zn	Phenol	Cyanide	Pesticides (Organo-chlorides)	
179	8.0	1.3	0.008	<0.1	1.2	<0.02	3.5	4.1	0.3	0.3	0.8	<0.01	<0.001	<0.001	<0.004	<0.003	no measurabl concentratio	
155	8.7	0.1	<0.001	<0.1	0.3	<0.02	1.8	6.9	<0.1	0.7	1.2	<0.01	<0.001	<0.001	<0.004	<0.003	"	"
125	6.9	1.0	0.021	0.1	0.8	<0.02	<0.1	<0.1	<0.1	<0.1	2.6	<0.01	<0.001	<0.001	--	--	"	"
110	7.5	1.6	0.031	<0.1	1.2	<0.02	<0.1	6.1	<0.1	0.3	12.9	<0.01	<0.001	0.008	--	--	"	"
65	7.3	2.9	0.010	<0.1	0.7	<0.02	0.5	1.5	<0.1	0.1	1.8	<0.01	<0.001	0.002	--	--	"	"
Illinois Criteria[26] (mg/ℓ)	-	-	-	1.5	-	1.0	-	1.0	-	1.0	0.0005	0.1	0.05	1.0	0.1	0.025		

*µg/ℓ

Appendix M. CHEMICAL ANALYSIS OF SEDIMENT SAMPLES COLLECTED FROM SELECTED DREDGED SITES MIDDLE MISSISSIPPI RIVER, SEPTEMBER 1973 (Solomon, et al., 1974)

	Sediment Analysis (mg/kg)*																			
River Mile	COD	NO_3,N	NO_2,N	NH_4,N	TKN	Arsenic	Total P	Total Fe	Ferrous Fe	Mn	Hg**	Pb	Cd	Zn	Phenol	Cyanide	Volatile Solids	Pesticides (Organo-chlorides)		
179	3,280	<1.0	<1.0	--	80.0	<0.2	6.0	3,150	<0.1	80.0	1.6	3.0	<0.1	15.0	0.04	0.03	3797	no measurabl concentratic		
155	983	<1.0	<1.0	--	36.0	<0.2	3.0	2,524	<0.1	43.0	1.9	1.0	<0.1	10.0	0.04	0.03	3491	" "		
125	2,126	<1.0	<1.0	—	101.0	<0.2	8.0	2,183	<0.1	42.0	2.4	2.0	<0.1	8.0	--	--	2808	" "		
110	1,180	<1.0	<1.0	—	40.0	<0.2	2.0	3,571	<0.1	61.0	1.0	3.0	<0.1	18.0	--	—	4002	" "		
EPA Criteria %(Dry wt. Basis)	5.0	—	—	—	0.10	—	—	—	—	—	0.0001	0.005	—	0.005	—	—	6.0			

*To convert mg/kg to %(dry wt. basis) multiply by 1.0×10^{-4}

**µg/kg

APPENDIX M_1

U. S. EPA REGION IX DREDGED MATERIAL DISPOSAL CRITERIA

Parameter	Maximum Percent Dry Weight
Volatile Solids	--
Chemical Oxygen Demand	--
Total Kjeldahl Nitrogen	--
Oil and Grease	--
Mercury	0.00005
Lead	0.0050
Zinc	0.0075
Cadmium	0.0002
Copper	0.0050

Source: Lee and Plumb, 1974

APPENDIX M_1

CRITERIA FOR DETERMINING ACCEPTABILITY OF DREDGED MATERIAL DISPOSAL INTO OPEN WATERS

Parameter	Units	Lightly Polluted		Heavily Polluted	
		Mean	Range	Mean	Range
Total Volatile Solids	Percent	2.9	0.7 - 5.0	19.6	10.2 - 49.3
Chemical Oxygen Demand	g/Kg	21	3 - 48	177	39 - 395
Kjeldahl Nitrogen	g/Kg	0.55	0.01 - 1.31	2.64	0.58 - 6.80
Total Phosphorus	g/Kg	0.58	0.24 - 0.95	1.06	0.59 - 2.55
Grease and Oil	g/Kg	0.56	0.11 - 1.31	7.15	1.38 - 32.1
Initial Oxygen Demand	g/Kg	0.50	0.08 - 1.24	2.07	0.28 - 4.65
Sulfides	g/Kg	0.14	0.03 - 0.51	1.70	0.10 - 3.77
Redox Potential	MV	+0.05	-0.18 - +0.41	-0.13	-0.22 - +0.11

Source: Lee and Plumb, 1974

Appendix N. Monthly Averages of Water Quality Data from the Mississippi River at East St. Louis, Illinois (River Mile 192.1) Taken by the U. S. Geological Survey from October 1971 to September 1972. (Concentrations in mg/l unless otherwise stated)(U. S. Geological Survey, 1972)

Date	Dissolved Sodium	Dissolved Potassium	Dissolved Chlorides	Dissolved Fluoride	Dissolved Nitrate	Dissolved Ammonia Nitrogen	Organic Nitrogen	Dissolved Phosphorus	Total Phosphorus	Methylene Blue Active Substance	Hardness (Ca and Mg)	Alkalinity as $CaCO_3$
Oct.			27		0.70	0.00	0.43	0.16	0.26	0.06	231	162
Nov.			28		0.50	0.02	0.82	0.12	0.40	0.05	225	156
Dec.			30		4.10	0.92	0.25	0.10	0.25	0.08	215	144
Jan.	16	3.6	29	0.2	4.10	0.63	0.33	0.12	0.15	0.07	285	177
Feb.			40		2.70	0.50	0.74	0.15	0.29	0.08	156	192
Mar.			38		1.80	0.01	1.70	0.15	0.29	0.10	276	160
Apr.			30		4.50	0.00	1.30	0.21	0.24		239	146
May			31			0.12	0.51				242	154
June	15	3.6	30	0.4	2.70	0.04	0.55	0.15		0.07	260	170
July	16	4.9	30	0.3	5.00	0.00	0.55	0.30	0.37	0.10	271	171
Aug.			23		3.95	0.00	0.62	0.20	0.76	0.04	224	161
Sept.			29	0.3	3.20	0.00	0.34	0.18	0.35	0.06	226	155

Appendix N. Concluded

Date	Specific Conductance (Micromhos)	pH	Color (Platinum Cobalt Units)	Turbidity	Temperature (Deg. C.)	Chemical Oxygen Demand	Biological Oxygen Demand	Dissolved Oxygen	Percent Saturation	Immediate Coliform (Col. per 100 ml.)	Fecal Coliform (Col. per 100 ml.)
Oct.	518	8.8	25	72	21.4	23.2	1.6	7.9	90.2	40200	
Nov.	420	8.0	28	110	12.1	28.7	2.2	8.6	84.7	20625	
Dec.	380	7.9	34	325	6.4	29.0	3.9	10.5	88.5	45000	
Jan.	520	8.0	37	135	4.6	31.5	3.6	11.1	86.2	3400	
Feb.	560	8.0	36	54	3.9		2.9	10.0	77.0	19800	
Mar.	520	7.8	36	269	8.2		5.6	9.6	81.2	14500	
Apr.	474	7.9	33	290	11.9		2.9	8.0	75.2	8250	
May	470	8.0	30	137	14.6		2.0	6.2	74.5	16600	
June	525	7.8	28	175	23.7		1.3	5.1	60.0	29500	
July	544	7.9	29	89	25.8		1.8	5.0	60.0	65000	
Aug.		7.7	29	186	26.5	13.0	0.6	5.4	66.7	55000	1600
Sept.	500	7.8	32	186	24.2		1.0	6.0	69.0	50000	

Appendix O. Continued

Monthly Averages of Water Quality Data from the Mississippi River at Cape Girardeau, Missouri (River Mile 54.3) Taken by the U.S. Geological Survey from October 1971 to September 1972 (Concentrations in mg/l unless otherwise stated)

Date	Dissolved Chlorides	Dissolved Fluoride	Dissolved Nitrate	Dissolved Ammonia Nitrogen	Organic Nitrogen	Dissolved Phosphorus	Total Phosphorus	Methylene Blue Active Substances	Dissolved Solids	Hardness (Ca,Mg)	Non-Carbonate Hardness
Oct.		0.0	0.90	0.00	0.68	0.10	0.14	0.15	380	225	65
Nov.		0.3	0.81	0.00	0.42	0.00	0.23	0.03	340	206	51
Dec.		0.2	0.80	0.15	1.40	0.05	0.22	0.05	337	189	43
Jan.		0.1	3.20	0.22	0.64	0.11	0.52	0.02	291	219	50
Feb.		0.3	1.10	0.00	1.10	0.12	0.18	0.10	410	266	82
Mar.		0.3	1.20	0.47	0.82	0.14	0.31	0.14	325	209	52
Apr.	24	0.0	2.00	0.01	1.50	0.14	0.35	0.14	290	190	48
May	22	0.2	0.14	0.02	0.66	0.08	0.18	0.05	263	193	44
June	23	0.5	2.00	0.04	0.76	0.11	0.11	0.08	327	232	68
July	22	0.2	1.40	0.01	0.02	0.25	0.82	0.05	315	226	52
Aug.	16	0.4	1.20	0.08	0.49	0.21	0.42	0.05	313	210	44
Sept.	19	0.3	1.70	0.02	0.72	0.15	0.82	0.06	280	198	42

Appendix O. Continued

Monthly Averages of Water Quality Data from the Mississippi River at Cape Girardeau, Missouri (River Mile 54.3) Taken by the U.S. Geological Survey from October 1971 to September 1972 (Concentrations in mg/l unless otherwise stated)

Date	Alkalinity (as Ca Co_3)	Specific Conductance (Miromhos)	pH	Color (Platinum Cobalt Units)	Turbidity	Temperature (Deg. C.)	Chemical Oxygen Demand	Biological Oxygen Demand	Dissolved Oxygen	Percent Saturation
Oct.	162	629	7.8	16	80	19.9	20	2.8	6.2	68
Nov.	152	539	7.8	21	145	10.6	22	2.9	8.6	78
Dec.	142	489	7.8	31	285	5.4	41	3.4	13.3	86
Jan.	160	548	8.0	28	188	2.5	29	3.2	10.6	75
Feb.	185	613	7.7	26	180	1.5	16	3.2	11.7	85
Mar.	157	509	7.7	27	295	7.2	27	4.4	9.9	82
Apr.	138	436	7.7	24	316	11.6	30	3.2	8.7	78
May	141	444	7.7	21	325	18.1	26	4.3	6.8	69
June	159	558	7.7	23	220	24.5	33	2.0	5.8	68
July	165	520	7.7	10	208	27.3	33	1.4	5.4	70
Aug.	155	490	7.7	18	230	27.6	18	1.0	5.5	70
Sept.	153	470	7.7	30	260	24.5	37	1.1	4.8	54

Appendix O. Concluded

Monthly Averages of Water Quality Data from the Mississippi River at Cape Girardeau, Missouri (River Mile 54.3) Taken by the U.S. Geological Survey from October 1971 to September 1972 (Concentrations in mg/l unless otherwise stated)

	Fecal Coliform (Col. per 100ml)	Streptococci (Col. per 100ml)
Date		
Oct.	79000	75
Nov.	1600	4400
Dec.		
Jan.	2300	3800
Feb.	800	2000
Mar.	100	220
Apr.	1000	750
May	1000	850
June	5000	600
July	8600	3600
Aug.	3000	2000
Sept.	8500	600

Appendix P. Seasonal chemical and physical characteristics of the Liberty, Ft. Chartres, and Osborne side channels and adjacent main channel border areas of the Mississippi River, 1972-1973 (Ragland, 1974)

	Secchi disk transparency (cm)		Platinum wire turbidity (mg/l)		Specific conductance (micromhos)		Total alkalinity (mg/l)		pH		Water temperature at surface (°C)		Water temperature at bottom (°C)		Dissolved oxygen at surface (mg/l)		Dissolved oxygen at bottom (mg/l)	
Study area	Side chan.	Main chan. border	Side chan.	Main chan. border	Side chan.	Main chan. border	Side chan.	Main chan. border	Side chan.	Main chan. border	Side chan.	Main chan. border	Side chan.	Main chan. border	Side chan.	Main chan. border	Side chan.	Main chan. border
Liberty																		
Summer	15.2	15.2	138	150	445	460	46	64	8.0	8.0	26.4	26.6	25.5	26.6	10.0	10.0	10.0	10.0
Fall	11.4	10.2	180	160	485	455	180	120	8.3	7.9	20.5	20.0	20.0	20.0	6.0	8.0	8.0	8.0
Winter	5.1	5.1	800	700	315	390	40	48	7.0	7.0	0.6	1.1	1.1	1.1	13.0	14.0	13.0	13.0
Spring	3.8	5.1	750	700	330	315	10	15	7.7	7.8	15.5	16.1	15.5	16.1	11.0	11.5	10.5	10.5
Station average	8.9	8.9	467	428	394	405	69	62	7.5	7.7	15.8	16.1	15.5	16.1	10.0	11.0	10.5	10.5
Ft. Chartres																		
Summer	34.3	12.7	110	205	475	455	62	125	8.3	7.9	29.4	27.8	22.2	27.5	15.0	10.5	9.0	9.5
Fall	20.3	8.9	75	250	470	530	180	140	8.3	8.3	21.6	20.0	19.7	20.0	6.0	5.0	6.0	6.0
Winter	25.4	15.2	88	230	460	550	75	78	7.8	7.8	2.2	1.7	2.8	1.9	14.0	14.0	12.0	13.0
Spring	6.4	5.1	600	500	360	320	20	10	7.8	7.8	16.9	16.6	16.6	16.9	9.5	10.5	10.5	10.0
Station average	21.6	10.2	218	296	441	464	84	88	8.0	8.0	17.5	16.6	15.3	16.6	11.0	10.0	9.5	9.5
Osborne																		
Summer	22.9	12.7	160	188	455	475	85	79	8.3	7.9	28.9	27.2	27.2	27.2	13.5	9.5	10.5	9.5
Fall	14.0	12.7	160	150	460	460	140	100	8.0	7.9	19.1	18.9	18.9	18.9	8.0	6.0	9.0	8.0
Winter	14.0	14.0	140	140	480	495	140	50	7.8	7.7	1.4	2.2	1.4	1.7	14.0	12.0	14.0	12.0
Spring	6.4	3.8	450	700	400	250	30	20	8.0	8.0	16.4	16.9	16.6	16.9	10.5	12.0	11.0	11.0
Station average	14.0	10.2	228	294	449	420	99	62	8.0	7.9	16.4	16.4	16.1	16.1	11.5	10.0	11.0	10.0
All stations																		
Summer	24.1	14.0	136	181	458	463	64	89	8.2	7.9	28.3	27.2	25.0	27.2	13.0	10.0	10.0	9.5
Fall	15.2	10.2	138	187	472	482	167	120	8.2	8.0	20.5	19.7	19.4	19.7	6.5	6.5	7.5	7.5
Winter	14.8	11.4	343	357	418	478	85	59	7.5	7.5	1.4	1.7	1.7	1.7	13.5	13.5	13.0	12.5
Spring	5.5	5.1	600	633	363	295	20	15	7.8	7.9	16.4	16.6	16.4	16.6	10.5	11.5	10.5	10.5
Grand average	14.8	10.2	304	340	428	430	84	71	7.9	7.8	16.6	16.4	15.5	16.4	11.0	10.5	10.0	10.0

Appendix Q. Public Notice of Channel Maintenance Dredging, Mississippi River Between Cairo, Illinois, and the Mouth of the Missouri River

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

LMSOD 1-1

16 September 1974

PUBLIC NOTICE OF CHANNEL MAINTENANCE DREDGING

1. Dredging Required. It is necessary that this District perform channel maintanance dredging in the Mississippi River between Cairo, Illinois and the mouth of the Missouri River. Dredging is required to maintain a project depth of nine feet within this reach. The attached project maps indicate all known and anticipated dredging sites as well as proposed dredged material disposal areas. Based on historical records, approximately 30 locations annually will require to be dredged. Dredging will be undertaken at those shoals which will afford a channel depth less than project dimensions to prevent a partial or total cessation of barge traffic on the Upper Mississippi River.

2. Federal Law and Regulations Applicable to the Proposed Dredging and Spoil Operation. Section 404, Public Law 92-500 (33 USC 1344) authorizes the Secretary of the Army, acting through the Chief of Engineers, to issue permits, after notice and opportunity for public hearings, for the discharge of dredged material into navigable waters at specified disposal sites. The selection of disposal sites will be in accordance with guidelines developed by the Administrator of the Environmental Protection Agency in conjunction with the Secretary of the Army. In accordance with regulations promulgated by the Secretary of the Army, 33 CFR 209.145, dredging to be performed by the Corps of Engineers will be subject to public review procedures that are followed in processing applications for Section 404 permits. The purpose of this notice is to inform interested parties of our dredging operations and to solicit comments.

3. Description of Authorized Channel Dimensions and Brief Account of Dredging Practices.

a. Authorized Project. The existing Mississippi River Navigation Project was authorized by the River and Harbor Act of 21 January 1927, Rivers and Harbors Commission Document No. 9, 69th Congress, Second Session, and 3 July 1930, Rivers and Harbors Commission Document No. 12, 70th Congress, First Session. The project provides for obtaining and maintaining a minimum channel depth of not less than nine feet, a minimum width of not less than 300 feet at low water, with additional width in bends from the mouth of the Ohio River to northern boundary of the City of St. Louis, and a minimum width of not less than 200 feet, with additional width in the bends from St. Louis to mouth of the Missouri River.

b. Dredging Practices. In order to provide authorized channel dimensions in the Mississippi River between Cairo, Illinois and the mouth of the Missouri, dredging has been required each year since 1930. In 1962, the peak year for dredging, 7 million cubic yards of bed material were removed from the channel at 37 dredging locations. During an average dredging season, approximately 4½ million cubic yards of material are removed from the channel at 26 locations. Channel dredging is performed by a hydraulic pipeline dredge that agitates and momentarily suspends the shoal material by means of water jets or a cutterhead, permitting the material to be drawn into the intake line and dredge so that it can be conveyed through 200 - 3000 feet of discharge line to an open water disposal site.

4. Description of Estimated Type and Composition of Deposits to be Dredged. Material dredged from the navigation channel between Cairo, Illinois and the mouth of the Missouri River generally consists of newly laid deposits containing five percent coarse gravel, ten percent pea gravel and 85 percent sand and silt. During the period November 1971 through October 1972, samples of material to be dredged from the navigation channel were obtained at 11 locations downstream of St. Louis. The samples were tested for concentrations of volatile solids, chemical oxygen demand, total Kjeldahl nitrogen, oil and grease, mercury, lead and zinc. None of the parameters tested were found to exceed pollution limits recommended by the Environmental Protection Agency. In September 1973, sediments at 15 sites with prior histories of maintenance dredging and disposal operations were sampled and tested. No significant quantities of heavy metals, organochloride, pesticides, or other toxic chemicals were found in sediment samples collected from the channel.

5. Estimated Quantities of Dredge Material at Each Site, Existing Use of Properties Adjacent to the Proposed Disposal Areas, and an Estimate of Related Dredging and Disposal by Others. An exhibit of known anticipated dredging locations and other pertinent data relating thereto is attached. Dredging is normally performed during a period beginning in July and continuing through January of the following year.

6. Environmental Impact Statement. All known environmental effects that result from this District's total channel maintenance dredging program in the Mississippi River between Cairo, Illinois and the mouth of the Missouri are being addressed in an Environmental Impact Statement under preparation. It is expected that a draft impact statement will be available for information and comments by November 1974.

7. Coordination With Other Federal and State Agencies. The following is a list of principal Federal and State agencies with whom these dredging operations are being coordinated:

U.S. Coast Guard Second District, St. Louis, Missouri
U.S. Environmental Protection Agency, Regions V and VII
U.S. Fish and Wildlife Service, Twin Cities, Minnesota and Kansas City, Missouri
U.S. Army Engineers Waterways Experiment Station, Vicksburg, Mississippi
Missouri Department of Natural Resources, Jefferson City, Missouri
Missouri Clean Water Commission, Jefferson City, Missouri
Missouri Department of Conservation, Jefferson City, Missouri
Illinois Environmental Protection Agency, Springfield, Illinois
Illinois Department of Conservation, Springfield, Illinois
Upper Mississippi River Basin Commission, Twin Cities, Minnesota

8. Supplemental Information. The proposed disposal sites have not previously been designated for such use by the Secretary of the Army or Administrator, Environmental Protection Agency. Currently, no spoil areas on the Mississippi River between Cairo, Illinois and the mouth of the Missouri, have been previously "specified" as provided by Section 404, Public Law 92-500.

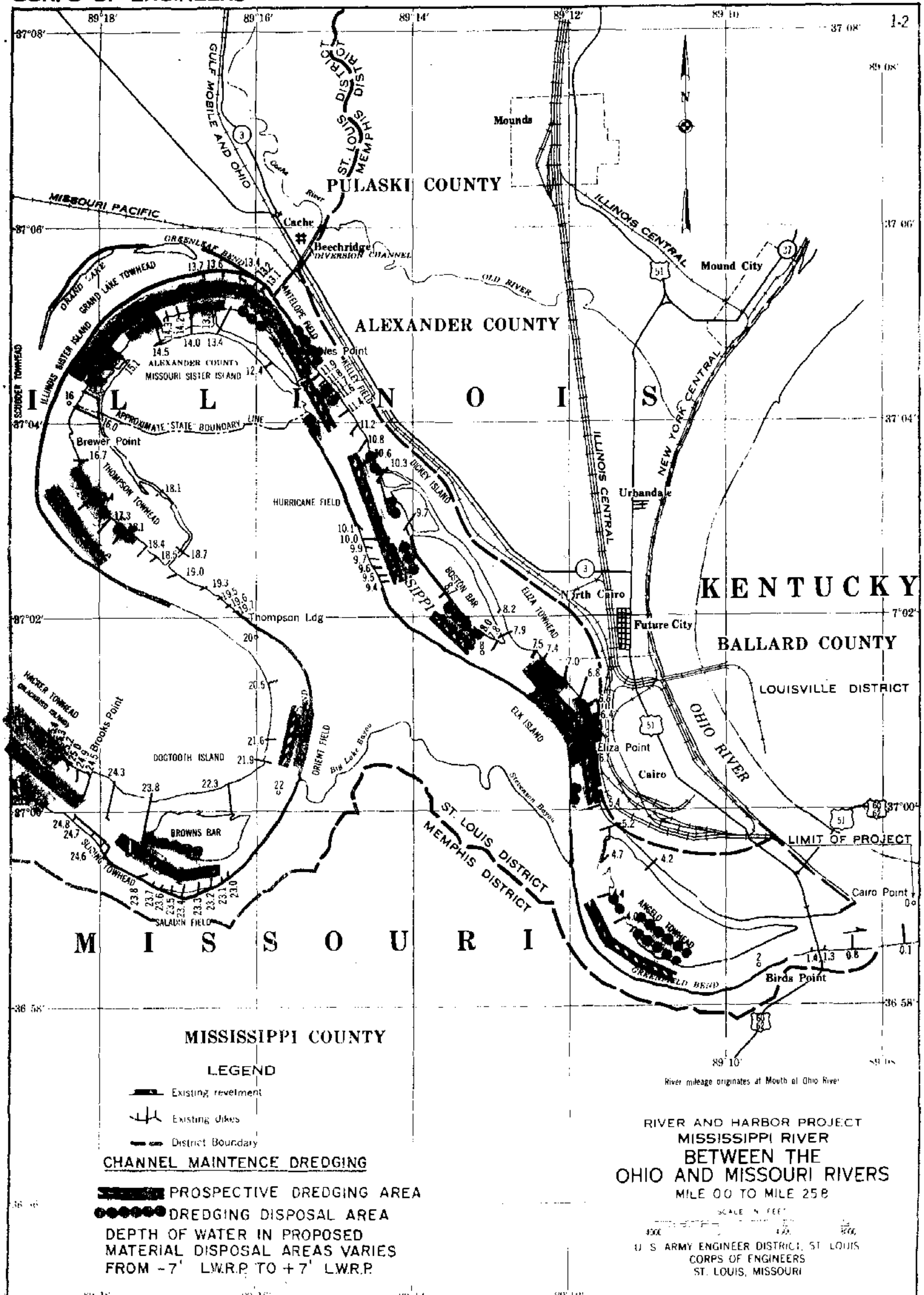
9. Designation of the proposed disposal sites for dredged material associated with this Federal project shall be made through the application of guidelines promulgated by the Administrator EPA in conjunction with the Secretary of the Army. If these guidelines alone prohibit the designation of these proposed disposal sites, any potential impairment to the maintenance of navigation, including any economic impact on navigation and anchorage which would result from the failure to use these disposal sites, will also be considered.

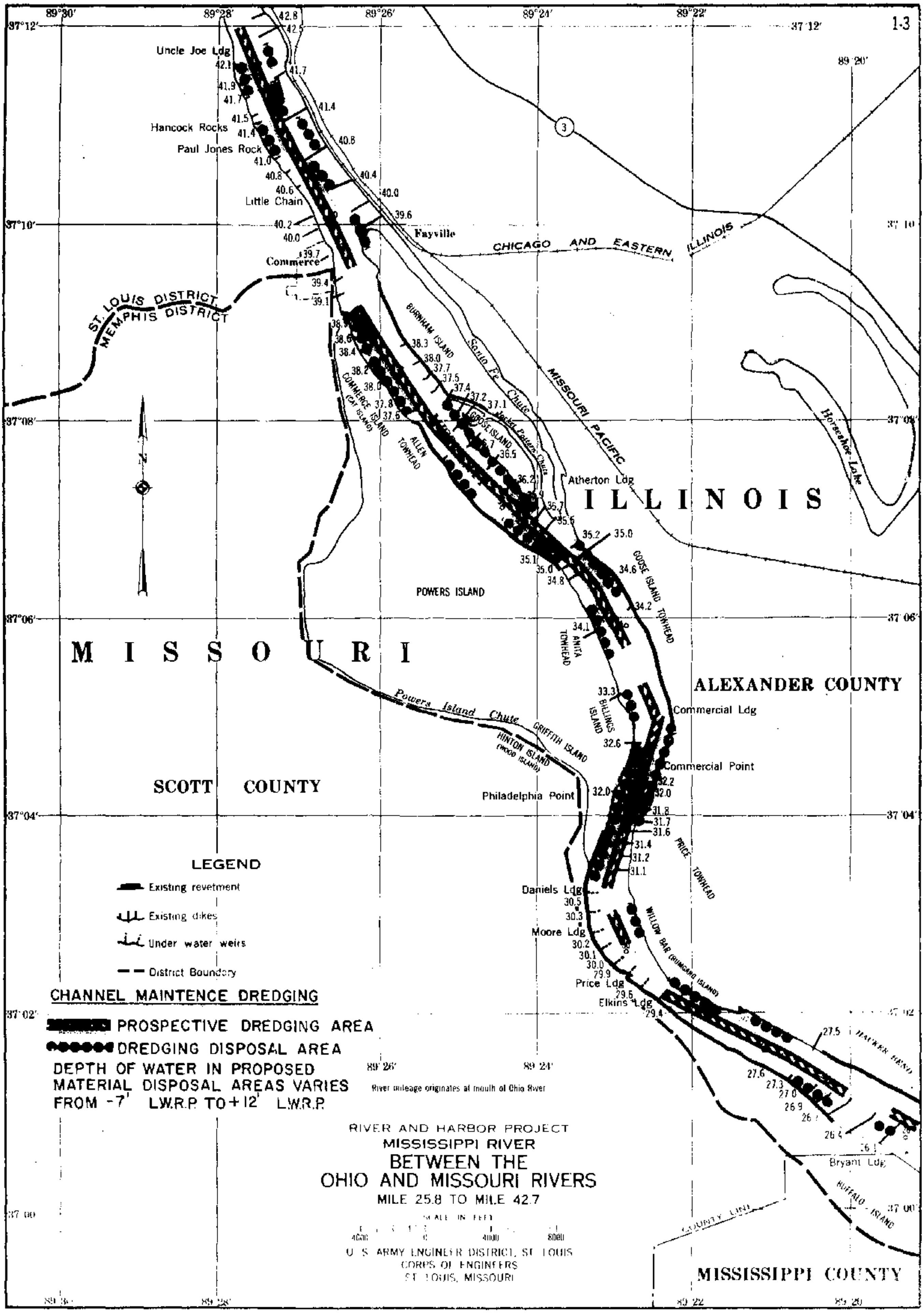
10. All interested parties are invited to submit to this office written facts, arguments or objections to the proposed disposal sites on or before 18 October 1974. Any person who has an interest which may be affected by the disposal of this dredged material may request a public hearing. The request must be submitted in writing to the District Engineer within 30 days of the date of this notice and must clearly set forth the interest which may be affected and the manner in which the interest may be affected by this activity.

Thorwald R. Peterson

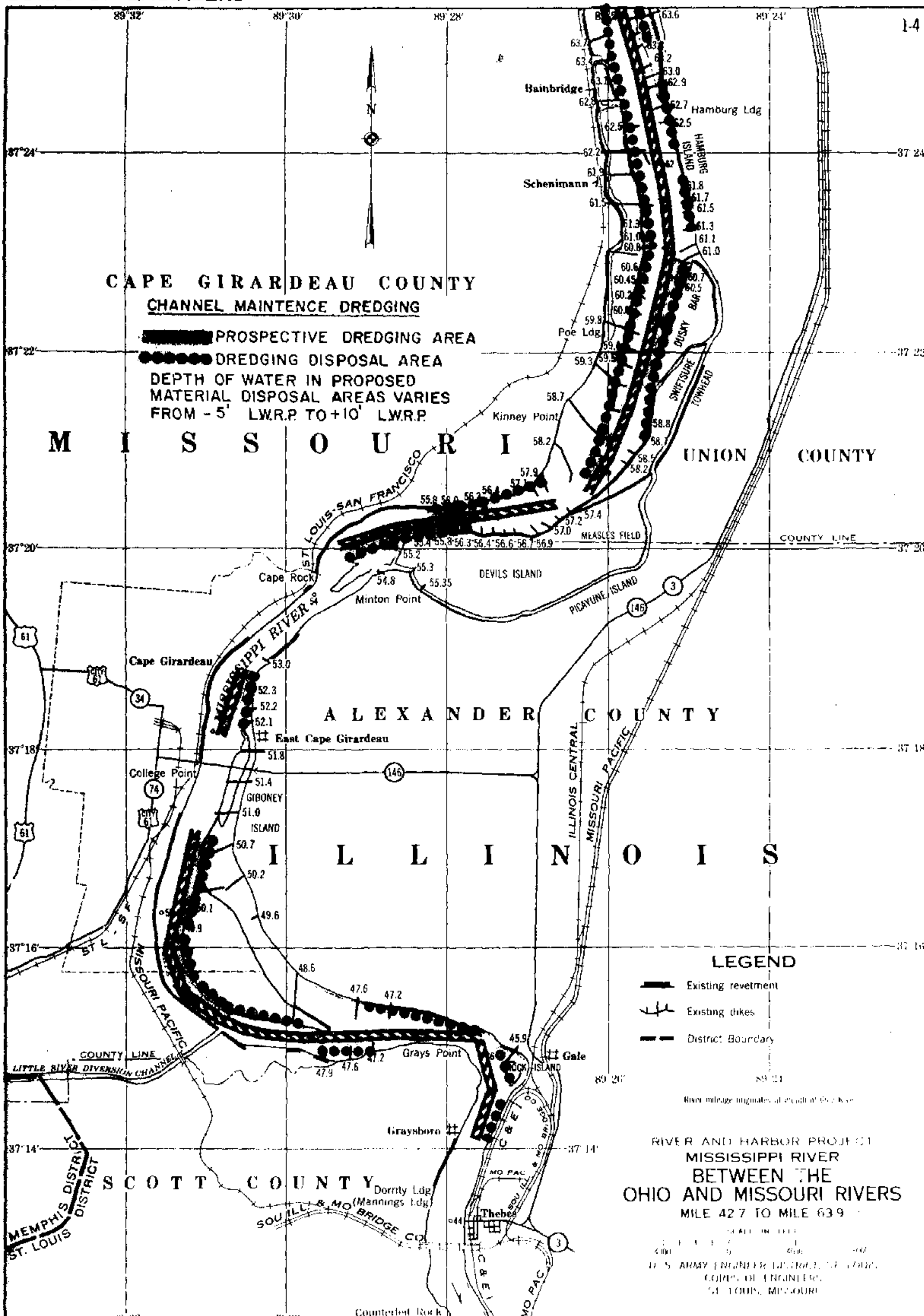
THORWALD R. PETERSON
Colonel, CE
District Engineer

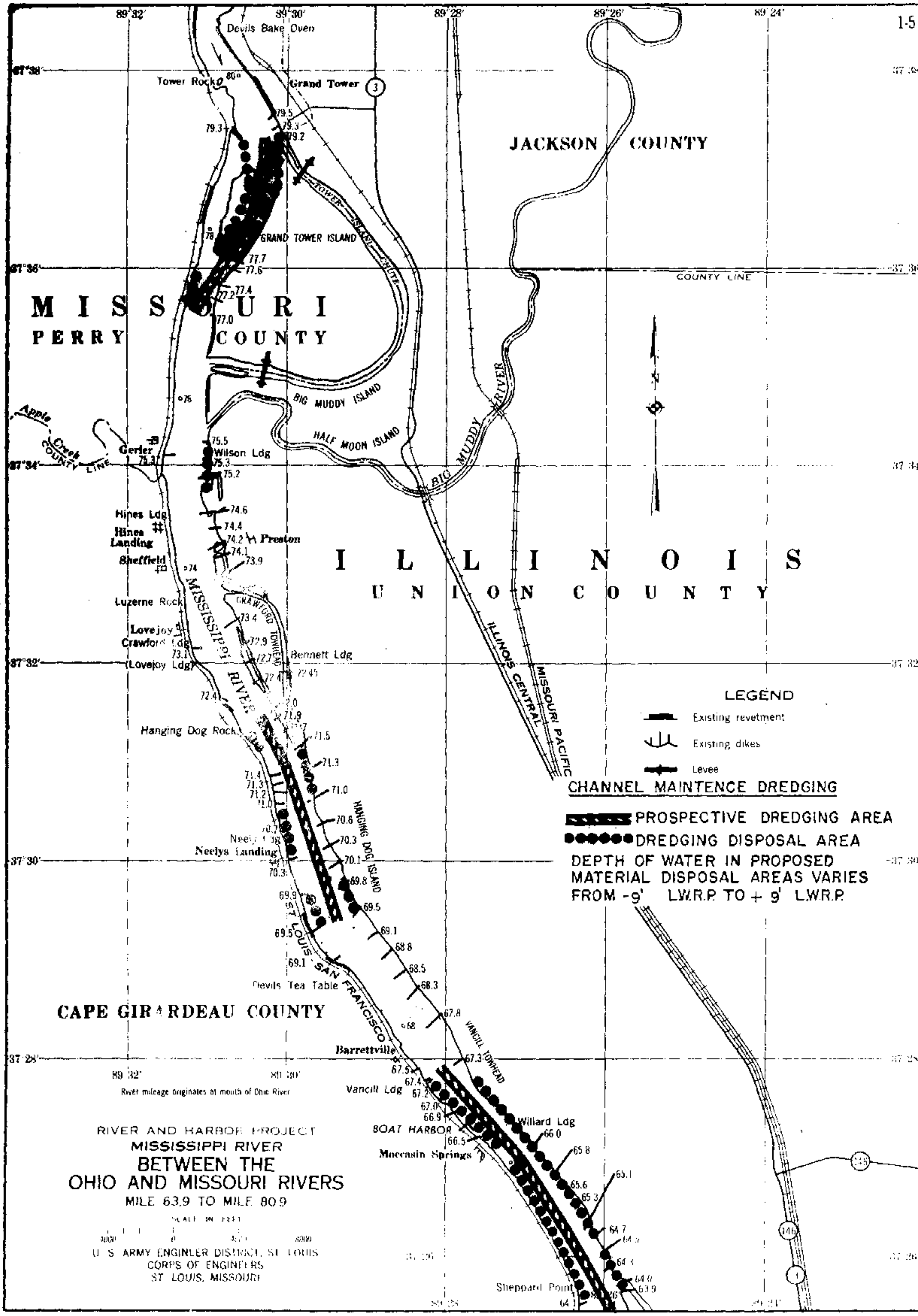
2 Incl
As stated


1-2
PULASKI COUNTY
ALEXANDER COUNTY
ILLINOIS
KENTUCKY
BALLARD COUNTY
MISSOURI
MISSISSIPPI COUNTY
LOUISVILLE DISTRICT
OHIO RIVER
ST. LOUIS DISTRICT
MEMPHIS DISTRICT
GULF MOBILE AND OHIO
MISSOURI PACIFIC
ILLINOIS CENTRAL
NEW YORK CENTRAL
Mounds
Mound City
Cache
Beechridge
DIVERSION CHANNEL
OLD RIVER
Urbandale
North Cairo
Future City
Cairo
Eliza Point
Cairo Point
Birds Point
Thompson Ldg
Brewer Point
Brooks Point
ALEXANDER COUNTY
MISSOURI SISTER ISLAND
APPROXIMATE STATE BOUNDARY LINE
HURRICANE FIELD
DOGTOOTH ISLAND
BROWNS BAR
ELK ISLAND
ORIENT FIELD
LIMIT OF PROJECT
River mileage originates at Mouth of Ohio River
LEGEND
Existing revetment
Existing dikes
District Boundary
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED
MATERIAL DISPOSAL AREAS VARIES
FROM -7' LWRP TO +7' LWRP
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 0.0 TO MILE 25.8
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

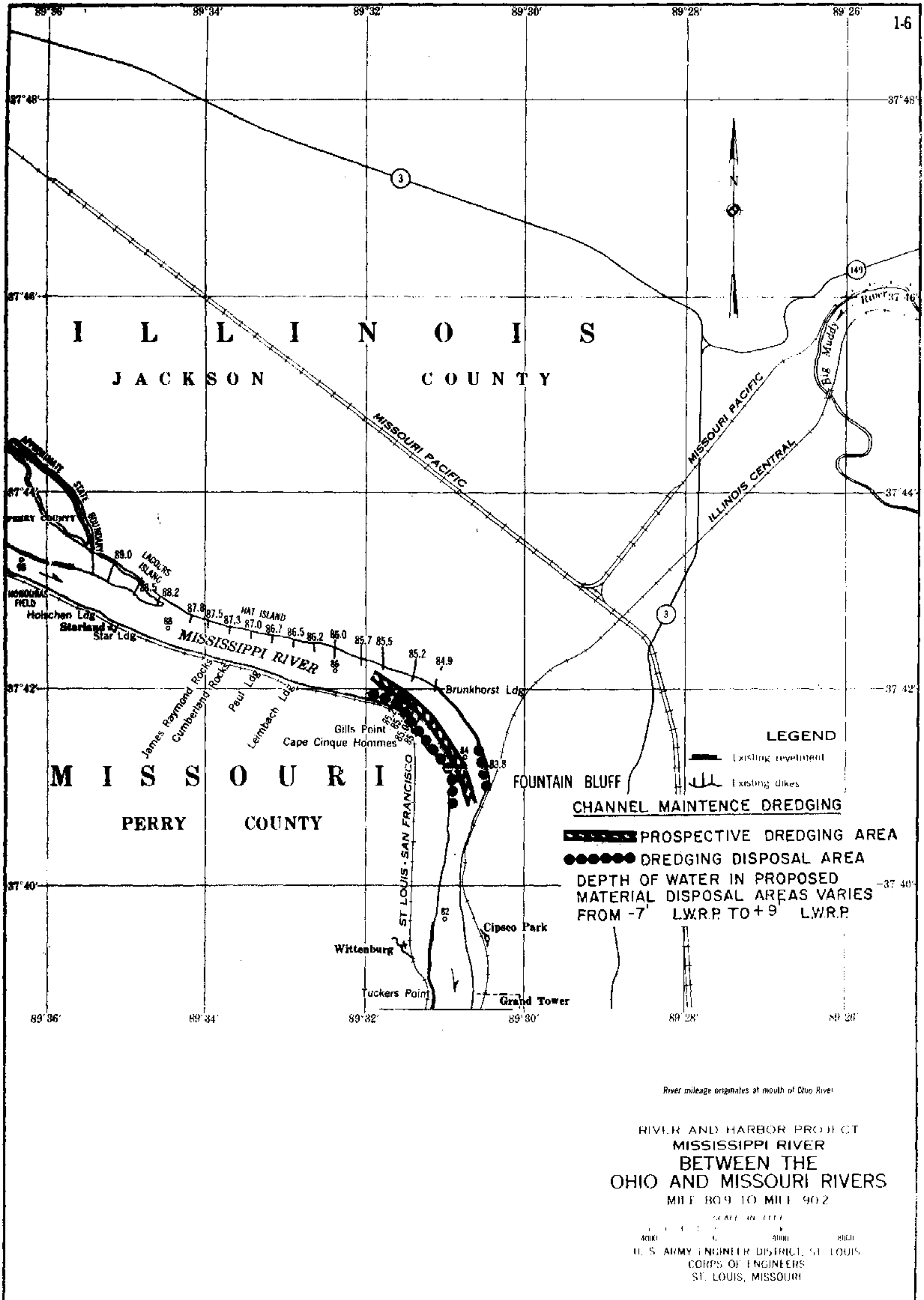


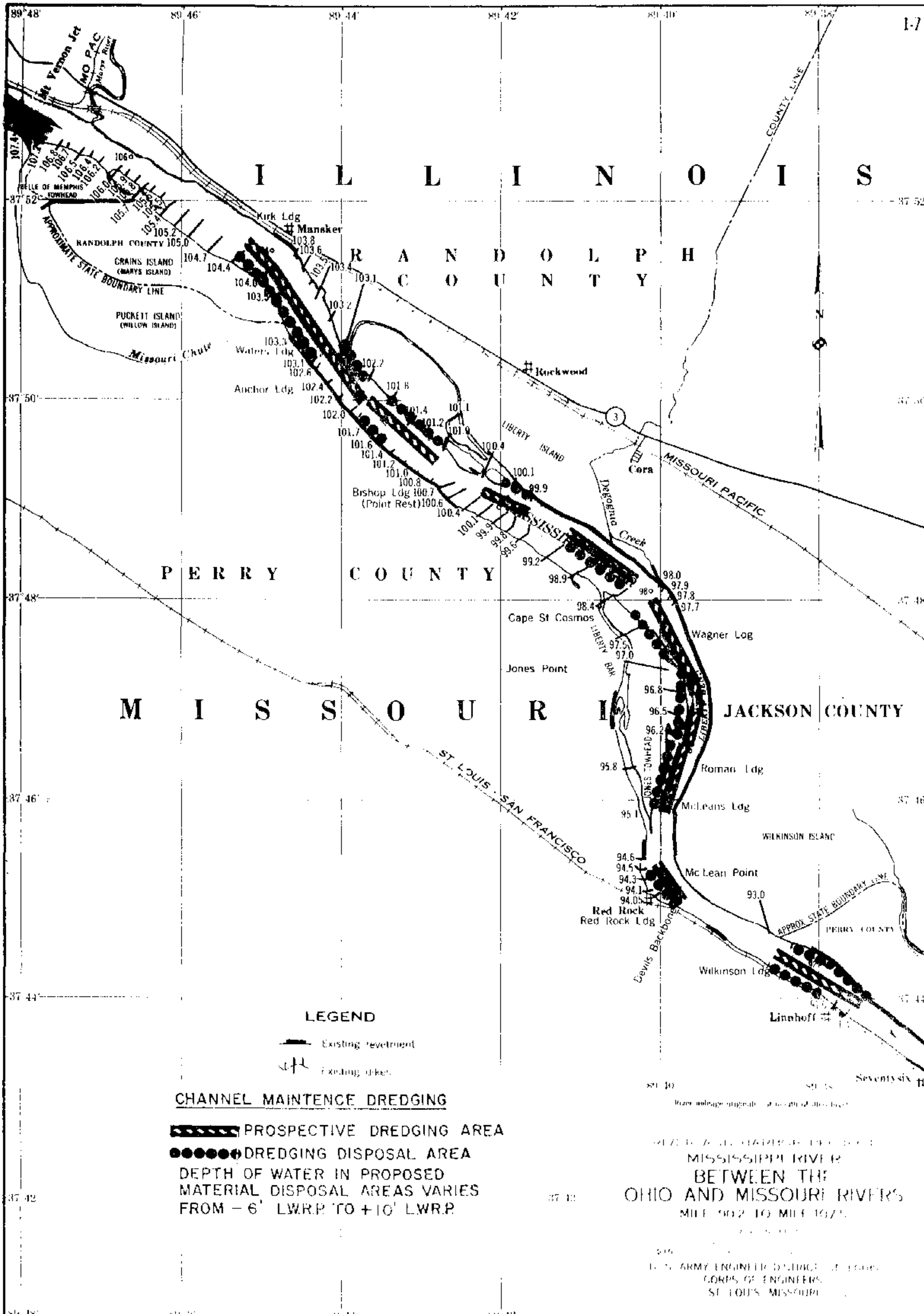
1-3
Uncle Joe Ldg
Hancock Rocks
Paul Jones Rock
Little Chain
Fayville
Commerce
CHICAGO AND EASTERN ILLINOIS
MISSOURI PACIFIC
ST. LOUIS DISTRICT
MEMPHIS DISTRICT
BURNHAM ISLAND
Santa Fe Chute
COMMERCE ISLAND (CAT ISLAND)
ALLEN TOWHEAD
GOOSE ISLAND
Atherton Ldg
ILLINOIS
Horseshoe Lake
POWERS ISLAND
GOOSE ISLAND TOWHEAD
ANITA TOWHEAD
MISSOURI
ALEXANDER COUNTY
BILLINGS ISLAND
Commercial Ldg
Powers Island Chute
GRIFFITH ISLAND
HINTON ISLAND (WOOD ISLAND)
Commercial Point
SCOTT COUNTY
Philadelphia Point
PRICE TOWHEAD
Daniels Ldg
Moore Ldg
WILLOW BAR (DUNGARO ISLAND)
Price Ldg
Elkins Ldg
HACKER BEND
Bryant Ldg
BUFFALO ISLAND
COUNTY LINE
MISSISSIPPI COUNTY
LEGEND
Existing revetment
Existing dikes
Under water weirs
District Boundary
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED MATERIAL DISPOSAL AREAS VARIES FROM -7' LWRP TO +12' LWRP
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE OHIO AND MISSOURI RIVERS
MILE 25.8 TO MILE 42.7
SCALE IN FEET
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

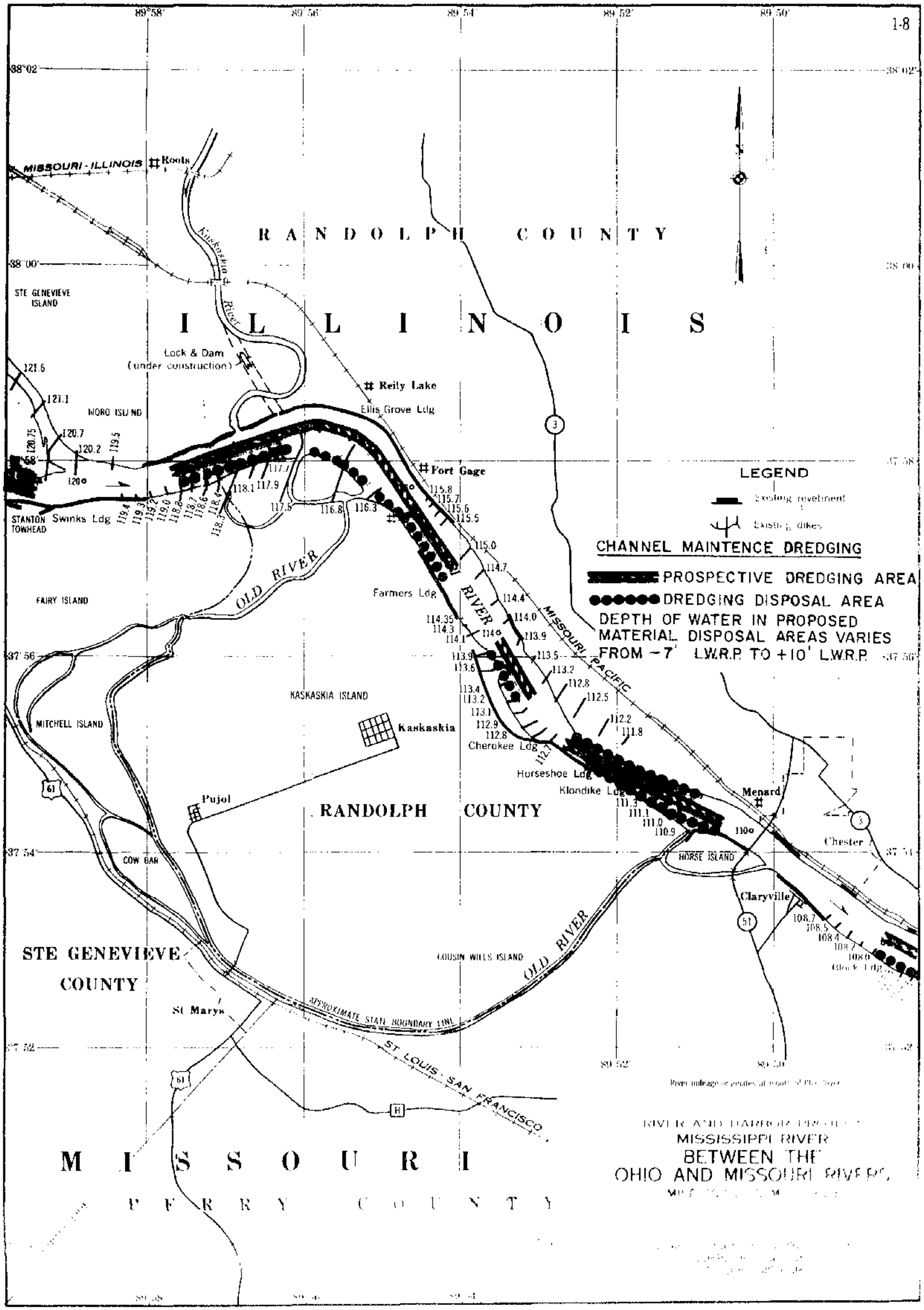

1-4
CAPE GIRARDEAU COUNTY
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED
MATERIAL DISPOSAL AREAS VARIES
FROM -5' LWRP TO +10' LWRP
MISSOURI
UNION COUNTY
ALEXANDER COUNTY
ILLINOIS
SCOTT COUNTY
Bainbridge
Hamburg Ldg
HAMBURG ISLAND
Schenimann
Poe Ldg
DUSKY BAR
SWIFTSURE TOWHEAD
Kinney Point
ST. LOUIS-SAN FRANCISCO
MEASLES FIELD
COUNTY LINE
DEVILS ISLAND
Cape Rock
Minton Point
PICAYUNE ISLAND
MISSISSIPPI RIVER
Cape Girardeau
East Cape Girardeau
College Point
GIBONEY ISLAND
ILLINOIS CENTRAL
MISSOURI PACIFIC
LEGEND
Existing revetment
Existing dikes
District Boundary
Grays Point
Gale
ROCK ISLAND
Graysboro
LITTLE RIVER DIVERSION CHANNEL
MEMPHIS DISTRICT
ST. LOUIS DISTRICT
Dornty Ldg
(Mannings Ldg)
SOU. ILL. & MO. BRIDGE CO.
Thebes
Counterfeit Rock
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 427 TO MILE 639
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

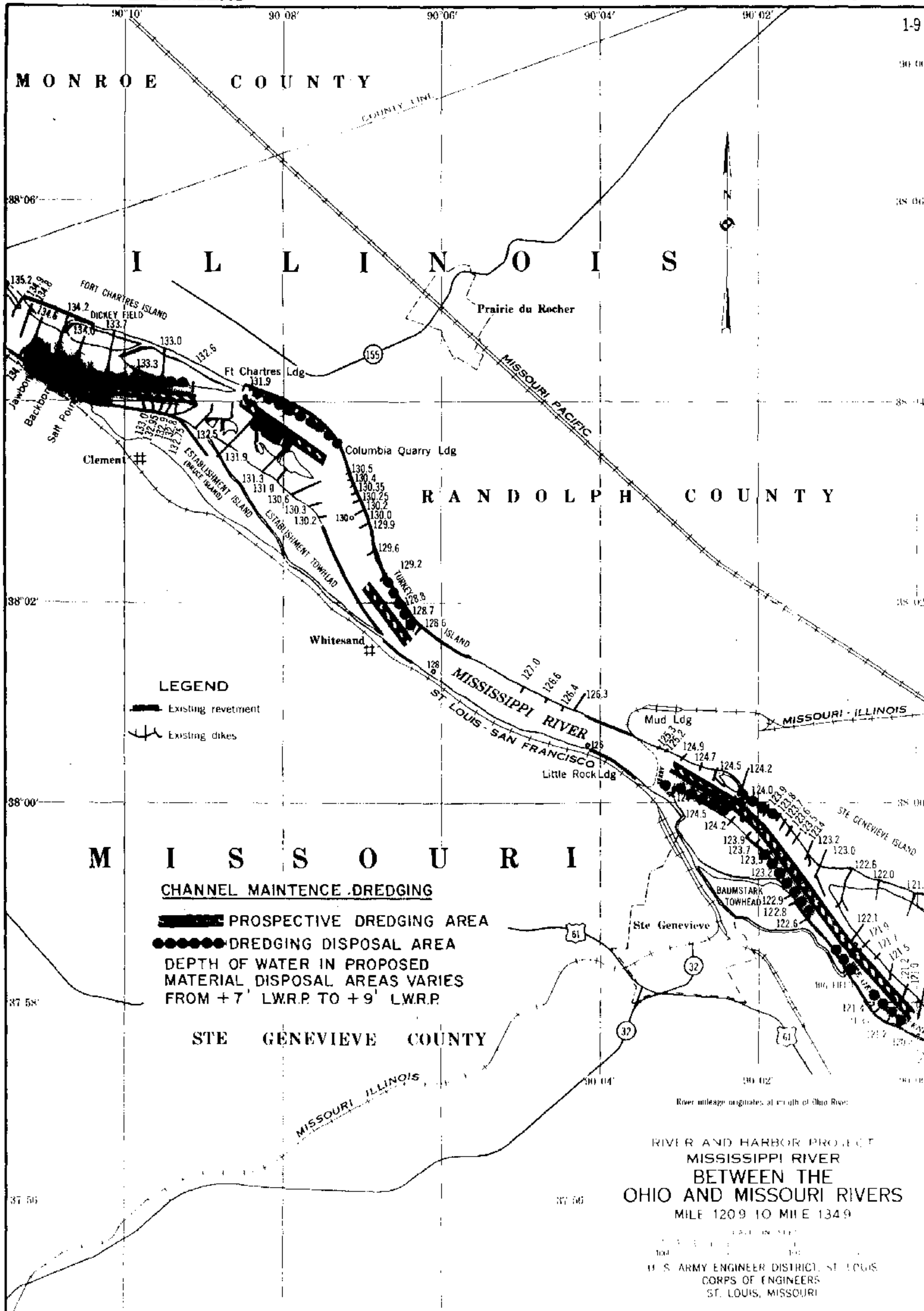

1-5
Devils Bake Oven
Tower Rock
Grand Tower
JACKSON COUNTY
GRAND TOWER ISLAND
TOWER ISLAND CHUTE
COUNTY LINE
MISSOURI
PERRY COUNTY
BIG MUDDY ISLAND
HALF MOON ISLAND
BIG MUDDY RIVER
Apple Creek
COUNTY LINE
Gerler
Wilson Ldg
Hines Ldg
Hines Landing
Preston
Sheffield
ILLINOIS
UNION COUNTY
Luzerne Rock
MISSISSIPPI RIVER
CRAWFORD TOWHEAD
Lovejoy
Crawford Ldg
(Lovejoy Ldg)
Bennett Ldg
ILLINOIS CENTRAL
MISSOURI PACIFIC
LEGEND
Existing revetment
Existing dikes
Levee
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED MATERIAL DISPOSAL AREAS VARIES FROM -9' LWRP TO + 9' LWRP
Hanging Dog Rock
HANGING DOG ISLAND
Neelys Landing
ST. LOUIS SAN FRANCISCO
Devils Tea Table
CAPE GIRARDEAU COUNTY
Barrettville
VANCILL TOWHEAD
Vancill Ldg
BOAT HARBOR
Willard Ldg
Moccasin Springs
Sheppard Point
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 63.9 TO MILE 80.9
SCALE IN FEET
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

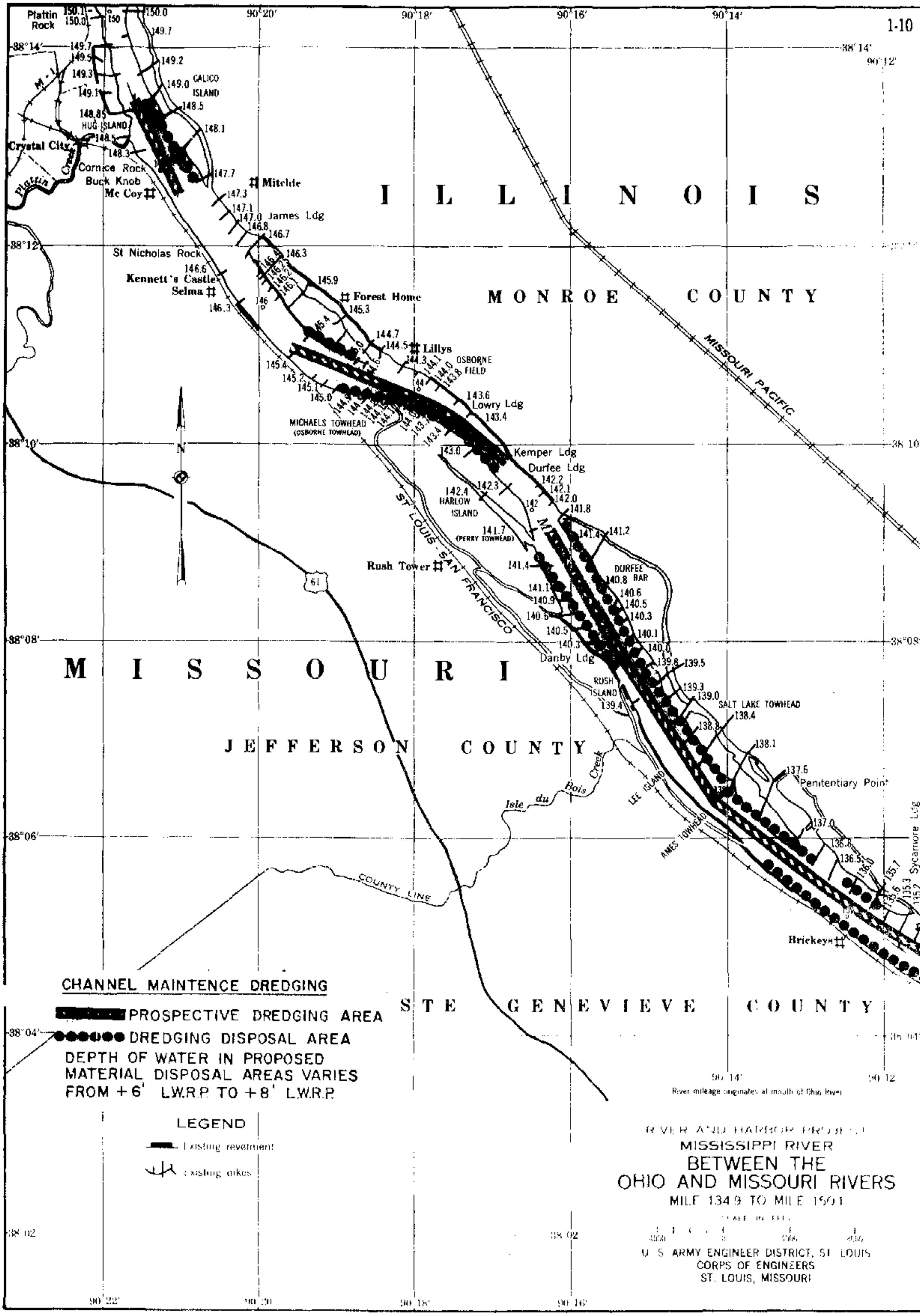
1-6

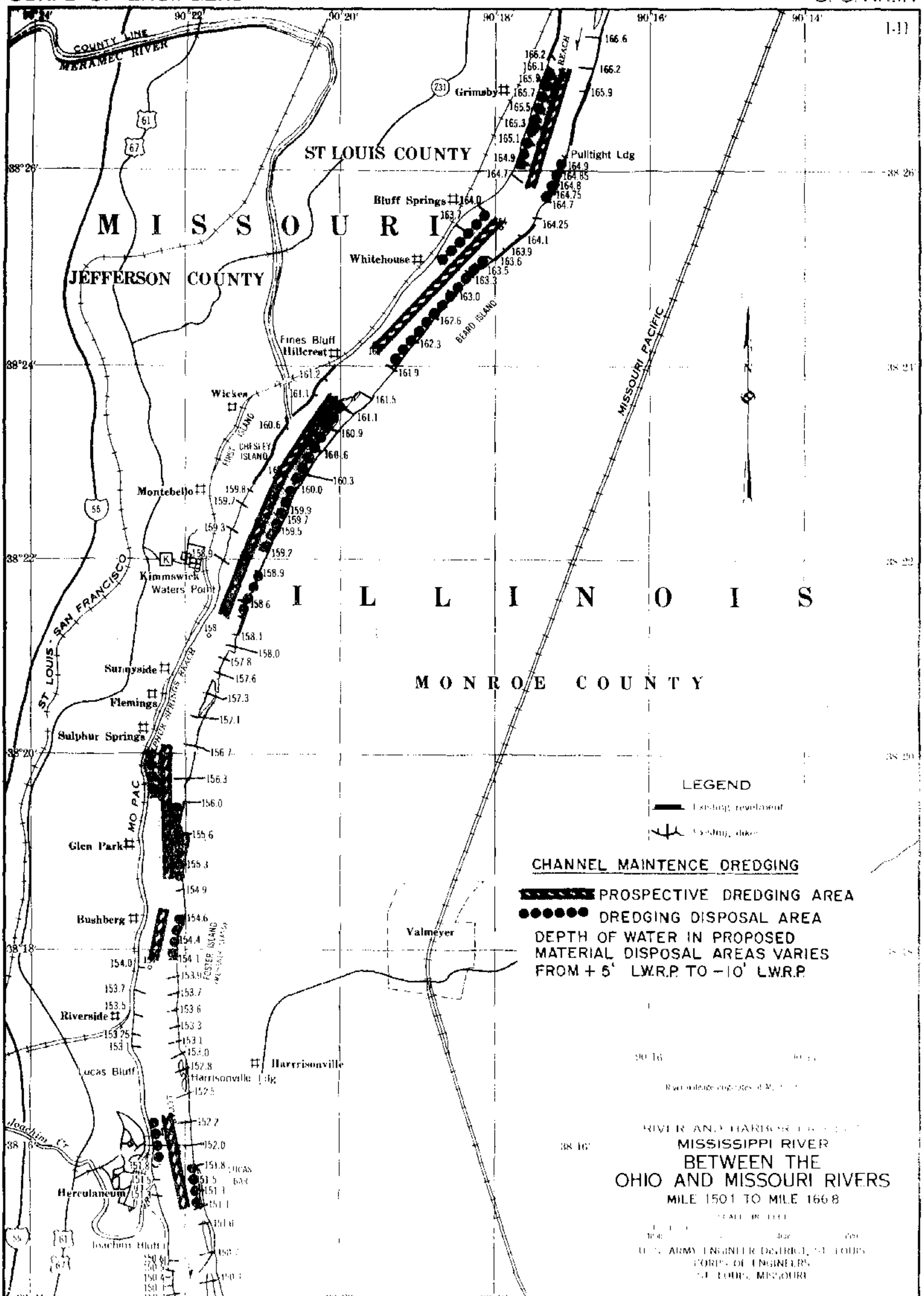

ILLINOIS
JACKSON COUNTY
MISSOURI
PERRY COUNTY
MISSISSIPPI RIVER
MISSOURI PACIFIC
ILLINOIS CENTRAL
ST LOUIS - SAN FRANCISCO
Big Muddy River
FOUNTAIN BLUFF
Brunkhorst Ldg
Gills Point
Cape Cinque Hommes
James Raymond Rocks
Cumberland Rocks
Paul Ldg
Leimbach Ldg
Holschen Ldg
Star Ldg
HAT ISLAND
Wittenburg
Tuckers Point
Cipsco Park
Grand Tower
LEGEND
Existing revetment
Existing dikes
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED MATERIAL DISPOSAL AREAS VARIES FROM -7' LWRP TO +9' LWRP
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 809 TO MILE 902
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

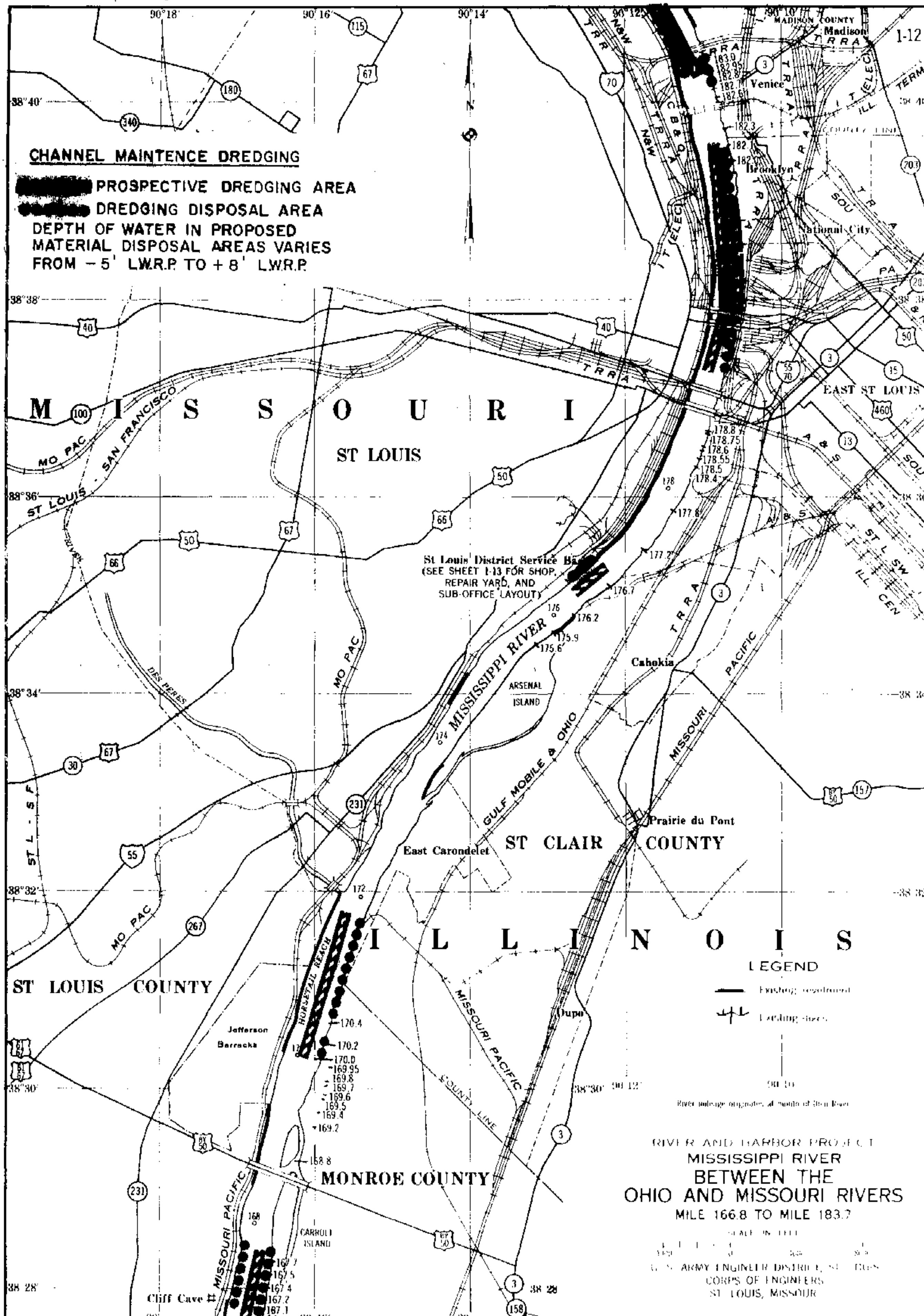

I-7
ILLINOIS
RANDOLPH COUNTY
PERRY COUNTY
MISSOURI
JACKSON COUNTY
St Vernon Jct
MO PAC
Kirk Ldg
Mansker
Rockwood
Cora
MISSOURI PACIFIC
COUNTY LINE
RANDOLPH COUNTY
CRAINS ISLAND (MARYS ISLAND)
PUCKETT ISLAND (WILLOW ISLAND)
APPROXIMATE STATE BOUNDARY LINE
Missouri Chute
Waters Ldg
Anchor Ldg
LIBERTY ISLAND
Bishop Ldg
(Point Rest)
Degognia Creek
Cape St Cosmos
LIBERTY BAR
Jones Point
Wagner Ldg
JONES TOWHEAD
Roman Ldg
McLeans Ldg
WILKINSON ISLAND
Mc Lean Point
Red Rock
Red Rock Ldg
Devils Backbone
APPROX STATE BOUNDARY LINE
PERRY COUNTY
Wilkinson Ldg
Linnhoff
Seventysix
ST LOUIS SAN FRANCISCO
LEGEND
Existing revetment
Existing dikes
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED MATERIAL DISPOSAL AREAS VARIES FROM -6' LWRP TO +10' LWRP
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
CORPS OF ENGINEERS
ST LOUIS MISSOURI

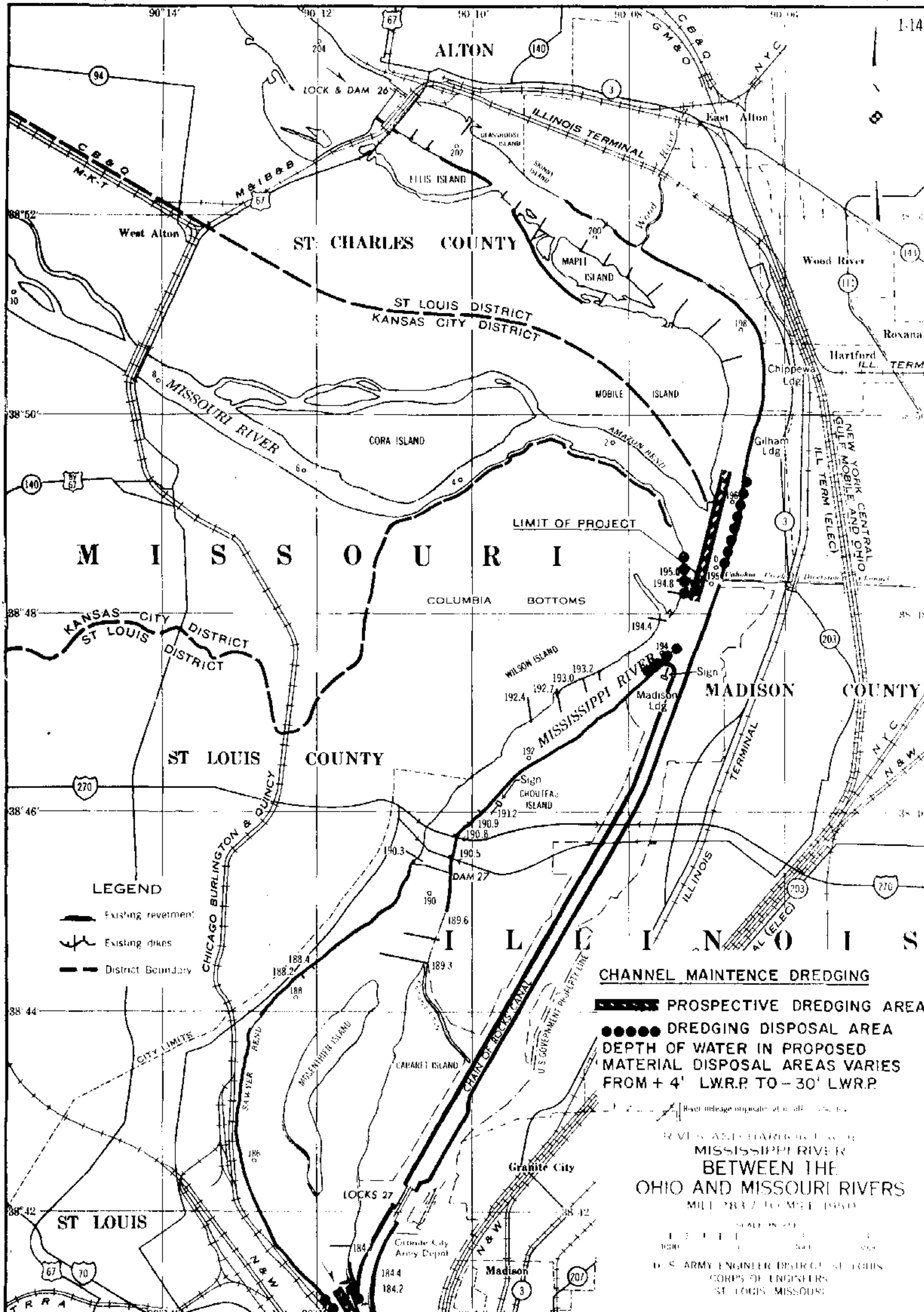

1-8
RANDOLPH COUNTY
ILLINOIS
STE GENEVIEVE ISLAND
Lock & Dam
(under construction)
Reily Lake
Ellis Grove Ldg
Fort Gage
MORO ISLAND
STANTON TOWHEAD
Swinks Ldg
OLD RIVER
FAIRY ISLAND
Farmers Ldg
RIVER
MISSOURI PACIFIC
KASKASKIA ISLAND
Kaskaskia
MITCHELL ISLAND
Cherokee Ldg
Horseshoe Ldg
Klondike Ldg
Menard
Chester
HORSE ISLAND
Claryville
Pujol
RANDOLPH COUNTY
COW BAR
STE GENEVIEVE COUNTY
COUSIN WILLS ISLAND
OLD RIVER
APPROXIMATE STATE BOUNDARY LINE
St Marys
ST LOUIS - SAN FRANCISCO
MISSOURI - ILLINOIS
MISSOURI
PERRY COUNTY
LEGEND
Existing revetment
Existing dikes
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED MATERIAL DISPOSAL AREAS VARIES FROM −7' LWRP TO +10' LWRP
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS


1-9
MONROE COUNTY
ILLINOIS
RANDOLPH COUNTY
MISSOURI
STE GENEVIEVE COUNTY
Prairie du Rocher
MISSOURI PACIFIC
FORT CHARTRES ISLAND
DICKEY FIELD
Ft Chartres Ldg
Columbia Quarry Ldg
Clement
ESTABLISHMENT ISLAND
ESTABLISHMENT TOWHEAD
TURKEY ISLAND
Whitesand
MISSISSIPPI RIVER
ST LOUIS - SAN FRANCISCO
Mud Ldg
Little Rock Ldg
MISSOURI - ILLINOIS
STE GENEVIEVE ISLAND
BAUMSTARK TOWHEAD
Ste Genevieve
LEGEND
Existing revetment
Existing dikes
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED MATERIAL DISPOSAL AREAS VARIES FROM +7' LWRP TO +9' LWRP
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 120.9 TO MILE 134.9
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI


1-10
ILLINOIS
MONROE COUNTY
MISSOURI
JEFFERSON COUNTY
STE GENEVIEVE COUNTY
MISSOURI PACIFIC
ST LOUIS - SAN FRANCISCO
COUNTY LINE
Isle du Bois Creek
Plattin Creek
Plattin Rock
Crystal City
HUG ISLAND
CALICO ISLAND
Cornice Rock
Buck Knob
Mc Coy
Mitchie
James Ldg
St Nicholas Rock
Kennett's Castle
Selma
Forest Home
Lillys
OSBORNE FIELD
MICHAELS TOWHEAD (OSBORNE TOWHEAD)
Lowry Ldg
Kemper Ldg
Durfee Ldg
HARLOW ISLAND
(PERRY TOWHEAD)
Rush Tower
DURFEE BAR
Danby Ldg
RUSH ISLAND
SALT LAKE TOWHEAD
LEE ISLAND
AMES TOWHEAD
Penitentiary Point
Sycamore Ldg
Brickeys
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED MATERIAL DISPOSAL AREAS VARIES FROM +6' LWRP TO +8' LWRP
LEGEND
Existing revetment
Existing dikes
River mileage originates at mouth of Ohio River
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 134.9 TO MILE 150.1
SCALE IN FEET
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI


MERAMEC RIVER
COUNTY LINE
ST LOUIS COUNTY
MISSOURI
JEFFERSON COUNTY
ILLINOIS
MONROE COUNTY
MISSOURI PACIFIC
ST LOUIS - SAN FRANCISCO
MO PAC
Grimsby
Pulltight Ldg
Bluff Springs
Whitehouse
BEARD ISLAND
Fines Bluff
Hillcrest
Wicken
CHESLEY ISLAND
Montebello
Kimmswick
Waters Point
Sunnyside
Flemings
Sulphur Springs
Glen Park
Bushberg
FOSTER ISLAND
Valmeyer
Riverside
Lucas Bluff
Harrisonville
Harrisonville Ldg
Joachim Cr
Herculaneum
Joachim Bluff
LUCAS BAR
LEGEND
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED
MATERIAL DISPOSAL AREAS VARIES
FROM + 5' L.W.R.P. TO − 10' L.W.R.P.
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 150.1 TO MILE 166.8


1-12
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED
MATERIAL DISPOSAL AREAS VARIES
FROM − 5' LW.R.P. TO + 8' LW.R.P.
M I S S O U R I
ST LOUIS
St Louis District Service Base
(SEE SHEET 1-13 FOR SHOP, REPAIR YARD, AND SUB-OFFICE LAYOUT)
MISSISSIPPI RIVER
ARSENAL ISLAND
Venice
Brooklyn
National City
EAST ST LOUIS
Cahokia
Prairie du Pont
East Carondelet
ST CLAIR COUNTY
I L L I N O I S
ST LOUIS COUNTY
HORSETAIL REACH
Jefferson Barracks
Dupo
MONROE COUNTY
CARROLL ISLAND
Cliff Cave
LEGEND
RIVER AND HARBOR PROJECT
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
MILE 166.8 TO MILE 183.7
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI


1-14
ALTON
LOCK & DAM 26
ILLINOIS TERMINAL
East Alton
C B & Q
G M & O
N Y C
M & I B & B
M-K-T
ELLIS ISLAND
West Alton
ST CHARLES COUNTY
MAPLE ISLAND
Wood River
Roxana
Hartford
ILL. TERM.
ST LOUIS DISTRICT
KANSAS CITY DISTRICT
Chippewa Ldg
MOBILE ISLAND
MISSOURI RIVER
CORA ISLAND
AMAZON BEND
Gilham Ldg
ILL TERM (ELEC)
NEW YORK CENTRAL
GULF MOBILE AND OHIO
LIMIT OF PROJECT
M I S S O U R I
COLUMBIA BOTTOMS
KANSAS CITY DISTRICT
ST LOUIS DISTRICT
WILSON ISLAND
MISSISSIPPI RIVER
Sign
Madison Ldg
MADISON COUNTY
ST LOUIS COUNTY
CHOUTEAU ISLAND
DAM 27
TERMINAL
ILLINOIS
N & W
CHICAGO BURLINGTON & QUINCY
LEGEND
Existing revetment
Existing dikes
District Boundary
I L L I N O I S
CHANNEL MAINTENCE DREDGING
PROSPECTIVE DREDGING AREA
DREDGING DISPOSAL AREA
DEPTH OF WATER IN PROPOSED
MATERIAL DISPOSAL AREAS VARIES
FROM + 4' L.W.R.P. TO – 30' L.W.R.P.
CITY LIMITS
SAWYER BEND
MOSENTHEIN ISLAND
CABARET ISLAND
CHAIN OF ROCKS CANAL
U S GOVERNMENT PROPERTY LINE
MISSISSIPPI RIVER
BETWEEN THE
OHIO AND MISSOURI RIVERS
Granite City
LOCKS 27
Granite City Army Depot
ST LOUIS
Madison
T R R A
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

Mouth of Missouri River to Chester, Ill.

Location of Disposal Site: Mile	Locality	Maximum Quantity of Dredged Material to be Deposited in any Dredging Season *	Existing Use of Adjacent Properties
195.0 R	Mouth of Missouri River	1,600,000 cubic yards	Primary Use: Industrial, Woodland, Barge Fleeting and Unused Flood Plain
195.0 L	Gilham Landing		
194.0 L	Chain of Rocks Upper Access		
184.2 L	Chain of Rocks Lower Access		
183.7 R	Bissel Point		
182.9 L	Merchants Bridge		
181.0 L	Above Veterans		
176.7 R	Service Base		
172.0 R	Mouth of River Des Peres		
171.0 L	East Ivory	2,200,000 cubic yards	Primary Use: Agricultural, Woodland and unused flood plain
170.1 L	East Horsetail		
167.4 R	Bussen's Quarry		
167.4 L	Carroll Island		
165.3 R	Twin Hollows		
164.8 L	Pulltight Landing		
163.6 R	Whitehouse		
162.6 L	Beard Island		
160.3 L	Smith Landing		
158.7 L	Merrimac		
156.3 R	Sulphur Springs		
155.5 L	Foster Island		
154.4 L	Foster Island		
152.0 R	Lucas Bluff		
151.3 L	Lucas Bar		
148.3 L	Calico Island		
145.2 L	Forest Home		
143.7 R	Michael's Towhead		
140.6 R	Rush Island		
139.3 L	Rush Island		
135.9 R	Brickeys		
135.9 L	Sycamore Landing		
134.0 R	Establishment Island		
133.7 L	Dickey Field		
131.8 R	Establishment Island		
131.6 L	Fort Chartres Landing		
128.8 L	Turkey Island		
124.5 R	Baumstark Towhead		
124.0 L	Moro		
123.0 R	Baumstark Towhead		
121.9 R	Big Field		
121.3 R	Big Field		
120.8 L	Moro Island		
118.3 R	Kaskaskia Island		
116.8 R	Kaskaskia Island		
115.7 R	East Kaskaskia		
113.4 R	Okaw Landing		
111.5 L	Menard		
111.1 R	Klonkike Landing		
109.5 L	City of Chester, Ill.		

* Estimate based on past dredging records. Although no specific proposals are currently under consideration, to the extent possible, disposal sites listed in this exhibit will also be used for disposal of materials resulting from dredging by others.

Chester, Ill. to Cape Girardeau, Mo.

Location of Disposal Site		Maximum Quantity of Dredged Material to be Deposited in Any Dredging Season *	Existing Use of Adjacent Properties
Mile	**Locality**		
109.5 L	City of Chester, Ill.	2,200,000 cubic yards	Primary Use: Agricultural, Woodland and Unused Flood Plain
107.5 R	Block Landing		
103.5 R	Waters Landing		
102.4 L	Liberty Island		
101.6 R	Bishop Landing		
101.3 L	Liberty Island		
100.0 L	Liberty Island		
98.9 R	Liberty Bar		
96.9 R	Jones Point		
94.1 R	Red Rock		
92.0 R	Linnhoff		
91.8 L	Wilkinson Island		
84.3 R	Cape Cinque Hommes		
83.8 L	Fountain Bluff		
78.8 R	Patrous Creek		
78.8 L	Grand Tower Island		
77.2 R	Gerler		
75.3 L	Wilson Landing		
71.9 R	Hanging Dog Rock		
71.3 L	Hanging Dog Island		
70.7 R	Neely Landing		
69.7 R	Indian Creek		
69.7 L	Hanging Dog Island		
66.9 R	Vancill Landing		
65.9 L	Willard Landing		
65.3 R	Moccasin Springs		
64.3 L	Hamburg Island		
63.5 L	Hamburg Island		
62.7 L	Hamburg Landing		
61.5 L	Hamburg Island		
61.4 R	Schenimann		
59.6 L	Dusky Bar		
56.2 L	Flora Creek		
55.2 L	Devils Island		
52.2 L	East Cape Girardeau		
52.0 R	City of Cape Girardeau Mo.		

*Estimate based on past dredging records. Although no specific proposals are currently under consideration, to the extent possible, disposal sites listed in this exhibit will also be used for disposal of materials resulting from dredging by others

Cape Girardeau, Mo. to Cairo, Ill.

Location of Disposal Site: Mile	Location of Disposal Site: Locality	Maximum Quantity of Dredged Material to be Deposited in Any Dredging Season *	Existing Use of Adjacent Properties
52.0 R	City of Cape Girardeau, Mo.		
49.6 L	Cape Bend Towhead		
47.6 R	Cape La Croix		
46.9 L	Rock Island		
45.9 L	Rock Island		
45.0 L	Rock Island		
42.1 L	Rock Springs		
41.9 R	Uncle Joe Landing		
41.5 L	Rock Springs		
41.3 R	Paul Jones Rock		
41.0 L	Muddy Creek		
40.6 L	Muddy Creek		
39.6 L	Fayville		
38.2 R	Commerce Island		
36.7 R	Allen Towhead		
36.7 L	Goose Island		
35.3 R	Powers Island		
34.7 L	Goose Island Towhead		
34.1 R	Anita Towhead		
33.2 R	Billings Island		
32.2 R	Commercial Point		
31.7 R	Philadelphia Point		
30.2 L	Willow Bar		Primary Use:
29.2 L	Willow Bar	3,600,000	Unused flood plain
28.0 L	Willow Bar	cubic yards	and agricultural
27.1 R	Buffalo Island		
26.1 R	Bryant Landing		
25.5 L	Hacker Towhead		
25.3 R	Sliding Townead		
23.5 L	Browns Bar		
21.6 R	Dogtooth Bend		
17.4 R	Thompson Towhead		
15.6 R	Thompson Towhead		
14.5 R	Sisters Island		
13.6 R	Sisters Island		
13.1 R	Sisters Island		
12.2 L	Antelope Field		
11.5 R	Hurricane Field		
10.6 L	Dickey Island		
10.0 L	Boston Bar		
9.5 L	Boston Bar		
8.5 L	Boston Bar		
7.1 L	Eliza Towhead		
6.4 R	Elk Island		
6.4 L	Eliza Point		
3.8 L	Angelo Towhead		
0.0 L	City of Cairo, Ill.		

* Estimate based on past dredging records. Although no specific proposals are currently under consideration, to the extent possible, disposal sites listed in this exhibit will also be used for disposal of materials resulting from dredging by others

Appendix R. Announcement of Public Meeting Regarding Proposed Channel Maintenance Dredging in the Mississippi River Between Cairo, Illinois, and the Mouth of the Missouri River

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

LMSOD (1-1)-2

8 November 1974

ANNOUNCEMENT OF PUBLIC HEARING

FOR THE PURPOSE OF OBTAINING INFORMATION AND THE VIEWS OF INTERESTED PARTIES CONCERNING DREDGING AND SPOIL OPERATIONS PROPOSED BY THE ST. LOUIS DISTRICT IN CONNECTION WITH THE MAINTENANCE OF A 9-FOOT CHANNEL IN THE MISSISSIPPI RIVER BETWEEN CAIRO, ILLINOIS AND THE MOUTH OF THE MISSOURI RIVER

MEETING TO BE HELD AT 1 P.M.
ON 12 DECEMBER 1974
IN THE MISSOURI ROOM, GATEWAY HOTEL
9th and WASHINGTON STREETS
ST. LOUIS, MISSOURI

Regulations recently adopted by the Secretary of the Army provide that dredging to be performed by the Corps of Engineers will be subject to public review procedures that are followed in processing applications for Department of the Army permits. The purpose of the hearing is to give all interested parties an opportunity to express their views freely, fully and publicly concerning proposed dredging and disposal sites, between Cairo, Illinois and the mouth of the Missouri River.

Based on historical records, approximately 30 locations must be dredged annually to prevent a partial or total cessation of barge traffic on the Upper Mississippi River. Project maps indicating all prospective dredging and disposal sites were circularized by public notice from this office 16 September 1974. Proposed disposal sites are listed on the attached sheets.

Designation of the proposed disposal sites for dredged material associated with this Federal project shall be made through the application of guidelines promulgated by the Administrator/Environmental Protection Agency, in conjunction with the Secretary of the Army. If these guidelines alone prohibit the designation of these proposed disposal sites, any potential impairment to the maintenance of navigation, including any economic impact on navigation and anchorage which would result from the failure to use these disposal sites, will also be considered.

LMSOD (1-1)-2

8 November 1974

All interested individuals, groups, and agencies are invited to be present or to be represented at the hearing. Everyone will be given an opportunity to express their views and furnish specific data that will assist in formulating sound conclusions as to the final action to be taken. Statements should be supported by factual information insofar as practicable. Written statements may be submitted at the hearing or mailed to me beforehand. Please bring this announcement to the attention of anyone you know who may be interested in the matter.

FOR THE DISTRICT ENGINEER:

James A. Petersen

1 Incl
As stated

JAMES A. PETERSEN
Chief, Operations Division

Proposed Mississippi River Disposal Sites

Mouth of Missouri River to Chester, Ill.

Location of Disposal Site: Mile	Locality	Maximum Quantity of Dredged Material to be Deposited in any Dredging Season *	Existing Use of Adjacent Properties
195.0 R	Mouth of Missouri River	1,600,000 cubic yards	Primary Use: Industrial, Woodland, Barge Fleeting and Unused Flood Plain
195.0 L	Gilham Landing		
194.0 L	Chain of Rocks Upper Access		
184.2 L	Chain of Rocks Lower Access		
183.7 R	Bissel Point		
182.9 L	Merchants Bridge		
181.0 L	Above Veterans		
176.7 R	Service Base		
172.0 R	Mouth of River Des Peres		
171.0 L	East Ivory	2,200,000 cubic yards	Primary Use: Agricultural, Woodland and unused flood plain
170.1 L	East Horsetail		
167.4 R	Bussen's Quarry		
167.4 L	Carroll Island		
165.3 R	Twin Hollows		
164.8 L	Pulltight Landing		
163.6 R	Whitehouse		
162.6 L	Beard Island		
160.3 L	Smith Landing		
158.7 L	Merrimac		
156.3 R	Sulphur Springs		
155.5 L	Foster Island		
154.4 L	Foster Island		
152.0 R	Lucas Bluff		
151.3 L	Lucas Bar		
148.3 L	Calico Island		
145.2 L	Forest Home		
143.7 R	Michael's Towhead		
140.6 R	Rush Island		
139.3 L	Rush Island		
135.9 R	Brickeys		
135.9 L	Sycamore Landing		
134.0 R	Establishment Island		
133.7 L	Dickey Field		
131.8 R	Establishment Island		
131.6 L	Fort Chartres Landing		
128.8 L	Turkey Island		
124.5 R	Baumstark Towhead		
124.0 L	Moro		
123.0 R	Baumstark Towhead		
121.9 R	Big Field		
121.3 R	Big Field		
120.8 L	Moro Island		
118.3 R	Kaskaskia Island		
116.8 R	Kaskaskia Island		
115.7 R	East Kaskaskia		
113.4 R	Okaw Landing		
111.5 L	Menard		
111.1 R	Klondike Landing		
109.5 L	City of Chester, Ill.		

* Estimate based on past dredging records. Although no specific proposals are currently under consideration, to the extent possible, disposal sites listed in this exhibit will also be used for disposal of materials resulting from dredging by others.

Chester, Ill. to Cape Girardeau, Mo.

Location of Disposal Site		Maximum Quantity of Dredged Material to be Deposited in Any Dredging Season *	Existing Use of Adjacent Properties
Mile	**Locality**		
109.5 L	City of Chester, Ill.		
107.5 R	Block Landing		
103.5 R	Waters Landing		
102.4 L	Liberty Island		
101.6 R	Bishop Landing		
101.3 L	Liberty Island		
100.0 L	Liberty Island		
98.9 R	Liberty Bar		
96.9 R	Jones Point		
94.1 R	Red Rock		
92.0 R	Linnhoff		
91.8 L	Wilkinson Island		
84.3 R	Cape Cinque Hommes		
83.8 L	Fountain Bluff		
78.8 R	Patrous Creek		
78.8 L	Grand Tower Island		
77.2 R	Gerler		Primary Use: Agricultural, Woodland and Unused Flood Plain
75.3 L	Wilson Landing	2,200,000 cubic yards	
71.9 R	Hanging Dog Rock		
71.3 L	Hanging Dog Island		
70.7 R	Neely Landing		
69.7 R	Indian Creek		
69.7 L	Hanging Dog Island		
66.9 R	Vancill Landing		
65.9 L	Willard Landing		
65.3 R	Moccasin Springs		
64.3 L	Hamburg Island		
63.5 L	Hamburg Island		
62.7 L	Hamburg Landing		
61.5 L	Hamburg Island		
61.4 R	Schenimann		
59.6 L	Dusky Bar		
56.2 L	Flora Creek		
53.2 L	Devils Island		
52.2 L	East Cape Girardeau		
52.0 R	City of Cape Girardeau Mo.		

*Estimate based on past dredging records. Although no specific proposals are currently under consideration, to the extent possible, disposal sites listed in this exhibit will also be used for disposal of materials resulting from dredging by others

Cape Girardeau, Mo. to Cairo, Ill.

Location of Disposal Site		Maximum Quantity of Dredged Material to be Deposited in Any Dredging Season *	Existing Use of Adjacent Properties
Mile	Locality		
52.0 R	City of Cape Girardeau, Mo.		
49.6 L	Cape Bend Towhead		
47.6 R	Cape La Croix		
46.9 L	Rock Island		
45.9 L	Rock Island		
45.0 L	Rock Island		
42.1 L	Rock Springs		
41.9 R	Uncle Joe Landing		
41.5 L	Rock Springs		
41.3 R	Paul Jones Rock		
41.0 L	Muddy Creek		
40.6 L	Muddy Creek		
39.6 L	Fayville		
38.2 R	Commerce Island		
36.7 R	Allen Towhead		
36.7 L	Goose Island		
35.3 R	Powers Island		
34.7 L	Goose Island Towhead		
34.1 R	Anita Towhead		
33.2 R	Billings Island		
32.2 R	Commercial Point		
31.7 R	Philadelphia Point		
30.2 L	Willow Bar		Primary Use:
29.2 L	Willow Bar	3,600,000	Unused flood plain
28.0 L	Willow Bar	cubic yards	and agricultural
27.1 R	Buffalo Island		
26.1 R	Bryant Landing		
25.5 L	Hacker Towhead		
25.3 R	Sliding Towhead		
23.5 L	Browns Bar		
21.6 R	Dogtooth Bend		
17.4 R	Thompson Towhead		
15.6 R	Thompson Towhead		
14.5 R	Sisters Island		
13.6 R	Sisters Island		
13.1 R	Sisters Island		
12.2 L	Antelope Field		
11.5 R	Hurricane Field		
10.6 L	Dickey Island		
10.0 L	Boston Bar		
9.5 L	Boston Bar		
8.5 L	Boston Bar		
7.1 L	Eliza Towhead		
6.4 R	Elk Island		
6.4 L	Eliza Point		
3.8 L	Angelo Towhead		
0.0 L	City of Cairo, Ill.		

* Estimate based on past dredging records. Although no specific proposals are currently under consideration, to the extent possible, disposal sites listed in this exhibit will also be used for disposal of materials resulting from dredging by others

Appendix S. Transcript of Public Meeting on Lower River Channel Maintenance Dredging

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

PUBLIC HEARING

ON

LOWER RIVER CHANNEL MAINTENANCE DREDGING

HELD IN THE MISSOURI ROOM

AT

THE GATEWAY HOTEL

12 DECEMBER 1974

PUBLIC HEARING

COLONEL PETERSON: Good afternoon ladies and gentlemen. I'd like to welcome you to the United States Army Engineer District, St. Louis public hearing, on channel maintenance dredging.

I am Colonel Thorwald R. Peterson, the District Engineer, and in my capacity I am assigned the responsibility for the administration of the Corps' civil works program with the District, and my position today is to act as the hearing officer.

The dredging area we will be discussing at today's hearing consists of the Upper Mississippi River reach between mile zero at Cairo, Illinois, or the confluency with the Ohio, and mile 195 at the confluency of the Missouri River. It is our stated desire to conduct this meeting in a foremat which will afford all interested agencies and individuals an opportunity to be fully heard and to have their views considered in arriving at recommendations or decisions concerning the use of navigable waters. The underlying purpose, then, of this meeting is to satisfy the needs and preferences of the people to the maximum degree possible within the bounds of local, State and Federal interests, responsibilities and authorities.

And first let me digress just a moment and say that I am extremely happy to have such a fine turn out at today's meeting.

I think it may be appropriate at this time to make a few introductions of those agencies other than the Corps of Engineers that are represented with us here today. To the best of my knowledge we have no members of the United States Senate or the United States Congress with us today

However, I would like to introduce Miss Rindy Belshe, who is Senator Thomas Eagleton's assistant. Miss Belshe are you here, thank you. I would also like to introduce Mr. Robert Koke of the Environmental Protection Agency. Bob. Mr. Charles Kulp, United States Department of Interior. Mr. Allen Miller, United States Department of Interior, Fish and Wildlife Service. Commander Bartels, United States Coast Guard, Ports and Waterways Laison Officer. Mr. Larry Dunham of the Illinois Department of Conservation. And Mr. Bill Dieffenbach, Missouri Department of Conservation. Have I missed anyone here that's present representing a -- either the United States or a State or a local agency, governmental agency?

I would like to at this time introduce Mr. James Petersen, who is sitting to my right and your left, who is our Chief of Operations in the St. Louis District.

As each of you came in you received an attendance card and anyone who did not fill one out I would appreciate it if you would and indicate whether you desire to make a statement, or if you want to present a written statement or a combination of the two. Also if you wish to be informed of further developments in this matter, please mark your card accordingly. At this time does anyone desire a card, who has not filled one out? Thank you.

A verbatim transcript will be made of this hearing and this transcript and all written statements and other data submitted will be made part of the record. We are being taped today. A copy of the transcript will be available for public inspection at the District Office, and if you wish to submit a written statement and do not have if prepared as yet, you may mail your statement to me at the Army Corps of Engineers' address, that's 210 North 12th Street, St. Louis. The record of this hearing will be closed on 22 December, so I would appreciate it if you would forward to me by 22 December any statements that you are either not presenting today or that we have not already received.

During the course of making statements all parties are encouraged to express their views freely and fully. Cross examination of participants will not be permitted. However, if a speaker desires to respond to previous questions they may elect to do so. My purpose at this public hearing is to seek and to accept all viewpoints for future evaluation, not to respond to comments.

The existing Mississippi River Navigation Project was authorized by the River and Harbor Act of 21 January 1927, Rivers and Harbors Commission Document Number Nine of the Sixty-ninth Congress Second Session, and the 3 July 1930 Rivers and Harbors Commission Document Number Twelve, Seventieth Congress, First Session. The project provides for obtaining and maintaining a minimum channel depth of not less than nine feet, a minimum width of not less than three hundred feet at low water, with additional width in bends from the mouth of the Ohio River to the Northern boundary of the City of St. Louis and a minimum width of not less than two hundred feet, with additional width in the bends from St. Louis to the mouth of the Missouri River.

In order to provide authorized channel dimensions in the Mississippi River between Cairo, Illinois, and the mouth of the Missouri, dredging has been required each year since 1930. In 1962 the peak year for dredging, seven million cubic yards of bed material were removed from the channel at thirty-seven dredging looations. During an average dredging season approximately four and one-half million cubic yards of material are removed from the channel at twenty-six different locations. Channel dredging is performed by hydraulic pipeline dredge that agitates and momentarily suspends the shoal material by means of water jets or a cutterhead permitting the material to be drawn into the intake line and dredged so that it can be conveyed through two hundred to three thousand feet of discharge line to an open water disposal site, and those distances are to a degree dependent on the type of dredge in operation.

Material dredged from a navigation channel between Cairo, Illinois and the mouth of the Missouri River generally consists of newly layed deposits containing five percent course gravel, ten percent pea gravel, and eighty-five percent sand and silt. During the period November 1971 through October 1972 samples of material to be dredged in the navigation channel were obtained at eleven locations downstream of St. Louis. The samples were tested for concentrations of volatile solids, chemical oxygen demand, nitrogen, oil and grease, mercury, lead and zinc. None of the parameters tested were found to exceed pollution limits recommended by the Environmental Protection Agency.

In September 1973 sediments of fifteen sites with prior history of maintenance dredging and disposal operations were sampled and tested. No significant quantities of heavy metals, organochloride, pesticides or other toxic chemicals were found in sediment samples collected from the channel.

Section. 404, Public Law 92-500, which is 33 United States Code 1344, for those of the legal profession, authorizes the Secretary of the Army, acting through the Chief of Engineers to issue permits after notice and opportunity for public hearings for the discharge of dredge material into navigable rivers, or waters, at specified disposal sites. The selection of disposal sites will be in accordance with guidelines developed by the Administrator of the Environmental Protection Agency, in connection, or in conjunction with the Secretary of the Army. In accordance with the regulations promulgated by the Secretary of the Army, this is 33 Code of Federal Regulations, 209.145; dredging to be performed by the Corps of Engineers will be subject to public review procedures that are followed in processing applications for Section 404 Permits. And, that, of course, is why we are here today.

The public review procedures include issuance of public notice, opportunity for public hearing if requested by interested parties, and where appropriate, the filing of Environmental Impact Statement. The public notice for this work was issued on 16 September 1974 and was open for comments until 18 October 1974. During this period ten responses were received of which two parties requested a public hearing. And which I determined were of sufficient significance to hold this public hearing today. These two letters were letters of 15 October 1974 from Mr. Conway Briscoe, the Water Commissioner, City of St. Louis, and by letter of 17 October 1974 from Mr. George M. Covington, Chairman of the Great Lakes Chapter, Sierra Club, Chicago, Illinois. Since notification of this public hearing, an additional twenty-nine responses have been received on this dredging work. Subparagraph (F)(1)(111)(B) of this regulation, however, provides that maintenance dredging projects commencing before 1 January 1970, of which this project that we are discussing does, may continue during the preparation of an Impact Statement if deferral of dredging is unacceptable from the standpoint of the overall public interest. This procedure is authorized until 1 January 1976 at which time and EIS, Environmental Impact Statement, must be on file with the Council of Environmental Quality for continued dredging in all cases determined to have potential significant environmental impact.

A few brief words about the Impact Statement for this particular stretch of the River. The St. Louis District has determined that an Impact Statement will be required for this overall project. All known environmental effects that result from operating and maintaining the navigation project including dredging and spoil operations are being addressed in an EIS now under preparation by this District. It is expected that a final Impact Statement for this project will be filed with the Council of Environmental Quality during the last quarter of 1975. The District has already completed a predraft of this statement which is under review at my next higher headquarters.

In memorandum to file dated 27 November 1974, I personally recorded my initial determination and findings that deferral of dredging until the Impact Statement has been filed would be contrary to the public interest. The memorandum is available for public review. This hearing is to provide the views of the interested public to serve as a basis for a final determination and finding.

The proposed disposal sites have not previously been designated for such use by the Secretary of the Army or Administrator, Environmental Protection Agency. Currently, no spoil areas on the Mississippi River between Cairo, Illinois, and the mouth of the Missouri, have been previously specified as provided by Section 404, Public Law 92-500.

Designation of the proposed disposal sites for dredged material associated with this Federal Project shall be made through the application of quidelines promulgated by the Administrator of EPA in conjunction with the Secretary of the Army. If these quidelines alone prohibit the designation of these proposed disposal sites, any potential impairment to the maintenance of navigation, including any economic impact on navigation and anchorage, which would result from the failure to use these disposal sites, will also be considered.

I'd like to offer just a few more comments on the procedures for today's hearing. All of the information which is presented today as part, as well as all prehearing and past hearing statements, will be made a part of the official record of this hearing. The St. Louis District will review the full record to determine an appropriate course of action as we are charged to do. If there are no unresolved substantive objections to the use of the prospective disposal sites, I will sign and date a Statement of Findings to that affect and it will be placed in the official file. The statement will include a description of conditions under which disposal of dredged material will be performed.

If substantive objections have not been resolved, as a result of this hearing and from the comments and views which we are seeking, a report on the matter will be forwarded to the Division Engineer, my next highest authority, along with a transcript of this hearing and copies of all correspondence, public notices and other pertinent documents. The Division Engineer has authority to review and evaluate all Federal Projects, resolve outstanding objections and authorize or defer commencement of this project. Under certain circumstances the Division Engineer will forward the matter to the Office of the Chief of Engineers.

Now, I'd like to get to the sequence of the speakers for this afternoon.

I would like to request the two parties who requested this hearing to, first, summarize their initial letters and these letters will be entered into the record. And these parties may make any additional presentations they wish to offer. First, may I call upon Mr. Conway Briscoe, or his presentative, Water Commissioner, City of St. Louis, do you wish to make a statement at this time, sir?

MR. FLETCHER: My name is Stanley Fletcher. I along with two other people from the Water Division, are here to make a statement. I would like to summarize the letter and then Mr. Walter Sollmann will make additional comments.

Just starting off in the first paragraph of the letter, this is in reply to your letter of September 16th, 1974, in which all interested parties are invited to submit arguments or objections to the proposed disposal sites. The City of St. Louis, Water Division, does have an objection to your disposal site 195R and also 194L. It has been quite a few years since the channel has been dredged in this area. We are concerned that the deposit material, particularly 195R, which is on the Missouri shore just south of the Missouri River effluent will cause a serious water treatment problem. We object to these locations of the deposits and would rather have them placed on the Illinois shore. We request a hearing concerning this matter.

COLONEL PETERSON: Thank you.

MR. ZOLLMANN: Walter Zollman, Chemical Engineer at the Chain of Rocks Plant. You already answered some of the questions about the testing for the organics and so forth in the river, but that is one of the things that we wanted to comment on, because we know that the river bottom has the organics, there's some oil products and so forth in the sludge and the trace metals and heavy metals that you mentioned, and that was giving us some cause since the EPA has some definite ideas about what they want in the finished water. And then, of course, these sludge products could cause a taste and odor problem, and from the past experience they do increase the suspended matter that's in the river water and they could give us reason to use more chemicals and, of course, would give us possible odor and taste problems. Then also in moving this sand we are also concerned about our intake towers out in the river, whether there could be additional sand come down and sand in those intake towers: Since the Corps doesn't dredge that area any longer, there is a build up of sand around the intake towers. And if they do decide to dredge we would like to be notified when they are dredging so we can take further precautions in our water treatment.

Many years ago they used to notify us, but we have not been notified in recent years that they were dredging there, or that they might even contemplate dredging up there.

That is all we have to say.

COLONEL PETERSON: Thank you very much, sir.

At this time I'd like to call on Mr. George M. Covington, Chairman of the Great Lakes Chapter, Sierra Club, for presentation of his statement.

DR. TOCKSTEIN: Mr. George Covington couldn't make it today and I'm Dr. Tockstein with the Great Lakes Chapter of the Sierra Club.

The letter that was sent to Colonel Peterson had five points in it, that stated: One, thirty days is far too -- is, for intensive study, is too short for comment. To comment specifically on more than ninety dredge spoil sites within thirty days after receival of public notice is virtually impossible. Therefore, comments will be made about dredge spoil in total. Two, dredge spoil on agricultural land. The sites for dredge spoil are listed as agricultural land and unused floodplain. The preliminary statement lists the composition of dredge spoil as basically sand and gravel. Such material provides a sterile base for growing crops. To deposit such sterile material on prime agricultural land deserves strong questions about the policies, plans and tactics of the Corps in regard to using agricultural land for dredge spoil.

Three, dredge spoil on unused floodplain. The Department of the Interior has stated on several occasions that depositing dredge spoil in sloughs and on flood plain present a serious threat to the ecology of the Mississippi River. We strongly agree with this view. Depositing dredge spoil in sloughs and or the floodplain eliminates important habitats for fish, wildlife and birds. The Mississippi River is one of the major flyways for migrating birds including our embattled national bird, the Bald Eagle. To state that the floodplain is unused reveals a profound lack of concern about Mississippi River ecology. Before dredge spoil is indiscriminately placed on the floodplain, studies should be made on each and every site in regard to the ecology of that site and the impact of depositing dredge spoil upon the site's ecology.

Four, dredge spoil adds to flooding. A law of physics that two things cannot occupy the same space at the same time also applies to dredge spoil and flood waters. Deposits of dredge spoil on the floodplain will occupy the space that flood waters would normally occupy. The obvious conclusion is that the only place the water can go is to higher stage heights. Depositing dredge spoil at ninety new sites appears to warrant a thorough investigation in relation to its affect on flood levels.

Five, no alternate proposals. No alternate proposals are mentioned much less evaluated about uses of dredge spoil other than the placement on agricultural land and on the flood plain. As most of the material is sand and gravel, why not find a more positive use for it than to destroy crop growing land or river ecology.

In addition I would like to make a statement that the Great Lakes Chapter of the Sierra Club is seeking a balance use of the river between navigational interests, boaters, fishermen and hunters, as well as protection of our environment, protection of our fish and wildlife, and protection of the flood victim. The original notice of the Corps was not detailed as to the exact locations and what effects the deposition of dredge spoil would have on this balance use of the river. The Great Lakes Chapter of the Sierra Club requests that the Corps include in their report the exact location of the deposition of the dredge spoil, the character of the land at each site, whether it be agricultural land, slough, marsh, channel or island, with the inclusion of maps showing all structures, the quantity of dredge spoil involved at each site, studies on the fish and wildlife habitat at each site, studies on what affects spoiling will have on fish and wildlife habitat at each site, and studies on the hydrological changes that will occur at each dredge spoil site. The Great Lakes Chapter also requests a long range study on the flooding problems created by deposition of large amounts of dredge spoil over a fifty year period, and a study of alternate uses of dredge spoil.

As an alternate solution the Great Lakes Chapter proposes that all dredge spoil be transported by barge to a centralized location, such as the Fort Bellefontaine Quarry in St. Louis County, and be used as a sand pool for the construction industry. This would alleviate the affects of dredge spoil on the environment and reduce construction costs to an inexpensive supply of sand.

COLONEL PETERSON: Thank you Mr. Tockstein.

In order to clarify one point in your later comments, sir, this is the additional comment that you made for our record. Thank you very much.

At this time we had one other letter which requested a statement to be read in as part of the record. The individual is unable to be here, so at this time I will read this letter into the record.

This is a letter from Mr. C. Ray North, who is the National President of the Propeller Club of the United States. It's addressed to Lieutenant General Gribble, the Chief of Engineers, and I will summarize this but put it in the record in its entirety.

The Propeller Club of the United States is the largest broadest based grass roots maritime and marine association dedicated to support of the American Merchant Marine and all of its segments on the oceans, the Great Lakes and our rivers. I am honored to serve as National President. And, I request that deepest consideration be given to this position, which I'll paraphrase in just a minute, so that our inland waterway shipping may properly meet our country's important economic needs.

The position, paraphrased: The application of the National Environmental Policy Act to maintenance dredging operations if not judiciously managed may cause serious delays which could threaten to obstruct essential waterway commerce on important segments of this country's navigable rivers and other waters. Maintenance dredging is a routine, recurring activity essential to assure the vital transportation needs will be protected and that the depth of navigable channels will be held at necessary levels as authorized by law. The Propellor Club calls upon the

United States Army Corps of Engineers in cooperation with the Council on Environmental Quality to develop an accelerated procedure on maintenance dredging projects for compliance with the NEPA requirements. Such procedure is deemed necessary by the Propeller Club as the only method short of legislative relief to permit on going projects to proceed without undue delay. And after that summary I will submit this entire letter to the record.

Next, I will take statements from the floor and following the presentation of all statements I will ask for any general comments from the floor. At the time you are called upon for a statement would you please announce your name, agency, if appropriate, and city address. It is requested that statements be summarized and held to about two minutes in length. All statements, however, in entirety will be entered into the record, all written statements.

First, in order to keep my procedures correct, I would like, once again, to ask if we have a representative of the United States Senate or Congress, that has a statement here today?

Mr. Charles Kulp of the United States Department of the Interior desires to make a statement. Mr. Kulp?

MR. KULP: Colonel Peterson, my name is Charles J. Kulp, Supervisor of the U. S. Fish and Wildlife Service Area Office at Rock Island, Illinois. We appreciate the opportunity to present this statement and we look forward to a continuance of communications with your District, with the view toward protecting fish, wildlife, and associated wetland resources of the Upper Mississippi River. We have communicated with your District personnel on this issue for several years. Our involvement has been through annual and semi-annual dredge spoil conferences, field investigations and through review and comment on hydrographic surveys provided by your staff.

Our comments are intended to protect fish and wildlife resources of the Upper Mississippi River. The September 16th '74 public notice indicated that approximately thirty locations need to be dredged annually and listed hundreds of prospective spoil locations, most of which are located immediately adjacent to a navigation channel. Approximately 7.4 million cubic yards maximum quantity would need to be dredged in any one dredging season.

Our October 18, 1974 letter of comment on the public notice emphasized: Number one, the need to improve dredge spoil maps so that we could more accurately determine the effects on fish and wildlife. We also found that approximately thirty-five spoil locations would be unacceptable from our viewpoint. Number two, the need for additional studies to examine possible public uses of the dredge spoil. Number three, that detailed maintenance information should be provided to our agency for review and comment thirty days in advance of dredging and spoiling activities. Number four, the implementation of telephone contact in the event emergency dredging and spoiling is necessary. Number five, continuation of the annual dredge spoil conferences. Six, the need for long range solutions to dredge spoil problems. Number seven, full implementation of the three thousand feet of dredge pipe states to be available for use.

Your November 13th letter of response indicated our comments would be given careful consideration in your final determination of the matter. We reiterate our October 18th comments and intend to continue to cooperate with your agency to protect fish and wildlife and wetland resources along the Upper Mississippi. The importance of wetlands to the nation has long been recognized and expressed in recent policies by our agency, the U. S. Environmental Protection Agency, State agencies and the Corps of Engineers.

In addition to our comments on the September 18th public notice we recommend that the objectives of the Upper Mississippi River Basin Commission adopted October 24, 1974 be fully implemented in your District. These objectives are as follows: One, develop a river system management plan that will incorporate total river resource requirements, such as fish and wildlife, navigation, recreation, watershed management, water quality, et cetera. Number two, devise means by which the volume of dredged material removed from navigation projects can be significantly reduced. Number three, open those back, water areas that have been deprived of necessary fresh water flow as a result of navigation maintenance activity. Number four, assure availability of necessary capability to maintain a total river resources on the Upper Mississippi River in an environmentally sound manner. Number five, contain or stabilize all floodplain dredge material disposal sites in a manner to benefit the river resource. Number six, assure all navigation project authorizations include fish, wildlife and recreational resources as a project purpose. Number seven, develop physical and biological baseline data to identify perameters controlling the river system. Number eight, identify sites that can be developed to provide for fish and wildlife habitat irretrievably lost to water resource development projects. Number nine, identify and devise means to use dredge materials as a valuable resource for productive uses. Number ten, implement programs to provide for the present and projected recreation needs on the river system. Number eleven, strive to comply with Federal and State water quality standards. Twelve, strive to comply with Federal and State floodplain management standards. Thirteen, develop procedures for assuring an appropriate level of public participation. I want to thank you very much, Colonel.

COLONEL PETERSON: Thank you, Mr. Kulp, for your statement.

At this time I would like to call on Mr. Dieffenbach of the Missouri Department of Conservation, who wishes to make a statement.

MR. DIEFFENBACH: I am Bill Dieffenbach of the Missouri Department of Conservation and I have a statement that I will read and since I have the same objectives in part of the statement from the Upper Mississippi River Basin that Mr. Kulp presented, I'm just gonna hit a couple of those and try to cut this thing down a little bit.

We have reviewed the public notice dated September 16th, 1974 regarding the spoil disposal operation of the District, St. Louis District on 196 miles of the Mississippi River between Cairo, Illinois and the Missouri River.

The Missouri Department of Conservation has for years been actively working with the Corps of Engineers to protect and preserve fish and wildlife on the Mississippi River. We have reviewed the rules and regulations published in the July 22nd, 1974 Federal Register, entitled Federal Projects Involving the Disposal of Dredged Material in Navigable and Ocean Waters. The Missouri Department of Conservation is concerned with the apparent canalization of the Mississippi River. While we recognize the need of providing for the nine foot channel, we note that the loss of wetlands, side channels and backwater habitat that has been tremendous during the life of the project. Part of these losses are due to dredge spoil operations conducted by the St. Louis District. In an effort to protect the remaining wetlands along the river, we have identified thirty major habitat areas, attachment one which I'm not going to read either.

To comply with section E3 of the rules and regulations of the disposal of dredge material in navigable waters, we recommend that no spoil be placed directly on wetlands or in such a manner that the spoil will be eroded and redeposited in wetland areas. Type one and type five wetlands exist in many of the major side channels identified in joint studies conducted by the Corps of Engineers, Fish and Wildlife Service, States of Illinois and Missouri.

In addition to these areas that were identified dredge spoil should not be deposited in other minor wetlands and backwater areas. Such areas can be identified when detailed reviews of dredge and spoil plans are made. In addition to our active participation in dredge spoil problem with the St. Louis District, we have been and are participating in the Upper Mississippi Basin Commissions' Dredge Spoil Practices Committee. That committee, through the efforts of the Corps of Engineers, North Central Division, and the Fish and Wildlife Service has reached consensus of the five member states and ten Federal agencies of the Upper Mississippi Basin Commission for the following purposes and objectives. And I'd just like to hit about three of these that I think are the most important. They are all, the whole bunch of them are important, all thirteen of them are important, but I think three that highlight what our interests are would be develop these objectives: Develop a river system management plan that will incorporate total river resources, including fish and wildlife, navigation, recreation and watershed management, water quality, et cetera. The second one I'd like to highlight is devise means by which the volume of dredged material removed from navigation projects can be significantly reduced. The third one and the last one of those I'd like to highlight is identify and devise means to use dredged materials as dredged materials as a valuable resource for productive use.

And now for the closing, we believe that strong effort must be made by all interests to continue to move toward the objectives listed by the Upper Mississippi Basin Commission and guarantee compliance with Federal rules and regulations. The Missouri Department of Conservation will continue to actively support the Upper Mississippi Basin Commission, Corps of Engineers, Fish and Wildlife Service, and other groups in an effort to protect fish and wildlife habitat on the Middle Mississippi River.

COLONEL PETERSON: Thank you Mr. Dieffenbach.

Are there any other representatives of Federal or States agencies that at this time wish to make a statement?

Are there any representatives of any local unit of Government at this time that wishes to make a statement?

In that case I'll go on to other individuals having an interest who have a desire to make a statement.

Mr. Jerry Tinkey, do you desire to make a statement, sir?

MR. TINKEY: I'm representing Mid-America Transporation Company, but also I brought along letters from Gordon Jones, Vice President of Alter Company, Mike Rushing, President of Missouri Barge Lines, which I have submitted for the public record.

COLONEL PETERSON: Do you wish to summarize your statement or just have it entered?

MR. TINKEY: Just enter it.

COLONEL PETERSON: All right, sir.

Mr. Billy Jackson?

MR. JACKSON: Thank you Colonel, I'm Billy Jackson, President of Teamster Local 54, which constitutes the Teamster Marine Division. I have a brief statement which I'll read. It's addressed to you concerning your notice, I won't go into the numbers.

This communication is forwarded on behalf of the entire membership of the Marine Officers Association, Teamster Local 54, which constitutes the Teamster Marine Division. Our membership is made up of professional river boat personnel who rank among the finest in the business of manning the vessels engaged in inland transportation. Which we regard as being the most nearly perfect form of transportation, in so far as environmental considerations are concerned.

The continuation of maintenance dredging in the Mississippi River is essentially -- in essentially the same manner which has prevailed for decades past is altogether vital to maintain the uninterruped flow of barge traffic upon which so much depends. The very economic life of the great Midwest depends upon the orderly flow of this form of transportation. It is a fact that the combined facilities of all of the modes of transportation are physically incapable of moving the grain produced in the Midwest. The necessary fertilizer or petroleum products and coal, to mention a few commodities imported in bulk, could not be moved into the area at a cost conducive to maintaining the population in an acceptable fashion. Failure to move grain out of the area would seriously impair the nation's ability to resolve a serious imbalance of monetary exchange as well as pose unsurmountable obstacles to our commitments to supply food grain to foreign needy nations.

We possess the notion that the migrating alluvium with which we are now concerned, that being the material which fills the channel and necessitate dredging will for the most part eventually find its way to the Gulf of Mexico in any event, and therefore, we find no reasonable basis for consideration of depositing dredge spoil in any place other than one adjacent to the channel by reason of cost and convenience. To do so would serve no useful purpose.

Finally, this union does possess strong, favorable feelings toward a program which is absolutely necessary for our continued existence. Therefore, we endorse the dredging program as proposed by the St. Louis District, Corps of Engineers.

COLONEL PETERSON: Thank you Mr. Jackson.

I may at this time call on Mr. David Bedan?

MR. BEDAN: My name is David Bedan, I'm Vice President of the Coalition for the Environment in St. Louis. I'll be submitting a more detailed statement later, so I'll just make a few general points now.

First of all the Coalition is interested in a balanced program of uses for the Mississippi River and as we see it the present trend has been increasingly to a single purpose. In the discussions of justification for the replacement of Alton Dam, for example, the Corps of Engineers speaks of a four-fold increase in navigation on the river. This may or may not be desirable, but we believe that a lot more study is necessary to see if this kind of increase in navigation is compatible with the multi-purposes use of the river. Secondly, we concur with the comments of Mr. Covington that the phrase unused floodplain reveals a great deal of insensitivity to environmental considerations, particularly to the problem of diminishing wetland habitats, which the representatives of the Interior Department had mentioned. Thirdly, we feel that there is also insufficient information for comment upon the specific spoil sites at this time. The Rock Island District of the Corps has published detailed Environmental Impact Statements on each navigational pool, pools ten through twenty-two, with maps that contain far more detailed information on their dredging operations, including specific botanical types and so forth, and I would suggest that we need that kind of information on this stretch of the river and I assume you will include that in your impact statement. And fourth, I believe there has been insufficient study of alternative uses of the spoil and would like to see, for example a study of the possibility of using the sand for construction purposes as the Sierra Club has suggested. And, also, would like to see more study of how deposited spoil areas can be used and developed for recreational purposes.

Thank you, Colonel.

COLONEL PETERSON: Thank you, Mr. Bedan. Would you please send your statement within ten days so we can incorporate it? Thank you, sir.

I'd like to call next on Mr. Thomas Steiniger, who indicates he desires to make a statement.

MR. STEINIGER: Colonel, Thomas F. Steiniger of Granite City Steel. I desire at this time to withdraw my verbal request for a statement, we will follow up with a written statement.

COLONEL PETERSON: All right, sir. Thank you.

Mr. John McDaniel, desire to make a statement?

MR. MCDANIEL: Colonel Peterson, I'm John E. McDaniel, Assistant Vice President for River Cement Company, whose office is at 9900 Clayton Road, St. Louis.

I want to state our position in support of the channel dredging proposed by the Corps of Engineers. River Cement has a manufacturing plant some forty miles south of St. Louis, on the Mississippi River. From the plant cement is moved by barge to distribution terminals in St. Louis, Cincinnati, Memphis and Natchez. We own twelve barges that are moved by three leased boats. These barges will transport some four and one-half million barrels of cement a year. When you count both loaded and empty trips into our plant, you are talking about 650 to 700 barge trips in and out of the plant, our plant, for a year. The economy of water transportation was a major factor in selecting the plant site ten years ago. Only because of water transportation are we able to compete and to contribute economically to distant markets like Cincinnati, Ohio, and Natchez, Mississippi.

It is vital to River Cement and other such shippers that a nine-foot channel be maintained on the Mississippi. Anything less than a nine-foot depth would require us to load the barges light. That would mean an increased number of trips to deliver the same amount of product. This, in turn, would be a waste of what is now a very precious item, the oil to operate the towboats. Without sufficient channel in the Mississippi it would be impossible for River Cement to supply the customers that we now are shipping throughout a ten states area. Rather than continue with statistics or barge movements, Colonel, if I may, I'd like to make a little personal analogy.

I'm an engineer and have lived and worked with the mighty Mississippi all my life in Memphis and for the past six years in St. Louis. I know the power of the river during flood stages and the fickleness of its changing ways with each rise and fall. The dredging proposed by the Corps will have about as much influence on the river as I have on my wife when we are shopping together. We can be strolling down the street or a shopping mall, I may nudge her to keep her from looking at a particular window or shop, but if she has her mind set she will find a way to get where she wants to. My nudging her arm won't change her appearance, nor will it change the shopping mall. The dredging is proposed by the Corps will cause about as much change to the river as I would make on my wife in the shopping mall.

We should direct and use this wonderful natural resource, the Mississippi River, for transporation, in that way it will continue to serve millions of people. Thank you.

COLONEL PETERSON: Thank you, Mr. McDaniel.

Call on Mr. Kenneth Schmidt, at this time do you desire to make a statement or not?

MR. SCHMIDT: I'll reserve my statement later.

COLONEL PETERSON: All right, sir.

Mr. Bruce Bussen do you desire to make a statement or not?

MR. BUSSEN: Yes sir. This statement is kind of expemporaneous. I am Bruce Bussen, I'm with Riverside Sand and Dredging. We are a commercial dredger operating primarily in the St. Louis Area. I have a particular objection to the suggestion that dredge spoil be collected and given away for construction material. I think that's understandable.

I have several problems involved. A), philosophically, I am opposed to the Government giving away that which we produce in a free enterprise and tax paying effort; B) I do not feel that it's practical to transport material the sort of distances necessary to a centralized spoil area, require too many barges and too many boats; C) Even if you could marshal the barges and the boats, once you got this spoil to the area it would likely be the wrong size resulting in further disposal problems. Most of the material is silty, not suitable for construction material, a great deal of it could be wood, which would create additional disposal problems. And, D) I don't believe it's economical. You transport the spoil to, let's say, Fort Bellefontaine Quarry as suggested. The cost of taking that material from Fort Bellefontaine, let's say, to south St. Louis would be vastly more than the value of the material. So basically I just think it's not a particularly good suggestion. Thank you.

COLONEL PETERSON: Thank you, Mr. Bussen, If you do desire to send in a formal statement, will you do sir before, within the ten day limit.

Mr. John Cunningham, do you desire to make a statement?

MR. CUNNINGHAM: I'm John Cunningham. I'm an engineer. But, I represent the Sierra Club, Eastern Missouri Group, which is part of the Ozark Chapter. And I would like to submit a statement, and I'm not going to read it, I just would like to summarize a few comments from it.

First, as a group we are concerned with the maintenance of water quality on the Upper Mississippi River. The Corps has stated in numerous Environmental Impact Statements relating to navigation work and dredging, that water quality indicators are one of the most representative of the overall environmental condition of the river system. And we heartily agree with that. And we think that the general values of water quality and its need for drinking water but also its relationship to the ecology of the river is of prime concern and we think it's only fitting that the navigation of the river should take this into account and that these two operations be dovetailed in some way.

I have some specific comments relating to the letter dated September 16th, 1974. Your letter, reference LMSOD -1-1, paragraph one, dredging requirements, this paragraph states that there are "thirty locations annually will require to be dredged" but it refers to maps which according to our particular count there are forty-nine locations, and we would like a more specific information as just to what specific locations that you're actually going to dredge and where you're going to put this dredge spoil. In other words, to make more specific comments we would request a little more specific information and we would welcome the chance though to make specific comments rather than just general comments.

Paragraph two on the Federal Law and Regulations, this paragraph states that the EPA will furnish guidelines for the selection of disposal sites. We have a question, are these guidelines available and are they -- will the actual 404 permits be filed, and expecially does the EPA follow up with field investigation as to guideline compliance, or is there merely a presumption of compliance? Paragraph 3.a., authorized channel dimensions, it talks about the River and Harbors Act of 1927, Document Number Nine, permitting a minimum channel depth of not less than nine feet. And it's our understanding that the present practice in the District is to construe this section to allow for a cut of approximately eleven feet on the average. This practice of a minimum cut of eleven feet allows for the possible ridging effects of the material and it seems imminently reasonable to us, but we certainly would not feel that it would be lawful or good dredging practice to dredge beyond that. And we have heard reports in some Districts, I think, that in some places they go as low as fifteen feet to maintain a, or fourteen feet, something like that, to maintain a nine-foot channel. And we feel that whatever the Corps can do to cut down the actual quantity of dredging would promote better water quality. In other words, it would make the problem smaller, so to speak.

And in paragraph 3.b. on dredging practices, it states in this paragraph that 1962 was the peak year with seven million yards removed but the average is about four million. Well, we note your accompanying disposal sites tabulation show a total quantity of 9.6 million yards and we were asking, of course, it says this is the maximum quantity to be dredged, we ask is this figure any indication of what will actually be dredged in this 1975 program. And we'd further like to comment that it would be our hypothesis that the quantity of dredging material trend line is increasing over time. Although, there are undoubtedly considerable yearly deviations from this trend line, and we would expect the Corps to analyze this problem or this, and see just what is happening with dredge spoil over time and perhaps the Environmental Impact Statement forthcoming would be the appropriate place to analyze this as would it be the appropriate place to analyze other dynamic factors in the river. In other words, what is happening to water quality over time and things like these. These are the questions that we think the Environmental Impact Statement should address itself to.

Well, I'm going to skip over the rest of this. I think it's already been covered. I just would like to make one closing summary statement and that is that as a, I suppose, as part of the public we welcome the opportunity to work with the Corps on this and we are looking to find solutions to some of these problems. We are trying to avoid ideological positions like shutdown the river and things like that and work this thing out in terms of what can practically be done. And I would say though that we would appreciate as much information as we could get and we think this is important in order for us to make intelligent comments and we would also appreciate along these lines something like a bibliography of the documents that are already out, that the Corps has relating to environmental impacts of dredging. Thank you.

COLONEL PETERSON: Thank you, Mr. Cunningham. I'd like to call on Mr. Lloyd Eneix. This box is sort of scratched up but that does indicate you want to make a statement?

MR. ENEIX: Correct.

COLONEL PETERSON: All right, sir.

MR. ENEIX: My name is Lloyd Eneix. I'm Director of Marine Operations of Agri-Trans Corporation. I'm here today representing Agri-Trans Corporation, St. Louis.

Our company operates seven towboats and over two hundred barges on the inland waterways system servicing America's most important industry, agriculture. Our present fleet has a capacity of annually moving 3.6 million tons of agriculture and fertilizer products. More importantly, we are just beginning a major expansion program designed to increase this capacity by a hundred and thirteen percent, just to service the known, future commitments, of the grain and fertilizer member owners of Agri-Trans.

At the outset, Agri-Trans would like to suggest that the topic of this hearing is diverting attention from a substantially more vital topic, that being the imperative of upgrading effectiveness of present dredging operations. When a barge operator is constrained by low water, commonly seven percent of his equipments' productive capacity is lost. This production loss can be as great as fifteen percent. Moreover when dredging operations are inadequate, grounding will occur. With present equipment costs, the delays occasioned by such groundings can cost between six to seven thousand dollars a day. This cost is in addition to equipment repair and a potential for personal injury attending a grounding incident.

The foregoing is not presented as an indictment of the Corps' dredging operations. We understand these resource limitations they experience and commend the job they perform under such constraints. But the economic impact of dredging ineffectiveness on carriers, shippers and the public at large must be recognized.

Turning to the specific question of today's hearing, it is clear that transportation efficiency is not the issue, rather it is survival of the river transportation industry. The cessation of Congressionally authorized maintenance dredging would effectively close off the upper reaches of the Mississippi River System to waterborne transportation service. Some argue that the only result would be the demise of an industry and certainly the environmental gains more than offset such a loss. Besides, they argue, other transportation modes could fill the void. These spokesmen are, of course, wrong on two scores. First, our industry is in business to serve the public's transportation needs. If the viability of our industry is jeopardized what does the public stand to lose? Merely the safest, least expensive, most energy efficient and environmentally respectful bulk transportation mode capable of servicing our nation's interior. These characteristics of our industry are well established in the public record. But even if the river industry did not measure up to that billing, which it does, the modal shift of commodities carried by the inland waterway is simply not feasible. Suffice it to say that alternative modes have neither the present capacity nor the financial strength to obtain the needed additional capacity to accommodate a shift of present and future river traffic. The serious impact of this continuing maintenance dredging must also be viewed in terms of the huge investment represented by the upriver flood control and navigation structures. To sever the upriver system is to deny that region the future benefits anticipated from the investment, a tragedy in view of the commercial development achieved there to date as a result of waterborne commerce. As for the specific impact on Agri-Trans only ninety percent of the aforementioned tonnage we transport now and plan for the future would gradually be curtailed. Fertilizer tonnage northbound, a sizeable portion of our overall movements and grain down river for its domestic and export uses would have to find new ways to market. As stated earlier, however, there is not feasible transportation alternative. Some have claimed that the primary purpose of the Mississippi River System should be for recreational purposes. We at Agri-Trans reject that view, but we equally stand against the contrary concept that commercial considerations should be preemminent. As in all public matters balance must be achieved in resolving legitimate interests that are in conflict. Reasonable men will agree that severing the inland waterways would not be a balanced response to ameliorating environmental harm which may result from dredging. The proper response we suggest is to insure that dredging is performed effectively from a transportation standpoint while minimizing the cost to the environment.

COLONEL PETERSON: Thank you Mr. Eneix.

Mr. Martenson you have a question mark, sir, do you desire to make a statement or not at this time?

MR. MARTENSON: No, because we'll file a written statement later.

COLONEL PETERSON: Thank you, sir.

Mr. Charles Belt, do you desire to make a statement, sir?

MR. BELT: Yes, I do. Colonel Jester, former Colonel Jester and Colonel Peterson now in command and Mr.

Doernhoefer. Sorry about getting the order fouled up here, I should have addressed Colonel Peterson first.

According to Tom Maher, who used to work for your office, the 1951 flood deposited a twenty-foot high mound of sediment in the Mississippi River which worked slowly downstream. And of course it must have had to do quite a bit of dredging to cut it down to size. Now, the channel, the normal channel of the Missouri River has been confined for navigation and reduced in bankfull width in a cross sectional area since 1880 for navigation. And according to a study of the U. S. Geological Survey, which was published in 1952, this has caused significant rise in stages of increase in frequency of flooding. My own research on the Missouri River has confirmed this. In addition, it is well-known hydrologic principle, when you confine a river either by levees or by navigation works, you increase velocity. And this has also been shown by another paper of Mr. Maher's and other people. Now, if you increase the velocity of a river, you increase its ability to transport material and you also increase the size, in which a river, of sediment, which a river can transport. Hence, one would expect the ability of the Missouri River to have been -- to transport large amounts of bedload to have been significantly increased since the 1920's. So that had might well have a larger ability to dump large amount of sediment into the St. Louis Harbor than it now does.

Hence, I would like to ask the Colonel to tell me how significant was the Missouri River, in the formation of the sediment deposition of the St. Louis each as a result of the 1973 flood. Secondly, what historical effects the confinement of the Missouri River has had on its ability to transport bedload during floods and dump it in the St. Louis Harbor.

Finally, I would also like to call upon the Corps of Engineers and Mr. Clapp to make as soon as possible public the research study that has been on the sedimentation in the St. Louis Harbor, that has been kindly financed at the behest of Mrs. Sullivan.

And now I'd like to make a little comment about Mr. Eneix comment about the waterway transportation being the most energy efficient. It seems that two studies have shown, one from the Oakridge National Laboratory and the other one by Mr. Sebald of the Center for Advanced Computation of the University of Illinois, that barge mode transportation on rivers is not, and I repeat not, significantly more energy saving that railroad mode transportation and furthermore, there is a suspicion that it is probably less energy saving than railroad transporation. And to sum up, I reside, my place of business is 3507 Laclede and I am not here representing any organization, I am speaking as an individual. Thank you.

COLONEL PETERSON: Thank you, Mr. Belt.

Mr. Charles Lehman, do you wish to make a statement?

MR. LEHMAN: Yes sir. Thank you. My name is Charles Lehman. I represent American Commercial Barge Line Company, Jeffersonville, Indiana.

Colonel and Mr. Petersen, we appreciate your allowing us to appear here on this timely subject of dredging and spoil operations on the Mississippi River. Our company operates over eleven hundred barges and some forty towboats, many of them in the reach of river now under consideration. My appearance here today is in support of the program of channel maintenance as historically has been accomplished by the Corps of Engineers in order to bring to the public the economic benefits of a nine-foot channel between Cairo and the mouth of the Missouri River. I have here today for display a traffic flow chart, represents the Mississippi River, the Ohio River, the Illinois, Tennessee, Cumberland, various other tributaries intercoastal. This traffic chart shows the density of the tonnages moved on the entire river system in this calendar year of 1972, which are the latest figures available. In particular it shows fifty-four million, four hundred thousand tons of cargo moved between Cairo and the mouth, that's this stretch right here. The light brown, tan figure represents upbound traffic. The blue represents downbound cargo tonnage.

When discussing the maintenance of this particular link of an entire river system, what has to be taken into consideration is the tonnage flow on the rest of what we call our western rivers. The Lower Mississippi tonnages, almost the entire upper, the Missouri River, and the Illinois system are dependent on this vital link being maintained, as well as certain tonnages moving on the Ohio River and the Tennessee system and other tributaries. Now what would this chart look like if this vital link, this section right in here, were allowed to silt in, was not maintained, and for all effects and purposes was closed to navigation.

Almost all the tonnage above Cairo, all of this up here, would be blacked out as well as about half of the lower Mississippi River tonnage. A significant degree of the other flows on the Upper Mississippi and other tributaries would also be lessened and the widths of these various links would be entirely lessened. This chart shows twenty-one millions tons of cargo flowing into the region and over thirty-three million tons moving out of this section in 1972. For the maintenance of this one link of waterway, what does it mean to the consuming public that is now concerned with the impact of inflation on their pocketbook. If maintenance dredging were continued and the channel on this section of waterway is not kept open, the products moved by water would then have to be moved basically by the railroads.

The cost of moving a ton mile of freight on our inland waterways system is approximately four mills; the cost of moving a ton of freight by railroads is estimated to be approximately one point four cents. This additional one cent per ton mile would add approximately $598,400,000 to the total cost per year of products moving into and out of the Upper Mississippi River. Or to put it another way, if the products were moved by the railroads each pound of freight moved would cost the consumer's bill for every pound consumed approximately five and a half cents. What does this mean to us in the river industry and ultimately to the consumers if we have delays, where the channel is blocked awaiting action, either by some means of administrative interpretation, court interpretations or legislative relief.

If because of the channel restrictions we are forced to lessen our drafts, each six inches represents approximately a hundred tons lost carrying capacity for each barge. This six inches represents approximately a hundred tons lost carrying capacity for each barge. This six inches represents one-fourteenth of the load or 7.14 percent. If we are forced to load to a substandard channel of seven feet due to inadequate or non-maintenance of the channel, this would represent a loss of approximately four hundred tons per barge or twenty-nine percent of the barge carrying capacity.

The reflective rates and economies of our capital equipment is based on the Congresssional decision to build and maintain a nine-foot channel in this reach. Most of our new and efficient towboats have drafts of 8.29 feet. It would be impossible for us to utilize these vessels in a restricted channel, even if our barges were light loaded. All of our barging equipment has been designed to operate efficiently and safely at nine-foot or greater drafts.

A barge makes an average of approximately ten loaded trips per year. At full industry capacity between Cairo and the mouth of the Missouri there would be about thirty-eight thousand, nine hundred loaded barges moving in and out of this stretch of the Upper Mississippi to carry the 54,400,000 tons of freight. At ten trips per year, this would amount to 3,890 needed barging vessels. If channel restrictions cause the barge to be loaded to a lesser draft, each six inches would mean that 295 more barges would be needed to move the tonnages. Moving these barges would take at least an additional fifteen modern towboats.

Figuring the cost of capital investments each six inches of tonnage lost would represent at 295 barges, approximately $48,675,000, and the fifteen towboats would represent some $22,500,000 or a total of $71,175,000 in needed capital equipment. To restrict the channel to a draft of seven feet and assuming no channel delays at that draft would cost the industry in new capital equipment approximately $285,000,000.

Increased revenue requirements would be approximately $73,000,000 annually to maintain the present level of service. The resulting cost can only be passed on to the consumer in the form of higher prices for goods and services.

What do we do if we load to the nine-foot depth and hope to make it through this stretch of river between Cairo and the mouth of the Missouri during low water periods if no channel maintenance is performed? A barge is generally loaded ten to twenty days before it would arrive at the section between Cairo and the mouth. Once it arrives there it's committed. To have a tow of twenty barges and a towboat waiting for enough water to get through this shallow section would amount to lost revenue of $11,200 per day. All of this would eventually be passed on to the public in the form of higher rates, which would have a direct bearing on the cost of a loaf of bread, a kilowatt of power, or a gallon of gasoline.

Economics aside, now let's address ourselves to the question of ecology. The question which needs an answer to satisfy the environmental concerns of the nation, and our company I might also add. We concede that to do maintenance dredging will result in some increased turbidity in the watercourse over a very short period and of a limited extent, by using the hydraulic dredges presently employed in keeping the channel open.

The effects of this increased or limited turbidity have not been documented. In areas such as between Cairo and the mouth of the Missouri the fear of adverse consequences rather than any factual adverse impact seems to be how the discourse is voiced. In-depth studies of this problem are now being made by the Waterway Experiment Station, by the Office of Dredge Material Research. But to not dredge will result in the requirement to build large amounts of equipment to move our goods, more barges, more railroad cars, and more trucks which will take an immense amount of energy and raw materials.

To move the products on the river at a lesser draft will result in more towboats burning more fuel per ton of cargo moved and this is certainly not going to do any thing to help the nation to strive for an independency of energy sources. If the tonnages did not move by water, but went by rail, and I beg to differ with the gentleman that was up here before, studies by the Rand Corporation as well as the Department of Transportation show rail to consume over fifty percent more fuel per ton mile moved than does the water movement. Truck transporation is even higher.

Any degradation of the water environment by maintenance dredging is more than offset by not allowing other and perhaps worse environmental degradation to occur as an alternate, such as increased hydrocarbons in the air, the unwise use of raw resources, as well as keeping the inflationary impact of increased transportation costs to a minimum.

What alternatives do we have to maintenance dredging? The question has been answered by some short-sighted persons by saying, no dredging. We have already talked of the consequence of that action. Others have said to only employ cutterhead dredges and move the dredged material to landfill sites. First of all, there are not enough dredges, and no new dredges which could be used to maintain the Mississippi River are being built. Secondly, in many areas landfill sites are not available. Thirdly, if the dredges and the fill sites were obtainable, the cost of dredging and removal of the material has been estimated to cost approximately ten times the present cost of maintenance dredging. With the present climate in Washington's OMB office, we know this increased cost would have the effect of no dredging or the no dredging alternative. The money is not there. It will not be there and for all the studies of what we have seen maintenance dredging does or does not do, it shouldn't be there.

We fully believe that to reduct the inflationary impact on our economy, to assist in operation independence, energy operation independence, and to comply with the ultimate environmental concerns of our nation, maintenance dredging must be continued, not only from the Cairo to the mouth of the Missouri, but the entire present navigational system in the United States as the only responsible action that can be taken by the Corps at this time. Thank you, Colonel.

COLONEL PETERSON: Thank you, Mr. Lehman.

I believe this is Mr. A. E. Witholt, is that correct? Winholt, excuse me, sir, do you care to make a statement?

MR. WINHOLT: Yes, Colonel, I assure you that it will not take very long to say what I have on my mind. Colonel Peterson, gentlemen, we have heard much comment about things all over the country so I feel that I could ramble just a little bit but this specifically was to be concerning the dredging of the nine-foot or maintenance of the nine-foot channel from the mouth of the Missouri River to Cairo, and we are very much in favor of that. I work for Mobil Oil Corporation, in the Marine Transportation Department. We barge petroleum products on the Mississippi River.

To give you a picture of what no dredging would amount to, a towboat costs from between three and four thousand dollars a day to operate and it can run with a given number of barges. If we cannot load these barges to their full capacity, eight and a half or nine feet, the cost of that transportation goes up. And what it would mean to you people and the rest of the people in the United States is that the price of gasoline, fuel oil, baggies, rubber goods, all kinds of petroleum products, anything that's made with petroleum will escalate. So it's definitely to our advantage to maintain a nine-foot channel.

There was much talk about the upper river in the wetlands and the recreation hunting and fishing, I happen to have spent thirty-two of my -- forty-two of my almost sixty years on the river. I have lived in Moline, Illinois and I've known this Mississippi River before there was any dredging to amount to anything, any locks and dams, any control. I have seen the river go from flood stage to a meandering creek that couldn't allow a small motor boat to pass. There are now wonderful fishing areas, wonderful recreation areas, hunting and fishing has never been so good on the upper river. The water has never been cleaner, not only on the upper river but in the Mississippi right here in St. Louis. The water supply has never been better for many people where their intake pipes were out of the bottom of the river.

The rivers were the avenues of exploration and development of the entire United States from the Appalachian Mountains to the Rocky Mountains. The Corps of Engineers has done much to improve those avenues for our use and we are using them. To stop dredging, or stop maintenance dredging on the river would be just like taking one lane of Highway 40 or Highway 55 or 70 or any of the interstate systems and just run two lanes of traffic instead of utilize what we've developed. So I'm for dredging.

COLONEL PETERSON: Thank you, sir.

Mr. Glenn Tockstein? Oh, excuse me, you made the original statement.

Mr. S. C. Gansner?

MR. GANSNER: My name is S. C. Gansner, property owner. And I have lived by the Mississippi River for about the last forty years, watching every phase of it, and I have a few comments here I'd like to make. Also, I'd like to say that I have yet for any of the navigation interests here to say anything about agriculture. It just seems to me like it might be a stacked deck, but ...

I am offering the Corps of Engineers two miles of river front for spoilage. This is on ground that has been cultivated for the last sixty years. The current high waters has not improved my situation, and I have yet to be convinced that spoilage hurts soil. I can show anyone so called spoilage that has produced twelve to fourteen foot willows in less than three years. Also, this ground once it's turned over will produce ground second to none, it contains all of Nebraska, Iowa, and you name it. Everyone here has complained once or twice about taking fifty dollars worth of groceries and putting it in her glove compartment. I think this is just another way of saying that we can take some of this river spoilage and put it on agricultural land in certain areas, and I think with a little investigation you will see a lot of people will be interested in seeing spoilage put on land rather than shuttling it around in the river or converting it over to commercial sand interests. Thank you.

COLONEL PETERSON: Thank you, Mr. Gansner.

Mr. R. L. Hafferty?

MR. HAFFERTY: Yes sir. Thank you. Colonel, my name is Richard Hafferty and I represent National Marine Services. I have a very brief statement and my statement will speak to losses to a segment of the economy including the agricultural interests and the losses suffered by National Marine Service represent only a small portion of the total losses suffered by the river transport interests in the shallow channels that we are having now between Cairo and Wood River.

We haul liquid petroleum and fertilizer for the agricultural industry, which is vital to a stable economy which I am told could not be hauled by the railroads or the truck lines as they currently exist. And if the railroads are more efficient than the barge lines, as the honorable gentleman over here suggested, I suggest that the only way that the consumer receives those benefits is by water compelled rates.

From July 19th of this year until the 15th of November we lost about thirty-three barge days due to channel delays and groundings. This cost about three hundred and eighty thousand dollars in transport lost time, and an additional amount in additional inventory required by our customers of about one hundred thousand dollars. Damages to our equipment suffered in the channel was in excess of one hundred thousand dollars, and this does not include lost barge days.

Examples of bad spots that we have seen is about mile 41, 183 and 170. We suggest that the turbidity caused by dredging is considerably less than that caused by Mother Nature created in her latest flood. Thank you.

COLONEL PETERSON: Thank you, sir.

Mr. Thomas Kenny?

MR. KENNY: Colonel, Mr. Petersen, I have a statement which I will submit, but I would just like to gloss over a few things.

My name is Thomas E. Kenny, I reside at 1522 Starlight Drive, Ferguson, Missouri, I am employed as the Marine Superintendent for Wisconsin Barge Line. I most ardently advocate and take the position that the dredging program be maintained throughout the entire St. Louis District of the Upper Mississippi River and that they continue to dredge in a maintenance program to maintain that nine-foot channel.

I take this position due to the economic factor involved. Now, prior to 1930 the Upper Mississippi River was an open river. You can say there were dikes and strategic revetments put in so as to keep the channel flowing in a certain direction and cause a certain amount of scouring and keep the sedimentation moving, but at that time you had boats, that, old packet boats that drew maybe three, four, five feet that could carry four to seven hundred ton of cargo. And you had low waters as the gentlemen mentioned at Moline, when you couldn't even get a motorboat past it.

Congress came along and realized that importance of the Upper Mississippi River, what it could mean to the public at large. So they enacted the laws, appropriated the money, and built the present system of locks and dams that we have. They also as you pointed out, Colonel, had enacted the directive to maintain a nine-foot channel between Cairo and St. Louis. This was good. This is what this part of the country needed. And I think if you will look through the cameras and the dotted i's and the crossed t's you will find somewhere where Congress had the intent and mentioned that they wanted some competitive form of transportation in this area so that the economic benefits could be absorbed here and that's what you got when you built the Upper Mississippi River system of locks and dams.

In the beginning when the locks were put in we had barges that were drawing 5, 6 feet, we had towboats that were ranged in maybe a thousand to fifteen hundred horsepower and drew six and seven feet, but the industry, the river industry, the barge industry as it grew became aware of what they could do and so consequently with the assurance that they were going to have a nine-foot channel, they geared their production facilities. They built barges that would haul nine feet. They built their towboats so that they could haul fifteen barges, and they had to build deeper towboats, they had to have bigger rudders, they had to have more horsepower on them. So, consequently, they did it. So here's an industry that saw what it had to do. They met their market and they produced the kind of equipment that would meet their market and tow it at a low cost and insure them of making a profit. And that's what we're all in business for. We have to make a profit. And the industries on shoresides, they recognize that. The volume of millions or billions of dollars that was invested in new plant equipment along the Upper Mississippi River is a very good testimony as to the fact that industry on shoreside saw, that here was a form of transportation they could use economically.

Not only that, you have a lot of resources in the South which are used in the North, and the St. Louis District sits right in the middle of it. And to stop the dredging program here, you're going to keep one end of the one section of the country from supplying the other section of the country with its needs at the most economical transportation dollar that you have, which is the barge industry.

Now, the company that I represent is one of maybe ten, twelve companies hauling grain. We haul out of the Upper Mississippi River over two million ton of grain each year. We bring up out of the south over a million and a half tons of fertilizer and salt, which is used on the roads, and also we haul coal into the power plants. Now, to let the river silt and where we would come to a point where we would have to lighten our barges a foot, it would mean in the type of barge that we use that we would lose 216 ton of revenue producing tonnage. We'd have to put that in another barge, just as some of the gentlemen made mentioned here, as Mr. Lehman had mentioned, this is a loss which we hadn't counted on. We had anticipated hauling at our capacity. When you reduce our ability to haul at our capacity we have to make it up some way. And how do we make it up? We have to increase the cost per ton mile of service charge that we make. So for that reason alone, as I say, we are only one company, we haul through the St. Louis District over three and a half million ton of cargo every year. And there are companies here that haul twice as much as we do to this area.

So I would very much advocate that the maintenance program be continued, and that we do continue to have the nine-foot channel to allow the river industry to maintain and provide the most economical transportation dollar that we have in this country today. Thank you.

COLONEL PTERSON: Thank you, Mr. Kenny.

I have no other cards of individuals who desired to make statements. So at this time I would like to ask for any comments, that is comments that will not normally be submitted as part of the record, although, they will, of course, be part of this transcript. Are there any comments desired to be made by any of the representatives of the Federal or State agencies here present?

Are there any comments that are desired to be made by any individuals here present at this time?

MR. JESTER: My name is Guy Jester, I'm here as a citizen, although, I work for J. S. Alberici Construction Company. Having had some difficulty as District Engineer from ex-District Engineers making statements I had vowed not to make a statement when I came today, but there are a couple of things that were said, which I feel like ought to be somewhat clarified.

One has to do with the sedimentation and what it does and how much moves on the river, if we will look at what the total sediment load is in the river some four hundred thousand tons per day, versus what will be dredged in the course of a year, it is less than one percent.

Secondly, you will find that the surface are dredge varies between one and two percent total surface area.

I think another statement here, and I'm sorry I'm going to have to mention your name, Mr. Belt, but it's unfortunate that some people will read documents and only read into it what they want to see. And there are the same documents which go on and clarify and state exactly what the situation is. For instance, on the Missouri River there is a geological survey report which points out that over a long period of time the sediment load has remained rather constant, in fact, over the last ten years it's going down some. This I think goes to point out one of the problems no matter what you try to do to cut down on the sediment load, if you clean the river up too much so far as sediment is concerned it will pick it up itself again. You cannot maintain a clean river, and I think when you go to making statements relative to what the river will or will not do, you really need to know a great deal about potomology and things of this nature, which you can easily find out how the river will act and what it will do under certain circumstances.

I think another thing that I would like to clarify is that the studies quoted concerning whether one mode of transportation is more efficient than another. There are as many or more studies, and one study which points out the fallacies in the Illinois study which shows that the river mode of transportation is much more energy efficient and some made by some rather erudite individuals and institutes. So, I don't want -- I don't know the answer to that question one way or another but I would not like for people to leave with the impression that those two studies are definitive, in fact, they are not. In fact, there has been some great deal of holes shot in it.

I'd also like to make one other statement as far as this is concerned. Now, sometimes you get the impression that fish and wildlife are the only reasons for the existence of human beings, and I would like to feel that it is vice versa. And there had been, you know, some very fine statements made today concerning compromise and common sense approaches as to the utilization of this resource and I think people should be congratulated for doing so. I do feel, though, that those people who feel that the resource is here for only one purpose, no matter what the purpose is, certainly need to take a very close examination of what their position is. Thank you, very much.

COLONEL PETERSON: Thank you, Colonel Jester.

Do we have anyone else that would care to make a comment at this time. Mr. Belt desires to make a statement.

MR. BELT: Sorry, Guy, I have to answer to that.

MR. JESTER: All right.

MR. BELT: In the first place, my recollection the U. S. Geological Survey was talking about suspended sediment load and I was talking about bedload. And I will agree that the suspended sediment load in the Missouri River has remarkably decreased. The Colorado State Report of 1974, Simon, Schumm, and Stephens, remarked and attributed this due to upstream dams. I disagree with this. I believe that it may have some part in it, The dams cannot completely stop suspended sediment load, but I do believe my opinion right now is that the wing dikes, bank protection have a significant effect on reducing sediment load. But people aren't concerned about suspended sediment load. We're concerned here is about bedload because bedload and bedload deposits are what are choking up the channel. And I refer you respectfully to

Mr. Maher's two papers which were written in 1964 and which are on file in the District. If you read them very carefully and I have not misquoted or misparaphrased because he specifically states that as a result of the Kansas Basin flood of 1951, the Missouri deposited a twenty-foot high mound of sediment in the Mississippi River and this thing worked gradually downstream, unquote.

Now, about the energy thing there are a couple of things I would like to say about that. First thing is that the barges are not as streamlined as open ocean transport, number one. Number two, they travel a longer distance. Their security is a significant percentage longer than railroad or open ocean transport. And then as a function the total systems approach of looking at barges plus trucks from terminal to terminal is another way of looking at it. And what I was saying is that at this time from my knowledge that the barge line transport is not significantly different statistically than rail transport. I have not studied it to the point where I can say that it is significantly less efficient energy wise.

And the third comment, the -- about the economics. Yes, if you don't dredge, if you don't dredge, if you don't maintain the river, yes, it's gonna cost the people that buy, the people -- let's say the jobbers that buy the products more, but it doesn't -- I can't see where it costs the people in St. Louis any more that buy gasoline that come in by railroad or truck or pipeline or barge or anything else. And the reason that the barge rates are lower and not because they are more energy efficient, it's because the entire system was paid for by the taxpayers and all of the maintenance thereof, and this is one of the main reasons, economically speaking. Thank you.

COLONEL PETERSON: Thank you, Mr. Belt. We have another comment, of this gentleman back here, Yes, you sir.

MR. CUNNINGHAM: John Cunningham, again. And I just wanted to make a short comment on a couple of things. One thing I keep hearing from some of the speakers is something that goes to the effect of the survival of the nine-foot channel and I didn't hear anybody at this meeting, maybe somebody someplace else has suggested we discontinue maintaining the nine-foot channel, but I don't think that's what we're talking about. At least the Sierra Club, we are talking about ways of maintaining the nine-foot channel and still maintaining the environment along the river. And, I just don't think it's come down to a either or situation we're talking about the economics of this thing, and we're talking about what costs are internalized on that balance sheet of the various transportation companies and what costs are externalized and are passed onto future generations to pay for.

And the second thing that I wanted to comment on was, I might have his name pronounced wrong, Mr. Gansman's comment, is that right?

COLONEL PETERONS: Gansner, I believe.

MR. CUNNINGHAM: Gansner, well, I wrote it wrong, excuse me. Mr. Gansner talked about the possibility of dredge spoiling back behind the levees for agricultural use, presumed back behind the levees, is that correct?

MR. GANSNER: Not just behind levees. I don't have a levee.

MR. CUNNINGHAM: You don't have a levee, well, anyway, for agricultural use. I don't know. I don't know what the value of that material is for farm use but it certainly would be a possibility. I notice that in your report you said that eighty-five percent was sand and silt, and so there is a considerable amount of fines in that material. And I just wanted to point out that there is quite a difference between open water dredging which is what occurs when they inundate often a back water slough area or an island and a diked or leveed dredging into a dike or a levee. Now, when they open water dredge most all of your fines run out of the material and you are simply left with the sands and the gravels and the heavier material. But in a diked levee, why, a lot more of the fines are retained and I would think that what might kill off island areas for habitat and that sort of thing might, with a different type of dredging be good for agricultural lands and so forth. That's a possibility.

And the third thing I wanted to comment was Mr. Lehman's talk about the cost of dredge -- of barge transportation versus the cost of rail transportation. I believe what he said was that there was a -- the cost of barge transportation was four mills per ton mile? And the railroad transportation is one and four tenths, and I just -- and then I think he said that the savings in St. Louis, in this area was something like $500,000,000 a year, is that correct?

MR. LEHMAN: Well, it's to the consumer where ever the product is used.

MR. CUNNINGHAM: Where ever the product is delivered. Well, in the context of $500,000,000 a year, I don't know how the economics of this thing precisely works, but what we're talking about in terms of dredge spoil and maintenance of the nine-foot channel between here and Cairo is just a drop in the bucket. And we are simply talking about different ways to dispose of this material. I don't know exactly what the cost, but certainly fifteen or twenty million dollars a year is some such a figure in terms of cost. And it would just mean to me that to -- we're not talking about shutting down $500,000,000 of transportation, we're talking about how to spend perhaps an additional fifteen or twenty million dollars to save the back waters and the sloughs and the wildlife habitat and to improve the water conditions to the Mississippi River.

And I just think that one thing certainly ought to be pointed out and that is that the dredge spoil program is financed a hundred percent by the taxpayer and one of the recommendations of the President's and the Congress' Water Commission Report of 1972, I believe of '73, was that the users of the river transportation be identified and share these costs. And we think this would be an admirable recommendation that should be carried out. And we would think that the river people, the barge line people, who say that their transportation is much more competitive than rail transportation would be anxious to assume some of these costs. Thank you.

COLONEL PETERSON: Thank you, Mr. Cunningham. Do we have any other comments at this time? Yes, sir.

MR. HERSCHBACH: I'm E. H. Herschbach of Chester, Illinois. I'd like to support the comments that were made by Mr. Gansner. I have two miles of river front, a two-mile river front at mile 91.6 and on the map it shows that there is a spoil area for that portion, and I want to offer that spoil area to the Corps any time they need it.

I'm familiar with the area and it will be an assistance to the agriculture if the spoil is placed on the bank there. We support it very much, thank you.

COLONEL PETERSON: Thank you, Mr. Herschbach. Mr. Gansner, desires to make a comment.

MR. GANSNER: I just have one more comment. America is blessed with agriculture. Agriculture is America, believe it or not. Without agriculture there would be no America. All I'm saying is that I think maybe the Corps of Engineers or the Government should take some positive steps to prevent the most massive waste we have in the United States, that is losing our top soil. The river carries it down and we just add more distance from New Orleans to the ocean.

COLONEL PETERSON: Mr. Gansner, may I have clarification on that. Are you speaking to the top soil on the high lands as well as along the river?

MR. GANSNER: It all goes into the river.

COLONEL PETERSON: It all ends up in the river.

MR. GANSNER: It all ends up in the river.

COLONEL PETERSON: Thank you. Yes, sir.

MR. TOCKSTEIN: Glenn Tockstein, again. I'd like to ask Mr. Gansner if he can grow wheat and corn on dredge spoil?

MR. GANSNER: I can grow grasses after the second year.

MR. TOCKSTEIN: You can't sell grasses to Russia.

MR. GANSNER: You can grow beef. You can't ship the barges on the river without the nine-foot channel either.

COLONEL PETERONS: Gentlemen, may I. Do we have anyone else who desires to make a comment. Yes, sir.

MR. JACKSON: Colonel, very briefly, in reading your Corps' proposal for the disposition of dredge spoil, I did not understand that you proposed to put it on farm land even though you have a few invites to do it. Looking at that document it appears to me you propose to deposit this material adjacent to farm lands, et cetera.

Secondly, what the gentleman has said, without erosion I think in a few years there would be no filling of the channel, but we do have erosion and we do have alluvia and what we basically are talking about here is a temporary relocation of this material to facilitate the passage of barges. And in all sincerity I see no damage to anybody to move it from point A temporarily to point B to facilitate this passage of boats. And I think it's perhaps a misunderstanding to confine this material, which as I have suggested earlier if left alone will eventually find its way to the Gulf of Mexico. I think this is a natural order of things and to make temporary reallocation

I think is the way it should be.

COLONEL PTERSON: Thank you, Mr. Jackson, We have another comment back here.

UNIDENTIFIED: I don't have a comment but I have a question. On this land, the spoil areas ... does the ...

COLONEL PETERSON: I will take comments today and if you have a question just state it and we'll see, we'll consider it and we'll get you the answer.

UNIDENTIFIED: Does the Corps of Engineers own or the Government own the spoil areas that are shown on the maps?

COLONEL PETERSON: Well, I can answer that one very simply, no, we do not own them. It's deposited into the river. We have navigation servitude only.

Are there further comments? If not, at this time, I would like to conclude this public hearing and I do wish to state my sincere appreciation, which will be most helpful to me personally and to the St. Louis District, all of you, your interest in this matter. And I would like to remind everyone once again that the record of this hearing will remain open for ten additional days and you may submit written statement during this period. The ten additional days means that it should be sufficient time and then we can get on with the purposes, the requirements of the statutes. These written statements should be mailed to me and I believe you all know the address of the St. Louis, Corps of Engineers, or you can find it.

And I would like to remind you that my final decision on this matter will be published after the record of hearing period is closed, and that this decision will be available to all those interested.

Again I'd like to thank you for your interest and your attendance and this closes this meeting. Thank you.

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Appendix T. Statement of Findings for Proposed Disposal of Dredged Material in Connection with Channel Maintenance Dredging in the Mississippi River Between Cairo, Illinois, and the Mouth of the Missouri River

STATEMENT OF FINDINGS
FOR
PROPOSED DISPOSAL OF DREDGED MATERIAL AT SPECIFIED SITES IN CONNECTION WITH ST. LOUIS DISTRICT'S CHANNEL MAINTENANCE DREDGING ON THE MISSISSIPPI RIVER BETWEEN CAIRO, ILLINOIS AND THE MOUTH OF THE MISSOURI RIVER

1. Purpose of This Statement

The St. Louis District has been assigned responsibility to maintain a navigation channel in the Mississippi River between Cairo, Illinois and the mouth of the Missouri River, as provided by the River and Harbor Act of 21 January 1927. The Act provides for the maintenance of a minimum channel depth of not less than nine feet at low water. Based on historical records, approximately 30 locations must be dredged annually to maintain project depths. On 22 July 1974, the Chief of Engineers adopted new regulations which specify that Corps dredging projects will be subject to public review procedures similar to those developed for the processing of Department of the Army permits under Section 404, Public Law 92-500. The public review procedures include issuance of a public notice, and where appropriate, the filing of an Environmental Impact Statement, and opportunity for public hearing. This Statement of Findings will summarize the nature and extent of public coordination achieved, identify issues brought to my attention, and record my findings in the matter.

2. Coordination with Federal, State, and Local Agencies, Environmental Groups, and General Public

a. Public Notices. On 16 September 1974, the St. Louis District circulated a public notice to over 700 individuals, agencies, and groups who were selected on the basis of probable interest in our dredging and disposal activities. Charts indicating prospective dredge and disposal sites were distributed with the public notice. In response to the notice, the Water Commissioner, City of St. Louis, and the Chairman, Great Lakes Chapter of the Sierra Club requested a public hearing. A notice of public hearing was issued by this office on 8 November 1974.

b. Public Hearing. On 12 December 1974, I conducted a public hearing at St. Louis, Missouri, to obtain the views of all interested parties with respect to our proposed disposal sites. The hearing was attended by 96 people, representing a wide range of interests. All participants were encouraged to express their views freely and fully.

3. Summary of Public Comment

I have reviewed the full record of the public hearing, including all pre-hearing and post-hearing statements, and I find there are no unresolved substantive objections to controlled use of 125 of the 126 prospective disposal sites described in Public Notice LMSOD 1-1, dated 16 September 1974. One prospective spoil site has been withdrawn from our maintenance dredging program on the basis of objection expressed by the Water Commissioner, City of St. Louis. During the course of the public coordination proceedings, 45 parties furnished oral or written statements. Many of the statements were entirely supportive of our proposed disposal operations. The remaining statements made reference to specific disposal sites or offered recommendations for consideration in implementing disposal operations. Although a number of parties expressed concern that environmental impairment could result from dredge material disposal activities, respondents and hearing participants made no recommendations that dredging of the project be abandoned. In letter dated 16 December 1974, the Regional Administrator, Environmental Protection Agency, Region VII stated "For the public hearing record, the Environmental Protection Agency, Region VII, concurs with your decision to continue channel maintenance dredging for navigation until the final guidelines for open water disposal of dredge spoil are published." Agencies and groups concerned with environmental and conservation issues made comments at the hearing and submitted supplemental written statements. These organizations included the Sierra Club, Illinois Department of Conservation, U.S. Fish and Wildlife Service, Missouri Department of Natural Resources, Missouri Department of Conservation, and Coalition for the Environment. I commend their recommendations for continued coordination on dredged material disposal matters, and I will inform the Waterways Experiment Station of their suggestions for further studies related to disposal operations.

4. Other Considerations

a. Status of Environmental Impact Statement. It has been determined that an Environmental Impact Statement will be filed for the project. All known environmental effects that result from operating and maintaining the navigation project, including dredging and spoil operations, are addressed in a pre-draft Environmental Impact Statement that is under review by the Division Engineer. I have reviewed the pre-draft statement, and I conclude that this District's dredging program, including its major adverse effects, has been adequately described and assessed. Our dredging and spoil operations are expected to result in disruption of benthic communities, some loss of side channels, temporary increases in turbidity, temporary reductions in dissolved oxygen concentrations, reduction in fish habitat diversity, and possible release of toxic materials and nutrients to the water column.

b. Project Maintenance During the Preparation of an Environmental Impact Statement. The regulations adopted 22 July 1974 provide that maintenance dredging projects commencing before 1 January 1970 may continue during the preparation of an impact statement if deferral of dredging is unacceptable from the standpoint of the overall public interest. In memorandum dated 27 November 1974, I recorded my findings that deferral of dredging would result in a severe impact on the local and national economy, and that maintenance of the project must continue in the public interest. Abandonment of the dredging project would eliminate a vital link between the Upper Mississippi, Illinois, and Missouri Rivers to the north, and the Ohio and Lower Mississippi Rivers to the south. More than 88% of the tonnage carried on the project neither originates nor terminates within the limit of the project. The memorandum is available for public review.

5. Conclusions

I have reviewed and evaluated the stated views of other interested agencies and the concerned public, relative to the selection and proposed use of disposal sites along the waterway. The possible consequences of the plan have been studied on the basis of economic, engineering feasibility, and anticipated effects on the total environment. In reviewing the proposed action, I have attempted to develop the soundest possible conclusions from the data compiled during the investigation. From the standpoint of the total public interest, the alternative of abandoning maintenance of the project was found to be clearly unacceptable. I conclude that the disposal plan developed by this District should be implemented subject to the following conditions:

a. Proposed disposal site 195.0R will not be used until further coordination has been achieved with the Water Commissioner, City of St. Louis. The Water Commissioner will be given advance notice of dredging to be performed upstream of the Chain of Rocks Water Plant.

b. In placing spoil at site 176.7R, material will be placed so as to minimize its migration to downstream dock sites.

c. Material deposited at site 140.6R will not be placed at or immediately upstream of Union Electric's water intake structure.

d. Material deposited at site 65.3R will be placed so as to minimize siltation at the Trail of Tears Marina.

e. To the extent feasible, adverse impacts identified in the pre-draft impact statement will be minimized by placement of dredge spoil in areas that are least sensitive to environmental damage.

f. Proposed dredge and disposal activities will continue to be coordinated with the U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Coast Guard, Waterways Experiment Station, Missouri Department of Natural Resources, Missouri Clean Water Commission, Missouri Department of Conservation, Illinois Department of Conservation, Illinois Environmental Protection Agency, and Upper Mississippi River Basin Commission.

g. In the event emergency dredging is required, the views of coordinating agencies will be solicited by telephone at the earliest practicable date.

6. Findings

I find that this District's selection and proposed use of disposal sites, subject to conditions specified in this statement, are based on thorough analysis and evaluation of the various factors pertinent to the total public interest; that where the proposed disposal plan has an adverse effect, this effect is substantially outweighed by other considerations; that the proposed use of the designated disposal sites is in accordance with the overall desires of the public; that the recommended action is consonant with national policy, statutes, and administrative directives; and that on balance, the total public interest should best be served by implementation of the recommended action.

4 February 1975
DATE

THORWALD R. PETERSON
Colonel, CE
District Engineer

Appendix U. Letters Received By The District Engineer On The Draft Environmental Statement

TABLE OF CONTENTS

Letter of Reply

United States Senate

COMMITTEE ON APPROPRIATIONS

WASHINGTON, D.C. 20510

June 10, 1975

Colonel Thorwald R. Peterson
District Engineer
U.S. Army Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Colonel Peterson:

Thank you very much for sending me a copy of the Draft Environmental Statement for the Middle Mississippi River Between the Ohio and Missouri Rivers, Regulating Works. I found it to be quite interesting and I am sure my staff will find it to be very helpful.

Yours very truly,

Tom Eagleton

THOMAS F. EAGLETON
United States Senator

TFE/df

LEONOR K. (MRS. JOHN B.) SULLIVAN
3D DISTRICT, MISSOURI

COMMITTEES:
CHAIRMAN
MERCHANT MARINE AND FISHERIES

BANKING, CURRENCY AND HOUSING

SUBCOMMITTEES:
CONSUMER AFFAIRS
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June 10, 1975

Colonel Thorwald R. Peterson
Department of The Army
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Colonel Peterson:

Just a note to let you know that I am in receipt of the Draft of the Environmental Statement.

Thank you for sending it along and when time permits I shall study it carefully.

Sincerely yours,

Leonor K. Sullivan

Leonor K. (Mrs. John B.) Sullivan
Member of Congress
3rd District, Missouri

LKS:fh

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
FEDERAL BUILDING, 911 WALNUT STREET
KANSAS CITY, MISSOURI 64106

REGION VII

June 11, 1975

IN REPLY REFER TO:
7CE

Mr. Jack R. Niemi
Chief, Engineering Division
Department of the Army
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

This is to acknowledge receipt of your Draft Environmental Impact Statement for the Middle Mississippi River between the Ohio and Missouri Rivers, dated May, 1975.

HUD programs for the area in which the project is located are administered by Elmo Turner, Director, St. Louis Area Office. By copy of this letter, Mr. Turner is requested to review the draft statement and forward his comments directly to you no later than July 28, 1975, as indicated in your request.

Thank you for the opportunity to comment on this statement.

Sincerely,

Harry Bearman
Harry B. Bearman
Environmental & Standards Officer
Community Planning and Development

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
CHICAGO AREA OFFICE
1 NORTH DEARBORN STREET
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REGION V
300 South Wacker Drive
Chicago, Illinois 60606

August 13, 1975

IN REPLY REFER TO:

5.2PT (Goldfarb

Mr. Jack R. Niemi
Chief, Engineering Division
Dept. of the Army
St. Louis Dist., Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

Subject: Mississippi River Between the Ohio and Missouri Rivers Regulating Works

Your office's EIS on the Middle Mississippi Regulating Works presented a great deal of useful information describing the Corps extensive work in providing a nine foot navigation channel for Mississippi water commerce and the relationship of this work to the Middle Mississippi ecosystem. The Corps deserves credit for maintaining this channel for, as the EIS states, non-maintenance would have substantial adverse impacts on the national economy. The Corps also deserves recognition for its recent attempts to maintain the viability of side channel areas and we at HUD would like to encourage the expansion of this effort by the Corps.

The Alternatives Section of the EIS discussed the possibility of "Post-Authorization Change" which would expand the Congressional mandate to include provision for environmental protection and enhancement and action by the Corps. The EIS points out the need for and advantages of such a change and we at the Chicago Area Office of HUD would like to support your actions towards achieving this end.

We thought the EIS was well prepared in most areas but we would like to see one change in the Final. The Draft EIS makes reference to insufficient equipment to place dredged materials at elevations higher than the adjacent river level. We would appreciate a discussion of the reasons for this condition and the cost and benefits relative to a change which would enable dredging disposal at higher elevations.

Thank you for the opportunity to comment on this EIS. Please forward a copy of the Final to us.

Sincerely,

John L. Waner
Director
Chicago Area Office

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230

July 22, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
Corps of Engineers - St. Louis Division
U. S. Department of the Army
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

The draft environmental impact statement "Mississippi River between the Ohio and Missouri Rivers (Regulating Works)," which accompanied your letter of June 4, 1975, has been received by the Department of Commerce for review and comment.

The statement has been reviewed and the following comments are offered for your consideration.

Geodetic control survey monuments are located in the immediate vicinity of the proposed project area. If there is any planned activity which will disturb or destroy these monuments, National Ocean Survey (NOS) requires not less than 90 days notification in advance of such activity in order to plan for their relocation. NOS recommends that funding for this project include the cost of any relocation required for NOS monuments.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving eight copies of the final statement.

Sincerely,

Sidney R. Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
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8400
July 24, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
Department of the Army
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Refer to: LMSED - BA,
Draft Envrionmental
Statement, Middle Mississippi
River

Dear Mr. Niemi:

Our Milwaukee office forwarded the above statement to us because only a small part of the project is adjacent to a National Forest.

The dredging will have little effect on woodland. If possible, the final statement could include an estimate of the area of wildlife habitat that is lost due to maintenance of the channel.

We appreciate the opportunity to review and comment on the draft.

Sincerely,

D. O. Van Deusen

DALE O. VANDENBURG
Staff Director
Environmental Quality Evaluation

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

P. O. Box 459, Columbia, Missouri 65201

July 28, 1975

Jack R. Niemi, Chief
Engineering Division
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, Missouri 65101

Dear Mr. Niemi:

The draft environmental impact statement for the Mississippi River Between the Ohio and Missouri Rivers (Regulating Works) appears to adequately display the affects and alternatives of maintaining a nine-foot navigation channel.

We appreciate the opportunity to review and comment on this work.

Sincerely,

J. Vernon Martin
State Conservationist

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P.O. Box 678, Champaign, Illinois 61820

July 28, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
U. S. Army Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

The draft environmental statement prepared by the U. S. Army Engineer District, St. Louis, Missouri, for Regulating Works on the Mississippi River Between the Ohio and Missouri Rivers, dated May 15, 1975, has been reviewed as requested and our comments are submitted for your consideration.

SOILS - Section 2.1.3 (page 94)

Section 2.1.3.2. on surficial soils states "no comprehensive system of soil classification for the lands bordering the Mississippi River between St. Louis, Missouri, and Cairo, Illinois exists." There is a nationwide system of soil classification through the National Cooperative Soil Survey under the leadership of the Soil Conservation Service. There is soil survey information based on this system for counties along the Mississippi River in Illinois. Both detailed and general soil maps exist for Alexander, Union, Jackson and St. Clair Counties. General maps exist for Madison, Monroe and Randolph Counties. The soils have been interpreted for their behavior related to a number of uses, agricultural as well as engineering. Representatives of the Soil Conservation Service in Illinois would be happy to discuss the soil survey information available with representatives of the U. S. Army Engineer District, St. Louis, Missouri.

LAND USE AND CONSERVATION TREATMENT IN THE WATERSHED

We recognize this statement covers only the middle section of the Mississippi River which has a total drainage area of approximately 700,000 square miles. However since the control and removal of sediment is one of the major phases or causes for the regulating works covered by this statement we suggest attention be given to the need for improved land use and additional conservation treatment in the watershed. We note on page 9 the fact that suspended sediment discharges taken at St. Louis average approximately 500,000 tons per day.

It may be beneficial to include the acres needing soil and water conservation treatment for Kaskaskia and Big Muddy rivers watersheds. The Soil Conservation Service has information from the Conservation Needs Inventory for these watersheds.

You may wish to add a statement such as "The Corps of U. S. Army Engineers will work closely with Federal, State and Local agencies and with local Soil and Water Conservation Districts in promoting an accelerated land treatment program throughout the watershed to reduce erosion, sedimentation and subsequent water pollution."

GENERAL

Following are some suggested changes for your consideration:

Nutrients (Water and Sediment) - 2.1.4.6 (page 99) - Soil and water conservation work on the watershed could be added as one of the factors influencing the quantity and quality of run-off water.

Air Quality 2.1.6 (page 106) - We question the validity of the statement which indicates animal feedlots create significant smoke. You may wish to make a separate reference to feedlots and delete this portion.

Cover Types 2.2.2.2. (page 128) "g. Cultivated Field" - Suggest this be changed to read "Cropland Fields."

Cover Types 2.2.2.2. (page 128) "h. Old Field" - These areas could be called "open land."

Past Land Use 2.3.3.1. (page 171) - Suggest eliminating the wording "due to exploitation of bottomland hardwood forests." The harvest of hardwood timber from bottomland is not necessarily exploitation.

Narrowing of River Width 4.1.1.4. (page 196) - Suggest eliminating the word "poor" in describing the land use practices between 1821 and 1888. The land use decision makers of that period may have acted in the best interests of their country.

Effect on Flows 4.1.1.6. (page 199), fifth paragraph - Watershed Protection and Flood Prevention projects under Public Law 566 along with soil and water conservation work on individual farms could be mentioned as a factor affecting run-off from the drainage basin.

Changes in Sediment Discharge 4.1.1.7. (page 201), Paragraph 5 - You may wish to include the influence soil and water conservation work has and can have on decreasing erosion and sediment in the river.

Impact on Wildlife 4.2.2.2. (page 214) - Suggest eliminating the last sentence in this section. Increased production from farms, timber production, and public land use does not have to be detrimental to all wildlife and wildlife habitat as stated. Soil and water conservation management practices on these lands can be beneficial to wildlife.

Impact on Threatened, Rare or Endangered Species 4.2.3 (page 215) - In the next to last paragraph suggest it be changed to read from "will be" to "can be detrimental." Land management practices can be planned and followed which will protect and enhance the habitat for rare and endangered species.

COORDINATION OF THE ENVIRONMENTAL STATEMENT 9.4 (pages 249 through 251) -

For coordination purposes you may wish to add the local Soil and Water Conservation Districts to your list. Each county in Illinois is in a Soil and Water Conservation District with responsibilities for the conservation of soil and water resources and for the control and prevention of soil erosion, floodwater and sediment damages within the district.

Enclosed is a copy of the latest directory of Soil and Water Conservation District's in Illinois for your use and information.

SCS SOIL AND WATER CONSERVATION TECHNICAL GUIDE

The Soil Conservation Service Technical Guide is available for use in each SCS Field Office in the Middle Mississippi River region. This can help serve as a technical guide in planning and establishing soil and water conservation work on levees, dikes, borrow areas and other such areas to reduce erosion and sedimentation. The guide contains information on soils, vegetative seedings, woodland and wildlife plantings, drainage and other soil and water conservation practices applicable to the area served by each SCS Field Office. Don't hesitate to get in touch with our Illinois SCS State Office or appropriate Field Office to utilize this technical information.

We appreciate the opportunity to review and comment on this Environmental Statement.

Sincerely,

William H. Moberly, Acting

Daniel E. Holmes
State Conservationist

Enclosure

United States Department of the Interior

OFFICE OF THE SECRETARY
NORTH CENTRAL REGION
230 S. DEARBORN STREET, 32nd FLOOR
CHICAGO, ILLINOIS 60604

ER 75/554

July 22, 1975

Colonel Thorwald R. Peterson
District Engineer
U. S. Army Engineer District
St. Louis
210 North 12th Street
St. Louis, Missouri 63101

Dear Colonel Peterson:

The Department of the Interior has reviewed the Draft Environmental Statement for the Mississippi River between the Ohio and Missouri Rivers (Regulating Works), as requested in Mr. Jack Niemi's transmittal letter of June 4, 1975, to our Assistant Secretary, Program Development and Budget. Our comments which are of both a general and specific nature relate to areas of our jurisdiction and expertise and have been prepared in accordance with the National Environmental Policy Act of 1969.

GENERAL:

In most instances the statement identifies and acknowledges the extreme modification and destruction of fish and wildlife habitat that has, and is continuing, to occur on the Middle Mississippi River as a result of the 9-Foot Navigation Project. This admission and the movement toward a post-authorization change document to include fish and wildlife conservation as a project purpose are hopeful signs of an improved future for a much abused resource.

SPECIFIC:

1. PROJECT DESCRIPTION AND HISTORY

1.2 HISTORY AND AUTHORIZATION OF THE PROJECT

Page 7: We believe that this statement should deal with the entire project area from the mouth of the Ohio River to the mouth of the Missouri River, including the St. Louis Harbor. St. Louis, the largest port on the inland waterway system, is an important and integral part of the river. Its segmentation from the rest of the river is not appropriate since dredging and other channel maintenance activities are performed there and barge traffic

AMERICAN REVOLUTION BICENTENNIAL 1776-1976 and use of the river and shoreline is particularly intense in the harbor area.

1.4 PROJECT DESCRIPTION

Page 48: It is our understanding that the St. Louis Corps District has generally dredged to a depth of about 13 feet below the low water reference plane elevation, not 9 feet as indicated in this section.

2. EXISTING ENVIRONMENTAL SETTING

2.1 PHYSICAL ELEMENTS

Page 51: This section should state that the formation of new side channels is nnlikely (see pages 205 and 207) due to the constriction and confinement of the river within its present channel by dikes and bank revetment. In fact, this feature of the project is later considered a benefit in the statement since farm fields are not being eroded into the river. Any side channels formed in new dike fields will be the result of land accretion at the river end of the dikes. This means that in order for the new side channel to be formed, the river will be filled and further constricted by the formation of the new island. The width of the river already has been severely reduced (5,000 feet to 2,200 feet) by navigation dikes and levee construction. The formation of temporary side channels does not justify continuation of this damaging process or compensate for fish and wildlife losses resulting from the project.

Page 52: Dike construction has created side channels but the total river contraction process has destroyed many more. This destruction has not been fully studied or compensated for as intended by the Fish and Wildlife Coordination Act (P. L. 85-624).

2.2 BIOLOGICAL ELEMENTS

Page 110: Figures 2-2e through 2-2h illustrating zooplankton occurrence are missing.

Page 114: The lack of public access to the river and the adverse effects of channelization on fish and wildlife habitat also should be included as causes for the low level of sport fishing use of the river.

Page 123: The brown creeper is only a rare breeder in the subject area. During migration periods, it is quite common and also occurs as a fairly common winter resident.

Table 2-5a The endangered bald eagle should be correctly listed to sub-species, Haliaeetus leucocephalus leucocephalus.

Page 143: An updated list of rare and endangered vertebrates of Illinois was published by the Illinois Nature Preserves Commission in 1973. This more recent list should be used instead of the 1971 Preliminary Draft.

2.3 CULTURAL ELEMENTS

Page 172: The data presented on land use in the flood plain is misleading. It appears that the acreage figures were taken from Table 1 of the publication by Terpening et al., prepared under Corps contract. This table gives data only for the unprotected flood plain but the statement represents this as data for the entire flood plain. The referenced Plates 2-5a through 2-5k show land use for the entire flood plain. Acreage for lake and backswamp should be 4,279 and not 4,729.

The Shawnee National Forest and city parks are not the only areas on the river formally dedicated to recreation. In Illinois there are Lewis and Clark and Fort Defiance State Parks and in Missouri there is Trail of Tears State Park.

Page 184: Through the Land and Water Conservation Fund, the Bureau of Outdoor Recreation is assisting Grand Tower, Illinois, in expanding Devils Backbone Park by 8.5 acres (project 17 - 00215). When developed it is planned that this park will provide camping and picnicking facilities and boat access to the Mississippi River. Trail of Tears State Park also makes use of the river through a recently developed marina and boat ramp. We suggest this section and Table 2-32 be expanded to recognize those major city parks which contribute to the public's enjoyment of the flood plain's natural resources and the Mississippi River.

The statement that the region lacks good accessibility from the St. Louis area seems based on the premise that the only good access consists of an interstate highway going to or near the point in question. I-55, U. S. 61 and Ill. 3 with their associated secondary roads provide travel at near maximum speed limits (55 mph) to almost the entire area.

4. IMPACT OF THE ACTION ON THE ENVIRONMENT

4.1 PHYSICAL IMPACTS

Page 188: The statement comparing the relative diversity of side channels in 1796 with today is speculative. Unless supported by further documentation, it should be removed.

Page 196: The 4 or 5 million cubic yards of material dredged annually also should be described in terms of percent of the river's bedload.

Page 199: We agree that a levee provides flood protection when it does not break or is not overtopped, but because of increased construction on and use of both the protected and unprotected flood plain, the amount of damage caused by floods apparently has been increasing. The statement leaves the impression that flood damages are less now than in the past, which is not necessarily true.

Page 204: In the 1973 flood, no government levees failed, but what was the level of flood related damages compared to 1927? When speaking of the 1927 flood, the statement mentions only "catastrophic damages", yet no mention is made of damages caused by the 1973 flood. The damages from the 1973 flood should be stated.

Page 210: Section 4.1.4.3 generally dismisses the effects of increased barge traffic as being comparatively insignificant, but does not provide a basis for comparison. Since the 9-foot navigation channel sustains and in fact, encourages river traffic, the total effect of navigation on the riverine environment should be defined in addition to effects generated by an increase in traffic. The latter only aggravates an already bad situation which itself deserves description in this statement.

4.2 BIOLOGICAL IMPACTS

Page 212: A survey of the location and composition of the freshwater mussel population of the Middle Mississippi River is needed. It generally is believed that very few mussels are able to survive the poor quality water, but no clear picture of the actual situation exists.

Page 217: The philosophy and realistic attitude expressed in the last paragraph is commendable. It is becoming increasingly important that we view our growth efforts with a critical eye toward their impacts on the global ecosystem.

4.3.4 OUTDOOR RECREATION

Page 218: It is stated that the regulating works will have no impact on the existing recreational resources. However, we believe, as noted in paragraph 4.2.1.1, "The effects of river contractions by dike fields and bank revetment . . . reduced the bank-to-bank river surface area by one-third, the island area by one-half, and the water surface area by one-half . . . " have discouraged the development of riverside recreational resources and boat marinas. Further contraction of the river will result in even less water surface, the need for more powerful boats in the faster current, and increased possibility of conflict and collision between pleasure boats and commercial barges. Greater contraction of the river also will probably continue to inhibit the development of riverside recreational resources and marinas.

4.3.5 IMPACTS ON CULTURAL RESOURCES

The statement does not clearly confirm consultation with the State Historic Preservation Officers for Illinois and Missouri. The statement should reflect that they were consulted to determine whether the proposal will affect any cultural site which may be eligible for inclusion in the National Register of Historic Places.

The statement also should present the views of the Illinois Archeological Survey (137 Davenport Hall, University of Illinois, Urbana, Illinois 61801) and the Missouri Archeological Survey (Mr. David R. Evans, Director, 15 Switzler Hall, University of Missouri, Columbia, Missouri 65201) regarding project effect upon cultural resources.

6. ALTERNATIVES

6.4 POST-AUTHORIZATION CHANGE

We support the joint efforts of conservation agencies to seek modification of the 1927 authorizing Congressional document to provide for environmental protection and enhancement.

APPENDICES

APPENDIX G: A notation should be included in this table indicating that the inclusion and status of some if the listed species is based on judgments made by the preparers of the statement and not on any published lists of rare, threatened, and endangered species.

The following species should be added and the bald eagle listed as two subspecies:

Common Name	Scientific Name	IL	MO	U.S.
Bigeye Shiner	Notropis boops	R	-	-
Mississippi Silverside	Menidia audens	-	R	-
Snowy Egret	Egretta thula	R	-	-
Pintail	Anas acuta	R	-	-
Northern Shoveler	Anas clypeata	R	-	-
Canvasback	Aythya valisineria	R	-	-
Southern Bald Eagle	Haliaeetus leucocephalus leucocephalus	E	-	E
Northern Bald Eagle	Haliaeetus leucocephalus alascensis	E	R	-

APPENDIX Q: The only reference to grain-size of typical dredged sediment that was noted in the statement is in Appendix Q (p. 2, par. #4), where the sediment is described as 5 percent coarse gravel, 10 percent pea gravel, and 85 percent sand and silt. Since the alternative of using dredge spoils for such commercial purposes as fill material, mortar sand, aggregate and concrete is under consideration (p. 228, par. 6.5), it would be helpful to provide any available data on grain-size distribution and other physical properties typical of the spoils.

Maps provided in the main body of the statement show the location of only about 40 disposal sites, all of these being within the Mississippi River immediately adjacent to the dredging areas (Plates 1-4a to 1-4j). It has not been mentioned until Appendix Q that about 125 disposal sites are under consideration. It had been stated in the main body of the statement that "insufficient equipment exists at this time to enable the dredged material to be placed at elevations higher than the adjacent river level" (p. 194, par. 4.1.1.3). However, the public notice published as recently as September 16, 1974 refers to disposal sites on land, and accompanying maps show elevations of some disposal sites as high as 12 feet above L.W.R.P. (App. Q, map for river miles 25.8 to 42.7). On the map covering river mile 63.9 to 80.9 Appendix Q, the area of prospective dredging in the vicinity of river mile 75.0 to 75.5 appears to have been omitted.

Sincerely,

Madonna F. McGrath

Madonna F. McGrath
Acting Special Assistant
to the Secretary

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
REGION VII
FEDERAL BUILDING
601 EAST 12TH STREET
KANSAS CITY, MISSOURI 64106

OFFICE OF
THE REGIONAL DIRECTOR

July 14, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
Department of the Army
St. Louis District,
Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

RE: Draft Environmental Impact Statement
Mississippi River Between the Ohio and Missouri
Rivers (Regulating Works)

Dear Mr. Niemi:

Review of the above referenced document indicates that there is no apparent impact on programs of the Department of Health, Education, and Welfare. It would appear that the impacts of the proposed action and the reasonable alternatives have been adequately addressed.

Thank you for this opportunity to review and comment relative to your anticipated actions.

Sincerely,

William Henderson

William H. Henderson
Regional Environmental Officer

DEPARTMENT OF TRANSPORTATION
REGIONAL REPRESENTATIVE OF THE SECRETARY

ROOM 634, FEDERAL BUILDING
601 EAST 12th STREET
KANSAS CITY, MISSOURI

REGION VII

July 24, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

Our review of the Corps of Engineers' Draft Environmental Statement for the Mississippi River between the Ohio and Missouri Rivers Regulating Works indicates that the Statement adequately considers the effects the project may have on areas within the jurisdiction of the Department of Transportation.

Thank you for the opportunity to comment on this draft.

Sincerely,

Jerome J. Coleman

(For) R. R. Waesche
RADM USCG (Ret.)
Secretarial Representative
Region VII

cc:
Mr. J. B. Kemp, FHWA
RADM G. H. P. Bursley, USCG
Mr. W. E. Loftus, FRA

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (G-WS/73)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: (202) 426-2262

28 JUL 1975

Mr. Jack R. Niemi
Chief, Engineering Division
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

This is in response to your letter of 4 June 1975 concerning a draft environmental impact statement for the Middle Mississippi River between the Ohio and Missouri Rivers (Regulating Works).

The concerned operating administrations and staff of the Department of Transportation have reviewed the material submitted. We have no comments to offer nor do we have any objection to this project.

The opportunity to review this draft statement is appreciated.

Sincerely,

D. J. Riley

D. J. RILEY
Captain, U. S. Coast Guard
Deputy Chief, Office of Marine Environment
and Systems
By direction of the Commandant

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION 5
18209 DIXIE HIGHWAY
HOMEWOOD, ILLINOIS 60430

June 30, 1975

IN REPLY REFER TO
05-00.5

Mr. Jack R. Niemi
Chief, Engineering Division
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

As requested, we have reviewed the draft environmental statement for the Middle Mississippi River between the Ohio and Missouri Rivers.

The statement acknowledges the potential for scour and channel deepening that can result from continuing maintenance. Since modification of existing dikes and construction of new dikes may be needed to help maintain the 9-foot channel, we believe some assurances should be provided that the substructures of existing bridges will be adequately protected during the construction and maintenance operations.

The opportunity to review and comment on the draft environmental statement is appreciated.

Sincerely yours,

H. L. Anderson
Regional Administrator

By:

W. G. Emrich, Director
Office of Environment and Design

[illegible]

[illegible]
ANSA[illegible]

[illegible]

Colonel Thorwald R. Peterson, USA
District Engineer, St. Louis District
U.S. Army Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Colonel Peterson:

Re: Mississippi River Between The Ohio And Missouri Rivers - Regulating Works

We have reviewed the Draft Environmental Impact Statement (EIS) for the operation and maintenance program referenced above. The program and statement are rated ER-2 meaning the Environmental Protection Agency (EPA) has environmental reservations with the project because of the historic and predicted degradation of wetlands and the probable violation of water quality standards due to resuspension of heavy metals into the water. In addition, we believe the final statement should be modified to include information on the subjects discussed in this letter.

Wetlands

The draft statement indicates that, through the use of regulating works, the surface area of the Middle Mississippi River has been reduced by one-third and the total island area by one-half. The unintentional act of destroying wetlands without mitigation is in conflict with both the EPA and Corps of Engineers wetland policies. Therefore, the Corps should take any or all means available to curtail further wetland destruction and provide a program of enhancement or restoration of the remaining wetland ecosystem consistent with the existing 1927 navigation mandate.

The backwater and side channel areas make up the adjacent wetland areas of the Middle Mississippi River. Major wetland reduction has taken place as a result of the present 1800-foot main channel contraction program. The further isolation of side channels from the main channel, which will result from the proposed 1500-foot contraction program, should be evaluated for its additional reduction in wetland areas. In addition, the anticipated reintroduction of nutrients and toxicants into the remaining wetland ecosystem, due to main channel scour under a 1500-foot contraction program, should be assessed.

Water Quality

Information included in Appendices H through P indicate coliform bacteria concentrations, chemical oxygen demand levels and heavy metals concentrations often exceed the EPA and Illinois Water Quality Standards. We believe the final statement should also provide data on organophosphate and chloro-hydrocarbon pesticides concentrations.

The draft statement indicates the bottom sediments at selected sites contain high concentrations of COD and heavy metals. In addition, these sediments may contain high concentrations of pesticides. Reintroduction of these materials through dredging or riverbed scour, due to confinement of the main channel, would severely degrade the downstream water quality. We believe any spoil material, which constitutes a pollution source, should be removed from the river regime, confined and the supernatant return flow monitored to minimize adverse impacts.

The statement indicates side channels exhibit thermal stratification. Anaerobic conditions may occur at the lower depths in these channels. Many pollutants which are insoluble under aerobic conditions become soluble under anaerobic conditions and subject to downstream release during high flows through the side channel. The final statement should provide an assessment of the anticipated impacts of the project on the aquatic environment of the side channels and the downstream water quality with respect to stratification.

The resuspension and deposition of pollutant laden sediments may cause a severe impact on the quality of public water supplies downstream. These may contain heavy metals, pesticides, and carcinogenic pollutants. The final statement should assess the anticipated impacts on municipal water supplies from the operation and maintenance program.

General Comments

The draft statement has provided an appraisal of the present program of 1800-foot main channel contraction. The final statement should include an appraisal of the environmental impacts of the proposed program of 1500-foot contraction.

The final environmental statement should identify any impacts of this particular operation and maintenance program which may affect other sections of the Mississippi River System.

The maps showing the locations of possible dredging sites and proposed disposal sites are not adequate. In some areas it appears the disposal sites depicted could close backwater areas, but as stated in the draft, this practice is no longer followed. Better maps indicating locations of disposal sites would clear up this confusion.

We appreciate this opportunity to review and comment on the draft statement. Please furnish us with three copies of the final when it is filed with the Council on Environmental Quality. If you or your staff have any questions concerning our review and classification, my staff is ready to meet with you and elaborate on our concerns.

Sincerely yours,

Jerome H. Svore

Jerome H. Svore
Regional Administrator

Advisory Council
On Historic Preservation
1522 K Street N.W. Suite 430
Washington D.C. 20005

July 21, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
St. Louis District
Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

This is in response to your request of June 4, 1975, for comments on the draft environmental statement for the Middle Mississippi River between the Ohio and Missouri Rivers Regulating Works, Missouri and Illinois. Pursuant to its responsibilities under Section 102(2)(C) of the National Environmental Policy Act of 1969 and the Council's "Procedures for the Protection of Historic and Cultural Properties" (36 C.F.R. Part 800), the Advisory Council has determined that your draft environmental statement is inadequate because it does not contain sufficient information on archeological resources to enable us to comment on your compliance with Executive Order 11593 "Protection and Enhancement of the Cultural Environment" of May 13, 1971, and the Council's procedures.

Under Section 1(3) and 2(b) of the Executive Order and Section 800.4(a) of the Council's procedures, Federal agencies are required to identify all Federal and non-federally owned properties within the area of their undertaking's potential environmental impact that may be eligible for inclusion in the National Register of Historic Places.

Although extensive archeological surveys have been conducted in the flood plain area, the environmental statement indicates that the proposed operation and maintenance activities will be confined to the river and river bank, an area which has apparently not been surveyed for potential National Register properties.

Without a survey to determine the nature and extent of archeological resources in the project area, National Register eligible sites may be inadvertently demolished or substantially altered. This possibility is mentioned by the Corps on page 219 of the environmental statement:

> In those instances where portions of the river bank are contoured, if an archeological site were to be present at that location, it might be adversely affected by the surface disruption.

In order to reduce the likelihood of such an occurance, the Advisory Council suggests that an archeological survey be undertaken by the Corps in those areas of the river bank where surface disruption is proposed. In addition, we support the June 17, 1975, position of the Missouri State Historic Preservation Officer (SHPO) concerning protection of unknown underwater archeological resources that may be affected by the proposed undertaking. A copy of the Missouri SHPO's letter is attached.

Until archeological resources in the project area have been identified and the need for further compliance with the Council's procedures has been ascertained, the Council cannot comment favorably with respect to your environmental statement.

For further information and assistance in this matter please contact Jordan Tannenbaum of my staff at 202-254-3380.

Sincerely yours,

John D. McDermott
Director, Office of Review and Compliance

Enclosure

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

Mr. Jack R. Niemi
Chief, Engineering Division
St. Louis District, Corps of Engineers
Department of the Army
210 North 12th Street
St. Louis, Missouri 63101

JUL 22 1975

Reference: LMSED-BA

Dear Mr. Niemi:

This is in reply to your letter of June 4, 1975, addressed to the Commission's Advisor on Environmental Quality, requesting comments of the Federal Power Commission on the draft environmental statement for the Mississippi River between the Ohio and Missouri Rivers (Regulating Works).

The project, authorized by Congress in 1927, consists of the continuing attainment and operation and maintenance of a 9-foot-deep by 300-foot-wide navigation channel within the Mississippi River between the Ohio and Missouri Rivers by the use of channel contraction dikes, protective bankline revetments, and any necessary dredging. This reach of the Mississippi River covers a distance of about 195 miles. The activities of construction of dikes and revetments and dredging would take place on the river and would not touch the land. Dredge spoil would not be placed upon the banks of the river, but would be placed back in the river outside the navigation channel.

These comments of the Federal Power Commission's Bureau of Power are made in accordance with the National Environmental Policy Act of 1969 and the August 1, 1973, Guidelines of the Council on Environmental Quality. Our principal concern with proposals affecting land and water resources is the possible effect of such proposals on bulk electric power facilities, including potential hydroelectric development, and on natural gas pipeline facilities.

Review of the draft environmental statement by the Commission's staff indicates that the proposed project would not have any significant effect on matters of concern to the Federal Power Commission. We note that there are several steam-electric power plants which depend on this reach of the Mississippi River as the source of cooling water supply. Care should be

AMERICAN REVOLUTION BICENTENNIAL 1776-1976 taken to protect the water intake and discharge works of these power plants from the proposed activities of dredging and dredged material disposal.

The opportunity to comment on the draft environmental statement is appreciated.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power

STATE OF ILLINOIS

DEPARTMENT OF CONSERVATION

605 STATE OFFICE BUILDING
400 SOUTH SPRING ST.
SPRINGFIELD 62706

ANTHONY T. DEAN
DIRECTOR

HAROLD L. ELLSWORTH
ASSISTANT DIRECTOR

CHICAGO OFFICE—ROOM 100, 160 N. LA SALLE ST., 60601

November 7, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
Department of the Army
St. Louis Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Re: LMSED-BA

Dear Mr. Niemi:

The Illinois Department of Conservation has completed its review of the draft environmental statement "Mississippi River Between the Ohio and Missouri Rivers Regulating Works."

We wish to compliment your office for the preparation of this document. The document properly addresses the issues caused by maintenance of the 9-foot channel and does not belittle the importance of the issues.

We do suggest that the document could be improved through a study designed to document the occurrence of mussels in this section of the river.

In our opinion, the study points out that, without a post-authorization change to include environmental work in the project, the continuance of current procedures can only result in continued degradatiou and loss of aquatic habitat.

As you are aware the Illinois Department of Conservation supports the post-authorization change. It is our belief that this document will help our joint efforts to secure these changes.

Thank you for the opportunity to comment.

Sincerely,

Tony Dean

Anthony T. Dean

ATD:mjk
cc: Owen Dutt, Corps
of Engineers

Recycled Paper

ILLINOIS NATURAL HISTORY SURVEY

~~Natural Resources Building~~
~~Urbana, Illinois 61801~~

Telephone: 333-6880
Area Code 217

GEORGE SPRUGEL, JR., *Chief*

304 Poplar Drive
Effingham, Ill. 62401
26 July 1975

Mr. Jack R. Niemi, Chief
Engineering Division
Dopt. of the Army
Corps of Engineers
210 N. 12th St.
St. Louis, Missouri 63101

Dear Mr. Niemi:

On behalf of the Illinois Chapter of The Wildlife Society, I want to thank you for the opportunity to comment on the Draft Environmental Statement for the Middle Mississippi River Between the Ohio and Missouri Rivers (Regulating Works). It is in the capacity of President of this organization and not the Illinois Natural History Survey that I comment.

Although information from the Illinois Natural History Survey is incorporated in the statement, I am disappointed that a copy of the draft was not sent to the Natural History Survey for comment.

The losses of fish and wildlife habitat due to this project appear to be of considerable magnitude. Therefore, I urge your continued cooperation with the Illinois Natural History Survey, the Fish and Wildlife Service, and other natural resource agencies and organizations to minimize the adverse effects of such projects on fish and wildlife.

Sincerely,

Ronald L. Westemeier, President
Illinois Chapter of
The Wildlife Society

ILLINOIS STATE GEOLOGICAL SURVEY
NATURAL RESOURCES BUILDING, URBANA, ILLINOIS 61801 TELEPHONE 217 344-1481

Jack A. Simon, CHIEF

August 1, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, MO 63101

Dear Mr. Niemi:

This letter is written in response to your request for comments on the Draft Environmental Statement for the Middle Mississippi River between the Ohio and Missouri Rivers. The impact discussed is to relate to the maintenance of a 9-foot-deep by 300-foot-wide navigational channel by the use of channel contraction dikes, protective bankline revetments, and any necessary dredging.

Sections of this draft were reviewed by several members of our Survey, and comments are as follows:

p. 52/2.1.2.1a. The Coastal Plain is a topographic feature, not a geosyncline.

p. 57 last sentence - part d. - Much of this 400-500 deep trench is now filled with sand and gravel and finer alluvium, on which the Mississippi now flows. The young trench south of Thebes was not eroded that deep.

p. 58 - part f. - If features such as Mommoth Cave and the fluorite district are going to be mentioned the physiographic map should include their locations.

p. 59.- paragraph 3 - Chesterian Series is a cyclic sequence of shallow-water limestones and clastics. The alternating beds consist of about one-half shale, one-fourth limestone and one-fourth sandstone.

Reference:

Swann, D. H., 1964, Late Mississippi rhythmic sediments of Mississippi Valley: Am. Assoc. Petroleum Geologists Bull., v. 48, p. 637-658.

p. 59 - last paragraph - the youngest marine sediments are both Cretaceous and early Tertiary (Paleocene and Eocene) in age in southern most Illinois.

p. 60 - first paragraph - Replace Cenozoic with Pliocene - Pleistocene fluvial chert gravels and Pleistocene sediments of glacial origin. 3rd sentence - Kansan, Nebraskan and Illinoian are glacial stages of the Pleistocene, (List in order of age). Last sentence - Wisconsinan is the age of most valley fill and terraces along the middle Mississippi River, also of large amounts of loess on the bluffs, especially on the east side of the valley and should be so noted.

3rd paragraph - Recent floodplain deposits are important enough to get more thorough treatment. Alluvium is deposited by the Mississippi and all its tributaries, not just the Salt River. Some types of river deposits are described under soils in 2.1.3.1. p. 93.

p. 60 - The reference to Harve & Koenig, 1961, is not listed in the Bibliography.

p. 74 - The Upper Devonian is not discussed.

p. 85 - The Carbondale Formation is not shown on the Generalized Geological Column of the Middle Mississippi River Region (Fig. 2-1, page 56).

p. 88/2.1.2.4. - Structural Geology; Additional information on Illinois may be found in the following.

Ross, C. A., 1963, Structural Framework of southernmost Illinois, IL. Geol. Survey, Circular 351, 27 p.

p. 90/2.1.2.5. - Seismic Activity

Even if the 1811-1812 Series had not occurred, this area would have to be classified as something more than a "minor" seismic region--Perhaps "moderate" seismicity would be more appropriate. There have been a couple of magnitude 6 quakes along what is referred to as "the New Madrid Fault Zone." A magnitude 6.0 occurred on Jan. 4, 1843 at 35.5°N 90.5°W, and a magnitude 6.2 occurred on Oct. 31, 1895 at 37.0°N 89.4°W near Charleston, MO. This together with other seismic and structural evidence seems to indicate "minor" is improper. Charleston, MO is about 20 miles due west of Cairo, IL., and St. Louis University's latest microearthquake studies extend the line of epicentiers associated with "the New Madrid Fault Zone" well into Illinois to about Ullin in Pulaski County.

Section 6.5

p. 228 - Alternate Uses of Dredged Material

Data are needed on the particle size distribution and mineralogy of the dredged material. This would highlight some possible uses while eliminating others.

Refer to:

Ehrlinger and Jackman, 1970, Lower Mississippi River Terrace Sands as a Commercial Source of Feldspar, IL. Geol. Survey, Illinois Mineral Note 43, 18 p.

Illinois Standard Specifications for Road and Bridge Construction, Department of Public Works and Buildings, Division of Highways, Springfield, IL Jan. 2, 1971.

The principal comment received from nearly all our reviewers had to do with the large volume of extraneous geological information included in your statement. Our reviewers believe that only geologic information relevant to the project should be included. We suggest that the detailed discussion of bedrock geology, structural geology, and other topics not directly related to the maintenance of a 9-foot deep 300-foot wide channel in the Mississippi Floodplain be deleted and replaced with brief references to the bibliography as to where additional information is available.

The draft needs to emphasize the geological aspects of the deposition of Pleistocene and Holocene materials in the bedrock valley. Particular attention should be given to the deposition of Wisconsinan materials and the reworking of these materials to form the present river bottomland. As is indicated above, the grain size distribution, mineralogy, and other characteristics of the dredged materials should be included in the impact to suggest concepts for disposition of these materials.

If the information is not available, this should be stated in the report so that research may be directed toward acquiring it.

I hope these comments are helpful. If you have any questions, we would be pleased to discuss any portion of the statement in detail.

Yours very truly,

Paul B. DuMontelle

Paul B. DuMontelle
Associate Geologist
Earth Materials Technology Section

STATE OF ILLINOIS

DEPARTMENT OF CONSERVATION
605 STATE OFFICE BUILDING
400 SOUTH SPRING ST.
SPRINGFIELD 62706

CHICAGO OFFICE—1227 S. MICHIGAN AVE. 60605

July 25, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
Department of the Army
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

The Department of Conservation has not yet completed its review of the draft EIS for the Middle Mississippi River between the Ohio and Missouri Rivers (Regulating Works).

We are, therefore, requesting an extension of the July 28 completion date to mid-August. We hope this will be satisfactory to your agency.

Sincerely,

Richard W. Lutz

Richard W. Lutz
Resource Planner
Division of Long Range Planning

RWL:meh

ILLINOIS ARCHAEOLOGICAL SURVEY

109 DAVENPORT HALL UNIVERSITY OF ILLINOIS URBANA, ILLINOIS 61801

Cooperating Institutions:
University of Illinois
Southern Illinois University
Illinois State Museum

June 16, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
St. Louis District
Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

Thank you for your recent letter of June 4 and copies of the Draft Environmental Statement for the Mississippi River Between the Ohio and Missouri Rivers (Regulating Works).

Sometime ago we provided the Waterways Experiment Station in Vicksburg with generalized areas on the Mississippi River floodplain where archaeological sites would be present. These are indicated in your report in Plates 2-5a through 2-5k, pages 173-183. Although these archaeological areas are of a general nature, please delete them from the final draft, particularly because your office contends that no archaeological resources will be impacted or affected by your project.

I do not concur with this reasoning of non-impact as indicated in paragraph 4.3.5 on pages 218-219 of the Draft. In the first place, there is a strong possibility that archaeological sites may be buried in select areas of the floodplain through years of continual silting and flooding, and the only way that this can be confirmed or denied would be through a site survey coring project. Moreover, you indicate on page 218 that in revetment construction river bank areas will be sloped or (page 219) contoured. Since these areas throughout the project area may contain archaeological sites, they would be consequently directly impacted or, in effect, destroyed by your project. I suggest therefore that in any type of action undertaken by this project involving dredging, filling, construction, or whatever, that affects the floodplain or banks or bluffs in any way that an impact on the archaeological resource base is not only possible but very likely will take place. I therefore recommend a detailed archaeological reconnaissance survey of the entire project area, in order to obtain specific data on the archaeological resource base from those locations where any type of dredging, construction, or alteration of land surface or even submerged land surface will take place. Without this survey, we will have no idea what the effect on the archaeological resource base may be by your project. I therefore find the Draft Environmental Statement totally inadequate with its assessment of this particular cultural resource.

Cordially yours,

Charles J. Bareis

Charles J. Bareis
Secretary-Treasurer

CJB:cb
cc: Frank Calabrese
Roy Reaves
Anthony Dean
James Porter

Christopher S. Bond
Governor

J. Neil Nielsen
Commissioner

State of Missouri
OFFICE OF ADMINISTRATION
Jefferson City 65101

Mark L. Edelman
Deputy Commissioner

August 12, 1975

Mr. Jack R. Niemi, Chief
Engineering Division
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

Subject: Draft Environmental Statement for the Middle Mississippi River Between the Ohio and Missouri Rivers (Regulating Works) OA 75060024

The Division of State Planning, as the designated State Clearinghouse, has coordinated a review of the above referred draft environmental impact statement with various concerned or affected state agencies pursuant to Section 102(2)(c) of the National Environmental Policy Act.

Enclosed please find the comments received. None of the other state agencies involved in the review had comments or recommendations to offer at this time.

We appreciate the opportunity to review the statement and anticipate receiving the final environmental impact statement when prepared.

Sincerely,

Terry L. Rehma
A-95 Coordinator

TLR:dk

JACK CURTIS, *Chairman*
930 E. Jefferson
Springfield 65802

DANIEL W. DUNCAN, *Vice Chairman*
2001 South Second St.
St. Joseph 64503

LYNN W. BAUER, *Member*
2201 Grand Avenue
Kansas City 64108

W. R. LOGAN, *Member*
Silex 63377

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444 Marie
Cape Girardeau 63701

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4935 Lindell
St. Louis 63108

MISSOURI
STATE HIGHWAY COMMISSION

ROBERT N. HUNTER, *Chief Engineer*

BRUCE A. RING, *Chief Counsel*

L. V. MCLAUGHLIN, *Ass't. Chief Engineer*

MRS. IRENE WOLLENBERG, *Secretary*

Jefferson City, Missouri 65101
Telephone (314) 751-2551

July 3, 1975

GENERAL: A-95 Review
Application No. 75060024

Mr. Terry Rehma, A-95 Coordinator
Division of State Planning and Analysis
State Capitol, P. O. Box 809
Jefferson City, Missouri 65101

Dear Mr. Rehma:

The Draft Environmental Statement covering regulating works along the Mississippi River between the Ohio and Missouri Rivers by the U.S. Army Engineer District, St. Louis, does not conflict with state highway crossings of the river. However, any plans covering the location of dikes which could alter current and cause scour at bridge piers, similar to the proposed alteration of the channel in Mississippi County, should be reviewed by this office to avoid any possible damage to existing bridges.

Very truly yours,

L. V. McLaughlin

L. V. McLaughlin
Assistant Chief Engineer
A-95 Review Agent

MISSOURI DEPARTMENT OF CONSERVATION

... Drive • Jefferson City • Missouri ...

... • Telephone ...

CARL R. NOREN, Director

August 8, 1979

Mr. Terry Rehma
Clearinghouse Coordinator
Division of State Planning and Analysis
Office of Administration
State Capitol Building
Jefferson City, Missouri 65101

Dear Mr. Rehma:

We have completed our review of the draft environmental statement for the Mississippi River between the Ohio and Missouri Rivers. The factual material presented in the statement generally depicts the changes that have occurred in the Middle Mississippi River. However, we disagree with two premises presented in the statement: (1) the Corps of Engineers takes credit for creating "numerous side channels" while (2) the "natural process of the river filled the side channels with sediment". Data presented in the form of maps and references indicate a tremendous permanent loss of side channel habitat has occurred due in large measure to dikes and revetments. The dynamic processes of a natural river system forming, then filling, and reforming side channels are ignored. Certainly natural fluvial rivers gradually fill side channels, and isolate chutes, but while one channel is eliminated other channels are formed.

Dike work may in some cases create limited side channel habitat, but the same dike work has over the years eliminated thousands of acres of habitat. Once dikes are constructed the permanent loss of water seems to be imminent.

The opportunity to review the draft is appreciated. Our detailed comments are attached.

Sincerely,

Allen Brohn

ALLEN BROHN
ASSISTANT DIRECTOR

cc: U. S. Fish and Wildlife Service
Kansas City, Missouri

August 8, 1975

DETAILED COMMENTS

by the

MISSOURI DEPARTMENT OF CONSERVATION

on

MIDDLE MISSISSIPPI RIVER DRAFT ENVIRONMENTAL IMPACT STATEMENT

1. Summary Sheet - Item 3, Lines 9 through 19. The statement fails to accept any responsibility for the loss of side channel habitat. Page 206, Item 5 the Colorado State University does indicate that the natural side channels were eliminated by the construction of dike fields. In addition, there is no recognition of the fact that the river would create new channels if it were not for the regulating works. The third paragraph of Section 1.2 (Page 1) gives slight indication of the river's natural condition.

2. Page 4 - Paragraph 5 - The interests demanding the deeper channel should be identified. Consideration should also be given to some form of cost sharing by these interests in the project. Page 5 - Second Complete Paragraph - What are the costs of developing a minimum channel depth of 9 feet as opposed to a channel 9 feet deep 90 percent of the time? Seventy-five percent? Such information should be presented to Congress.

3. Page 7 - Paragraph 1 - Does this include the work being performed on Mosenthien Island?

4. Page 12 - Paragraph 3 - The loss due to dike work is quite permanent. In the natural river, new side channels would be formed.

5. Pages 34 - 44 - Comments on dredging maps are as follows:

a. Plate 1-4a - Mile 158.0 - Dredging in November 1970 was omitted.

b. Plate 1-4d - Mile 122.2 - Dredging in September 1970 was omitted. Mile 117.1 - Dredging in December 1969 was omitted. Mile 117.0 - Dredging in October 1970 was omitted. Mile 117.0 - Dredging in August 1971 was omitted.

c. Plate 1-4e - Mile 111.5 - Dredging in December 1970 was omitted. Mile 110.4 - Dredging in December 1972 was omitted. There are no notations for years when sites were frequently dredged. For example: 1973 - Mile 96.5 was dredged on three occasions. 1971 - Mile 95.8 was dredged and Mile 96.0 was dredged on two occasions. 1970 - Mile 96.7, 96.5, 95.3 were all dredged. 1973 - Mile 103.6 was dredged and 103.5 was dredged on two occasions.

d. Plate 1-4j - 1969 - Mile 27.0 - Dredging in November 1969 was omitted.

6. Page 45 - The Dredge Kennedy has limited capabilities and is often unable with its 1,000 feet of pipeline to reach the least damaging spoil site.

7. Page 49 -a. Paragraph 1 - The study should also include costs due to flooding as well as fish and wildlife recreation. b. Third paragraph - The do nothing alternative is not discussed.

8. Page 51 - a. Credit is taken for creating side channel (Paragraph 2) while blame is given the river for filling them with sediment (Paragraph 3). There is no discussion of the dynamics of a natural river.

b. Paragraph 5 - How has the effect of dike fields changed if; "In the past. . . the dike fields reduced the width of the river."?

9. Page 97 - Paragraph 1 - Appendix C is a listing of benthic organisms.

10. Pages 133-141 - An imbalance seems to exist in that more than eight pages are dedicated to a detailed discussion of "Pestiferous Plants and Animals" while two pages and a table constitute a very general discussion of Threatened, Rare and Endangered Species.

11. Page 148 - Paragraph 1 - It is noted that approximately one-third of the tonnage originates or terminates at St. Louis--a seemingly favorable situation when considering that St. Louis is competing with Minneapolis, Chicago and New Orleans.

12. Page 162 - Paragraph (4) - Conclusions - Is the intent of the discussion to indicate that the economic condition of families is due to their living in the flood plain?

13. Page 170 - Table 2-31 - Industries using water transportation also typically use other modes of transportation. Percentages of waterway use vs. truck or rail should be tabulated for comparison purposes.

14. Page 184 - a. Paragraph 2 - Is the project area considered a part of the Upper Mississippi River Basin or the Lower Mississippi River for outdoor recreation purposes? b. Paragraph 3 - Trail of Tears State Park is located on the Mississippi River and makes active use of the river.

15. Page 188 - Paragraph 2 - Data or a more complete discussion of facts that form the basis for the statement "nor as diverse" in reference to early side channels would be of interest to our staff.

16. Page 190 - Paragraph 2 and 3 - What data supports the statement that wooden pile dikes or screens produce a more rapid rate of sedimentation than stone filled dikes.

17. Page 194 - a. - Line 1 - Field observations indicate notched dikes are performing well in some areas. The notches in deposition areas may allow sediments to move over the dike more readily but we doubt that notches "draw more material into dike fields". Observations in the mile 140 to 154 reach indicate no diversity without notches. b. Last Paragraph of Section 4.1.1.2. The paragraph ignores the impact of floods such as 1881, 1883, 1908, 1909, 1927, 1943, 1944 and 1973 on the river. With regulation works the river is unable to create new habitat. If it is true that there has been relatively little change in river width since 1907, then it might be inferred that the change has been toward a narrower canalized river with less and less diversity and flood carrying capacity.

18. Page 196 - Table 4-1 - Once again the loss of river area is apparent. The fact that the loss is permanent due to the regulating works should be discussed. Would the flood of 1973 have increased the river area if it were unregulated? This discussion seems to indicate that the river <u>was</u> dynamic.

19. Page 199 - Paragraph 1 - Second sentence should be changed to: "The flood plain was a storage area". Since levees have been built, it has in a large part been lost for flood storage.

20. Page 202 - a. - Line 9 - Are there statistics to indicate where the sediments are flushed to? Is this flushing of sediment considered to be part of the deposition problem in the downstream navigation channel? b. Next to last paragraph - Is it possible that levees are built close to the channel because the channel is "pinned down"? Are there techniques for assessing the synergistic effect on a narrow pinned down channel with levees close to the river bank? c. Last paragraph - Data should be presented on the impacts of levees and channelization on flood heights along the entire reach of the Middle Mississippi River.

21. Page 206 - Our understanding is that bedload had easy access to notches in the Colorado State University model study. Are there actual stream data that indicate means to salvage side channels?

22. Page 207 - Last paragraph - We strongly disagree with the sentence beginning with "However". Although it may be unrealistic under present circumstances, the river would revert to a pre-1900 condition if dike and revetment work were to cease. This was observed on the Missouri River during the 1973 floods.

23. Page 208 - A discussion of the impacts that have occurred due to material being flushed downstream through the river system should be included.

24. Page 212 - Paragraph 4 - Dredge spoil disposal is very slightly similar to natural processes. However, dredge spoil disposal is an unnatural process that deposits thousands of cubic yards of sand at a single site at low water stages.

25. Page 213 - Paragraph 1 - With equipment limitations as described on page 45, it is difficult to understand how disposal in critical areas is avoided.

26. Page 214 - a. - Paragraph 2 - Is the increased efficiency of the hydraulic system for flood control, navigation, recreation, fish and wildlife, sediment transport or what? b. - Line 1 and Paragraph 3 - The Middle Mississippi River and its riparian land could tolerate a tremendous increase in use before the uniqueness would be damaged. Timber harvesting and public utilization are not necessarily detrimental to wildlife habitat. However, conversion of the remaining forests to cleared cropland in many cases would be detrimental.

27. Page 218 - Section 4.3.3. - a. - Land Use - In practice the pattern of land use along the Middle Mississippi River has been (1) stabilize; (2) clear; (3) protect; and (4) drain. b. 4.3.4. - Outdoor Recreation - The public, especially recreationists, have lost tremendous acreages of public water due to the canalization of the Middle Mississippi River.

28. Page 222 - a. - Paragraph 2 - If all channel maintenance activities ceased, the river would revert to a more natural state. Filling would continue, but new habitat in the form of side channels and chutes would be formed. One recent

example of the river trying to revert is Cape Bend Towhead where the river threatened to seek a new course. b. - Last Paragraph - On what basis is deposition in dike fields considered to be natural? Man induces the change for a purpose.

29. Page 226 - Paragraph 2 - New habitat would be formed if channel maintenance ceased. Old side channels would fill, but new channels and chutes would be formed. b. Species living in and along the Mississippi River evolved with the dynamic, natural river. What data is available that indicates which plants and animals "could be eliminated" by allowing the river to revert? c. How would the hypothetical condition of clearing during the low flows differ from what is occurring with the present project? d. Paragraph 3 - If the waterway was phased out over a ten or twenty year period, the impacts would be less traumatic. e. Paragraph 4 - This paragraph seems to disagree with Paragraph 2 and tends in part to support the idea that the river would revert.

30. Page 227 - Paragraph 3 - Data on anticipated loss of side channel habitat due to locks and dams should be presented. Our observations indicate more permanent habitat would likely be formed.

31. Page 229 - Recreation - a. The canalization of the river has destroyed much of its appeal for camping and beach type recreation. b. It is doubtful that landscaping in the floodway would be practical.

32. Page 230 - Wildlife Habitat - Give specific examples of where dredge spoil would be utilized to "enhance" aquatic habitat along the Middle Mississippi River.

33. Numerous references were omitted from the Bibliography (Page 252-258). Several of those noted by page of citation are as follows:

    a. Page 218 - Ehrlich and Ehrlich, 1970.

    b. Page 95 - Hynes, 1972.

    c. Page 134 - Kingsbury, 1964.

    d. Page 100 - Lee and Plumb, 1974.

    e. Page 107 - Kearney, 1973.

    f. Page 113 - Schram and Lewis, 1973.

    g. Page 192 - Shull, 1922.

    h. Page 143 - Stansbery, 1968.

    i. Page 94 - Thornbury, 1969.

    j. Page 113 - UMRCC, 1972.

University of Missouri - Columbia

Room 22 Switzler Hall
Columbia, Missouri 65201

COLLEGE OF ARTS AND SCIENCE
Archaeological Survey

Telephone
314-882-8364

July 16, 1975

Mr. Jack Niemi
Chief, Engineering Division
Department of the Army
St. Louis District, Corps of Engineers
210 N. 12th St.
St. Louis, Mo. 63101

Dear Mr. Niemi:

In reference to correspondence LMSED-BA of 4 June 1975, on the Draft Environmental Statement of the Mississippi River between the Ohio and Missouri River Regulating Works, I have noted that you reference archaeological resources and indicate that there will be no impact through the operation and management of the river on the flood plain. So long as this statement remains true then the environmental statement on archaeology seems adequate. The actual in-the-field survey for archaeological resources in Missouri has not, to the best of my knowledge, been done by professional archaeologists and, should impact on the flood plain take place, a professional archaeological survey should be conducted.

If I may be of any assistance please feel free to contact me.

Sincerely yours,

David R. Evans

David R. Evans
Manager

DRE:clm

CHRISTOPHER S. BOND
GOVERNOR

JAMES L. WILSON
DIRECTOR

missouri department of natural resources

P.O. Box 176 Jefferson City, Missouri 65101 314-751-3332

June 17, 1975

Col. Thorwald R. Peterson
District Engineer
Corps of Engineers
210 N. 12th Street
St. Louis, Missouri 63101

Dear Col. Peterson: Ray

Re: Draft Environmental Statement, Mississippi River between the Ohio and Missouri Rivers Regulating Works

My staff at the Historical Survey and Planning Office has determined that it is unlikely the project will affect any known archaeological sites as long as the project is contained within the river channel. I should point out, however, that dredging activities can destroy underwater archaeological sites such as sunken boats, steamboat wrecks, or boats involved in Military operations during the Civil War. Hence, if such a wreck is found during dredging projects, the Corps or its subcontractors should cease operations and notify this office.

My Historical Survey and Planning Staff will be glad to coordinate with the Corps in this office and will offer all assistance possible. The office is located in Suite 215, 909 University Ave., Columbia, Missouri 65201 (telephone 314/449/0725).

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Jim

James L. Wilson
Director, and
Missouri State Historic
Preservation Officer

JLW:dic

cc: Mr. Roy W. Reaves
Mrs. Ann Webster Smith

OFFICE OF THE MAYOR
CITY OF SAINT LOUIS
MISSOURI

JOHN H. POELKER
MAYOR

June 9, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
Department of Army
Saint Louis District
Corps of Engineers
210 North 12th Street
Saint Louis, Missouri

Dear Mr. Niemi:

Thank you for sending a draft of the Environmental Statement for the Middle Mississippi River between the Ohio and Missouri Rivers.

I am sending the report to William Wilson, Director of Streets, whose office is in charge of wharf development. I am asking him to send his comments directly on to you.

Sincerely,

John H Poelker

Mayor

Missouri Chapter
of the
American Fisheries Society

CHARTERED MARCH 10, 1964

July 25, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
Department of the Army
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

Enclosed please find a copy of our Environmental Impact Committee's comments on your draft environmental statement for the Middle Mississippi River between the Ohio and Missouri rivers (regulatory works). Thank you for the opportunity to make comments on this important issue.

Sincerely,

Joe G. Dillard

Joe G. Dillard, President
Missouri Chapter of the
American Fisheries Society

JGD:ta

Enclosure

Comments of the Missouri Chapter of the American Fisheries Society on the Draft Environmental Statement for the Middle Mississippi River Between the Ohio and Missouri Rivers (Regulatory Works).

This statement is reasonably well written with little of the jargon and redundancy which frequently mar such documents. It purports to be an environmental impact statement and many of the impacts of the agency's activities on the environment are discussed. A great deal of time, however, is taken up discussing economic and sociological problems in the area and there is the distinct feeling that it is these things the writer wants to be sure the reader has in mind. It is refreshing to have the Corps of Engineers admit to having altered the environment to the extent that they have. However, here they not only admit to having altered the Mississippi River, they seem to be claiming to have created it. At any rate, they make it sound sacrilegious to suggest that they cease altering it.

Although much space is used discussing economic considerations, much of this seems rather irrelevant. Is the relative importance of the fishery in the river and the barge traffic on it to be determined on the basis of the number of people employed in each? If we are going to discuss economics, should not we talk about the relative cost of alternative methods of transportation and the effects on them of an annual federal subsidy of $11,500,000, the equivalent of the annual expenditure to maintain a nine foot navigation channel in the river.

Side channels received considerable attention in the statement. These portions of the river habitat have been demonstrated to be especially productive of fish and provide fishing sites favored by fishermen, removed from the treacherous current and dangerous traffic of the main channel. The Corps admits its structures often cause side channels to silt full and thus be obliterated. It also claims that side channels are created by its structures, although specific examples are not cited. Notches in dikes were suggested by conservation agencies as a means of prolonging the life of side channels. Experimental notches were placed in several dikes, a comment on the cooperation between the Corps and the conservation agencies. The effects of the notched dikes were evaluated in a model study conducted by Colorado State University and the results of this study are quoted in the statement. The report points out that ultimately all side channels will fill with sediment, which certainly is recognized. No one expects a particular side channel to last forever. The important factor is the element of time; there is a great deal of difference between a geologic and a human-oriented time scale. While neither makes any definite statement of the time scale under discussion, in general the CSU report is more encouraging than the statement as to the "life expectancy" of side channels. Why in the statement are the most negative aspects of the CSU report emphasized, the more positive aspects ignored?

In the statement the fishery of the Mississippi River is said to be underused and the implication seems to be that for this reason the fishery resource is not worthy of much consideration. In the past, the fish caught from much of the section of river under consideration had an unappetizing flavor, attributed to pollution from the St. Louis metropolitan area. With improved sewage treatment in recent years, the fish should be more desirable and fishing use should increase. This is only part of the cause of limited use, however, and much of the rest is directly attributable to the Corps of Engineers and the navigation project. Favored fishing places on the river are the side channels where bass, bluegills, crappies, and other sport fish are abundant and can be readily caught. The quiet water of the side channels is safe for small boats. According to the statement, many side channels have been eliminated in the navigation project and the few remaining will be eliminated eventually. The main channel has been made narrower and deeper, with a swifter current, as a result of the navigation project. This channel is hazardous for fishermen in small boats and the hazards are increased enormously when a tow of barges goes by, as happens quite frequently. Finally, access to the river is limited. There are few places where a fisherman can launch his boat. Lack of access is cited in the statement as a reason for limited recreational use of the river. Certainly, all these things tend to inhibit use by fishermen.

Much is made in the statement of the finding by a research team that many invertebrates are produced on the rock dikes and revetments. This is not a surprising discovery. Aquatic biologists have long known that rock rubble is a more productive substrate for benthic organisms than shifting sand. Much more pertinent would have been for the research team to determine how much of the 90 miles of dike and 140 miles of revetment was available for production of invertebrates and how much has been silted in. Then they might have demonstrated what relationship, if any, there is in the Mississippi River between production of invertebrates and fish production.

The main thrust of the statement is that the project and its structures must be maintained. It is also stated that the dikes must be extended and the width of the main channel reduced from 1,500 to 1,200 feet. Why is it necessary to extend the dikes? Who made this decision? Nowhere in the statement are these questions discussed.

There is an extensive list of "pestiferous" plants and animals in the statement. Each species is listed and its undesirable qualities are discussed but little effort is made to relate these species to the Mississippi River or put the dangers from them in a suitable frame of reference. Will the project increase or decrease the nuisance effects of these organisms? Can this be an attempt to frighten those whose knowledge of the outdoors was gleaned from reading "Peter Rabbit"?

The treatment of rare and endangered species in the statement is very superficial. The species known to occur in the Mississippi River are given but nothing is said about the possible effects of the project on them. No mention is made of any effort to minimize such effects. The alligator gar, Alabama shad, sicklefin chub, sturgeon chub, pallid sturgeon and blue sucker have all declined in abundance during the past 80 years, the period in which the Corps has been manipulating the channel of the middle Mississippi River. Can they prove there is no relationship between the changes in the river channel and the changes in the fish population?

The Corps of Engineers admits in the statement that in the 80 years between 1888 and 1968, the period when they were most active on the middle Mississippi River, the surface area of the river was reduced about one-third, the island area one-half, the river bed area by one-fourth. The river has been deepened an average of about 11 feet, due to contraction of the main channel. This is serious alteration of a great natural resource, comparable to the cutting of a great forest, the draining of an extensive marshland, or the damming of a great river. Is the Corps contention that, having done so much to the Mississippi River, they should be permitted to continue to have their way with it a tenable argument? What do you do with a natural resource which has been changed almost beyond recognition?

The Mississippi River will never again be the same as it was when Joliet and Marquette sailed their canoes on it or even when Mark Twain piloted steamboats. It must be recognized that navigation is only one of several major uses of the middle Mississippi. Extension of the dikes should not be continued unless it can be conclusively shown that other valuable habitat, such as side channels, will not be damaged. The Corps has made much of their cooperation with the Conservation Departments of Illinois and Missouri. This relationship has been good and unusually productive. It has been a one-sided game, however, in which the Corps claimed all the trump cards because of their insistence that they had no funds for any purpose not directly related to navigation. The Environmental Quality Act should have made it clear that when the federal government engages in an activity which has an impact on the environment, funds appropriated for the activity must be used to reduce the impact. When will the Corps of Engineers recognize that the Environmental Quality Act is as much the law of the land as the Rivers and Harbors bill?

Environmental Impact Committee

the
WATERWAYS JOURNAL
Weekly
SINCE 1887
701 CHEMICAL BUILDING
ST. LOUIS, MO. 63101
314-241-7354

August 8, 1975

Colonel Thorwald R. Peterson
District Engineer
210 North 12th Street
St. Louis, MO 63101

Dear Colonel:

I take the liberty of sending you herewith a statement on the draft environmental statement on the Mississippi River between the Ohio and Missouri Rivers, regulating works.

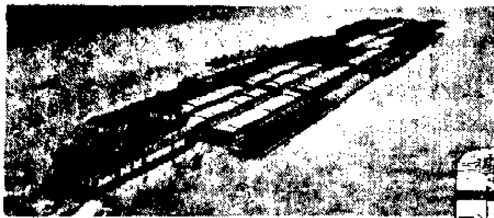
I hope that these comments are pertinent to the statement and, if there is any question on any of them, we invite you to call us for clarification.

Respectfully,

James V. Swift
Vice-President

JVS/ksc

Enclosure



the
WATERWAYS JOURNAL
Weekly
SINCE 1887

701 CHEMICAL BUILDING
ST. LOUIS, MO. 63101

314-241-7354

STATEMENT ON THE DRAFT ENVIRONMENTAL STATEMENT

ON THE MISSISSIPPI RIVER BETWEEN

THE OHIO AND MISSOURI RIVERS,

REGULATING WORKS

August 8, 1975

This statement is presented to the St. Louis District Engineer, Corps of Army Engineers, in response to requests for comments on a draft environmental statement on the Mississippi River between the Ohio and Missouri Rivers, regulating works.

The Waterways Journal is a weekly publication devoted to commercial marine interests on the inland waterways. We have been publishing since 1887 and are, therefore, very familiar with the needs and problems of the inland waterways marine industry. We appreciate this opportunity to express our views on the draft environmental statement.

We should like to take this opportunity to commend the St. Louis District on the thoroughness of the preparations for this environmental impact statement, and the wide scope of interests of organizations and individuals who were contacted by the District prior to the publication of this environmental statement.

In evaluating this statement, we believe it is imperative to remember that in the National Environmental Policy Act, as passed by Congress, language therein is explicit that a balance should be maintained in the consideration of environmental features between the welfare of nature and man. Nowhere do we read in NEPA that Congress has given governmental agencies the authority to place the human race in "second place" when environmental considerations are made.

In reading this environmental statement, we feel that the proper balance has indeed been kept, and that the statement demonstrates a need for the continued construction and maintenance of regulating works between the mouths of the Missouri and Ohio Rivers.

We conclude that the continued construction and maintenance of these regulating works is necessary for the well-being of the human environment. The Mississippi River between Cairo and the mouth of the Missouri carries a large and important volume of traffic which unites industry and agriculture in all sections of the United States through the inland waterways system. Some of the most important items moving through this stretch of river are energy materials such as coal, fuel oil, gasoline, and other petroleum products needed to keep industry and commerce active. In addition, much of the grain products which will be moving to the Gulf of Mexico for export will move on this stretch of river, and any delay of these wheat, corn, and other grain products will have an adverse effect on the balance of payments of the United States. Other shipments are destined for domestic consumption, and any delay in these shipments would result in higher cost for the American consumer and, therefore, added inflation.

It should be pointed out that a recent study done for the United States Maritime Commission by the consulting firm of A. T. Kearney, of Chicago, predicts that inland waterways transportation will double by the year 2000. To move this volume of water-borne commerce effeciently and safely, it will make it necessary for the channel between Cairo and the mouth of the Missouri River to be kept at the project width and depth at all times.

We would now like to address the environmental impact of these regulating works. As we pointed out in the statement presented to you during the hearings in St. Louis in December, 1974, at the Gateway Hotel, we emphasize the fact that the river between Cairo and the mouth of the Missouri has been traditionally used for commerce for hundreds of years; first by the Indians, then by the French and Spanish settlers, and finally by Americans. Even if all the fish and wildlife were forced off this stretch of river--which could not be the case--we feel that the need of this channel for the betterment of the human environment would outweigh the bad effects on the natural environment.

We also pointed out in our statement to you during the previous hearing that the states of Illinois and Missouri have adequate water, through other streams and through impoundments, to offset any loss (if there really is any) from navigation projects between Cairo and the mouth of the Missouri. As we said at that time, these water resources are:

1. In the state of Illinois there are impounded water areas (lakes and reservoirs) covering 428 square miles or 273,796 acres, and 134 square miles or 85,771 acres covering inland stream water areas. Boundary water areas cover 1,745 square miles or 1,118,397 acres. (1972 Illinois Surface Water Inventory--Illinois Department of Conservation.)

2. In the state of Missouri the figures are not as complete, but they show that there are 315,000

acres of impounded water in lakes and reservoirs and 11,500 miles of inland streams. (Missouri Conservation Department.)

If environmental groups wish to provide more area for fish and wildlife on the Mississippi River between Cairo and the mouth of the Missouri, we suggest that the Bureau of Fish and Wildlife provide these areas through its own budget, with financial assistance from the Sierra Club, Izaak Walton League, and other environmental groups. It must be made sure, however, that these areas do not in any way hinder navigation.

Statements have been made by certain environmentalists concerning the bad effects that would result from these navigation improvements for commerce on the Mississippi River. We believe these should be answered as follows:

Dredge Spoil Disposal--Any change in bank and channel material is going to cause effects on vegetation and organisms. This has been going on for centuries through floods, bank cave-ins, and other natural forces. True, there is a temporary change in what has been coined the "ecosystems," but apparently this has not been too devastating to wildlife inasmuch as there are muskrats, beaver, and amphibians around in 1975, and many fish. Nature takes care of itself.

Noise Pollution--There have been comments about protecting animals and birds from noise pollution through the elimination of construction of ports and terminals on the waterways. This would have a devastating effect on the future development of river traffic. Cargos moved by river must be loaded and unloaded, or there would be no river commerce at all. There are many examples of wildlife living close to industrial facilities, especially on the Gulf Coast. They have adjusted to the noise, just as humans do.

Wave Wash--Various reports that we have seen about the effect of wave wash on animals and fish that nest and breed along the river would indicate that they are intelligent enough to stay out of main channels, and that the wave wash from vessels does not generally reach the sloughs and chutes where these animals would naturally gravitate. Although recreational craft are generally omitted from these reports, indications are that the wave wash from these vessels has more velocity and height than that from commercial vessels.

Food Chain--Through natural floods and run-offs, the food chain is continually changing on the river bottom and, once again, since this turbidity has been going on for centuries, it would appear the turbidity caused by towboats, operating in the main channels, would have very little effect on the food chain necessary for wildlife. Food necessary for fish and wildlife is in the sloughs, not in the main channels of the river.

Accidents and Spillages--It should be pointed out that the pollution in the water of the Mississippi is due primarily to sewage and chemical wastes from shore, not from boats and barges. If there is one thing we are sure of, it is that the Coast Guard has been most diligent in its efforts to stop pollution on the waterways and that anyone responsible is libel to fines and even imprisonment.

In conclusion, we wish to emphasize that the continued and improved maintenance of regulating works on the "Middle Mississippi" between the mouths of the Ohio and the Missouri Rivers is necessary for the maintenance of the human environment and the welfare of the human race. We also wish to point out that even with the zero population that is now advocated by certain organizations and individuals, there will be millions of young persons growing up who will need homes, fuel, and food. Much of this material is moved by river at a low rate of cost and with the use of less energy than by other modes. The river between Cairo and the mouth of the Missouri is a key link in the chain of waterways that carry these vital materials.

We again wish to commend the St. Louis District for what we consider a very adequate and comprehensive statement.

Respectfully submitted,

James V. Swift
Vice-President

Sierra Club

August 12, 1975

Colonel Thorwald R. Peterson
Department of the Army
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Colonel Peterson:

Enclosed herewith is our comment on the Draft Environmental Statement: Mississippi River Between The Ohio And Missouri Rivers, Regulating Works.

Yours Truly,

John C. Cunningham

John C. Cunningham
Sierra Club, Ozark Chapter,
Eastern Missouri Group.

OZARK CHAPTER RESPONSE TO DRAFT ENVIRONMENTAL STATEMENT: MISSISSIPPI RIVER

BETWEEN OHIO AND MISSOURI RIVERS REGULATING WORKS

INTRODUCTION

A. Time of Filing Response - This response is written in order to meet the August 12 deadline for commentary to be published with the above final EIS, which we will refer to hereafter as the Middle Mississippi EIS or M.M. EIS. The Ozark Chapter, Eastern Missouri Group, which has been designated as the particular Sierra Club entity to make the response to the M.M. EIS, had asked for an extension of time until August 28 (see letter to Mr. Owen Dutt, July 3, 1975).

We understand that the St. Louis District's timetable of higher agency review precludes this kind of extention; but we also understand from Mr. Dutt that additional comments can be submitted within the next three weeks and still go forward for review by higher agencies, but that such comments will not be reprinted in the final EIS. We intend to follow this statement with more detailed remarks.

B. Present Status of M.M. EIS - Our observation is that there has been an explosion of knowledge concerning the Middle Mississippi in the past three years. The five very important studies listed in the preface (Johnson et al., 1974:Ragland, 1974:Schramm and Lewis, 1974:Simons, Schumm, and Stevens, 1974; and Turpening et al., 1974) all of which form one of the major bases of the EIS, plus other studies in the last several years listed in the bibliography, have together given the scientific community a completely new perspective of what is happening over time in this reach of the Upper Mississippi River System. Thus, the M.M. EIS is a particularly significant statement of environmental impacts of Corps O & M practices and other development features on the flood plain, because it is much richer in scientific back-up than previously issued O & M EIS's of the

Upper Mississippi.

We are pleased to see the Draft M.M. EIS condensed to one single volume with the back-up studies as reference material. In general, EIS's should not be judged on their quantity of assertions, but rather by the quality of expertise exhibited.

We note in reviewing this new literature on the Middle Mississippi that it raises many new questions. Continuing scientific studies are a necessity. Clearly, supplemental impact statements are required to reflect this future generated scientific information.

C. Purpose of the NEPA Act of 1969 - The first question one should ask of an EIS is, does it satisfy the purpose for which it was intended? These requirements are set out in the NEPA Act of 1969. The Act's legislative history (cf. U. S. Congress, 1969:2753) sets forth its rationale as seen by the Congressional committee that unanimously reported out H. R. 12549, which later became incorporated in the NEPA 1969 Act:

> By land, sea, and air, the enemies of man's survival relentlessly press their attack. The most dangerous of all of these enemies is man's own undirected technology.

Congress intended to "reverse what seems to be a clear and intensifying trend toward environmental degradation." They were particularly concerned about the impact on the environment of federal agencies which were by prior acts of Congress, "development-oriented"; that is, agencies which had developed over the years institutional policies which promoted economic development and new generations of technology without regard to their future effects on the environment. (cf. Anderson, 1973:18)

The NEPA 1969 Act was intended to be a blanket directive to all federal agencies to revise their basic policies and goals where necessary in order to cease this federally-promoted onslaught on the environment. The Senate committee in reporting out the legislation which was later to be the NEPA Act of 1969 (cf. Senate Committee on Interior and Insular Affairs, 1969) stated in their report that the purpose of the Act was to:

> lay down a general requirement that would be applicable to all agencies that have responsibility that effect the environment rather than trying to go through agency by agency.

The House Committee (U. S. Congress, 1969:2753) echoed similar sentiments as follows:

> It is simply a fact of life that policies of agencies of the Federal Government may and do conflict: it is equally true that there are occasions where, without the benefit of conflicting policies, these Government agencies may and do adopt courses that appear to conflict with the general public interest.

Dr. David M. Gates, Director of the Missouri Botanical Gardens, and Chairman of the Board of Advisors to the Ad-Hoc Committee on the Environment, probably best summed up the purpose of an EIS such as the one for the Middle Mississippi, when he made the following statement as reprinted in the legislative history.

> There are two types of issues. There are the brush fire crises: the Santa Barbaras, the Rhine Rivers, the Great Lakes; and then there are the long-term methodical concerns about the environment.
>
> The latter is by far the most difficult. It is the least spectacular yet by far the most significant . . . .
>
> Today we are manipulating an extremely complex system: the eco systems of the earth, the units of the landscape, and we do not know the consequences of our actions until it is too late. We need to study eco systems in advance and work out the strategies of living with the landscape.

It was this legislative setting that eventually resulted in Sections 101 and 202 of the 1969 NEPA Act that required all Federal agencies to make a "systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and environmental design arts in planning and in decisionmaking which may have an impact on man's environment; . . ." Clearly the mandate laid on development-oriented federal agencies by the Congress in the 1969 NEPA Act was to discuss scientifically, frankly and impartially the environmental impact of their present and proposed policies and projects and to find ways to bring these policies and projects into line with the now Congressionally-imposed restraints protecting the environment.

Critique of the Middle Mississippi EIS

A. Goals - The Corps of Engineers as a Federal agency has had particular problems in responding to this redirection of goals or agency missions in response to the 1969 NEPA Act. This critique is made with the idea of encouraging the acceleration of that response. It is intended as an institutional critique rather than directed against any particular level of command within the Corps. We see the M.M. EIS, the Corps contract research assignments, the research itself, the operation and maintenance procedures, and the Corps' relations with the public all as a reflection, although in different degrees, of the Corps' unfortunate "biased" or "ideologically motivated" commitment to the original missions of navigation expansion and flood plain development rather than a broader spectrum of goals and values. These would include in general mitigation of environmental damage and more particularly preservation of existing rivering ecological systems, preservation of water quality standards within the river system, enhancement of recreation uses of the river, protection of fish and wildlife habitat, maintenance of the flood storage capacity of the river, and the maintenance and preservation of the long term uses of the river flood plain for agriculture.

B. EIS Methodology - In order to satisfy the purpose of the EIS as intended by Congress, the first methodological requirement is that the EIS show the long term trends or the dynamic relation of the particular technology being imposed on the eco system to the key indicators of river systems stability.

5

These indicators might be considered as the first-order impacts of a technology on our environment.

The technologies are twofold. First is the technology of river modification in order to make the river navigable for waterborne commerce. This technology itself has been in a constant state of change, influenced by expansion of barge transportation technology, such as larger towboats, longer tows and deeper barge drafts. The second basic technological change is that of ubranization of the flood plain; that is, modifying flood plain use from agricultural, wildlife and wilderness purposes to urban purposes such as port facilities, manufacturing, power plant installations, commercial use and housing and land transport systems. The first-order environmental impacts of these two advancing technologies are as follows:

1. loss of the backwaters of the Middle Mississippi River
2. loss of the flood storage capacity of the river
3. loss of the water quality rejuvenation potential of the river

These first-order impacts can all be operationally defined. For instance, the backwater area of the river may be measured as the difference between the total river surface area at low water discharge less the "target channel area" of the river. As Simons, Schumm, Stevens (1974:12) notes, this target channel width can best be defined in an open river as the "distance between ends of wing-dikes on opposite sides of the river." Except for the test section between mile 138 and mile 154, the target channel width is 1,500 feet (cf. Simons, Schumm, Stevens, 1974:12).

The flood storage capacity of the river can be measured by comparing the flood discharge at a certain gauge reading with subsequent and previous flood discharges at that same gauge reading. For instance, on the Middle

Mississippi, according to Simons, Schumm, Stevens (1974:28), the gauge reading at the Eads Bridge in St. Louis for the 1973 flood was 43.3 feet. The gauge reading for the maximum flood of record which was in 1844, was 41.3 feet. The actual discharge for the 1973 flood was 855,000 CFS, whereas the discharge for the 1844 flood was 1,300,000 CFS. Assuming the maximum stage gauge readings to be equal for these two floods, which would be a very conservative assumption, and assuming the flood storage capacity at the site of the Eads Bridge in 1844 was 1.0, then the flood storage capacity in 1973 is 855,000 divided by 1,300,000, or .658, a reduction of some 34% in the flood storage capacity.

The third first-order impact, the loss of water rejuvenating capacity of the river, is more difficult to define, but it is, to say the least, some function of the backwater area of the river as opposed to the navigation channel. The backwater is relatively rich in biological organisms as opposed to the main channel which has a sand bottom and is sterile. Fremling (1972) explains the positive role of the backwaters in achieving water quality rejuvenation. The relationship of advancing technology to water quality requires considerably more study than it has received so far. There could very well be other major first-order impacts of advancing technologies on the river system, but these are the ones of major concern on the Middle Mississippi.

The methodology of adverse environmental impact assesment which the M.M. EIS uses does focus on the loss of the backwaters and the loss of flood storage capacity of the Middle Mississippi, but displays some rather significant departures from objective methodological analysis which are as follows:

1. It avoids any quantification of adverse environmental impacts, either in physical quantities or in dollars.

2. It extolls the virtues of developmental values and minimizes the adverse effects of operations and maintenance on the environment.

3. It segments its statement in such a way as to externalize or place outside of the EIS, Corps operations that adversely effect the environment. These externalized adverse effects on the environment are often explained as "natural processes of the river" or other euphemisms that tend to depict them as other than man-induced or Corps-induced, The result of such a methodology produces significant departures between the EIS descriptions of the dynamics of adverse environmental impacts and the descriptions contained in Corps-funded scientific technical reports and other scientific and objective discussions of the processes involved.

It is the intent of this critique that a detailed notation of methodological deficiencies will be submitted subsequent to the deadline of August 12. A more generalized critique, however, is offered herein of the conclusional statements shown in paragraph 3 of the summary sheet of the Middle Mississippi EIS. These conclusional statements are analyzed in five parts which are as follows:

1. Navigation expansion of waterborne commerce
2. Levees and other flood protection structures
3. Contraction of the channel
4. Dredging
5. Loss of the flood storage capacity of the river

1. <u>Navigation Expansion of Waterborne Commerce</u>

The Corps interprets this charge of Congress as one not only to "attain and maintain a dependable 9 foot navigation channel" but, furthermore, projects its role beyond this to that of one that will "facilitate the normal economic expansion of waterborne commerce and stimulate industry dependent upon this mode of transportation." Such language seems to imply a charge from Congress that navigation be expanded in perpetuity. Such language would overstate the precise mandate which the Corps has from Congress. There is considerable scientific evidence to indicate that the Mississippi River system is indeed a finite resource and does not have unlimited navigation expansion capabilities.

Furthermore, focusing exclusively on the virtues of taxpayer-subsidized stimulation of industries dependent upon this mode of transportation ingores the adverse economic impact which such artificial stimulation has on other industries not so stimulated and the adverse economic impact on alternate modes of transportation. The Corps exceeds its authority from Congress if it presupposes that it is charged with stimulation of unlimited flood plain urbanization. It is just this type of mindless, unplanned development that the 1969 NEPA Act speaks out against.

2. Levees and Other Flood Protection Structures

This statement does not distinguish between the argricultural levees designed to protect farmland and the 150 year flood frequency protection required by urbanized areas. The two contrasting levee systems have entirely different impacts on the flood storage capacity of the river, particularly at the higher flood stages. The land protected by agricultural levees retains its potentiality for further deposition of alluviam and thus the potentiality for increasing land elevation to keep pace with increasing flood stages; whereas urban land fixes forever the elevation of the terrain in the flood plain. Overtopping of the first type of levee results in minimal damage whereas overtopping of the second type of levee can result in catastrophic damages.

3. Contraction of the Channel

Here the Corps concludes that the area of the river other than the navigation channel "will eventually fill with sediment". There seems to be complete agreement then, that on the Middle Mississippi the total backwater area will completely disappear over time and all that will remain will be the navigation channel. Considering that the Corps' present target channel width is 1,500 feet, this would mean that the Mississippi River from St. Louis to Cairo would be approximately 1,500 feed wide for the entire length of this reach of the river. In addition, the Middle Mississippi EIS implies that further contractions may be necessary to maintain even a 9-foot channel. What the Middle Mississippi EIS is trying to convey, however, in their concluding paragraph, is that this resultant navigation channel is due to "natural processes of the river" in addition to their channel narrowing efforts. What is actually happening is that the Corps' operations are an overridding process. As noted by Simons, Schumm, Stevens (1974:57), the river in its natural state is one where the main channel grows and recedes in size and where the side channels sometimes deteriorate in size and at other times increase. The Corps-induced changes in the hydrology and geomorphology of the river pre-empt the enlargement of side channels and the main channels through wing-diking and closing chutes, whereas side channels that are filling up naturally are allowed to continue to do so. This is explained in a number of sections of Simons, Schumm, Stevens, but we particularly call your attention to Simons, Schumm, Stevens, 1974:46 wherein they state:

> The features of side channel formation in both the Power's Island reach and in the laboratory model discussed above were the same as those described by Shull. A straight reach of the channel will divide if we have the right depositional environment and a trigger mechanism to start the deposition. The development of vegetation on the deposition enhances the deposition processes and makes the bar more permanent. In Shull's case, the side channels filled naturally. In the Power's Island reach, most of the side channels were closed with the help of the engineering works.

In general, the Middle Mississippi EIS mental model of the Middle Mississippi is quite different than that displayed by Simons, Schumm, Stevens (1974:9). In the Middle Mississippi EIS model there is a river that is in part influenced by "natural processes" and part influenced by man-made decisions.

The Simons, Schumm, Stevens view of the river considers the river "natural" river up until about the beginning of the 20th century, and from there on it became a "developed" river. In the developed river, more and more the processes that control the hydrology and the geomorphology of the river are dictated by man's decisions. It would be too narrow a view to think of the entire siltation process of the Middle Mississippi as being controlled completely by the design and operation of the regulating works within this reach of the river. There are other important factors: such as the discharge regulating effects of the mainstem dams on the upper Missouri & channel contraction works on the Missouri River; channelization of other tributaries coming into the Middle Mississippi; and urbanization of the flood plain. But these too are all man-induced impacts on the hydrology and geomorphology of the Middle Mississippi. As Ogburn (1956) once noted, as man comes to invade more and more a natural environment through the process of urbanization, his technology itself becomes the environment. The Corps, or any Federal agency, cannot claim the direct intended benefits of their development programs on the one hand and on the other hand claim the unintended consequences of those very same development programs are "acts of nature" or external to their studies. This is a form of system segmentation. The Corps further states in their conclusion paragraph the following:

> Cessation of the ongoing efforts to obtain and maintain the authorized 9-foot navigation channel would not significantly reduce the above siltation processes.

This statement is misleading in that it simply picks out one of the many man-induced changes of the Middle Mississippi and states if that one change were eliminated, siltation would still continue. What is germane is that if all man-induced changes were discontinued, then the river would revert

11

back to its natural state.

The statement is misleading in another way in that it implies the only policy choices are continuation of the 9-foot navigation channel by using present operation and maintenance procedures or complete cessation of the 9-foot channel. In view of the economic considerations on the one hand and the 1969 NEPA Act on the other, neither of the above two alternatives is realistic.

The only logical choice would be a change in O & M procedures that would protect the integrity in the backwaters.

4. Dredging

The statement on dredging appears to be in agreement with the supporting scientific technical literature. We comment further that if for some reason procedures were changed so that all dredging was diverted from the backwaters to the higher land areas in the flood plain, the backwaters would continue to silt up because of wing-diking and closure diking.

5. Loss of Flood Storage Capacity of the River

The Corps' comment on this adverse environmental impact is as follows:

> Similarly, the construction of flood protective works to protect urban areas and thousands of acres of productive farmland from floods has caused a significant increase for flood flows as compared to the past.

This statement clearly shows the counter-productive nature of Corps policies which are originally intended to protect areas in the flood plain but in actual practice cause unintended consequences of increasing flood flows as compared to the past. The program in itself is counter-productive to the Corps' stated intentions. Thus, for example, farmers who may have been induced in some previous time to build an agricultural levee that would withstand a 20 year flood probability, now find the same levee depreciated in value to where it is good for only a five year probable flood. In effect, the flood storage capacity of the Middle Mississippi is in a state of disequilibrium due to urbanization of the flood plain, continuing placement of new levee systems and channel modification. Again, there is a rather striking disparity between the Corps' description of the causes of this increased flooding and those contained in Simons, Schumm, Stevens (1974). The Corps attributes all loss of flood storage capacity to flood protective works whereas Simons, Schumm, Stevens attributes this loss to both flood protective works and navigation contraction work. For instance, Simons, Schumm, Stevens (1974:34) states:

> The increase in river stage for any particular flood is the result of the combined effects of levees on the flood plain, dikes in the river channel, and alterations of the flood plain between the levees and the river channel due to land use changes.

While they do not try to distinguish one causal change from the other, they clearly suggest that the channel modification works have a significant effect on flooding in the Middle Mississippi. The effect of navigation works on the loss of flood storage capacity on the Middle Mississippi was first discussed by Belt (1973). He notes particularly the high stages reached during the 1973 flood at Chester, Illinois, at mile 100. These stages were accomplished even though the low agricultural levees in the surrounding vicinity were generally overtopped, thus opening up the entire flood plain in this reach of the river to the flood flow. (cf. Belt 1975)

C. Correction of Methodological Deficiencies

The Middle Mississippi EIS contains a number of conclusatory statements which are not correlated with the basic scientific and technical reports. These deficiencies could be overcome by a tighter methodological format that would include the following:

1. Referencing statements made to documents in the bibliography

2. Citing only references that are contained in the bibliography

3. Using baseline data for comparing of facts displayed. Many statements are made in the EIS that lose their significance as they are not compared to meaningful baseline data.

4. Quantitative analysis of the dynamic characteristics of the river - adverse environmental impacts particularly are handled on a qualitative rather than a quantitative basis. Many of the scientific technical reports cited in the bibliography do contain more quantitative analysis. Loss of the backwaters and loss of the flood storage capacity of a river do lead directly to economic losses that could be quantified first in operational physical terms and next in dollars.

5. Lack of legislative history--we're referring particularly here to pages 4 and 5 which would appear to be a series of representations to Congress from the Corps of Engineers of what it would take to achieve first the 8-foot channel in 1881 and later the 9-foot channel starting in 1927. Actual achievement of a stable, dependable 9 foot channel in this reach of the river always seems to be something that will be achieved upon the next program of channel contraction. This starts with a 2,500 foot channel target width in 1881, 1,800 feet in 1927, and now 1,500 feet. The record suggests that continuing contractions of the channel are necessary in order to keep dredge quantities from moving exponentially out of sight.

6. Lack of public disclosure of planning alternatives. The Middle Mississippi EIS considers basically three alternatives, the first being continuation of the present O & M practices, the second being complete cessation of navigation on the Middle Mississippi and the third being a post-authorization change which simply amounts to alloting a very small proportion of the present O & M budget for experiment with methods to decrease environmental damage. It would seem that an extensive discussion of the alternatives offered by a present technology for complete mitigation of environmental damage should be in order, including the costs involved.

   Planning alternatives relative to the 12-foot channel are particularly vague. (cf. Middle Mississippi EIS 1975:48-49). This section states the cost deficiency in the original phase one 12-foot channel study. The section also implies a serious shorage in water availability on the Middle Mississippi in the more distant future. Will there be enough low water discharge available for navigation at that time?

In conclusion, it is our understanding of the law that navigation on the Middle Mississippi should proceed only if there is a concurrent program of environmental mitigation, a program to protect the integrity of the backwaters. Flood plain development must also proceed in such a way as to protect the flood storage capacity of the river.

The notion that economic development can and must proceed at a cost of continuing environmental degradation, will in the end bankrupt the environment.

John C Cunningham
Dr. Charles B. Belt

Sierra Club - Ozark
Chapter E.M.G.

August 12, 1975

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Bootheel Regional Planning Commission
& Economic Development Council

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PAT LEA, CHAIRMAN
PHILIP SHELTON, DIRECTOR

July 30, 1975

Mr. Thorwald R. Peterson
Colonel, CE
District Engineer
210 North 12th Street
St. Louis, MO 63101

Dear Mr. Peterson:

Please find enclosed a copy of the comment letter we sent Mr. Jack R. Niemi for the Draft Environmental Statement on the Mississippi River Between the Ohio and Missouri Rivers Regulating Works.

If you have any questions please feel free to contact me.

Sincerely,

Ronald C. Yersak

Ronald C. Yersak
Planning Director

RCY:dm
Encl.

cc: Mr. Philip Shelton

"Be Regionable"

Missouri
Bootheel

Bootheel Regional Planning Commission & Economic Development Council

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PAT LEA, CHAIRMAN
PHILIP SHELTON, DIRECTOR

June 26, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
Department of the Army
St. Louis District, Corps of Engineers
210 North 12th Street
St. Louis, MO 63101

Dear Mr. Niemi:

Both the Bootheel's A-95 PNRS Committee and the Bootheel Regional Planning Commission have reviewed and approved the Draft Environmental Statement on the Mississippi River Between the Ohio and Missouri Rivers Regulating Works.

The Bootheel Regional Planning Commission appreciates the opportunity to review such projects.

Sincerely,

Ronald C. Yersak
Planning Director

RCY:gw

cc: Mr. Philip Shelton

"Be Regionable"

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July 21, 1975

Mr. Jack R. Niemi
Chief, Engineering Division
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210 North 12th Boulevard
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Dear Mr. Niemi:

DRAFT ENVIRONMENTAL STATEMENT
MISSISSIPPI RIVER BETWEEN THE
OHIO AND MISSOURI RIVERS
REGULATING WORKS

As requested in your June 4, 1975 letter and in the text of the subject Draft Environmental Statement dated May 1975, our comments are submitted:

Section 4.1.1.5 Lowering of Riverbed Elevation (Page 196)

As discussed in the report, the engineering concept of channel development is to redirect the river's energy to the task of scouring out a suitable navigation channel by contracting the river width with a corresponding increase in current velocity. As the report indicates, the riverbed elevation is reduced through degradation or scouring. As a result, the riverbed has been lowered by about 8 feet between the years 1889 and 1966. The 15-mile long test or prototype section between miles 140 and 154 was lowered an additional 3 feet during the period from 1967 to 1971.

Section 4.1.1.8 Effect on River Stages (Page 201)

The reduction in river stage at low flows is discussed, and figure 4-3 (a) shows that the stage-discharge relationship at a discharge of 54,000 cfs. has been lowered by 11 feet between 1837 and 1946 due to degradation of the riverbed brought about as a result of the channel improvement project. At higher discharges, the reduction in river stage is less marked reaching a no-change condition between 1837 and 1946 at a flow of 290,000 cfs. At 500,000 cfs. flow the stage is 2-1/2 feet higher for 1946 than was recorded for an equivalent flow in 1837.

UNION ELECTRIC COMPANY
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JOHN K. BRYAN
VICE PRESIDENT
ENGINEERING & CONSTRUCTION

MAILING ADDRESS:
P. O. BOX 149
ST. LOUIS, MISSOURI 63166

Mr. Jack R. Niemi

July 21, 1975

Our concern is the reduction in elevation of the river surface at low flows of 54,000 cfs. and below. As noted in Section 4.1.1.6, Effect on Flows (page 197), a minimum discharge at St. Louis of 18,000 cfs. occurred in 1863. We became concerned over lowering of the river surface elevation at low flows at our various steam electric generating plants along the Mississippi River in the St. Louis area during the mid-to-late 1950's. As a result, we adopted a program of setting the water inlet sill of new circulating water intake facilities at a lower elevation than had been used based on earlier design criteria, since it appeared that this reduction in river level due to bottom scouring would continue.

The need to employ the mechanism of bottom scouring to maintain the 9-foot channel through use of contracting dikes is recognized, and indeed Union Electric is dependent on availability of the 9-foot river channel for the receipt of barge coal at Meramec Plant and for delivery of oil to our plants and to our suppliers. Therefore, we are not specifically objecting to the use of this mechanism in maintaining the channel.

However, a continual lowering of the riverbed elevation at all points along the middle Mississippi River could result, if carried to extremes, in lowering the river surface to a point at which--for very low flow conditions--the river water intakes of our plants and those of other industries and municipalities served by the river would be unable to obtain cooling water or other water supplies. The effect which this river bottom scouring will have on the river surface with the corresponding availability of water to industrial, commercial and municipal intakes, and the extent to which it may be permitted to continue, must be considered in the overall impact of the channel constriction program on the economy in the middle Mississippi River area.

We are not concerned with the effect of regulating works on river stages at high flows, as our plants are built to appropriate design criteria for protection against flows of the greater-than-500-year-flood magnitude.

Very truly yours,

John K. Bryan

John K. Bryan

FWB/MGW

cc/Messrs. J. F. McLaughlin
J. E. Birk
K. E. Bridegroom
G. W. Arras

THE AMERICAN WATERWAYS OPERATORS, INC.

WASHINGTON EXECUTIVE OFFICES

1600 WILSON BOULEVARD • SUITE 1101 • ARLINGTON, VA. 22209

JAMES R. SMITH, President

Telephone: 703-841-9300

July 21, 1975

Colonel Thorwald R. Peterson
District Engineer
U. S. Army Engineer District, St. Louis
210 North 12th Street
St. Louis, Missouri 63101

Dear Colonel Peterson:

As the national trade association representing the barge and towing industry, The American Waterways Operators, Inc. submits the following comments in connection with the draft environmental statement on the Mississippi River between the Ohio and Missouri Rivers Regulating Works.

The membership of AWO fully supports the channel maintenance work of the Corps of Engineers. The Congressionally-authorized nine foot channel on this segment of the river has brought to the public a wealth of economic benefits through the availability and reliability of low-cost water transportation. These benefits, while chiefly transmitted through water rates, have also been felt through reduced rail charges along water competitive routes.

The Mississippi segment detailed in this draft, the portion between the Missouri and Ohio, is an extremely critical link to the entire inland waterway system. While the maintenance of the nine-foot channel has direct implications for the immediate area, secondary effects are seen as far as such points as Pittsburgh, Chicago, Minneapolis, New Orleans, and a host of other major river ports located along the nation's inland waterway system.

In this era of energy shortages, it is important to note that nearly 60% of total tonnage moved on the nation's waterways consists of "fuel for others", such as coal, oil, and refined petroleum products. Products moved on the Mississippi River between the Ohio and Missouri Rivers Regulating Works are, in large part, the same "fuel for others".

Current transportation and economic trends dictate the maintenance of a nine-foot channel in this strategically located area. AWO urges the St. Louis District of the Corps of Engineers to expedite the channel maintenance program in this area as a significant means supporting urgent economic, social, and energy needs.

Respectfully submitted,

James R. Smith
President

Department of the Army
Corps of Engineers, St. Louis District
210 North 12th Street
St. Louis, Missouri 63101

August 11, 1975

Attn: Mr. Jack R. Niemi
Chief, Engineering Division

The following comments, in response to your letter of June 4, 1975, are pertinent to the Draft Environmental Statement for the MIDDLE MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS (REGULATING WORKS).

Consideration of threatened species gives rise to conjecture--is not the American taxpayer ("status undetermined") entitled to the protection --species, habitat and livelihood--of the government and agencies he supports? This was the intent of NEPA and this Environmental Statement, prepared in compliance with that law, fails as a procedural safeguard against environmental, economic and social damage. This Statement is at an incomplete, deficient and often inaccurate stage. Much more research, sincere effort, and expertise is needed to produce the January, 1976 EIS to be submitted to the CEQ, Congress and the general public.

I. Validity of the Benefit/Cost ratio of 4.01 to 1 is questionable; figures, estimates and items used in calculations are inaccurate, incomplete or non-existent.

(1) No inclusion is made of the discount rate utilized in the B/C ratio calculation.

(2) The Draft Environmental Statement itself notes the exclusion of estimates for cost and maintenance of disposal sites and costs to the navigation block resulting from adverse channel conditions.

(3) Numerous references in the Draft indicate that dredging is "never eliminated", "always needed", "never ending", and that annual amounts of dredge material are merely estimated because of deviations due to uncontrollable river conditions. Such deviations or increased dredging necessary could impose an additional annual cost. Yet the "average annual" of $11,428,000 is represented as a fixed annual amount in arriving at the B/C without noted concern for annual changes arising from river conditions, economic pressures, labor demands or technological changes.

(4) The Benefit/Cost Summary uses terms "cost" for the project and "charges" for the annual average. In reality navigation interests have never experienced "charges" for use or abuse of either national waterways or revenue.

I. (continued- B/C validity)

(5) The derivation of project benefits is cloudy at best and no adjustment in B/C ratio is exhibited compiled from figures reflecting
---Federal subsidies to offset handicaps to competing transportation modes due to lack of Corps development and maintenance
or
---decrease in navigation benefits if charges were imposed to offset Corps services rendered.

II. No Benefit/Cost ratio type comparison for Energy Efficiency is reported. Comparative studies of the energy utilization of establishing and maintaining the channel as well as utilization by the various existing modes of transportation are conspicuous by their absence.

III. I find it embarrassing to point out that the statement on page 219 "O&M activities do not have an impact on the flood plain" manifests an unbelievable ignorance of elementary sand box physics! Flood waters unable to occupy filled spoil sites will occupy wetlands and/or flood plain. This resulting creation of flood-prone land may involve federally subsidized flood insurance, local qualifying ordinances, flood plain zoning, and jeopardize recreational sites, cultural resources and the environmental quality of natural resources. Little or no evidence is presented to indicate an understanding of these involvements. In fact a total disregard is apparent from the statement on page 231 summarizing environmental cost as the disappearance of side channels and loss of water surface with no mention of water or air quality. These oversights take on even greater significance considering the imminent commercial expansion based upon project completion. One navigation company quotes in the Draft a planned 113% expansion program.

IV. Other obvious queries which arise after review of this Draft:

(1) Clarification needed as to site selection guidelines, permit issuance, compliance inspection and reporting.

(2) Table 1-1 omits documentation of the 1966 authorization for the prototype reach used to develop design criteria to implement the 9-foot channel project.

(3) Clarification needed as to the issue of transportation efficiency vs. survival of river transportation industry as raised by a December, 1974 hearing participant.

These comments and questions are submitted in the hope that such input will enable the Corps to develop a sensitivity to public overview rather than the mere "navigation servitude" philosophy professed by Colonel Peterson in the Draft Statement.

Sincerely,
Marty Nelson

(Mrs.) Marty Nelson
12 Quatoga Bluff
Godfrey, Illinois 62035