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STUDY PLAN FOR AN ENVIRONMENTAL INVENTORY AND ASSESSMENT OF THE MISSISSIPPI RIVER 9-FT CHANNEL PROJECT BETWEEN ST. LOUIS, MISSOURI, AND CAIRO, ILLINOIS

by

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FOREWORD

The U. S. Army Engineer District, St. Louis (SLD), allocated funds to the U. S. Army Engineer Waterways Experiment Station (WES) to organize and compile a study plan that would (a) outline procedures and techniques for an overall environmental inventory of the Mississippi River 9-ft channel project between St. Louis, Missouri, and Cairo, Illinois, and (b) provide the framework for the assessment of data and analyses of relationships of the physical, biological, chemical, and cultural elements of the project area.

The study plan organized and compiled by WES will be implemented by a Cooperative Research Team of personnel from WES, SLD, Missouri Department of Conservation, Southern Illinois University, Colorado State University, Illinois Department of Conservation, and Illinois Natural History Survey. The inventory data and analyses performed by each agency of the research team will be published separately. WES will prepare and publish a summary of conclusions and recommendations.

The study plan was prepared by William P. Emge, Project Manager, Office for Environmental Studies (OES), under the general direction of Dr. John Harrison, Chief, OES.

BG E. D. Peixotto, CE, and COL G. H. Hilt, CE, were Directors of WES during the period of preparation and publication of this report. Mr. F. R. Brown was Technical Director.

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SUMMARY

The Mississippi River 9-ft channel project was authorized by the River and Harbor Acts of 21 January 1927 and 3 July 1930, for the purpose of obtaining and maintaining a 9- by 300-ft channel for navigation from the confluence of the Missouri River to the confluence of the Ohio River. The project was modified by the River and Harbor Act of 2 March 1945 to provide for the construction of the Chain of Rocks Canal and Lock No. 27, and further modified by the River and Harbor Act of 3 July 1958 to provide for the construction of Low Water Dam No. 27.

A limited amount of data is available on the Middle Mississippi River, its side channels and floodplain. An extensive terrestrial and aquatic inventory is required to establish a data base sufficient for biological analysis, and assessment of physical changes resulting from contraction efforts to obtain and maintain a 9-ft channel. A geomorphic model is required to determine the hydraulic response of the river to construction and extension of dikes.

This study plan, organized and compiled by the U. S. Army Engineer Waterways Experiment Station, outlines procedures and techniques for an overall environmental inventory of the Mississippi River floodplain between St. Louis, Missouri, and Cairo, Illinois, and provides the framework for the assessment of data and analyses of relationships of the physical, biological, chemical, and cultural elements of the project area.

Participants in the study will begin their studies simultaneously in order to meet designated completion dates. A longer project duration would allow some studies to generate data for others, resulting in a more systematic and comprehensive inventory and assessment. Parameters will only be sampled over about a 1-1/2-year period, which will prohibit an in-depth analysis and correlation of data for such a large, complex system.

SECTION I: JUSTIFICATION AND AUTHORIZATION

Navigation on the natural river was extremely hazardous and people living within the floodplain were subject to frequent floods; therefore, they petitioned the Federal Government to provide a more navigable waterway and flood protection works.

The existing 9-ft channel project was authorized by the River and Harbor Acts of 21 January 1927 and 3 July 1930, for the purpose of obtaining and maintaining a 9- by 300-ft channel for navigation from the confluence of the Missouri River to the confluence of the Ohio River. The project was modified by the River and Harbor Act of 2 March 1945 to provide for the construction of the Chain of Rocks Canal and Lock No. 27, and further modified by the River and Harbor Act of 3 July 1958 to provide for the construction of Low Water Dam No. 27.

SECTION II: PROJECT AREA DESCRIPTION

The authorized 9-ft channel project extends from the confluence of the Missouri River (river mile 195) to the confluence of the Ohio River (river mile 0) at Cairo, Illinois. The area between river miles 195 and 168.7 will be included in the St. Louis Harbor Project. The project area for this study extends from St. Louis, Missouri (Jefferson Barracks Bridge at river mile 168.7), to Cairo, Illinois, and covers the entire Mississippi River floodplain. This reach of river will be referred to as the Middle Mississippi River. Fig. 1 outlines the floodplain and levee system. The original unprotected floodplain, which is primarily in Illinois, has generally been reduced to about a mile in width by levees throughout the project area.

Side channels as defined in this study are channels that parallel the main channel or cut across a bendway. There are 23 major side channels (also known as chutes, sloughs, or backwater areas) within this restricted (unprotected; or areas riverward of the levees or bluffs) floodplain which were selected for study. Flow through them varies with river stages. Names and locations of the side channels are in Appendix A.

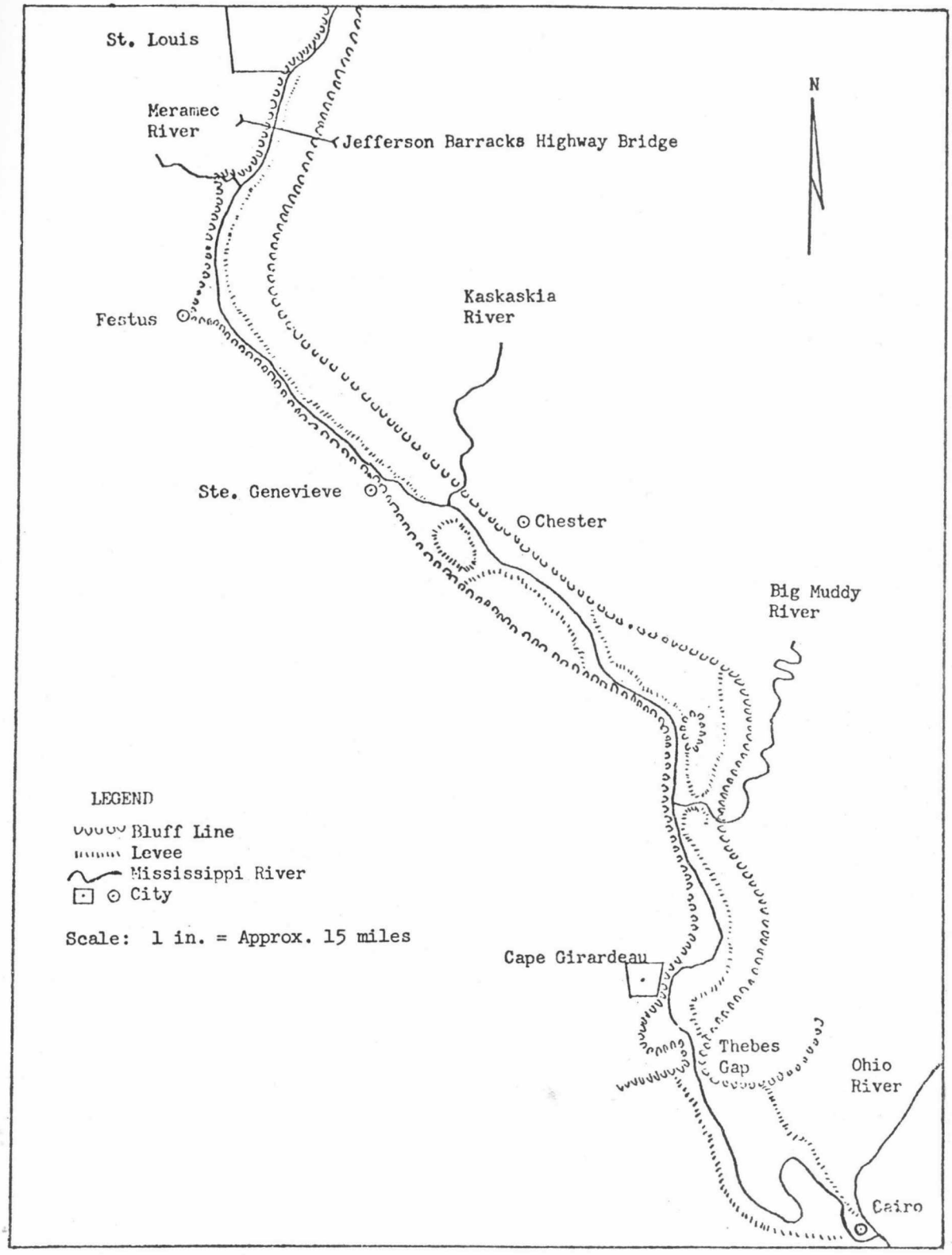


Fig. 1. Mississippi River Floodplain and Levee System

SECTION III: STUDY OBJECTIVES

Current design criteria to obtain and maintain a dependable 9-ft channel call for extension and/or construction of dikes roughly perpendicular from either or both banklines into the river throughout the project area, thereby constricting the river to an average width of 1500 ft. St. Louis District (SLD), Corps of Engineers, has allocated funds to the U. S. Army Engineer Waterways Experiment Station (WES) to perform an overall environmental inventory, assessment of data, and analysis of relationships of physical, biological, chemical, and cultural elements within the project area. The primary study objective is to provide a reference source for the preparation of an Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act of 1969. The SLD will ascertain the qualitative and quantitative impacts of the river regulating works based on this study and prepare an EIS. Additional objectives are (a) to establish a comprehensive data base, (b) to use the results of the study for better environmental planning in order to preserve or improve the areas riverward of the levees as habitats for biological communities, (c) to use the data base in the selection of alternatives or mitigatory factors to compensate for any adverse environmental impacts, and (d) to facilitate evaluation of other alternatives to preserve or improve biological communities.

These objectives will require (a) an extensive inventory and analysis of the entire floodplain (bluff to bluff), (b) intensive studies to determine the ecological values of the unprotected floodplain, and (c) model studies of various configurations of dike fields (both notched and unnotched) to determine general shoaling processes.

A chart summarizing the time phasing of the study objectives is located in Appendix B.

SECTION IV: STUDY PLAN

A. Cooperative Research Team

The SLD, WES, Missouri Department of Conservation, Southern Illinois University (SIU), Colorado State University (CSU), Illinois Department of Conservation, and Illinois Natural History Survey have formulated an interdisciplinary study team to accomplish a bluff to bluff environmental inventory which will consist of an intensive sampling program of the aquatic, riparian, and terrestrial environments on the unprotected floodplain; physical model studies; and analysis of data. The study will be performed under the direction of William Emge, Project Manager, Office For Environmental Studies (OES), WES. Basic missions and pertinent personnel of each agency are outlined in the following paragraphs.

1. St. Louis District

Provide project objectives and guidance; study aesthetic considerations; and prepare an EIS. Principal investigators are: Eugene Degenhardt, Potamologist, Hanley Smith, Ecologist, and Rea Boothby, Fisheries Biologist, Environmental Resources Section.

2. Waterways Experiment Station

Perform field data collection of selected physical, biological, and chemical parameters on the main channel and 23 side channels; perform part of the macroinvertebrate identification; perform part of the biological portion of the bluff to bluff inventory in conjunction with Southern Illinois University; analyze field data; evaluate alternatives and mitigating factors; make recommendations concerning current design criteria; and prepare overall report. Principal investigators are: William Emge, Environmental Engineer, Charles Solomon, Research Biologist, Jeffrey Johnson, Limnologist, Rex Bingham, Limnologist, Ross Hall, Jr., Limnologist, and David Mathis, Fisheries Biologist, OES.

Perform bluff to bluff inventory of physical and cultural parameters; and digitize side channel profiles to determine various water relationships as a function of river stage. Principal investigators are Jack Stoll, Geologist, and Victor LaGarde, Physicist, Mobility

and Environmental Systems Laboratory.

Perform particle size distribution analysis of selected sediments. Principal investigator is Gene Hale, Agronomist, Soils and Pavements Laboratory.

Perform chemical analysis of selected sediments and water. Principal investigator is Leonard Pepper, Chemical Engineer, Concrete Laboratory.

3. Missouri Department of Conservation

Perform field data collection of selected physical, biological, and chemical parameters on three side channels and adjacent river border areas to be selected by WES; perform macroinvertebrate, fish, and zooplankton identification; analyze data collected and assess the three side channels and river border areas. Principal investigators are Dan Ragland and Jack Robinson, Fisheries Biologists, Fish and Game Research Center.

Provide wildlife information. Principal source is Clarence Daniels, Wildlife Specialist.

4. Southern Illinois University

Review literature pertaining to the significance of side channels as fish habitats, identification of juvenile fish, plankton, part of the macroinvertebrates, and botanical samples collected by WES. Principal investigators are William Lewis and Roy Heidinger, Fisheries Biologists, Cooperative Fisheries Research Laboratory; and John Stahl, Limnologist, Joseph Beatty, Invertebrate Zoologist, and Jerry Looft, Limnologist, Zoology Department.

Identify, locate, and study utilization of important wildlife species; and perform most of the biological portion of the bluff to bluff inventory in conjunction with the WES. Principal investigators are Samuel Jewell, Wildlife Ecologist, and Virginia Terpening, Wildlife Researcher, Cooperative Wildlife Research Laboratory.

5. Colorado State University

Perform physical model studies to determine effects on side channels of notched and unnotched dike systems in the main and side channels. Principal investigators are Daryl Simons, Potamologist, Stanley Schumm,

Geomorphologist, and Michael Stevens, Potamologist, Civil Engineering Department.

6. Illinois Department of Conservation

Provide existing data on fish. Principal source is Larry Dunham, Fisheries Biologist.

Provide wildlife information and waterfowl counts. Principal source is Dave Kennedy, Wildlife Specialist.

7. Illinois Natural History Survey

Provide existing fish information. Principal source is George Bennett, Fisheries Biologist, Fisheries Research.

Provide wildlife information and waterfowl counts. Principal source is Glen Sanderson, Wildlife Biologist, Wildlife Research.

B. Implementation of Requirements to Achieve Objectives

The requirements necessary to achieve the objectives have been divided into three categories, (a) bluff to bluff inventory, (b) intensive studies of the unprotected floodplain, and (c) physical model studies.

Data for the bluff to bluff inventory will be recorded on base maps, scales 1:62,500 and 1:24,000. Data for the intensive studies on the unprotected floodplain will be recorded on base maps, scales 1:9,600 and 1:4,800. Format and scale of maps to be included in final report will be determined later.

1. Bluff to Bluff Inventory

Several levels of intensity of effort will be applied in this study in order to better understand the interrelationships of the inventory elements with the 9-ft channel project. The area landward of the levees is predominantly agricultural and will not be directly affected by the proposed river regulating works. The area riverward of the levees is directly affected by both river regulating and flood protection works. These areas will be studied with intensities of effort relative to project impacts in order to provide sufficient quantitative and qualitative data for a description of the setting without

continuation of construction activities to obtain and maintain a 9-ft channel. The differences in the natural and man-made environment that may occur as a result of latitudinal changes will be recognized.

The requirements listed under the other two categories--Intensive Studies of Unprotected Floodplain and Physical Model Studies will also provide data for the bluff to bluff inventory.

a. Physical elements - WES, SLD, and CSU. This will include the compilation of pertinent geological, climatological, and hydrological data, literature review, consultation with acknowledged specialists, and field data collection. These data will be presented in the report to indicate possible interrelationships of inventory elements and to readily permit analysis and interpretation of the data.

(1) Geological elements - WES.

(a) Geological conditions. This will include a discussion of the geology and topography of the floodplain and establish the physical setting of the environment. The following items will be discussed and depicted on base maps.

[1] Physiography-geomorphology

[2] Structural geology

[3] Groundwater geology

[4] Regional geology

[5] Historical geology

[6] Economic geology

(b) Rare and unusual geological features. This will include a description of such features and their location on the base maps.

(c) Soils. This will include soil maps, identification and description of general soil associations found in the floodplain, and discussion of their overall physical characteristics and production capabilities.

(2) Physiographic changes as a result of man's action - CSU. This will include a physiographic analysis of the Middle Mississippi River from about 1800 A.D. to the present. Existing data will be used to graphically depict gross changes in the river configuration, along

with a general discussion of the natural evolution of a river and how man-made changes affect this evolution.

(3) Climatological elements - WES. All information will be obtained from existing climatological data derived from stations located near the upper, middle, and lower reaches of the study area. Topics to be considered include the relationship of the floodplain to major climatological groupings, monthly average of high and low temperatures, record maximum and minimum temperatures, length of growing season in days, monthly precipitation, and type and occurrence of severe weather.

(4) Hydrological elements.

(a) General - SLD. This will include a discussion of water resources in the floodplain and an indication of related present and future needs and problems.

(b) Existing surface water resources - WES and SLD.

[1] Significant streams and impoundments will be located and identified on the base maps - WES.

[2] A general discussion will be given on the hydraulic characteristics of the Middle Mississippi River and its major tributaries - SLD.

(c) Water quality - WES. This will include a general discussion of water quality problems in the floodplain. The discussion will relate to a(4)(a) and (b)[1] above.

b. Biological elements - WES and SIU. This will include the compilation of pertinent biological data through literature review, consultation with acknowledged specialists, and field data collection. These data will be presented in the report to indicate possible interrelationships of inventory elements and to readily permit the analysis and interpretation of data.

(1) General. This will characterize the floodplain as an ecosystem and relate it regionally and nationally.

(2) Environmental changes resulting from man's actions. This will include the historical development of resources in the floodplain and relate these developments to changes in the natural environment.

Discussions will be time-phased, providing a continuum from about 1800 A.D. to the present, and projected into the future. The discussion will include changes in vegetative types, forest conditions, wildlife, and original stream conditions.

(3) Biological communities. The identification, location, and description of major terrestrial, riparian, and aquatic communities within the floodplain are viewed as a major activity. Description will include site conditions, terrestrial successional stages, dominant and indicator species, uses by man, and vulnerability of important species to change. In order to determine project impacts, community types will be confined to terrestrial, riparian, and aquatic communities not currently under intensive management or disturbance. Major biological communities will be mapped.

(4) Species inventory - field and literature. This will include a listing of all vertebrates known to be present in the floodplain, with appropriate indications of their importance and abundance. The inclusion and discussion of invertebrates will be governed by their importance in community structures and food chains, or their importance from a scientific, economic, and public health point of view. Botanical elements will include a listing of all known woody and herbaceous plants. Some of the plants will be identified and discussed in relation to their importance in community structures, their contribution to fish and wildlife habitat, and their aesthetic and scientific importance.

(5) Rare and endangered species. Those rare and endangered species (from state and national lists) or unique communities found in the floodplain, and their habitat and status will be thoroughly described and discussed.

(6) Wildlife habitat. This will be restricted to wildlife species of recreational or commercial importance and significance in food chains, and their associated wildlife areas. Wildlife habitat will be keyed to biological communities described in paragraph (3) above.

(7) Fish habitat. This will highlight fish species of recreational or commercial importance and significance in food chains. Harvest data will be included as appropriate. Fishery data will be

related to previously identified aquatic communities.

c. Cultural elements - WES. This will include the compilation of pertinent sociological, demographic, economic, and cultural data through literature review, and consultation with acknowledged specialists. These data will be presented in the report to indicate possible interrelationships of other inventory elements and to readily permit the analysis and interpretation of data.

(1) Population. This will include a discussion and evaluation of the floodplain in terms of population distribution and size. Future population trends will be addressed.

(2) Economic conditions. This will include the present state of economic development in the floodplain in terms of past, present, and future trends using U. S. Bureau of Census data.

(3) Waterborne commerce. This will be a discussion of the status of waterborne commerce on the Middle Mississippi River in terms of past, present, and future trends based on a 9-ft channel. The discussion will include tonnages, types, and value of cargo. Other alternatives of moving cargo will be discussed.

(4) Land use. This will include a general discussion of land use and will outline the different uses on the base maps. Land utilization will be defined as follows:

(a) Cities or towns

(b) Industries

(c) Woodland

(d) Surface water resources

(e) Agricultural

(5) Archeological elements. This will include the location of archeological resource areas on the base maps and a discussion of their significance and importance. Features potentially affected by river regulating works will be discussed in sufficient detail to allow adequate assessment of the impact on their scientific and cultural values.

(6) Historical elements. This will include the location of historical sites on the base maps and a discussion of their significance and importance. Features potentially affected by river regulating

works will be discussed in sufficient detail to allow adequate assessment of the impact on their cultural values.

(7) Outdoor recreation. This will include a general discussion of outdoor recreation resources in the floodplain. It will include an enumeration of types and intensity of use and a discussion of future recreational demands on floodplain resources. Recreational areas will be located on the base maps.

2. Intensive Studies of Unprotected Floodplain

Intensive studies will be required to identify, describe, and evaluate the present and potential biological value to the ecosystem of those aquatic, riparian, and terrestrial environments along the unprotected floodplain of the Middle Mississippi River which are presently affected or may in the future be affected by the 9-ft channel project. These are recognized primarily as those environments associated with the side channels.

a. Aquatic environment

(1) General. The purposes of the aquatic studies are (a) to report on the importance, abundance, natural history, and biogeography of significant aquatic species inhabiting areas riverward of the levee; (b) to describe ecologically important aquatic communities in terms of site conditions, successional stages, dominant and indicator species, species diversity as related to present stage of habitat, and vulnerability to change; (c) to determine the value of the various icthyofauna for recreational, commercial, and scientific purposes; and (d) to determine biological aspects needing new or more intensive research.

(2) General objectives of aquatic sampling program and analytical techniques.

(a) Field sampling program.

[1] Selected physicochemical parameters will be measured and described, and the benthic and planktonic communities of 23 side channels and 4-6 main channel border areas will be sampled.

[2] The benthic and planktonic samples collected in objective [1] will be evaluated as fish food organisms based on their diversity and density. Numerical descriptors of the diversity of the

benthic and planktonic communities will be generated by using various diversity indices.

[3] Seining for young-of-the-year fishes will be conducted in all side channels and adjacent main channel border areas to determine the relative values of these areas as nursery areas for the river and side channel fisheries.

[4] Intensive sampling of fish populations will be conducted in three representative side channels and adjacent main channel border areas to determine their relative value as fish habitats on a seasonal basis.

[5] The physicochemical data of objective [1], the analysis of biological data generated in objective [2], and the fish data of objectives [3] and [4] will be used to investigate the following:

[a] Difference among all side channels

[b] Differences between fast and slack water side channels at high water stages

[c] Differences between side channels open at the upper end and those open at the lower end

[d] Differences among all sampling stations

[e] Differences between side channels with continuous flowing water and those with water flowing only at high stage

[f] Differences between side channels and main channels border areas

[g] Importance of side channels to main channel

(b) Identification of fish, plankton, and botanical elements. The biota will be classified to species, when possible, to allow a better understanding of the interrelationships between the biota, and the physical and chemical parameters. This will permit a more accurate interpretation of the interrelationships within the ecosystem.

(c) Particle size distribution and chemical analysis of sediments. Standard soil classifications of the sediments will be determined and related to data from other completed studies of sediments and their associated biota. The composition of sediments will be used

to determine current depositional patterns and to permit analysis of differences in physical systems among side channels. Chemical analysis of the sediments will be used to determine if specific pollutants are present which might affect aquatic communities.

(d) Core samples. Core samples will be taken to determine past depositional patterns and to help predict the siltation rates in the side channels and main channel border areas.

(e) Soundings. Profiles of side channels, main channel border areas, and sampling stations will be obtained to assist in the correlation and analysis of data.

(f) Digitization of side channel profiles. Most benthic, plankton, and fish communities can be associated with particular water-basin regimes (e.g. current, depth, substrate, and cover). The controlling structure (dike or sandbar) at the entrance and exit of side channels and any dikes within, determine different water-basin regimes as a function of high river stages. At low river stages, evaporation and other inputs determine the water-basin regime. A computer model will be used to determine various relationships such as surface area to volume which when correlated with the biological and chemical data, might suggest which physical relationships are more important in maintaining or improving these areas as habitats.

(g) Literature review. A literature review of the present state of knowledge relevant to the significance of backwater areas to a river fishery will be conducted. Particular reference will be given to the type of water regime existing or that which could exist in the study area. The review will include a comprehensive literature review and an annotated bibliography.

(3) Sampling program and analytical techniques - WES.

(a) Locations and times of sampling. Three sampling stations will be established within each of the 23 side channels. They will be selected to reflect obvious differences within the side channel and as nearly as possible be symmetrically established along the length of the channel. The sampling stations will be marked on aerial photographs and will be sampled four times during the program: once each

during early summer, late summer, early winter, and spring. Each station will have 3 sampling sites - left and right banks and center of side channel.

(b) Biological elements.

[1] Benthic sampling for collection of macroinvertebrates will be conducted at each sampling site. A benthic sample will consist of two or more composited Peterson dredge hauls. The samples will be processed by screening through a U. S. Standard No. 30 sieve, placing the retained material in containers, and adding a preservative of 70 percent ethanol. Drift macroinvertebrates will be sampled with a 20-in. diameter, 5-ft long, cone shaped No. 10 plankton net towed through the water just below the surface. Samples will be preserved with 70 percent ethanol.

[2] Since the sampling sites on the sides of each station are shallow, plankton samples will only be collected in the center of the channel at various depths throughout the water column. During the first sampling period six liters of water will be collected at surface, middepth, and bottom using a three liter Van Dorn water bottle. The plankton will be concentrated by passing the sample through a No. 20 plankton net. If analysis of the first plankton samples indicates that a greater volume of water must be concentrated, 30 liters of water will be collected throughout the water column during subsequent surveys. Water-alcohol-formalin (6:3:1 v/v), Lugols, or merthiolate preservatives will be tried and the best one selected.

[3] The macroinvertebrates in the benthic samples will be identified to species when possible. The community density and diversity of the macroinvertebrates, zooplankton, and phytoplankton will be summarized using various methods of diversity indices such as that proposed by Patten (1962) and alternative techniques suggested by Hurlbert (1971).

[4] Juvenile fish will be collected with a 25-ft, 3/16-in., regent style, nylon seine using six drag seine hauls at each station and along the bank of the main channel border areas selected for

sampling. The collected fish will be placed in jars and fixed with 10 percent formalin.

[5] Samples of submergent and emergent aquatic vegetation plus all types of botanical species from the water's edge to high bank will be systematically collected (e.g. location of transect, type of habitat, date, etc.) and pressed in the field. Vegetation will be classified using appropriate botanical keys for the Middle Mississippi River floodplain.

(c) Physical and chemical parameters.

[1] Temperature, dissolved oxygen, phenolphthalein and total alkalinity, pH, and turbidity will be measured at the surface, middepth, and bottom at the center of the channel at each sampling station during the first sampling period. Depth selections during subsequent periods may be changed if analysis of data from previous period(s) indicates more samples are required. The time of day and the selected meteorological parameters, air temperature, cloud cover, and wind velocity will be recorded.

[2] Temperature and dissolved oxygen will be measured in situ using a Weston and Stack DO meter (calibrated in the field using the Winkler method, Azide modification). Phenolphthalein and total alkalinity, pH, and turbidity will be determined in the field immediately following sample collection with a Van Dorn water bottle. Phenolpthalein and total alkalinity will be measured as directed in Standard Methods (APHA 1971). The pH will be measured using an Orion pH meter and Fisher glass electrodes. Turbidity will be estimated photoelectrically using a Hach Model DR-EL laboratory kit and Secchi disc.

[3] Sediment samples will be collected at each sampling site. A sample of the upper 3 in. of a standard Peterson or Ekman dredge haul will be placed in a plastic vial and retained for appropriate smell, feel, and visual comparisons of sediments among stations and side channels. Pint-size samples of each sediment that appears different from the ones previously taken when compared by smell, feel, and visual field tests will be taken for particle size distribution analysis. A three quart size sample of silty or clayey sediments

will be collected from sampling stations in the three side channels closest to St. Louis and analyzed for COD, mercury, total Kjeldahl nitrogen, lead, zinc, phosphates, and volatile solids. Both filtered and unfiltered water samples from the same locations will also be analyzed for the same seven parameters and compared with the sediment analysis if "expected" naturally associated values for the sediments are exceeded.

[4] Current velocity will be measured with a Price current meter for each period when flow is obvious. When velocities are small or when water is passing through a break in a dike, an estimate of flow will be made. When available, an SLD survey team will take discharge measurements.

[5] During the second sampling period, the extremes of the profiles obtained with a Raytheon DE 119-D fathometer by St. Louis District in May 1972 will be verified. Side channel widths will be surveyed with level, rod, and stadia board to provide additional data for the computer model described below. Another complete set of profiles of the side channels will be taken during the low water period in 1973. Soundings will be taken in all main channel border areas to be sampled and for each sampling station.

[6] Fathometer profiles (cross-section) within each side channel, and the distance between them, will be entered into a computer program that will provide the water-basin relationships described in [b] below. These relationships will be analyzed in conjunction with biological and chemical data to determine any possible correlations. The top-of-bank elevations are irregular which allows water to be over bank in some places along the side channel and not in others. The relationships will be generated for each two-foot change in river water surface elevation from low stage until the water is over 50 percent of the length of the high banks of the side channel. When the high banks are overtopped less than 50 percent of their length, the relationships will be a function of river stages as long as the side channels remain open to the river. It will be assumed that a vertical wall exists on top of the overtopped high banks in this category. When the

river stage falls below the bottom elevations of the controlling profiles (sandbars or dikes) near the entrance and exits of the side channel, the relationships will be a function of the side channel water level and its input flows and evaporation rates.

[a] The side channels will be described in terms of: (1) side channel length ℓ , (2) width b , (3) depth z , (4) surface area A , (5) volume V , and (6) shoreline length L .

[b] The digital computer model will generate the following relationships between river stage and water surface elevation and: (1) water volume; (2) shoreline length; (3) surface area; (4) underwater surface area for different intervals in water depth expressed in area and percent of total underwater area; (5) development of shoreline (D), $D = L/[2(\pi A)^{1/2}]$ where L = length of shoreline, A = surface area; (6) rate of change of surface area with respect to river or side channel water level; (7) ratio of surface area to volume (A/V); (8) ratio of shoreline length to surface area (L/A); and (9) cross-sectional areas of side channels at sampling stations.

(4) Identification of fish, net plankton, and macroinvertebrates collected by the WES - Southern Illinois University. This work is to include the identification of juvenile fishes, determination of young of the year, juveniles and adults, and a summarization of the relative abundance of different fishes in a series of seine samples. Juvenile fishes are to be identified to species when possible.

This work will also include the identification and summarization of the abundance of all of the phytoplankton and zooplankton, and macroinvertebrates from the last two sampling seasons (WES will identify the macroinvertebrates from the first two seasons). The zooplankton will be identified to species when possible. The phytoplankton will be identified to genera (to species in a few cases where sufficient taxonomic information is available). Enumeration of phytoplankton, zooplankton, and macroinvertebrates in each classification will be recorded.

(5) Sampling program and analytical techniques - Missouri Department of Conservation.

(a) Locations and times of sampling.

[1] Portions of three side channels will be selected as study areas, each representing a different type of habitat. The three selected will be representative of the side channels of the study area. Paired with each side channel will be a section of the nearby main channel border approximately equal in area to the side channel study section. These will be representative of the channel border habitat in this portion of the river. Each pair of study sections (side channel and main channel border) will be sampled at the same time, with approximately the same amount of effort and, insofar as possible, using the same methods and gear.

[2] Collections will be made from each pair of study areas during each season (Spring - March, April, May; Summer - June, July, August; Fall - September, October, November; Winter - December, January, February). Each paired area will be sampled for approximately one week in the same sequence each season, and the total sampling for a given season will be accomplished within about two months time.

(b) Biological elements.

[1] Fish will be collected with a variety of gear (electric shocker, hoopnets, frame nets, trammel nets, gill nets, and mid-water trawl) to minimize gear selectivity. Piscicides may be used where they will not interfere with future work or cause public relations problems. Reproduction and recruitment will be assessed with meter nets and small mesh seines. Seine collections will be used to assess the abundance of forage fish. Artificial substrates and a limited number of grab and drag samples from a variety of substrates will be used to indicate abundance of fish food organisms. A standard tow with a standard plankton net will be made near the center of each area each time it is sampled.

[2] All organisms will be enumerated, measured, and identified; fish to species and invertebrates to species where possible or to appropriate groups. Weights will be determined by appropriate methods. Fish abundance will be determined by catch per unit effort. Length frequency distribution will be calculated. Number per standard seine haul and diversity will be used in the assessment of forage

fishes. Likewise, both quantity and variety of invertebrate organisms will be used. Utilization of fish food organisms will be determined by examining the stomach contents of a limited number of 3-5 different fish species. Plankton samples will be measured both quantitatively (No/ℓ) using standard methods.

(c) Physical and chemical parameters. Surface water turbidity and temperature, and air temperatures will be taken daily during each sampling period approximately at noon. Once, approximately at noon, during each sampling period, physical (temperatures, turbidity, velocity) and chemical (dissolved oxygen (DO), pH, total alkalinity, specific conductance) determinations will be made at surface and bottom in the deepest part of each side channel, and main channel border area. If surface and bottom temperatures differ more than 5°F or DO more than 2 ppm, additional determinations will be made in a vertical series. Standard Methods (APHA, 1971) will be used for all determinations.

(6) Literature review - Southern Illinois University. A thorough review will be made of all literature pertaining to fish in habitats similar to those found in the study area. An attempt will be made to document the value of these side channels as fish spawning, rearing, and development areas and their importance to the main channel through a comparison with other similar physical regimes.

b. Riparian and terrestrial environments

(1) Wildlife and vegetation inventory - Southern Illinois University.

(a) Objectives. The objectives of this project are: (1) to describe and map the littoral and terrestrial plant communities existing in the unprotected floodplain; (2) to inventory the plants, mammals, birds, reptiles, amphibians, and invertebrates associated with each community type; (3) to describe association between species of plants and animals in each community type; (4) to establish recent past, present, and hypothesized future successional trends in undisturbed plant and animal communities; (5) to determine land-use trends; (6) to describe fully any rare or endangered species in terms of known ecological requirements; (7) to evaluate higher flora and fauna for recreation

and commerce, and unique flora and fauna for scientific, public health, or aesthetic purposes; (8) to map impounded water areas in the unprotected floodplain and discuss their importance with respect to present or potential recreation; (9) to determine the uniqueness of the unprotected floodplain in the region and nation; and (10) to propose new or more intensive research on management for existing ecosystems.

(b) Methods and materials. The objectives of the research will be accomplished by conducting (1) extensive reviews of literature on the five animal groups and the flora; (2) personal interviews with specialists and informed laymen in Illinois and Missouri concerning unpublished research on, and observations of, the biology of the unprotected floodplain; and (3) field investigations in selected study areas containing representative plant communities of the unprotected floodplain.

[1] Reviews of literature. Published information about the biology of the Middle Mississippi River floodplain has resulted from zoological and botanical research conducted by members of Southern Illinois University and other universities in Illinois and Missouri; the Illinois Natural History Survey; other Illinois and Missouri State agencies, especially the Departments of Conservation; and Federal agencies including the U. S. Forest Service and the Bureau of Sport Fisheries and Wildlife. The reviews of this literature will be designed to avoid duplication of effort by the researchers. Citations and information will be recorded on Keysort cards for rapid retrieval. Lists of research works will be requested from Federal, State, and local agencies, and various private institutions, and at the same time indices and abstracts, such as the Agricultural Index, BASIC, Dissertation Abstracts, Pesticides Documentation Bulletin, and Wildlife Review, will be systematically searched. Researchers will review the periodicals in their field and will share responsibility for general periodicals. Although information published in the last 50 years will be emphasized, other relevant information will be abstracted.

[2] Personal interviews. A number of botany and zoology professors have conducted collecting trips with their classes along the

Middle Mississippi floodplain; some have published their findings. In addition, wildlife conservation officers, soil conservation specialists, biologists, and lay people with biological avocations, who are familiar with the floodplain would be able to furnish valuable information. A questionnaire will be developed to facilitate communication.

[3] Field investigations. Although extensive information can be collected through literature reviews and personal interviews, field investigations are necessary to provide more current information. At least five areas will be selected for intensive studies using cover maps developed from topographical maps, aerial photographs, infrared aerial photographs, field observations, and recorded information about the unprotected floodplain. These areas will be observed and sampled in the fall, winter, and spring.

All flora and fauna will be sampled along one to several transects in each of the five designated areas. Each of the transects will extend perpendicularly from the littoral zone of the Middle Mississippi River to the top of the appropriate levee. The transects will be sufficient in number and width to obtain representative samples. Basal areas of trees greater than two inches in diameter will be estimated at 100-ft or appropriate intervals along the transects using a wedge prism and the Bitterlich Variable Radius Technique. Basal areas per acre can then be extrapolated (Grosenbaugh 1952 by Phillips 1959). Herbs, shrubs, grasses, vines, and trees less than two inches in diameter will be sampled in 1/1000-acre circular quadrats established at each basal area sampling point. Frequency estimates of these flora will be determined in each quadrat. These quantitative data will be supported by qualitative observations in the remainder of each area and the floodplain.

The invertebrates will be sampled along the transects in the fall, winter, and spring using sweep nets, pitfall traps, tree bait, sifters, and Berlese funnels (Ross 1966, Oman and Cushman 1948, Beatty personal communication 1972). Due to the inactivity of the herpetofauna during the late fall and winter, direct observations will be unproductive during these periods. However, spring inventories

can be expedited by locating probable dens, nests, and habitats of these species during the inactive periods. Spring collections will be conducted by hand and by using established trapping techniques for turtles, frogs, and toads (Conant 1958, Anderson 1965, selected articles from Copeia and Herpetologica). The trapped animals will be marked prior to release to enable identification if they are trapped again.

Due to their mobility, visibility, habits, and diversity, birds create great interest among recreationists. Hence, there is much more information about the birds in the Middle Mississippi River floodplain than about other groups of animals. Even so, the unprotected floodplain is much less frequented than the protected floodplain by bird watchers and researchers. Consequently, birds will be mist-netted throughout the investigation (Harris and Morse 1958, Lincoln and Baldwin 1929, Low 1957), banded (Federal Permit #9892), and released. Observations to associate species with specific communities and habitats within communities will also be conducted by walking the transects at random periods during daylight hours.

Most small mammals are secretive and nocturnal in nature. Therefore, small rodents will be inventoried along the transects at 50-ft intervals with Museum Special traps and rat traps. Shrews will be trapped with tin can traps and rabbits with box traps. A number of mammals will only be observed or presence determined by sign. The burrows of moles will be used to estimate their abundance, whereas the populations of aquatic and arboreal rodents and larger mammals will be estimated by nests, burrows, dens, vegetation cuttings, feces, and tracks (Giles 1971). Bats will be mist-netted in flyways or shot during twilight periods over water areas.

[4] Coordination and report. The data from reviews, interviews, and field collections will be integrated to present a holistic analysis of the interrelationships between the flora, fauna, and environment in the unprotected floodplain of the Middle Mississippi River. The major plant communities identified by dominant plant species will be the functional units to which all other biological and environmental information will be related. Emphasis will be placed on

the natural communities versus those modified by man, although land-use trends will be shown. All species of flora and fauna will be defined on the basis of specificity to major plant community types, distribution, abundance, and known importance to man. In the report, the importance of the Middle Mississippi River floodplain as a natural system and its significance in the region and the nation will be established.

(2) Waterfowl censuses - Illinois Natural History Survey. Aerial censuses of ducks, geese, herons, and eagles will be conducted during the period 19 October 1972 to 26 April 1973. Because of a lack of previous waterfowl censuses on this portion of the river, this year's census information cannot be related to population levels or food situation. Another census for 1973-74 will be taken.

3. Physical Model Studies

a. Sand-bed model studies - Colorado State University

(1) General discussion.

(a) A network of side channels had existed adjacent to the Middle Mississippi River prior to an extensive program of dike construction which was initiated in the early 1900's. Successive contractions of the river has probably accelerated the creation of additional side channel networks in some areas. Such man-made side channel areas were created by the formation of sandbars between the riverward tips of adjacent dikes. These side channels provide slack water landward of the newly formed islands.

(b) The study will involve an analysis of the impact of dikes and the extension of dikes on the geomorphology of the main channel system and side channel areas. For proper analysis of alternative engineering designs, it will be essential to vary the geomorphology of typical main channel segments and side channels, to vary discharges, and to vary the dike structure and arrangement to determine, if possible, some combination of factors that will optimize the objectives of navigation and improvement of the environment. Included will be studies on the different designs and locations of notches in dikes, various dike designs, and arrangements around the upper and lower entrances to the side channels as to their effects on sediment deposition. Photography

will document the results of model studies and will provide a permanent record for comparison with the prototype.

(c) An attempt will be made to document the geomorphic history of side channels. This will involve a geomorphic study of side channel development and deterioration and will be utilized in evaluating the efficiencies of dike structures designed for navigation purposes.

(2) Study phases. The contract work will be divided into two phases.

(a) Phase I will include (1) familiarization with the prototype through review of available maps and literature; reconnaissance of a typical reach of the Middle Mississippi River; and a conference with a Corps of Engineers Committee composed of experienced potamology personnel from SLD and WES, and the WES interdisciplinary study team assigned to the project; (2) preparation of a study plan outlining theoretical concepts, proposed model parameters, method of validation, testing program (variation of river stage), and expected results of model studies; and (3) presentation of study plan in (2) above to the Committee for approval.

(b) Phase II will consist of the testing program as outlined in the Phase I study plan. The daily results of the tests will be recorded and be made available as raw data upon request. Representatives from the Committee will visit the test model during Phase II to observe and provide any requested guidance or assistance.

(3) Report. The final written report and photography will document the geomorphology of the river including the interaction among the river, its side channels, and river control structures such as dikes. More specifically, methods of maintaining or prolonging the life and usefulness of side channels will be reported in detail. The report will indicate the possibility of keeping side channels operative on a continuing basis considering the dynamic and ever changing nature of the river.

b. Moveable bed model studies - WES. Further exploration of the concepts resulting from the CSU sand-bed model studies may be conducted by the WES using large scale physical models if deemed necessary.

Primary consideration will be the optimum main channel dike system that will provide adequate navigation depths and concurrently produce the best physical conditions for productive side channels which have been determined from the biological analysis.

APPENDIX A: LIST OF SIDE CHANNELS

Side Channel No.	River Mile	Name
1	168.7-166.5-L	Jefferson Barracks
2	148.3-147.4-L	Calico
3	146.3-144.3-L	Osborne
4	143.0-141.7-R	Harlow
5	141.5-136.8-L	Salt Lake
6	134.3-132.3-L	Fort Chartres
7	132.5-130.1-R	Establishment
8	122.6-120.1-L	Moro
9	118.0-115.8-R	Kaskaskia
10	105.6-104.4-R	Crains
11	102.8- 99.9-L	Liberty
12	98.3- 95.0-R	Jones
13	78.5- 77.8-R	Grand Tower*
14	73.7- 71.6-L	Crawford
15	62.5- 57.1-R	Schenimann
16	60.6- 54.8-L	Picayune
17	51.4- 47.6-L	Cape Bend
18	40.4- 35.4-L	Sante Fe
19	34.0- 32.7-R	Billings
20	26.8- 24.7-R	Buffalo
21	24.7- 21.7-L	Browns
22	18.7- 15.3-R	Thompson
23	14.4- 11.9-R	Sister
24	10.4- 7.7-L	Boston
25	5.0- 1.2-L	Angelo**

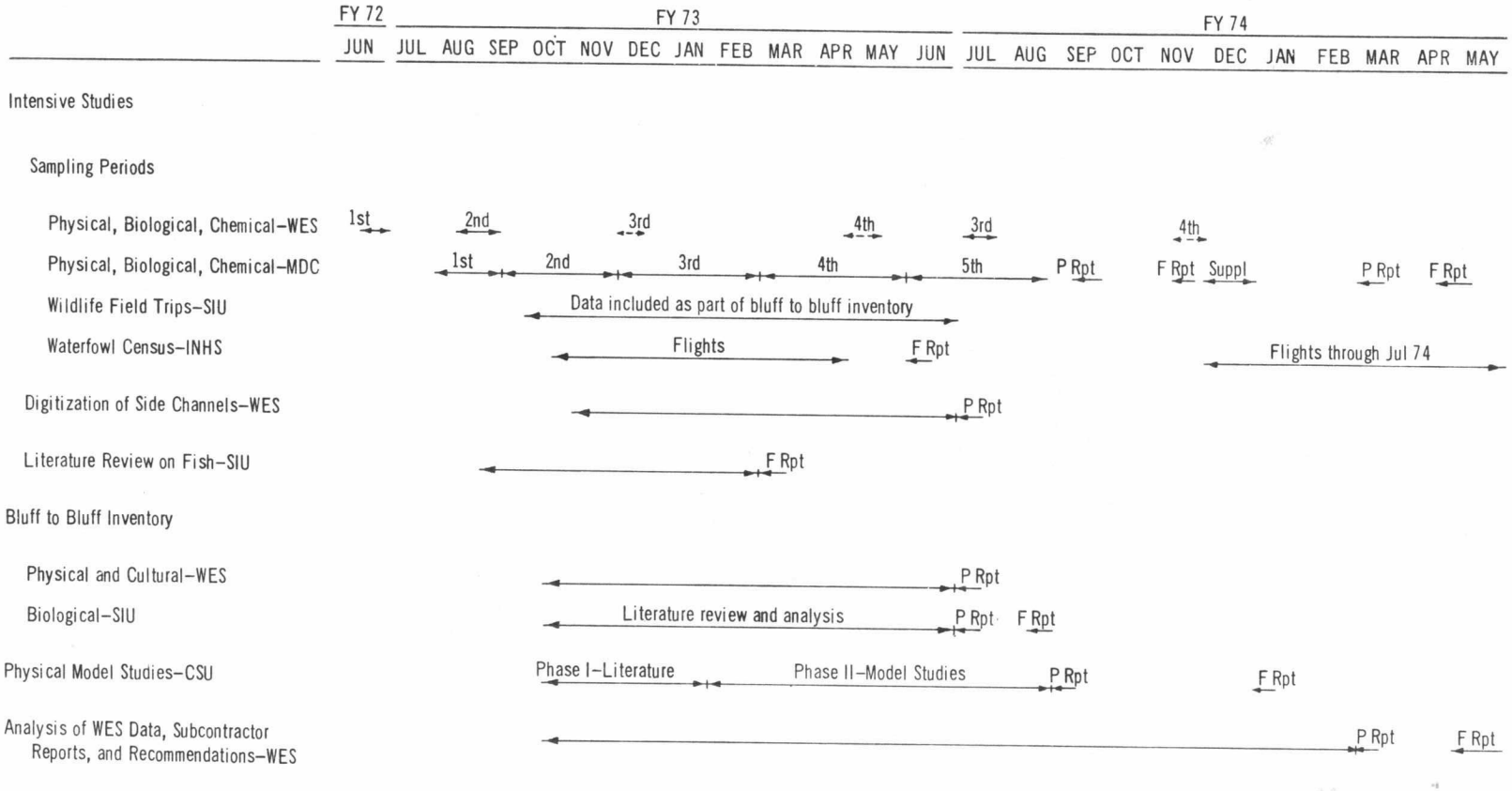
Note: Nos. 13 and 25 may be sampled for some elements depending on water conditions.

* Now considered a divided flow reach.

** No longer considered because of influence of Ohio River.

APPENDIX B

TIME PHASING OF STUDY PLAN



LEGEND

WES	Waterways Experiment Station	CSU	Colorado State University
MDC	Missouri Dept of Conservation	P Rpt	Preliminary Report
SIU	Southern Illinois University	F Rpt	Final Report
INHS	Illinois Natural History Survey	←--→	Tentative

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13. ABSTRACT

The Mississippi River 9-ft channel project was authorized by the River and Harbor Acts of 21 January 1927 and 3 July 1930, for the purpose of obtaining and maintaining a 9- by 300-ft channel for navigation from the confluence of the Missouri River to the confluence of the Ohio River. The project was modified by the River and Harbor Act of 2 March 1945 to provide for the construction of the Chain of Rocks Canal and Lock No. 27, and further modified by the River and Harbor Act of 3 July 1958 to provide for the construction of Low Water Dam No. 27. A limited amount of data is available on the Middle Mississippi River, its side channels and floodplain. An extensive terrestrial and aquatic inventory is required to establish a data base sufficient for biological analysis, and assessment of physical changes resulting from contraction efforts to obtain and maintain a 9-ft channel. A geomorphic model is required to determine the hydraulic response of the river to construction and extension of dikes. This study plan, organized and compiled by the U. S. Army Engineer Waterways Experiment Station, outlines procedures and techniques for an overall environmental inventory of the Mississippi River floodplain between St. Louis, Missouri, and Cairo, Illinois, and provides the framework for the assessment of data and analyses of relationships of the physical, biological, chemical, and cultural elements of the project area. Participants in the study will begin their studies simultaneously in order to meet designated completion dates. A longer project duration would allow some studies to generate data for others, resulting in a more systematic and comprehensive inventory and assessment. Parameters will only be sampled over about a 1-1/2-year period, which will prohibit an in-depth analysis and correlation of data for such a large, complex system.

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Navigation channels						
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In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

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