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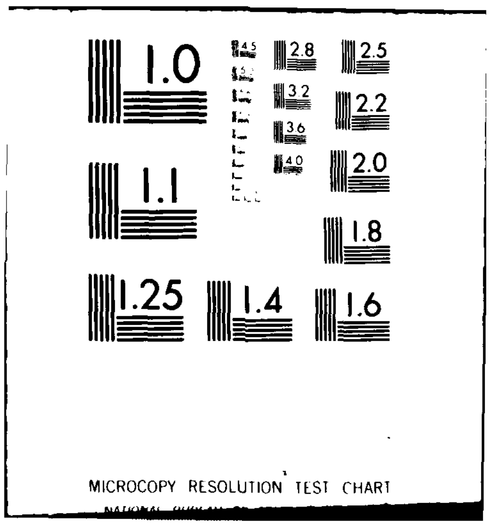
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The overall objectives of this report is to assess the impacts, both positive and negative, of Corps of Engineers' activities on Pool 9 (Lynxville, Wisconsin) on the Upper Mississippi River. This report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life, geology, and water quality. Socioeconomic systems include industrial and recreational activities, and cultural considerations, such as archaeological and historical sites.

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FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

POOL 9

of the Northern Section of the UPPER MISSISSIPPI RIVER

for the

ST. PAUL DISTRICT CORPS OF ENGINEERS
Under Contract No. DACW37-73-C-0059

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Decorah, Iowa
November 1973

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FOREWORD

Purpose of the Environmental Studies

The National Environmental Policy Act of 1969 directs that all agencies of the Federal Government "Include in every report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement...on the environmental impact of the proposed action." The Act deals only with proposed actions. However, in keeping with the spirit of the Act, the U.S. Army Corps of Engineers has developed its own policy that requires such reports on projects it has completed and for which continuing operational and maintenance support are required.

In keeping with its policy, on January 15, 1973, the St. Paul District of the U.S. Army Corps of Engineers contracted with the North Star Research and Development Institute to prepare a report assessing the environmental impact of the Corps of Engineers' operations and maintenance activities on the Mississippi River from the head of navigation in Minneapolis, Minnesota, to Guttenberg, Iowa. Included also are the Minnesota and St. Croix Rivers from their respective heads of navigation at Shakopee and Stillwater, Minnesota to the Mississippi River. This portion of the Mississippi River basin will subsequently be termed the"Northern Section" of the Upper Mississippi River, the "the study area", or the St. Paul District.

The Corps of Engineers has been active in the Northern Section since the 1820's, when they first removed brush and snags from the river to permit navigation as far north as Fort Snelling. Later in the 1870's, further improvements were made, primarily through construction of wing dams, to deepen and maintain the channel. Presently, the river in the study area consists of a series of pools, which were created by the construction of navigation locks and dams in the 1930's. Several recreation areas along the river were also built by the Corps.

The purpose of the environmental impact study is to assess the impacts, both positive and negative, of the Corps' activities on the Northern Section. These activities are defined as operations and maintenance activities and mainly include operations of facilities (locks and dams) and maintenance of the navigation channel (dredging). Actually, the impacts on the environment of the earliest operations are also being sought, but most of the information will concern those of the present navigation system.

The studies are designed not only to identify the impacts, but to assess their effects on both the natural and social environment. Such impacts may include effects of river transportation on the area economy, effects of creation of the pools on recreational activities and wildlife habitat, effects of dredge spoil disposal on the natural ecosystem and on recreation, and many others. As a result of identification and assessment of the impacts, it may be possible to suggest ways of operating the facilities and maintaining the navigation and recreation system to amplify the positive and minimize the negative results of the Corps' activities. The study will provide a comprehensive basis for the St. Paul District to prepare an environmental impact statement consistent with the National Environmental Policy Act of 1969 and the policy of the U.S. Army Corps of Engineers.

Scope of Current Report

The present report covers the entire study program from January, 1973 through November, 1973. The report contains both historical information and data collected in the field from studies on both aquatic and terrestrial habitats of Pool 9.

Research Approach

Three aspects of the research approach used in the study are: (1) the benchmark point in time, (2) data collection and analysis on the natural systems, and (3) data collection and analysis on the socioeconomic activities.

Benchmark Time Period

In order to analyze the impact of the activities of the Corps of Engineers on the Northern Section of the Upper Mississippi River, it is necessary to select a time period that can serve as a benchmark. This benchmark represents the state of the Mississippi River prior to the time activities related to the nine-foot channel were initiated. As the nine-foot channel project was constructed in the 1930's, the preconstruction benchmark was taken as 1930. Wing-dams were built and other Corps' activities took place prior to 1930, however, and earlier data were also used where they were readily available. The preconstruction benchmark data were obtained from available reports and from a variety of other sources cited at the end of each section.

Analysis of the Natural Systems

The impacts of Corps' activity on the natural environment for a given pool were determined by the individual investigator responsible for that particular pool. The Northern Section of the Upper Mississippi River was subdivided into fourteen distinct segments for purposes of study of the natural environment: Pools 1 through 10, Pool 5A (lying between Pools 5 and 6), the Upper and Lower Saint Anthony Falls (SAF) Pools (a single report covers both pools), the Minnesota River, and the St. Croix River. A segment was assigned to an investigator on the natural sciences team as listed below:

Number of River Segments Involved	Total Length in River Miles	River Segment	Responsibility	Organization
5	92.4	Upper and Lower Pools, Pool 1, Pool 2, Minnesota, and St. Croix River	Roscoe Colingsworth	North Star Research and Development Institute, Minneapolis, Minn.
1	18.3	Pool 3	Edward Miller	St. Mary's College, Winona, Minn.
4	82.6	Pools 4, 5, 5A & 6	Calvin Fremling	Winona State College, Winona, Minn.
2	35.1	Pools 7 & 8	Thomas Claflin	University of Wisconsin at LaCrosse, LaCrosse, Wisconsin
1	31.3	Pool 9	James Eckblad	Luther College, Decorah, Iowa
1	32.8	Pool 10	Edward Cawley	Loras College, Dubuque, Iowa

Because different problems arise in different segments of the river, each investigating team used its own judgment in conducting its studies.

However, North Star--in conjunction with the investigators cited above --developed general guidelines for conducting the field studies, acquiring data, and presenting the data in a final report. This required that North Star develop a reporting format that could be used for all pool reports so that the series of reports would have maximum utility and comparability.

Analysis of Socioeconomic Activities

The socioeconomic analysis for all pools in the study area was conducted by a team including Dr. C. W. Rudelius of the University of Minnesota, and Willima L. K. Schwarz of North Star. The socioeconomic impacts were analyzed by the same team for all fourteen segments of the Northern Section because substantial economies in data collection were possible with this approach. The initial data for each pool were collected and then were submitted for review and updating to the investigator analyzing the natural systems for that pool. The suggestions of these investigators were incorporated in the socioeconomic portions of each pool report.

Report Objectives

Since the Corps is required to submit an environmental impact statement for each pool and tributary in the Northern Section on which they carry out operation and maintenance activities, this study is being carried out and reported on by pool (and tributary).

The present report deals only with Pool 9 on the Upper Mississippi River, described in detail in subsequent pages. Background information that applies to two or more pools in the study area appears as a portion of each appropriate report. This is necessary since the report on each pool must be capable of being read and understood by readers who are interested only in a single pool.

The overall objectives of this report are to identify and provide an assessment of the impacts of the Corps of Engineers activities related to Pool 9. Specifically, following this section, the report is in the format required for the Environmental Impact Statement, and seeks:

1. To identify the environmental, social, and economic impacts of the Corps activities related to Pool 9.
2. To identify and, where possible, measure the beneficial contributions and detrimental aspects of these impacts and draw overall conclusions about the net effects of Corps' activities.
3. To recommend actions and possible alternative methods of operations that should be taken by the Corps of Engineers and other public agencies and private groups to reduce detrimental aspects of the project.
4. To identify additional specific research needs to assess the impacts and increase the net benefits of Corps operations.

The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life as well as the nature of the land and quality of the water. Socioeconomic systems include industrial activities, such as income and employment generated by barge traffic or activities in operating the locks and dams and commercial fishing; recreational activities, such as fishing, boating, or hunting that are affected by Corps operations; and cultural considerations, which include archaeological and historical sites.

1. PROJECT DESCRIPTION

Lock and Dam No. 9 is located on the Mississippi River, 647.9 river miles above the mouth of the Ohio River, 31.3 river miles below Lock and Dam No. 8, and 32.8 river miles above Lock and Dam No. 10. The lock is on the left bank, or Wisconsin side of the river, about 3 miles below the village of Lynxville and 13 miles above Prairie du Chien, Wisconsin. This section of the Mississippi River, known as Pool 9, is shown in Figure 1.

Pool 9 is the only pool in the St. Paul District with boundaries formed by three states - Minnesota and Iowa on the right bank and Wisconsin on the left bank. No signs of glacial action are apparent in the high bluff areas of Pool 9 but the lowland and flood-plain areas consist of alluvial fill deposited in the form of terraces by the receding glacial stream outwash. These features have been generally retained except for changes in configuration caused by recurring flood stages which have eroded, carried, and deposited material all along the river's course.

The main channel parallels the high Wisconsin shoreline from the lock upstream to the village of Lynxville, angles sharply across the valley to the Iowa shoreline which it then parallels to the town of Lansing, again angles across the valley to the village of De Soto and continues upstream at or near Wisconsin high ground until it reaches Lock and Dam No. 8 at Genoa. Because of the channel alignment about 78 percent of federally owned above-water lands are located on the right side of the main channel in Minnesota and Iowa. Two small tributary rivers flow directly into the Mississippi River in Pool 9 - the Bad Axe, entering from Wisconsin, and the Upper Iowa, entering from Iowa.

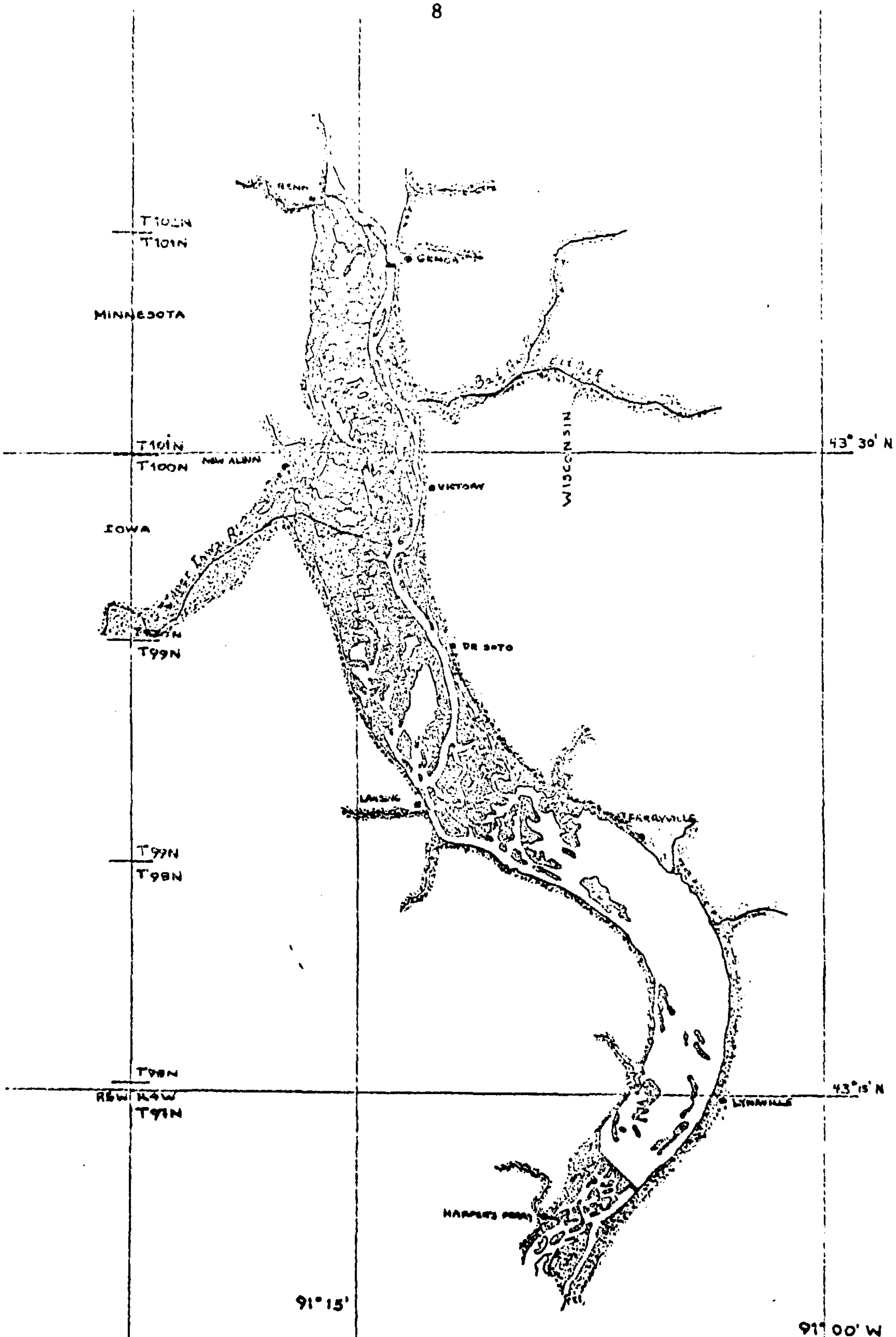


Fig. 1. Pool 9 of the Upper Mississippi River.

The project was officially authorized by the Rivers and Harbors Act when Congress approved the 9-foot channel on 3 July 1930. Construction of the lock was completed on 4 March 1935, the earth dike was completed on 22 December 1936, and the dam was completed on 30 April 1937. Sixty wing dams, built mostly between 1878 and 1910, and about 17 miles of riprap bank protection occur within Pool 9. The on-going project includes the operations of the lock, the operations of the dam (reservoir regulation), and the maintenance of the navigation channel. This maintenance includes periodic dredging to maintain a minimum 9-foot depth, disposing of the dredge spoil, and clearing debris from the channel.

HISTORY

About 10,000 years ago, the last epicontinental glacier covered most of Minnesota, extending southward as far as Des Moines, Iowa (Bray, 1962). The southeastern corner of Minnesota, northeast corner of Iowa, and a portion of western Wisconsin were left virtually unglaciated. The tri-state region bordering Pool 9 was part of this unglaciated area.

As the glacier melted northward into Canada, it produced a large volume of melt water which could not flow northward into Hudson Bay because the glacier blocked the Red River drainage system. Glacial melt waters collected behind the ice dam to form Glacial Lake Agassiz which covered northwestern Minnesota, extreme eastern North Dakota, and southern half of Manitoba, southeastern Ontario and a narrow strip in east central Saskatchewan. Finally, when Lake Agassiz became overfull, a major portion of its overflow rushed down the Minnesota River Valley, to enter the Mississippi River at Minneapolis, Minnesota. This southern outlet stream was named the Glacial River Warren. The flow of the River Warren was augmented by the Glacial River St. Croix, which drained Glacial Lake Duluth - the ancestor of Lake Superior. Other smaller glacial rivers, the Mississippi proper, and the Chippewa added more water to the Glacial Mississippi River which cut a deep valley through limestone and sandstone strata as far south as Dubuque, Iowa. Consequently, along the section known as Pool 9, the Mississippi River flows through a valley which is as much as 600 feet deep and 3.5 miles wide.

In its original condition prior to any improvement, the navigable channel of the Mississippi River at low water had a natural depth in many places of only 3 feet or less. The main channels were divided by islands and bars which formed chutes, sloughs, and secondary channels through which considerable parts of the low water flow was diverted to the detriment of navigation.

In 1823 the first sternwheeler "Virginia" inaugurated the era of steam navigation on the Mississippi making the 800 mile journey from St. Louis to Fort Snelling in 20 days. The next year, the Corps of Engineers began to improve river navigation by removing snags, boulders, shoals, and sandbars. In 1829, Captain Henry Shreve was commissioned to construct and operate a special twin-hulled snag boat on the upper river. It was imperative to the growth of the U.S. that the river be improved to provide a water highway to the sea because the interior of the continent was relatively inaccessible to overland freight haulers. Early channel improvements, however modest, enabled the United States to quickly exploit the interior of the entire North American continent. By the 1870's, hundreds of shallow-draft steamboats routinely navigated the Upper Mississippi River.

The influx of whites inevitably brought conflicts with the Indians. In 1827, a group of Winnebagos under Chief Red Bird killed two white men to avenge the rumored murder of two of their tribe. They later attacked two boats that approached their encampment near the mouth of the Bad Axe River, killing several of the crew. Red Bird finally surrendered to government troops and died in prison a few months later.

Five years later, at almost the same place, the Battle of the Bad Axe ended the protracted Black Hawk War. Pursued by troops and militiamen, the Sauk Chief, Black Hawk and his starving band of warriors, women and children, reached the Mississippi on August 1, 1832. There they attempted to send the women and children downriver on boats and rafts, but the steamer Warrior, stationed in the middle of the river, indiscriminately fired on women, children, warriors and truce parties. Black Hawk and a few of his band escaped the massacre, but he was later captured and exhibited. He died six years later on a reservation in Iowa.

In 1878 Congress authorized the 4 1/2 foot channel, the first comprehensive project on the upper river from St. Paul, Minnesota to the mouth of the Ohio River, and in 1907 authorized the 6-foot channel. The increase in depth was obtained mainly by the construction of hundreds of rock and brush wing dams, low structures extending radially from shore into the river for varying distances to constrict low water flows. Usually, on the opposite side of the river from the wing dams, the shore was fortified with rock so that water which rushed around the ends of the wing dams did not erode away the opposite shore. Also, a number of rock closing dams on side channels were constructed so that water which ordinarily went down side chutes was conducted into the river proper. For example, closing dams were constructed at the beginning of McDonald and Harpers Ferry sloughs in what is now known as the Pool No. 9.

The short-lived logging boom which began in 1875 hit its peak about 1892, and in 1915 the Ottumwa Belle snaked the last remnants of Wisconsin lumber down the Mississippi River. Six-foot draft steams also began to disappear from the upper river, apparently because they could not compete with the railroads.

In 1871 a little over 117 miles of railroad track were laid along the west bank of the river from Dubuque, Iowa to a point above LaCrescent, Minnesota (Worley, personal communication). On December 31, 1927 the property was conveyed by deed to the present owner, the Chicago, Milwaukee, St. Paul and Pacific Railroad Company. Railroading on the east side of the river was controlled by the Burlington Northern (Anderson, personal communication).

The 1922 _Iowa Gazetteer_ gives the following descriptions of the two Iowa Rivers towns in this area, Lansing and New Albin (Polk, 1922):

> Lansing has a population of 1,500. Settled in 1850, it now is supported by a rich agricultural district. It has a Catholic, a Lutheran, and two Presbyterian churches, good schools, electric lights, an excellent system of water works, first-class hotels, 3 banks, a moving picture theatre and two weekly newspapers, the _Allamakee Journal_ and the _Lansing Mirror_.
>
> New Albin has a population of 683 and was originally settled in 1872. It has Catholic, German Reformed, and Methodist churches, a consolidated school, a news-

paper, the Herald, a moving picture theatre and two banks.

The Rivers and Harbors Act of 1930 authorized the Corps of Engineers to modify the obsolete 6-foot channel to provide a minimum depth of 9 feet and a minimum width of 400 feet. Two categories were generally referred to by those favoring the 9-foot channelization project: national defense and national economic growth and progress. The defense arguments for the dam system were summarized by Halleck W. Seaman of Clinton in an address before the Rotary Club at Davenport. His remarks were also inserted in the Congressional Record (Seaman, 1930). He asserted that:

> Should this country be attacked by a coalition of two or more first-class European powers, with Japan in the Pacific, and should they break through our naval defenses on either one or both of our ocean coasts, then by falling back upon the Mississippi our forces could hold indefinitely and bid defiance to the world. We could starve out an invading enemy.

But this would only be possible, he argued, if the River were easily navigable for the transport of food, arms and other supplies. This necessitated the 9-foot channelization.

The supporting arguments based upon the notion of facilitating economic growth and progress were the ones most often cited by the proponents of the system. The River-traffic firms which had previously often lost out to the railroads were tremendously anxious to see the project completed. And, of course, the anticipated lower transportation costs appealed to most industries along the River as well as to many farmers. With huge barge lines able to more easily navigate the waters, immense tonnage could be moved by a single tow. Arguing specifically for the concerns of farmers, U.S. Congressman Goodwin of Minnesota stated

(Goodwin, 1930):

> The 9-foot channel would equalize the competition between our inland States and the agricultural regions of other countries that are more advantageously located near the ocean. Therefore, the completion of this project will be, in my opinion, the source of relief to agriculture, which will equal, if not surpass, any legislative relief heretofore applied to agriculture.

Beyond the reasons of national defense and national economic growth and progress, there were a few area-specific arguments advanced for the lock and dam system. One of these was the immediate employment benefits of the construction projects. Many of the areas along the River had large portions of unemployed population, and the jobs that would be available in all phases of project construction were a strong argument to a depressed area.

Another reason advanced for support of the project was the specific benefits which, it was hoped, would come to the cities along the River. The dream was that the increased commerce would make these towns boom with expanding industry. Halleck W. Seaman, mentioned earlier, asserted the following (Seaman, 1930):

> The interior Iowa towns will continue to grow, but the River towns will become bigger centers. They will eventually slaughter the cattle and hogs of Iowa that now go to Chicago. They will become the logical locations for grain elevators with their by-product conversion mills, will become the seat of a new pig-iron and steel-making industry, will become ports of entry for the distribution by rail and motor truck to the interior for the raw materials that originate in our own Southland or that are imported through New Orleans.

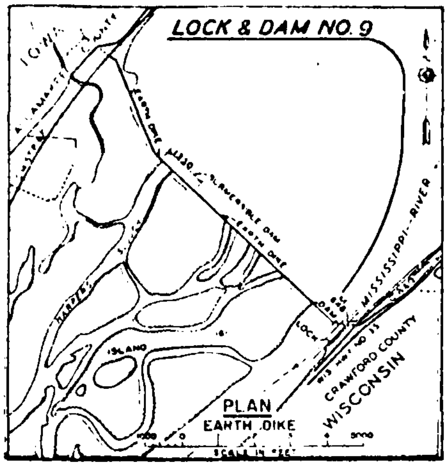
Such high hopes as those just mentioned were not universally shared by many of the citizens affected by the proposed Lock and Dam 9. The issue was a highly controversial one. According to the Oelwein Register of September 1933 the 9-foot channelization project was, next to the National Recovery Administration, the most popular editorial subject of the year among the newspapers of Iowa (Allamakee Journal, 1933). And the surprising thing was that newspapers circulated in this area were nearly unanimous in their opposition to it. Although the Des Moines Register favored the project, the only paper in the Pool 9 area that strayed from the opposing majority was the Howard County Times. All of the others apparently took their cue from the opposition of their Fourth District U.S. Congressman Fred Biermann of Decorah. In fact Biermann, as the past publisher and editor of the Decorah Journal, may have carried considerable weight in determining the positions of his former professional colleagues.

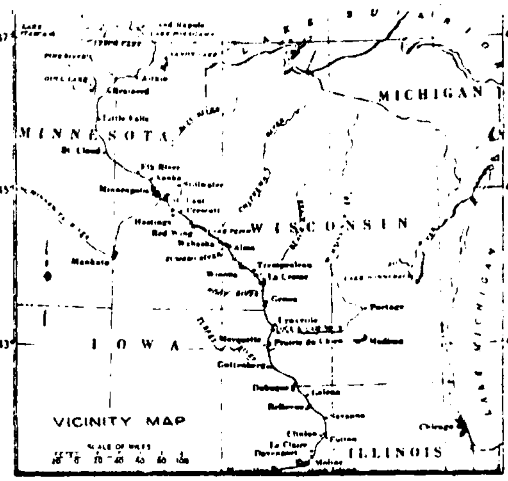
In any event Biermann, first elected with the Democratic landslide of 1932, was ardent in his opposition. One story has it, though not verified, that this issue was the only one that ever prompted him to speak on the floor of the House of Representatives. One of the planks of his election platform was opposition to the project. A summary of his opinion provides a sketch of the basis for most of the local opposition. Biermann claimed that the lock and dam would destroy the scenic beauty of the River, and for no good purpose. He saw the previous alterations of the River channel to 4 1/2 and 6 feet as failures and expected the same of the 9-foot project. The losses of land by area farmers as a result of the anticipated deepening and widening of the River were another source of contention (Allamakee Journal, 1933). And, the railroads, who opposed the project, gained Congressman Biermann's support. He claimed that the railroads, the heaviest tax-payers, would lose heavily--and some railroads in Iowa were not even able to meet their tax payments of the previous year on time and without penalty. Biermann (Morris, 1933) termed the project "pork barrel political graft," and advised against what he called "pouring money into the river."

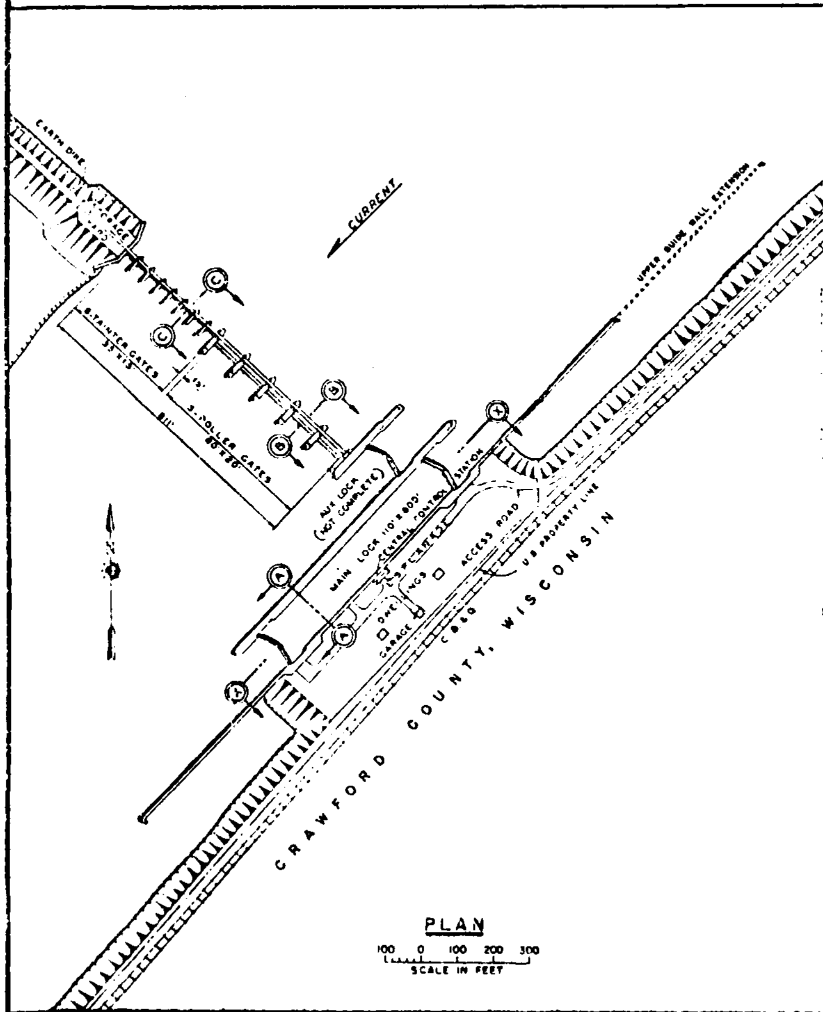
CORPS FACILITIES

Lock and Dam No. 9 is supported on timber piling, driven in sand and gravel, with steel sheet piling cutoff walls. The main lock chamber is 110 feet wide and 600 feet long, and the upper gate bay of an auxiliary lock is provided in the event it becomes necessary to add another lock in the future (Figures 2, 3). From the river wall of the auxiliary lock, a movable dam section consisting of five roller gates, 20 feet x 80 feet, and eight tainter gates, 15 feet x 35 feet, extends across the main channel to the right bank of the river. A service bridge spans the entire length of the movable dam and storage yard, providing for the operation of the locomotive crane and flat car. An earth dike, 9100 feet in length with a 20-foot wide bituminous surfaced roadway at its crest, extends from the end of the movable dam to high ground on the Iowa side of the river. A submersible dam, 1,350 feet in length, is constructed in the earth dike at the intersection with Harper's Slough.

The project design flood for Lock and Dam No. 9 is the flood of 1880, and the design high water is Elevation 635.80 with an estimated flow of 193,000 c.f.s The extreme low water occurred in 1933 (before canalization) at Elevation 615.80 with a flow of 3,300 c.f.s.







TOTAL LENGTH OF EARTH DIKE - 8004.0 FT
DEPTH ON UPPER GATE SILL - 15.0 FT (U.P.EL 620.0)
DEPTH ON LOWER GATE SILL - 13.0 FT (L.P.EL. 611.0)
ELEVATION UPPER GATE SILL - 604.0
ELEVATION LOWER GATE SILL - 598.0

ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

Fig. 2. Lock and Dam No. 9.

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCK & DAM NO. 9

IN 2 SHEETS — SHEET NO. 1
SCALE AS SHOWN

CORPS OF ENGINEERS — U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT — ST PAUL, MINN
JUNE 1961

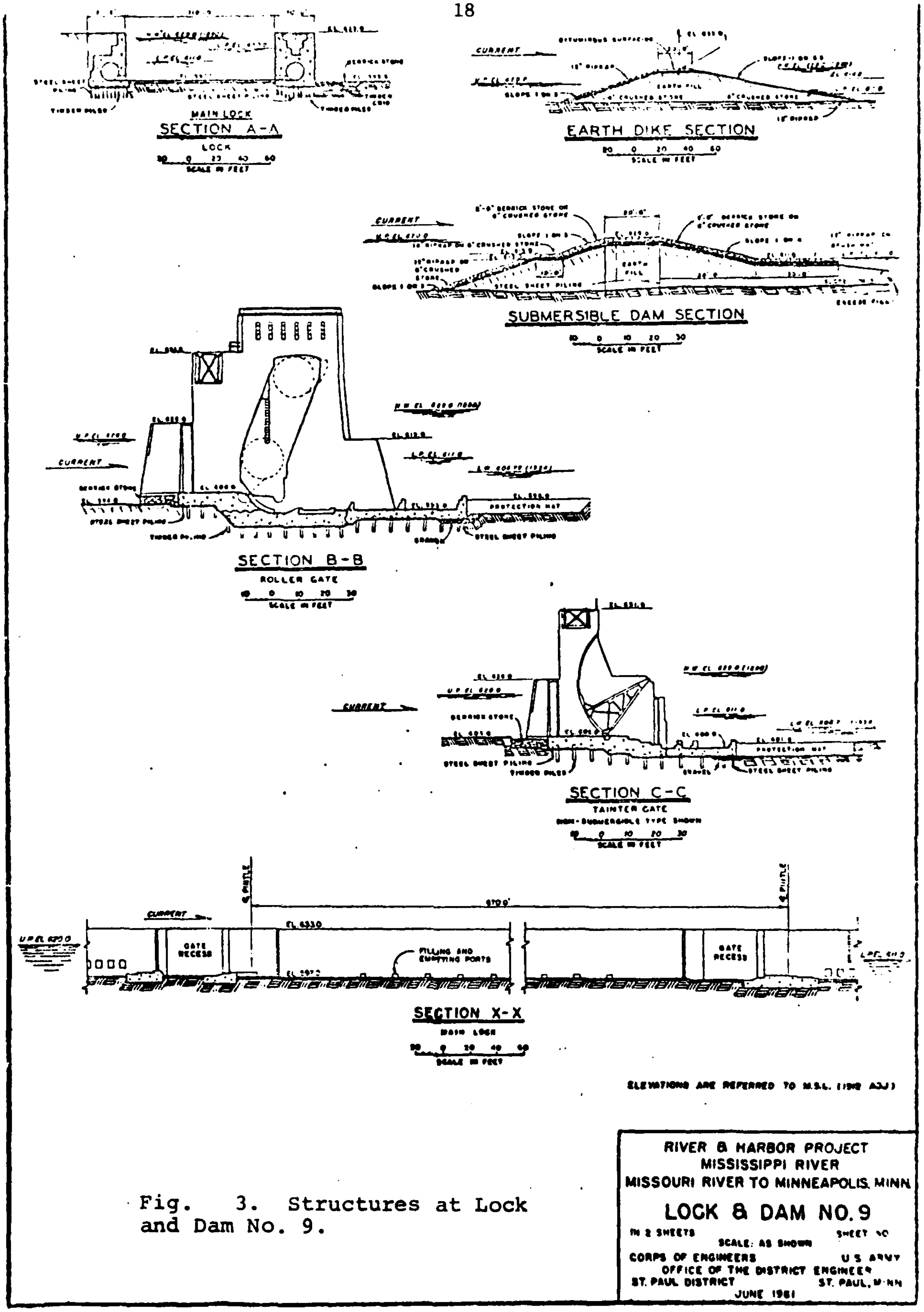


Fig. 3. Structures at Lock and Dam No. 9.

In a report to the St. Paul District Engineer, dated 20 May 1964, the Regional Director of the Bureau of Sport Fisheries and Wildlife stated as follows:

> Aeration facilities during the winter months serve to keep the backwaters ice-free for a considerable distance below the structure. This ice-free state assists the natural oxygenation processes. The amount of open water is influenced by the volume of flow and extremes of air temperature. Therefore, it is essential that capacity or near capacity flows (of the aeration facilities) be maintained during the winter months. With little or no flow through the structures, due to obstructions or closed water control gates, aeration facilities are of little value.
>
> Aeration facilities have improved the water quality and provided better winter conditions for fish life in the backwaters below Dams 5, 5A, 8 and 10. Capacity flows should be maintained at the gate controlled aeration structures of Dams No. 5 and 8.
>
> It is recommended that the St. Paul District Engineer modify the dikes and spillways of Dams No. 4, 6, 7, 8 (right submersible dam), and 9 to include aeration facilities similar to those installed at Dams No. 5, 5A, 8 (left submersible dam) and 10.

In May 1970, an arched, flat-bottomed, corrugated metal culvert, 65 inches wide and 40 inches high was installed through the submersible dam above Harpers Slough. At project pool, Elevation 620.0 a continuous flow of 70 cfs is maintained.

In accordance with audited accounts of Federal lands owned or managed by the Corps of Engineers in connection with construction and operation of Lock and Dam and Pool No. 9, the Corps of Engineers has acquired and presently administers about 8,708 acres of federally-owned land and water area and holds special rights on an additional 25,050 acres administered by the Bureau of Sport Fisheries and Wildlife. Of the 8,708 acres of Corps administered land and water areas, about 8,700 acres have been made available to the Bureau of Sport Fisheries and Wildlife for management as part of the Upper Mississippi Wildlife and Fish Refuge in conjunction with Bureau-owned lands. About 8 acres of Corps lands at the structure site (Lock and Dam No. 9) have been retained solely for Corps use.

Under regulations which permit multiple management and use of designated wildlife area lands, one outgrant has been issued by the Corps of Engineers for 225 acres included in the 8,700 acres made available to the Bureau of Sport Fisheries and Wildlife. The 225 acres have been leased to Vernon County, Wisconsin, for use as a general purpose park with water access. The outgrant does not void any of the rights of the Bureau to control and supervise the lands for the purpose of wildlife conservation and management to the extent that it does not conflict or interfere with rights assigned under the outgrant. In addition, numerous special-use permits have been issued for various uses that do not conflict with the basic management objectives for the areas involved.

Of the Federal lands owned in fee in Pool 9, about 18,790 acres protrude above the normal flat pool elevation of 620.0. Of this total, 6,620 acres are under the jurisdiction of the Corps of Engineers and 12,170 acres are under the jurisdiction of the Department of the Interior. Any development contemplated by the Corps will be restricted to selected sites on the 6,620 acres of Corps above-water lands.

OPERATION OF LOCK AND DAM NO. 9

The basic plan of operation for this lock and dam is detailed in paragraph D-15 of the "Master Regulation Manual" (U.S. Army Corps of

Engineers, 1969).

The primary control point for Pool No. 9 is at Lansing, Iowa where project pool, Elevation 620.0 is maintained by the operation of Dam No. 9 until the discharge at the dam exceeds 32,000 c.f.s. At this discharge, the maximum drawdown of the pool at the dam, one foot to Elevation 619.0, is reached, and control of the pool is shifted to secondary control at the dam.

As the discharge increases above 32,000 c.f.s., the pool level at the dam is held at Elevation 619.0, and the stage at all other points in the pool is allowed to rise. Also, as the discharge increases, the operating head at the dam decreases. When the discharge reaches 64,000 c.f.s., the head at the dam will be reduced to less than one foot, and all the gates in the dam are then raised clear of the water. As the flow increases above 64,000 c.f.s., open river conditions are in effect, and the dam is out of control. On the recession, the gates are returned to the water when the pool at the dam drops to Elevation 619.0, secondary control. This elevation will be reached at a flow of 64,000 c.f.s., and secondary control elevation is maintained at the dam until the water level at the primary control point drops to project pool, Elevation 620.0, at a flow of 32,000 c.f.s. At the latter flow, control of the pool is returned to the primary control point, and as the discharge decreases, the water surface at the dam will rise, and the drawdown will decrease.

The lock miter gates are never used for regulating the discharge. When the pool level exceeds Elevation 629.0, the lock gate operating motors must be removed, and the upper miter gates are kept in the closed position while the lock is out of operation.

The total inflow into Pool No. 9 is the sum of Dam No. 8 discharge, Upper Iowa River flow, and any miscellaneous inflow. The miscellaneous inflow may be from rainfall, melting snow, or small streams. As a rule, in Pool No. 9 each inch of rainfall will result in an additional miscellaneous inflow of about 1,300 c.f.s. for 24 hours after the precipitation. The runoff from melting snow depends on the water content of the snow, temperature, rate of percolation, etc. The Upper Iowa River flow is obtained each morning by mail, and in the routing, this discharge is lagged one day.

After the inflow into Pool No. 9 has been determined, the stage at the control point, primary or secondary as the case may be, must be considered by the regulating engineer. When the inflow is steady, all inflow should be discharged if the stage at the control point is within ± 0.2 of a foot of the desired stage. If the stage at the control point is not within this range, the regulating engineer should increase or decrease the storage as necessary to bring the stage at the control point to the correct level.

In Pool No. 9 the desired stage at the primary control point during the winter freeze-up is Elevation 619.75, and at secondary control the desired stage is Elevation 618.75. Before the operation of the movable gates in the dam becomes too difficult because of icing conditions, the Reservoir Regulating Section of the Corps estimates the probable base flow for the winter period, so that the tainter gate openings (normally a total of 8 to 12 feet) can be set, and the tainter gates allowed to freeze in place. The tainter gates have electric side seal heaters, but the heaters alone are seldom able to free the tainter gates from the ice so that they can be moved. Usually, considerable time must be spent in steaming and chopping before the tainter gates are movable. During the winter months the roller gates at Dam No. 9 are lowered to the submerged position, and the remainder of the base flow, not discharged in the tainter gate section, is passed over the submerged roller gates. These gates can be submerged as much as 5 feet below project pool, and in the submerged position most of the difficulties caused by ice are eliminated. If possible, the flow in the roller gate section is distributed equally over the 5 gates, and all changes in the outflow are made in the submerged roller gate section of the dam. However, since the discharge capacity of a submerged roller gate is limited, winter thaws or rains can cause so large an increase in the outflow that it may become necessary to raise one or more of the roller gates into the normal position and possibly to increase the tainter gate outflow. The roller gates are equipped with electrical drum and side seal heaters, but if the roller gates have been submerged one foot or less, some steaming and chopping may be necessary before the roller gates can be moved. Throughout the winter, the tainter valves in the lock walls are kept open about a foot or two so that the discharge will prevent the formation of a solid sheet of ice and also reduce sedimentation in the lock chamber. It is estimated that this discharge is equal to 1/10 of the discharge under a normal roller gate with the same head (pool - tailwater) and the same gate opening.

When the pools are either freezing over or the ice is melting, ice jams often occur and sometimes almost completely cut off the flow in the

Mississippi River. In order to maintain the pool below an ice jam, it may be necessary to seal all the roller gates until the ice jam breaks up and to discharge the available flow through the tainter gates only. Additional procedures for emergency operation are discussed elsewhere (U.S. Army Corps of Engineers, 1969).

Whenever flooding threatens in the Mississippi River valley because of high water content of the winter's accumulation of snow, many people believe that the navigation pools should be drawn down to provide storage capacity for the coming floodwaters. However, there are two reasons why this drawdown cannot be performed, one legal and one technical. The legal reason is the so-called "Anti-Drawdown Law." The act of Congress dated 10 March 1934 entitled "An act to promote the conservation of wildlife, fish and game, and for other purposes," as amended by Public Law 732 on 14 August 1946 was amended by Public Law 697 on 19 June 1948 to include the following new section:

> Sec. 5A. In the management of existing facilities (including locks, dams and pools) in the Mississippi River between Rock Island, Illinois, and Minneapolis, Minnesota, administered by the United States Corps of Engineers of the Department of the Army, that Department is hereby directed to give full consideration and recognition to the needs of fish and other wildlife resources and their habitat dependent on such waters, without increasing additional liability to the Government, and, to the maximum extent possible without causing damage to levee and drainage districts, adjacent railroads and highways, farmlands, and dam structures, shall generally operate and maintain pool levels as though navigation was carried on throughout the year.

The technical reason for not drawing the pools down suggested by the Corps (U.S. Army Corps of Engineers, 1969), is the fact that the storage capacity of the navigation pools is so small in comparison with the magnitude of the flood flows that a drawdown would be refilled in a matter of hours and would not appreciably lower the stages reached by the flood.

A priority system for vessels locking through has been established by the Secretary of the Army, as follows:

1. U.S. military vessels
2. Vessels carrying U.S. mail
3. Commercial passenger ships
4. Commercial tows
5. Commercial fishing boats
6. Pleasure boats

LAND MANAGEMENT AND CHANNEL MAINTENANCE

In the Pool 9 area, the Corps of Engineers exercises varying degrees of management, both directly and by delegation, over lands under its jurisdiction for navigation, flood control, recreation, and preservation of natural resources. The Bureau of Sport Fisheries and Wildlife is managing Corps lands in Pool 9 in connection with special use as a wildlife and fish refuge and for recreational development. Outgrants to non-Federal agencies provide for delegated management of lands for recreational purposes and preservation of related resources. Plans, programs and procedures of all agencies managing Corps lands for any purpose are subject to coordination with or approval by the Corps of Engineers.

Dredging by the Corps of Engineers to establish the 9-foot channel in Pool 9 began in 1933 (Table 1). There was rather massive dredging in this pool associated with implementation of the 9-foot channel, especially during the summer of 1937. Since 1930 there has been some dredging by

TABLE 1

Cubic yards dredged in Pool 9 of the Mississippi River (1933 - 1972)

	Locations						
	Below Lock 8	Island 126	Twin Island	Battle Island	Indian Camp	Above Lansing	Pool Total
Pre-1938 Total	250,849	-	167,286	213,770	187,928	109,081	2,432,514
Per year average since 1938	18,971	21,125	47,389	21,425	12,336	25,261	155,416
Number of years in which dredging occurred since 1938	11	16	23	11	8	13	33

Source: Annual Dredging data (St. Paul: U.S. Corps of Engineers, St. Paul District, Unpublished Reports).

the Corps within Pool 9 each year except for 1940 and 1957. The six main dredging sites are shown in Figure 4. Together they account for 94.3% of the volume dredged within this pool.

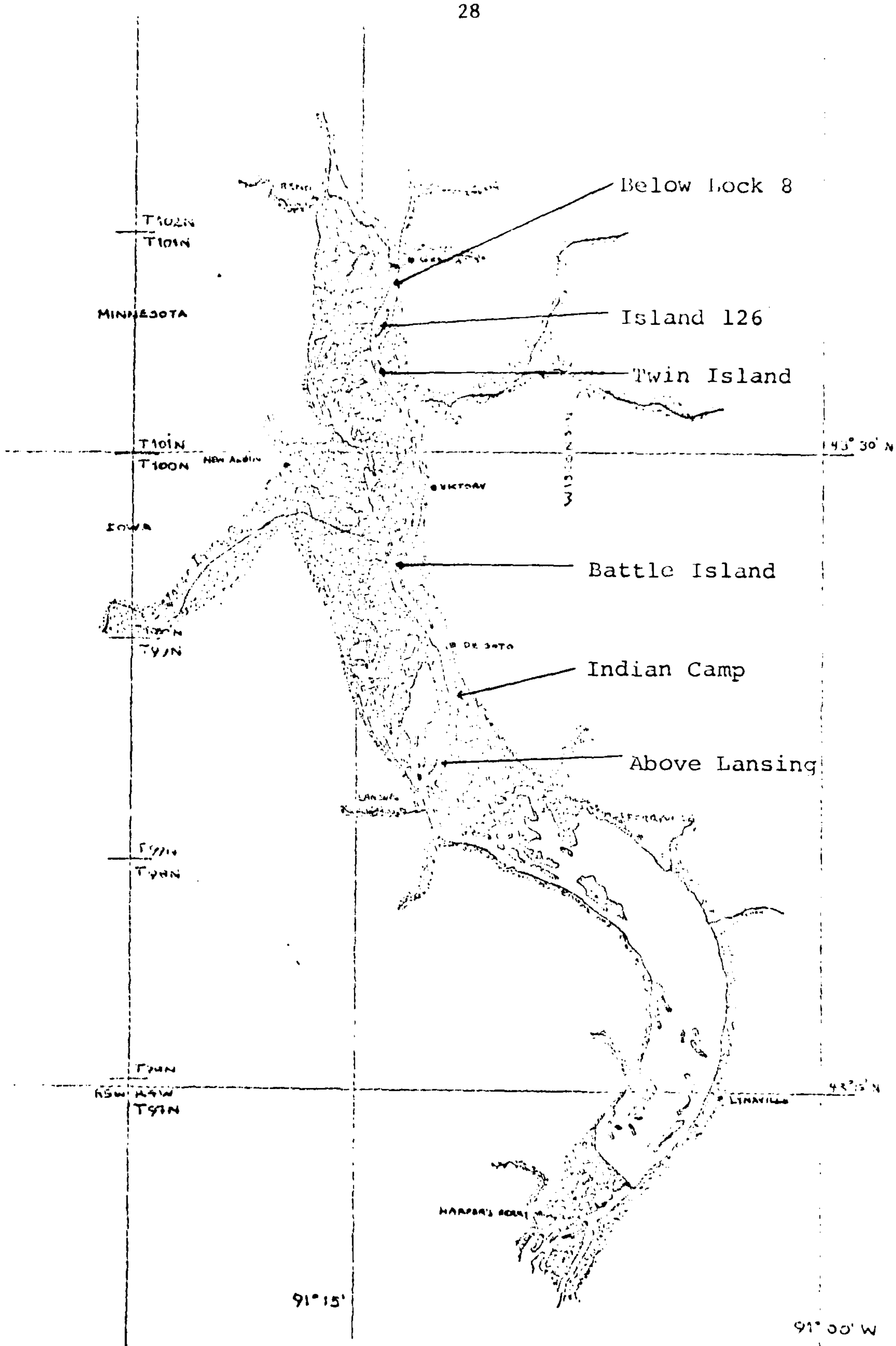


Fig. 4. Map of Pool 9 with the six most frequent dredging sites indicated.

REFERENCES

Allamakee Journal. Sept. 20, 1933. "The Nine-Foot Channel" Reprinted from the Oelwein Register.

Andersen, B. G. personal communication. Assistant Vice President - Engineering of Burlington Northern. Letter of 28 February 1973 to Ms. Marsha Bergan.

Brav, E. C. 1962. A Million Years in Minnesota. Science Museum. St. Paul, Minn.

Goodwin. 1930. U.S. Congress, House, Congressional Record, "Debate", 71st Congress, 2nd Session, 1930, LXXII, pt. 5:7779.

Morris, E. . . Sept. 27, 1933. "Pouring Money into the River" Allamakee Journal.

Polk, R. L. 1922. Polk's Iowa State Gazetteer and Business Directory, Vol. XX, pp. 591-592, R. L. Polk and Co., Chicago.

Seaman, H. W. 1930. U.S. Congress, House, Congressional Record "Inland Waterways", 71st Congress, 2nd session, 1930, LXXII, pt. 10:11401.

U.S. Army Corps of Engineers. 1968. Master Plan for Resource Management. Part XI-Pool 9. St. Paul, Minn.

U.S. Army Corps of Engineers. 1969. Master Regulation Manual for Mississippi River Nine-Foot Channel Navigation Projects. St. Paul, Minn.

Worley, B. J. personal communication. Vice-President - Chief Engineer of Chicago, Milwaukee, St. Paul and Pacific Railroad Company. Letter of 9 March 1973 to Ms. Marsha Bergan.

2. ENVIRONMENTAL SETTING

NATURAL SETTING

The present natural environmental setting includes the project from its authorization in 1930 to the present. Construction work on Lock and Dam No. 9 began late in 1933. The environmental setting without the project, in this case prior to 1933, must be reconstructed from available published information.

From its source at Lake Itasca downstream to Lock and Dam No. 9, the Mississippi River drains a watershed of 66,610 square miles. The watershed total just before Pool 9, i.e., at Lock and Dam No. 8, is 64,720 square miles. The increase in drainage area by 1,840 square miles within Pool 9 is divided between a number of tributaries as shown in Table 2. The Upper Iowa River drainage area makes up about 57.6% of the increase within Pool 9.

The habitats of Pool 9 may be divided into aquatic and terrestrial. The UMRCC has proposed a uniform classification separating aquatic habitats into seven different categories. These are tail waters, main channel, main channel border, side channel, slough, lake and pond.

Tail waters include areas immediately below the dams which are affected by the passage of water through gates of the dam and out of the locks. These areas change in size according to water stage, and the arbitrary lower boundary for fishery purposes has been set at a distance of one-half mile below the dams.

Main channel includes only the portion of the river through which

TABLE 2

DRAINAGE AREAS ADDED WITHIN POOL NO. 9

Location	Miles above Ohio River	Drainage Area (square miles)
Winnebago Creek	675.2	90
Bad Axe River	675.1	170
Upper Iowa River	671.0	1,060
Clear Creek	663.0	50
Village Creek	662.1	70
Rush Creek	659.5	90
Sugar Creek	656.7	20
Buck Creek	656.2	20
Copper Creek	655.2	30
Other		240
	Total	1,840

large commercial crafts can operate. It is defined by combinations of construction works (wing dams), river banks, islands, and buoys and other markers. It has a minimum depth of 9 feet and a minimum width of 400 feet.

The main channel border is the zone between the 9-foot channel and the main river bank, islands, or submerged definitions of the old main river channel. It includes all areas in which wing dams occur along the main channel.

Side channels include all departures from the main channel and main channel border in which there is current during normal river stage.

The classification river lakes and ponds, along with sloughs, replaces the old term "backwaters". River lakes and ponds in general are open expanses of water with little or no current. Several types of lakes occur along the Mississippi. These are: lakes of formation due to fluviatile dams, lakes of mature flood plains and lakes due to behavior of higher organisms. Ponds differ from lakes only in size.

Sloughs include all of the remaining aquatic habitat found in the river. Sloughs often border on the "lake or pond" category on the one side and on the "side channel" category on the other. They have little current at normal water stage, muck bottoms, and an abundance of submerged and emergent aquatic vegetation.

The acreage of aquatic habitats of Pool 9 classified according to the above UMRCC method are shown in Table 3. Total acreage of surface water in Pool 9 according to the calculation by Helms (1968) is less than

TABLE 3

ACREAGE AND PERCENTAGE OF AQUATIC HABITATS

IN POOL 9 OF THE MISSISSIPPI RIVER*

Habitat	Acreage	Percent of Total
Tailwaters	104.4	0.3
Main Channel	2,206.3	7.9
Main Channel Border	1,633.1	5.9
Side Channel	1,331.6	4.8
Slough	9,847.1	35.3
Lake and Pond	12,772.7	45.8
Pool Total	27,895.2	

*Data from Helms (1968)

that provided by the U.S. Army Corps of Engineers (See Table 4), but he attributed the differences to the inclusion of certain island and land areas in the Corps figures.

An inventory of terrestrial habitats within Pool 9 has been started by the Bureau of Sport Fisheries and Wildlife (U.S. Army Corps of Engineers, 1968), but no total acreage values are yet available. Their system involves the division of forested lands into five basic timber associations (Table 5) as well as noting understory development.

During 1973, sampling of aquatic and terrestrial habitats was conducted along three transects in Pool 9. In addition, special studies were conducted in Big Lake, and in the region where the Upper Iowa River enters the Mississippi. These sampling locations are described under the section entitled Biological Aspects.

Physical Aspects

Geology and Physiography

During the ice age, about a million years ago, four great glaciers advanced and retreated across most of the Upper Mississippi River Drainage Basin. The last of the glaciers (the Wisconsin) left this area about 10,000 years ago. An area of about 15,000 square miles in southwestern Wisconsin and which extends into southeast Minnesota and northeast Iowa is part of a region which was not covered by the Wisconsin glaciation.

In the bluffs of the Upper Mississippi Valley along Pool 9 are exposed Lower Paleozoic sedimentary rocks, dominantly carbonates (limestones and dolomites) and sandstones, overlain by unconsolidated materials of

TABLE 4

PRINCIPAL PHYSICAL FEATURES OF POOL 9

Length of pool	31.3 river miles
River miles	647.9 to 679.2
Pool elevation (flat pool)	620
Water area of pool	29,125 acres
Total area (bounded by Lock and Dam No. 8 to the north, Chicago Burlington and Quincy railroad track on the east, Lock and Dam No. 9 to the south and the Chicago, Milwaukee, St. Paul and Pacific railroad track to the west)	51,997 acres
Shoreline miles (meandering outer perimeter limits, main and secondary channels and main traversed sloughs adjacent to firm, high ground accessible by land)	90 miles
Federal lands above normal flat pool (approximate)	
(1) Administered by Corps of Engineers	6,620 acres
(2) Administered by the Department of the Interior	12,170 acres
(3) Total above-water lands	18,790 acres

TABLE 5

BASIC TIMBER ASSOCIATIONS
(PREVALENT SPECIES COMBINATIONS)

Mapping code	Dominant	Subdominant	Incidental	Explanation
I	Willow	Cottonwood Maple	Birch Box elder	Found on wet sites along shore, on sand bars, and in areas with standing water.
II	Cottonwood	Maple Elm	Willow Birch Box elder	Found on sites that stay moist most of the time but are generally free of standing water.
III	Birch	Maple Elm	Willow Cottonwood Box elder Oak	Found on silty shore lines and in old fields that now remain moist most of the time. Prominent on narrow island remnants of old bottomland ridges.
IV	Maple	Elm Ash Cottonwood	Willow Birch Hackberry Oak	Found on flats that are moderately well-drained during growing season.
V	Elm	Maple Oak Basswood	Birch Ash Hackberry Locust Cottonwood Hickory Willow	Found on higher, better drained sites

Source: U.S. Army Corps of Engineers (1968)

Quaternary (Upper Cenozoic) age, largely tills and loess of the earlier glacial advances. This stretch is part of the so-called Driftless Area which was not covered by the Wisconsin advances of the ice sheet.

In the stretch from Lynxville, Wisconsin, north to Reno, Minnesota, the units exposed in the base of the bluffs are the Upper Cambrian sandstones from the Dresbach (lower Upper Cambrian) in the north to the Jordan (upper Upper Cambrian) to the south. Overlying the Jordan Sandstone with a transitional contact is the Lower Ordovician Prairie du Chien Formation, a dolomite sequence with a middle sandstone member and much shale and sand in thin stringers in the upper part.

The Prairie du Chien caps the bluffs in most of the stretch under consideration. In the southernmost portion of this area, the St. Peter Sandstone occurs as outliers on certain hilltops, generally two or more miles back from the river.

Geological sections have been prepared for the northern end of Pool 9 (Figure 5), near the control point of Pool 9 (Figure 6), and at the southern end of Pool 9 (Figure 7); these approximately correspond to the locations of three sampling transects described in Biological Aspects section.

In the stretch from Harpers Ferry to Lansing, Iowa, the Mississippi trends around an arc swinging from NE-SW to NW-SE; from Lansing north to LaCrosse the trend is approximately N-S. The valley of Pool 9 varies in width from about two miles (at Lynxville, Wisconsin) to over three and a half miles (at New Albin, Iowa). The bluffs are steep on both sides and

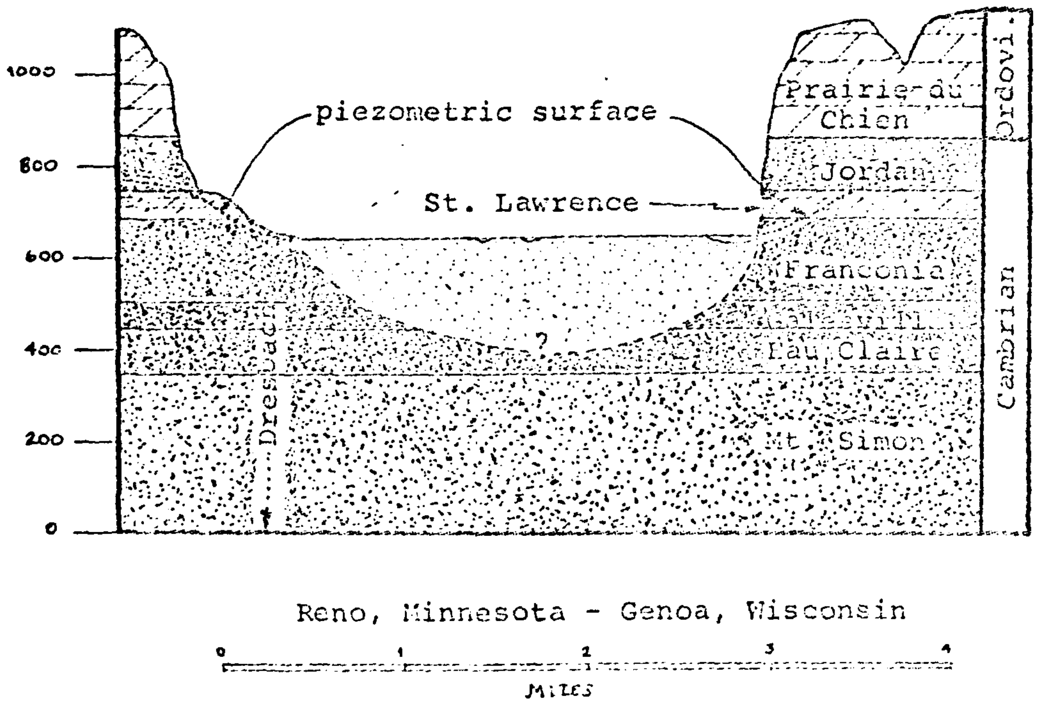


Fig. 5. Geologic section at northern end of Pool 9.

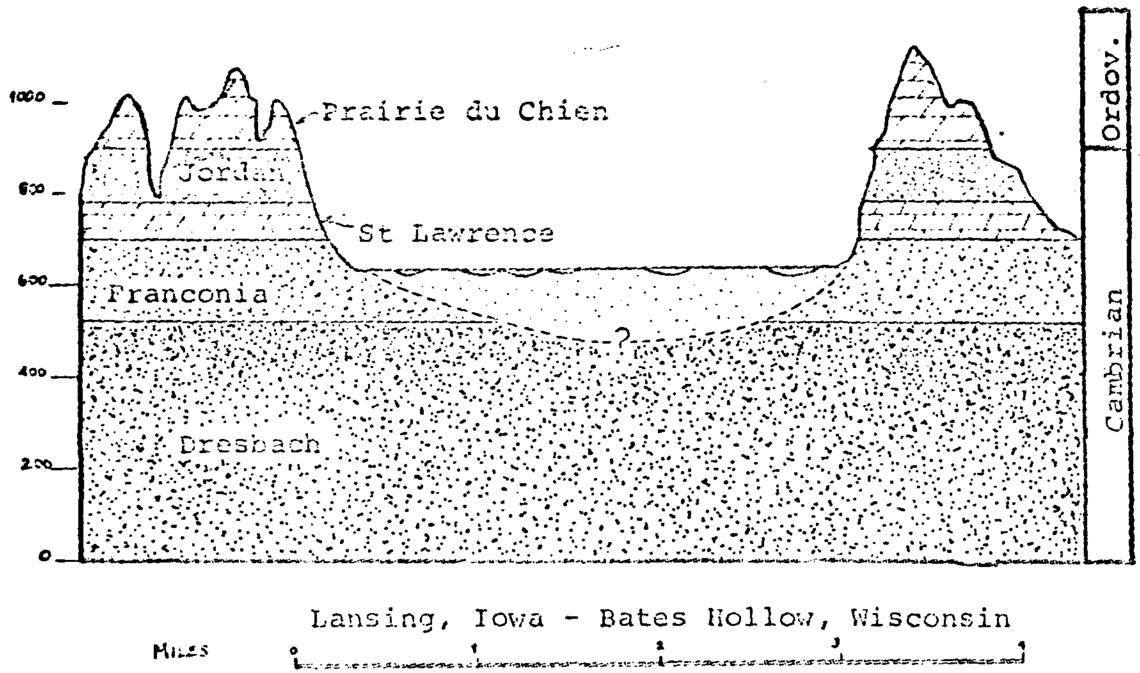
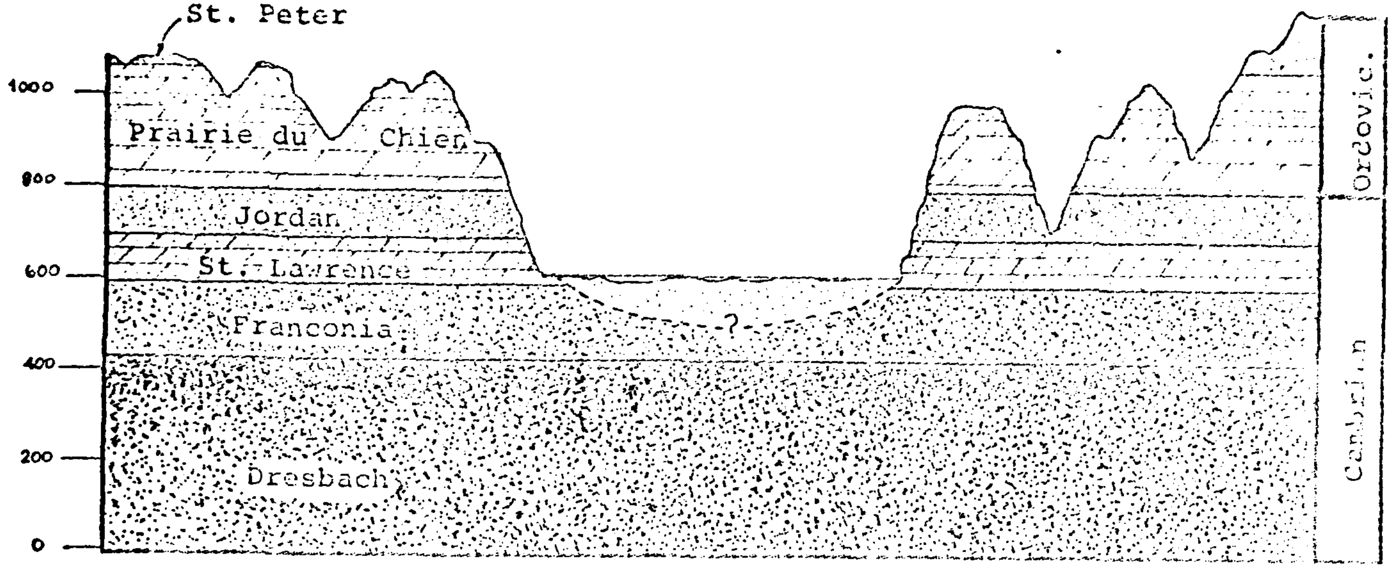


Fig. 6. Geologic section near control point of Pool 9.



Harper's FerrY:

Mooney Ridge, Iowa to Wall Ridge, Wisconsin

Fig. 7. Geologic section at southern end of Pool 9.

highly dissected, with a maximum relief of 500-600 feet (elevations range from about 620 to 640 feet at river level to over 1200 on the uplands). Steep-sided tributary valleys (called "coulees" in Wisconsin) may widen abruptly as they debouch into the river to form "coves" or elevated deltaic areas filled with alluvial materials, mostly sand and silt. The valleys of such tributaries as the Upper Iowa River and Winnebago Creek display prominent, complex terrace systems up to more than 100 feet high, and lesser tributaries have terraces in proportion to size.

Soils

The principal parent materials of soils in the drainage basins associated with Pool 9 are loess, alluvium, and glacial drift.

Many pockets and fans of glacial outwash occur associated with the old melt-water channels formed as ice melted during the most recent Wisconsin glacial period. Melt water flowed from the margins of the ice sheet and redeposited a partly sorted mixture of gravel, sand and silt. Many of these melt water channels are now streams in the glacial till areas along the Mississippi River.

Loess is a silty wind-deposited material originating from minerals carried away from the melting ice sheet of the Wisconsin glacier during warm seasons. During cool seasons water flow ceased and soil materials were deposited in broad, flat areas such as the Mississippi bottomlands. After drying, this material was picked up by wind action and redeposited many miles from its source. Loess over bedrock or over clay loam till is the major historical parent material of Pool 9 and associated uplands.

Alluvium is material which was deposited by water in the floodplains along streams entering the Mississippi bottomlands. Soils derived from alluvian deposits are frequently stratified with layers of gravel, sand, silt, and clay.

The surface parent materials in the Pool 9 area have been exposed to natural forces for something on the order of 16,000 to more than 24,000 years. The modern landscape resulted principally from erosioned activities which accompanied the Wisconsin glacial period. The soils which occur on its modern landscape may be young even though its deposited parent materials may be old.

Soils in the Pool 9 area developed under forest cover and belong to the great soil group referred to as the Gray-Brown Podzolics. These soils generally occur on gently rolling to steep topography along major streams.

The principal soil associations of the Pool 9 area are the Fayette and Fayette-Dubuque-Stonyland (FDS) (Figure 8). The two soil associations areas are similar in many respects throughout the area. The FDS association generally contains a higher percentage of shallow limestone soils on steep, stony land than the Fayette soil association. The limestone is often exposed on the steep slopes of the FDS association. The 1 to 60 degree slopes associated with these soil types make them very susceptible to erosion in upland areas, where cover of plants is sparce or where adequate soil conservation practices are not carried out. The sediment load carried into Pool 9 by its major tributary, the Upper Iowa River, produces significant natural siltation which accumulates in backwater areas and to

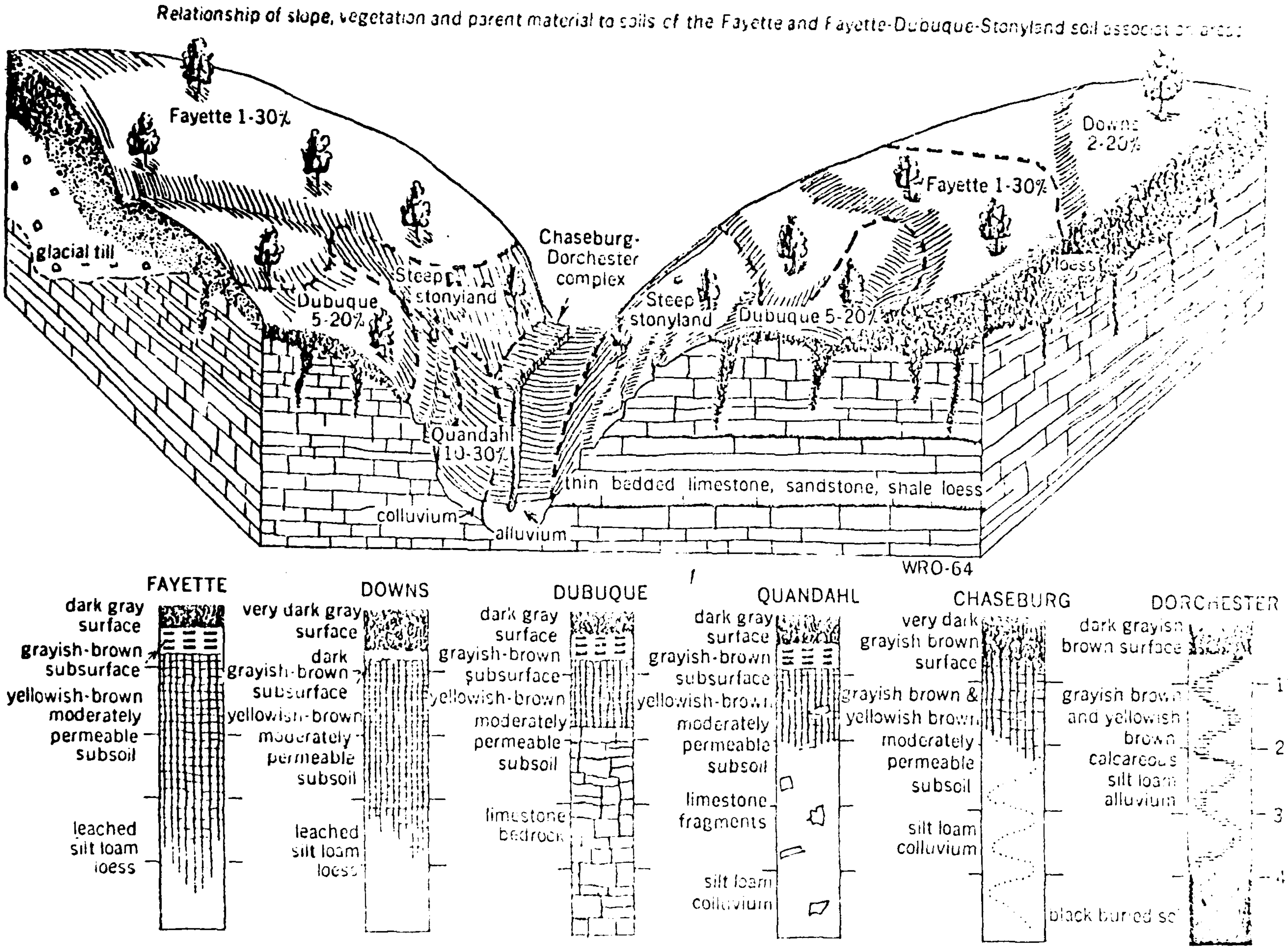


Fig. 8. Source: Oschwald, et al. (1965)

some extent in the navigation channel. The drainage basins associated with Pool 9 have been little studied and it is evident that these areas exert significant primary impact on the pool as well as considerable secondary impact on vegetation, fish and wildlife associated with areas subjected to heavy siltation. The rolling topography and well entrenched streams which contribute to siltation in Pool 9 also make the area very scenic and pleasurable for outdoor recreation.

The major soil type of islands and upland peninsular in Pool 9 is Dorchester silt loam with 0 to 1 percent slope. This soil is light colored, generally lacks a B horizon and is built up on black buried soil (Figure 8). The texture is sandy in some places and the profile may contain thin layers of sand. The bottomland soils are flooded nearly every year for a short time. Flooding generally occurs during thaws early in spring or after heavy rains prior to the growing season.

Climate

The National Weather Service, formerly the U.S. Weather Bureau, has maintained a station at the LaCrosse Municipal Airport since 1950. This is approximately 19 miles north of Pool 9, but their data is probably the best available for this section of the river. Prior to 1950, weather stations were maintained at various locations in LaCrosse.

Temperatures in the region are typical of the extremes of a continental climate. Average temperatures vary from 19°F in the three months of winter to 71°F in the summer months. A record maximum temperature of 108°F was recorded at LaCrosse in July, 1936; the record low of -43°F was recorded in January, 1873.

Monthly precipitation in the area averages two to four inches between March and October, and one to two inches for the rest of the year. Average yearly precipitation is 31.2 inches. Monthly snow and sleet averages between five and fourteen inches from November through March, the largest amount normally occurring during March. The normal annual amount of snow and sleet is 43.5 inches.

The high bluffs of the Mississippi River valley channel the winds. Airport data showed prevailing southerly winds for eight months of the year and prevailing northwest winds during January, February, March and April (Figure 9).

Hydrology

The Upper Mississippi River above Lock and Dam No. 9 drains an area of 66,610 square miles. At its source in Lake Itasca the elevation is 1465 feet above sea level, so that by the time the river reaches Pool 9 it has dropped over half way to sea level (Figure 10). This portion of the basin includes portions of Minnesota and Wisconsin, and minor portions of South Dakota and northeast Iowa.

There are comparatively large fluctuations in total precipitation from year to year in the basin, e.g., at LaCrosse, Wisconsin the minimum of 16.77 inches occurred in 1910, and the maximum of 42.37 inches was recorded in 1938. In general, the variation from minimum to maximum precipitation is over 20 inches. Total annual precipitation increases from north to south as reflected in the average annual runoff (Figure 11).

The movement of water upstream from Pool 9 is regulated by the series

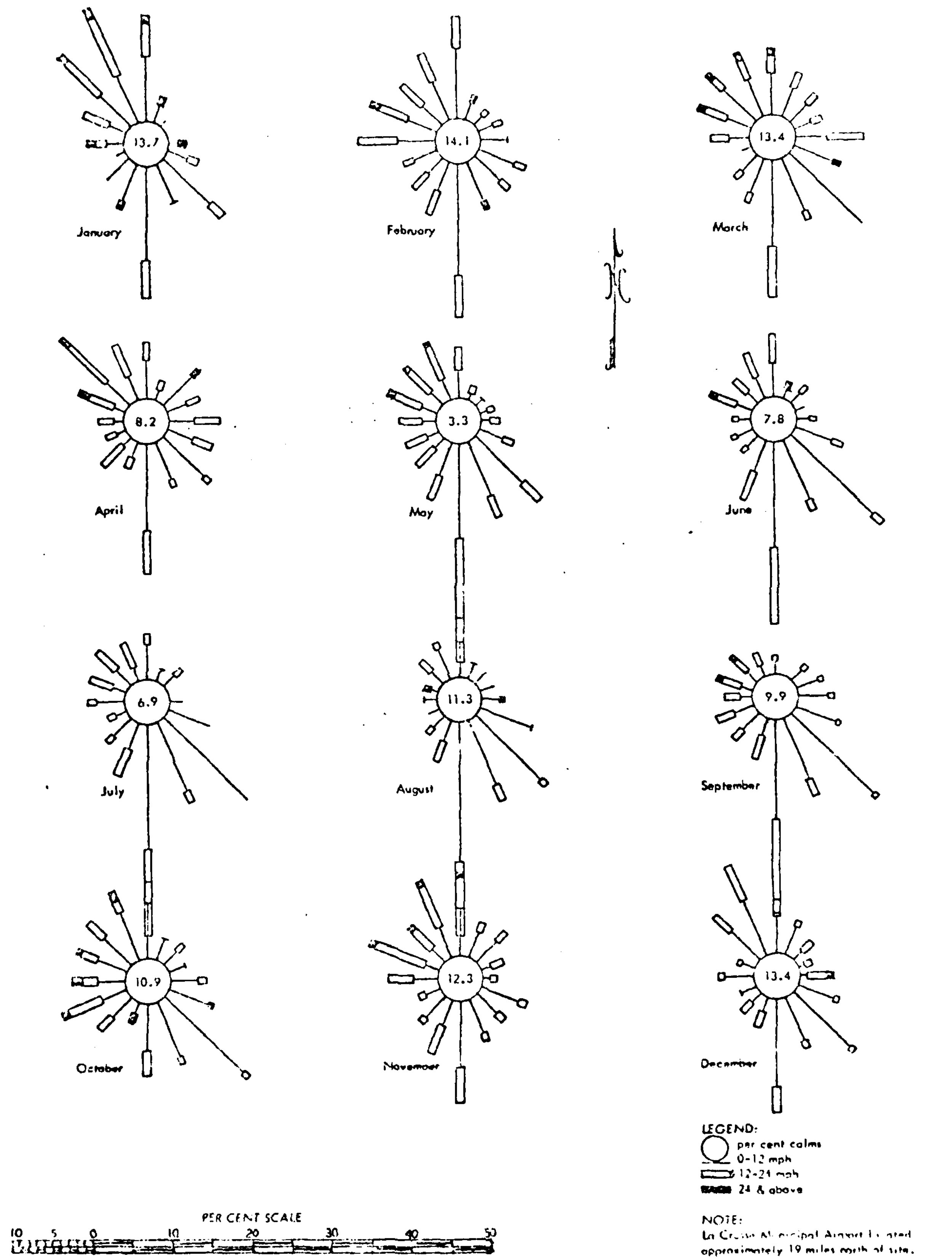


Fig. 9. YEARLY VARIATION IN SURFACE WINDS, LA CROSSE MUNICIPAL AIRPORT

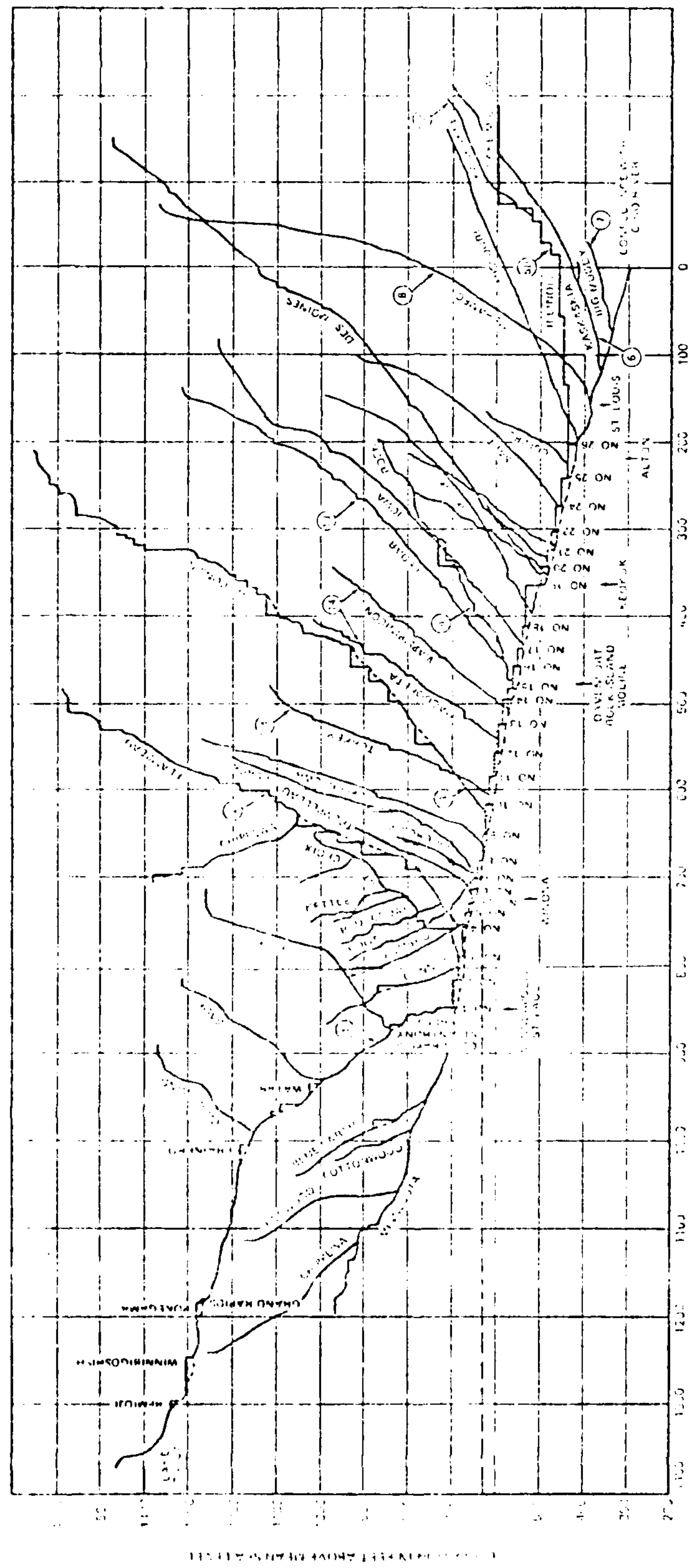


Fig. 10. River profiles, main stem and major tributaries.

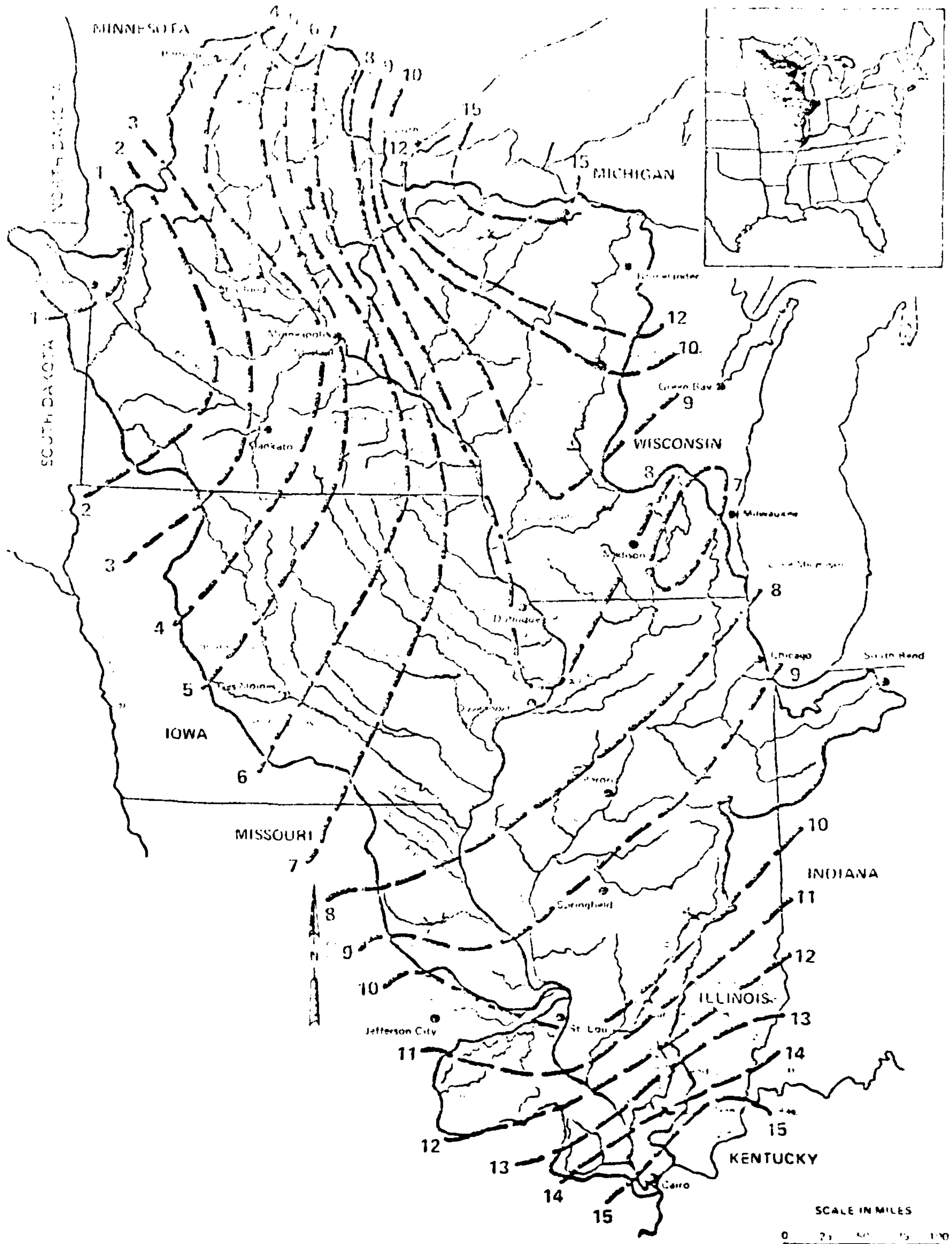


Fig. 11. Average annual runoff in inches.

of locks and dams between Minneapolis, Minnesota and Genoa, Wisconsin. Minimum river stages have thus been somewhat stabilized, assisting navigation on the river. However, the basic low-flow discharge pattern is still apparent. Low flows in Pool 9 occur in the fall and winter; the lowest monthly average flow is most frequently recorded in February (about 12,000 - 13,000 c.f.s.).

An analysis of peak flows expected in Pool 9 has been made by Dairyland Power for their electric power station located on the east bank of the Mississippi River at Genoa, Wisconsin (Dairyland Power, 1972). The records for discharge at the LaCrosse gauging station (about 21 miles upstream from Pool 9) go back to 1873, and it was possible to do a graphical analysis, based on methods generally used by the Geological Survey (Figure 12). A conservative extrapolation suggested that a flood with a recurrence interval of 100 years has a magnitude of 220,000 c.f.s. (cubic feet per second). This means that there is a 1% chance that a flood equaling or exceeding 220,000 c.f.s. will occur in any one year. Floods of greater magnitude will occur, but according to this analysis (Dairyland Power, 1972), have a smaller than 1% chance of occurring in any one year.

The highest flood of record occurred in 1965, with a discharge of 265,900 c.f.s. and elevation of 638.40 feet above sea level at the Genoa gauge just above Pool 9. At the Lynxville gauge (at Lock and Dam No. 9) the water level reached 633.80 feet, and the peak discharge was 275,500 c.f.s.

Various curves developed by the U.S. Army Corps of Engineers related to water level and discharge of Pool 9 have also been included (Figures

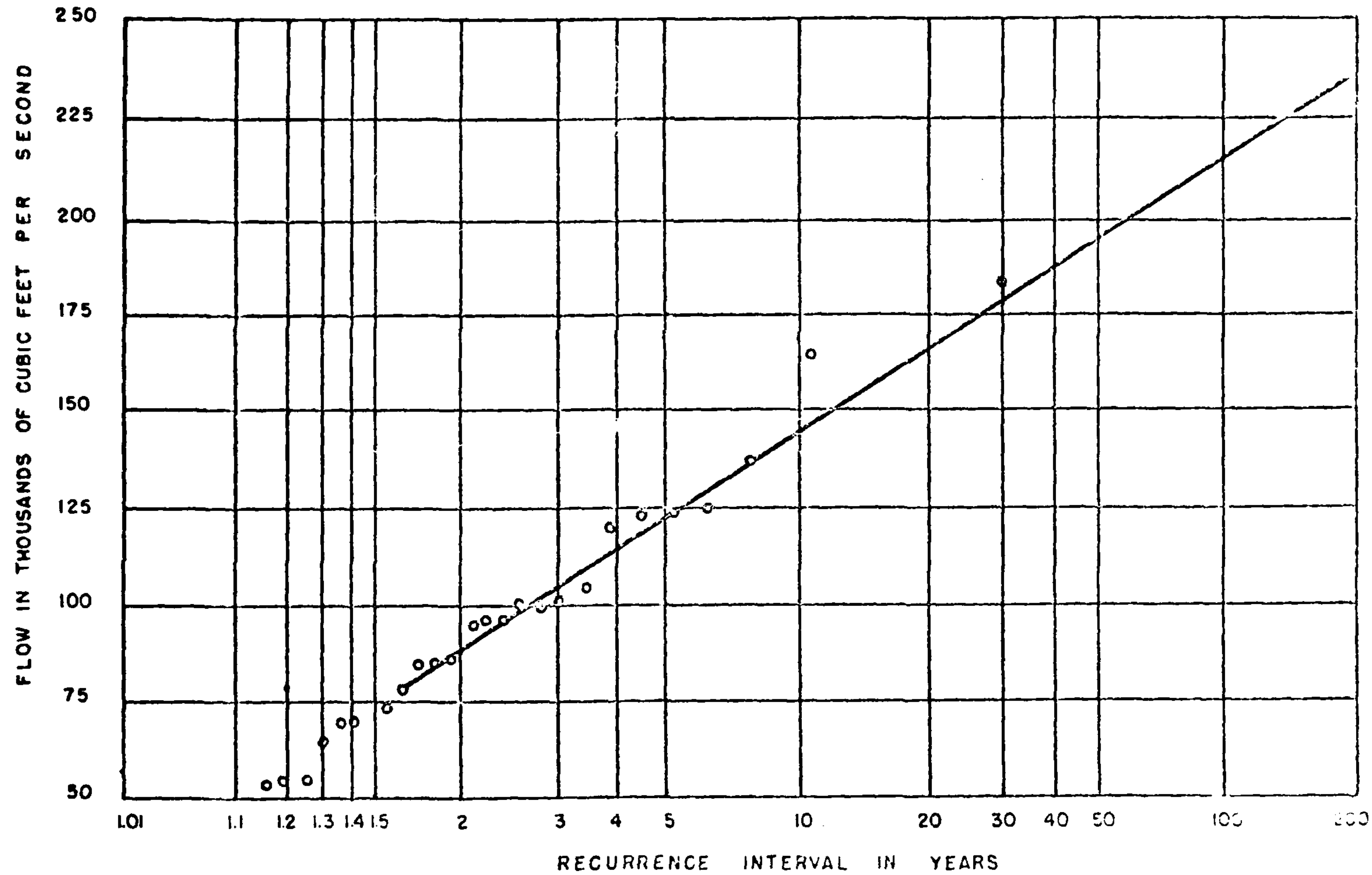


Fig. 12. FLOOD-FREQUENCY CURVE FOR MISSISSIPPI AT LACBWR

13, 14, 15).

Ground water

Large quantities of ground water are present in the highly permeable, surficial sand deposits. The principle aquifer for shallow wells (less than 150 feet) would be the Franconia formation. Deeper wells in the northern end of the Pool 9 region may penetrate into the Galesville or Eau Claire formation, although water quality would probably not differ much from that of the Franconia formation.

The chemical characteristics of two wells at the Dairyland Power electric power station are shown in Table 6. These wells are relatively shallow (casing depths of 92 and 129 feet) and are apparently in the Franconia formation. The chemical constituents of the shallow ground water are not greatly different from those of the river. However, the ground water is considerably harder than the Mississippi River in Pool 9.

Biological Aspects

The Upper Mississippi River valley is unique in its flora and fauna. It enjoys conditions not generally associated with its geographic location. What has been referred to as a "pseudo-Carolinian zone" extends north along the Mississippi into the Alleghanian Zone. Thus, refuge flora and fauna, although primarily Alleghanian, have representatives of Carolinian species as well as occasional Canadian forms. A feature making the refuge even more interesting is the overlapping of eastern and western species and subspecies. There are also several high "sand prairie" areas scattered along the length of the refuge, offering habitat conditions normally found much farther west. These sand areas reach elevations high enough to pro-

Table 6

Analysis of Water from LACBWR Supply Wells (ppm)

Parameter	Well No. 3	Well No. 4
pH @ 25 C	7.7	7.7
Alkalinity (HCO_3)	340	337
Sulfate (SO_4)	15	10
Chloride (CL)	8	7
Nitrate (NO_3)	5	5
Silica (SiO_2)	15	15
Phosphate, ortho (PO_4)	0.2	0.2
Phosphate, meta (PO_4)	0.1	0.1
Hardness (as $CaCO_3$)	294	302
Calcium (Ca)	65	65
Magnesium (Mg)	32	34
Iron (Fe)	0.05	0.08
Manganese (Mn)	0.03	0.03
Color (APHA units)	.5	.5
COD	1	1
Suspended solids (est)	5-10	5

Source: Dairyland Power (1972)

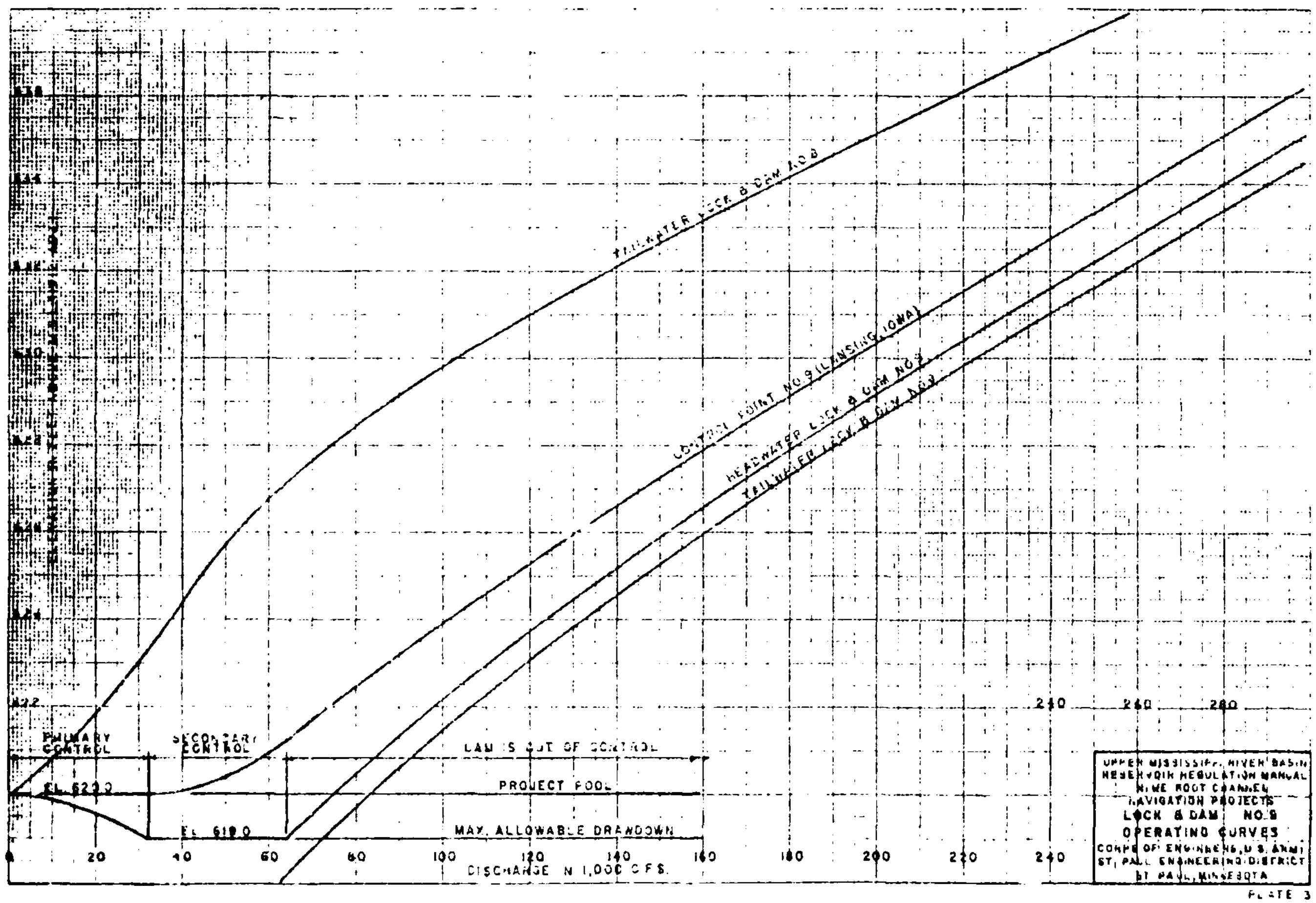


Fig. 13. Lock and Dam No. 9 operating curves.

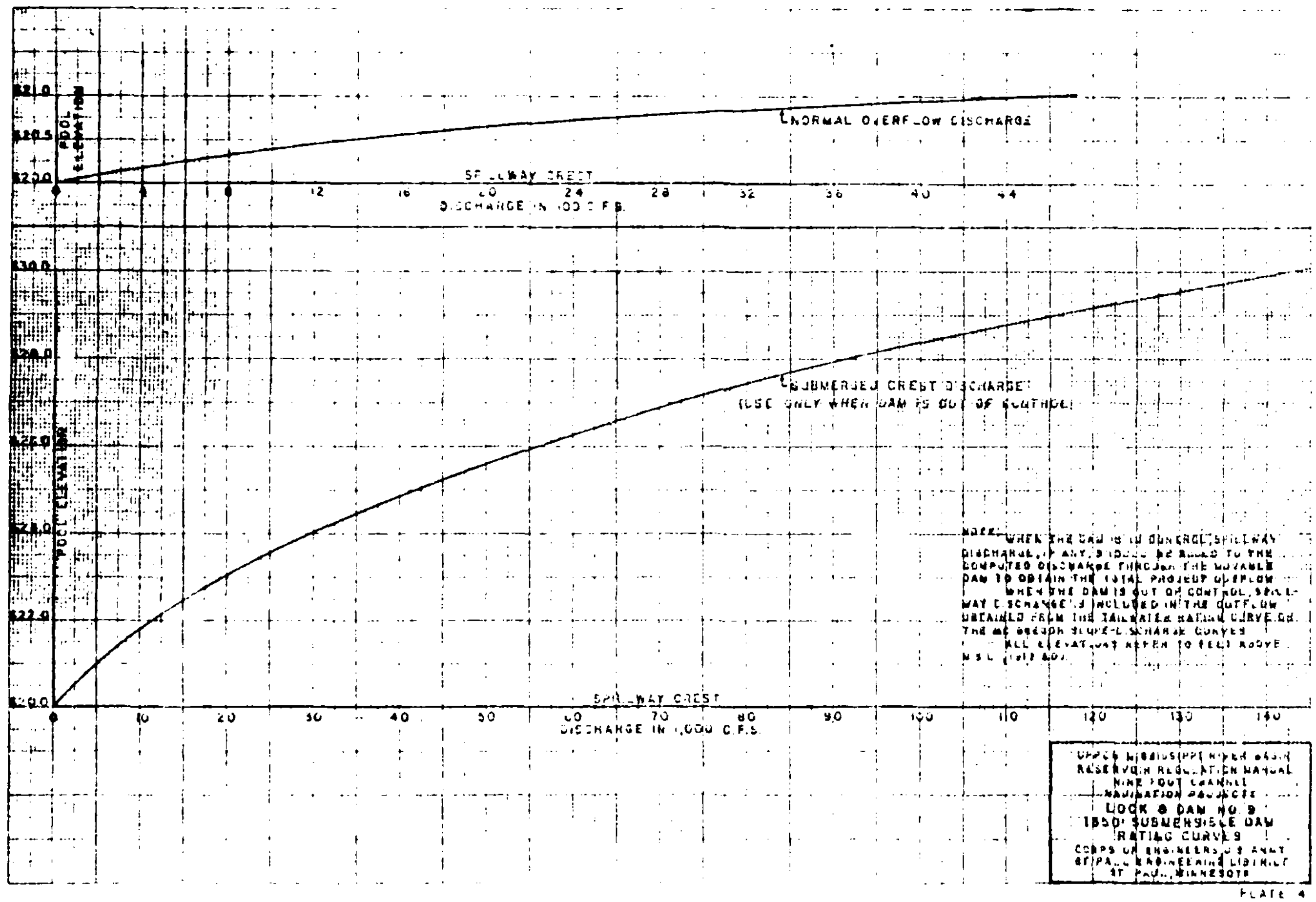


Fig. 14. Lock and Dam No. 9 submersible dam rating curves.

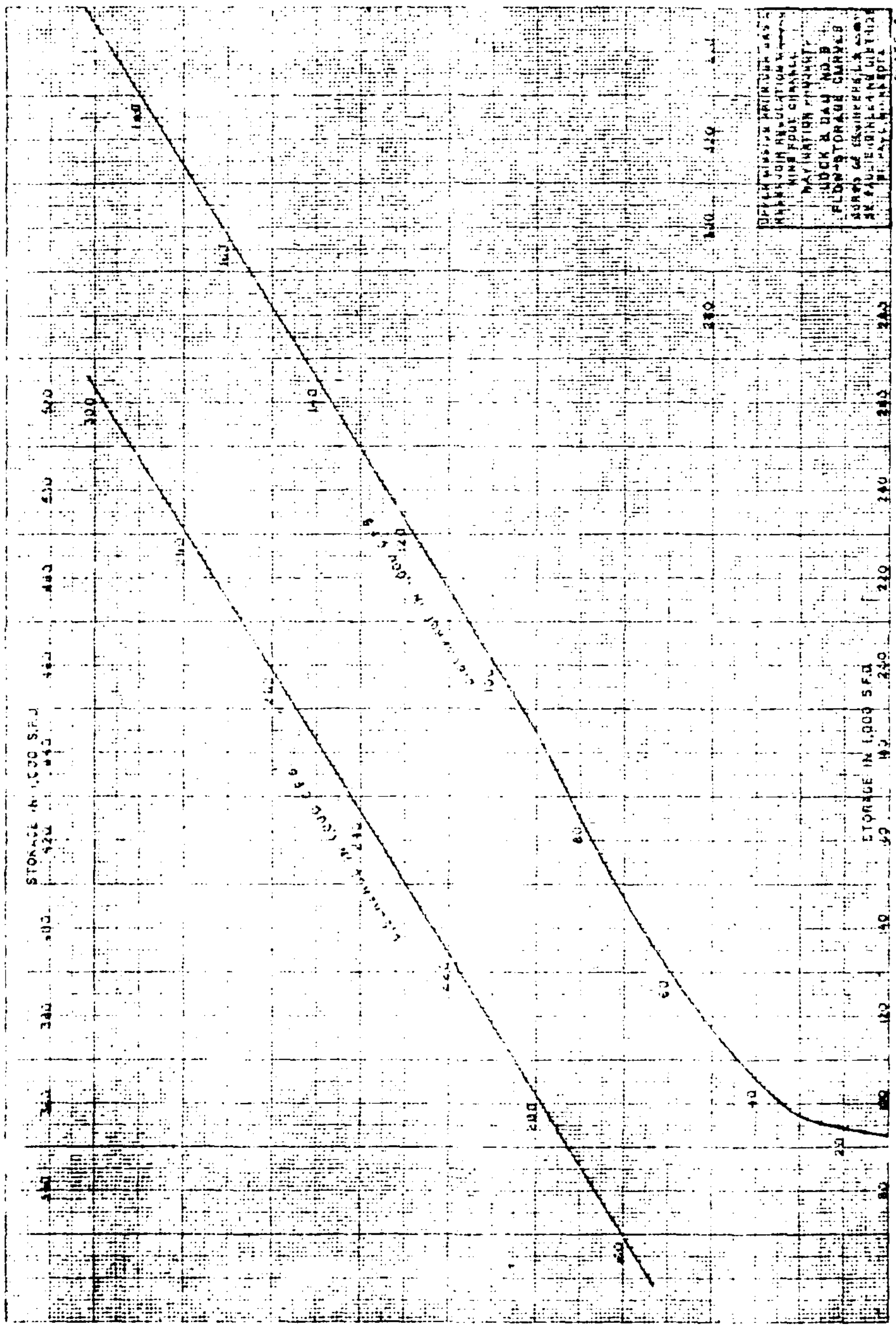


Fig. 15. Lock and Dam No. 9 flow-storage curves.

tect them from severe floods, and consequently have developed a flora very distinct from that of the true flood plain, with plants of dry upland prairie predominating.

Environmental Inventory (1973)

Data were collected during 1973 in conjunction with the development of this impact statement. There was a sparcity of quantitative data on the biotic communities for this pool in the past, and much of what data had been previously collected is not readily available. It is hoped that the data collected during 1973 will serve as a comparative "baseline" for future studies. Data collected, and the methodology, are presented in Appendix A.

The map of Pool 9 (Fig. 16) shows the location of the three standard sampling transects, and the two special study areas at the entrance of the Upper Iowa and Big Lake. Transect AA is located in the tailwater section, transect BB is near the primary control point, and transect CC is located about 0.1 mile upstream from Lock and Dam 9 in the lake-like section of the pool (Table 7). The special study area at the mouth of the Upper Iowa consists of several sampling sites, as is also true of the study area at Big Lake.

Transects AA and BB were laid out in February and March, 1973. Flagging tape was used initially, and subsequently small aluminum tags (1.5" by 4") have been attached to larger trees along the transect. These aluminum tags have a number punched on them which is the distance in feet from the railroad tracks on the Iowa side.

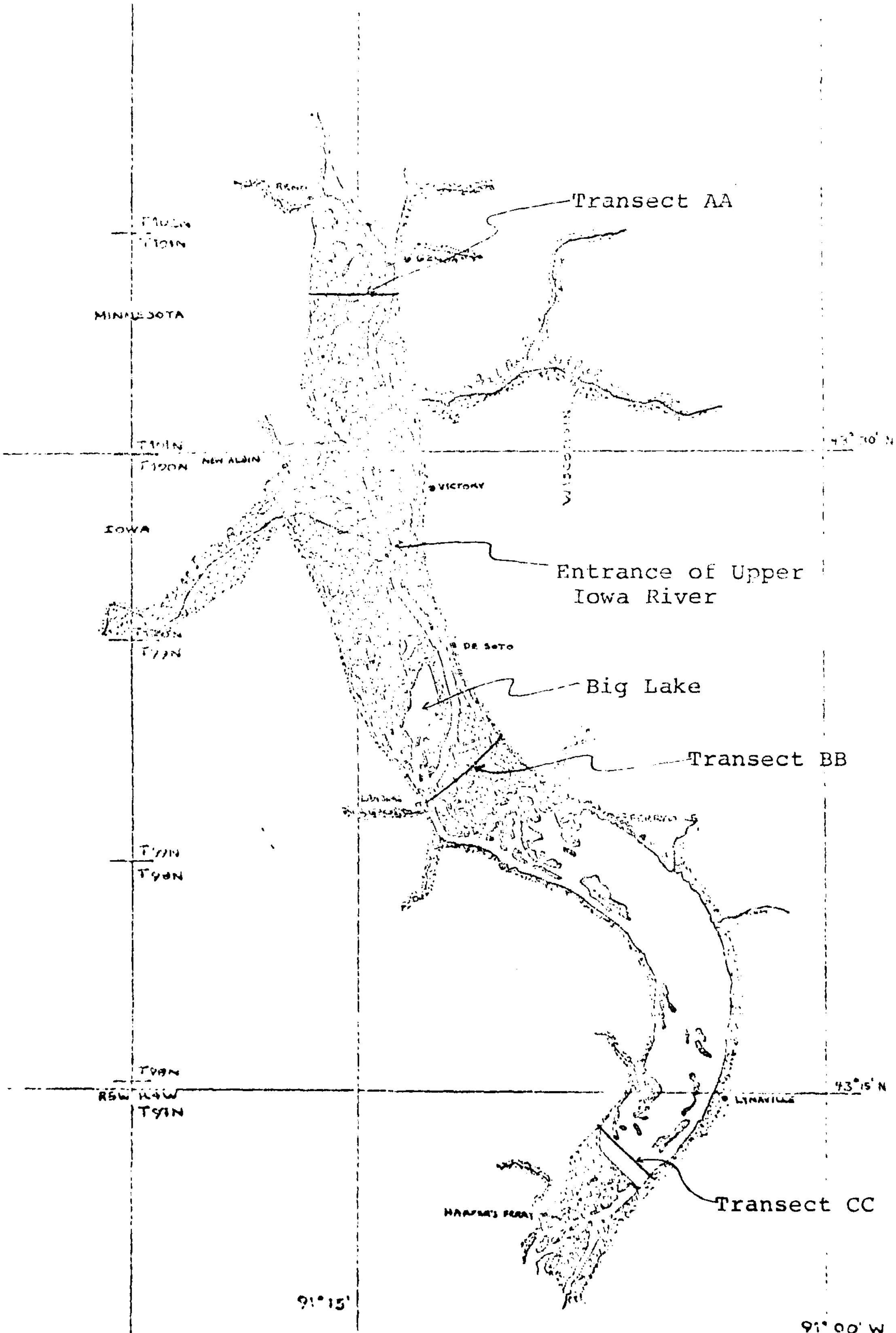


Fig. 16. Locations of sampling transects and special study areas of Pool 9, Upper Mississippi River.

Table 7

Transects of Pool 9

Designation	River Mile	Azymith	Length (miles)	Location
Transect AA	678.6	87°	2.4	From track to track 200 feet upstream and parallel to power line of Dairyland Power
Transect BB	663.3	65°-30°	2.7	300 feet downstream and parallel to Wisconsin Highway 82
Transect CC	648.2	132°	2.0	About 1/4 mile upstream from Lock and Dam 9
Special Study Area	671.0			Entrance of Upper Iowa River
Special Study Area	666.0			Big Lake

A Locke hand level and Jacob's staff were used to survey elevations along the transects. Elevation of the bottoms of aquatic sections of the transects were also determined, using either a sounding line or sonar depth finder. These elevations are presented in Tables 8-10. The study area of Big Lake was extensively surveyed in 1973 and a bottom contour map was developed (Fig. 17).

There were 53 sampling stations from various aquatic habitats during the 1973 environmental inventory studies. Six of these stations were along transect CC at the southern end of the pool (Fig. 18). Stations 7-19 were near the center of the pool, either below Lansing on the main channel, on transect BB, or above Lansing on the main channel (Fig. 19). Stations 20-39 were either on or nearby Big Lake, just north of Lansing, Iowa (Fig. 20). Stations 40-48 were located in vacinity of the entrance of the Upper Iowa River into the Mississippi (Fig. 21), and stations 49-53 were located along transect AA (Fig. 22). Sampling for benthos, plankton, and water chemistry was done at these stations; not all parameters were measured at every station. Some stations were sampled 4-5 times, while others were sampled only once.

Various types of stratified random sampling were conducted along the three transects and in the two special study areas in order to sample from a variety of terrestrial and aquatic habitats. The data obtained will be presented in the sections which follow as part of the information which describes the environmental setting.

Fig. 17. Depth contour map of Big Lake in Pool 9 during the summer of 1973. One-foot depth contour intervals shown for normal pool level of 620 feet.

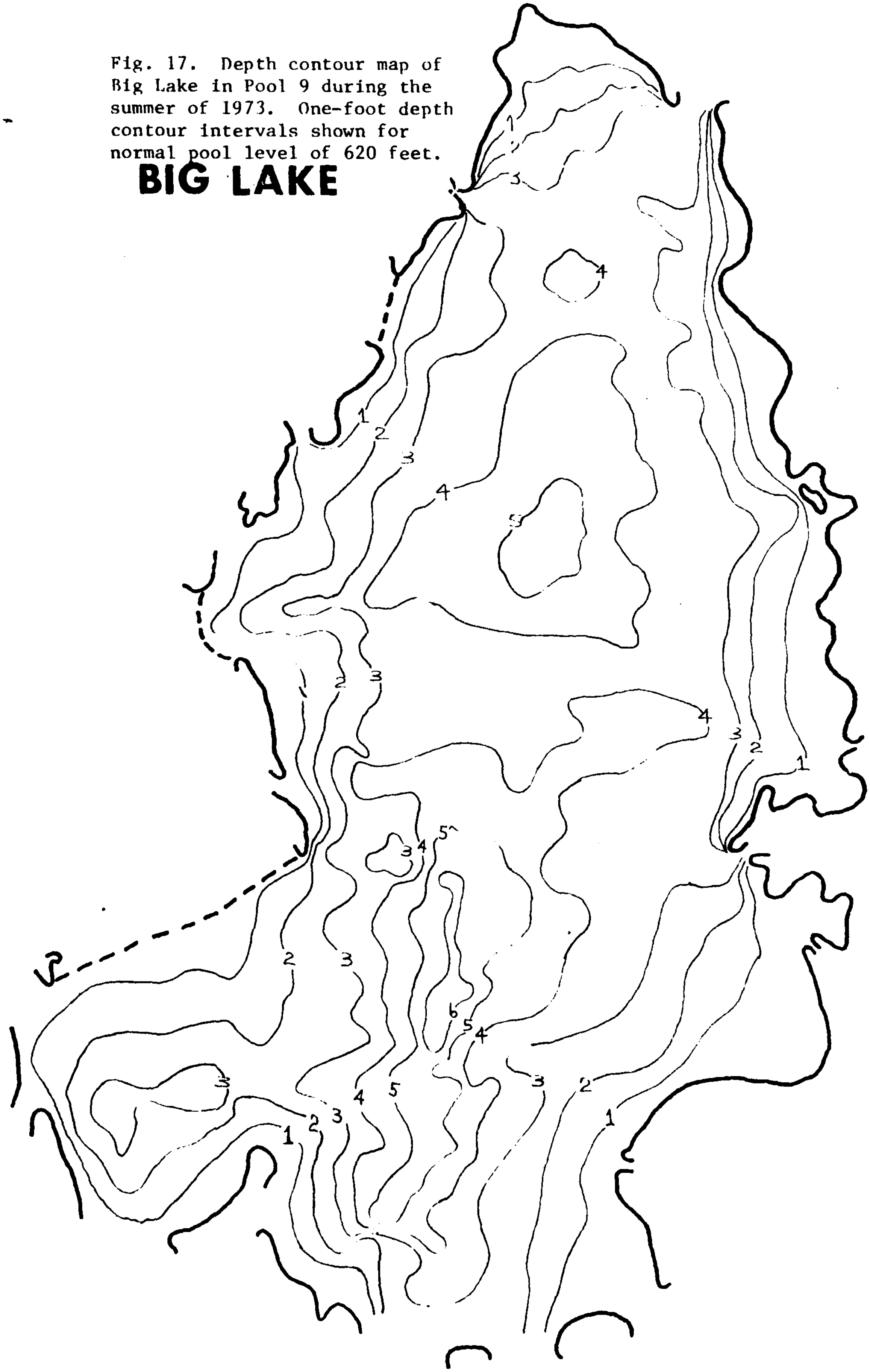
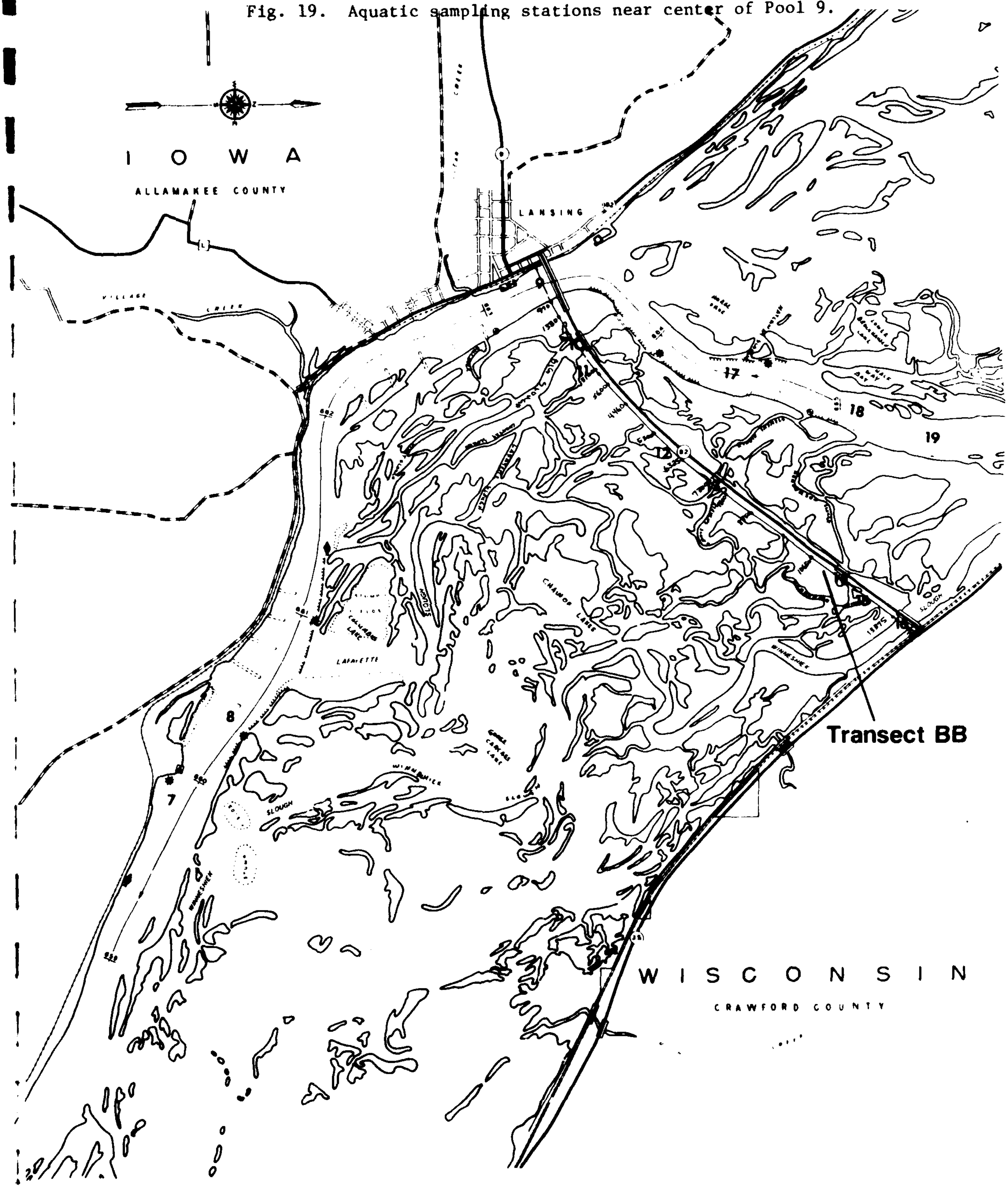


Fig. 18. Aquatic sampling stations along transect CC

Fig. 19. Aquatic sampling stations near center of Pool 9.



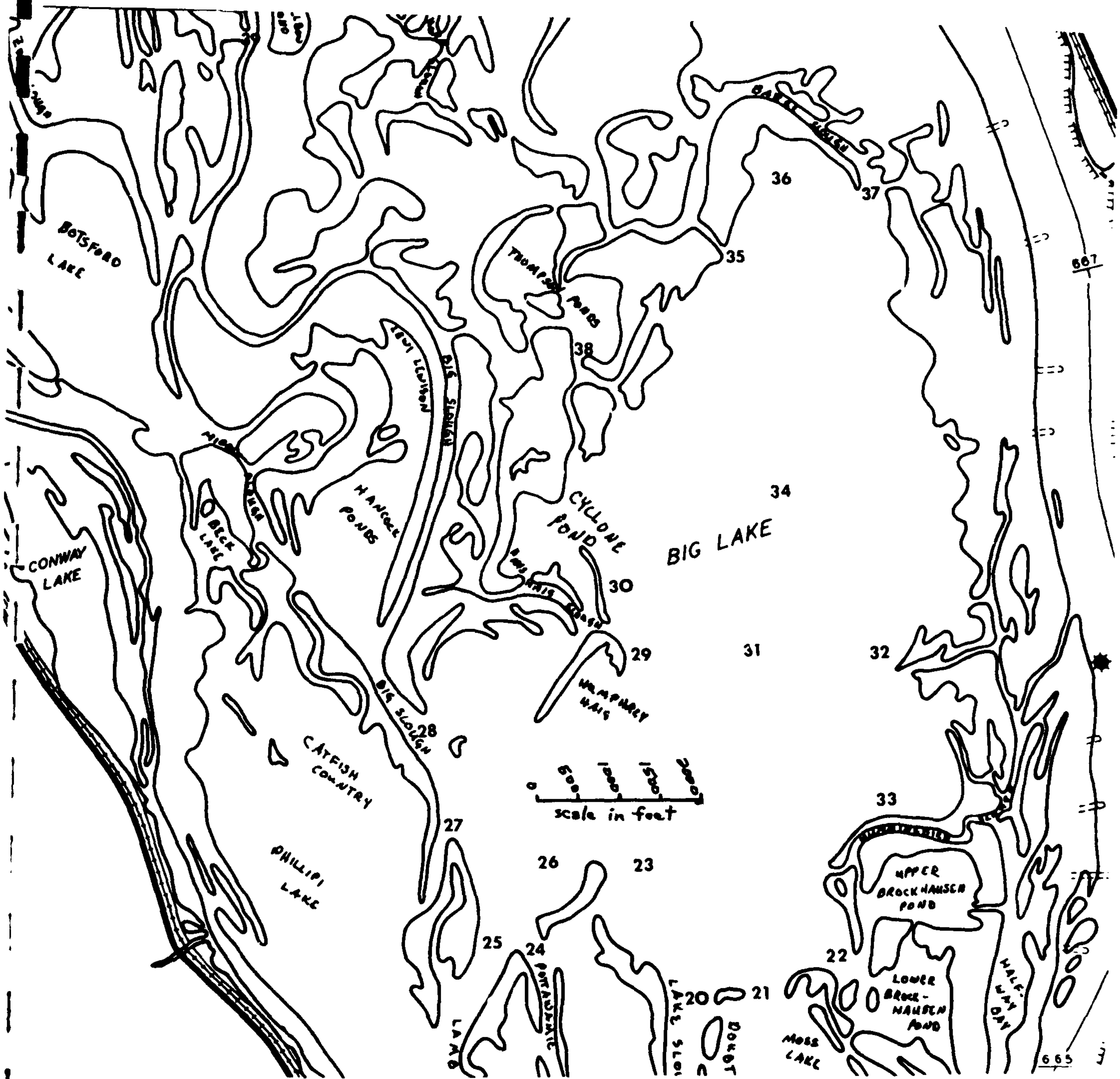


Fig. 20. Aquatic sampling stations of Big Lake in Pool 9.

Fig.   uatic sampling stations near mouth of Upper Iowa River.

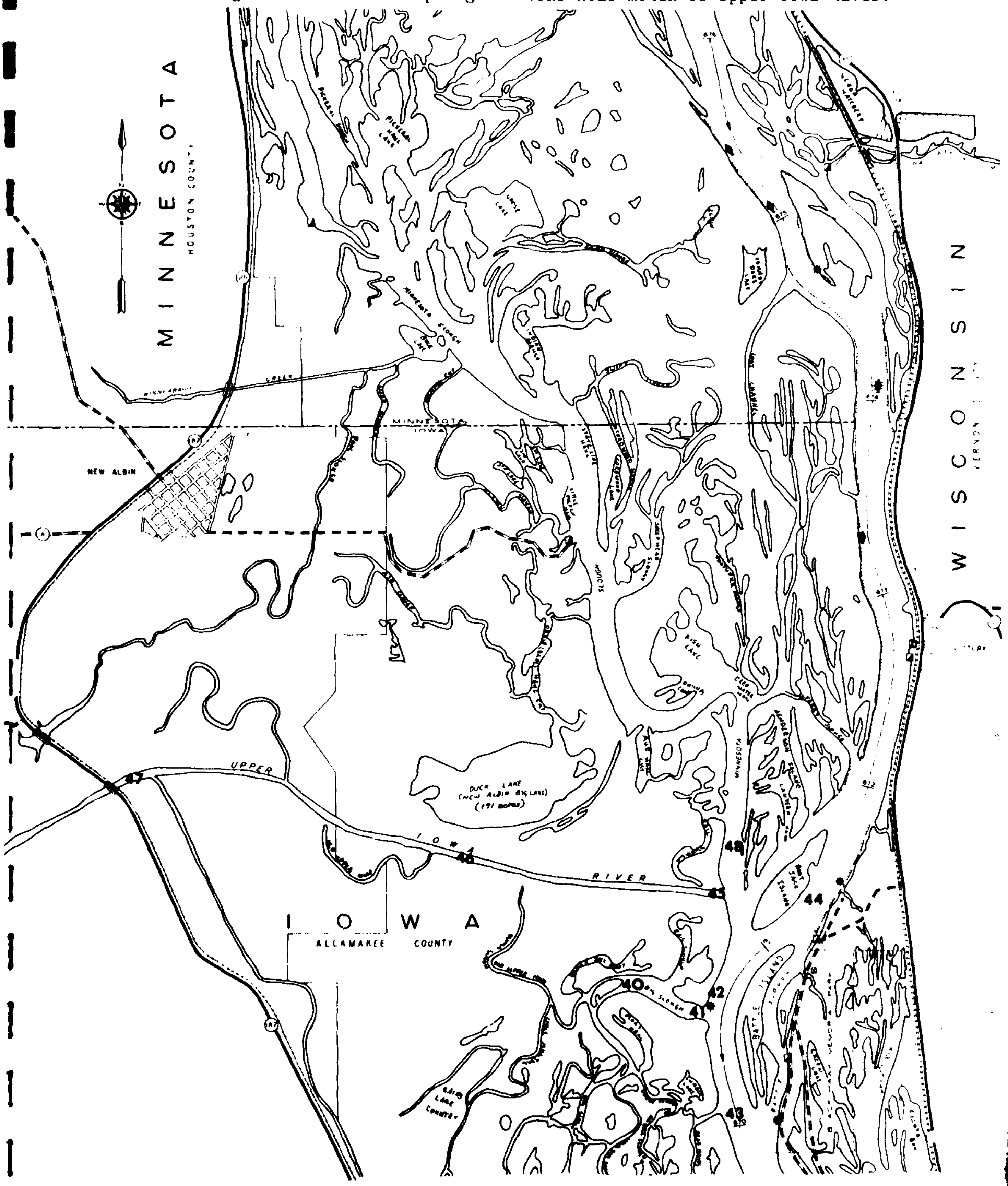


Fig. 22. Aquatic sampling stations along transect AAof Pool 9.

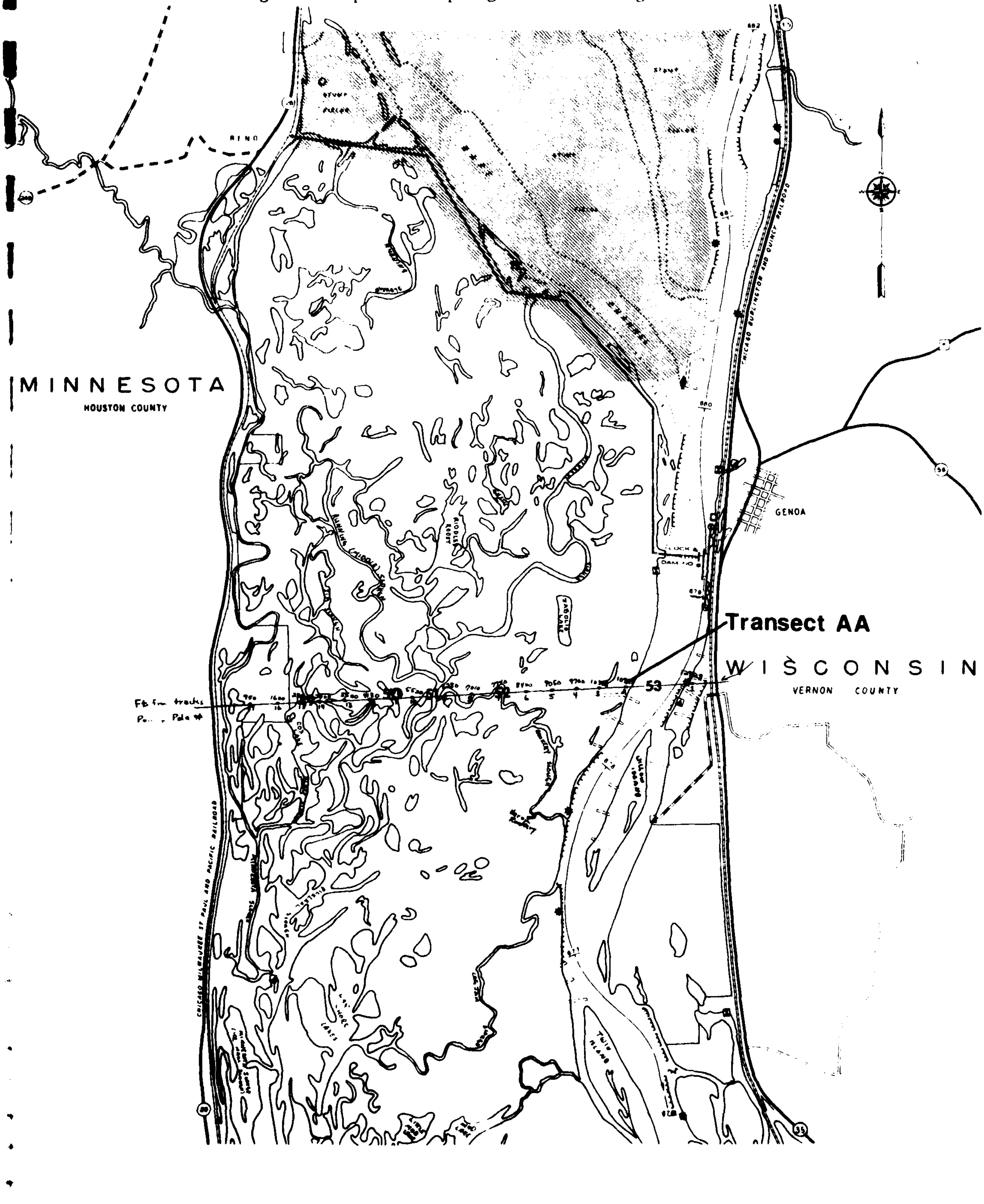


Table 8

Ground Contour of Transect AA

Feet from railroad tracks on Iowa side	Elevation in feet	Power-line Pole Number
0	640	
100	622	
150	619	
950	622	17
1500	619	
1600	622	16
2220	622	
2120	619	
2320	619	15
2500	621	
2900	622	14
3100	622	
3200	619	
3500	622	13
4000	619	
4130	622	12
4330	622	
4380	620	
4480	622	
4600	619	
4830	622	11
4930	622	
4980	620	
5300	620	
5520	622	10
5700 (Pickerel Slough)	614	
6250	622	9
6450	619	
6475	622	
6900	619	
7010	622	8
7640	619	
7740	622	7
8400	622	6
9050	622	5
9700	622	4
10328	625	3
10600	619	
10963	622	2
11260	617	
11560	616	
12000 (Main Channel: 11260–12750)	600	
12300	604	
12700	604	
12750	620	
12828	638	1

Table 9

Ground Contour of Transect BB

Feet from railroad tracks on Iowa side		Elevation in feet
0		640
20		620
30		612
100		610
200		605
300		600
400	Main Channel	595
500		600
600		610
700		615
800		618
935		622
985		621
990		619
1030		619
1035		623
1485		623
1650		622
1800		619
1945		619
1950		621
2125		622
2250		623
2260		612
2400	Big Slough	605
2600		615
2650		620
2675		623
2780		622
2750		620
2875		620
2880		622
3020		622
3025		619
3100		618
3150		620
3220		622
3225		619
3450		619
3500		621
3525		619
3670		619
3675		622

Table 9 (Continued)

Feet from railroad tracks on Iowa side		Elevation in feet
3800		621
4100		621
4150		620
4325		620
4400		621
4835		622
4885		619
5000		619
5020		622
5300		622
5400		619
7000		619
7025		620
7385		623
7465		623
7460		619
7500	Steven's Slough	609
7530		620
7535		622
7700		623
10575		622
10600		619
10790		619
10800		622
11100		622
11525		624
11660		620
11750	Henderson Slough	608
11825		620
11830		621
11975		620
11992		615
12040	Henderson Slough	615
12075		620
12080		620
13000		621
13025		619
13130		620
13150		623
13525		623
13540		622
13542		620
13545		614
13570		610
13663	Winneshiek Slough	602
13725		598
13850		608
13910		620
13915		640

Table 10

Ground Contour of Transect CC

Feet from railroad tracks on Iowa side		Elevation in feet
1980		620
2000		619
2100		618
3500		617
3600		618
4200	Old Harpers Slough	617
4500	Old Harpers Slough	606
5020	Old Harpers Slough	616
5780		615
6540		617
7000		612
7400		616
7850		612
7900		615
8000		614
8900		613
9000		617
9500	Main Channel	613
9800	Main Channel	592
10250	Main Channel	588
10340	Main Channel	607
10400	Main Channel	613
10410		620

Benthic Invertebrates

Although there have been a variety of studies on benthic invertebrates of the Upper Mississippi River (e.g., Fremling, 1960; Carlson, 1968; McConville, 1969) little data were available specifically for the Pool 9 macroinvertebrates prior to the 1973 study.

A rather comprehensive survey of freshwater mussels conducted by Max M. Ellis during the summers of 1930 and 1931 included samples from 5 sites in what is now known as Pool 9 (van der Schalie and van der Schalie, 1950). What Ellis referred to as zone III of the Upper Mississippi consisted of 8 sampling sites, 4 of which were in Pool 9 and 4 just above Pool 9. The site descriptions are given in Table 11, and the species he collected are recorded in Table 12.

Recent sampling by Claflin (1972) from transects above and below the Dairyland Power Station at Genoa (Figure 23) provides additional records of bottom organisms of Pool 9 (Table 13).

Considerable data were collected on macroinvertebrates for the major tributary of Pool 9 during a 1972 summer study of the Upper Iowa River (abstracted in Hill, 1972). Additional studies were conducted during the summer of 1973 on this tributary, but these data were not available in time for this report.

Benthic macroinvertebrates were sampled during 1973 at many of the 53 aquatic sampling stations. Most of these stations were off the main channel, and sampling was done with an Ekman grab. Three samples were taken each time per site, so that an estimate of the standard error was

Table 11

Some Sites Samples by Max M. Ellis
in 1930-31 Survey
of Upper Mississippi Mussels

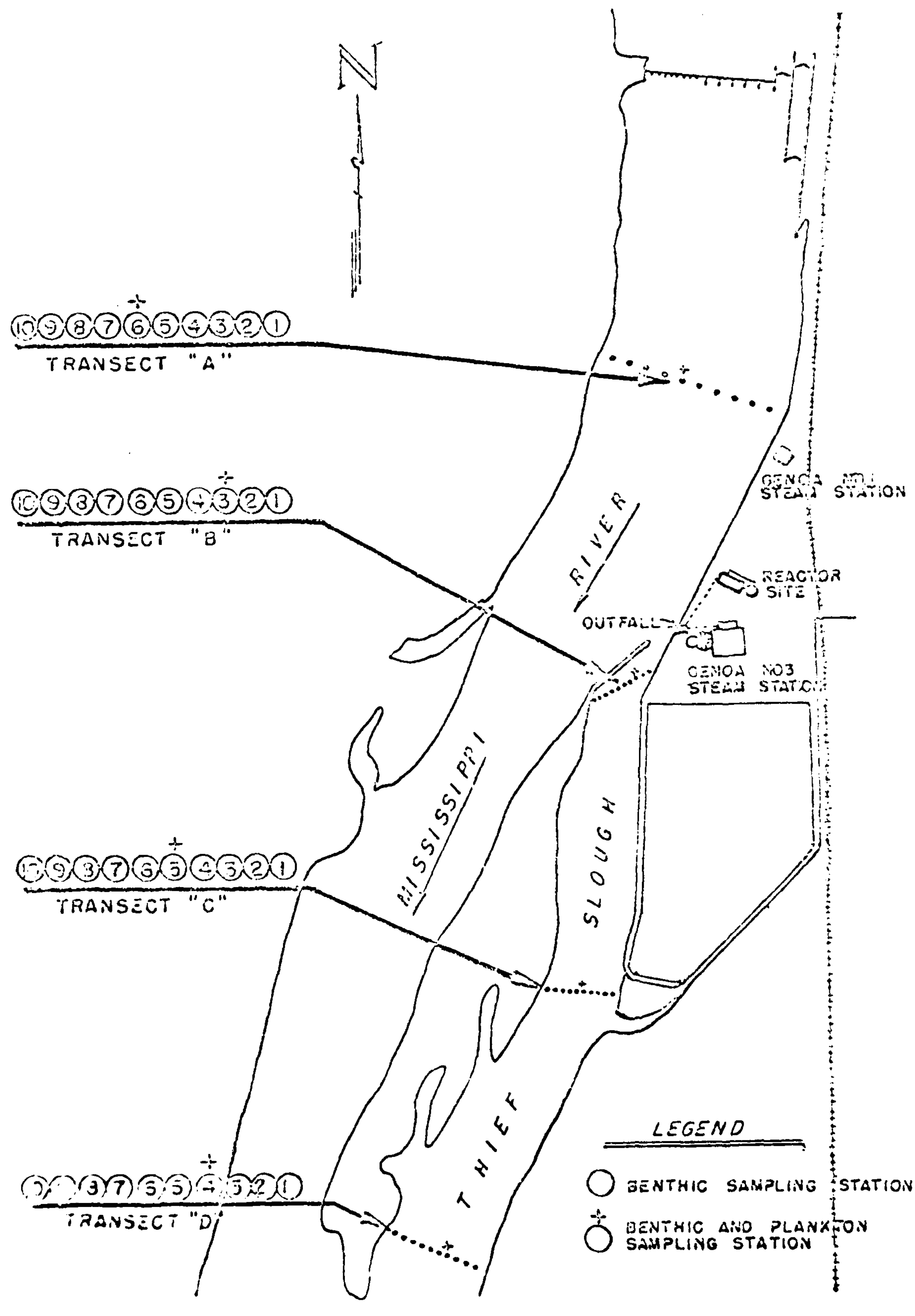
Approximate River Mile	Present Pool No.	Site Description
706.1	7	One mile upstream from Dakota, Winona Co., Minn.; two beds of mussels between a pair of wing dams off the west shore of the river; the bed nearest shore on rock bottom with mud over the rocks contained principally the Amblema peruviana; there were many good shells dead along the shore; nearer the channel end of the wing dams and separated from the "near shore" bed by a pair of small parallel sand bars is a bed of mussels containing old specimens of L. ventricosa and young A. peruviana and O. pustulosa.
701.8	8	Near Minnesota shore 3.7 miles above LaCrosse, Wis. at Island No. 98 light (820).
698.1	8	LaCrosse, LaCrosse Co., Wis.; mussels from backwater slough near Wigwam Creek on Goose Island below LaCrosse; on Wisconsin side slough known as Brownsville slough. Mussels in package taken from muskrat shell piles.
680.2	8	Genoa, Vernon Co., Wisconsin.
663.0	9	At Lansing, Allamakee Co., Iowa just above Iowa State Fisheries Station.
660.0	9	Near Wis. shore 3 miles below Lansing, Iowa.
659.8	9	On Iowa side of river, 3.2 mi. below Lansing, Iowa; depth 1.4 meters; bottom rock with some mud.
651.9	9	Lynxville, Crawford Co., Wis. general region quite sandy.

Source: Van der Schalie and Van der Schalie (1950)

Table 12

Freshwater Mussels Sampled by Max M. Ellis in 1930-31
from Section of the Upper Mississippi River
Which Included the Present Pool 9 Region

Species	Number
Fusconaia ebenus	2
Fusconaia undata	21
Megalonaias gigantea	5
Amblema peruviana	24
Quadrula pustulosa	11
Quadrula nodulata	1
Quadrula metanevra	1
Tritigonia verrucosa	16
Elliptio dilatatus	24
Arcidens confragosus	2
Lasmigona complanata	8
Anodonta corpulenta	22
Anodonta imbecillis	10
Strophitus rugosus	38
Obliquaria reflexa	23
Obovaria olivaria	6
Actinonaias carinata	32
Truncilla truncata	8
Truncilla donaciformis	4
Plagiola lineolata	6
Leptodea fragilis	20
Proptera alata	49
Ligumia recta latissima	2
Lampsilis anodontoides	14
Lampsilis anodontoides fallaciosa	4
Lampsilis siliquoidea	30
Lampsilis ventricosa	29
Lampsilis higginsii	2



[illegible]ONS OF AQUATIC SAMPLING TRANSECTS

Table 13

Species and Occurrence of Benthos Collected on Four Transects on the Mississippi River at Genoa, Wisconsin in June 1972

(organisms per square meter)

Species	Upstream Transect A	Downstream Transects B	C	D
Amphipoda				
Hyallella azteca	60	23		63
Insecta				
Tendipendidae				
Tendipes plumosus	132	40	21	92
Tendipes tentans	441	159	928	219
Tendipes sp.	34	14		
Heleidae	267*		536	333
Palpomyia sp.	266	342		
Unidentified	76			
Cuclicidae				
Chaeoborus sp	11		12	
Plecoptera	14			
Trichoptera				
Hydropsychidae				
Clematopsyche sp.	34			
Oligochaeta	110	49	201	211
Total/m^2	1445	627	1698	918
Biomass mg/m^2 expressed as wet weight	457.4	172.2	660.8	194.7

*First instar Larvae

Source: Claflin (1972)

possible. Organisms were keyed only to the family level (although reference specimens have been preserved), and counts and dry weights were determined. The Sphaeridae (fingernail clams) have considerable weight in their shells, and the biomass calculations reflect this. It was found that, generally, shell-free dry weight for Sphaeridae was about one-tenth of the biomass which included shell weights.

The benthic samples are summarized in Appendix A. The largest numbers, and biomass, were recorded from Transect CC. The mean number per m^2 from Transect CC was 9812, with a biomass of 119.8g/m^2. The two dominant family groups were Sphaeridae and Ephemeridae; Sphaeridae accounted for 70.8% of the numbers and 73.8% of the biomass, Ephemeridae accounted for 21.9% of the numbers and 13.9% of the biomass.

The second most productive benthic community sampled was Big Lake. The mean number per m^2 was 3254, and the mean biomass was 46.8g/m^2. Again the Sphaeridae were prominant, accounting for 46.3% of the numbers and 45.4% of the biomass. The Ephemeridae of Big Lake accounted for 37.5% of the numbers and 21.1% of the biomass.

Sampling from the main channel during 1973 showed it to be somewhat less productive (as would be expected with a sandy substrate), although quantitative sampling was not done behind wing-dams where the diversity and productivity is usually noticeably higher.

Planktonic Organisms

The data collected by Claflin (1972) are shown in Table 14 and Table 15. Dr. Claflin concluded that there were no extreme differences among the

Table 14

Occurrence of Phytoplankton Collected Above and Below the Heated Outfall of the Dairyland Power Cooperative Complex at Genoa, Wisconsin

ORGANISM	ORGANISMS/liter LOCATIONS			
	Tran. A	Tran. B	Tran. C	Tran. D
Ulothrix aequalis, Kuetz	18,581	35,325	15,651	25,488
Ulothrix variabilis, Kuetz	4,940	7,957	3,803	7,213
Scenedesmus quadricauda, (Turp.) de Brebisson	480	524	349	568
Scenedesmus dimorphus, (Turp.) Kuetz	568	349	262	306
Pediastrum boryanum, (Turp.) Meneghini	262	874	306	437
Pediastrum duplex, Meyen		174		131
Golenkinia radiata, (Chod.) Wille	43			
Selenastrum westii, Smith		306		
Tetraedon trigonum, (Naez.) Hansgirg		131		
Pandorina morum (Muell.) Bory		43		
Gloeocystis gigas (Kuetz.) Lagerheim				174
Actinastrum hantzchu, Lagerheim	87	393	43	262
Staurastrum paradoxum, Meyen			87	87
Coelastrum microporum, Naegeli			43	43
Chlomydomonas sp.	87			87
Ankistrodesmus falcatus (Chod.) Lemm				43
Anabaena circinalis, Rabenhorst	218	131	87	87
Oscillatoria sancta. (Kuetz.) Gomont	918	612	349	306
Gomphosphaeria lacustris, Lemm	43	43	43	87
Nodularia spumigena, Mertens	393	87		43
Merismopedia elegans, Braun	43			
Dactylococcus fasciculoris, Lemm	43			131
Chroococcus minor, (Kuetz.) Naegeli				218
Phormidium retzii, (Ag.) Gomont	174	43	131	
Microcystis aeruginosa, Kuetz, emend, Elenkin		87		
Euglena sp.	43		43	
Dinobryon sertularia, Ehrenberg				43
Navicula sp.	306		218	393
Synedra delicatissima, W. Sm.	918	393	306	480
Stephanodiscus astraea, Grun.	5,246	568	1,748	3,104
Fragillaria crotonensis, Kitton	480	830	524	1,049
Melosira distans, Kutz.	1,136	7,476	131	480
Asterinella formosa, Hass.	4,109	5,333	2,229	3,934
Asterinella ralfsii, W. Sm.	743	524	87	262
Gyrosigma acuminatum, Rabenhorst		87		

Source: Claflin (1972

Table 15

Occurrence of Zooplankton Collected Above and Below the Heated Outfall of the Dairyland Power Complex

Organisms	Number of Organisms Per Liter			
	Upstream Transect	Downstream Transects		
	A	B	C	D
Eucyclops agilis	16.3	14.6	16.0	15.2
Cyclops vernalis	2.2	.3	.1	.7
Diatomus ashlandi	.5	.7	.3	.4
Diaptomus sp.	.3	.4	.1	.2
Daphnia pulex	1.3	1.7	.8	.7
Daphnia longispina	2.0	.9	3.9	1.9
Bosmina longirostris	.3	.6	.5	.4
Biomass* (mg. dry wt./l.)	4.686	5.069	4.025	5.392

*Phytoplankton and zooplankton combined.

Source: Claflin (1972)

four transects in phytoplankton or zooplankton species diversity. *Ulothrix* was the dominant green algae at all stations. Diatoms were represented mainly by *Stephanodiscus*, *Melosira* and *Asterinella*. No large standing crops of undesirable blue-green algae were found. Zooplankton population densities range from 0.2 to 16.3 organisms per liter of water sieved through a #20-mesh net. *Eucyclops agilis*, a copepod, was the most common form. Biomass, expressed as milligrams of dry weight per liter of phytoplankton and zooplankton combined, ranged from 4.025 to 5.392.

Plankton data collected during 1973 are shown in Appendix A. Samples were taken with a pump, and passed through a #20 monofilament nylon net. These data do not differ much from the samples collected by Claflin (1972). Transect CC was the most productive, with a mean number per liter (phytoplankton and zooplankton) of 86,365. Big Lake was also quite productive with a mean of 73,771 per liter. Biomass calculations were not too reliable due to the quantity of abiotic materials suspended in the river water.

Water Quality

The chemical parameters of water quality of Pool 9, as reflected from sampling in the main channel at the Dairyland Power Station at Genoa, suggests that the water is of relatively high quality (Table 16). The discharge water from this power plant appears to be within the Iowa and Wisconsin standards for chemical effluents.

Cooling water for the main condenser of the Dairyland Power Station at Genoa (referred to as the LaCrosse Boiling Water Reactor, or LACBWR)

Table 16

Intake and Discharge Water Quality

Parameter	Intake Untreated for Cooling mg/l	Discharge mg/l
Alkalinity	142	133
B O D	2	3
C O D	7	14
Total Solids	225	280
Total Dissolved Solids	220	250
Total Suspended Solids	34	30
Total Volatile Solids	100	80
Ammonia (as N)	0.10	0.10
Kjeldahl Nitrogen	1.0	1.10
Phosphorous (as P)	0.20	0.21
Nitrate (as N)	1.24	1.1
Turbidity	7*	7*
Organic Nitrogen	0.9	1.0
Sulfate	14.	12.
Sulfite	5.0	5.0
Chloride	10	7
Chromium	0.05	0.05
Potassium, total	2.30	2.90
Sodium, total	7	13
Zinc, total	0.10	0.05
Phenols	0.001	0.001
Surfactants	0.05	0.05

*Jackson Units

Source: Dairyland Power (1972)

is withdrawn from the Mississippi River. The total transit time for the LACBWR cooling water from intake to discharge is 2.14 minutes. The heated water enters the Mississippi River as a surface discharge and flows into Thief Slough. The cooling water from the LACBWR is discharged at the rate of 71 or 142 c.f.s. depending on whether one or two pumps are in operation. The increase in temperature of the effluent at full power compared to temperatures of intake water, ranges from 11 to 33°F, with higher temperatures for winter months resulting from recirculation of discharge water to de-ice the intake structure.

Section 3-A-1 of Water Quality Standards for Wisconsin applies to surface waters where fish reproduction is of primary importance. For waters of this type, temperatures are not to exceed 84°F, and temperatures are not to exceed ambient temperature by more than 5°F outside a "zone of mixing". Section 3-B-1 of the standards, applicable to surface waters where fishing is desirable in conjunction with other uses, stipulates that temperatures shall not exceed 90°F and temperatures outside the zone of mixing also shall not be elevated in excess of 5°F.

The waters of the Mississippi River in the Genoa area of Pool 9 have been classified by Wisconsin DNR water quality personnel as an interstate water. Assuming that the mixing zone is defined as Thief Slough to the lower end of Island 126, the combined discharge from the LACBWR and Genoa 3 is within even the more stringent standard.

The heated effluent is not detectable in the Iowa section of the Mississippi River during the warm months. In winter, it elevates the temperature sufficiently to keep the river ice-free for some distance below the Iowa boundary, 4.5 miles south of the plant. However, an increase of a fraction of a degree above freezing is sufficient to prevent the formation of ice.

Biologists familiar with the Genoa area indicate that fishing in the upper portion of Thief Slough has improved for winter months. This is attributed to the heated effluents from the LACBWR. Plant operations have apparently had no adverse affects on commercial fishing in Pool 9.

The data collected on water chemistry during 1973 is presented in Appendix A. Some mean values for the three standard transects and Big Lake are shown in Table 17. The Turbidity and total solids of the Upper Iowa River were always higher than for the main channel of the Mississippi. This was most noticeable after a heavy rainfall, like occurred in the Upper Iowa Watershed on 17 June, 1973. Samples from the lower channelized portion of the Upper Iowa on 19 June 1973 had turbidity readings as high as 180 JTU's and total solids as high as 1548 mg/l. Samples the same date from the main channel of the Mississippi River had values which did not exceed 38 JTU's of turbidity and did not exceed 312 mg/l total solids.

Bacterial analysis reflected the fact that Upper Iowa River drains agricultural land (Table 18). Bacterial counts were generally much higher from this tributary than from the Mississippi River itself.

Attempts were made during 1973 to get some preliminary data on the rate of sedimentation in Big Lake. There was considerable concern expressed over the loss of water depth of the lake in the past two decades.

Table 17

Mean values of some chemical parameters estimated during 1973

	Total Alkalinity mg/1	Turbidity JTU	Diss O_2 mg/1	Ortho-PO_4 mg/1	Nitrate-Nitrite N mg/1
Transect AA	130	16	7.8	0.58	0.10
Transect BB	145	15	10.5	0.73	0.60
Transect CC	133	27	6.8	0.47	0.25
Big Lake	138	31	7.6	0.56	0.08

Table 18

Bacteriological Data Comparing the Upper Iowa (Station 47) with the Main Channel of the Mississippi River about 0.5 mile below mouth of the Upper Iowa*

Date	Bacteria/100 ml	Upper Iowa	Miss. River
9 June 1973	Total Coliforms	47,500	280
	Fecal Coliforms	3,400	80
	Fecal Strep.	960	167
	FC/FS	3.54	0.48
17 July 1973	Total Coliforms	1,800	1,000
	Fecal Coliforms	200	250
	Fecal Strep.	155	300
	FC/FS	1.71	0.83
9 August 1973	Total Coliforms	209,000	7,550
	Fecal Coliforms	77,300	317
	Fecal Strep.	47,000	345
	FC/FS	1.93	0.92

*Counts were made using membrane filtration as described in APHS, 1971.

Eight weighted stainless steel pans (about 4.5 inches deep and 1.5 $ft.^2$ in area) were placed at various locations throughout the lake. Unfortunately, apparent vandalism prevented the retrieval of all except one of these pans. The one pan (at sampling station 33) from which data were obtained had 1574.7 grams of sediment between 15 July - 29 August, and 1463.8 grams of sediment between 29 August - 29 September. After both periods the depth of the sediment was about 0.75 inch. Rainfall data from the Decorah, Iowa weather station (Decorah is located in about the center of the Upper Iowa Watershed which is the largest drainage area added within Pool 9) recorded 4.98 inches between 15 July - 29 August, and 4.24 inches between 29 August - 29 September.

The analysis of waters entering Big Lake showed that the mean turbidity values, and total solids, were higher than waters at the outlets of Big Lake. Further sampling is needed to determine vertical differences in solids for entering and exiting sloughs. Once this is established it should be possible to get a better picture of the sedimentation rate.

There was evidence that in some of the backwater habitats there was a temporary thermal stratification with low dissolved oxygen values in the bottom waters. For example, at sampling site 12 on transect BB on 14 June water depth was 3 feet. Surface temperature (about 2:00 pm) was 30°C and the dissolved oxygen was 14 mg/l. At a depth of 2.5 feet the temperature was 20°C, and the dissolved oxygen was 6 mg/l.

Fish

There are 80 species of fish reported from Pool 9 (UMRCC, 1967), and 38 species are known from its main tributary, the Upper Iowa River (Table 19).

Table 19

FISH SPECIES OF THE UPPER IOWA RIVER DRAINAGE BASIN
AND POOL NINE OF THE MISSISSIPPI RIVER

	Upper Iowa*	Pool Nine**
Silver Lamprey		x
Chestnut Lamprey		x
Lake Sturgeon		x
Paddlefish		x
Skipjack Herring		x
Brown Trout	x	x
Rainbow Trout	x	x
Brook Trout	x	x
Grass Pickerel		x
Muskellunge		x
Central Mudminnow		x
River Carpsucker	x	x
Northern Hogsucker	x	x
White Sucker	x	x
Quillback Carpsucker	x	
Spotted Sucker		x
Golden Redhorse	x	x
Silver Redhorse		x
Blue Sucker		x
Smallmouth Buffalo		x
Largemouth Buffalo		x
Black Buffalo		x
Stoneroller	x	x
Common Shiner	x	x
Spotfin Shiner	x	
Spottail Shiner		x
Rosyface Shiner	x	x
Sand Shiner	x	x
Bigmouth Shiner	x	x
Golden Shiner		x
Pallid Shiner		x
Ghost Shiner		x
Weed Shiner		x
Mimic Shiner		x
Suckermouth Minnow	x	x
Bluntnose Minnow	x	x
Flathead Minnow	x	x
Bullhead Minnow		x
Brassy Minnow		x
Longnose Dace	x	x
Blacknose Dace	x	
Creek Chub	x	x
Speckled Chub		x
Southern Redbelly Dace	x	

Table 19 (Continued)

	Upper Iowa*	Pool Nine**
Hornyhead Chub	x	
European Carp	x	x
Black Bullhead	x	x
Brown Bullhead	x	x
Stonecat	x	x
Channel Catfish		x
Yellow Bullhead		x
Blue Catfish		x
Flathead Catfish		x
Tadpole Madtom		x
American Eel		x
Trout Perch		x
Pirate Perch		x
Burbot		x
Largemouth Bass	x	x
Smallmouth Bass	x	x
Rockbass	x	x
Black Crappie		x
White Crappie		x
Orangespotted Sunfish		x
Green Sunfish		x
Pumpkinseed		x
Bluegill		x
Warmouth		x
Western Sand Darter		x
Mud Darter	x	x
Bluntnose Darter		x
Iowa Darter		x
Johnny Darter	x	x
Banded Darter	x	x
Blackside Darter		x
Slenderhead Darter	x	x
River Darter		x
Yellow Perch		x
Log Perch		x
Sauger		x
Walleye	x	x
Rainbow Darter	x	
Fantail Darter	x	
Brook Silverside		x
Freshwater Drum		x
White Bass		x
Yellow Bass		x
Slimy Sculpin	x	
Brook Stickleback	x	

*Source: Records from studies at Luther College
**Source: UMRCC, (1967)

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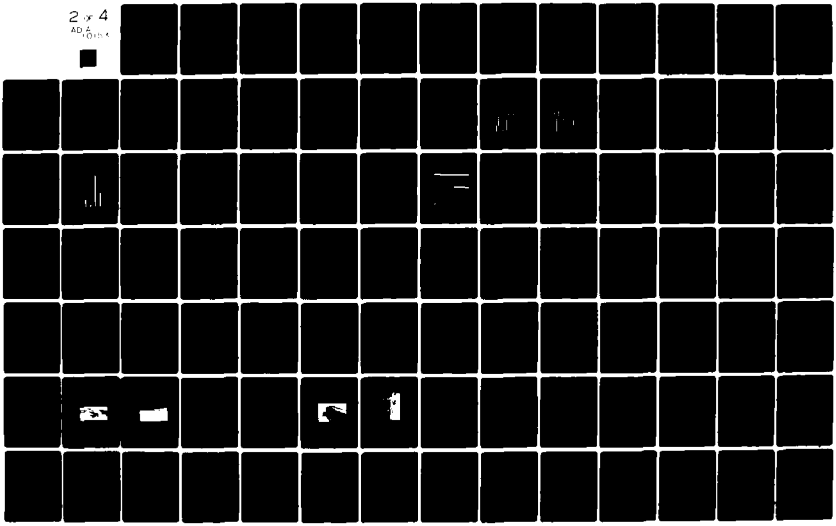
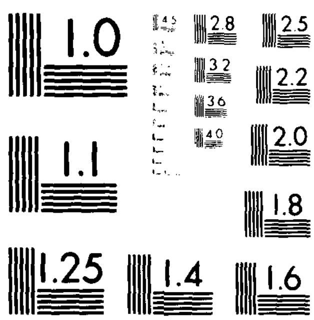




MICROCOPY RESOLUTION TEST CHART

Fish catches in Pool 9 are discussed later in socioeconomic material in both sections 2 and 3 of this report.

Aquatic vegetation

There has been considerable development of aquatic and marsh vegetation in Pool 9 since impoundment. A species list of common aquatic plants is included (Table 20), and the summary which follows from Green (1960) is quite appropriate to this vegetation of Pool 9.

The year following impoundment, very dense beds of Muhlenberg's smartweed came in, often in such dense beds that the bottoms took on the reddish tinge of the blooms. For several years this species supplied an abundance of duck food. It was the growth of this species which led to the enthusiasm with which Fisheries and Wildlife personnel greeted initial improvement following first impoundment. For about five years following flooding this species produced an abundance of seed and during that time held the distinction of being the most important single species of duck food on the entire Upper Mississippi Refuge. After about five years it was found that although in some areas it continued to make vegetative growth, in a few areas where it still hung on it was almost entirely sterile. With the disappearance of this plant many areas had greatly reduced aquatic growth. Since then various other aquatics, notably the pondweeds, have come in and have replaced it.

River bulrush, which was probably the most common marsh species prior to impoundment, has continued to be an important marsh plant. Coming in dense, solid stands for several years following impoundment, this species deliquesced for a few years, but has since made a comeback and is at present

Table 20

List of Common Aquatic and Marsh Plants
Found in the Upper Mississippi River

Common Name	Scientific Name
American Pondweed	Potamogeton americanus
Sago Pondweed	Potamogeton pectinatus
Leafy Pondweed	Potamogeton foliosus
Flatstem Pondweed	Potamogeton zosteriformis
Curly Pondweed	Potamogeton crispus
Redhead grass Pondweed	Potamogeton richardsoni
Ribbonleaf Pondweed	Potamogeton epihydrus
Horned Pondweed	Zannichellia
Bushy Pondweed	Naias
Waterweed	Elodea
Duckweed	Lemna
Coontail Hornwort	Ceratophyllum
Water-milfoil	Myriophyllum
Bladderwort	Utricularia
Buttercup	Ranunculus
Lotus	Nelumbo
Waterlily	Nymphaea
Wild Celery	Vallisneria
Water-Stargrass	Heteranthera
Wild Rice	Zizania
Burreeds	Sparganium
Smartweed	Polygonum
Bulrush	Scirpus
Cattail	Typha
Arrowhead	Sagittaria
Cutgrass	Leersia

Source: U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sports Fisheries and Wildlife.

an important marsh species, especially for muskrats. Although this species seldom sets seed to any extent on the river, there have been years when it seeded heavily, and then it was of considerable value to waterfowl also.

Cattail is still rare, although extending its range somewhat. Most of the stands are Typha latifolia, although there are several small areas in which T. augustifolia occurs.

Burreed was present and well distributed, but not too abundant prior to flooding. Since impoundment this species has increased markedly. Shortly after impoundment the burreed-arrowhead association was probably the dominant emergent association, but with the increase in other emergents, together with some reduction in burreed, the association is of lesser importance at the present time. It is still abundant enough, however, to be important for waterfowl cover, and for muskrat housebuilding material.

Rice cutgrass is well distributed on ridges and islands. Locally, extensive marginal stands of this species occur, and since it usually seeds well, it is an important food. In wooded areas another cutgrass (Leersia lenticularis) is often more common than is rice cutgrass. Both species are valuable as duck food.

Extensive stands of arrowhead occur, with Sagittaria latifolia on the semidry margins and shallow water, followed by a zone of S. arifolia, and with S. heterophylla in beds in deeper water. While these plants are often found in association with burreed and the bulrushes, there are extensive pure stands in many areas. These plants are important both to waterfowl and muskrats.

Probably the most common aquatic macrophytes of Pool 9 are American pondweed, sago, leafy pondweed, small pondweed, flat-stemmed pondweed, bush pondweed, curly muckweed, coontail, elodea, water stargrass, wild celery, and the pond lilies.

Perhaps the most abundant species is American pondweed, which is the most important single species of aquatic so far as waterfowl food is concerned. This species occurs in extensive beds in a great variety of conditions from very shallow water to deep flowing channels. In some places this species grows in such dense beds over extensive areas that boat travel is rendered difficult. It makes its best growth in water 12-30" in depth. This species normally is a heavy seeder and is of outstanding importance as waterfowl food.

Sago and flat-stemmed pondweed are also well distributed and abundant, both mixed with other aquatics and in pure stand. Sago ranks a close second to American pondweed, and has been increasing steadily. Flatstem, on the other hand, has fluctuated up and down, but at this time ranks about third among pondweeds, and is often in pure stand over wide areas.

The coontail-elodea association formerly was the most common in ponds and lakes prior to filling of pools. Even after flooding the group was for a time the dominant aquatic association on the Upper Mississippi. With continued stabilization of water, however, this association has been replaced over wide areas by pondweeds.

The sampling along Transect AA and BB during 1973 showed extensive stands of emergents Sagittaria sp. and Sparganium sp. (Table 21).

Terrestrial vegetation

Prior to the construction of the lock and dam, the river bottoms in the region presently known as Pool 9 were primarily wooded islands. There were some hay meadows on the islands, together with some small farming areas, but the bottoms were essentially wooded. Marsh development was limited to the shores of lakes and cuts leading off the sloughs. Marsh flora was also limited, with river bulrush making up the dominant habitat. These marshes probably dried up completely by the end of the summer. (Green, 1960).

At present floodplain forest dominates the vegetation of the north end of Pool 9 (See Table 22). The dominant trees are American Elm, Red and Silver Maple and Green Ash, with others present as indicated in Table 23. The typical pattern is one of nearly pure small stands of a single species of the three dominant trees. In some cases an area will be totally dominated by large trees (nearly 20 feet in circumference), with trees spaced 75 feet or more apart and no understory tree or tree seedling present.

Within the forests which make up most of the area in the north end of Pool 9, herbaceous vegetation patterning is determined by the time at which soil surfaces are free of standing water in the early part of the growing season. The earliest land to emerge in those areas completely dominated by trees is covered with solid stands of Wood Nettle (Laportea canadensis), with Green Dragon (Arisaema dracontium) generally present in in limited numbers. Parts of the forest floor emerging before mid-June

Table 21

Extent of Most Common Aquatic Vegetation
Intercepted along Transects*

Plant	Transect AA	Transect BB
Sagittaria sp.	665	3035
Sparganium sp.	610	1950
Potomogeton sp.	200	435
Lemna sp.	210	335
Ceratophyllum sp.	200	230
Lotus	30	210

*Values shown are approximate number of feet along transect (about a 2 meter wide transect) where plants were present. In most cases there were not pure stands so that these numbers are not additive to give total extent of aquatic vegetation along transect. Sampling done during last half of July, 1973.

Table 22

Percentage of North (AA) and Middle (BB) Transects in Various Vegetational Categories

	Transect AA	Transect BB
Forested area Elm, Maple, Ash Birch Willow	53.0%	29.5%
Shallow back-waters, mud flats, marsh	30.9% includes running sloughs	54.9%
Running sloughs	-	8.9%
Main channel	9.2%	6.6%
Industrial (Dairyland Power Co. property)	6.8%	-

Table 23

Density, Dominance, Frequency and Importance Value for the Species in Pool 9

Species	TRANSECT AA* Density stems/acre	TRANSECT AA* Dominance Basal-area/acre	TRANSECT AA* Frequency % occur-rence	TRANSECT AA* Importance Value	TRANSECT BB** Density stems/acre	TRANSECT BB** Dominance Basal-area/acre	TRANSECT BB** Frequency % occur-rence	TRANSECT BB** Importance Value
American Elm	108.3	7805	.80	106.8	159.5	14608	.87	142.6
Red Maple***	70.5	10699	.60	92.1	64.8	10202	.52	80.5
Green Ash	38.9	5988	.38	53.7	39.8	1158	.39	34.7
Silver Maple***	11.8	2177	.13	18.0				
River Birch	4.4	582	.06	6.6	11.6	686	.13	12.1
Black Willow	1.3	205	.02	2.1	6.6	1087	.08	9.9
Swamp White Oak	0.5	2	.02	1.1	11.6	163	.10	9.3
Peach Leaf Willow	0.6	143	.01	1.2	8.3	604	.06	7.8
Poplar (all species)	2.5	1181	.03	6.3				
White Ash	4.8	768	.08	8.4	3.3	33	.04	3.2
Burr Oak	1.0	485	.008	2.4				
Sandbar Willow	1.9	14	.01	1.3				
Black Ash	0.6	89	.01	1.0				

*Values based on 100 point-quarter samples with a minimum of 10 points in each forest stand of more than 4 acres that the transect line intercepted.

**Values based on 60 point-quarter samples with a minimum of 10 points in each forest stand of more than 4 acres that the transect line intercepted.

***The distinction between these two species is difficult to make precisely. They could be lumped in a soft-Maple complex for the purposes of this investigation.

are likely to have at least some wood nettle coverage. Those shaded places emerging later are likely to have no herbacious understory cover at least up to the end of July, and few or no plants flowering or setting seed before killing frosts. Patches of sensitive fern (Onoclea sensibilis) are locally present, but not common. Poison Ivy (Rhus radicans) occurs abundantly in those places where more light reaches the forest floor. Common Elder (Sambucus canadensis) is often obvious in more open sunny areas within the forest, along with Wood Nettle, which is by far the most abundant and widespread understory herb. Elder and Poison Ivy are the most common shrub layer vegetation, although neither is abundant in the forest proper. Vine form Poison Ivy, Virginia Creeper (Parthenocissus sp.), Wild Grape (Vitis sp.) and Smilax sp. are the common woody vines. The high unshaded edges of running sloughs in the forest areas often have thick stands of Reed Canary Grass (Phalaris arundinacea).

In shallow backwater areas with gently sloping shores and around larger woodland ponds at the north end of Pool 9, vegetation zones related to water depth are obvious. Sparganium species and Sagittaria species are most abundant emergents in these zones. Sagittaria sp. most often form the zone in contact with open water, although they may be replaced by Sparganium sp. in this position or the two plants may be mixed. Most frequently the zone just uphill from the water margin is dominated by Sparganium sp. which may extend up to the forest edge, or be succeeded by a shrub willow zone, which ends abruptly at the forest edge. The forest margin is most often dominated by red or silver maple. Buttonbush (Cephalanthus occidentalis) and Wild Blue Flag (Iris versicolor) are obvious if not abundant inhabitants of the forest-Sparganium transition.

The vegetation zonation around ponds and shallow backwater areas in Pool 9 is shown in the diagram below.

Wet ———————————————————————————————————— Dry

Open water or mud flats with lotus or water lily, duckweed, Potamogeton	Sagittaria	Sparganium	Willow or Reed Canary Grass	Maples	Elm Maple Ash forest

The above diagram indicates the most complete zonation likely to be observed. In any given instance, one or more zones may be missing or reversed.

The central section of pool nine, represented in this study by transect BB (a line 300 feet south of Wisconsin Highway 82), is more water dominated than the north section. The forest stands sampled along the middle transect are, however, similar to those of the north transect. The calculated similarity index based on importance values for trees, is 77% which compares well with similarity idices calculated for different stands along the same transect. This approaches the maximum which might be expected for any two samplings of the same forest. No forested area on either transect is more than a few feet above water level, and they might be expected to show similar vegetation patterns.

With more water along the transect BB, there is more forest-water edge, with a greater development of the transitional vegetation zones previously described. Stands of shrub willow and dogwood are also common along the forest-water edge. Within forest stands, however, appearance and sampling both reinforce the idea of similarity for all sampled forest in pool nine. Small scale local dominance of a single tree species as described previously is only a function of differential patterns of reproduction and not evidence for several forest types.

Size class distributions for the three major dominant tree species were compiled from the sampling data, and cores were collected from a number of trees in an effort to correlate size with age for trees up to 10 inches Diameter Breast High (DBH). No correlation could be established and thus size classes could not be identified with age classes. The size distributions are included in Appendix A.

Areas near the main channel covered with old dredge spoil or with sandy outwash from such spoil are at a higher elevation than any other sites in pool nine, and support a vegetation different from other areas. They are dominated by low grasses, dry land annual and perrenial weeds, and small trees, mostly oaks. Willow shrubs are common in sections at lower elevations. These areas make up a very small part of the total land area of pool nine, but they are the places receiving most use and observation by recreational users of the river. These sites do not appear in the forest sampling data, since none intersecting the transects were large enough or old enough to merit forest sampling.

Wildlife

The Upper Mississippi River Wildlife and Fish Refuge contains an abundance of wildlife. The faunal composition of the refuge is determined in part by it being river bottomland, and in part by the curious blend of life zones found there. The area contains a rich mixture of vertebrate animals from the northern and southern United States, as well as an overlapping of eastern and western species. Since the Mississippi River is essentially a continuous link between the Great Lakes Region and the Gulf of Mexico, it provides a good route for aquatic and semi-aquatic species to utilize in range expansion. In addition, it is at the heart of the great Mississippi Flyway for bird migration.

Although the Upper Mississippi Refuge is not of great importance as a nesting area for waterfowl (other than wood ducks) it is an important resting area during spring and fall migration. Day use of Pool 9 by waterfowl ranged from 2,246,975 to 4,128,001 during the period from 1965 to 1971 (Table 24).

Several bird species occur in Pool 9 which are of special interest because of their status as rare or endangered species. Foremost among these is the bald eagle, of which there is a sizable winter population. Other species known to occur in Pool 9 which are of special interest include the osprey, double-crested cormorant, pileated woodpecker, and wood duck. There is one large heron rookery at about river mile 677.7 and just west of the main channel;it is currently being studied by the Bureau of Sports Fisheries and Wildlife.

The Pool 9 area contains many smaller mammals such as shrews, moles,

Table 24

Day Use by Waterfowl on Pool 9 of the
Mississippi River by 18-Week Periods

Year	Spring	Summer	Fall	Total
1965	475,237	316,520	1,794,550	2,586,301
1966	1,203,400	521,040	1,935,340	3,659,780
1967	801,920	473,310	1,299,925	2,575,155
1968	722,610	292,625	1,231,740	2,246,975
1969	792,645	415,530	1,508,470	4,963,620
1970	1,080,930	1,931,665	380,975	3,393,570
1971	903,496	500,045	2,724,470	4,128,011

Source: U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sports Fisheries and Wildlife, Upper Mississippi River Wild Life and Fish Refuge, Winona, Minnesota.

bats, rabbits, mice, and squirrels. Larger carnivores such as bobcat and coyote are infrequent with exception of the raccoon, red fox, and gray fox which are common in Pool 9. White-tailed deer is the most popular big game animal in Pool 9, while other big game animals are very limited in the area.

The fur-bearing animals of the region are represented in large numbers by the beaver and muskrat and to a lesser extent by minks and river otter. At high water levels when many of the beaver lodges are flooded, beavers are forced out into more open habitat. During such an occasion (20 March 1973) 40 beaver were counted while surveying the Pickerel Slough area of Pool 9. Appendix C contains tables of species of birds, mammals, amphibians and reptiles found in the Upper Mississippi River Wildlife and Fish Refuge.

A series of 11 time-area bird counts were conducted on Pool 9 of the Upper Mississippi River between 28 June 1973 and 10 July 1973 to determine the incidence and numbers of nesting species. The counts were made in mid-day, the earliest beginning at 10:30 a.m. and the latest ending at 3:20 p.m. The method used was simply a one hour walk by one observer recording everything seen and heard. An attempt was made to maintain a constant and steady speed so that these would be bona fide time-area counts, but frequently the topography made this impossible. The only deviation from this method was at site number 6, where a jon boat was allowed to drift down the Upper Iowa River for one hour.

Sites are arbitrarily numbered on the map from the southern end of the Pool to the northern end (Figures 24 - 27). The sites are then grouped

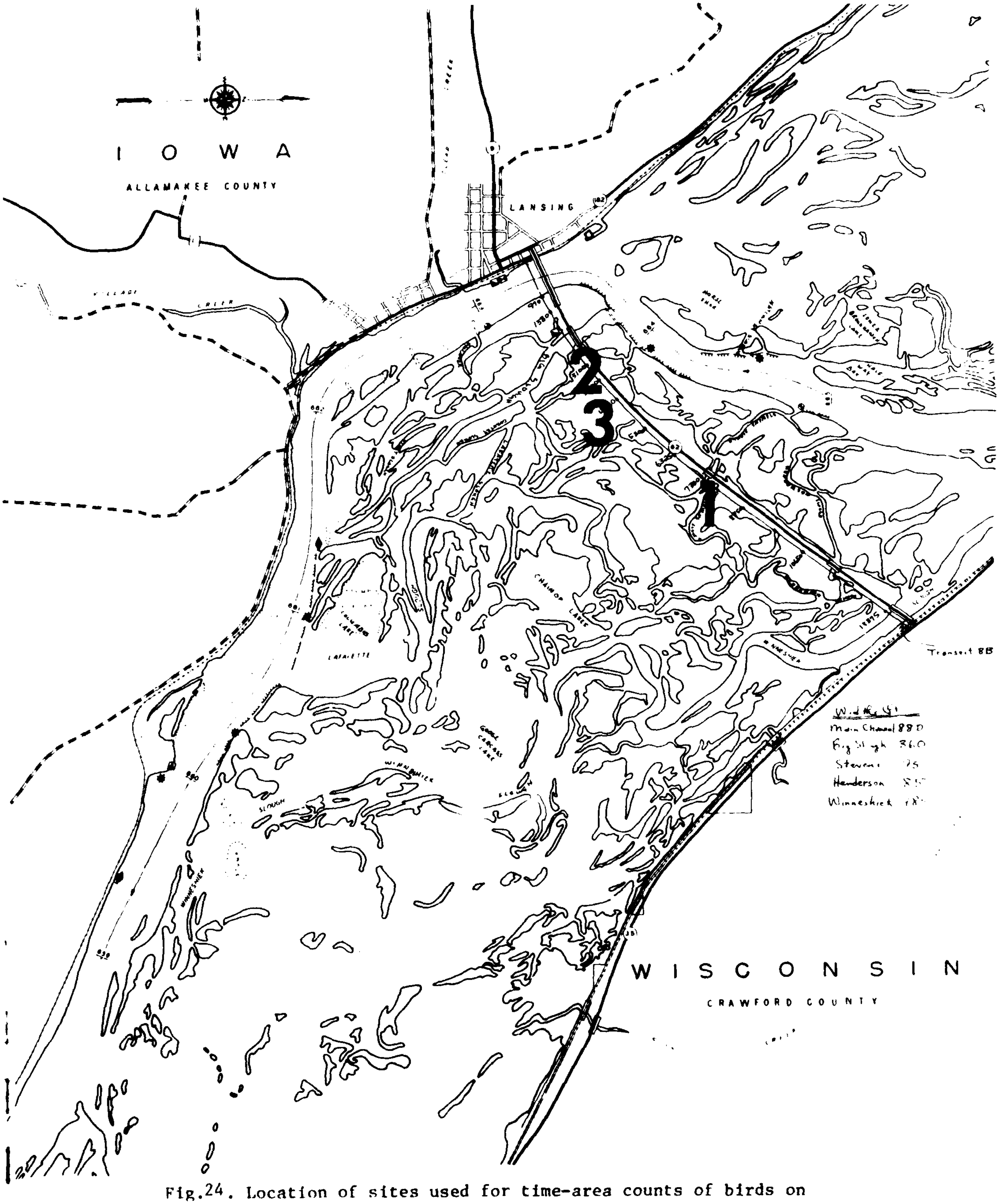


Fig.24. Location of sites used for time-area counts of birds on on transect BB, Pool 9, 1973.

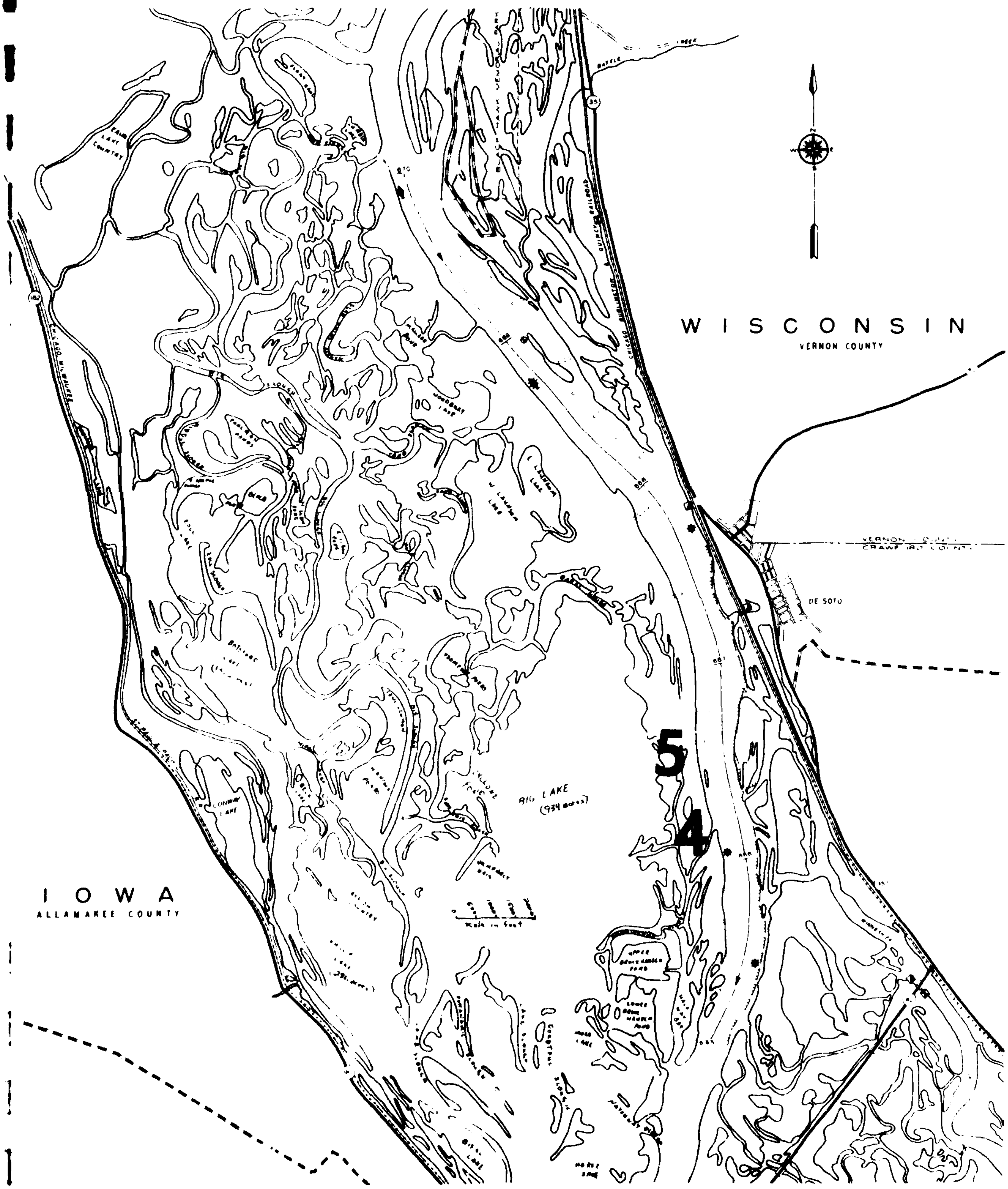


Fig. 25. Location of sites used for time-area counts of birds in in woodland habitat, Pool 9, 1973.

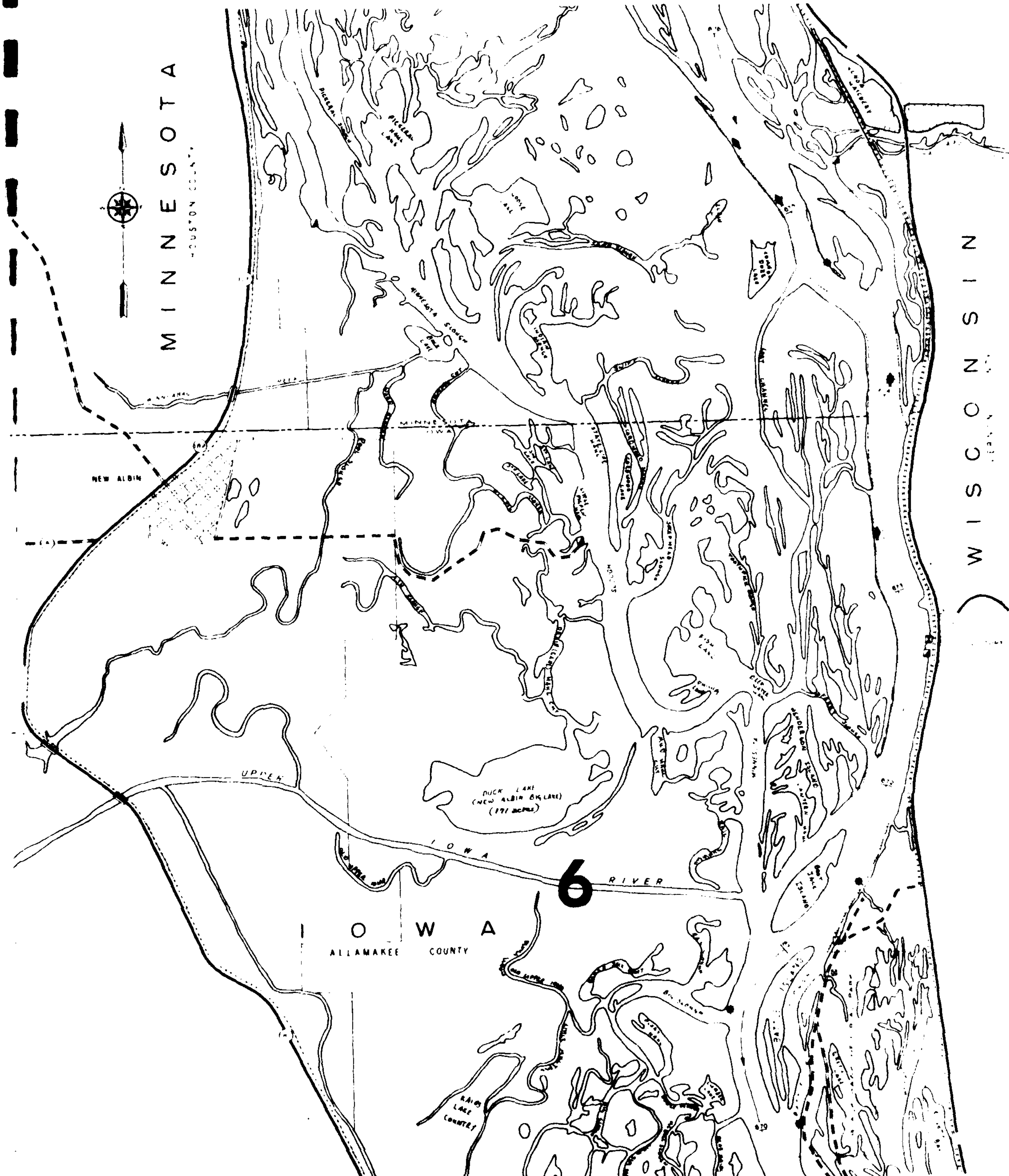


Fig.26. Location of site used for time-area bird count in flood plain of Upper Iowa River, Pool 9, 1973.

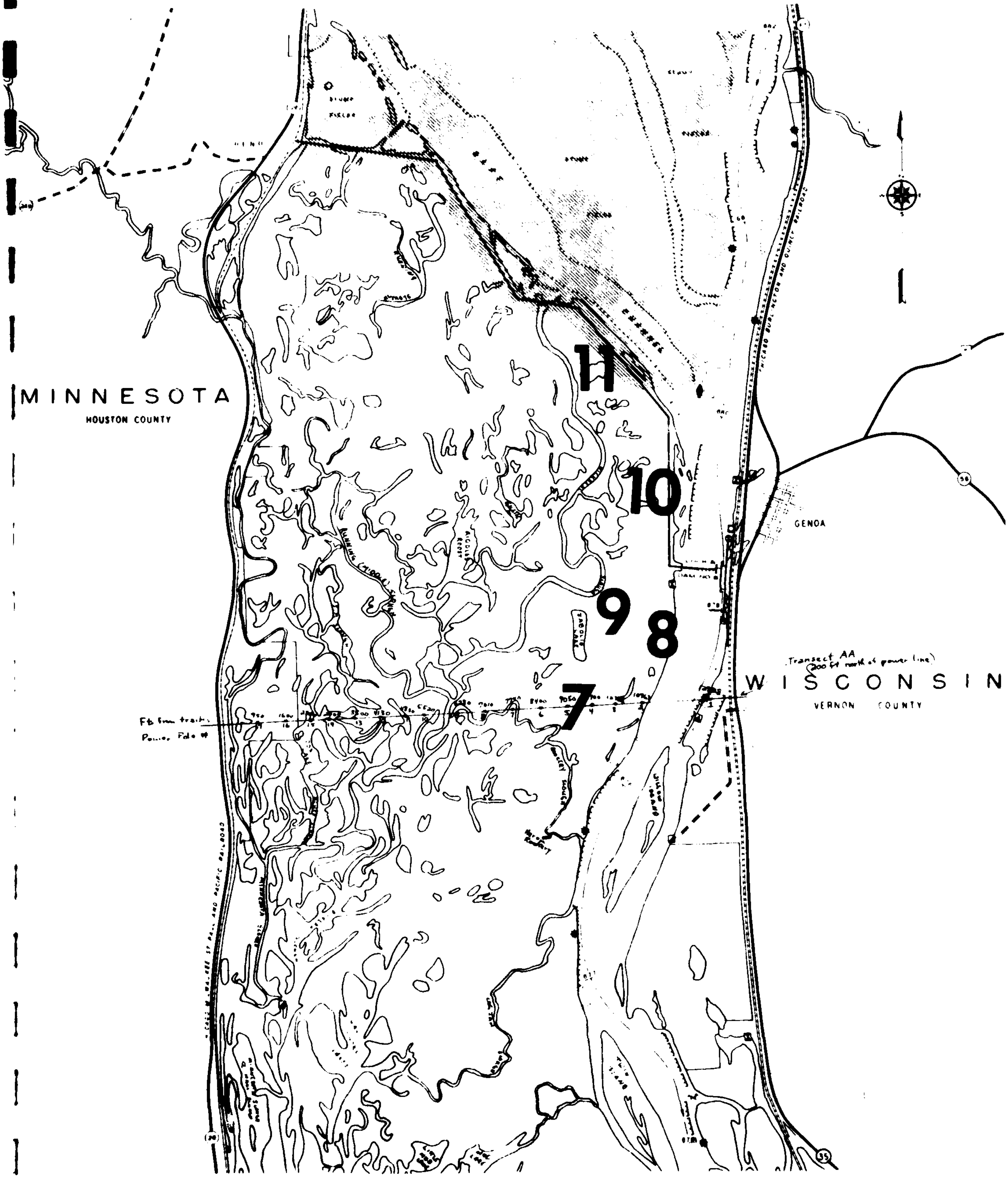


Fig.27. Location of sites used for time-area bird counts in the vacinity of transact AA, Pool 9, 1973.

by general habitat type in Table 25.

The results of this study indicate that channelization had little effect on either total numbers of different species or total numbers of birds using the selected portions (Figures 28,29). Site #6 was the only channelized section of river sampled, and it proved to be the richest of all the areas in both categories. This is in partial agreement with a similar study made in Indiana which showed that channelization had little effect on total species but reduced total numbers of birds (New, 1972).

As a group the ecotonal habitat types had a mean total species of 22.5 and mean total individuals of 115.5. The purer woodland habitats had a mean total species of 20 and mean total individuals of 93. These differences were probably not significant; if they were they might serve to illustrate a basic ecological principle - the phenomenon known as edge effect (i.e., the tendency for increased variety and density at community junctions).

Time-area counts of non-game avian species indicate the desirability of maintaining and encouraging as much habitat diversity as possible, consistent with other management goals. Avian species recorded in Pool 9 during the spring and summer of 1973 are presented in Appendix A.

During the period June 20 to July 19, 1973 a total of 1575 trap nights were expended trapping small mammals at five locations in Pool 9, Upper Mississippi River (Figures 30-31). A summary of the habitat types at these trap sites is presented in Table 26. The predominate species at all trap sites was Peromyscus. Both the Woodland Deer Mouse (Peromyscus maniculatus) and the white-footed mouse (Peromyscus leucopus) occured on transects AA and

Table 25

Habitat Description for Time-Area Bird Count Sites in Pool 9, Upper Mississippi River, 1973

Site Number	Descriptions
	(Woodland Habitat Sites)
1	Floodplain forest with mostly poison ivy understory, plus one large Sparganium patch.
3	Mostly floodplain forest with poison ivy understory, some slough edges.
4	Mostly floodplain forest with little understory; some slough edge.
5	Mostly floodplain forest with sparse understory of wood nettle; several ponds and willow thickets.
9	Deep floodplain forest with wood nettle understory.
	(Ecotonal Habitat Sites)
7	Reed canary grass (Phalaris) - floodplain forest edge.
8	Spoil bank - floodplain forest edge.
10	Edge of dike road (with prairie grasses) and floodplain forest - swamp.
11	Same as site 10.
	(Other)
2	Disturbed area; mostly dense willow thicket; interspersed with some floodplain forest.
6	Channelized river banks; in about half of the area banks were bordered by tall grasses, in the other half the river was bordered by willows and bottomland forest.

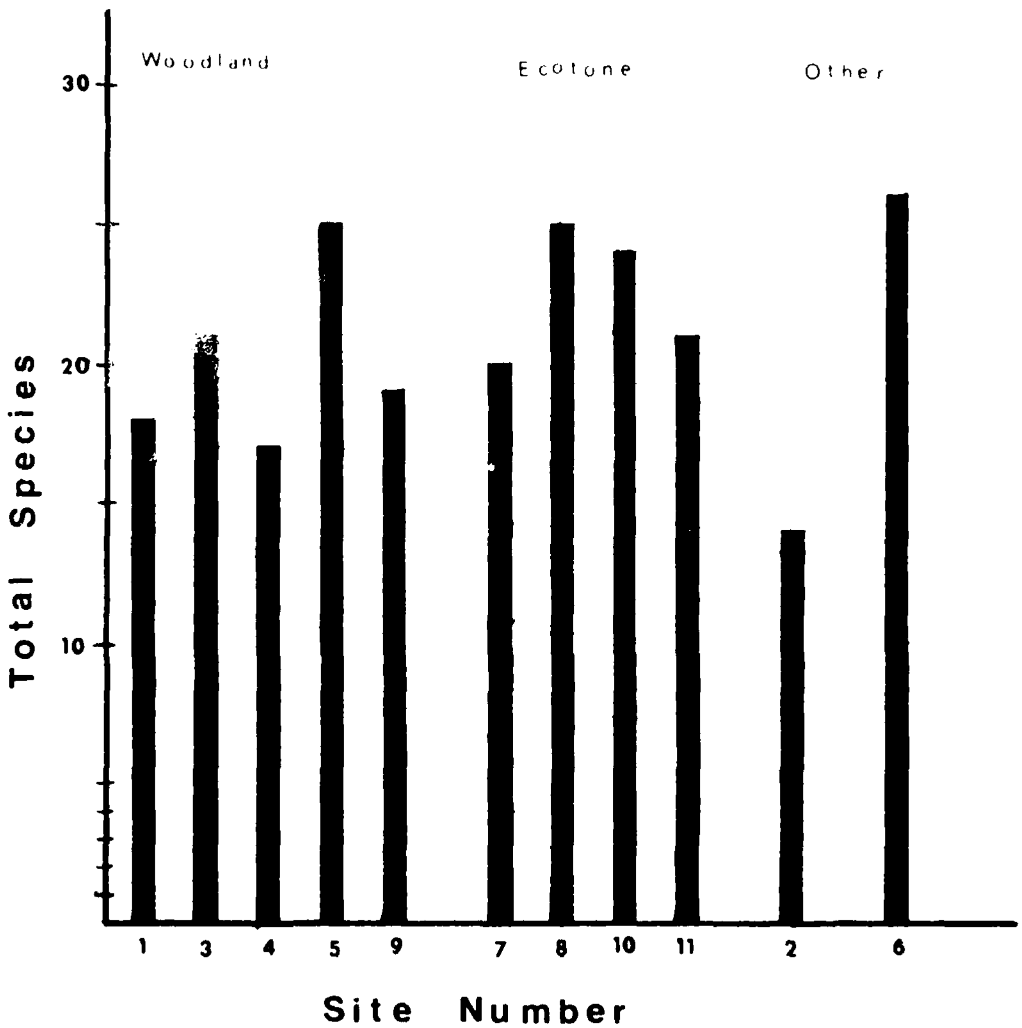


Fig. 28. Number of species of nesting birds observed at 11 sites in Pool 9, summer 1973.

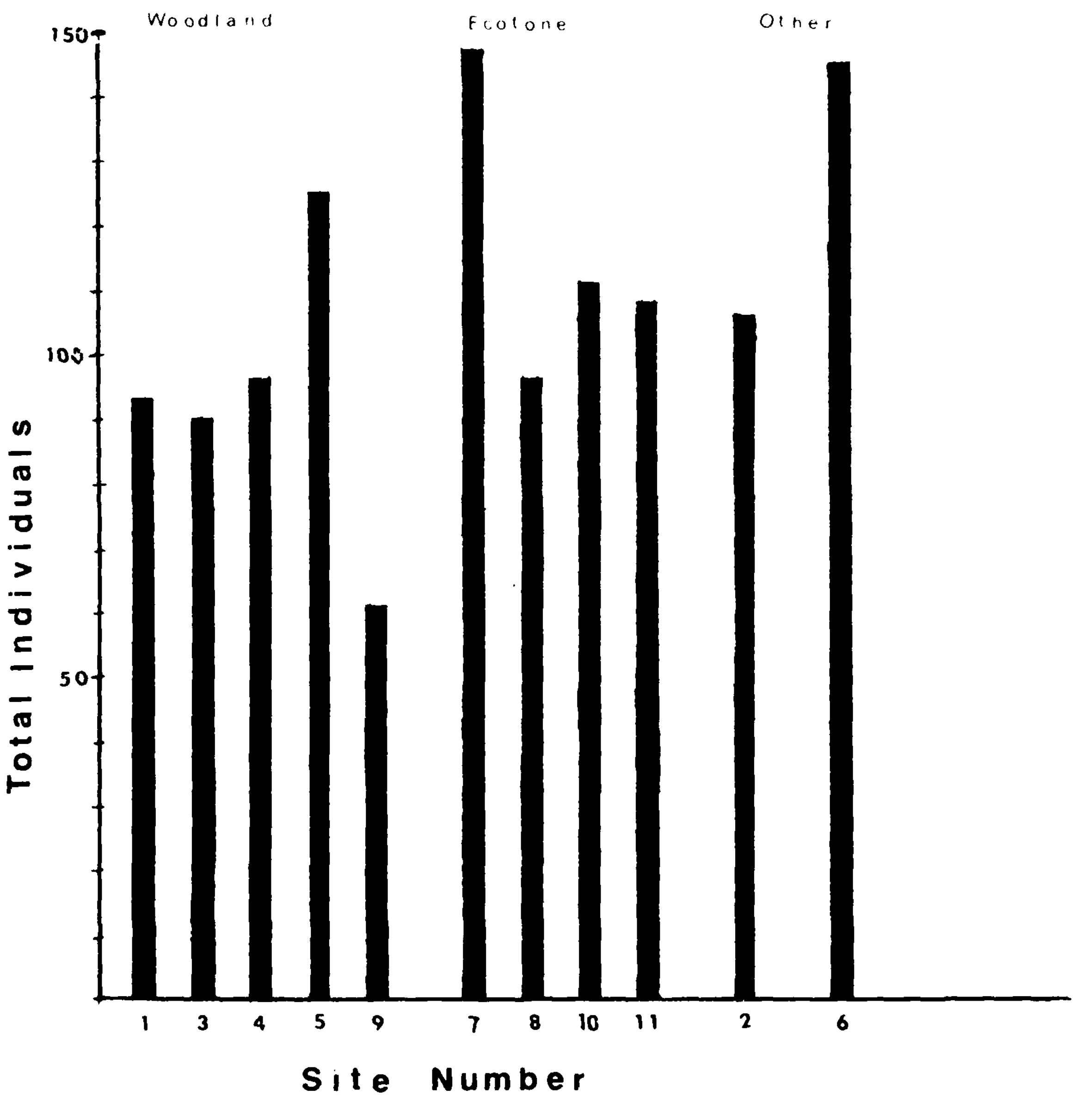


Fig. 29. Total number of nesting birds observed at 11 sites in Pool 9, summer 1973.

Figure 30. Island location of grid site used for small mammal population study on transect CC, Pool 9, Upper Mississippi River.

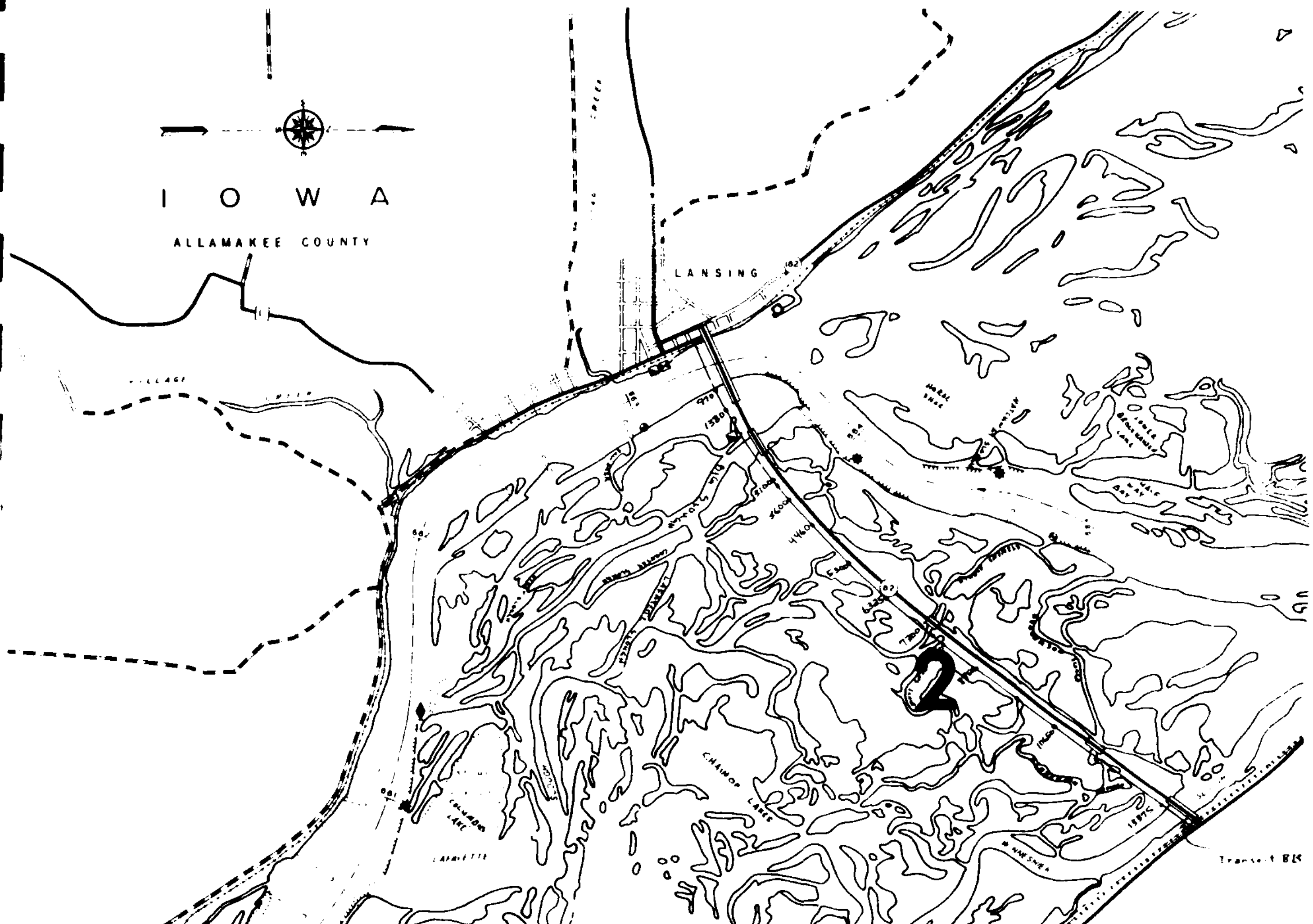


Figure 31. Location of line-transect site used for small mammal population study on transect BB, Pool 9, Upper Mississippi River.

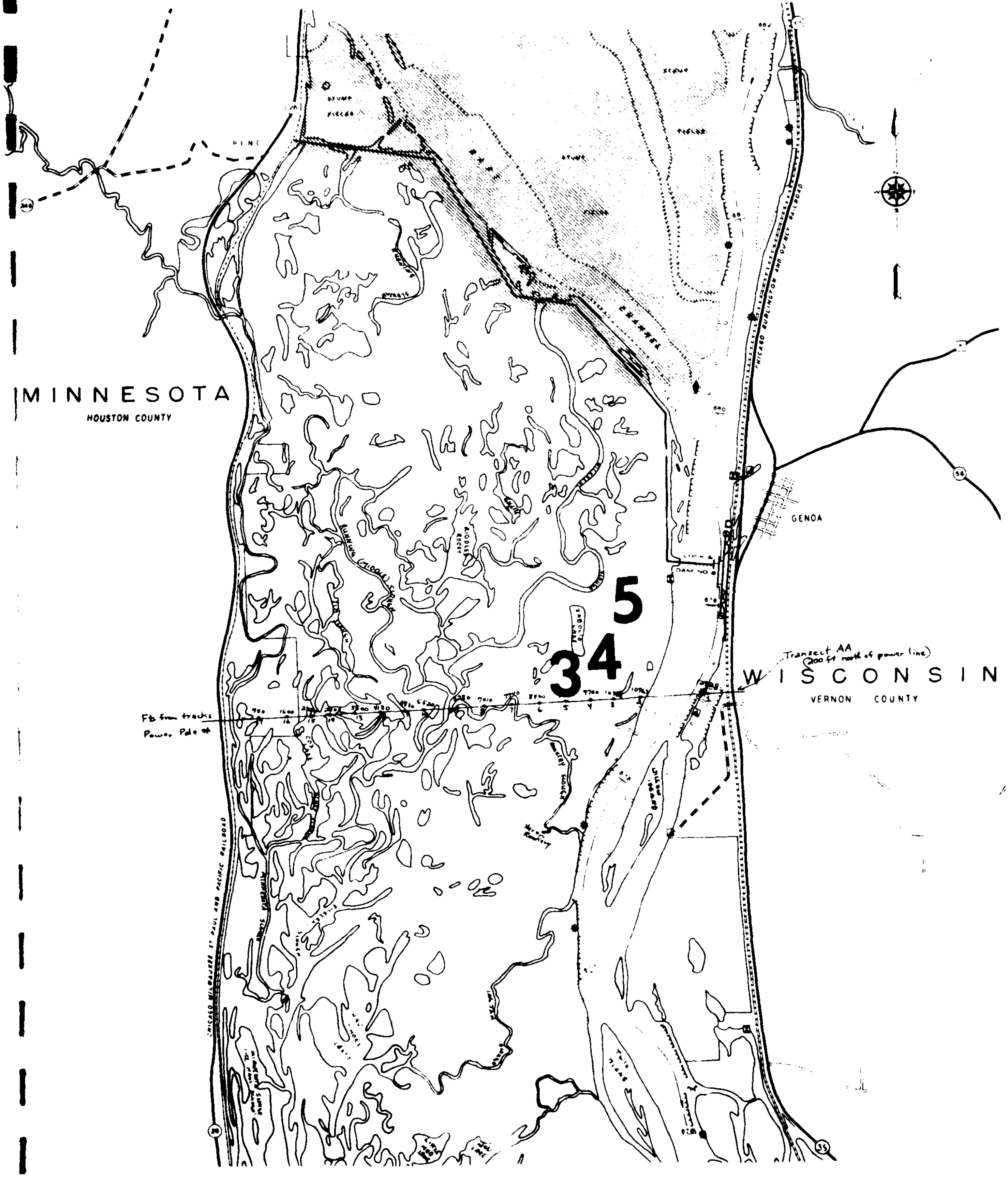


Figure 32. Locations of grid and line-transect sites used for small mammal population studies on transect AA, Pool 9, Upper Mississippi River.

Table 26

Habitat Descriptions for Sites Used in Small Mammal Population Studies, Pool 9, 1973.

Trap site	Transect	Description
1	CC	Island, floodplain forest dominated by River Birch, Cotton wood, American Elm and Burr Oak, understory of grapevine, Poison Ivy and grasses. (Elevation 0-4 feet above mean Pool level).
2	BB	Lowland floodplain forest dominated by Maple, American Elm, and River Birch, understory sparce with scattered grape-vines and Poison Ivy. (Elevation 1-3 feet above mean pool level).
3	AA	Lowland floodplain forest dominated by American Elm, Red Maple, Silver Maple and Green Ash. Area lacked understory with exception of one area of slightly higher elevation containing a stand of Wood Nettle. (Elevation 0-4 feet above mean Pool level).
4	AA	Upland floodplain forest dominated by American Elm, Slippery Elm, Silver Maple, Red Maple and Ash. Heavy understory of Wood Nettle and Poison Ivy. (Elevation 4-10 feet above mean Pool level).
5	AA	Upland floodplain forest and old spoil bank dominated by Elm, Maple and Ash. Understory was dominated by Wood Nettle, Poison Ivy and in higher elevation by Black Locust. Some old spoil areas with no understory. (Elevation 2-10 feet above mean Pool level).

and BB. All species appeared to be absent from the island on transect CC. This island is subject to periodic flooding and colorization of small mammals would appear to be very difficult. The third most abundant small mammal in the sample was the masked shrew (Sorex cinereus). No other species were captured. Estimated total numbers are shown in Figure 33.

During spring and summer of 1973 records of mammal sitings were kept by all project personnel. A checklist of these mammal sitings is presented in Appendix A.

Beaver and muskrat appeared to be relatively common in many areas of Pool 9 (River miles 660-679). Detailed statistics are compiled on these furbearer species by the Bureau of Sports Fisheries and Wildlife, USDI. These records are available from the BSFW office at Lansing, Iowa.

The White-tailed deer occurred commonly in the floodplain forest areas in the vicinity of transect AA. Habitat for deer will probably improve in the upper pool areas as the predominant tree, American Elm, succumbs to Dutch Elm Disease. This will increase the available radiant energy available in the understory and browse species of vegetation should increase in abundance.

During the spring and summer 1973 species sitings for amphibians and reptiles were recorded. This information is presented in Appendix A.

Spoil bank areas in the vicinity of transect AA appeared to be important congregating areas for turtles. It is undetermined if spoil bank utilization was a matter of preference or availability. Spoil banks were favored locations for the deposit of turtle eggs; however, these open bank areas

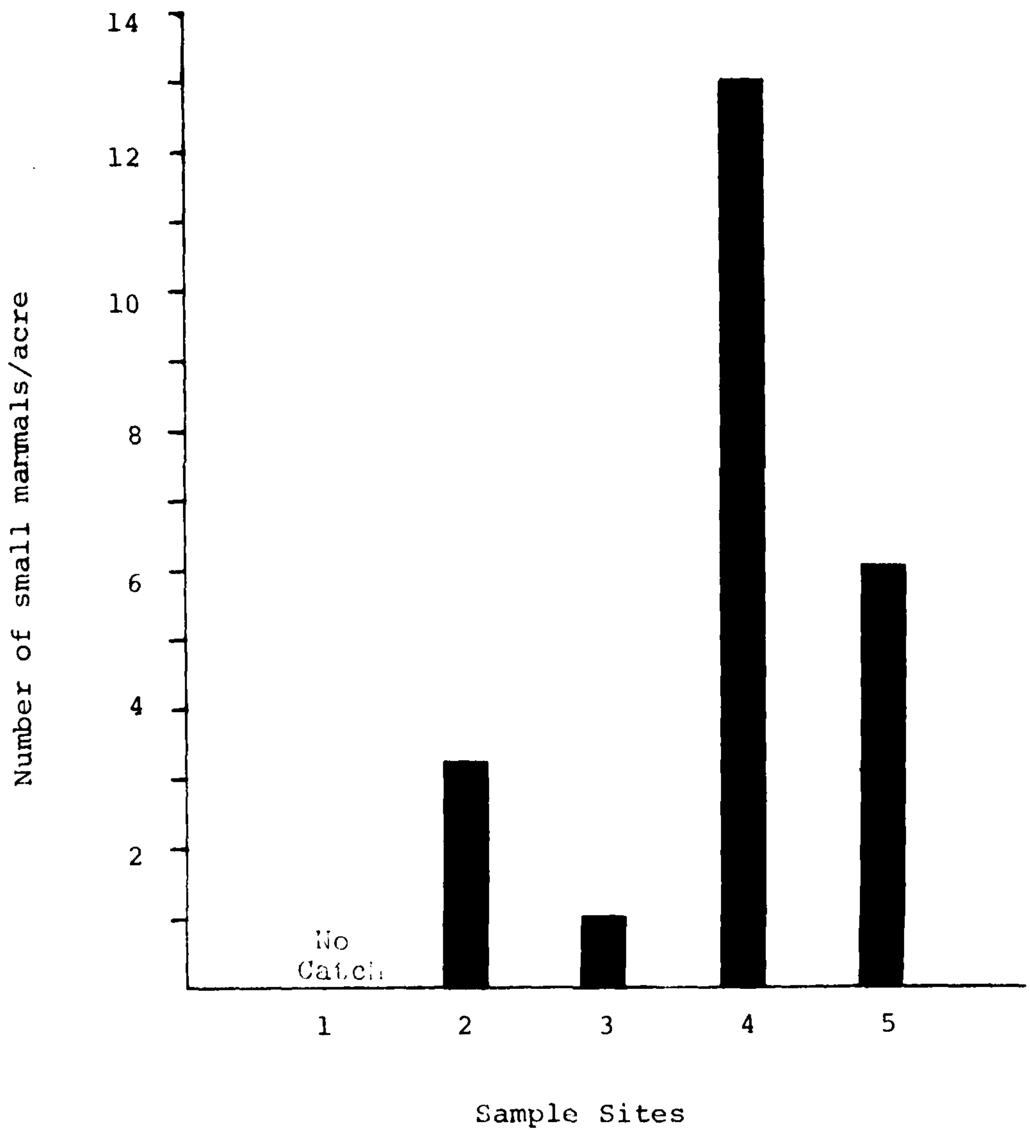


Figure 33. Estimated small mammal populations (mice /acre) at five sites in Pool 9, Upper Mississippi River, 1973.

seemed to make the eggs particularly vulnerable to predation and nest destruction.

No attempts were made to systematically survey Pool 9 for amphibians and reptiles. No species appears to be particularly vulnerable to environmental manipulation at the present time.

Miscellaneous Environmental Parameters

Climographs relating temperature to precipitation and to relative humidity were prepared for the Pool 9 area (Figures 34, 35). This information is presented as basic information for the Pool 9 region and no attempt was made to related faunal or floral conditions observed in the Pool area to these climatic parameters. It is obvious that both faunal and floral components within the region are responsive to environmental parameters such as temperature, precipitation and relative humidity.

Soil organic matter determinations were obtained from soil samples collected at varying depths on spoil banks and in a flood plain forest (Figure 36). Organic matter was determined after the method of Cox (1967). The lowest organic matter content was observed in dredge spoil samples collected 24 hours after spoil placement by the Army Corps of Engineers. Fresh spoil samples averaged less than one percent organic matter except at the 4 to 5 inch depth. Increased organic matter at this depth occured due to leeching of water through the freshly deposited spoil. Surface organic matter accumulation in spoil banks generally increases with the length of time the banks have been left undisturbed. The rate of organic matter accumulation is slow; however, the rate of decomposition is also reasonably slow and surface values of 4 to 9 percent organic matter were

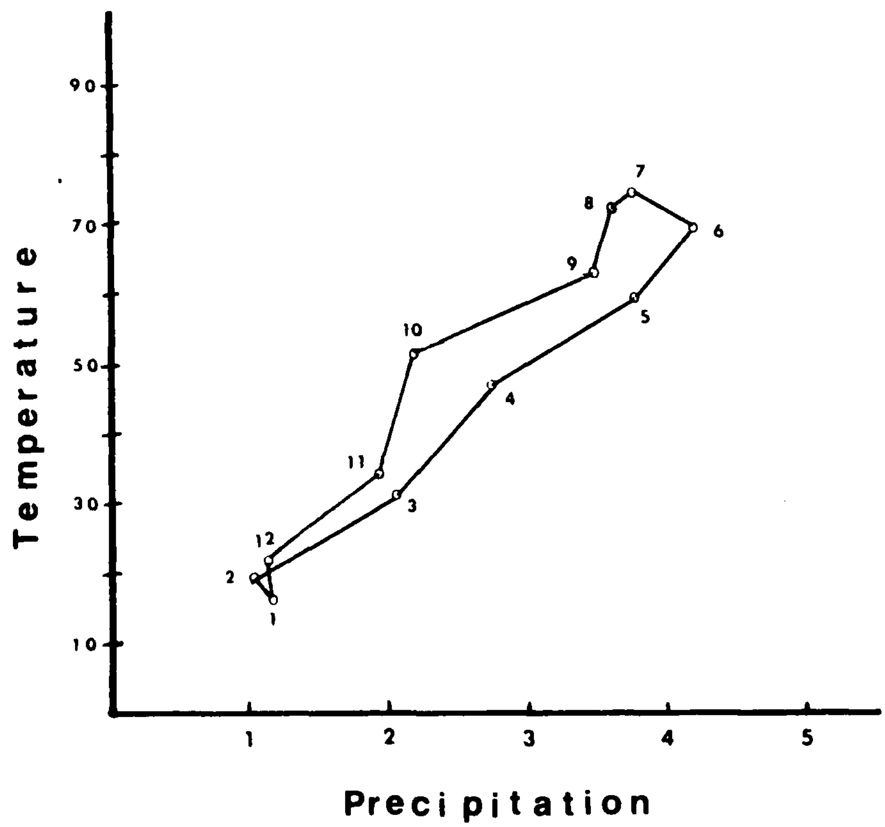


Figure 34. Climograph for LaCrosse, Wisconsin (1931-1960). Normal total precipitation (inches) vs. normal monthly temperature (OF). Months are numbered consecutively beginning with January. (Dairyland Power, 1972)

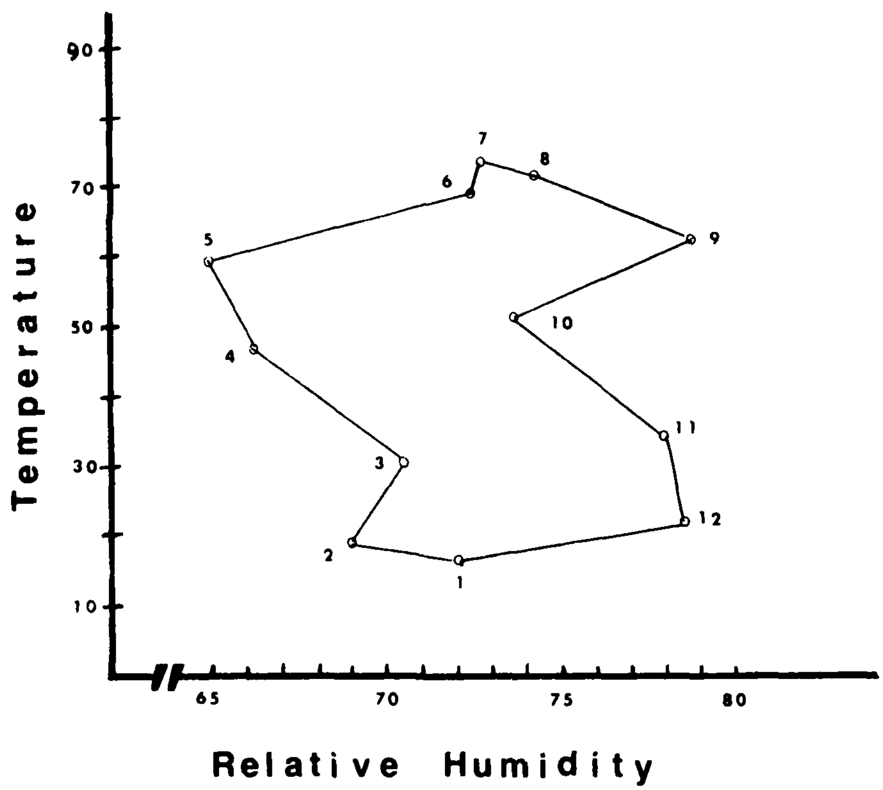


Figure 35. Climograph for LaCrosse, Wisconsin (1931-1960) Mean relative humidity (%) vs. normal monthly temperature (°F). Months are numbered consecutively beginning with January. (Dairyland Power, 1972)

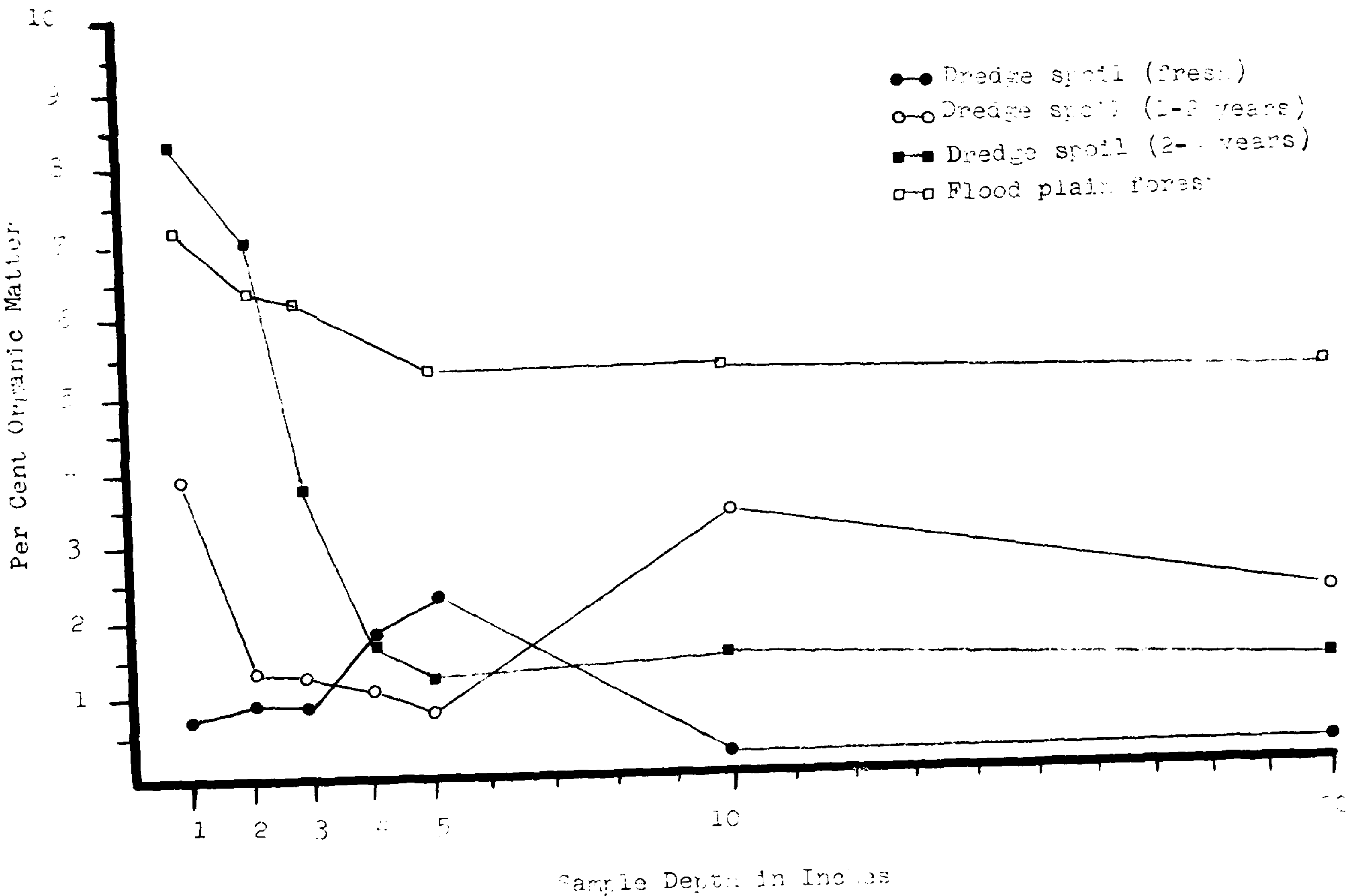


Figure 36. Organic matter accumulation in soil samples collected at various depths on the floodplain forest floor and on spoil banks of varying age.

found from spoil banks. Soil samples from undisturbed floodplain forest were generally highest in organic matter. The rate of both organic matter accumulation and decomposition tends to be high in a floodplain forest.

Soil arthropod determinations were completed on samples of soil collected from spoil banks and from the floodplain forest along transect AA. Species diversity and total numbers of soil arthropods varies directly with the type of substrate (Figure 37). Surface samples from fresh spoil (24 hours after dredge deposit) were reasonably free from soil arthropods while samples from a relatively mature floodplain forest were rich in arthropods. Aging dredge spoil banks (2-4 years) were generally intermediate for both species and numbers of arthropods.

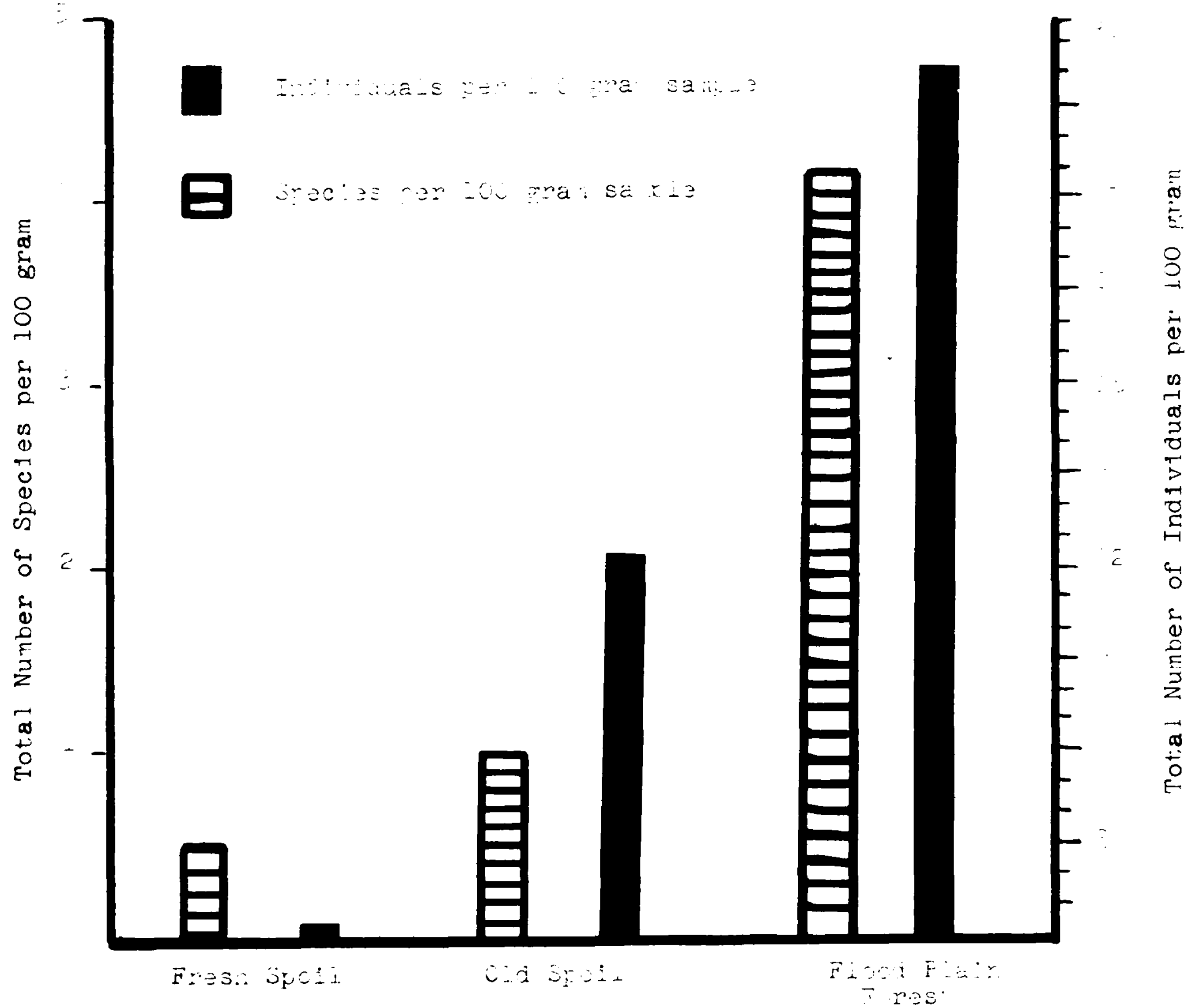


Figure 37. Comparisons of species and numbers of soil arthropods per 100 gram samples of soil from randomly selected sampling sites on spoil bank and floodplain forest.

SOCIOECONOMIC SETTING

The socioeconomic aspects of the environmental setting are discussed (1) by identifying the three-way subdivision of socioeconomic activities used in this report and (2) by presenting an overview of these activities in Pool 9 as they also relate to the Northern Section of the Upper Mississippi River.

Three Subdivisions of Socioeconomic Activities

It is useful to divide a discussion of the socioeconomic setting of the study area of the Upper Mississippi River into (1) industrial activity, (2) recreational activity, and (3) cultural considerations.

Industrial Activity

Industrial activity includes agricultural, manufacturing, transportation, and related pursuits that affect employment and income in the study area directly; this includes employment on farms, in barge operations, commercial dock facilities, lock and dam operations, and commercial fishing and trapping. While it is probably most desirable to measure industrial activity in terms of jobs or dollars generated, lack of available data makes this impossible in the present study. As a result indices of this industrial activity -- such as tons of commodities moved, industrial facilities constructed, or pounds of fish caught -- are generally used.

Recreational Activity

Recreational activity has two aspects of interest. One is the value to the users themselves of being near or on the Mississippi River for leisure activities. A second aspect is the impact of the recreational activity on employment and income. Recreational activity is more indirect in its effect on employment and income than is industrial activity and relates mainly to leisure-time activities of people using the Mississippi River for recreational purposes; examples include boating, sport fishing, hunting, sightseeing, camping, and picnicking. Recreational use is usually summarized using units of measurement like number of boaters or fishermen using a lake or river, fishing licenses sold, or visitor-days. It is often very difficult to find such measures for a particular pool on the Mississippi River. Where such data are available -- such as pleasure boat lockages -- they are used. Where they are not available -- such as fishermen using a specific pool -- proxy measurements are used; for example, number of sport fishermen observed annually by lock and dam attendants are taken as a measure of fishing activity in the pools -- even though this is not as precise a measure as desired. Problems involved with placing dollar values on these recreational activities are discussed in Section 6.

Cultural Considerations

Cultural considerations are the third component of the socioeconomic setting. These considerations include three kinds of sites of value to society: archaeological sites, historic sites, and contemporary sites. These sites can include such diverse physical assets as burial mounds, historical battlegrounds or buildings, or existing settlements of ethnic groups such as Amish communities. Because of the difficulty of placing any kind of value on such sites, they are simply inventoried in the present study.

Overview of Socioeconomic Activities in the Study Area

The industrial, recreational, and cultural aspects of Pool 9 are discussed below in relation to the entire Northern Section of the Upper Mississippi River to provide a background with which to analyze the impact of operating and maintaining the nine-foot channel in Section 3 of this report.

Industrial Activity

The existence of the Mississippi River and its tributaries has had a profound effect on the industrial development of the American Middle West. It has served as a route of easy access for transportation and communication tying together the industrialized East with the agricultural Middle West as well as the varied economies of the North and South.

Historical Development of the Waterway. The development of the Northern Section of the Upper Mississippi as a waterway for shipment has paralleled the rise of the American economy, keeping pace with the need to move bulk raw materials and heavy, high-volume commodities over the wide geographical areas served by the river network. This has allowed barge transportation to remain competitive with other forms of transportation. It is noteworthy that competing systems of land transportation such as railroads and highway trucking utilize the relatively gentle river valley terrain in order to simplify both engineering design and fuel energy demands. Thus, the Mississippi River Valley is intensively utilized to meet the transportation needs of the Midwest.

Long before the coming of the first white settlers, the Mississippi River was a transportation corridor for the Indians. It was used to facilitate the primitive barter economy and as a route for other forms of social and cultural communication and contact.

In its primitive condition, the Upper Mississippi was characterized by numerous rapids and rock obstructions. Fluctuations in water flow during various seasons of the year were minor inconveniences to the Indian canoe, but demanded modification before substantial commercial use of the river could take place. Prior to improvements, such traffic was limited to periods of high water when log rafts and small boats could pass between the Falls of St. Anthony and the mouth of the Ohio River.

The necessity of modifying the natural course of the river to make it suitable for commercial navigation gradually became apparent as the size of the river boats and barges grew. Since the first river steamboat arrived at Fort Snelling in 1823, steamboat transportation for freight and passenger use grew to a peak in the decade 1850 to 1860 when over 1000 steamboats were active on the entire length of the river. By 1880 the growth of the railroad system in the U.S. and the lack of a channel of sufficient depth marked a decline in the use of the river for transportation. However, on the upper reaches of the Mississippi, growth in freight traffic continued. A peak was reached in 1903 with 4.5 million tons moved between St. Paul and the mouth of the Missouri River. A subsequent rapid decline coincided with a drop in river use for moving logs and lumber. In 1916 only 0.5 million tons were shipped on this section of the river.

As the population and industry of the Upper Midwest region grew, there was a corresponding growth in the need for cheap coal for power generation. A technological consequence of this need was the development of the barge and towboat which gradually replaced the steamboat on the river. The barge and towboat required a deeper channel than the earlier steamboats. The need for coal in the Upper Midwest was complemented by the need to ship large quantities of grain south to other centers of population. Thus, economies were realized by having at least partially compensating cargoes going both directions on the upper reaches of the river. In the later 1920's large grain shipments from Minneapolis began.

Although four-and-one-half-foot and six-foot channels had been authorized in recognition of the increasing role of the river in the transportation network of the U.S. and technological developments in barges and tugs led to the authorization of a nine-foot channel to Minneapolis in 1930. By 1940 the channel and the requisite locks and dams were essentially complete.

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to Corps activities. For example, the following factors complicate the problem of data analysis during the period prior to 1940:

1. Statistical data collected by the Corps of Engineers covered different segments of the Upper Mississippi River during these years. Some of the reasons for this appear to be changes in the administration of river segments during that time, as well as some experimentation with better methods of statistical collection.

2. Shipping in the Upper Mississippi was distorted during the decade of the 1930's due to the construction of locks and dams in the St. Paul District.

3. From 1941 to 1945 all forms of transportation were utilized for the war effort without regard to maximizing economic return. Therefore, data for these years (as with the 1930's) does not necessarily reflect a normal period of transportation on the Upper Mississippi.

Barge Shipments. Table 27 shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

In more recent years, data are available for the St. Paul District. Table 28 shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

When these two tables are compared, the growth of shipping on the Upper Mississippi becomes readily apparent. Thus, the total traffic for the St. Paul District in 1962 was about six times the traffic in 1945, which was a war year. In fact, traffic in the St. Paul District for 1962 was more than five times greater than all of the traffic on the Upper Mississippi between Minneapolis and the Mouth of the Ohio River in 1930. Traffic about doubled in the St. Paul District between 1962 and 1971. This was due to a large degree to grain shipments from the District and to an increase in receipts of coal.

Table 27

River Shipment from 1920 through 1945

Year	Total Tonnage (short tons) Shipments and Receipts*	River Segment
1920	630,951	Mpls. to Mouth of Missouri River
1925	908,005	Mpls. to Mouth of Missouri River
1926	691,637	Mpls. to Mouth of Missouri River
1927	715,110	Mpls. to Mouth of Missouri River
1928	21,632	Mpls. to Mouth of Wisconsin River
1929	1,390,262	Mpls. to Mouth of Ohio River
1930	1,395,855	Mpls. to Mouth of Ohio River
1935	188,613	St. Paul District
1940	1,097,971	St. Paul District
1945	1,263,993	St. Paul District

*Tonnages exclude ferry freight (cars and other) and certain cargoes-transit.

Source: Annual Report of the Chief of Engineers, U.S. Army, Part 2 "Commercial Statistics", Table 7, by selected year.

Table 28

River Shipment from 1962 through 1971.

Year	Total Traffic St. Paul District*
1962	8,168,594
1963	9,266,361
1964	9,621,336
1965	9,205,538
1966	11,346,457
1967	11,618,849
1968	10,736,350
1969	12,647,428
1970	15,423,713
1971	15,070,082
1972**	16,361,174

Sources:

*Comparative Statement of Barge Traffic on Mississippi River and Tributaries in St. Paul District, U.S. Army Engineer District, St. Paul, Minnesota.

**Estimated

In 1928 data were collected on receipts and shipments for the river segment from Minneapolis to the mouth of the Wisconsin River. This approximates the navigable segment of the Upper Mississippi within the St. Paul District, and the data for this segment can be equated with data for the St. Paul District with little difficulty. In that year, 21,600 tons were received and shipped. By 1940, tonnages handled reached 1,000,000 tons annually, when the lock and dam system and the nine-foot channel were virtually complete. Tonnages reached 2,000,000 by 1946, and 3,000,000 by 1953. By 1962 over 8,000,000 tons were shipped and received in the St. Paul District. In the decade between 1962 and 1972 this had doubled to 16,000,000 tons.

Table 29 shows the number of trips made on the Mississippi between Minneapolis and the mouth of the Missouri River in 1971.

Because, as will be noted later in this section, Pool 9 contains only two commercial docks that serve utility companies, the pool is really a thoroughfare for the river trips shown in Table 29 between the river south of Pool 9 and the Twin Cities. An indication of the "thoroughfare" function that Pool 9 provides for barge traffic in the study are the commercial lockages through all locks in the Northern Section that are shown in Figure 38. These also provide another indication of the recent increase in barge traffic. From 1960 to 1972 the number of lockages in the portion of the River between Lock and Dam 2 and Lock and Dam 10 increased by about 600, the increase that was also present in Pool 9.

The shipping season for most of the Mississippi River within the St. Paul District is usually eight months, from mid-April to mid-December.

Table 29

River Trips in 1971

Transportation Mode	Upbound	Downbound
Self Propelled		
Passenger & dry cargo	1,900	1,875
Tanker	3	2
Towboat or Tugboat	8,433	8,419
Non-Self Propelled (barge)		
Dry cargo	25,250	25,237
Tanker	7,312	7,311
TOTAL	42,898	42,844

Source: Waterborne Commerce of the United States Calendar Year 1971, Part 2; Department of the Army U.S. Corps of Engineers, p.165.

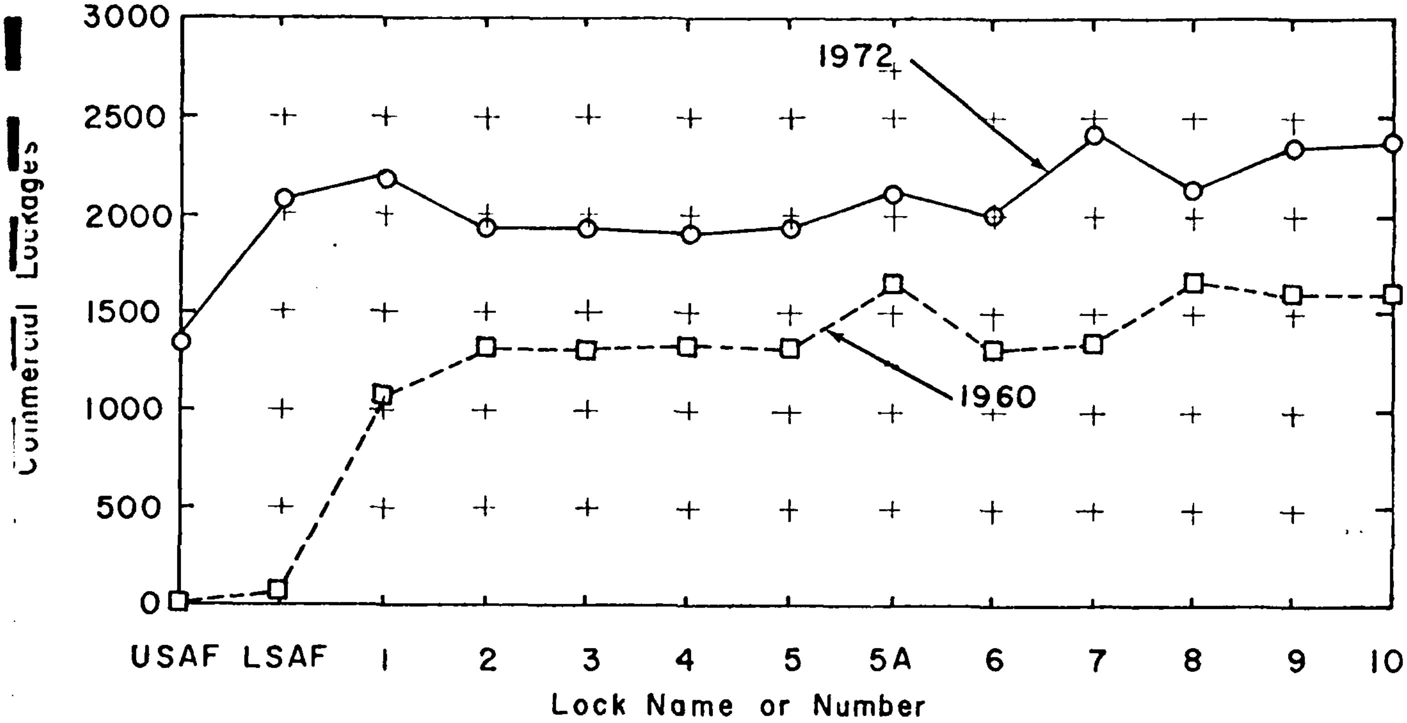


Figure 38. Commercial Lockages in Upper Mississippi River in 1960 and 1972. Source: St. Paul District of the U.S. Army Corps of Engineers, Annual Lockage Data, 1960 and 1972.

The navigable rivers maintained and operated by the St. Paul District should be viewed within the context of the system as a whole including the Mississippi, Ohio, Missouri and other tributary rivers. In 1964 a detailed analysis of origin-destination waterborne commerce traffic patterns showed that the average miles per ton on the Upper Mississippi River Waterway System ranged from 700 to 800 miles. This indicates that the great bulk of shipments and receipts have origins or destinations outside the St. Paul District. Each pool then in addition to its own shipments and receipts contributes to the economic benefits enjoyed by the system as a whole. Thus, any measure of the economic benefits of the river commerce on an individual pool must include the benefits that it contributes as a necessary link in the Upper Mississippi system.

Agriculture. Bordering Pool 9 are Vernon and Crawford Counties in Wisconsin, Houston County in Minnesota, and Allamakee County in Iowa. The land within the vicinity of Pool 9 is largely rural. In 1969, almost 80% of the land in Vernon County was in farms, as was 86% and 77% of neighbor-Houston and Allamakee Counties, respectively. Dairying is the major source of farm income and the principal cash crop is tobacco (Candeub et al.,1969).

The trend in Vernon County has been towards a decrease in the total numbers of farms, mainly through consolidation, and total farm acreage. There were 465 fewer farms in the county in 1969 than in 1964, and 55,571 fewer acres in farms. Thus, the proportion of land in farms decreased from 89.8% in 1964 to 79.4% in 1969. During that time, the number of farms with sales of $2,500 and over decreased from 2,339 to 1,991. Despite this, the marked value of all agricultural products sold went up from $21,432,500 in

1964 to $26,408,883 in 1969.

The primary agricultural activity in Vernon County, as well as Houston and Allamakee Counties, is dairying. Livestock, poultry and their products accounted for approximately 88% of the market value of all agricultural products sold by farms in Vernon County in 1969, and almost 90% for farms in Houston and Allamakee Counties.

Vernon County produces more tobacco than any other county in Wisconsin. Nevertheless, the market value of all crops, including tobacco, accounted for slightly less than 11% of the total value of all agricultural products sold in Vernon County in 1969.

Steep slopes are characteristic of much of the farmland in Vernon and neighboring counties, especially the highly dissected "coulee country" near the Mississippi River. Such slopes limit cropland use, largely because they are difficult to cultivate with contemporary mechanized equipment. While 24.7% of Vernon County, 29.2% of Houston County and 25.5% of Allamakee County were in forest land in 1969, forest products accounted for less than 1% of farm sales in each county.

According to the Mississippi River Regional Planning Commission (MRRPC), a third of the farms of the three counties are classified as "poverty farms" and many farmers must hold other jobs. The planning agency has recommended diversification of farm activities to include other commercial uses such as pet breeding and boarding, gift shops, produce stands and horsebackriding.

Commercial Fishing and Trapping. As population along the Northern Section of the Mississippi River increased, industrial specialization also took place. The result was the development and growth of commercial fishing and trapping along the Upper Mississippi in the last half of the nineteenth century and during the twentieth century.

From 1925 to 1950, fairly complete records of commercial catch were kept by Rose Ehrlich of the Lansing Fish Company in Lansing, Iowa. Her records show a general increase in the pounds per year handled. This data was compiled with UMRCC data for fish poundage taken in Pool 9 from 1953 to 1964 in Figure 39. It is seen in this graph that in 1950, the last year represented in Miss Ehrlich's records, the total poundage of fish handled was 2,274,483. In 1953, the first year in which data was kept for Pool 9 by the UMRCC, the total fish poundage taked in the pool was 750,759. This discrepancy between the last year of Miss Ehrlich's data and the first year of the UMRCC data may be accounted for in that the Lansing Fish Company handled fish sold to it by fishermen from neighboring pools as well as in Pool 9 (Rose Ehrlich, personal communication). The UMRCC data deals only with the pounds of fish taken in Pool 9. The UMRCC data for the years 1953-1964 also shows a general trend toward increased poundage.

Data on commercial fishing in the 1960's in the pools in the study area are shown in Figure 40. In 1969 the Northern Section of the Upper Mississippi River produced about 5.5 million pounds of fish that were sold commercially; this was an increase of about 9 percent from the 1960 total. The commercial value of the fish caught in 1969 was about $400,000.

Figure 40 shows that the bulk of the commercial fishing in the pools in the study area -- about 4.8 million pounds of fish and 86 percent of the total -- occurred in Pools 4, 8, 9, and 10. Pool 9 is the major contrib-

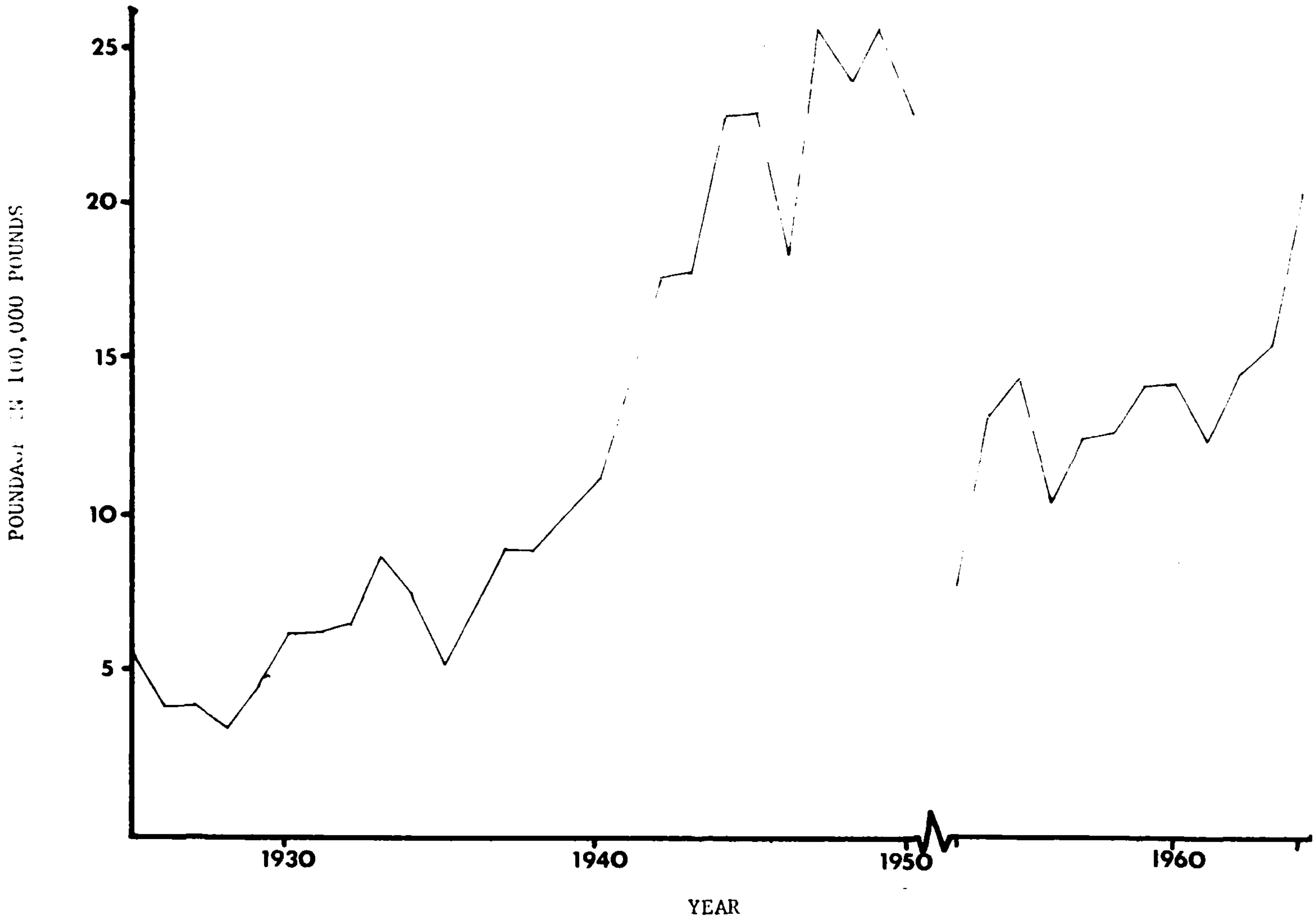


Fig. 39. Poundage of fish taken from the Pool 9 region 1925-1964. Data for 1925-1950 taken from records of the Ehrlich Fishery in Lansing, Iowa. Data for 1953-1964 from the UMRCC records. The Ehrlich Fishery bought fish from outside of Pool 9, so there are substantial differences between their last records and the 1953 UMRCC data.

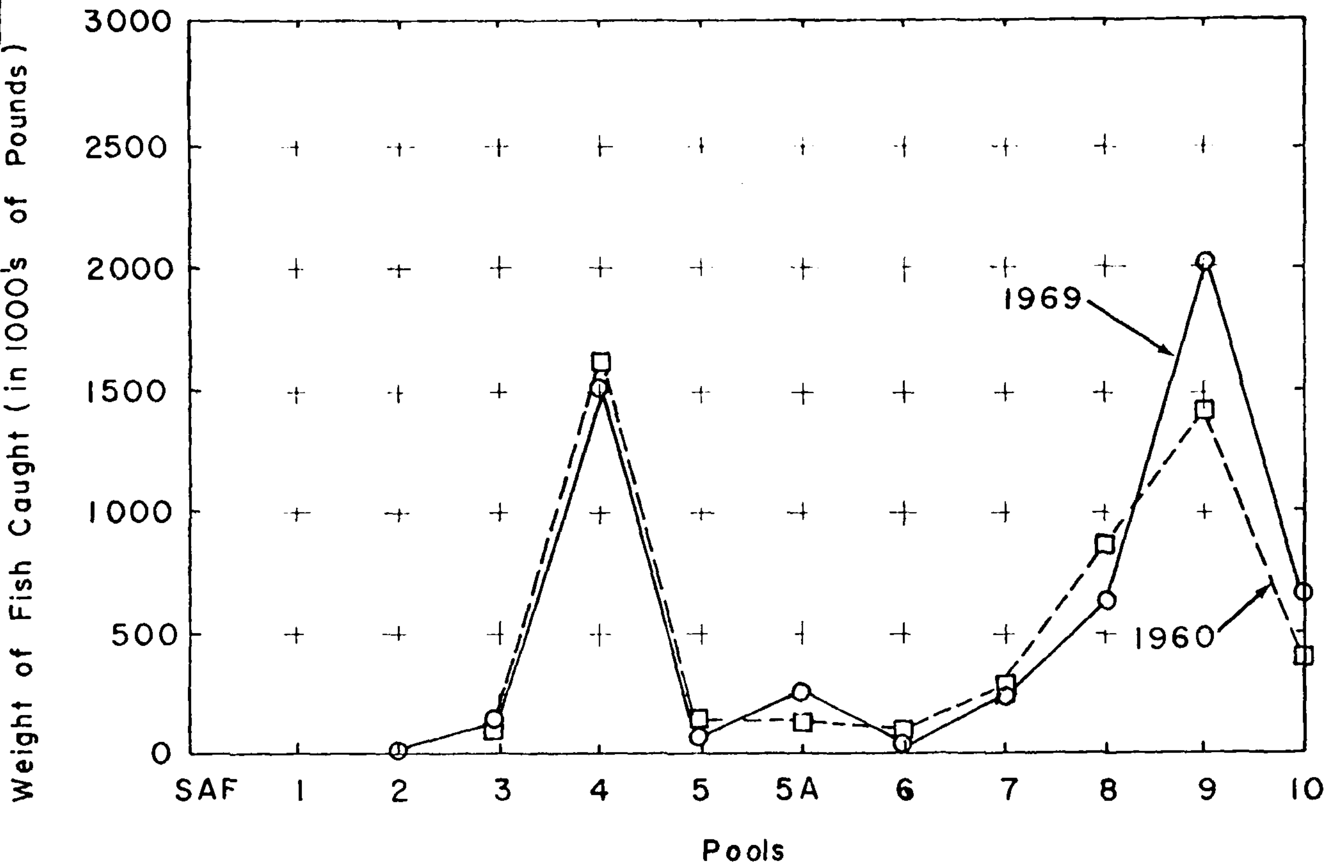


Figure 40. Thousands of Pounds of Fish Caught Annually by Commercial Fishermen in Upper Mississippi River Pools in 1960 and 1969. Source: UMRCC. Proceedings of Annual Meeting, 1962 and 1971.

utor, with 2 million pounds in 1969. None of the other pools contributed more than 250,00 pounds during that year. Figure 40 also shows that little change in the weight of fish caught in each pool occurred from 1960 to 1969. Pool 9 registered the largest increase during the period from 1960 to 1969, an increase of 600,000 pounds of fish caught.

Another aspect of the commercial fishery of the Upper Mississippi is the mussel fishery. Its commercial importance has greatly diminished since the 1920's when the market for pearl buttons disappeared. The clamming industry is discussed in the UMRCC Compendium of 1967 by Alan Finke, former fishery biologist of the Wisconsin Conservation Department. Until the 1920's, clams were fished heavily and provided the raw material for pearl buttons. With the advent of plastics, the demand diminished. The Lansing Company of Lansing, Iowa, was formerly one of the major manufacturers of pearl buttons. The company now imports plastic buttons from Japan and manufactures zippers (John Brophy, personal communication).

The mussel populations of the Upper Mississippi went virtually unexploited until, in 1964, interest in mussel shells was renewed. In that year, the clamming industry revived slightly. Four southern companies moved operations to Prairie du Chien, Wisconsin. This move was prompted by two prime factors - the constant Japanese market for 5,000 tons of clam shells per year and the depletion of the mussel beds in the Tennessee River. In Japan, pellets of freshwater clam shell are used to stimulate the production of cultured pearls in oysters. The four companies operating out of Prairie du Chien in 1964 were the Tennessee Shell Company with 34 boats, the George Borden Company with 10 boats, the Automatic Button Company and the Blumenfeld Company, each with 6 boats. The estimated production figures for each of these companies as of 10 August 1965 were: Tennessee Shell Company - 300 tons dried weight, George Bordon Company - 100-150 tons dried weight, and the Blumenfeld Company - 26 tons. In 1965, a ton of clams - live weight - brought $40. A ton of cooked-out shells was worth $60.

The most important species fished today is the Three-ridge. Other less important species include the Pig-Toe, the Warty-Back, the Maple Leaf, and the Niggerhead, which was previously of prime value. Most clamming is done in Pool 10 but there has been some recently in the Lansing-Ferryville-De Soto area of Pool 9.

Trapping data have been collected for the past three decades by the Upper Mississippi River Wildlife and Fish Refuge, which is managed by Bureau of Sport Fisheries and Wildlife of the U.S. Department of the Interior. This 200,000 acre refuge was established by Congress in 1924 and runs for 284 miles along the Upper Mississippi River from about Wabasha, Minnesota to above Rock Island, Illinois -- or from approximately Lock and Dam 4 to Lock and Dam 13. Between 1940 and 1970 an average of 748 trappers per year obtained trapping permits. Between 1940 and 1970 25,000 beavers and over 2.25 million muskrats were trapped whose furs averaged nearly $100,000 annually (Green, 1970). By the 1971-72 season, the price of muskrat pelts was over $1.00 and the annual harvest was valued at about $200,000.

Recreational Activity

In addition to the industrial activity described above, the Northern Section of the Upper Mississippi River has provided innumerable recreational opportunities for the entire region it serves. Even prior to Congressional authorization of the 4-1/2-foot channel in 1878--the first comprehensive project on the Upper Mississippi, from the mouth of the Ohio River to St. Paul--settlers used the river extensively. The Upper Mississippi provided settlers the opportunity to boat, fish, hunt, and sightsee. However, the need for these settlers to carve out an existence in the Minnesota wilderness of the early nineteenth century meant that recreational uses of the upper River were few. Thus, boating then was not for recreational purposes; it was essential for the settlers' continuing existence to move people and supplies to where they were needed. Similarly hunting and fishing were not for sport; they provided the food needed to feed the settlers' families; surplus fish or game were sold or traded for other necessities required for daily living.

As the twentieth century dawned, leisure time accompanying the settler's higher standard of living led to recreational uses of the Upper Mississippi River. Segregating present-day recreational uses of the study area due to Corps' operations from those existing in 1930, prior to the nine-foot channel, presents problems. These arise because of the difficulty of isolating the increased recreational uses of the river caused by more people in the region, higher standards of living, and increased leisure from those caused by improved navigational and other recreational opportunities.

A significant portion of the recreational activity on the Upper Mississippi is due (1) to the improved navigation opportunities for large pleasure craft on the river, and (2) to improved fish and game habitat resulting from higher water levels in the river. The potential for improved fishing and hunting is not always realized because increased industrialization along the river has polluted the river and has reduced the available hunting areas, which often more than offset the increased habitat.

Boating Activity and Related Facilities. As noted above, much of the increased boating in the study area of the river -- and virtually all of it for the deeper-draft pleasure boats -- is made possible by the improved navigational opportunities provided by the system of locks and dams. Figure 41 illustrates the dramatic growth in pleasure boating in the study area from 1960 to 1972. The figure shows that number of pleasure boats moving through each lock in the study area increased by an average of about 1,500 boats during the twelve-year period. It can be seen that the number of pleasure boats moving through Locks 8 and 9, those at each end of Pool 9, increased by about the average for the District during this period.

During July, 1973, time-area recreational counts were conducted on Pool 9 to determine the numbers of people using the main channel and immediately associated backwaters. Additional information was obtained on numbers of powerboats of all types observed on the main channel and immediately associated backwaters. Mean numbers of river craft and people actually observed per mile of river surveyed is presented in Figures 42, 43. A projection of the mean numbers of people using the river per hour of day use is presented in Figure 44. It is apparent from this data that river use by people for all purposes is greatest in the upstream two-thirds of of Pool 9 (River Miles 660-679). The mean number of motorized craft ob-

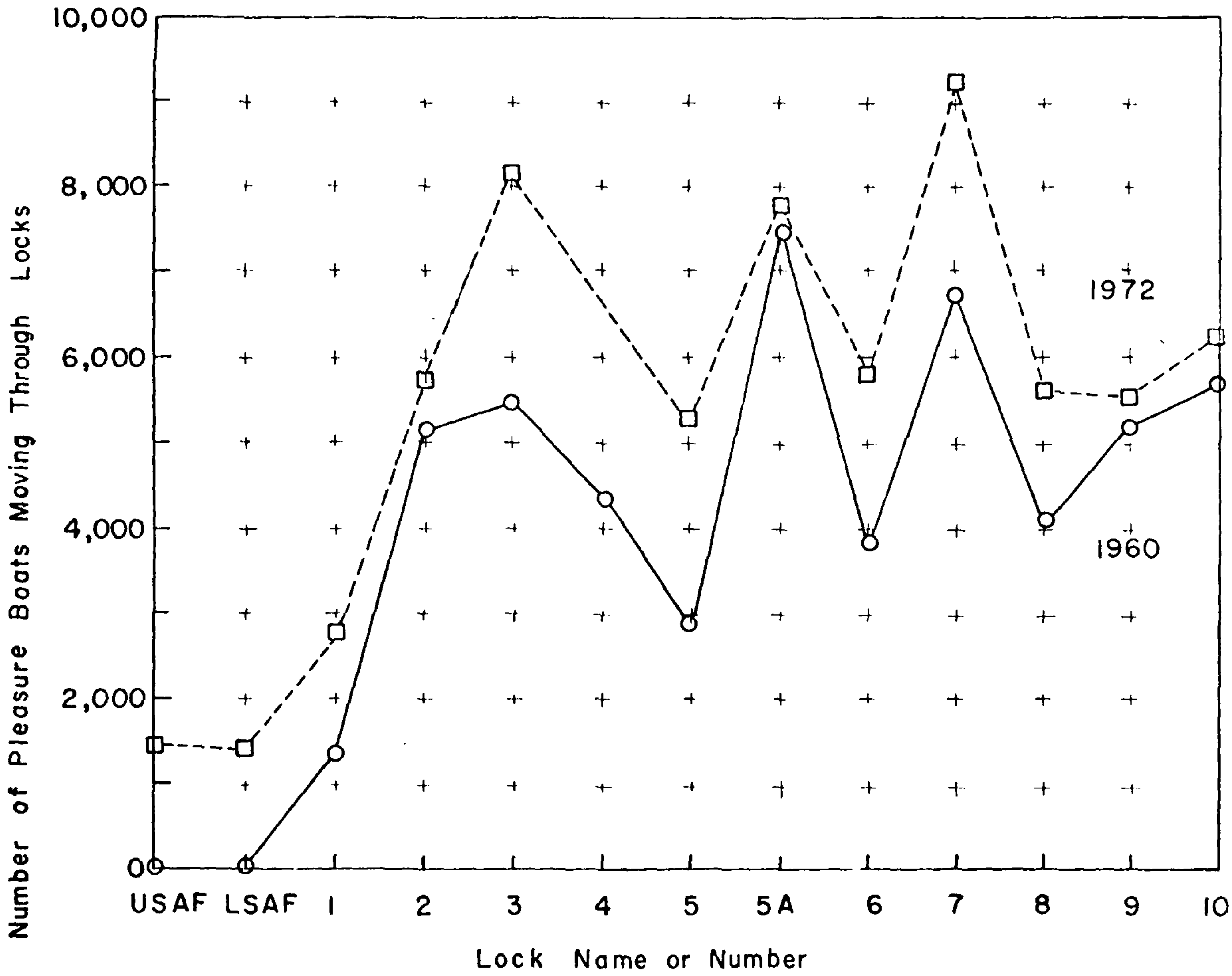


Figure 41. Pleasure Boats Moving Through Upper Mississippi River Locks in 1960 and 1972. Source: St. Paul District of the U.S. Army Corps of Engineers, Annual Lockage Data, 1960 and 1972.

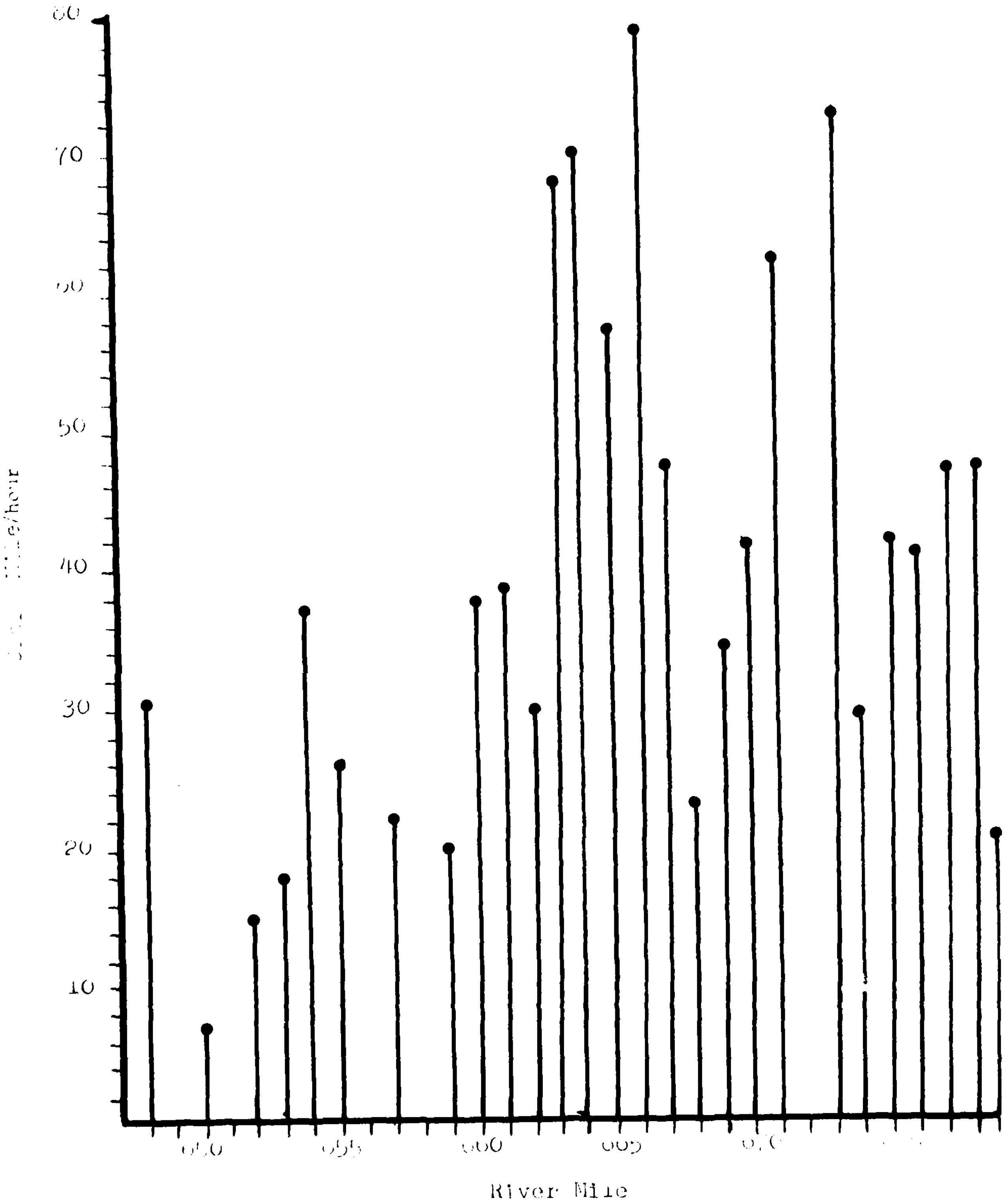


Figure 42. Average number of river craft of all types per mile of river in Pool 9, Upper Mississippi River, during July 1973 survey period.

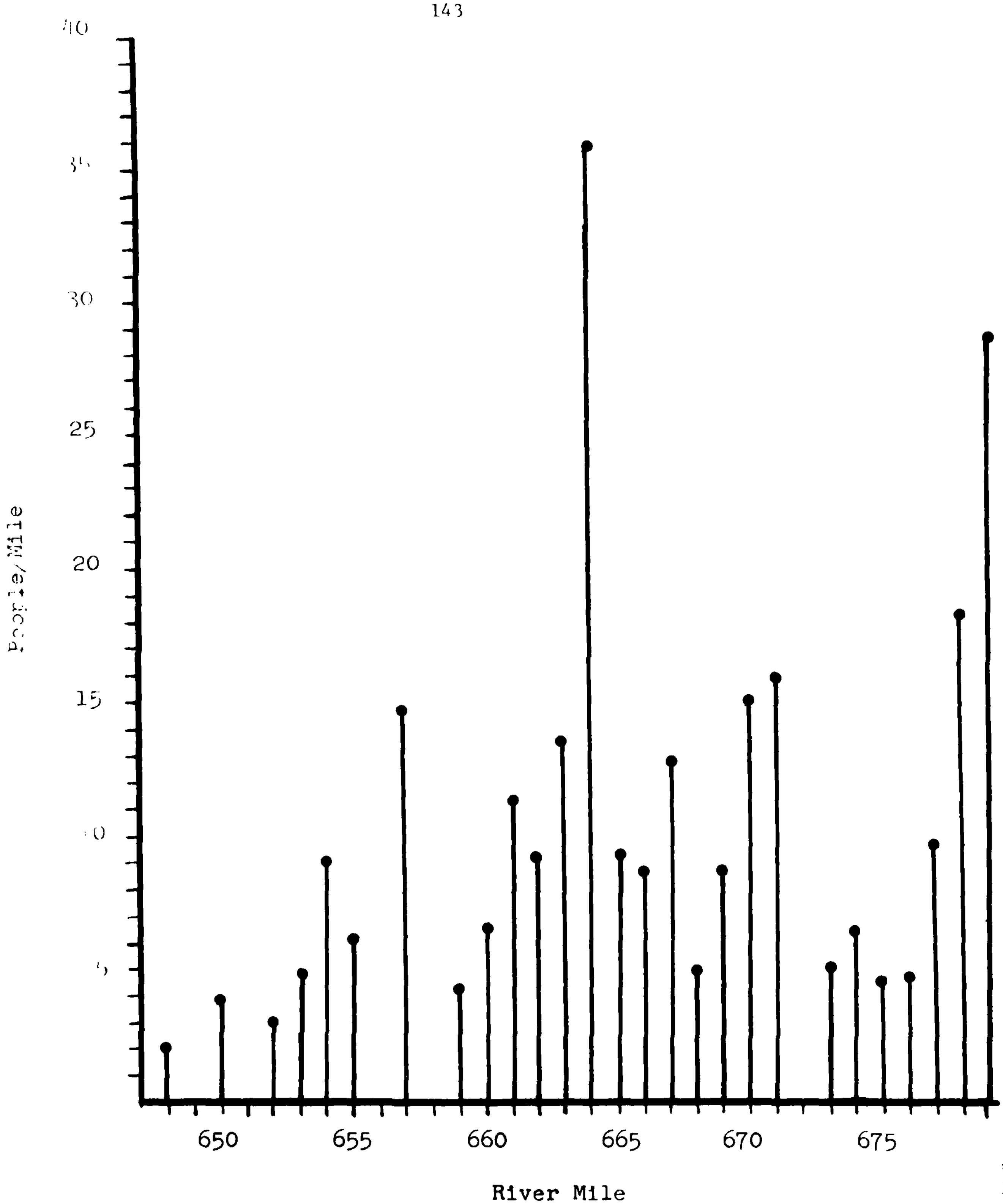


Figure 43. Average number of river users per mile of river in Pool 9, Upper Mississippi River, during July 1973 survey period.

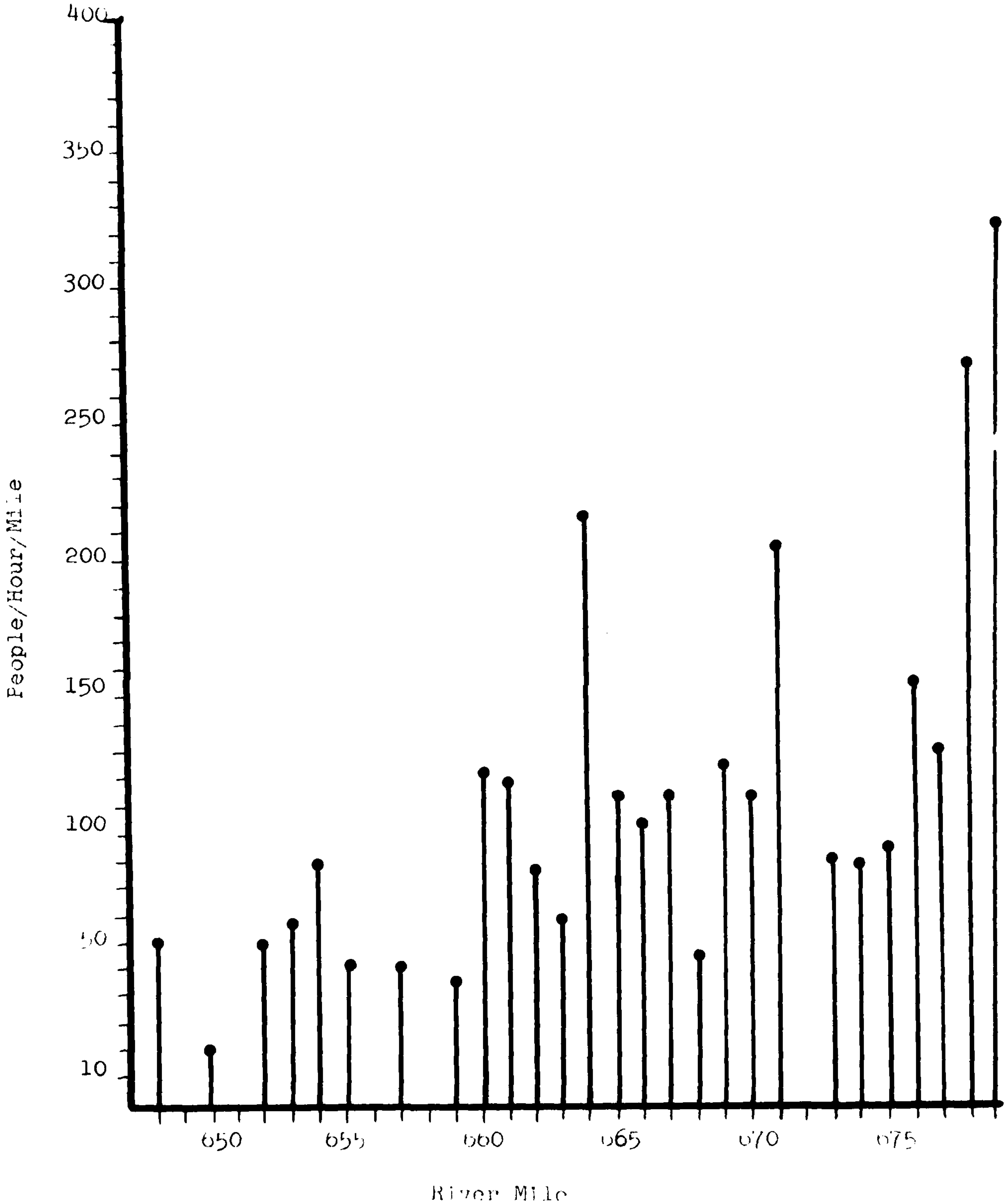


Figure 44. Projected average number of river users per hour per mile of river in Pool 9, Upper Mississippi River. (Projections based on July, 1973 survey period).

served on the river per hour of day use is also greatest in the upper two-thirds of Pool 9. The numbers of people and craft observed in an area relates directly to the location of recreation facilities along the river and to the location of population centers.

Hunting, fishing, boating, water skiing and camping seem to be concentrated in the upper two-thirds of Pool 9. Increased recreational use of Pool 9 could lead to over use in some areas and under utilization in other regions of the Pool.

Although no Federal or State parks border Pool 9, a variety of other facilities have developed on the river mainly to serve the pleasure boaters. These include boat access sites and landings, as well as picnic and camping sites. The major portion of visitation to the pool is accommodated by 17 public-use recreational and access sites developed in the pool area by various Federal and non-Federal agencies and private interests. Most of the sites have been constructed to provide water-access for on-water type activities and, in most instances, the provision of facilities for other activities is incidental.

Of the 17 public-use sites 5 have been developed on Corps of Engineers lands, 3 on Bureau of Sport Fisheries and Wildlife lands, 2 on State of Wisconsin lands, 6 on local Government lands and 1 on private land. Extent of development and participation by the various contributing agencies is discussed in the following paragraphs. Some sites appear under two or more agency headings where multi-interests exists because of land ownership, joint development and operation and maintenance under lease agreements. Available facilities and features of the 17 sites are listed in Table 30.

Table 30

Major [illegible] public-use facilities - Pool 9

Site	River Mile	River Bank	Developed by	Managed by	Landowner	Ramp: Number of lanes	Ramp: Surface	Parking: Number of spaces	Parking: Surface	Other facilities or remarks
					On Corps of Engineers Lands					
Millstone Landing	676.8	R	Bureau Sport Fisheries & Wildlife and Corps of Engineers	Bureau Sport Fisheries & Wildlife	Corps of Engineers	(30 feet) 2 lanes	Gravel	20	Gravel	
Bad Axe Landing	675.2	L	Bureau Sport Fisheries & Wildlife and Corps of Engineers	Bureau Sport Fisheries & Wildlife	Corps of Engineers	(25 feet) 2 lanes	Shale	20	Shale	
New Albin Recreation Area	675.2	R	Bureau Sport Fisheries & Wildlife	Bureau Sport Fisheries & Wildlife	Corps of Engineers	1 lane	Gravel	10	Gravel	Minimum development.
Black Hawk Memorial Park (Lower Access)	670.5	L	Vernon County	Vernon County	Corps of Engineers	2 lanes	Gravel	30	Gravel	Picnic and camping facilities. (Another access on county land)
De Soto-Lansing Causeway Landing	665.3	L	Wisconsin Highway Department	Wisconsin Highway Department	Corps of Engineers	2 lanes	Crushed rock	20	Crushed rock	(2 parking areas) Picnic facilities.
					On Bureau of Sport Fisheries and Wildlife Lands					
New Albin Access	673.3	R	Iowa Conservation Commission	Iowa Conservation Commission	Bureau Sport Fisheries & Wildlife	2 lanes 1 lane	Concrete Crushed rock	75	Crushed rock	Two separate ramps.
Big Slough Landing	663.3	L	Wisconsin Conservation Department	Wisconsin Conservation Department	Bureau Sport Fisheries & Wildlife	3 lanes	Crushed rock	35	Crushed rock	Picnic facilities.

Table 30 (continued)

Major existing public-use facilities - pool 9

Site	River Mile	River Bank	Developed by	Managed by	Landowner	Ramp: Number of lanes	Ramp: Surface	Parking: Number of spaces	Parking: Surface	Other facilities or remarks
On Bureau of Sport Fisheries and Wildlife Lands (cont)										
Cold Springs Landing	653.2	L	Bureau Sport Fisheries & Wildlife	Bureau Sport Fisheries & Wildlife	Bureau Sport Fisheries & Wildlife	1 lane	Crushed rock	20	Crushed rock	
On State of Wisconsin Lands										
De Soto-Highway 35 Landing	667.2	L	Wisconsin Highway Department	Wisconsin Highway Department	Wisconsin Highway Department	2 lanes	Gravel	25	Gravel	
Lynxville Landing	651.2	L	Wisconsin Highway Department	Wisconsin Highway Department	Wisconsin Highway Department	1 lane	Crushed rock	15	Crushed rock	
On County and Municipal Lands										
Victory Landing	672.7	L	Wisconsin Highway Department & Township	Wheatland Township	Wheatland Township	1 lane	Gravel	30	Gravel	
Blackhawk Memorial Park (Upper access)	671.2	L	Vernon County	Vernon County	Vernon County	2 lanes	Concrete plank	40	Gravel	Picnic and camping facilities (Another access on Corps of Engineers land)
De Soto-Depot Landing	667.8	L	Village of De Soto	Village of De Soto	Village of De Soto	1 lane	Gravel	15	Gravel	

Table 30 (continued)

Major existing public-use facilities - pool 9

Site	River Mile	River Bank	Developed by	Managed by	Landowner	Ramp: Number of lanes	Ramp: Surface	Parking: Number of spaces	Parking: Surface	Other facilities or remarks
					On County and Municipal Lands (cont)					
Lansing Small-Boat Harbor	663.7	R	Corps of Engineers	Town of Lansing	Town of Lansing	2 lanes	Concrete	30	Crushed rock	Concession facilities
Lansing Landing	663.2	R	Town of Lansing	Town of Lansing	Town of Lansing	1 lane	Concrete	20	Blacktop	
Ferryville Boat Ramp	657.8	L	Village of Ferryville	Village of Ferryville	Village of Ferryville	2 lanes	Concrete	35	Blacktop	
					On Private Land for Public Use					
Power Plant Landing	677.8	L	Dairyland Power Coop.	Dairyland Power Coop.	Dairyland Power Coop.	2 lanes	Shale	70	Shale	

Source: U. S. Army Corps of Engineers (1968)

A total of 510 parking spaces is indicated as available at the 17 sites, for both car and trailer and car parking. Since the principal use of most of the sites is for water access and since parking facilities generally are located adjacent to or near the boat launching areas it can be assumed that most of the spaces were intended for parking of cars and trailers. Only two sites have semi-permanent surfaces (blacktop) on parking areas which provide for about 55 cars. Parking areas at all other sites have nonpermanent surfacing which requires considerable seasonal maintenance. In this case also, lack of maintenance due to general shortage of funds has resulted in considerable deterioration. In addition to the 510 designated parking spaces available, contiguous areas of natural ground at most sites can provide supplemental parking when weather is favorable and pool level conditions permit.

Sport Fishing and Hunting. Precise measures of the number of sport fishermen using a specific pool are not available. Although creel census data are available for Pools 4, 5, and 7, comparable data do not exist for Pool 9. Probably the best data available are the number of sport fishermen observed annually by attendants at lock and dam sites. Attendants to each lock and dam observe the river pool areas above and below their site at 3:00 p.m. each day and record the number of sport fishermen seen; the annual data are simply a sum of these daily estimates.

The number of sport fishermen observed by attendants at each lock and dam in the study area are shown in Figure 45 for the years 1960 and 1970. There has been little change during the ten-year period of the number of sport fishermen observed. Because fish tend to seek water with a high concentration of dissolved oxygen and dams tend to aerate the

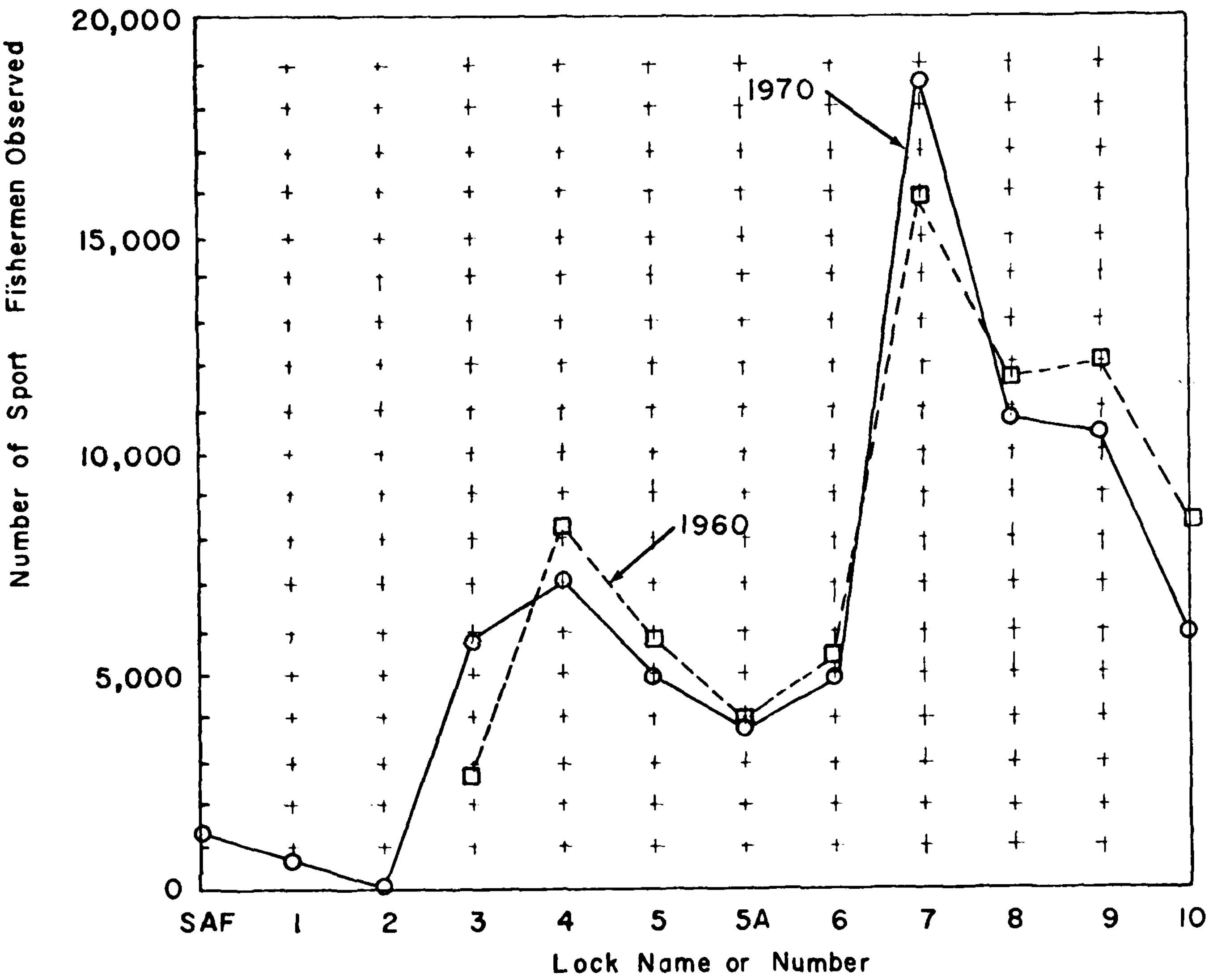


Figure 45. Number of Sport Fishermen Observed Annually by Attendants from Lock and Dam Sites on the Upper Mississippi River in 1960 and 1970. Source: UMRCC, Proceedings of Annual Meeting, 1962 and 1971.

water, the bulk of the sport fishermen tabulated in Figure 45 are probably in the pool downstream from the lock and dam cited on the horizontal axis of the figure. The figure shows that in 1970 Pool 9, below Lock and Dam 8, probably had the second highest number of sport fishermen in the District. The largest number of sport fishermen in any pool in the St. Paul District were observed from Lock and Dam 7.

Sport hunting of waterfowl along the Mississippi River study area is large. It is estimated that in 1963, the year for which the most precise data are available, about 6,200 visits by hunters were made to Pool 9. The Lansing District of the Upper Mississippi River Wildlife and Fish Refuge, which covers Pool 9, estimates that for the ten years from 1961 to 1970 an average of 5,375 hunters in Pool 9 logged an average of 9,970 waterfowl annually.

Sightseeing and Picnicking. Studies in general indicate that a body of water is often essential for most recreation activities. People want this water not only to boat on or to fish or swim in, but also simply to look at, picnic beside, and walk along. The study area of the Upper Mississippi has served this purpose for settlers for two centuries. Again, because precise data are lacking, it is generally difficult to isolate the effect of Corps' operations on recreational activities such as sightseeing, picnicking, and hiking. To assist sightseers, the Corps of Engineers operates overlooks at locks and dams in the study area. In addition, a variety of parks exist along the river that are available for sightseeing and other recreational activities.

REFERENCES

Brown, W. N., Inc. 1930. Upper Mississippi River, Hasting, Minnesota to Grafton, Illinois, Survey 1929-1930.

Candeub, *et. al.*, 1969. Mississippi River Region Background Report, MRRPC.

Carlson, C. A. 1968. Summer bottom fauna of the Mississippi River, above dam 19, Keokuk, Iowa. Ecology 49:162-169.

Claflin, T. O. 1972. Untitled report to Dairyland Power Cooperative.

Cox, G. W. 1967. Laboratory manual of general ecology. Burgess Publishing Company.

Dairyland Power. 1972. Environmental Report DPC-ED-3, LaCrosse Boiling Water Reactor. Dairyland Power Cooperative, LaCrosse, Wisconsin.

Ellis, M. M. 1931. A survey of conditions affecting fisheries in the Upper Mississippi. Bur. Fish. Circular No. 5:1-18.

Fremling, C. R. 1960. Biology of a large mayfly, *Hexagenia bilineata* (Say), of the Upper Mississippi River. Iowa State Univ. Agr. Home Econ. Exp. Sta. Res. Bull. 482:841-852.

Fremling, C. R. 1970. Mayfly distribution as a water quality index. Water Quality Office, EPA.

Green, W. E. 1960. Ecological changes on the Upper Mississippi River Wildlife and Fish Refuge since inception of the 9-foot channel. Bureau of Sport Fisheries and Wildlife Fish and Wildlife Service. U.S. Department of the Interior.

Helms, D. R. 1968. Aquatic habitat of the Mississippi River bordering Iowa. Iowa Quarterly Biology Reports. Vol. XX(4):11-14.

McConville, D. R. 1969. Macroinvertebrates of the Mississippi River in the Monticello region. M. A. Thesis. St. Cloud Library, Minn.

Oschwald, W. R. *et. al.*, 1965. Principal soils of Iowa. Special Report No. 42, Cooperative Extension Service, Iowa State University, Ames.

Ranthum, R. C. 1971. The effects of heated effluent from the Dairyland Power Plant at Genoa on water temperatures and fish of the Mississippi River. Wisconsin Department of Natural Resources, Division of Forestry, Wildlife and Recreation, Bureau of Fish Management.

UMRCBS. 1970. Upper Mississippi River Comprehensive Basin Study. Appendix D. U.S. Army Engineer District, St. Paul.

UMRCC. 1967. A compendium of fishery information on the Upper Mississippi River. Compiled by R. C. Nord.

U.S. Army Corps of Engineers. 1968. Master plan for resource management part XI - Pool 9. St. Paul Minn.

van der Shalie, H. and van der Shalie A. 1950. The Mussels of the Mississippi River. American Midland Naturalist. Vol. 44 No. 2.

New, James. 1972. A non-game survey in Indiana on selected portions of natural and channeled streams in the Kankakee and Elkhart River Basins. Mimeo paper prepared for Midwest Wildlife Conference, Des Moines, Iowa, December 1972.

3. ENVIRONMENTAL IMPACT OF THE PROJECT

INTRODUCTION

The major impacts due to the 9-foot channel project can be divided between: (1) construction of the lock and dams, and (2) the maintenance activities and operation by the Corps of Engineers.

Following impoundment the water level rise of Pool 9 resulted in the flooding of many low lying marshes and wooded areas. However, many more acres of relatively permanent marsh developed with the more stable water conditions.

The dredging required to maintain the 9-foot channel has resulted in the accumulation of dredge spoil at sites along the main navigation channel. In places this could close off rapid flowing sloughs. At other locations, e.g., above Lansing, Iowa from river mile 664 to 665, dredge spoil may be accumulating at a rate faster than can be colonized by the native tree species.

NATURAL SYSTEMS

Impacts resulting from the project are discussed under somewhat artificial divisions in the following paragraphs. It should be apparent that many of these categories are closely interrelated.

Dredge Spoil

The 150,000+ cubic yards of dredge spoil removed each year from the navigation channel in Pool 9 is largely deposited at one of 6 sites (see Figure 4). Of these, the region just above Lansing has received the most frequent spoil placement in the past ten years, getting an average of

77,905 cubic yards every other year during this period. The spoil has formed narrow islands on the Iowa side of the main channel (Figure 46). On the other side of this island is the southern edge of the marsh south of Big Lake. Because of the extensive spoil placement in some of these areas, there are regions where the spoil is spilling over into the marsh, e.g. stands of Sagittaria are being covered by spoil (Figure 47). This has happened on the Iowa side of the river above Lansing, and on the Wisconsin side of the river further upstream at the site known as Indian Camp.

Another problem with the rapid rate of spoil placement above Lansing is that trees are probably being covered faster than they can be replaced. What results is an extensive vegetation-free sand pile - extremely subject to rapid wind and water erosion. In addition to the sand beach created, there may be rather dangerous debris left behind as evidence of the dredging operations; it is often the case that the wire used to hold the spoil conduit pipe sections together gets left behind when the dredging is completed. On 18 May 1973, during a period of about 20 minutes at a spoil bank above Lansing (while on a Corps sponsored aerial survey), 5 such barbed wires were seen partially buried in the dredge spoil placements of 1971 and 1972.

Another potential impact of dredge spoil is the closing of rapid flowing sloughs off the main channel. Most of the Pool 9 sites noted in the 1969 Upper Mississippi River Dredge Spoil Survey (UMRCC, 1970) where spoil should not be placed were at such sloughs. Thus far there is no evidence that sloughs have been closed due to spoil placement in Pool 9 in the past decade. However, there was extensive spoil placement very close to both Hummingbird and Natchway Sloughs during 1973. Additional spoil

Figure 46. View of narrow islands created north of Lansing, Iowa due to spoil placement. Note light area in center of picture showing spoil taken from the main channel that is now spilling over into the marsh area north of main channel.

Figure 47. View from dredge spoil shown in Figure 46, looking north into rich marsh habitat. Note the sand impinging on the extensive stands of Arrowhead plants.

placement at these sites would probably spill over into these sloughs.

Sedimentation

The impoundment of water has resulted in the deposition of sand that would normally remain suspended in a running water habitat. This has been greatly accelerated due to the way man's land use patterns have changed since the initiation of the project. The intensive agriculture practiced in the immediate watershed of Pool 9, along with the considerable land relief, has speeded the relentless erosion of the land. As a result, the pool is filling rapidly with sand. The pronounced delta at the mouth of the Upper Iowa River gives mute evidence of soil and sand lost to the river.

In 1959 the lower 7.6 miles of the Upper Iowa was channelized so that it now empties into the Mississippi just above the beginning of Big Slough. Sediment carried by the Upper Iowa is now largely carried directly into the main channel of the Mississippi instead of being deposited, as formerly was the case, when the Upper Iowa meandered in the mature floodplains region. There are at least two related consequences: (1) the amount of dredging required downstream has increased and (2) there is more sediment entering Big Slough - which accelerates the rapid sedimentation of Big Lake.

During the 14-year period prior to the channelization of the Upper Iowa (1944-1958) there was dredging 3 times at Indian Camp and 5 times in the section above Lansing. The combined yearly average dredged during this 14-year period was 36,409 cubic yards per year. In the 14-year period since channelization (1959-1973) there has been dredging 5 times at Indian

Camp, and 8 times above Lansing. The combined yearly average dredged during this 14-year period was 58,298 cubic yards per year. There has been about a 60% increase in both the frequency and quantity dredged downstream since the channelization project on the Upper Iowa.

The amount of sediment presently carried into Big Slough (just downstream from the mouth of the Upper Iowa) is evident from the extensive sand bars visible during at normal pool level (Fig. 48). At high water (next spring) much of this will be carried down and deposited in Big Lake. The presence of extensive adventitous root systems on the stems of young trees is evidence they were previously covered by sand (Fig. 49).

As water depth is reduced, the character of aquatic habitats change. Commercial fishermen in the Lansing area implicate the reduction in water depth of Big Lake with a decline in fish habitats (Hartman, personal communication).

Impoundment of Water

The most apparent effect has been the creation of a vast pool where once there was a meandering river. In Pool 9 from the dam up to river mile 660 there is primarily open water. Features identified on the 1929-30 Brown Survey map, but now inundated with water, include St. Paul Slough, Harpers Slough, Caya Lake, Flat Lake, Bass Lake, Mansfield Lake, Dubuque Lake, Kettle Lake, Pease Boys Lake, Muskrat Lake and Capoli Slough.

From river mile 660 to Lock and Dam No. 8 at mile 678.2 there exists a series of deep sloughs and wooded islands with scattered flooded hay meadows. Above mile 671 the river has been relatively unmodified by impoundment.

Figure 48. View of deposited sand bar just west of beginning of Big Slough. Photo taken in late June, 1973.

Figure 49. View of adventitious roots from the stem of a young tree on sandbar near beginning of Big Slough. Photo taken in late June, 1973.

Table 31 shows some of the impoundment effects in terms of acreage in land and water within Pool 9. It can be seen that over 16,000 acres of land has been flooded by this project. There is very little difference in the area of the main channel, but the acreage of backwaters (including side channels, sloughs, lakes and ponds) have increased by a factor of about 3.4.

The impoundment has eliminated the extreme low water conditions that were characteristic of the river during late summer and winter. This has provided a more stable environment, and the variety in fauna and flora has probably increased as a result (Green, 1960).

The fact that the impounded water acts as a settling basin means that nutrients adhering to soil particles are likely to be retained. To what extent nutrients are available for uptake by aquatic plants will influence the systems productivity. Too much primary production is often undesirable since it often leads to noxious blue-green algae blooms and oxygen depletion as the plants decompose.

Flood Frequency

Extreme fluctuations in river level have been observed for many years on the Mississippi River. However, there have been two "hundred-year" floods within the past eight years in Pool 9 (in 1965 and 1969). It is recognized that severe spring floods are caused mainly by factors such as heavy snow cover on frozen grounds, a late spring, and heavy rains during the spring thaw. Still it seems reasonable that the elevation of the floodplain is at least partially responsible for the increase in the height of flood crests in recent years. If areas in Pool 9, e.g., Big Lake, are

Table 31

Pre-impoundment and Post-impoundment Acreage in Pool 9 of Mississippi River

Habitat	Pre-impoundment*		Post-impoundment**	
	1929-30	Percent	1968	Percent
Main channel	4449.3	8.5	3839.4	7.4
Backwaters	7083.8	13.5	24055.8	46.4
Land	40899.3	78.0	24101.8	46.2
Totals ***	52432.4		51997	

** Source: data from Helms (1968)

* Source: calculations made from 1929-30 Brown survey maps

*** Totals differ slightly due to error associated with the two *independent* techniques of map analysis.

filling in with sand and silt as previously suggested, then it would be expected that a 5-foot rise of the river bottom must be attended by a commensurate rise in flood crests.

Benthic Invertebrates

Sediment from eroded farm land has collected within the pool, and it is likely that in some locations sand-inhabiting mussel populations have been reduced. Also, the maintenance dredging of the main channel has reduced one popular mussel bed below Lansing, Iowa (Walliser, personal communication).

Burrowing mayflies are useful as indicators of general water quality (Fremling, 1970). Their presence indicates that the body of water retains high oxygen levels and that it is not poisoned by pollutants. Also, mayfly nymphs are probably the most important single food source for many Mississippi River fishes. Mayflies are excellent converters of organic sediments to high quality fish food. The most efficient food chains in nature are short chains. The algae-mayfly-fish food chain is extremely efficient.

The burrowing mayfly Hexagenia has increased in numbers since the water was impounded. People who live along most of the Upper Mississippi River are accustomed to periodic invasions by hordes of recently emerged adult mayflies. They do well in most silted impoundments as long as there is sufficient current to supply oxygen-rich water. The mean number of Hexagenia in Big Lake during the summer of 1973 was about 1200 per square meter, and the mean number at the southern end of the pool (transect CC) was about 2150 per square meter.

Logging of Bottomland Timber

Prior to the impoundment of water behind Lock and Dam No. 9 there was extensive logging in the pool during January 1937. About 3,000 acres of narrow wooded islands were logged during this period. Trees removed included elm, ash, cottonwood, maple, and willow.

Wing Dams and Closing Dams

The 60 wing dams of Pool 9 and several closing dams now lie just beneath the water's surface. Many motor boat operators have discovered that these structures are just about at propellor-depth. The wing dams now provide rocky corrugations on the river floor. In effect, they have increased the total surface area of the river bottom - thus increasing its carrying capacity for bottom dwelling fauna and flora. These rocky substrates have some of the most diverse benthic fauna present in the river.

Wildlife Habitat

The rise in water level and more stable habitat conditions have produced excellent habitats for waterfowl. Annual harvest of waterfowl in Pool 9 for 1965 through 1971 ranged from 570 to 1,451 birds with an average hunter bag rate of 1.62. Day use of Pool 9 by waterfowl ranged from 2,246,975 to 4,128,011 days during this seven year period.

The increase in waterfowl usage is a direct result of the changes in waterfowl habitat. Early studies by Vernon Bailey, F. M. Uhler, and A. O. Steven showed that marsh and semi-aquatic species formerly were present in river bottom area but in limited numbers. The lakes and marshes situated in the area were subject to periodic flooding and drying during the summer and fall which was detrimental to marsh and aquatic development. The periodic or seasonal fluctuation of the various ponds and lakes also had considerable influence on the development of aquatic plants which form the cornerstone of the food chain. The wet-dry cycle in the marsh and pond areas resulted in greatly reduced growth, and loss of a primary food source for many waterfowl. Few birds remained in the area for any length of time because of the dearth of food (Green, 1960).

The high semi-dry bottoms at one time held higher populations of upland mammals such as foxes, rabbits, skunks, and badgers were quite high due to the favorable environment. The prairie chicken utilized the bottomland meadows as a suitable habitat for reproduction and feeding.

The completion of the impoundment abruptly changed the river bottom from an area of wide fluctuation in pool levels (ranging from floods in the spring to drying out in the summer) to an area of semi-stabilized water. Although spring floods still occur, the bottoms do not dry out in the summer. Thus, instead of wooded islands and dry marshes a vast marsh and aquatic habitat has developed with relatively stable water levels throughout the year (Green, 1960).

A marked increase in waterfowl usage was evident after completion of the impoundment. The marsh and aquatic development resulted in ducks lingering in the area throughout the fall. With increased availability hunting is more extended throughout the season, rather than concentrated in a few days of migrational "flights".

Fur animals such as beaver, raccoon, otter, mink, and muskrat have responded with significant increases. Beaver, once almost trapped out, were restocked and open season was reinstated in 1948. Muskrats have flourished in the marsh area with about 800,000 muskrats being taken between 1940 and 1960 in the entire refuge. During that same period, 19,000 mink were removed from the refuge (Green, 1960). The Bureau estimates for population numbers present December 1970 in Pool 9 were 22,000 muskrats, 1,875 beaver, and 100 mink.

The numbers of several of the upland mammals have been lessened due to reduced habitat (e.g., the prairie chicken has completely vanished). Many other species, however, have increased.

In summary, the impoundment has created valuable wildlife habitat for marsh and semi-aquatic species and has increased the numbers of many species. There is, however, concern that these habitats may be degraded by the Corps' channel maintenance activities.

SOCIOECONOMIC SYSTEMS

Specific impacts of Corps' operations on the subdivisions of socioeconomic systems for Pool 9 are identified below and then discussed in detail.

Identification of Impacts

The impacts on the socioeconomic systems related to the study area of the Upper Mississippi River divide into the industrial, recreational, and cultural effects.

Industrial Impacts

In contrast to some pools in the study area that have had considerable industrialization along their banks, Pool 9 has had comparatively little and is the origin or destination of only a minor portion of the commodities that move through the pool. The result is that the industrial impacts of operating and maintaining the nine-foot channel in Pool 9 have been limited. The principal industrial impacts are:

1. Increased turbidity of water in some portions of the Upper Mississippi River due to barge movement.

2. Additional employment due to the operation of Lock and Dam 9.

3. An initial increase in commercial fishing and trapping because higher water levels caused increased acreage of suitable fish and fur-bearer habitat. More recently, a potential decline in commercial fishing because recent improper dredge spoil placement is reducing suitable fish habitat.

To summarize, beneficial industrial impacts that result from operating and maintaining the nine-foot channel and its associated locks and dams by the Corps of Engineers are the through-traffic link for commodities moving up and down the river, the employment in lock and dam operation, and an initial increase in the potential for commercial fishing and trapping. The detrimental effects are a decline in water quality due to river barge movement and spills and -- with continued improper dredge spoil placement -- a likely decline in commercial fishing.

Recreational Impacts

1. An increase in recreational boating due to stable, navigable water levels which leads directly to more recreation facilities. Spoil sites are favorite sites for camping and picnicking.

2. An immediate increase in sport hunting and fishing due to an increase in --

   a. Waterfowl habitat, and

   b. Fish spawning areas resulting from rising water levels

   Again, as with commercial fishing cited above, improper dredge spoil placement has recently had a detrimental effect on sport hunting and fishing.

3. An increase in sightseeing visitors to the locks and dams at both ends of the pool.

Cultural Impacts

No archaeological, historical, or contemporary sites of cultural significance in Pool 9 are known to have been affected by Corps' operations.

Discussion of Impacts

The industrial and recreational impacts identified above are examined in detail in the following three sections. Resource implications of these three socioeconomic impacts are discussed in Section 6.

Industrial Activities

The hope that the river towns would become thriving commercial centers following impoundment was not realized for Pool 9. Lansing and New Albin, the two largest river towns along Pool 9, currently have populations that are lower now than in 1930. Lansing has, however, been able to support a fairly substantial recreation and tourist trade. Many claim this would not have occurred without the changes in the River.

There are some who speculate that the decline of the clamming industry was an effect of the Army Corps project, since resultant silting-in largely covered the clams. It appears, however, that the clamming industry was well on its way down before the lock and dam began operating.

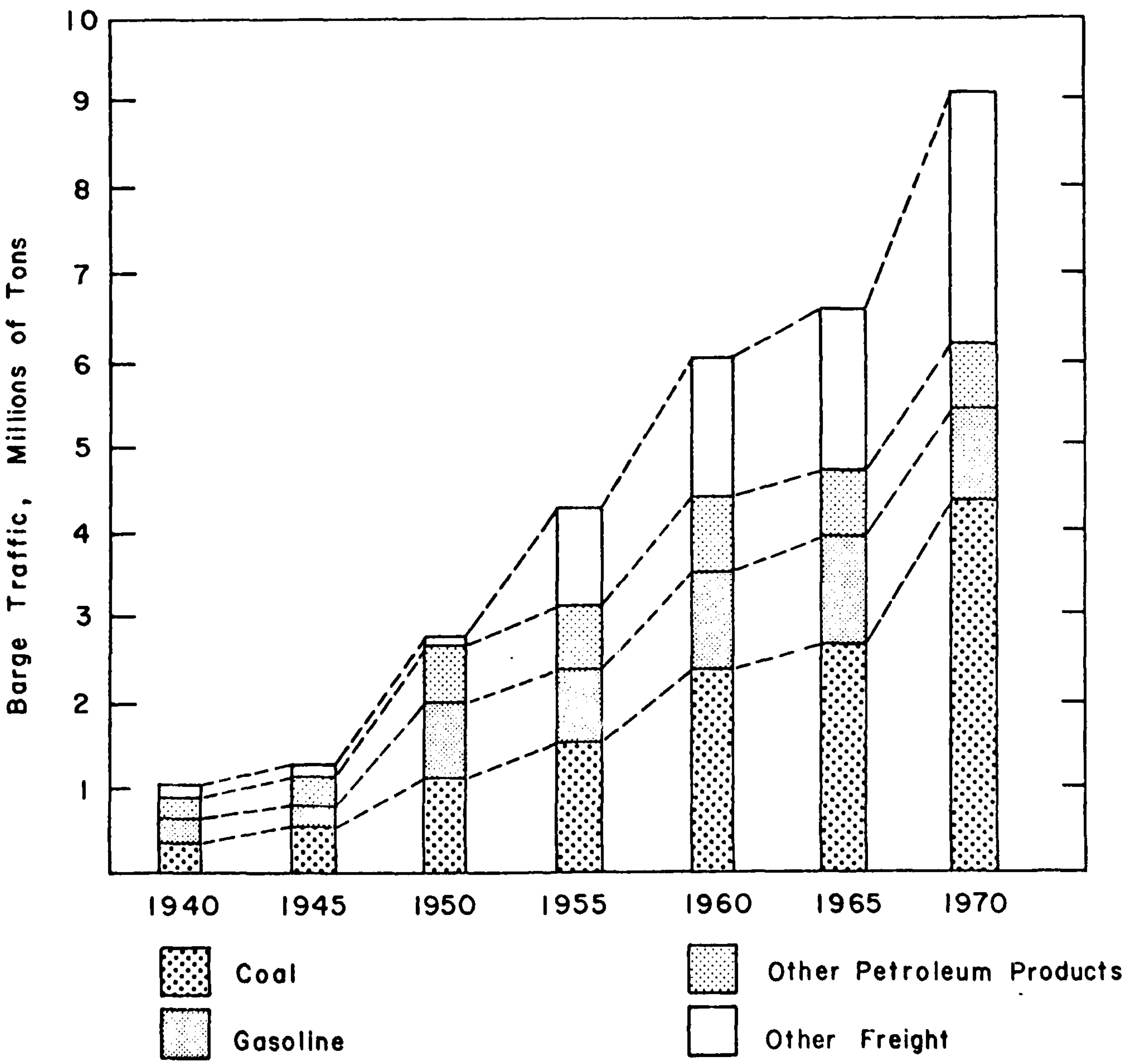
[illegible]ity. The most obvious impact of the activities of the [illegible] been the modification of the transportation system due to the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (e.g. locks and dams and the two commercial docks) on the shores and the barge tows moving along the river. However, Pool 9 has not been the origin or terminal for most of the commodities that move in barges along the Upper Mississippi River. Rather, it serves as an important water link between important commodity terminals upstream and downstream from it.

Figures 50 and 51 show graphically the growth of receipts into and shipments from the St. Paul District in the 30 years from 1940 to 1970. Commodities shown in the figures, with the exception of coal for the two utilities in Pool 9, flow through the pool enroute elsewhere. Although receipts in the St. Paul District still substantially exceed shipments, the growth in shipments (89 percent grain) from the district in these three decades indicates the great impact of the river on the regional economy.

In 1970 some rough projections (based on 1964 data) were made of the growth of commerce in the St. Paul District (UMRCBS, Study Appendix J, 1970). The projections suggest that the tonnage of barge traffic moved in the Upper Mississippi River basin will about double from 1964 to 1980 and about triple from 1964 to 2000.

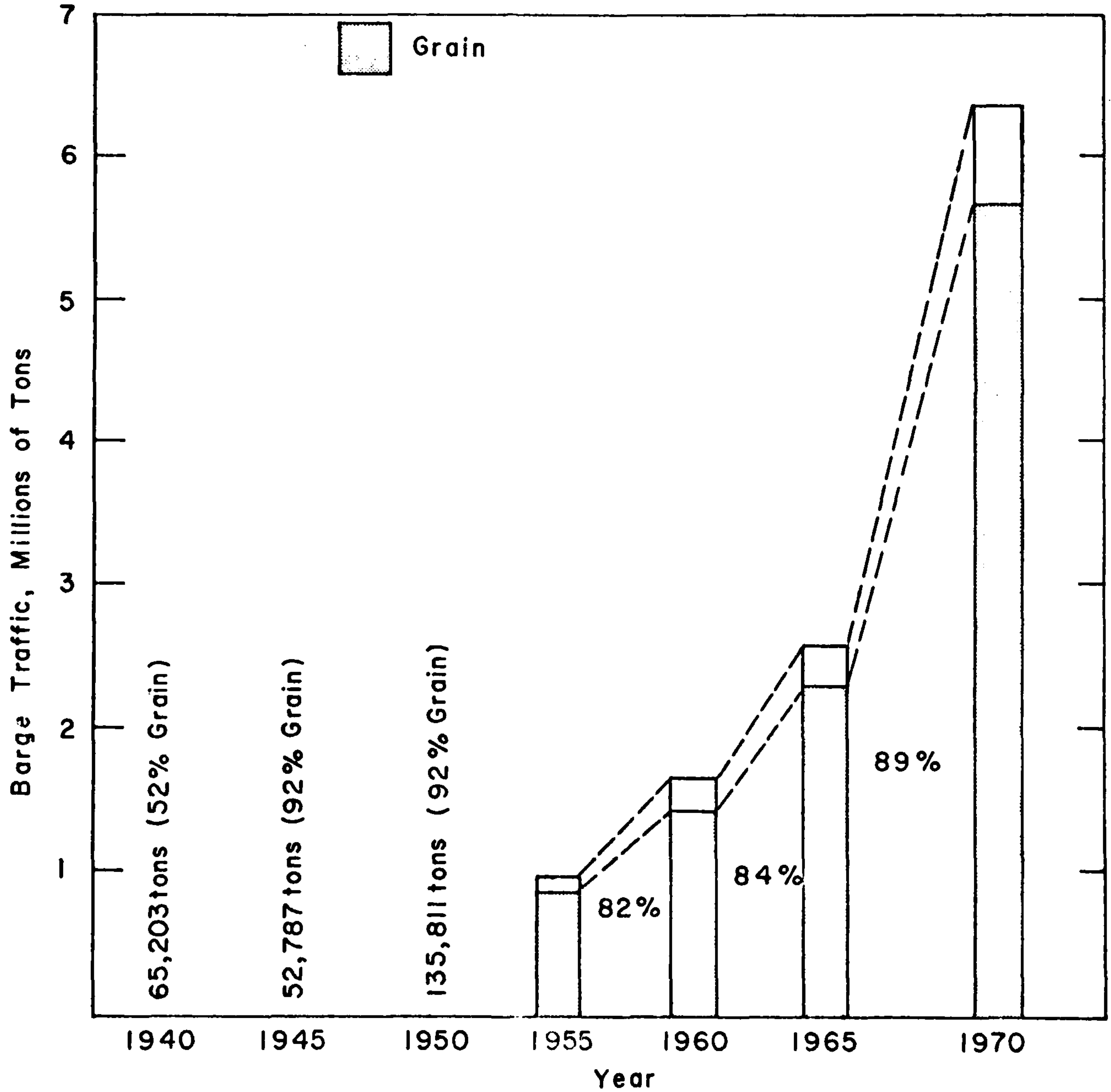
It is noteworthy that receipts into the St. Paul District have always exceeded shipments. In earlier years this imbalance was often extreme (e.g., 1953 receipts = 3,052,144 tons, shipments = 334,233 tons). Recently however the ratio has been around 2:1. Inasmuch as grains and soybeans constitute the preponderant tonnage of shipments, fluctuation in waterborne transport of these products can be profound due to crop conditions

Figure 50. Receipts of Major Commodities -- All Ports, St. Paul District



Source: Based on Data from U.S. Army Corps of Engineers, St. Paul District, St. Paul, Minnesota.

Figure 51. Shipments Out of the St. Paul District



Source: Based on data from Army Corps of Engineers, St. Paul District, St. Paul, Minnesota.

and storage facilities, foreign sales, and competing forms of transportation.

Data are not available on the numbers of vessels originating, terminating, or passing through the St. Paul District. However, some comparative idea of shipping activity can be gained from the following information. Vessel traffic measured in tons from Minneapolis to the mouth of the Missouri River is shown for selected years as follows:

Year	Total Vessel Traffic (Tons)
1962	30,526,626
1964	34,108,482
1966	41,311,941
1968	46,174,929
1970	54,022,749
1971	52,773,097

Statistics on the numbers of vessels originating, terminating, or passing through Pool 9 are not available directly. However, some comparative idea of barge activity can be gained from studying the commercial lockages through Lock 8 and Lock 9 (the locks at either end of Pool 9) which are shown in Table 32. From 1954 to 1972 commercial lockages through Lock 8 increased by 4 percent and those through Lock 9 increased by 59 percent.

Commercial Dock Facilities. The only two commercial docks in Pool 9 are used for coal traffic exclusively (docks at the Interstate Power Company in Lansing and the Dairyland Power Company at Genoa), so that agricultural products are not received or shipped from Pool 9. The presence of only these two docks in Pool 9 reinforces the point made

Table 32

Commercial Lockages in Pool 9

Year	Commercial Lockages Lock 8	Commercial Lockages Lock 9
1954	2,046	1,466
1955	1,967	1,581
1956	1,884	1,673
1957	1,633	1,526
1958	1,618	1,547
1959	1,644	1,719
1960	1,670	1,606
1961	1,432	1,538
1962	1,405	1,646
1963	1,600	1,627
1964	2,090	1,754
1965	1,748	1,351
1966	1,631	1,724
1967	1,678	1,776
1968	1,661	1,748
1969	1,625	1,823
1970	1,951	2,101
1971	2,208	2,324
1972	2,135	2,336

Source: Annual Lockage Data (St. Paul: U.S. Corps of Engineers, St. Paul District, Unpublished Reports).

earlier that the hope expressed by many that the river towns would become thriving commercial centers after the locks and dams were operating has not been realized in Pool 9.

Commercial Fishing. Pool 9 shares with Pool 4 the distinction of being the most important pool in the Northern Section of the Upper Mississippi River for commercial fishing. In every year during the 1960's but 1969 the catch in Pool 4 slightly exceeded that of Pool 9.

The commercial catch in the 1960's is shown in Table 33. There is considerable variation from year to year in the catches with a discernible trend toward larger catches in the latter years shown in the table. Increased commercial fishing in Pool 9 since the lock and dam construction is at least partially due to the beneficial impact of a larger area of fish habitat caused by the rising water level. However, in recent years improper dredge spoil placement and sedimentation behind wing dams has reduced fish habitat. Major year-to-year variations in commercial fish catches are less affected by the supply of fish in the river than by market demand, as reflected in prices commercial fishermen receive for their catch. For example, high meat prices in mid-1973 have caused fish prices to increase with an attendant increase in commercial fishing activity on the river (Fernholtz, personal communication).

Carp ranks first in commercial value in Pool 9, with an average of 607,734 pounds per year from 1953 to 1964 (UMRCC, 1967). Catfish catch during this same period was 248,741 pounds in Pool 9. The twelve-year average (1953 to 1964) catch for all commercial species in Pool 9 was 1,333,856 pounds, greater than that for any other pool in the Upper

Table 33

Pounds of Fish Caught Annually by Commercial Fishermen in Pool 9 of the Upper Mississippi River, 1960 to 1969

Year	Commercial Fish Catch
1960	1,410,000
1961	1,227,000
1962	1,437,000
1963	1,523,000
1964	2,025,000
1965	Not Available
1966	2,172,000
1967	1,886,000
1968	1,837,000
1969	2,010,000

Source: UMRCC, Proceedings of Annual Meetings, 1962 through 1971.

Mississippi except for Pool 4.

Recreational Impacts

Recreational impacts may be divided into boating activities and related facilities, sport fishing and hunting, and other recreational activities.

Boating Activities and Related Facilities. For Pool 9 a principal measure of pleasure boating activity is the record of pleasure boats locking through Locks 8 and 9 -- the locks at each end of the pool. Unfortunately, these are imprecise measures since most pleasure boating is done near Lansing, which is in the middle of Pool 9. The data on numbers of pleasure boats locking through Locks 8 and 9 -- along with the total pleasure-boat lockages through these two locks -- are shown in Table 34 for the years 1954 to 1972. The table shows significant increases in pleasure craft locking through both Lock 8 (from 140 in 1954 to 5,600 in 1972) and Lock 9 (from 600 to 5,500 during the period). The table also shows an accompanying increase in the number of pleasure boat lockages at both locks during the period.

The nine-foot channel and associated locks have provided stable water levels that have contributed significantly to the increased boating activity in Pool 9, along with increased regional population, higher levels of family income, and more leisure time. The increased pleasure boating has led directly to 17 public-use sites identified in Section 2.

Sport Fishing, Hunting, and Other Recreational Activities. The size of the pool and the variety of access points, and the lack of an adequate survey program have precluded obtaining an accurate count of

Table 34

Pleasure-Boat Lockages of Pool 9

Year	Pleasure Boats Through Lock 8	Pleasure Boats Through Lock 9	Pleasure-Boat Lockages Through Lock 8	Pleasure-Boat Lockages Through Lock 9
1954	143	609	126	465
1955	238	937	227	711
1956	767	1,826	580	1,224
1957	1,206	3,101	907	1,888
1958	2,010	5,569	1,341	2,996
1959	2,992	5,740	1,876	2,944
1960	4,069	5,186	2,500	2,677
1961	3,719	5,596	2,412	2,947
1962	3,683	4,333	2,586	2,371
1963	5,157	5,243	3,434	2,785
1964	4,893	5,468	3,036	2,979
1965	3,694	3,935	2,379	1,984
1966	3,827	4,816	2,395	2,634
1967	3,943	4,445	2,433	2,380
1968	3,523	4,370	2,292	2,466
1969	4,159	4,131	2,225	2,081
1970	4,749	4,430	2,425	2,259
1971	5,368	4,983	2,518	2,415
1972	5,569	5,465	2,940	2,638

Source: St. Paul District of the U.S. Army Corps of Engineers, Annual Lockage Data, 1954 through 1972.

Pool 9 visitation for past years. Neither the Wisconsin Department of Natural Resources (Fernholtz, personal communication) or the Iowa Conservation Commission (Brenton, personal communication) nor the U. S. Bureau of Sport Fisheries and Wildlife (Chase, personal communication) have recent, continuing data on sport fishing, sport hunting, and other recreational activity for Pool 9. The most precise data available are for 1963 and appear in Table 35. The data are a composite of both Corps of Engineers and Bureau of Sport Fisheries and Wildlife (from the Upper Mississippi River Wildlife and Fish Refuge) visitation compilations for that year. In addition to being the most accurate data available to date, they are the most usable since visitation survey estimates were broken down to show ratios of participation in the seven most appropriate activities on an annual and peak month basis. Total annual visitation to Pool 9 in 1963 was estimated at about 120,000, which represents the equivalent of about 1.4 visits for each of the 85,000 people residing in the zone of influence (St. Paul District, April, 1968).

Visitation during the peak month of July 1963 was estimated at about 30,000 or 25 percent of the annual visitation. Table 35 shows a breakdown of total annual, peak month, and peak day visitation by activities. Visitation for hunting is included with other visitation under the annual category only since this activity does not occur in the summer months and does not influence determination of summertime peak loads. It is estimated that about 75 percent of the total visitation shown in Table 35 is generated at or through available public-use sites. With the possible exceptions of camping and picnicking, the other five activities cited, which account for over 92 percent of the total participation, are water-related. It seems

Table 35

Pool 9 Total Visitation - 1963

Activity	Annual 1963		Peak periods		
	Percent of total	Activity participation	Percent of total	Activity participation Month (July)	Peak Day
Camping	3.0	3,600	2.6	780	60
Picnicking	4.8	5,760	5.5	1,650	125
Boating	21.0	25,200	27.6	8,280	625
Fishing	63.4	76,080	60.5	18,150	1,375
Water Skiing	1.4	1,680	1.8	540	40
Swimming	1.2	1,440	2.0	600	45
Subtotal	94.8	113,760	100.0	30,000	2,270
Hunting	5.2	6,240		(Oct) 4,050	(Oct) 305
Total annual	100.0	120,000			

Source: U. S. Army Corps of Engineers (1968) reasonable to conclude that the higher, stable water level in Pool 9 resulting from the construction of Lock and Dam 9 has had a favorable impact on these five activities.

More recent data on the recreational use of Pool 9 have been collected by the Lansing District of the Upper Mississippi River Wildlife and Fish Refuge. These data appear in Table 36 and again emphasize the importance of the river as a recreational resource.

Another source of data on sport fishing is available because attendants at each lock and dam make daily observations at 3:00 p.m. each day throughout the year of the number of sport fishermen observed from their work location. Annual data for the most recent years for which these records are available appear in Table 37. The table shows some variation in sport fishermen observed from Lock and Dam 9 since 1963. Because most sport fishermen observed from a lock and dam are downstream from the dam, most of the fishermen seen from Lock and Dam 9 are in Pool 10. Fishermen in Pool 9 -- as seen from Lock and Dam 8 have remained at consistently high numbers from 1960 to 1970. The data are somewhat biased because just below Dam 8 Clements Fishing Float is located that can hold several hundred fishermen. It is still apparent that Pool 9 is one of the most heavily fished of any of the pools in the study area. Even though the number of fishermen are only indicative of the fishing pressure in this pool, when these numbers are combined with the commercial fish catch some indication of the value and capacity of this natural resource can be gained. Although in the entire Upper Mississippi, blue-gills ranked first in sport catch in the surveys made in both 1956-1958 and 1962-1963, in Pool 9 the 1956-1957 survey revealed, in order of importance to sport catch, that crappie species,

Table 36

Recreational Visits to Pool 9
(Lansing District of the Upper Mississippi
Wildlife and Fish Refuge)

Recreational Activity	Number of Visits in 1971
Fishing	128,255
Duck Hunting	15,100
Deer Hunting	60
Other Hunting	45
Miscellaneous[a]	96,445
Total	239,905

[a]Includes both water-sport and camping activities as well as bird-watching and wildlife observation and photography.

Source: Narrative report for the year 1972. Winona, Minnesota Office of the Upper Mississippi River National Wildlife and Fish Refuge of the U.S. Department of the Interior.

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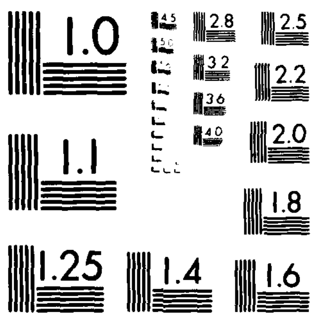

MICROCOPY RESOLUTION TEST CHART

Table 37

Number of Sport Fishermen Observed Annually by Attendants from Lock and Dam Sites at Both Ends of Pool 9 on the Upper Mississippi River, 1960 to 1970

Year	Lock and Dam 8	Lock and Dam 9
1960	11,690	11,997
1961	10,139	10,777
1962	12,084	9,648
1963	11,514	12,208
1964	12,557	11,478
1965	Not Available	Not Available
1966	Not Available	Not Available
1967	11,768	12,404
1968	14,567	13,846
1969	17,377	9,187
1970	10,773	10,327

Note: Counts are made once each day at 3:00 p.m.

Sources: Upper Mississippi River Conservation Committee, U.S. Army Corps of Engineers Data published in the Proceedings of the UMRCC Annual Meetings, 1962 through 1971.

sunfish species, sauger, freshwater drum, and walleye ranked first to fifth respectively (UMRCC, 1967).

In terms of the impact on sport fishing, the higher water level in Pool 9 has increased the spawning areas for fish. In theory this offers the potential for more sport fishing. However, the potential both for increased commercial and sport fishing in Pool 9 may be partially offset by river pollution and turbidity from barge activity in it. Also in recent years improper dredge spoil placement has reduced the acreage of available fish habitat in Pool 9, and sedimentation has also hurt fish habitat -- particularly in areas below wing dams. Therefore, Corps' operations following the construction of Lock and Dam 9 have had both positive and negative effects on fish (and also waterfowl) habitat in the pool. As for the net effect of the project on fishing, opinion is tremendously varied. Generally it is agreed, though, that there has been a considerable increase in both commercial and sport fishing since 1938, when Lock and Dam 9 was constructed.

As the water levels in Pool 9 was raised by Corps' operations, habitat for residential and migratory waterbirds was initially increased. As with fish habitat, improper dredge spoil placement in recent years has also reduced waterfowl habitat. This suggests the potential for greater bird hunting adjacent to Pool 9. Some measure of hunting activity in the pool is shown in Table 35 that notes 6,240 hunting visits to Pool 9 in 1963.

Recreational sites along the perimeter of Pool 9 also facilitate sightseeing, picnicking, hiking, and camping. While non-boating visitors to these sites might be there whether Corps' operations existed on the

Upper Mississippi or not, virtually all of the activities at these sites by boaters are attributable to Corps' activities. In addition, visitors to overlooks at locks and dams are a direct result of Corps' operations.

Leisure is no longer considered a luxury by the American public. Greater productivity at all levels has increased the availability of leisure time. A population of about 20 million people living within a 250 mile radius of Pool 9 will increasingly demand water based recreation in the coming decades. Local and state conservation agencies in the tri-state area associated with Pool 9 have already recognized this by starting extensive development of parks, forests and recreation areas (See Appendix B). The proposed development of the Great River Road will further accelerate the demands for recreation in the Pool 9 area. The influence of recreationists on Pool 9 is currently centered primarily on such activities as fishing, hunting and boating. The Bureau of Sports Fisheries and Wildlife and state conservation agencies have compiled estimates of visits to Pool 9 by hunters and fishermen. This information is available from BSFW at Lansing, Iowa. Little or no adequate information is available on the use of Pool 9 by recreationists interested in boating, waterskiing, and camping.

Cultural Impacts

Research and conversations with the State Archaeologists for Iowa and Wisconsin (McKusick and Freeman, personal communications) revealed no evidence to indicate any cultural impacts on sites in Pool 9 through the activities of the Corps of Engineers. Difficulties involved in identifying archaeological sites that may have been affected by Corps operations are discussed in Appendix C.

REFERENCES

Brenton, Steve. 1973. Personal communication. Planning Section of the Iowa Conservation Commission.

Chase, Dennis. 1973. Personal communication. U.S. Bureau of Sport Fisheries and Wildlife of the U.S. Department of the Interior.

Fernholtz, Willis. 1973. Personal communication. Wildlife and Fish Manager for the Wisconsin Department of Natural Resources.

Freeman, Joan. 1973. Personal communication. Wisconsin State Archaeologist.

Fremling, C. R. 1970. Mayfly distribution as a water quality index. Water Quality Office, EPA.

Green, W. E. 1960. Ecological changes on the Upper Mississippi River Wildlife and Fish Refuge since inception of the 9-foot channel. Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service, U.S. Department of the Interior.

Hartman, W. Personal communication. Commercial fisherman and trapper in Pool 9, Director of Iowa Commercial Fisherman's Association. Resident of Lansing, Iowa.

Helms, D. R. 1968. Aquatic habitat of the Mississippi River bordering Iowa. Iowa Quarterly Biology Reports. Vol. XX(4) : 11-14.

McKusick, Marshall. 1973. Personal communication. Iowa State Archaeologist.

St. Paul District of the U.S. Army Corps of Engineers. 1954 through 1972. Annual Lockage Data.

St. Paul District of the U.S. Army Corps of Engineers. Selected years. Comparative Statement of Barge Traffic on Mississippi River and Tributaries in St. Paul District.

UMRCC. 1970. The 1969 Upper Mississippi River Dredge Spoil Survey.

Upper Mississippi River Comprehensive Basin Study. 1970. Appendix J, Table J-30, p. J-98.

Upper Mississippi River Conservation Committee. 1962 through 1971. Proceedings of Annual Meeting.

Walliser, J. Personal communication. Has done commercial clamming in Pool 9 as recently as 1972. Resident of Harpers Ferry, Iowa.

4. ANY ADVERSE ENVIRONMENTAL EFFECTS WHICH COULD NOT BE AVOIDED AS THE PROJECT WAS IMPLEMENTED

NATURAL SYSTEMS

The frequent need for removal of bottom sediments in order to maintain a minimum 9-foot depth in the navigation channel is probably the major concern. This maintenance dredging naturally causes great disturbance to benthic communities, especially mollusks. Terrestrial and semi-aquatic biotic communities are disturbed by the deposition of dredgings. It might also be argued that the piles of dredge spoil along the banks adversely affect the aesthetics of the riverscape; to the boaters looking for landing sites this is unlikely however. Also, the lack of suitable sites to retain the spoil favors its return to the river bed within a short period of time, and hence the need for redredging in that reach.

The initial filling of the pool resulted in the inundation of over 16,000 acres of what had been bottomland forest and temporary marsh. Also, the lower section of this pool was changed from a free-flowing river to a slackwater pool, with drastic changes to the biota in this reach.

The presence of the dam probably prevents some fish from migrating upstream, although some will work their way through the Harpers Slough spillway, and others probably move up within the lock during lockage.

The presence of a slackwater pool in place of the former river reach has reduced the mollusk populations in the area, by reducing opportunities for aeration of the water (through reduced turbulence and higher temperature), and reduced current which would bring in and keep in suspension food particle required by them and carry off their wastes. Aggradation of sediments in the pool has occurred and will continue to occur with the drop in current velocity, possibly increasing the probability of flooding within the pool.

Operations associated with the dam have caused few adverse effects to the natural environment since the Anti-Drawdown Law became effective in 1948.

SOCIOECONOMIC SYSTEMS

The general public pays some environmental penalties for the presence of navigation on the river, in addition to taxes for support of the operations. Among these are the water pollution caused by barge washing, barge leakage, and occasional major spillage accidents. In recent years improved regulations have reduced the occurrance of these events and their consequent effects.

5. ALTERNATIVES TO THE PRESENT OPERATIONS AND MAINTENANCE ACTIVITIES AND FACILITIES

CHANNEL MAINTENANCE

Frequency of Dredging

Presently two types of dredges are used in the St. Paul District: the hydraulic dredge, Thompson, is shared by the St. Paul and Rock Island Districts, and the clamshell dredge, Derrickbarge 767, operates exclusively in the St. Paul District. The clamshell dredge, with a capacity of about 2,000 yards^3/day, is usually used in rocky areas, such as some parts of Pool 1. It is ideally suited to depositing spoil directly in barges for hauling to more remote locations or for utilization by construction contractors. Its relatively low capacity makes it much more costly for large volume channel maintenance than the hydraulic dredge.

Dredge Thompson is ideally suited to removing large volumes of sediment for channel and harbor maintenance. It transports the sediment-water slurry by pipeline to a selected spoil disposal site within about 1600 feet of the dredge. The disposal site is limited by length of conduit and by the power of the pumps.

One prime alternative in method of operation is the frequency of dredging; more frequent, low volume versus the current less frequent, large volume dredging. Dredging might be done whenever channel depth has been reduced by a predetermined amount, say one foot. Certain economies are realized by dredging deeper once the dredge is in position; however, lesser volumes of spoil deposited in given areas at any one time may better permit survival of vegetation and reduce harmful impacts. Further, a lesser volume may permit other disposal and placement options. The trade-offs need to be examined for each spoil site.

The primary alternatives appear to relate to the way in which the dredging is carried out, the distance the spoil is transported, the means of transport, and placement or utilization of spoil rather than method of dredging itself.

Dredge Spoil Disposal or Utilization

The principal option in dredge spoil disposal under current operating guidelines is the placement of the spoil, and that is generally limited to the 1600-foot reach of the spoil line. However, there are many other disposal options that should be considered. Some may not be attractive economically when compared with past costs; however, when disposal sites near the dredging operation become less and less available, some options may become feasible. The current average cost of about 25¢ per cubic yard dredged (UMRCBS, 1970) means that the average total annual cost at present for Pool 9 is about $39,000. Only detailed economic, and perhaps market, analysis will provide the necessary information. Some of the possible alternatives are listed below.

Disposal farther from the dredge than is now possible: modification of dredge capability would be required through lengthened spoil lines and increased pump power or size. This would permit a greater choice of disposal sites on the floodplain, providing spoil for selected local needs for fill, road sanding, recreation areas, and others.

Disposal by hauling to remote sites for reuse: hauling by barge or rail to markets for road building, sand and gravel operations, and filling operations. Hauling by barge from the clamshell dredge is utilized to some extent today: it could be practical to haul from the hydraulic dredge by first depositing at a primary site and then loading and hauling to a final site, or by pumping directly into specially designed barges. Hauling by barge is the most economical approach to hauling to remote sites near the river. At sites away from the river valley, unit trains may become the most attractive. The up-bound barge has a great advantage in the free lock use which permits raising the load to higher elevations at very low energy cost.

The Bureau of Sport Fisheries and Wildlife of the U. S. Department of the Interior has conducted a study of the potential for spoil utilization, considering likely markets for the spoil (BSFW, 1973). They have concluded that such an approach is feasible -- there is an adequate market and the net cost of disposal would be little if any greater than it is now.

Alternative sites for deposition -- present sites are not always the best in a given stretch of the river. A method of choosing alternative sites is to conduct annual surveys to select best deposition sites for given dredging areas

Annual Dredge Spoil Volume

Among the possible alternatives are actions that would reduce the volume of spoil to be removed from the channel. One approach relates to decreasing the total channel volume; another to decreasing the spoil that enters the channel.

Reducing channel size -- current navigation technology permits more exact navigation than was possible when the 400-foot minimum channel width was established. For example, radar with corner reflecting buoys and guides or a guideway device imbedded deep in the channel to be used with an automatic pilot on board ship would permit more precise navigation. It might be possible, for example, to operate effectively with a 100-foot-wide nine-foot channel, and a 200-foot-wide four- five, or six-foot channel, allowing, of course, wider channels at river bends and in selected "passing" zones.

Minimizing soil entering river -- soil conservation practices in drainage areas of tributaries seems to have retrogressed in recent years. Great quantities of soil enter the tributaries and then the Mississippi River with runoff. A concentrated effort to encourage the practice of contour plowing, to take marginal hillside land out of production, and to plant protective cover would significantly reduce the rate at which the channel filled. The Upper Iowa River which enters near the middle part of Pool 9, drains rich agricultural lands. The kinds and extent of soil conservation needs for this watershed are outlined in Table 38.

Minimizing spoil returning to channel -- much spoil dredged and deposited one summer is washed back into the channel by the floods (or merely high water) the following spring. Effort has been expended in recent years, with some demonstrated success in developing grasses that will grow quickly enough on the sandy terrain to reduce wind and water erosion. Accelerated activity for development and use of such plants could be an important factor in reducing spoil wash-back, and thus, reducing the dredging requirement.

Such activities as those above to reduce the volume to be removed from a channel could be practiced independent of and in combination with

Table 38

KINDS AND EXTENT OF SOIL CONSERVATION
PROBLEMS NEEDING PROJECT ACTION
FOR THE UPPER IOWA RIVER

1. Floodwater and sediment damage (acres)	
a. Agricultural	28,787
b. Urban	15
2. Erosion damage (acres)	30,355
3. Drainage (acres)	21,265

Source: State Conservation Needs Committee. 1970.
Iowa Conservation Needs Inventory

other dredging and spoil disposal changes. They may reduce the spoil problem, but the need for better methods of and places for disposal would still exist.

BACKWATERS

Since the activities of the Corps' on the main channel influence water flow to the backwaters it is important that they demonstrate active concern for these habitats. This would include taking steps to reduce sedimentation in backwaters, and allowing more water to flow into backwaters. Both of these actions are further discussed in Section 8 of this report.

DAM OPERATION

The primary variable in dam operation is the location of the primary control or "hinge" point. It is at about the center of the pool, except at flood time, to minimize long-term flooding of land and hence minimize the need for the government to purchase land in the floodplain. Other methods of operation do not offer any obvious ecological or other advantages. It is important, however, for the conservation of fish and wildlife, to maintain as consistent a water level as possible. This requires that all dams be operated in the same manner.

LOCK OPERATION

Methods of lock operation have relatively little effect on the natural environment; their primary effects are on commercial and pleasure craft operation and through these, on transportation and recreational activities. At present, barge traffic has priority over pleasure craft. This often is unnecessarily detrimental to recreation traffic and discourages recreational use of the locks. For example, without significantly slowing barge movement, recreation craft might be moved through the locks during the half-cycle of returning the water level for the next barge load.

A second alternative is to restructure priorities. One approach is to give four or more recreation boats priority over commercial craft for one lockage. Another alternative to current operation would be a toll for lockage, based on cargo value, weight, or other. Such a toll, in addition to reducing net operating costs to the Corps of Engineers or providing funds for service or facility improvement, may encourage further development of competitive transportation means. This in turn might reduce the impact of projected heavy future traffic increases. The slight increase in transportation cost would be a negative feature to this alternative.

REFERENCES

BSFW. 1973. Upper Mississippi River Dredge Spoil Survey. Minneapolis Office of Bureau of Sport Fisheries and Wildlife.

UMRCBS. 1970. Upper Mississippi River Comprehensive Basin Study. Appendix G. U. S. Army Cngineer District, Rock Island.

6. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The project has resulted in a complex matrix of initial and long-term effects as indicated below.

The creation of the impoundment resulted in the flooding of over 16,000 acres of land. Just prior to impoundment about 3,000 acres of narrow wooded islands were logged. However, the new wildlife habitat created by impoundment has been extensive. This resulted in considerable increase in sports fishing and duck hunting. Commercial fishing also increased initially, but there is real concern about the rate at which sedimentation is filling in some of the better fishing habitats (Hartman, personal communication; Verdon, personal communication).

Higher pool elevation also decreased hydraulic efficiency which increased deposition both in the main channel and in the backwaters. It also increased residence time of water and solutes which increased water temperature, and thus contributed to increased aquatic plant growth and increased eutrophication of the river. Further, it converted marshland to shallow lakes. This decreased some plant and animal populations and increased others. It decreased productivity in areas, but increased that in previously dry, but low lying land. The higher water level also increased bank erosion, which increased turbidity, and then reduced water quality, and the population of clean-water organisms. The increased sedimentation smothered bottom organisms. It also increased the need for dredging which began a new chain of events, including increased turbidity and decreased adjacent marsh and woodland through spoiling.

The long term value of the pool, both esthetically and recreationally, is probably being degraded by the dredging activity. Continued massive dredge spoil placement on narrow islands like those just above Lansing, Iowa will lead to sand-dune type islands, with very little native vegetation.

Resource Implications for Socioeconomic Activities

Table 39 summarizes the major resource implications of continuing to operate and maintain the nine-foot channel in the St. Paul District.

Corps' Operations

Table 39 identifies the major first order direct benefits associated with lock and dam operation and dredging operations. These include employment in lock and dam and dredging operations, maintenance of relatively stable water levels in each pool, and the presence of a navigable nine-foot channel in the St. Paul District. About 150 people are involved with lock and dam operations in the district and about 75 with dredging operations; thus about 225 people derive jobs and income directly from Corps' operations. The annual direct cost to taxpayers for lock and dam operations was $2,601,000 and for dredging operations is $1,200,000. Specific environmental costs of the stable water levels in the pools and the nine-foot channel in the St. Paul District are an increase in sedimentation behind dams and wing dams and a reduction in fish and waterfowl habitat due to improper dredge spoil placement.

Industrial Activities

As summarized in Table 39, the major direct impacts of Corps'

Table 39

First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Corps' Operations	Lock and dam (L/D) operation	1. L/D employment. 2. Stable water levels.	1. Cost of L/D operation. 2. Sedimentation behind dams and wing dams.
	Dredging Operations	1. Dredging employment. 2. 9-foot channel	1. Cost of dredging operation. 2. Destruction of fish and wildlife habitat due to improper dredge spoil placement.
Industrial	Barge Operation	1. Barge Employment. 2. Low-cost water transportation. 3. Energy saving compared to alternate transportation modes.	1. Increased river turbidity. 2. River pollution from oil and gasoline from barges.
	Commercial Dock Operation	1. Dock employment. 2. Attraction of barge transportation-oriented firms that provide local employment.	1. Increased river pollution from industrial activities along shore.
	Commercial Fishing and trapping	1. Increased employment of fishermen and trappers. 2. Increased number of fish and pelts available for consumers.	
Recreational	Boating Activity	1. Increased recreational opportunities for boaters.	
	Operation of Recreational Facilities	1. Increased employment and business opportunities for facilities serving recreational users of the river (boaters, sport fishermen and hunters, etc.).	

Table 39 (Continued)

Socioeconomic Activity: General Category	Socioeconomic Activity: Specific Activity	Qualitative Summary of Socioeconomic Benefits and Costs: First-Order Socioeconomic Benefits	Qualitative Summary of Socioeconomic Benefits and Costs: First-Order Socioeconomic Costs
Recreational (Cont.)	Sport Fishing	1. Initially increased habitat for fish.	1. Increased sedimentation in fish habitat. 2. Decreased fish habitat from improper dredge spoil placement.
	Sport Hunting	1. Initially increase habitat for waterfowl.	1. Decreased waterfowl habitat from improper dredge spoil placement.
	Sightseeing, camping, picnicking, swimming, water skiing	1. Improved opportunities for miscellaneous recreational activities.	
Cultural	Archaeological Sites		1. Loss of selected sites due to L/D construction and rising water.
	Historical Sites		1. Loss of selected sites due to L/D construction and rising water.
	Contemporary Sites		1. Loss of selected sites due to L/D construction and rising water.

operations on industrial activities are for barge operations, commercial dock operations, and commercial fishing. Table 39 notes that there are employment implications for each of these three activities but these benefits must be balanced against accompanying increases in sedimentation, turbidity, and possibly other pollution in the river.

Of special importance in the current energy crisis are the answers to two questions that relate to barge transportation: How effective is barge transportation relative to other modes of transportation with respect to:

1. Energy usage?
2. Air pollution?

Because the answers have major resource allocation implications for the Upper Mississippi River, these two questions are analyzed below in some detail. In addition savings in transportation costs due to barge movements are discussed.

Barge Transportation and Energy Usage. Effective energy utilization is particularly important due to the present (and probably continuing energy crisis. It also affects air pollution which relates directly to transportation energy consumption.

At present transportation utilizes about 25 percent of the total U.S. energy budget for motive power alone. This usage has been increasing at an average annual rate of about 4 percent per year.

In comparing the efficiency of energy utilization between various transportation modes the term "energy intensiveness" is commonly used. Energy intensiveness is defined as the amount of energy (in BTU's) needed to deliver one ton-mile of freight. Mooz (1973) has compared the energy intensiveness of various modes of freight transportation as follows:

Freight Mode	Energy Intensiveness (BTU's/ton-mile)	Ratios of E.I.
Waterways	500	1
Rail	750	1.5
Pipeline	1,850	3.7
Truck	2,400	4.8
Air Cargo	63,000	126

It is apparent from the above that motive energy is utilized more efficiently in water transportation than through any other mode of freight transportation. Therefore, under conditions of restricted petroleum energy availability the use of barging wherever feasible should be encouraged. Indeed, an increased use of the Upper Mississippi and its tributaries is likely. Influencing this will be increased shipments of grain out of the St. Paul District and increased imports of coal and petroleum products into the region. Exports of grain to other countries and shipments of other parts of the U.S. are expected to increase. Energy demands in the Upper Midwest are also expected to rise. In addition freight which is now only marginally involved in barging may shift from other forms of transportation to the less energy-intensive forms. This shift may also be expected to change existing concepts of the kinds of freight suitable for barging with consequent impact on storage facilities. In many cases economic trade-offs may exist between the mode of transportation and the size of inventories considered to be suitable. If the costs energy rise sufficiently, increased capital necessitated by use of the slower-moving barge transportation and tied up in inventory and in storage space may be justified. If this occurs, other kinds of cargoes presently shipped by rail or truck or pipeline may be diverted to barge.

In addition to energy conservation, the importance of the Upper Mississippi as a transportation artery is shown by the burden which would be placed on the rail system (as the major alternative transportation mode used to move heavy, high-bulk commodities) in the absence of barge traffic on the river. In 1972 an estimated 16,361,174 tons of various commodities were received and shipped from the St. Paul District. Under the simplifying assumption that the average box or hopper car carries 50 tons, this amounts to the equivalent of 327,223 railroad cars or some 3,272 trains of 100 cars each or approximately nine trains each day of the year.

Barge Transportation and Air Pollution. Barge transportation also results in less air pollution per ton-mile than either rail or truck modes. Diesel engines are the most common power plants used by both tugboats and railroads. A large percentage of over-the-highway trucks use diesel engines as well. The diesel engine is slighly more efficient that the gasoline engine due to its higher compression ratio. Thus, less energy is used to move one ton of freight over one mile by diesel than by gasoline engines. Among users of diesel engines, barging is more efficient than either rail or truck, as we have seen. Consequently a smaller amount of fuel is required to move freight. With less fuel used, air pollution is reduced.

The amount of air pollution caused by either diesel fuel or gasoline varies substantially only in the type of air pollution. The following summary illustrates these pollution effects (U.S.P.H.S., 1968):

Type of Emission	Emission Factor Pounds/1,000 gallons diesel fuel	Pounds/1,000 gallons gasoline
Aldehydes (HCHO)	10	4
Carbon monoxide	60	2300
Hydrocarbons (O)	136	200
Oxides of Nitrogen (NO_2)	222	113
Oxides of Sulfur (SO_2)	40	9
Organic Acids(acetic)	31	4
Particulates	110	12

Based upon the energy intensiveness ratios shown earlier, a diesel train will produce 1.5 times as much air pollution and a diesel truck 4.8 times as much air pollution per-ton-mile as a tug and barges. In any event, no matter which kind of pollutant is of concern in a particular case, the efficiency of barging compared with other modes of freight transportation will result in reduced air emissions per ton-mile.

Barge Transportation and Cost Savings. A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least cost alternatives of between 4.0 and 5.4 mills per ton-mile (UMRCBS, 1970). It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that have these characteristics are examples of such commodities that originate, terminate, or move through the St. Paul District pools on river barges.

Recreational Activities

Table 39 identifies the variety of recreational activities -- from boating and sport fishing to sightseeing and camping -- that may be helped or hindered by Corps' operations. Ideally it would be desirable to place dollar values on each of the benefits and costs to the recreational activities cited in Table 39 to weigh against the benefits of barge transportation made possible by maintaining the nine-foot channel. Unfortunately both conceptual problems and lack of precise data preclude such an analysis. The nature of these limitations can be understood by (1) looking initially at a theoretical approach for measuring the benefits and costs of recreational activities and (2) applying some of these ideas to the measurement of only one aspect of all recreational activities -- sport fishing.

Benefits and Costs of Recreational Activities. Theoretical frameworks exist to perform a benefit-cost analysis of a recreation or tourism activity. One example is a study prepared for the U.S. Economic Development Administration (Arthur D. Little, Inc., 1967). Unfortunately even this example closes with a "hypothetical benefit-cost analysis of an imaginary recreation/tourism project" that completely neglects the difficulty of collecting the appropriate data.

Applying even this theoretical framework to the nine-foot channel project presents both conceptual and data collection problems. For example, continuing to operate and maintain the nine-foot channel may hurt sport fishing because of the reduction in fish habitat. This means that the total value of sport fishing in the river should not be considered in the analysis. Rather, only the incremental increase or decrease in sport fishing attributable to present Corps' operations (not due to the initial lock and dam construction)should be weighed against those operations; no estimates are presently available to assess the effect of current Corps' operations on fish and wildlife. Also, reduced fish and waterfowl habitat may eventually increase terrestrial wildlife habitat. What the fishermen lose, the hunter and trapper or birdwatcher may gain.

This raises a second difficulty: How does one measure the total value of sport fishing on the river in order to start to measure the incremental portion attributable to Corps' operations? For sport fishing various measures have been identified, each having its own drawbacks (Clawson and Knetsch, 1966): gross expenditures by the f hermen, market value of fish caught, cost of providing the fishing opportunity, the market value as determined by comparable privately owned recreation areas, and the direct interview method -- asking fishermen what hypothetical price they would be willing to pay if they were to be charged a fee to fish.

If some average price per fisherman or trip were available, it still would be possible to assess the total value of sport fishing in the study area only if estimates of the number of sport fishermen or number of sport fishing trips were available. In the St. Paul District these estimates are available through sport fishery surveys for only three pools: Pool 4, Pool 5, and Pool 7. The most recent data available for these pools are for the 1967-68 year (Wright, 1970); comparable data for 1972-73 have been collected but are not expected to be published in report form until about December, 1973.

Valuing Sport Fishing in the Study Area. A variety of studies have been done on recreation and tourism in Minnesota and the Upper Midwest during the past decade (North Star Research Institute, 1966; Midwest Research Institute, 1968; Pennington, *et al.*, 1969). For purposes of analyzing sport fishing and other recreational activities on the Upper Mississippi River, however, they have a serious disadvantage; these studies are generally limited to recreationers who have at least one overnight stay away from home. In the case of the St. Paul District, with the exception of campers and boaters on large pleasure craft with bunks virtually all river users are not away from home overnight and are omitted from such studies.

Information is then generally restricted to that available in the UMRCC sport fishing studies such as those shown below for 1967-68 (Wright, 1970):

Pool Number	Total Number of Fishing Trips	Value at $5.00 Per Trip[a]	Value at $1.50 Per Trip[b]
4	169,361	$846,805	$254,042
5	51,786	258,930	77,699
7	63,238	316,190	94,857

[a] Based on data reported in the "1965 National Survey of Fishing and Hunting" that the average daily expenditure for freshwater sport fishing was $4.98 per day.

[b] Based on data in Supplement No. 1 (1964) to Senate Document 97 that provides a range of unit values of $0.50 to $1.50 a recreation day for evaluating freshwater fishing aspects of water resource projects.

Thus the sum of the values of sport fishing given above for these three pools varies from about $0.4 million to $1.4 million depending upon the valuation of a fishing trip. Assuming one of these values were usable, the researcher is still left with the task of determining the portion (either as a benefit or cost) of Corps' operations. With the limited funds available for the present research and the limited existing data, detailed analysis is beyond the scope of the present study.

Similar problems are present in evaluating the other recreational activities in the study area. Hence, the need for better data as suggested in Section 8 of this report.

REFERENCES

Clawson, Marion and Jack L. Knetsch. 1966. Economics of outdoor recreation. Washington: Resources for the Future, Inc., Chapters 5 and 8.

Hartman, Willis. personal communication. Commercial fisherman and trapper in Pool 9. Director of Iowa Commercial Fisherman's Association.

Little, Arthur D. 1967. Tourism and recreation: a state-of-the-art study. Washington: U.S. Economic Development Administration of the U.S. Department of Commerce, Cpater 8.

Mooz, William E. 1973. Energy in the transportation sector. Santa Monica, California: Rand Corporation Report. P - 4974.

Midwest Research Institute. 1968. The who, how much, what, and where of tourism of Minnesota. St. Paul: Minnesota State Planning Agency.

North Star Research Institute. 1966. Developing and financing private outdoor recreation in the Upper Midwest. Minneapolis: Upper Midwest Research and Development Council.

Pennington, Allan L., Ivan Ross, and William Rudelius. 1969. Minnesota tourism '68: a market analysis. St. Paul: Minnesota State Planning Agency.

Upper Mississippi River Comprehensive Basin Study. 1970. Appendix J. page 90.

U.S. Public Health Service U.S. Department of Health, Education, and Welfare. 1968. Compilation of air pollutant and emission factors (pages 50 and 52).

Verdon, Harold. personal communication. Commercial fisherman. Owner of Lansing Fish Market.

Wright, Kenneth J. 1970. The 1967-68 sport fishing survey of the Upper Mississippi River. La Crosse, Wisconsin: Upper Mississippi River Conservation Committee.

7. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH HAVE BEEN INVOLVED IN THE PROJECT SINCE IT WAS IMPLEMENTED

RESOURCES LOST, INCLUDING LAND USE CHANGES

At least 3,000 acres of forest bottomlands were lost due to impoundment. The comments by Howard Odum below provide an interesting analysis concerning the worth of a tree (Odum, 1971):

> First consider the actural value in energy units and convert. The value as a public recreation and life-support system is its replacement cost. To replace complex, diverse, and beautiful forest requires about 100 years. The photosynthesis per square meter of a forest may be approximately 40 kcal/(m^2)/day. The dollar equvalent of work driven by organic fuels is about 10,000 kcal/dollar. With 4047 m^2/acre, the dollar forest is $590,000 per acre. Losing the development value of 100 years for an acre of land is a major loss. A single tree of about 100 years of age is estimated in this way to be worth $3000.

Since the floodplain forests of the Mississippi River probably requires less than 100 years to be replaced, we can conservatively adjust Odum's time period to 50 years. On this basis the dollar forest would be about $295,000 per acre. Based upon present tree density in the tailwater section of Pool 9, we would estimate mean density of 250 trees (over 2" in stem diameter) per acre prior to impoundment. The 3,000 acres of forest lost through impoundment then has a dollar forest value of about 885 million, or a per tree value of about $1180.

The "state-of-the-art" of resource economics has many unanswered (and probably unanswerable)questions, and many economists would not agree with the above analysis based upon energy replacement costs. However, the calculations leading to cost benefit ratios where resources are arbitrarily given dollar values are probably much more suspect.

Labor, materials, and energy used in the construction of facilities associated with the project have already been committed. Labor, materials, and energy have been and are being committed annually in maintenance activities of the locks and dams, but to a greater extent in maintenance of the 9-foot navigation channel. The buildup of sediments on present unconfined spoiling sites and their erosion back into the channel may necessitate the expenditure of energy to either build containments for the spoil or transport it out of the floodplain.

About 31 miles of free-flowing river and bordering habitat were committed when the pool was filled. Biologically and aesthetically some irreversible changes have occurred. The biota differs now, and certainly the river does not appear as it did prior to channel improvements for navigation. The primeval landscape has been altered and the locks and dams, as well as the relatively stable level of the pools are now "natural" and do alter the appearance of the river.

SOCIOECONOMIC SYSTEMS LOSSES

There are few identifiable adverse economic effects due to the 9-foot channel. From a cultural point of view, however, some adverse effects were irreversible. There may have been the destruction of some archaeological sites (although none in Pool 9 have been identified yet), and some historic sites could have been flooded by raising of the water levels.

REFERENCES

Odum, Howard T. 1971. Environment, Power, and Society, Wiley-Interscience, New York.

8. RECOMMENDATIONS

These recommendations are based upon the data collected during the 1973 environmental study, and data available from previous studies and other sources.

DREDGE SPOIL UTILIZATION

Since the removal of dredge spoil from the navigation channel and harbors is a constant duty of the Corps of Engineers, year after year, accumulation of dredgings will always be a problem with cumulative dimensions. It is therefore recommended that a detailed survey be undertaken to find beneficial uses for dredgings inside and outside the valley, and to locate markets for them. The cost of removing them from the river is low, and the market price high enough to enable contractors to realize a profit from their sale of dredged sand and hauling to buyers at least 20 miles away from the river (BSFW, 1973).

It should be noted that this beneficial use of dredgings would constitute a double benefit to the natural environment: sand and gravel are removed from a site where it is not wanted, and hence do not need to be removed from a sand and gravel pit where removal creates negative aesthetic impact, and disruption of the local wildlife habitat.

If markets for sand from dredging operations should dwindle because of lesser needs for construction and fill, serious thought should be given to transporting it to the upland where it can be returned to the land by spreading. Although this method of disposal would not bring in a monetary return, it may eventually be necessary to subsidize removal of this material from the floodplain. Flood reduction benefits and benefits accruing from the replacement of soil mass in upland fields might be realized.

There are likely beneficial uses of spoil in specific areas of the floodplain. The sand which is dredged up can be used for boat beaching areas, to create shallow bays for wildlife, and other uses which will create a more attractive and interesting riverscape. More boat landings might be developed from river mile 648 to 662 in order to encourage more recreational use of this section of the river. An extensive survey should be conducted to identify the areas that could be benefited.

DO NOT INCREASE SEDIMENT INPUTS

Good soil conservation practices should be encouraged in all tributary basins. It should be recognized the channelization of tributary streams, as occurred in 1959 on the 7.6 mile lower reach of the Upper Iowa River, has its affect downstream. Sediments previously deposited as the Upper Iowa meandered across the mature floodplain are now carried via a more rapid flowing straight channel to be largely deposited only after reaching the main navigation channel. The flood control benefit to a few farmers in the area is a questionable justification for a project that increases sediment input downstream.

REDUCE SEDIMENT INPUTS TO BIG SLOUGH

Big Slough begins about 0.6 mile downstream from the mouth of the Upper Iowa. At this point there has not yet been complete mixing of the Upper Iowa with the Mississippi and much of the sediment gets carried along the Iowa side into the entrance of Big Slough. The placement of a wing dam to divert the Upper Iowa flow out into the center of the main channel should decrease the sediment entering Big Slough. Some study by hydraulic engineers is needed to determine the best location of such a structure.

MONITOR DREDGE SPOIL PLACEMENT

Whenever dredge spoil is placed along the edges of the main channel it is recommended that the Corps require its dredging personnel to take photos of and briefly survey the area before and after the placement of dredge spoil. These photos and survey records would then be available to state conservation agencies, and other groups concerned about the river's ecology. This would help fulfill the spirit of the National Environmental Policy Act of 1969 (Public Law 91-190), and the Corps environmental policy statement of June, 1970. In addition, the requirement of photos after spoil placement might encourage dredging personnel to "clean-up" the area before they left. Hopefully the wire used to hold the conduit pipes would no longer be left behind.

ALLOW MORE WATER INTO BACKWATERS

With increased channelization there has been a reduction in the water flow to the backwater lakes and sloughs. It is important that this trend be reversed if these are to be diverse and productive aquatic habitats.

At the northern end of Pool 9 the only source of water to the backwaters (at normal level for Pool 8) is through two small culverts. One culvert is located in the submersible dam above Running Slough, and the other culvert is in the submersible dam above Pickerel Slough. Their combined flow (at normal pool level) is only 120 cubic feet per second. As a result there is very little flowing water feeding the extensive backwater habitats in the northern section of Pool 9. It is suggested that the Corps add one more culvert to each submersible dam as a step that would benefit these backwater aquatic habitats.

At river mile 674.7 the slough known as Lost Channel originates on the Iowa side of the main channel. At river mile 677.4 Log Jam Slough originates on the Iowa side of the main channel. Both of these sloughs have the potential of providing water to extensive backwater areas. However, there is little flow through these sloughs at normal pool level under present conditions. The Corps should take positive action toward improving these areas by taking steps to allow more water into these sloughs.

BACKWATER DREDGING

The possibility of removing sediments from some backwater areas should be investigated. This may be a controversial issue, but specific cases should be evaluated with reference to their merits. Increasing the depth of areas in Pool 9 like Big Lake (or allowing more water to enter via bigger sloughs) may retard the rate of eutrophication and increase fish productivity.

IMPROVE COVER ON SPOIL BANKS

During high water, the river carries away sediments which have been dredged from the channel and piled on the banks or on islands causing them to redeposit downstream. Methods of quickly developing good vegetative cover over these spoil banks would greatly reduce their aesthetic, environmental and economic impact. These studies should be conducted in conjunction with Refuge personnel, the Wisconsin DNR, and the Iowa Conservation Commission.

FURTHER STUDY NEEDED ON NATURAL SYSTEMS

The collection of data during one season (1973) provides only a minimal basis for management decisions. It is expected that varying water levels from year to year, plus other temporal variables, will influence abiotic and biotic parameters of interest. Without this kind of information on year to year variability it is difficult to interpret much of the field data from 1973.

FUTURE STUDY NEEDED ON WATER-BASED RECREATION IN POOL 9

Additional study will be necessary to determine the economic, sociological and biological factors which undoubtedly affect recreational demand in Pool 9. The effect of these factors on recreation has not been adequately measured for Pool 9 recreational uses; or for that matter adequately measured for water related users in other areas. Information is needed that focuses on the user of particular activities at specified facilities as well as knowledge of the determining factors that motivate recreationists to participate in water-based recreational activities. The attitudes of people toward multiple use and controlled use must be determined if recreation, fish and wildlife, and Corps activities are to be compatible. It will be necessary to determine how an individuals perception of pollution influences the selection and use of recreation facilities.

The major objectives of future study should focus on the following:

1. To determine the recreational preferences, expenditures, and potential conflicts of the present and future users of the Pool 9 area.
2. To determine the attitudes, beliefs, and knowledge that the Pool 9 users have toward water based recreation.
3. To determine the attitudes of the public toward the existing water management agencies and policies affecting recreation.

POSSIBILITY OF REGULATING RECREATIONAL USE SHOULD BE INVESTIGATED

It is anticipated that increased pressure for water based recreation in Pool 9 will lead to potentially serious conflicts of interest between resource agencies, the Army Corps of Engineers, and recreationist. It is recommended that state and federal agencies look closely at the utilization and regulation of recreational activities on the pool.

Boating development on Main Channel

Power boats in the 50 to 150 horsepower, and up to 400 horsepower range, can cause potentially severe disturbance to other river users, to river banks and to wildlife. The development of facilities for large power boats and water skiing should be encouraged in the southern part of Pool 9 (River miles 648 to mile 663). This might require some stump removal and dredging at the southern end of the pool. Greater river use by large power boats in this region of the pool should minimize their impact on the areas of the pool that are more favored by fish and wildlife.

Horsepower limitation on backwaters

After additional evaluation of the impact of recreation users on each other and on wildlife in backwater areas of the pool, it may prove advisable to limit the horsepower of boats operating in areas other than on the main channel.

Pool 9 Zoning

After additional evaluation it may be advisable to zone Pool 9 for a variety of uses. Limiting some users in some areas may be advisable so that multiple use does not degrade into multiple misuse. This will be particularly important as public use increases. A plan might follow the general pattern of the Bureau of Sports Fisheries and Wildlife in setting both refuge and open hunting areas for Waterfowl along the Upper Mississippi River. If the habitat can be zoned for hunters it might be possible to apply the same principle for other water based recreation activities.

Some examples of special zone use might be:

a. Heavy sand bar and dredge spoil areas along river miles 664-666 might be designated high priority for camping and picnicking. Dredge spoil accumulation in this area would be desirable from the standpoint of public recreation. This however, would involve certain environmental trade-offs related to other resources in the Big Lake area. Serious consideration might be given to development of a dredge spoil containment system for use along river mile 664-666.

b. Open pool areas (river miles 648-663) might be designated high priority for power boating, sailboating and water skiing.

c. Ecotonal areas in backwater areas (river miles 667-679) might be designated high priority for fish and wildlife.

d. Specified area on river mile 677.7 known as Genoa Heron Rookery might be designated high priority as an avian sanctuary with little or no human use.

Specific recommendations for zoning Pool 9 for multiple use should be made only after further study and with simultaneous involvement by various local, state, and federal agencies. It is recommended that this aspect of Pool 9 management be completed before recreation pressure increases to unmanageable limits.

REFERENCES

BSFW. 1973. Upper Mississippi River Dredge Spoil Survey. Minneapolis Office of Bureau of Sport Fisheries and Wildlife.

9. APPENDIX A - ENVIRONMENTAL INVENTORY (1973)

Members of the Department of Biology at Luther College, Decorah, Iowa, conducted an environmental inventory study during 1973. Most of the data were collected from May - September. Dr. James Eckblad supervised the collection of data pertaining to the aquatic habitats. Dr. Roger Knutson was in charge of obtaining data on terrestrial vegetation, and Dr. David Roslien handled wildlife and recreation studies during 1973. Luther students assisting in this data collection were Anne Temte (aquatic studies), Ken Ostlie (aquatic studies), Donna Poesch (aquatic studies), Tex Sordahl (time-area bird counts, wildlife data), Jerry Roppe (aquatic studies, wildlife data), Ron Liljedahl (aquatic studies, wildlife data), Jon Kucera (wildlife and recreation data), and John Fylpaa (terrestrial vegetation). Tex Sordahl and Jerry Roppe are presently in graduate school at Utah State University and Colorado State University, respectively.

METHODS OF DATA COLLECTION

The methods referred to in this section are those used in the generation of new data during 1973 for this report.

Sampling Techniques

Aquatic Habitats

Water samples were collected using a 3 liter Van Dorn bottle, or a "guzzler" hand pump. Plankton were taken in whole water samples and in number 12 plankton net tows. Benthic organisms were sampled using an Ekman grab, with 3 samples taken each time a station was sampled. Coliform bacteria were counted with the membrane filtration technique.

Terrestrial Habitats

Wildlife populations were studied using techniques discussed by (Giles, 1971) under the direction of Dr. David Roslien of Luther College. Terrestrial vegetation was analyzed by the quarter method (Cottam and Curtis, 1956) under the direction of Dr. Roger Knutson of Luther College. A series of points was located along a transect line. At each point the surrounding space was divided into four quarters with the transect line as one axis, and a line 90° to it forming the other. Within each quarter the distance to, basal area of, and species of the nearest tree was determined. To calculate absolute density and dominance, all the individual distances were summed and divided by four times the number of points used. This gives an average distance which is equal to the square root of the mean area of the plants. This distance squared, divided into 43560 gives the total number of individuals per acre. This total density was then multiplied by the relative densities of each species to get absolute density of each species per acre. Total basal area per acre was obtained by multiplying average basal area per tree by the number of individuals per acre. Dominance values were obtained by multiplying the total basal area per acre by the relative dominance for each species.

Shrubs and herbs were sampled in quadrants centered on each randomly chosen point along the same transect.

Estimation of parameters

Temperature

Temperature was measured using a thermister and a Precision Scientific meter.

Dissolved Oxygen

Dissolved oxygen was measured using the Winkler method, azide modification.

Turbidity

Turbidity was measured in JTU's on a Hach Model 2100A turbidimeter.

Water Depth

Water depth was measured with sonar using Herter's Model 1250 Fish Finder.

pH

pH was measured with electrodes using a Beckman Model N portable pH meter.

Phosphate

The ortho-phosphate was determined using the stannous chloride method (APHS, 1971).

Nitrate

The nitrate-nitrite-nitrogen was determined using the cadmium reduction method (APHS, 1971).

Solids

Solids were determined by gravimetric methods (APHS, 1971).

Current

Current velocity was determined using a Gurley No. 625 Pygmy current meter.

Figures and Tables in Appendix A

Figures A-1 to A-5 show the aquatic sampling sites in Pool 9. Tables A-1 to A-40 summarize numbers and dry weights of benthic macroinvertebrates. Tables A-41 to A-60 summarize plankton numbers. Tables A-61 to A-106 summarize water chemistry data. Table A-107 contains calculations of diversity and redundancy indices for benthic macroinvertebrates.

Figure A-6 and A-7 deal with size frequency distributions for American Elm, Green Ash, and Red Maple. Tables A-108 and A-109 deal with avian, amphibian, and reptile species observed during spring and summer of 1973. Table A-110 shows the mammals observed during 1973.

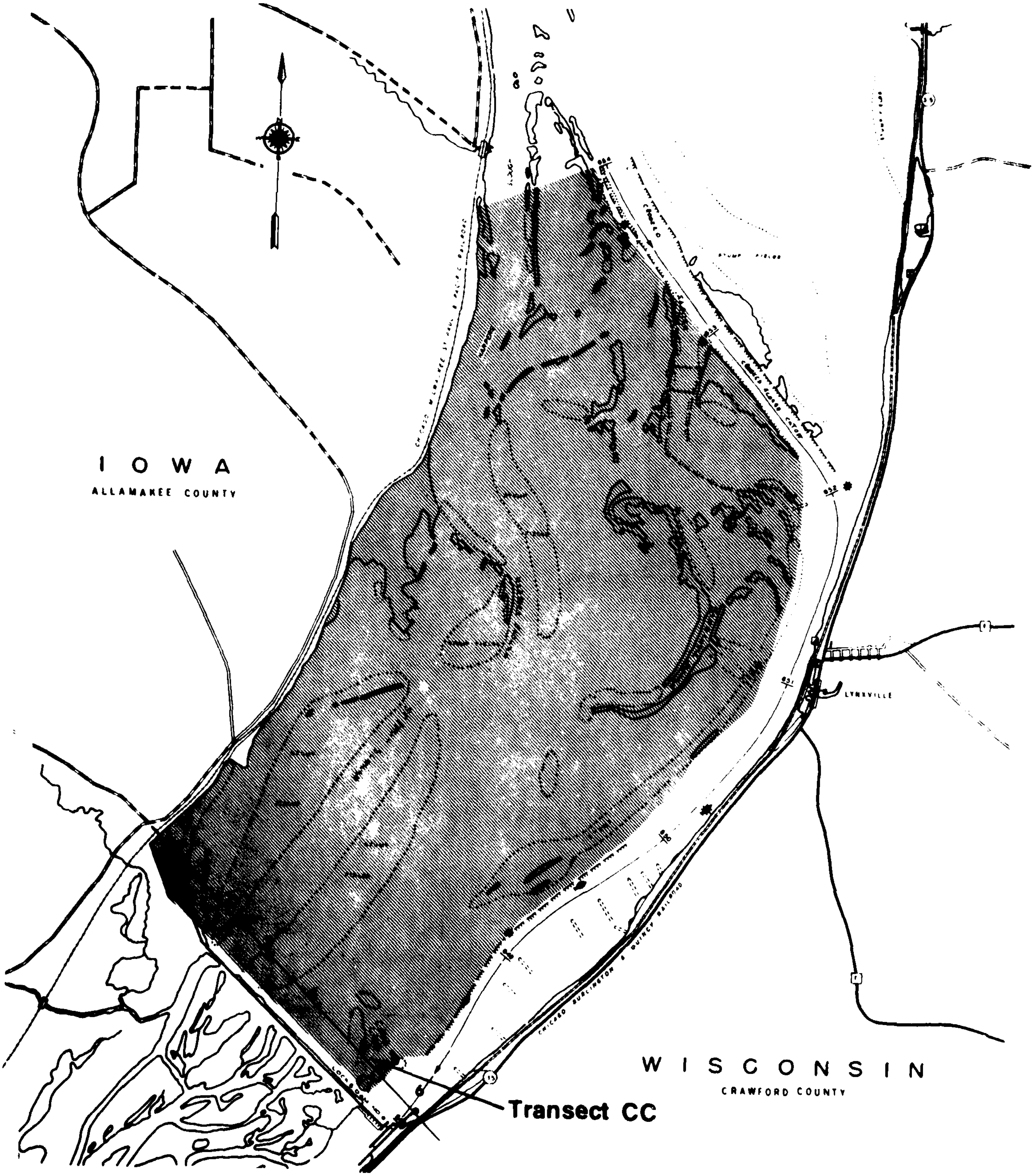

Fig. A-1. Aquatic sampling sites, Pool 9, 1973.

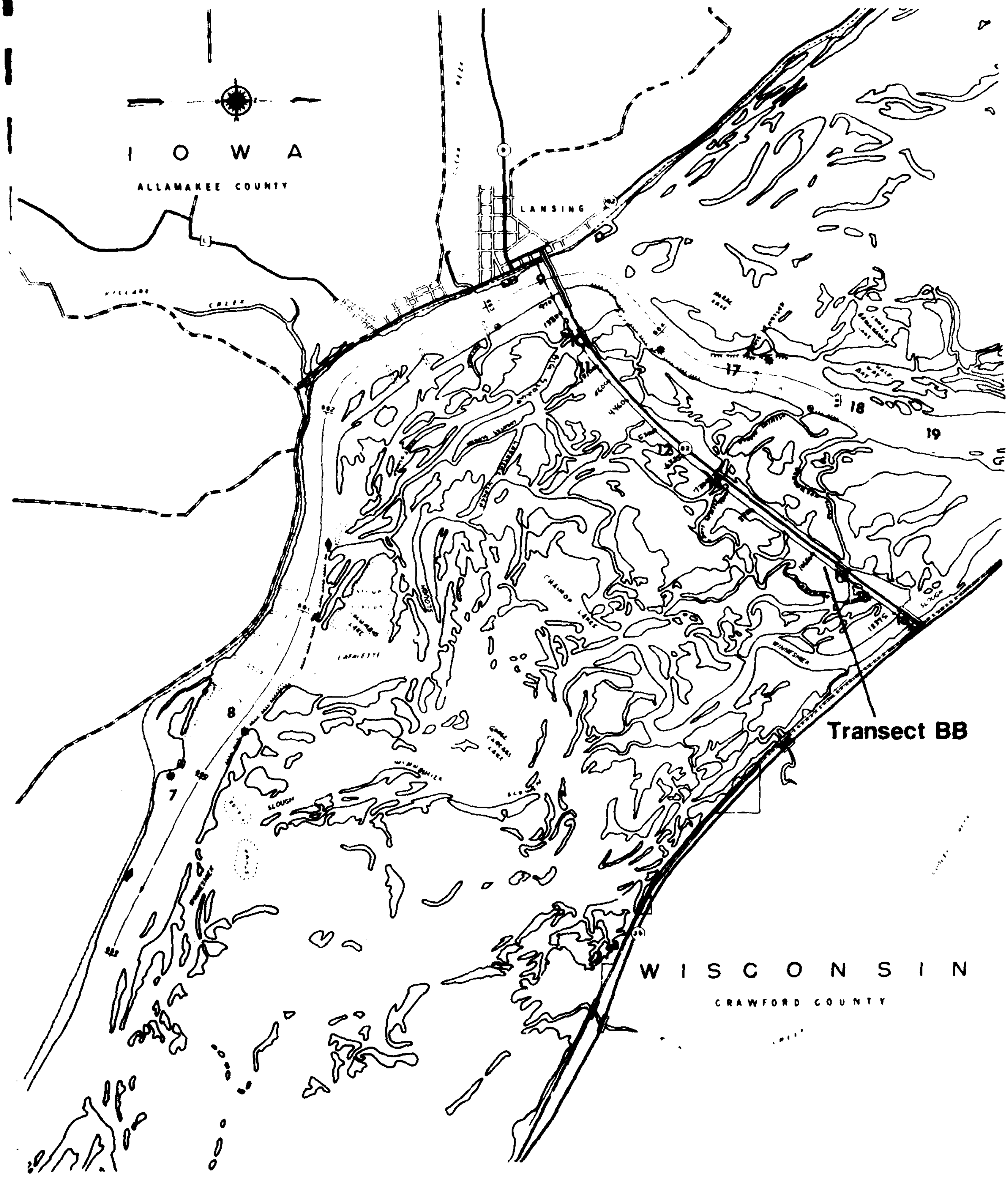

Fig. A-2. Aquatic sampling sites, Pool 9, 1973.

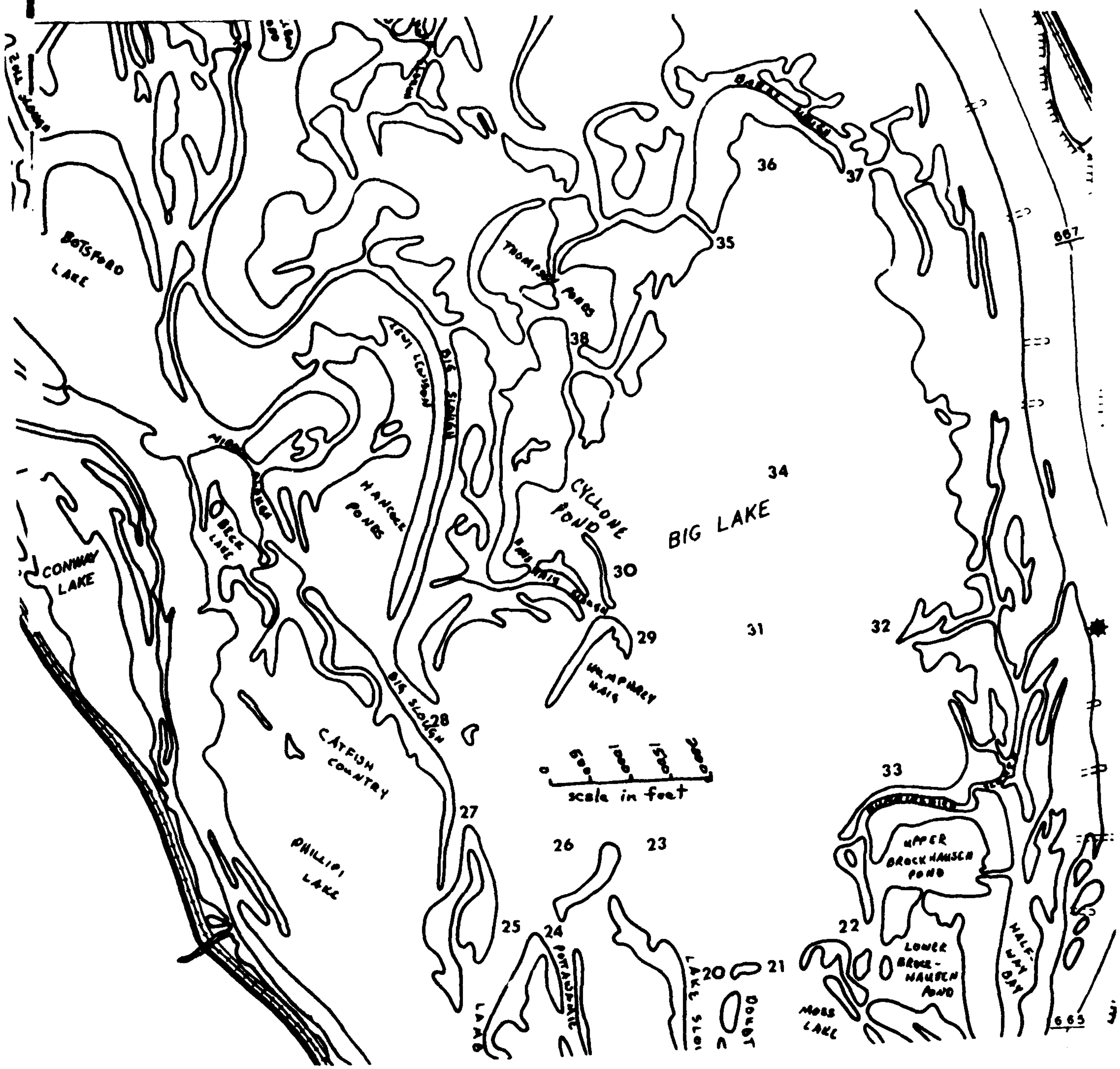

Fig. A-3. Aquatic sampling sites, Pool 9, 1973.

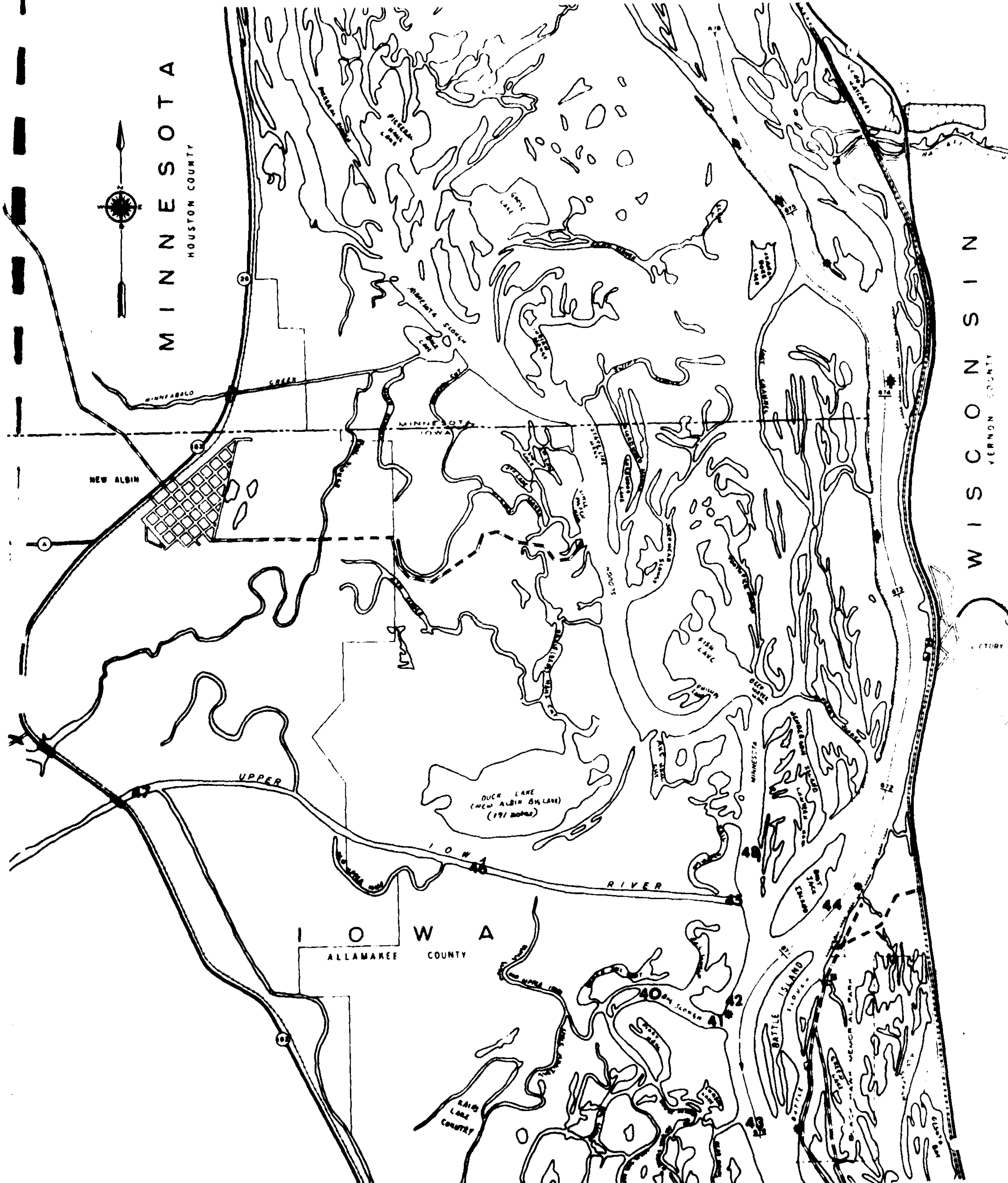

Fig. A-4. Aquatic sampling sites, Pool 9, 1973.

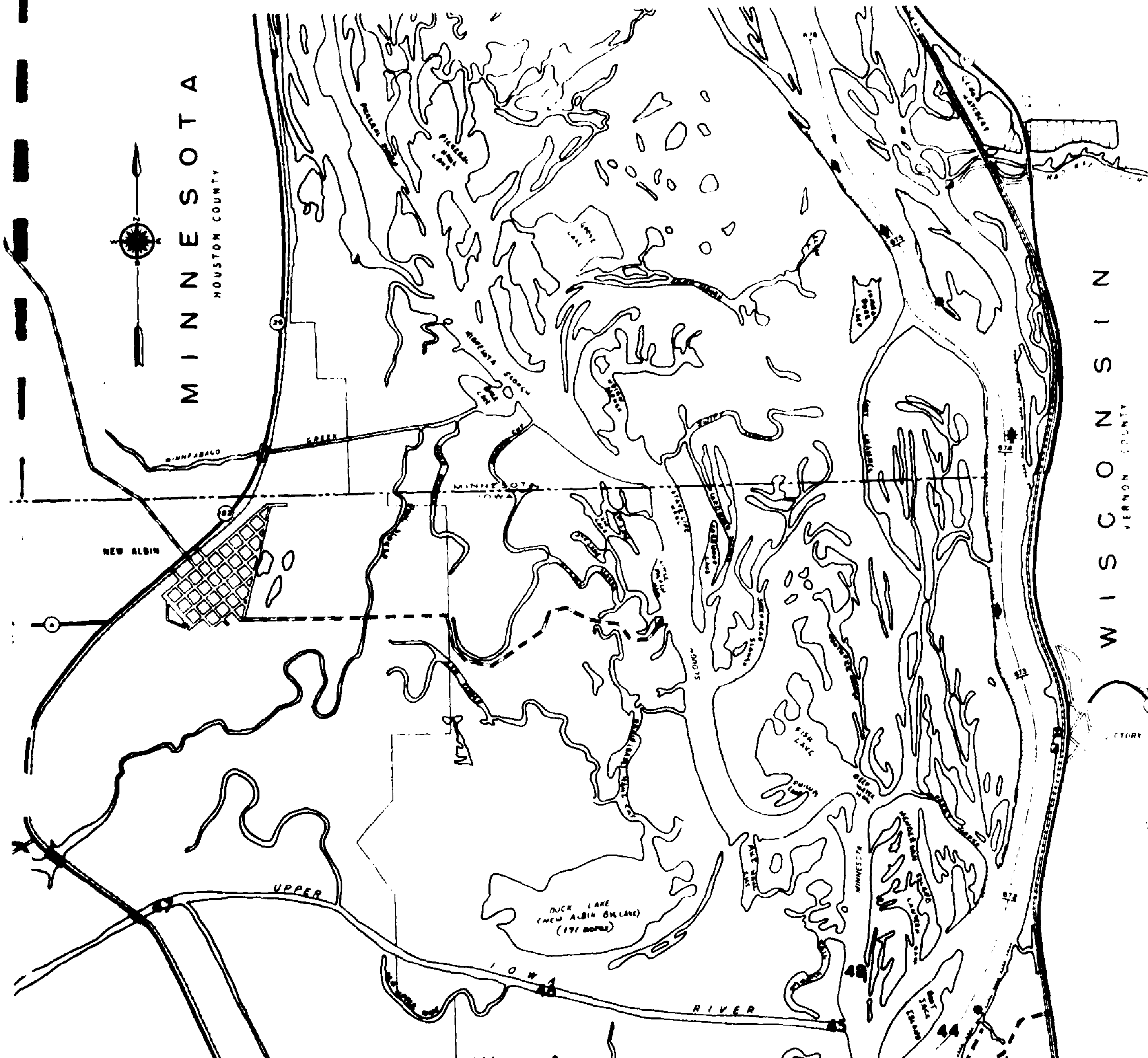

Fig. A-4. Aquatic sampling sites, Pool 9, 1973.

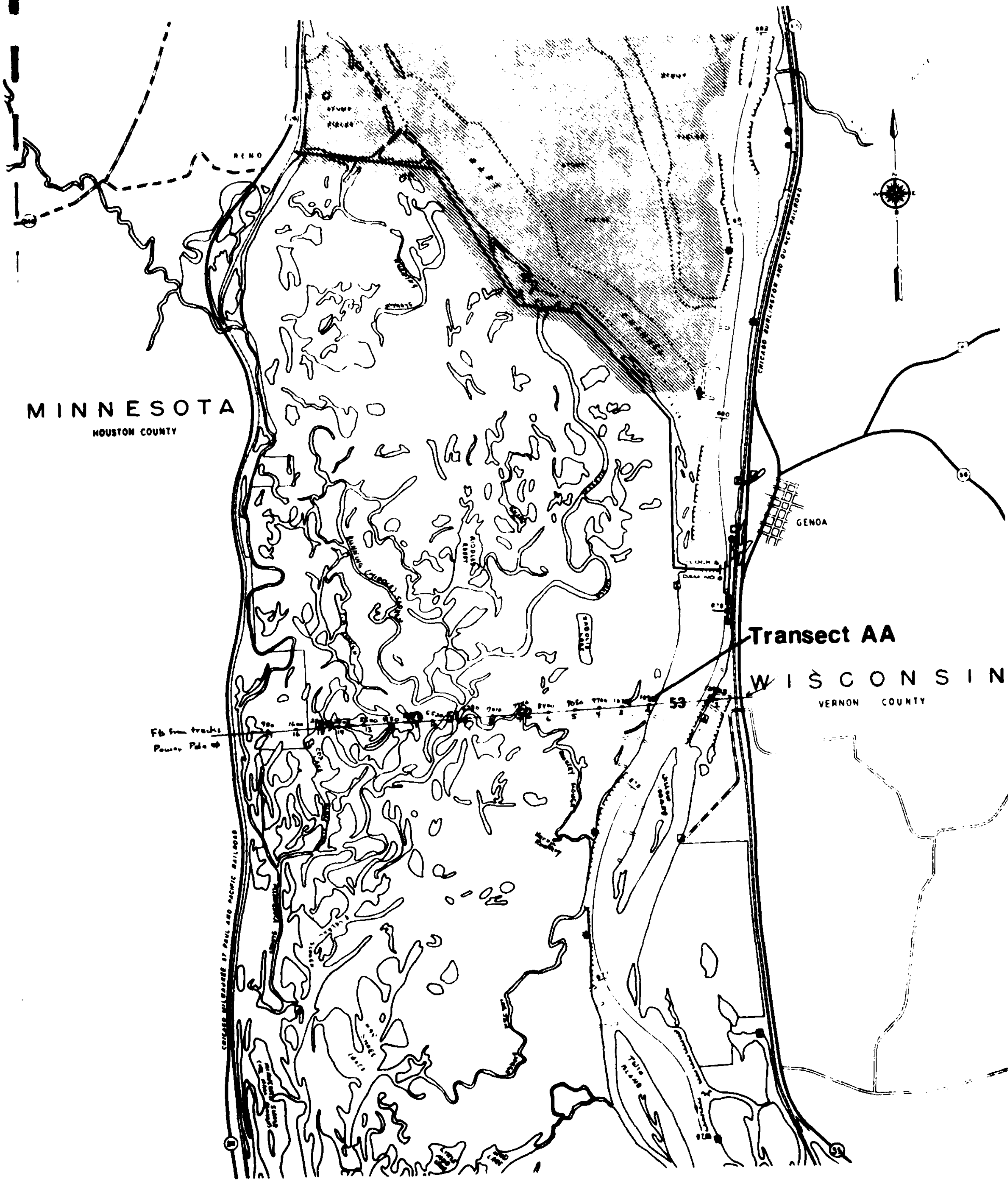

Fig. A-5. Aquatic sampling sites, Pool 9, 1973.

Table A-1
Benthos at site 1, 2 July 1973

SUMMARY FOR BENTHOS AT SITE CC2VII73-1

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	229.867	76.0213	316.067	100.073
EPHEMERIDAE	2126.27	362.599	5513.93	319.85
BAETIDAE	114.933	39.0106	139.357	62.0766
HYDROPSYCHIDAE	14.3667	14.3667	1.43667	1.43667
OLIGOCHAETA	338.433	103.599	80.4533	34.8669
TALITRIDAE	57.4667	57.4667	27.2967	27.2967
ASELLIDAE	43.1	24.8838	17.24	11.4032
SPHAERIDAE	14.3667	14.3667	25.86	25.86
ELMIDAE	14.3667	14.3667	15.8033	15.8033
HELEIDAE	14.3667	14.3667	2.87333	2.87333
PLANORBIDAE	28.7333	28.7333	714.023	714.023
TOTALS	2983.27	258.493	6354.34	440.485

Table A-2

Benthos at site 1, 31 July 1973

SUMMARY FOR BENTHOS AT SITE CCS:VII73-4

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	114.933	76.0213	[illegible]11.15	536.596
EPHEMERIDAE	1091.87	311.13	12687.2	2954.67
OLIGOCHAETA	389.9	49.7676	93.3833	26.1379
SPHAERIDAE	129.3	74.6514	2381.95	1494.97
TOTALS	1724	342.095	16373.7	2936.6

Table A-3

Benthos at site 2, 2 July 1973

SUMMARY FOR BENTHOS AT SITE 002VII73-2

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	258.6	65.8363	87.6367	22.579
EPHEMERIDAE	2887.7	484.436	9799.5	424.289
BAETIDAE	43.1	24.8838	24.4233	13.7049
HYDROPSYCHIDAE	14.3667	14.3667	11.4933	11.4933
LEPTOCERIDAE	14.3667	14.3667	120.68	120.68
OLIGOCHAETA	143.667	79.9932	173.147	92.3163
GLOSSIPHONIIDAE	57.4667	23.7333	113.497	60.5619
SPHAERIDAE	2054.43	666.	53231.4	21837.9
VIVIPARIDAE	43.1	24.8838	1830.31	999.007
PLEUROCERIDAE	14.3667	14.3667	3732.46	3732.46
TOTALS	5531.17	1129.5	69129.5	26393.7

Table A-4

Benthos at site 2, 31 July 1973

SUMMARY FOR BENTHOS AT SITE CC31V2173-3

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	129.3	86.2	86.2	48.4436
EPHEMERIDAE	2571.63	491.625	31697.2	8329.37
TALITRIDAE	43.1	24.8838	31.6067	15.998
SPHAERIDAE	10933	1208.93	52109.3	5229.94
HELEIDAE	14.3667	14.3667	14.3667	14.3667
TOTALS	13691.4	721.332	83938.7	3097.12

Table A-5

Benthos at site 3, 2 July 1973

SUMMARY FOR BENTHOS AT SITE C02VII73-3

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	57.4667	28.7333	40.2267	38.092
EPHEMERIDAE	2614.73	438.36	9628.54	5868.49
BAETIDAE	57.4667	28.7333	31.89	52.9622
OLIGOCHAETA	244.233	38.0106	479.847	196.351
TALITRIDAE	71.8333	38.0106	31.89	61.6094
ASELLIDAE	14.3667	14.3667	56.03	56.03
GLOSSIPHONIIDAE	86.2	65.8363	349.07	479.405
SPHAERIDAE	10559.5	1811.74	132824.	8068.32
UNIONIDAE	14.3667	14.3667	25058.3	25058.3
VIVIPARIDAE	14.3667	14.3667	12885.5	12885.5
PLANORBIDAE	14.3667	14.3667	181.02	181.02
TOTALS	13748.9	2192.18	182166.	34783.3

Table A-6

Benthos at site 3, 31 July 1973

SUMMARY FOR BENTHOS AT SITE   0031VII73-2

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	71.8333	28.7333	156.597	116.192
EPHEMERIDAE	3471.07	52.6206	28898.5	6689.72
OLIGOCHAETA	272.967	137.049	2245.95	1375.61
TALITRIDAE	402.267	62.6228	484.157	158.6
GLOSSIPHONIIDAE	158.333	117.596	2518.48	1806.44
SPHAERIDAE	16837.7	773.122	112277.	15639.5
TRICHOPTERA	14.3667	14.3667	48.8467	48.8467
TOTALS	20228.3	611.708	146631.	16737.8

Table A-7

Benthos at site 4, 2 July 1973

SUMMARY FOR BENTHOS AT SITE CC2VII73-4

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	71.8333	51.7998	182.003	87.3536
EPHEMERIDAE	1379.2	174.186	9460.45	4506.9
BAETIDAE	28.7333	28.7333	35.9167	35.9167
OLIGOCHAETA	186.767	100.567	122.117	69.6894
TALITRIDAE	71.8333	38.0105	63.96	41.1148
GLOSSIPHONIIDAE	215.5	65.8363	695.347	443.192
SPHAERIDAE	8691.83	1456.36	251734.	14086.
VIVIPARIDAE	71.8333	51.7998	27555.3	21273.6
TOTALS	10717.5	1695.45	289774.	22373.7

Table A-8

Benthos at site 4, 31 July 1973

SUMMARY FOR BENTHOS AT SITE CC31V1173-1

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	186.767	100.567	40.2267	14.1495
EPHEMERIDAE	1724	248.838	29734.7	4878.37
OLIGOCHAETA	57.4667	28.7333	3300.02	3284.95
TALITRIDAE	732.7	323.489	1669.41	822.824
ASELLIDAE	86.2	86.2	38.79	38.79
GLOSSIPHONIIDAE	474.1	348.373	466.917	140.242
SPHAERIDAE	5545.53	2974.66	95299.9	34943.8
UNIONIDAE	86.2	65.8363	2608.99	1701.48
VIVIPARIDAE	43.1	24.8838	38636.3	21148.4
ERPOBDELLIDAE	28.7333	28.7333	136.483	136.483
TOTALS	8964.8	3383.37	171932.	52862.3

Table A-9

Benthos at site 5, 2 July 1973

SUMMARY FOR BENTHOS AT SITE CC2VII73-5

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	143.667	51.7998	132.173	69.6894
EPHEMERIDAE	2528.50	249.251	12295	1050.83
BAETIDAE	14.3667	14.3667	14.3667	14.3667
OLIGOCHAETA	86.2	49.7676	232.74	130.8
TALITRIDAE	43.1	24.8838	79.0167	60.6641
ASELLIDAE	14.3667	14.3667	35.9167	35.9167
GLOSSIPHONIIDAE	71.8333	14.3667	895.043	288.183
SPHAERIDAE	7758	914.625	95243.8	8644.5
VIVIPARIDAE	28.7333	28.7333	2721.05	2721.05
TRICHOPTERA PUPA		14.3667	14.3667	166.653
166.653				
HELEIDAE	14.3667	14.3667	17.24	17.24
TOTALS	10717.5	935.151	111833.	11944.9

Table A-10

Benthos at site 9, 5 July 1973

SUMMARY FOR BENTHOS AT SITE BB5VII73-1

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	14.3667	14.3667	4.31	4.31
HYDROPSYCHIDAE	344.8	344.8	475.537	475.537
GLOSSOSOMIDAE	28.7333	28.7333	1020.03	1020.03
GLOSSIPHONIIDAE	14.3667	14.3667	7.18333	7.18333
TOTALS	402.267	402.267	1507.06	1507.06

Table A-11

Benthos at site 9, 3 August 1973

SUMMARY FOR BENTHOS AT SITE BB3VIII73-6

	#/SQ.M	S.E.	WT/SQ.M	S.E.
HYDROPSYCHIDAE	14.3667	14.3667	35.9167	35.9167
OLIGOCHAETA	100.567	79.9902	38.79	30.5777
GLOSSIPHONIIDAE	373.533	62.623	199.697	44.8139
SPHAERIDAE	2269.93	1083.61	34457.	12127.8
PHYSIDAE	14.3667	14.3667	807.407	807.407
TOTALS	2772.77	1182.	35538.8	12128.2

Table A-12

Benthos at site 10, 5 July 1973

SUMMARY FOR BENTHOS AT SITE BB5VII73-2

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	316.367	149.992	158.033	78.4662
BAETIDAE	416.333	161.904	123.553	39.9176
HYDROPSYCHIDAE	258.6	163.174	112.06	62.3586
ASELLIDAE	28.7333	28.7333	4.31	4.31
ELMIDAE	14.3667	14.3667	2.87333	2.87333
TOTALS	1034.4	442.344	400.83	155.339

Table A-13

Benthos at site 10, 3 August 1973

SUMMARY FOR BENTHOS AT SITE BB3VIII73-5

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	114.933	28.7333	166.653	143.084
EPHEMERIDAE	445.367	161.984	229.867	82.8422
ELMIDAE	14.3667	14.3667	2.87333	2.87333
TOTALS	574.667	127.694	399.393	64.4262

Table A-14

Benthos at site 11, 5 July 1973

SUMMARY FOR BENTHOS AT SITE   BB5VII73-3

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	71.8333	33.0106	77.58	43.5999
EPHEMERIDAE	2485.43	137.047	11829.5	1585.09
BAETIDAE	129.3	43.1	122.117	44.2577
OLIGOCHAETA	100.567	100.567	47.41	47.41
TALITRIDAE	5243.83	4123.53	2083.17	1809.64
ASELLIDAE	129.3	43.1	91.9467	36.6843
GLOSSIPHONIIDAE	57.4667	14.3667	51.72	28.0426
SPHAERIDAE	14.3667	14.3667	21.55	21.55
ELMIDAE	28.7333	14.3667	20.1133	10.36
CORIXIDAE	71.8333	51.7998	25.86	14.9303
HYDRACARINA	14.3667	14.3667	4.31	4.31
TOTALS	8347.03	4000.21	14375.3	3380.48

Table A-15

Benthos at site 13, 3 August 1973

SUMMARY FOR BENTHOS AT SITE BB3VIII73-4

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	57.4667	38.0106	17.24	11.4032
EPHEMERIDAE	287.333	137.049	1143.59	562.045
HYDROPSYCHIDAE	14.3667	14.3667	2.87333	2.87333
OLIGOCHAETA	14.3667	14.3667	99.13	99.13
SPHAERIDAE	14.3667	14.3667	1.43667	1.43667
TOTALS	387.9	114.032	1264.27	469.93

Table A-16

Benthos at site 14, 3 August 1973

SUMMARY FOR BENTHOS AT SITE BB3VIII73-2

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	71.8333	38.0166	18.6767	9.42085
EPHEMERIDAE	517.2	49.7674	1228.35	256.882
OLIGOCHAETA	28.7333	14.3667	14.3667	12.2749
TOTALS	617.767	62.6229	1261.39	267.154

Table A-17

Benthos at site 15, 3 August 1973

SUMMARY FOR BENTHOS AT SITE BB3VIII73-3

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	1465.4	719.912	3239.97	1187.17
EPHEMERIDAE	316.067	159.98	7304.01	3953.94
OLIGOCHAETA	28.7333	14.3667	28.7333	20.7199
TALITRIDAE	14.3667	14.3667	31.6067	31.6067
GLOSSIPHONIIDAE	71.8333	71.8333	146.54	146.54
HELEIDAE	747.067	152.042	270.093	90.7605
TOTALS	2643.47	799.902	11071.	2854.36

Table A-18

Benthos at site 16, 3 August 1973

SUMMARY FOR BENTHOS AT SITE BB3VIII73-1

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	14.3667	14.3667	2.87333	2.87333
EPHEMERIDAE	14.3667	14.3667	77.58	77.58
TOTALS	28.7333	28.7333	80.4533	80.4533

Table A-19

Benthos at site 20, 22 June 1973

[illegible] 1

	[illegible]	S.E.	[illegible]	S.E.
[illegible]	[illegible]	[illegible]	[illegible]	14.9992
[illegible]	[illegible]	59.7195	445.367	423.999
[illegible]	14.3667	14.3667	14.3667	14.3667
[illegible]	[illegible]	[illegible]	[illegible]	254.452
[illegible]	71.[illegible]	51.7[illegible]	11.4[illegible]	7.60813
[illegible]	14.3667	14.3667	7.18333	7.18333
[illegible]	215.5	[illegible]	137.92	69.1394
[illegible]	[illegible]	65.8869	541.683	120.842
[illegible]	790.167	149.992	36218.4	8504.56
[illegible]	14.3667	14.3667	8720.57	8720.57
ELMIDAE	14.3667	14.3667	2.87333	2.87333
[illegible]	[illegible]	49.7676	34126.6	22632.2
[illegible]	14.3667	14.3667	7.18333	7.18333
TOTALS	[illegible]	605.449	[illegible]	25606.8

Table A-20

Benthos at site 20, 16 July 1973

[illegible]

	[illegible]	S.D.	[illegible]	S.D.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	49697.
UNIONIDAE	[illegible]	[illegible]	[illegible]	149.144
GOMPHIDAE	14.3667	[illegible]	57.4667	57.4667
TOTALS	[illegible]	[illegible]	[illegible]	[illegible]

Table A-21

Benthos at site 20, 30 July 1973

SUMMARY FOR BENTHOS AT SITE EL30VII73-1

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	[illegible]66.567	51.7298	140.667	116.777
EPHEMERIDAE	[illegible]580.9	[illegible]96.281	23531.2	11573.6
OLIGOCHAETA	129.0	29.7193	73.27	39.108
ASELLIDAE	71.8333	14.3667	127.863	51.1381
GLOSSIPHONIIDAE	129.3	74.6514	138.203	120.894
SPHAERIDAE	9122.33	2592.93	110873.	24345.1
VIVIPARIDAE	14.3667	14.3667	5396.12	5396.12
ELMIDAE	57.4667	38.0106	40.2267	26.6074
TOTALS	11306.6	3509.79	140373.	40837.8

Table A-22

Benthos at site 23, 22 June 1973

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	44.1	301.7	15[illegible].4[illegible]
CERATOPOGONIDAE	[illegible]	[illegible]	[illegible].74667	5.74667
[illegible]	[illegible]	[illegible]	1057.[illegible]	1123.51
[illegible]	[illegible]	[illegible]	1[illegible].[illegible]	1[illegible].93
[illegible]	[illegible].1	[illegible]	1[illegible].[illegible]7	[illegible]
LIMNEPHILIDAE	4[illegible].1	[illegible]	435.1[illegible]	[illegible].14[illegible]
HEPTAGENIIDAE	114.[illegible]	[illegible]1.7[illegible]	1[illegible].[illegible]	3.[illegible]106
OLIGOCHAETA	14.[illegible]	14.[illegible]7	[illegible]	2.97333
TALITRIDAE	1[illegible].[illegible]7	14.[illegible]7	3.07[illegible]	2.97333
ASELLIDAE	57.4[illegible]	[illegible].91[illegible]	35.7[illegible]	32.5398
[illegible]	1[illegible].[illegible]	4[illegible].7[illegible]	370.[illegible]	100.[illegible]9
[illegible]	[illegible].7[illegible]	[illegible].7[illegible]	1030.09	1030.09
[illegible]	14.3[illegible]7	14.3[illegible]	5492.[illegible]	5492.33
TOTALS	1487.93	[illegible].1[illegible]	[illegible]940.35	4320.7

Table A-23

Benthos at site 23, 16 July 1973

[illegible] AT [illegible] [illegible]

	#/SQ.M	S.E.	WT/SQ.M	S.E.
[illegible]	71.[illegible]	[illegible]1.7[illegible]	108.68	101.902
[illegible]	15[illegible].33	19[illegible].567	9164.5	1[illegible]43.32
[illegible]	[illegible].7333	[illegible].7333	143.667	143.667
[illegible]	[illegible]3.7333	[illegible]	21.55	21.55
[illegible]	1[illegible]1[illegible].77	[illegible]	[illegible]9443.	1363.92
[illegible]	[illegible]	[illegible]	[illegible]3.4	2965.3[illegible]

Table A-24

Benthos at site 23, 30 July 1973

SUMMARY FOR BENTHOS AT SITE EL30VII73-3

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	28.7333	14.3667	77.58	38.79
EPHEMERIDAE	617.767	141.495	6467.87	1766.85
OLIGOCHAETA	172.4	65.8363	265.783	117.833
GLOSSIPHONIIDAE	28.7333	28.7333	35.9167	35.9167
SPHAERIDAE	2241.2	348.373	19775.7	6050.07
UNIONIDAE	57.4667	28.7333	41149.	24184.1
TOTALS	3:46.3	333.081	67771.9	31494.2

Table A-25

Benthos at site 26, 22 June 1973

[illegible] AT SITE [illegible]

	[illegible]	[illegible]	[illegible]	S.E.
[illegible]	114.[illegible]	[illegible]	152.[illegible]7	139.556
[illegible]	71.[illegible]	[illegible]	[illegible]	9.42085
[illegible]	71.[illegible]	1[illegible]	3154.92	1611.97
[illegible]	1[illegible]	[illegible].1	[illegible]5047.[illegible]	[illegible]315.
[illegible]	[illegible]	[illegible]	[illegible]	34753.6

Table A-26

Benthos at site 26, 30 July 1973

SUMMARY FOR BENTHOS AT SITE EL30VII73-2

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	301.[illegible]	155.399	874.93	445.809
EPHEMERIDAE	316.667	94.2085	5914.76	540.93
OLIGOCHAETA	114.933	71.3334	570.357	413.268
TALITRIDAE	43.1	24.8338	47.41	23.7376
GLOSSIPHONIIDAE	71.8033	51.7998	106.313	66.4138
SPHAERIDAE	1896.4	366.561	24888.8	3094.54
UNIONIDAE	14.3667	14.3667	452.55	452.55
TOTALS	2758.4	505.087	32855.1	2514.7

Table A-27

Benthos at site 29, 22 June 1973

[illegible] AT SITE [illegible]

	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	187.3	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	4307.75
OLIGOCHAETA	[illegible]	[illegible]	[illegible]	137.47
[illegible]	88.7333	[illegible]	17.[illegible]	17.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	14.[illegible]	[illegible]	19007.5
[illegible]	14.0667	14.[illegible]	2.[illegible]	2.07333
TOTALS	1316.[illegible]	524.334	46100.2	10252.1

Table A-28

Benthos at site 29, 30 Julv 1973

SUMMARY FOR BENTHOS AT SITE EL30VII173-7

	#/SQ.M	S.E.	WT/SQ.M	S.E.
EPHEMERIDAE	43.1	43.1	1432.64	1432.64
SPHAERIDAE	201.133	201.133	3254.05	3254.05
VIVIPARIDAE	14.3667	14.3667	12743.2	12743.2
TOTALS	258.6	258.6	17479.9	17479.9

Table A-29

Benthos at site 30, 22 June 1973

[illegible]

	[illegible]	[illegible]	[illegible]	S.E.
[illegible]	[illegible]	[illegible]	104.313	102.034
[illegible]	201.133	[illegible]	1211.11	631.632
[illegible]	14.[illegible]	14.[illegible]	7.18333	7.18333
[illegible]	[illegible]	14.[illegible]	7.18333	7.18333
[illegible]	[illegible]	14.[illegible]	[illegible]	66.0067
[illegible]	[illegible]	40.1	35.9167	35.9167
[illegible]	40.1	40.1	5.74667	5.74667
[illegible]	[illegible]	165.[illegible]	120.553	55.3257
[illegible]	57.4667	23.7333	976.933	649.45
TOTALS	730.7	361.458	2546.03	1393.76

Table A-30

Benthos at site 31, 22 June 1973

[illegible] AT SITE [illegible]

	[illegible]	S.D.	[illegible]	S.D.
[illegible]	[illegible]	[illegible]	560.3	494.474
[illegible]	[illegible]	[illegible]	5677.47	3004.4[illegible]
[illegible]	[illegible]	[illegible]	208.57	10[illegible].25
[illegible]	14.[illegible]	[illegible]	1.40667	1.40667
[illegible]	730.7	[illegible]	7091.91	645.473
[illegible]	14.3667	[illegible]	66.96	66.96
TOTAL	9696.57	[illegible]	17202.6	2967.54

Table A-31

Benthos at site 32, 22 June 1973

[illegible] AT SITE [illegible]

	[illegible]	S.D.	WT/[illegible]	S.E.
CHI[illegible]	2[illegible].167	[illegible]1.7[illegible]7	16[illegible].343	23.[illegible]
[illegible]	14.3667	14.[illegible]7	2.57333	2.57333
[illegible]	[illegible]	[illegible].70[illegible]	[illegible]4.66	1368.24
[illegible]	3[illegible]	4[illegible].757[illegible]	6[illegible].26	42.5215
[illegible]	1[illegible].767	1[illegible]7.394	79.3967	64.0405
[illegible]	[illegible]7.[illegible]	[illegible]7.[illegible]67	[illegible].62	8.62
[illegible]	[illegible]1[illegible]	1[illegible].547	11[illegible].86	71.7327
[illegible]	14.36[illegible]7	14.[illegible]	754.25	754.25
[illegible]	42.1	[illegible]	11.4933	6.26228
[illegible]	2[illegible].7333	2[illegible].7333	14799.1	14799.1
TOTALS	2390.53	[illegible]3.526	22394.8	17382.4

Table A-32

Benthos at site 32, 16 July 1973

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	S.E.
[illegible]	[illegible]	[illegible]	[illegible]	7.60212
[illegible]	[illegible]	[illegible]	[illegible]	690.334
[illegible]	[illegible]	[illegible]	[illegible]	2.57333
[illegible]	[illegible]	[illegible]	[illegible]	7.46513
[illegible]	[illegible]	[illegible]	[illegible]	12.4419
[illegible]	[illegible]	[illegible]	[illegible]	19.0053
[illegible]	[illegible]	[illegible]	5012.53	1332.5
[illegible]	[illegible]	[illegible]	[illegible]	41165.8
[illegible]	14.3667	14.3667	1.43667	1.43667
TOTAL[illegible]	[illegible]	[illegible]	[illegible]	41934.6

Table A-33

Benthos at site 32, 30 July 1973

SUMMARY FOR BENTHOS AT SITE EL30VII73-5

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	229.867	103.1	54.5933	14.5806
EPHEMERIDAE	919.467	373.534	13271.9	3376.4
OLIGOCHAETA	114.933	94.2055	515.763	426.467
GLOSSIPHONIIDAE	57.4667	37.4667	97.6933	97.6933
SPHAERIDAE	545.933	112.287	4364.59	918.601
TOTALS	1867.67	531.566	18304.6	4400.16

Table A-34

Benthos at site 33, 22 June 1973

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTALS	[illegible]	[illegible]	[illegible]	[illegible]

Table A-35

Benthos at site 33, 16 July 1973

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	368.5[illegible]	[illegible]	[illegible]
OLIGOCHAETA	43.1	43.1	[illegible]	[illegible]
[illegible]	14.[illegible]	14.[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTALS	[illegible]	[illegible]	[illegible]	[illegible]

Table A-36

Benthos at site 33, 30 July 1973

SUMMARY FOR BENTHOS AT SITE BL30VII73-4

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	57.4667	14.3667	418.07	280.426
EPHEMERIDAE	2155	566.3	28013.6	10757.6
OLIGOCHAETA	57.4667	14.3667	73.27	8.97198
SPHAERIDAE	1091.87	372.704	6034	2777.8
TOTALS	3361.8	933.39	34538.9	13231.9

Table A-37

Benthos at site 36, 30 July 1973

SUMMARY FOR BENTHOS AT SITE   EL30VII73-6

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	158.033	79.9992	304.573	285.398
EPHEMERIDAE	2197.[illegible]	145.334	36600.5	8918.14
OLIGOCHAETA	301.1	151.362	330.433	199.588
ASELLIDAE	23.7333	28.7333	28.7333	28.7333
GLOSSIPHONIIDAE	71.8333	14.3667	122.117	31.3114
SPHAERIDAE	1235.53	353.957	15273.2	5616.01
TOTALS	3893.37	632.624	52659.6	14727.2

Table A-38

Benthos at site 50, 11 July 1973

SUMMARY FOR BENTHOS AT SITE AA11VII73-2

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	129.3	74.6514	11.4933	6.26228
EPHEMERIDAE	330.433	71.3334	3966.64	1601.3
SPHAERIIDAE	57.4667	57.4667	221.247	221.247
TOTALS	517.2	89.7196	4199.38	1490.84

Table A-39

Benthos at site 51, 11 July 1973

SUMMARY FOR BENTHOS AT SITE AA11VII173-1

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	129.3	74.6514	31.6067	21.7407
EPHEMERIDAE	244.233	28.7333	2301.54	567.912
SPHAERIDAE	14.3667	14.3667	68.96	68.96
HELIDAE	129.3	24.8838	25.86	12.93
TOTALS	517.2	99.5351	2427.97	664.469

Table A-40

Benthos at site 53, 9 August 1973

SUMMARY FOR BENTHOS AT SITE AA9VIII73-1

	#/SQ.M	S.E.	WT/SQ.M	S.E.
CHIRONOMIDAE	43.1	24.8838	10.0567	6.26229
HELEIDAE	14.3667	14.3667	2.87333	2.87333
TOTALS	57.4667	38.0106	12.93	8.97198

Table A-41

Plankton at site 3, 31 July 1973

SUMMARY FOR PLANKTON AT SITE CC31VII 73-2

	MEAN NUMBER PER LITER	
PEDIASTRUM	1213.4	
SCENEDESMUS	1213.4	
ULOTHRIX	606.698	
ACTINASTRUM	1213.4	
MELOSIRA	74623.8	
SYNEDRA	2426.79	
STEPHANODISCUS	2426.79	
MICRACTINIUM	1213.4	
GOMPHOSPHERIA	606.698	
CHORELLA	606.698	
KERATELLA	128.571	
FILINIA	32.1429	
CALANOID	21.4286	
CYCLOPOID	21.4286	
CLADOCERA	10.7143	
TOTAL PLANKTON NUMBERS =	86365.4	PER LITER
PLANKTON BIOMASS =	3.55915	MILLIGRAMS PER LITER

Table A-42

Plankton at site 6, 31 Julv 1973

SUMMARY FOR PLANKTON AT SITE CC31VII73-6

	MEAN NUMBER PER LITER	
MELOSIRA	18767.2	
STEPHANODISCUS	1294.29	
MICPACTINIUM	647.145	
CLADOPHORA	647.145	
KERATELLA	22.8571	
CYCLOPOID	57.1429	
FILINIA	11.4286	
TOTAL PLANKTON NUMBERS =	21447.2	PER LITER
PLANKTON BIOMASS =	3.74643	MILLIGRAMS PER LITER

Table A-43
Plankton at site 20, 29 June 1973

SUMMARY FOR PLANKTON AT SITE BL29VI73-8

	MEAN NUMBER PER LITER
EUDORINA	768.484
MELOSIRA	84533.2
SYNEDRA	3073.94
STEPHANODISCUS	5379.39
KERATELLA	95
FILINIA	13.5714
CYCLOPOID	54.2357
COPEPOD	95
CLADOCERA	13.5714

TOTAL PLANKTON NUMBERS = 94026.5 PER LITER

PLANKTON BIOMASS = 1.52254 MILLIGRAMS PER LITER

Table A-44

Plankton at site 21, 30 July 1973

SUMMARY FOR PLANKTON AT SITE BL30VII73-1

	MEAN NUMBER PER LITER	
SCENEDESMUS	1051.61	
MELOSIRA	17877.4	
STEPHANODISCUS	1051.61	
CYCLOPOID	55.7143	
KERATELLA	18.5714	
TOTAL PLANKTON NUMBERS =	20054.9	PER LITER
PLANKTON BIOMASS =	4.3875	MILLIGRAMS PER LITER

Table A-45

Plankton at site 23, 29 June 1973

SUMMARY FOR PLANKTON AT SITE BL29VI73-7

	MEAN NUMBER PER LITER
ACTINASTRUM	687.591
MELOSIRA	68759.1
ASTERIONELLA	4813.14
SYNEDRA	2750.36
STEPHANODISCUS	2750.36
SUIRIRELLA	687.591
KERATELLA	2750.36
COPEPOD	1375.18
CYCLOPOID	1375.18

TOTAL PLANKTON NUMBERS = 85948.9 PER LITER

PLANKTON BIOMASS = 1.26362 MILLIGRAMS PER LITER

Table A-46

Plankton at site 23, 30 July 1973

SUMMARY FOR PLANKTON AT SITE BL30VII73-3

	MEAN NUMBER PER LITER	
MELOSIRA	8706.12	
CYCLOPOID	10.25	
TOTAL PLANKTON NUMBERS =	8716.37	PER LITER
PLANKTON BIOMASS =	.615	MILLIGRAMS PER LITER

Table A-47

Plankton at site 26, 29 June 1973

SUMMARY FOR PLANKTON AT SITE EL29VI73-2

	MEAN NUMBER PER LITER	
MELOSIRA	6738.39	
SYNEDRA	396.376	
STEPHANODISCUS	396.376	
CYCLOPOID	14	
TOTAL PLANKTON NUMBERS =	7545.14	PER LITER
PLANKTON BIOMASS =	.30625	MILLIGRAMS PER LITER

Table A-48

Plankton at site 26, 30 July 1973

SUMMARY FOR PLANKTON AT SITE EL30V1170-2

	MEAN NUMBER PER LITER	
MELOSIRA	3397.51	
CYCLOPOID	7.5	
TOTAL PLANKTON NUMBERS =	3405.01	PER LITER
PLANKTON BIOMASS =	.338469	MILLIGRAMS PER LITER

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ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
NOV 73 J W ECKBLAD, B J GUDMUNDSON DACW37-73-C-0059

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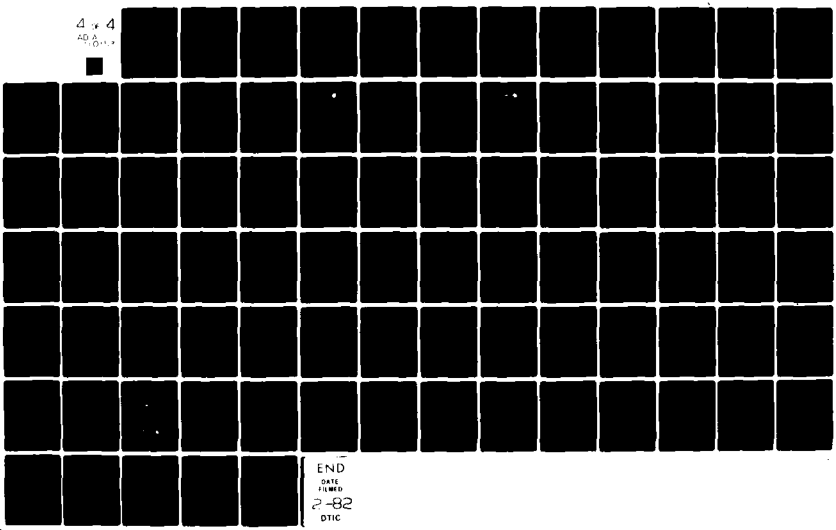

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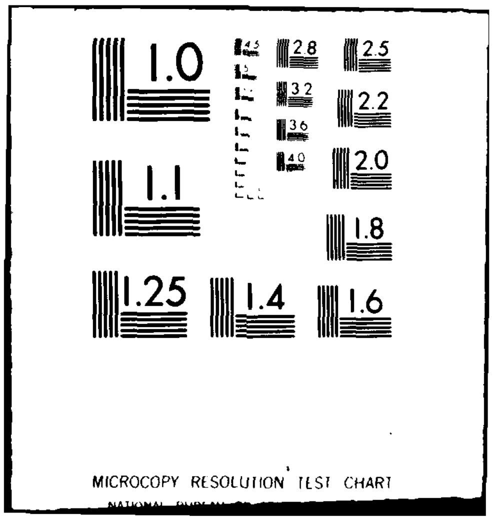
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1.6
MICROCOPY RESOLUTION TEST CHART

Table A-49

Plankton at site 29, 11 June 1973

SUMMARY FOR PLANKTON AT SITE EL11VI73-1

	MEAN NUMBER PER LITER
PEDIASTRUM	202.233
SCENEDESMUS	404.465
MELOSIRA	18403.2
ASTERIONELLA	6375.91
FRAGILLARIA	34379.5
SYNEDRA	3437.95
STEPHANODISCUS	6875.91
SURIRELLA	202.233
CYCLOTELLA	606.698
CHROOCOCCUS	202.233
PROTOCOCCUS	202.233
KERATELLA	32.1429
ASPLANCHNA	3.57143
CYCLOPOIDA	17.8571
CLADOCERA	7.14286

TOTAL PLANKTON NUMBERS = 71853.3 PER LITER

PLANKTON BIOMASS = .113839 MILLIGRAMS PER LITER

Table A-50

Plankton at site 29, 29 June 1973

SUMMARY FOR PLANKTON AT SITE BL29V173-3

	MEAN NUMBER PER LITER
MELOSIRA	9555.49
FRAGILLARIA	3822.2
CYCLOPOID	6.75

TOTAL PLANKTON NUMBERS = 13384.4 PER LITER

PLANKTON BIOMASS = .972422 MILLIGRAMS PER LITER

Table A-51

Plankton at site 30, 29 June 1973

SUMMARY FOR PLANKTON AT SITE BL29VI73-4

	MEAN NUMBER PER LITER	
MELOSIRA	7134.77	
STEPHANODISCUS	594.564	
KERATELLA	10.5	
COPEPOD	10.5	
CYCLOPOID	10.5	
CLADOCERA	10.5	
TOTAL PLANKTON NUMBERS =	7771.33	PER LITER
PLANKTON BIOMASS =	3.10734	MILLIGRAMS PER LITER

Table A-52

Plankton at site 31, 11 June 1973

SUMMARY FOR PLANKTON AT SITE BL11VI73-2

	MEAN NUMBER PER LITER
OSCILLATORIA	161.786
SCENEDESMUS	161.786
ACTINASTRUM	485.358
MELOSIRA	6633.23
FRAGILLARIA	42388.
STEPHANODISCUS	485.358
NAVICULA	161.786
ASTERIONELLA	2912.15
ANABENA	485.358
CLADOCERA	17.1429
KERATELLA	31.4286
CYCLOPOIDA	2.85714

TOTAL PLANKTON NUMBERS = 53926.2 PER LITER

PLANKTON BIOMASS = 9.19643E-02 MILLIGRAMS PER LITER

Table A-53

Plankton at site 31, 19 June 1973

SUMMARY FOR PLANKTON AT SITE BL19VI73-6

	MEAN NUMBER PER LITER
ACTINASTRUM	3421.78
MELOSIRA	34788.1
ASTERIONELLA	17679.2
FRAGILLARIA	35928.6
SYNEDRA	2281.18
STEPHANODISCUS	13687.1
NAVICULA	1140.59
MICRACTINIUM	570.296
KERATELLA	171.214
CLADOCERA	50.3571
FILINIA	10.0714

TOTAL PLANKTON NUMBERS = 109728. PER LITER

PLANKTON BIOMASS = .280112 MILLIGRAMS PER LITER

Table A-54

Plankton at site 31, 29 June 1973

SUMMARY FOR PLANKTON AT SITE BL29VI73-6

	MEAN NUMBER PER LITER
ACTINASTRUM	869.6
MELOSIRA	119135.
ASTERIONELLA	13913.6
FRAGILLARIA	31305.6
SYNEDRA	1739.2
STEPHANODISCUS	17392.
COPEPOD	15.3571
KERATELLA	122.857
FILINIA	15.3571
CLADOCERA	15.3571

TOTAL PLANKTON NUMBERS = 184524. PER LITER

PLANKTON BIOMASS = 1.84286 MILLIGRAMS PER LITER

Table A-55

Plankton at site 32, 11 June 1973

SUMMARY FOR PLANKTON AT SITE BL11VI73-3

	MEAN NUMBER PER LITER
PEDIASTRUM	1031.39
SCENEDESMUS	2062.77
ACTINASTRUM	4125.55
EUDORINA	515.693
MELOSIRA	87657.9
ASTERIONELLA	121188.
FRAGILLARIA	36098.5
STEPHANODISCUS	29394.5
TABELLARIA	4125.55
PANDORINA	1547.08
CYCLOTELLA	515.693
KERATELLA	72.8571
CYCLOPOIDA	18.2143
CLADOCERA	18.2143
COPEPOD	18.2143

TOTAL PLANKTON NUMBERS = 288400. PER LITER

PLANKTON BIOMASS = 1.67628 MILLIGRAMS PER LITER

Table A-56

Plankton at site 32, 29 June 1973

SUMMARY FOR PLANKTON AT SITE BL29V173-5

	MEAN NUMBER PER LITER
ACTINASTRUM	626.921
MELOSIRA	94038.2
ASTERIONELLA	1253.84
SYNEDRA	626.921
STEPHANODISCUS	1880.76
NAVICULA	626.921
GOMPHOSPHERIA	626.921
COPEPOD	11.0714
CLADOCERA	11.0714

TOTAL PLANKTON NUMBERS = 99702.6 PER LITER

PLANKTON BIOMASS = 1.50502 MILLIGRAMS PER LITER

Table A-57

Plankton at site 32, 30 July 1973

SUMMARY FOR PLANKTON AT SITE BL30VII73-5

	MEAN NUMBER PER LITER	
MELOSIRA	41209.	
SYNEDRA	1741.22	
STEPHANODISCUS	580.408	
PEDIASTRUM	580.408	
GOMPHOSPHERIA	580.408	
CLADOCERA	10.25	
CYCLOPOID	10.25	
FILINIA	10.25	
TOTAL PLANKTON NUMBERS =	44722.1	PER LITER
PLANKTON BIOMASS =	2.87	MILLIGRAMS PER LITER

Table A-58

Plankton at site 33, 29 June 1973

SUMMARY FOR PLANKTON AT SITE BL29V173-1

	MEAN NUMBER PER LITER
ACTINASTRUM	731.408
MELOSIRA	74603.6
ASTERIONELLA	6582.67
FRAGILLARIA	35839.
SYNEDRA	5851.26
STEPHANODISCUS	8045.49
NOSTOC	4388.45
CUCLOPOID	12.9167
KERATELLA	64.5833

TOTAL PLANKTON NUMBERS = 136119. PER LITER

PLANKTON BIOMASS = .875912 MILLIGRAMS PER LITER

Table A-59

Plankton at site 33, 30 July 1973

SUMMARY FOR PLANKTON AT SITE FL30JI173-4

	MEAN NUMBER PER LITER
SCENEDESMUS	693.658
MELOSIRA	22890.7
GOMPHONEMA	693.658

TOTAL PLANKTON NUMBERS = 24278. PER LITER

PLANKTON BIOMASS = 1.07953 MILLIGRAMS PER LITER

Table A-60

Plankton at site 45, 19 June 1973

SUMMARY FOR PLANKTON AT SITE U119VI73-1

	MEAN NUMBER PER LITER	
OSCILLATORIA	662.514	
FRAGILLARIA	20537.9	
NAVICULA	12587.8	
CYMBELLA	662.514	
CYCLOTELLA	662.514	
TOTAL PLANKTON NUMBERS =	35113.3	PER LITER
PLANKTON BIOMASS =	13.9925	MILLIGRAMS PER LITER

Table A-61

Chemistry at site 1, 27 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE CC27VI73-1

TEMPERATURE (C)	25
DISS. OXYGEN (MG/L)	5.3
TOTAL ALKALINITY (MG/L)	110
TURBIDITY (JTU)	46
ORTHO-PHOSPHATE (MG/L)	.95
TOTAL SOLIDS (MG/L)	322
VOLATILE SOLIDS (MG/L)	200
% VOLATILE SOLIDS	62.1

Table A-62

Chemistry at site 1, 31 July 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE CC31V1173-4

DISS. OXYGEN (MG/L)	6
TOTAL ALKALINITY (MG/L)	145
TURBIDITY (JTU)	19
ORTHO-PHOSPHATE (MG/L)	.45
NITRATE-NITRITE-N (MG/L)	.3
TOTAL SOLIDS (MG/L)	294
VOLATILE SOLIDS (MG/L)	126
% VOLATILE SOLIDS	42.8

Table A-63

Chemistry at site 2, 27, June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE CC27VI73-2

TEMPERATURE (C)	25
DISS. OXYGEN (MG/L)	6.3
TOTAL ALKALINITY (MG/L)	130
TURBIDITY (JTU)	30
ORTHO-PHOSPHATE (MG/L)	.27

2

Table A-64

Chemistry at site 2, 31 July 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE CC31VII73-3

DISS. OXYGEN (MG/L)	4.9
TOTAL ALKALINITY (MG/L)	143
TURBIDITY (JTU)	19
ORTHO-PHOSPHATE (MG/L)	.45
NITRATE-NITRITE-N (MG/L)	.3
TOTAL SOLIDS (MG/L)	326
VOLATILE SOLIDS (MG/L)	106
% VOLATILE SOLIDS	32.5

Table A-65

Chemistrv at site 3, 27 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE SC27VI73-3

TEMPERATURE (C)	25
DISS. OXYGEN (MG/L)	6.6
TOTAL ALKALINITY (MG/L)	12Ø
TURBIDITY (JTU)	31
NITRATE-NITRITE-N (MG/L)	.Ø5
TOTAL SOLIDS (MG/L)	3Ø8
VOLATILE SOLIDS (MG/L)	158
% VOLATILE SOLIDS	51.2

Table A-66

Chemistry at site 3, 31 July 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE CC31VII73-2

DISS. OXYGEN (MG/L)	7
TOTAL ALKALINITY (MG/L)	150
TURBIDITY (JTU)	22
ORTHO-PHOSPHATE (MG/L)	.5
NITRATE-NITRITE-N (MG/L)	.5
TOTAL SOLIDS (MG/L)	314
VOLATILE SOLIDS (MG/L)	294
% VOLATILE SOLIDS	93.6

Table A-67

Chemistry at site 4, 27 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE CC27VI73-4

TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	7
TOTAL ALKALINITY (MG/L)	14[illegible]
TURBIDITY (JTU)	[illegible]
ORTHO-PHOSPHATE (MG/L)	.[illegible]7
NITRATE-NITRITE-N (MG/L)	.0[illegible]
TOTAL SOLIDS (MG/L)	27[illegible]
VOLATILE SOLIDS (MG/L)	1[illegible]
% VOLATILE SOLIDS	4[illegible].[illegible]

4

Table A-68

Chemistry at site 4, 31 July 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE CC31VII173-1

DISS. OXYGEN (MG/L)	7.6
TOTAL ALKALINITY (MG/L)	120
TURBIDITY (JTU)	22
ORTHO-PHOSPHATE (MG/L)	.53
NITRATE-NITRITE-N (MG/L)	.4
TOTAL SOLIDS (MG/L)	410
VOLATILE SOLIDS (MG/L)	98
% VOLATILE SOLIDS	23.9

Table A-69

Chemistry at site 5, 27 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE CC27VI73-5

TEMPERATURE (C)	27
DISS. OXYGEN (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	[illegible]
TURBIDITY (JTU)	32
ORTHO-PHOSPHATE (MG/L)	.55
NITRATE-NITRITE-N (MG/L)	.02
TOTAL SOLIDS (MG/L)	284
VOLATILE SOLIDS (MG/L)	166
% VOLATILE SOLIDS	58.4

Table A-70

Chemistry at site 6, 31 July 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE CC31VII73-5

DISS. OXYGEN (MG/L)	7
TOTAL ALKALINITY (MG/L)	135
TURBIDITY (JTU)	<1
ORTHO-PHOSPHATE (MG/L)	.45
NITRATE-NITRITE-N (MG/L)	.4
TOTAL SOLIDS (MG/L)	360
VOLATILE SOLIDS (MG/L)	270
% VOLATILE SOLIDS	75

Table A-71

Chemistry at site 7, 11 July 1973

[illegible]	11JUL73-5
TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	[illegible]
TURBIDITY (JTU)	[illegible]
NITRATE-NITRITE-N (MG/L)	[illegible]
TOTAL SOLIDS (MG/L)	[illegible]
VOLATILE SOLIDS (MG/L)	[illegible]
% VOLATILE SOLIDS	[illegible]

Table [illegible]

Chemistry of Site 8, 11 [illegible] 1973

[illegible] WATER [illegible] SITE EB11V1173-4

TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	[illegible]
TURBIDITY ([illegible])	[illegible]
ORTHO-PHOSPHATE ([illegible])	[illegible]
NITRATE-NITRITE-N (MG/L)	[illegible]
TOTAL SOLIDS (MG/L)	[illegible]
VOLATILE SOLIDS (MG/L)	[illegible]
% VOLATILE SOLIDS	[illegible]

Table A-73

Chemistry at site 9, 31 May 1973

SUMMARY FOR W..ER DEPTH [illegible] FROM SURFACE [illegible] SITE B[illegible]

TEMPERATURE (C)	17
DISS. OXYGEN (MG/L)	8
TURBIDITY (JTU)	11
ORTHO-PHOSPHATE (MG/L)	.65

Table A-74

Chemistry at site 9, 5 July 1973

[illegible] VIII73-1

[illegible]	[illegible]
[illegible] (MG/L)	[illegible]
[illegible] (MG/L)	[illegible]
[illegible] (JTU)	[illegible]
[illegible] (MG/L)	1.1
[illegible] (MG/L)	[illegible]
[illegible] (MG/L)	[illegible]
[illegible] SOLIDS (MG/L)	116
[illegible] SOLIDS	[illegible]

Table A-75

Chemistry at site 9, 3 August 1973

SUMMARY [illegible] WATER CHEMI[illegible] SITE [illegible]3VIII173-6

DISS. OXYGEN (MG/L)	11.[illegible]
TOTAL ALKALINITY (MG/L)	1[illegible]
PH	[illegible]
ORTHO-PHOSPHATE (MG/L)	.[illegible]
NITRATE-NITRITE-N (MG/L)	.[illegible]

Table A-76

Chemistry at site 10, 31 May 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE DB31V73[illegible]

TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	[illegible]
TURBIDITY (JTU)	7
ORTHO-PHOSPHATE (MG/L)	[illegible]

Table A-77

Chemistry at site 10, 14 June 1973

SUMMARY OF WATER CHEMISTRY FROM SURFACE AT SITE [illegible] 173-5

TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	[illegible]
PH	[illegible]
TURBIDITY (JTU)	14
ORTHO-PHOSPHATE (MG/L)	[illegible]
NITRATE-NITRITE-N (MG/L)	[illegible]
TOTAL SOLIDS (MG/L)	[illegible]
VOLATILE SOLIDS (MG/L)	110
% VOLATILE SOLIDS	43.6

Table A-78

Chemistry at site 10, 5 July 1973

[illegible] AT SITE [illegible]VII73-2

TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	136
TURBIDITY (JTU)	[illegible]
ORTHO-PHOSPHATE (MG/L)	.24
NITRATE-NITRITE-N (MG/L)	[illegible]
TOTAL SOLIDS (MG/L)	[illegible]
VOLATILE SOLIDS (MG/L)	[illegible]
NONVOLATILE SOLIDS	[illegible]

Table A-79

Chemistry at site 10, 3 August 1973

SUMMARY FOR WATER CHEMISTRY [illegible] SITE EB3VIII73-5

TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	[illegible]
PH	[illegible]
TURBIDITY (JTU)	[illegible]
ORTHO-PHOSPHATE (MG/L)	[illegible]
NITRATE-NITRITE-N (MG/L)	[illegible]
TOTAL SOLIDS (MG/L)	[illegible]
VOLATILE SOLIDS (MG/L)	[illegible]
% VOLATILE SOLIDS	[illegible]

Table A-80

Chemistry at site 12, 31 May 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE [illegible]-2

DISS. OXYGEN (MG/L)	11
TURBIDITY ([illegible])	[illegible]
ORTHOPHOSPHATE (MG/L)	.4

Table A-81

Chemistry at site 12, 14 June 1973

SUMMARY OF WATER CHEMISTRY FROM SURFACE AT SITE [illegible]14V173-4

[illegible] (C)	30
[illegible] (MG/L)	[illegible]
[illegible] ALKALINITY (MG/L)	[illegible]
[illegible]	[illegible]
TURBIDITY (JTU)	1[illegible]
ORTHO-PHOSPHATE (MG/L)	[illegible]
NITRATE-NITRITE-N (MG/L)	1
TOTAL SOLIDS (MG/L)	23[illegible]
VOLATILE SOLIDS (MG/L)	14[illegible]
% VOLATILE SOLIDS	61.3

Table A-82

Chemistry at site 13, 31 May 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE OF SITE OBS [illegible] 73-4

TEMPERATURE (C)	18
DISS. OXYGEN (MG/L)	11
TURBIDITY (JTU)	11
ORTHO-PHOSPHATE (MG/L)	.5

Table A-83

Chemistry at site 13, 3 August 1973

SUMMARY FOR WATER CHEMISTRY [illegible] AT SITE DB3VIII73-4

TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	[illegible]
PH	[illegible]
TURBIDITY (JTU)	[illegible]
ORTHO-PHOSPHATE (MG/L)	[illegible]
NITRATE-NITRITE-N (MG/L)	[illegible]
TOTAL SOLIDS (MG/L)	[illegible]
VOLATILE SOLIDS (MG/L)	[illegible]
% VOLATILE SOLIDS	[illegible]

13

Table A-84

Chemistry at site 14, 14 June 1973

[illegible] CHEMISTRY FROM [illegible] AT SITE LL14VI73-[illegible]

[illegible]	[illegible]5
[illegible] (MG/L)	[illegible]3
[illegible]ALINITY (MG/L)	[illegible]
[illegible]	[illegible].7
[illegible]	14
[illegible]PHATE (MG/L)	.75
NITRATE-NITRITE-N (MG/L)	1
TOTAL SOLIDS (MG/L)	364
VOLATILE SOLIDS (MG/L)	180
[illegible] VOLATILE SOLIDS	49.[illegible]

Table A-85

Chemistry at site 14, 3 August 1973

SUMMARY FOR WATER CHEMISTRY [illegible] AT SITE EE3VIII173-2

TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	[illegible]
PH	[illegible]
TURBIDITY (JTU)	[illegible]
ORTHO-PHOSPHATE (MG/L)	[illegible]
NITRATE-NITRITE-N (MG/L)	[illegible]
TOTAL SOLIDS (MG/L)	[illegible]
VOLATILE SOLIDS (MG/L)	[illegible]
% VOLATILE SOLIDS	[illegible]

Table A-86

Chemistry at site 15, 14 June 1973

SUMMARY FOR WATER CHEMISTRY FROM STREAM AT SITE ED14VI73-3

[illegible]	[illegible]
[illegible] (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	19[illegible]
PH	[illegible].7
TURBIDITY (JTU)	14
ORTHO-PHOSPHATE (MG/L)	.71
NITRATE-NITRITE-N (MG/L)	1
TOTAL SOLIDS (MG/L)	300
VOLATILE SOLIDS (MG/L)	202
% VOLATILE SOLIDS	67.[illegible]

Table A-87

Chemistry at site 15, 3 August 1973

[illegible] WATER CHEMISTRY [illegible] ITE HL3VIII173-3

[illegible] OXYGEN (MG/L)	[illegible]
[illegible] ALKALINITY (MG/L)	[illegible]
[illegible] ITY (NTU)	[illegible]
ORTHO-PHOSPHATE (MG/L)	[illegible]
NITRATE-NITRITE-N (MG/L)	[illegible]
[illegible] SOLIDS (MG/L)	[illegible]
VOLATILE SOLIDS (MG/L)	[illegible]
[illegible] VOLATILE SOLIDS	[illegible]

15

Table A-88

[illegible]hemistr[illegible] at site 16, 14 June 1973

[illegible] AT SITE [illegible]14[illegible]173-1

[illegible]	
[illegible] (MG/L)	[illegible]
[illegible] ALKALINITY (MG/L)	[illegible]
[illegible]	[illegible]
TURBIDITY (JTU)	[illegible]
[illegible] (MG/L)	[illegible]
[illegible]-N (MG/L)	[illegible]
[illegible] (MG/L)	[illegible]
[illegible] (MG/L)	[illegible]
[illegible]	[illegible]

Table A-89

Chemistry at site 16, 3 August 1973

SUMMARY FOR WATER CHEMISTRY FROM [illegible] SITE BB3VIII73-1

TEMPERATURE (C)	[illegible]
DISS. OXYGEN (MG/L)	[illegible]
TOTAL ALKALINITY (MG/L)	[illegible]
PH	[illegible]
TURBIDITY (JTU)	[illegible]
ORTHO-PHOSPHATE (MG/L)	[illegible]
TOTAL SOLIDS (MG/L)	[illegible]
VOLATILE SOLIDS (MG/L)	[illegible]
% VOLATILE SOLIDS	[illegible]

Table A-90

Chemistry at site 18, 11 July 1973

QUALITY FOR WATER CHEMISTRY FROM SURFACE AT SITE HC11VII73-1

TEMPERATURE (C)	2[illegible]
DISS. OXYGEN (MG/L)	7.[illegible]
TOTAL ALKALINITY (MG/L)	13[illegible]
TURBIDITY (JTU)	1[illegible]
ORTHO-PHOSPHATE (MG/L)	[illegible]
NITRATE-NITRITE-N (MG/L)	.5
TOTAL SOLIDS (MG/L)	33[illegible]
VOLATILE SOLIDS (MG/L)	14[illegible]
% VOLATILE SOLIDS	43

Table A-91

Chemistry at site 18, 11 July 19[illegible]

[illegible]	
TURBIDITY (JTU)	1[illegible]
TOTAL SOLIDS (MG/L)	344
VOLATILE SOLIDS (MG/L)	132
% VOLATILE SOLIDS	38.3

Table A-92

Chemistry at site 19, 11 July 1973

SUMMARY FOR WATER CHEMISTRY AT SURFACE AT SITE MC11VII73-2

TEMPERATURE (C)	2[illegible]
DISSOLVED OXYGEN (MG/L)	7
TOTAL ALKALINITY (MG/L)	10[illegible]
TURBIDITY (JTU)	1[illegible]
ORTHO-PHOSPHATE (MG/L)	.74
NITRATE-NITRITE-N (MG/L)	.3[illegible]
TOTAL SOLIDS (MG/L)	314
VOLATILE SOLIDS (MG/L)	70
% VOLATILE SOLIDS	22.2

Table A-93

Chemistry at site 19, 11 July 1973

[illegible] CHEMISTRY FROM 6 FT AT SITE [illegible]11VII73-2

TURBIDITY (JTU)	16
TOTAL SOLIDS (MG/L)	308
VOLATILE SOLIDS (MG/L)	60
% VOLATILE SOLIDS	19.4

Table A-94

Chemistry at site 20, 26 July 197[illegible]

SUMMARY FOR [illegible] FRO[illegible] SURF[illegible] SIT[illegible] BL[illegible] 3-.

TEMPER[illegible]TURE (C)	[illegible]
DISS. [illegible]YGEN (MG/L)	7
TOTAL [illegible]KALI[illegible]ITY (MG/L)	[illegible]
TURBIDITY ([illegible])	[illegible]
ORTHO-[illegible]OSPHATE ([illegible])	[illegible]

Table A-95

Chemistry at site 29, 11 June 1973

[illegible] FOR WATER CHEMISTRY [illegible] AT SITE [illegible]V173-1

WATER TEMP (C)	14.
DISS. OXYGEN (MG/L)	[illegible].8
PH	[illegible]
TURBIDITY (JTU)	[illegible]8
ORTHO-PHOSPHATE (MG/L)	.5[illegible]
NITRATE-NITRITE-N (MG/L)	.0[illegible]
TOTAL SOLIDS (MG/L)	10.[illegible]
VOLATILE SOLIDS (MG/L)	[illegible]
% VOLATILE SOLIDS	3[illegible]

Table A-96

Chemistry at site 29, 26 July 1973

S[illegible] [illegible]R [illegible] [illegible] FROM [illegible] [illegible] AT SI[illegible] BL26V1173-2

[illegible]	[illegible]
DISS. OXYGEN ([illegible]L)	[illegible]
TOTAL [illegible] (MG/L)	[illegible]
T[illegible]BIDITY [illegible]	[illegible]
ORTHO-PHOSPHATE (MG/L)	[illegible]

Table A-97

Chemistry at site 31, 11 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE BL11VI73-2

TEMPERATURE (C)	25
DISS. OXYGEN (MG/L)	9
PH	8.8
TURBIDITY (JTU)	17
NITRATE-NITRITE-N (MG/L)	.002
TOTAL SOLIDS (MG/L)	12.4
VOLATILE SOLIDS (MG/L)	7.4
% VOLATILE SOLIDS	59.6

Table A-98

Chemistry at site 31, 19 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE BL19VI73-3

TEMPERATURE (C)	24
DISS. OXYGEN (MG/L)	7
TOTAL ALKALINITY (MG/L)	130
PH	8.2
TURBIDITY (JTU)	30
ORTHO-PHOSPHATE (MG/L)	.6
NITRATE-NITRITE-N (MG/L)	.3

Table A-99

Chemistry at site 32, 11 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE BL11VI73-3

TEMPERATURE (C)	26
DISS. OXYGEN (MG/L)	10
PH	8.7
TURBIDITY (JTU)	16
NITRATE-NITRITE-N (MG/L)	.003
TOTAL SOLIDS (MG/L)	11.8
VOLATILE SOLIDS (MG/L)	4.3
% VOLATILE SOLIDS	36.4

Table A-100

Chemistry at site 33, 26 July 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE BL26VII73-4

TEMPERATURE (C)	25
DISS. OXYGEN (MG/L)	9
TOTAL ALKALINITY (MG/L)	140
TURBIDITY (JTU)	40

Table A-101

Chemistry at site 34, 26 July 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE BL26VII73-3

TEMPERATURE (C)	25
DISS. OXYGEN (MG/L)	6.3
TOTAL ALKALINITY (MG/L)	130
TURBIDITY (JTU)	33
ORTHO-PHOSPHATE (MG/L)	.55

Table A-102

Chemistry at site 37, 26 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE BL26V173-1

TEMPERATURE (C)	26
DISS. OXYGEN (MG/L)	8.6
TURBIDITY (JTU)	37
TOTAL SOLIDS (MG/L)	346
VOLATILE SOLIDS (MG/L)	186
% VOLATILE SOLIDS	53.7

Table A-103

Chemistry at site 49, 12 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE AA12VI73-3

TEMPERATURE (C)	26
TURBIDITY (JTU)	5.5
TOTAL SOLIDS (MG/L)	340
VOLATILE SOLIDS (MG/L)	150
% VOLATILE SOLIDS	44.1

Table A-104

Chemistry at site 51, 12 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE AA12VI73-2

TURBIDITY (JTU)	16.5
TOTAL SOLIDS (MG/L)	274
VOLATILE SOLIDS (MG/L)	132
% VOLATILE SOLIDS	48.1

Table A-105

Chemistry at site 52, 12 June 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE AA12V173-1

TEMPERATURE (C)	24
DISS. OXYGEN (MG/L)	9
TURBIDITY (JTU)	22.5
TOTAL SOLIDS (MG/L)	358
VOLATILE SOLIDS (MG/L)	112
% VOLATILE SOLIDS	31.2

Table A-106

Chemistry at site 53, 9 August 1973

SUMMARY FOR WATER CHEMISTRY FROM SURFACE AT SITE AA9VIII73-1

TEMPERATURE (C)	24
DISS. OXYGEN (MG/L)	6.7
TOTAL ALKALINITY (MG/L)	130
PH	7.8
TURBIDITY (JTU)	18
ORTHO-PHOSPHATE (MG/L)	.58
NITRATE-NITRITE-N (MG/L)	.1
TOTAL SOLIDS (MG/L)	254
VOLATILE SOLIDS (MG/L)	102
% VOLATILE SOLIDS	40.1

Table A - 107

Benthic macroinvertebrate number and dry-weight mean diversity and redundancy in 1973*

Site	Date	Mean diversity of numbers	Redundancy of numbers	Mean diversity of dry-weights	Redundancy of dry-weights
1	2 July	1.573	0.551	1.096	0.686
1	31 July	1.442	0.278	0.965	0.518
2	2 July	1.606	0.518	1.128	0.661
2	31 July	0.812	0.651	0.974	0.580
3	2 July	1.043	0.700	1.305	0.620
3	31 July	0.875	0.689	0.991	0.645
4	31 July	1.761	0.470	1.610	0.489
5	2 July	1.207	0.653	0.779	0.772
9	5 July	0.800	0.607	0.967	0.518
9	3 August	0.877	0.624	0.230	0.901
10	5 July	1.780	0.231	1.688	0.266
10	3 August	0.880	0.453	0.999	0.382
11	5 July	1.431	0.588	0.885	0.746
13	3 August	1.246	0.475	0.530	0.780
14	3 August	0.784	0.510	0.201	0.880
15	3 August	1.607	0.377	1.176	0.546
20	16 July	1.278	0.598	0.482	0.848
20	22 July	2.574	0.303	1.561	0.578
20	30 July	0.964	0.680	0.891	0.702
23	16 July	1.232	0.471	0.857	0.631
23	22 July	2.574	0.307	1.808	0.512
23	30 July	1.269	0.512	1.327	0.487

Table A - 107 (Continued)

Site	Date	Mean diversity of numbers	Redundancy of numbers	Mean diversity of dry-weights	Redundancy of dry-weights
26	30 July	1.539	0.452	1.115	0.603
29	22 July	2.246	0.195	1.572	0.440
29	30 July	0.940	0.411	1.086	0.314
30	22 July	2.426	0.233	1.735	0.456
31	22 July	1.581	0.388	1.286	0.503
32	16 July	2.010	0.367	0.651	0.794
32	22 July	1.621	0.515	1.229	0.631
32	30 July	1.796	0.228	1.040	0.553
33	16 July	1.102	0.528	1.069	0.540
33	22 July	0.593	0.775	1.082	0.582
33	30 July	1.138	0.433	0.781	0.610
36	30 July	1.639	0.367	0.998	0.614

*Mean diversity calculated using Stirling's formula for $\bar{H}$, and the redundancy formula given by Wilhm and Dorris, 1968, "Biological parameters of water quality criteria", Bioscience 18:477-481. Redundancy is an expression of the dominance of one or more species and is inversely proportional to the wealth of species. The two indices, derived from information theory, permit an expression not only of the compositional richness of a mixed-species aggregation of organisms (mean diversity), but also of the dominance of one or more species (redundancy). The calculations in this table were based upon identifications to only the family level.

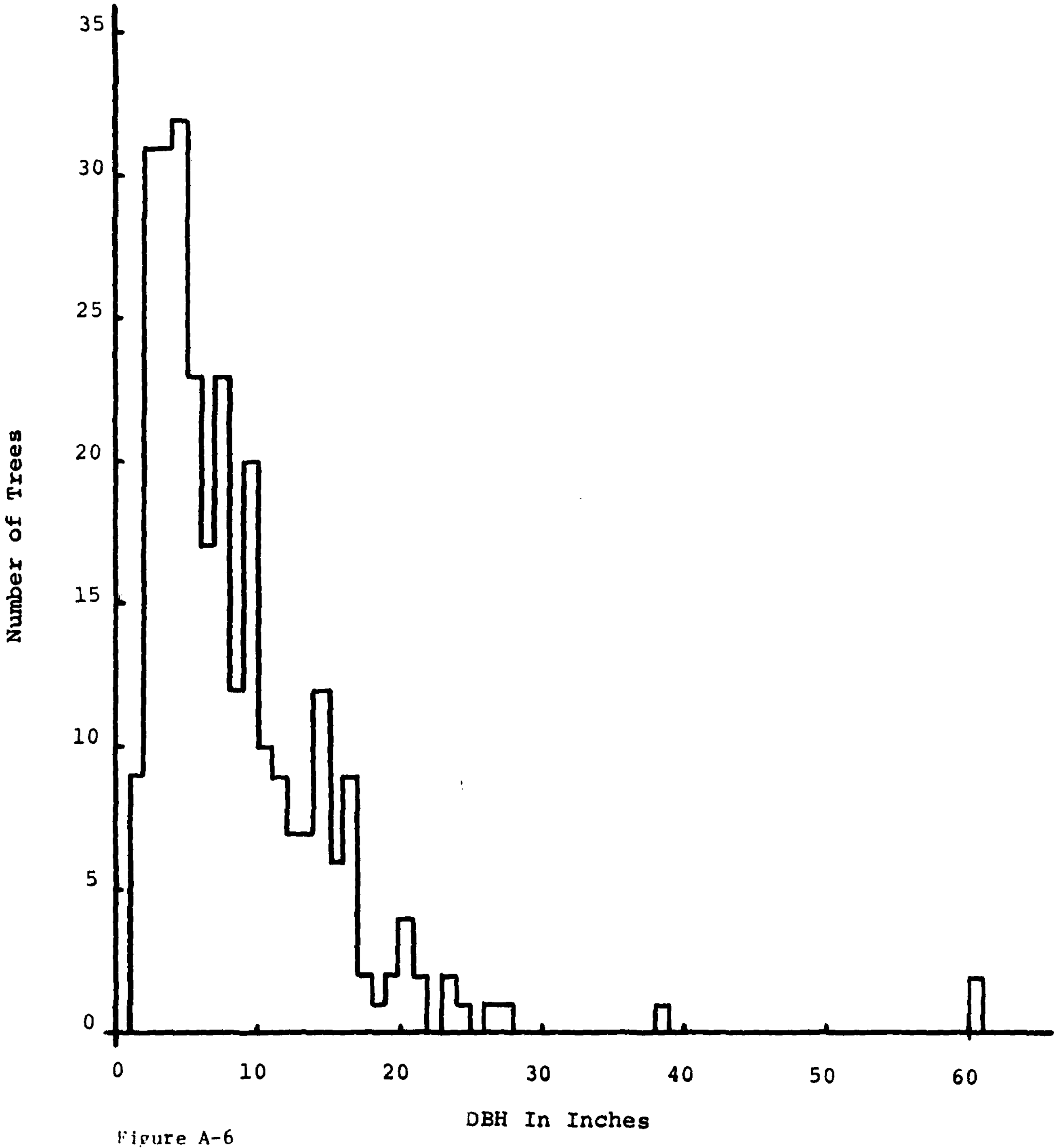


Figure A-6
Size class distribution of American Elm along North and Central transects of Pool 9.

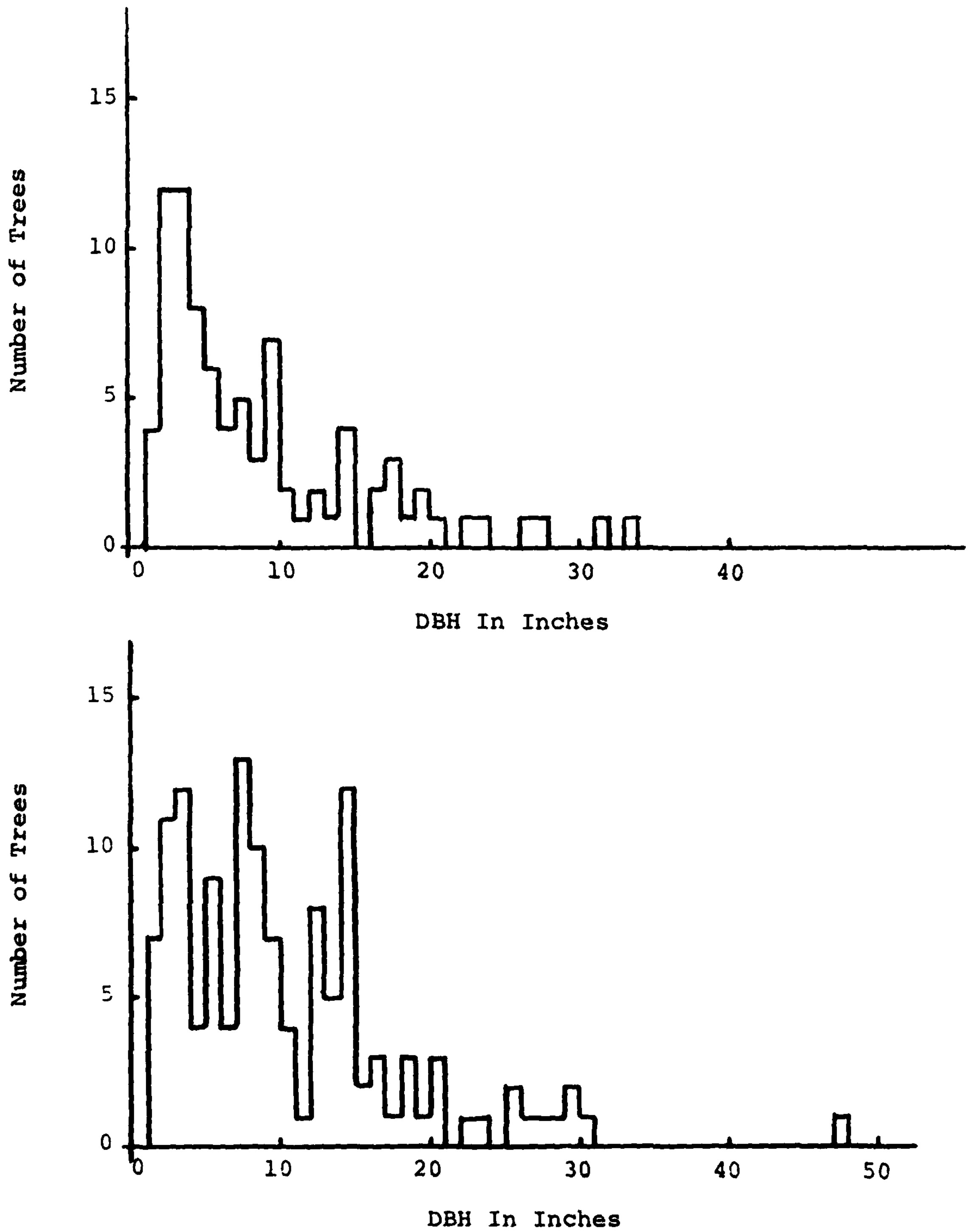


Figure A-7.
Size class distribution of Green Ash (top figure) and Red Maple (bottom figure) along North and Central transects of Pool 9.

Table A-108

Check list and relative abundance of avian species observed in the Upper Mississippi River Wildlife and Fish Refuge (Pool 9) during spring and summer of 1973.

Species	Relative abundance
Pied-billed Grebe	common
Double-crested Cormorant	2 birds, May 17
Great Blue Heron	common
Green Heron	common
Common Egret	common
Cattle Egret	1 bird, May 17
Mallard	abundant
Pintail	uncommon, spring
Blue-singed Teal	common
Shoveler	common, spring
Wood Duck	common
Lesser Scaup	abundant
Bufflehead	common, spring
Hooded Merganser	uncommon
Common Merganser	common, spring
Turkey Vulture	common
Red-tailed Hawk	common
Bald Eagle	occasional, spring
Marsh Hawk	uncommon
Ruffed Grouse	uncommon
American Coot	common to abundant
Killdeer	common
Spotted Sandpiper	common
Solitary Sandpiper	common, spring
Willet	6 birds, July 7
Herring Gull	common, spring
Ring-billed Gull	common, spring
Black Tern	common, spring
Morning Dove	abundant
Rock Dove	abundant
Yellow-billed Cuckoo	common
Green Horned Owl	common
Barred Owl	common
Whip-poor-will	common
Common Nighthawk	common
Chimney Swift	abundant
Ruby-throated Hummingbird	uncommon
Belted Kingfisher	common
Yellow-shafted Flicker	common
Pileated Woodpecker	occasional
Red-belted Woodpecker	uncommon

Table A-108 (Continued)

Species	Relative abundance
Red-headed Woodpecker	common
Yellow-bellied Sapsucker	common
Hairy Woodpecker	uncommon
Downy Woodpecker	common
Eastern Kingbird	abundant
Great Crested Flycatcher	abundant
Eastern Phoebe	common to uncommon
Traill's Flycatcher	common
Least Flycatcher	common
Eastern Wood Pewee	common
Tree Swallow	abundant
Bank Swallow	abundant
Rough-winged Swallow	occasional
Barn Swallow	common
Cliff Swallow	common
Purple Martin	abundant
Blue Jay	uncommon
Common Crow	common
Black-capped Chickadee	common
White-breasted Nuthatch	common
Brown Creeper	common
House Wren	abundant
Catbird	common
Brown Thrasher	common
Robin	common
Swainson's Thrush	common, spring
Eastern Bluebird	uncommon
Blue-gray Gnatcatcher	uncommon
Ruby-crowned Kinglet	common, spring
Cedar Waxwing	common
Loggerhead Shrike	1 bird, March 20
Starling	common
Yellow-throated Vireo	abundant
Red-eyed Vireo	common
Warbling Vireo	abundant
Black-and-white Warbler	1 bird, May 17
Yellow Warbler	common
Myrtle Warbler	abundant
Palm Warbler	common, spring
Ovenbird	occasional
Northern Waterthrush	common, spring
Yellowthroat	abundant
Wilson's Warbler	occasional
American Redstart	abundant
House Sparrow	abundant
Eastern Meadowlark	common

Table A-108 (Continued)

Species	Relative abundance
Yellow-headed Blackbird	uncommon
Red-winged Blackbird	abundant
Baltimore Oriole	abundant
Brewer's Blackbird	occasional
Common Grackle	abundant
Brown-headed Cowbird	common
Cardinal	common
Rose-brested Grosbeak	common
Indigo Bunting	common
Dickcissel	common
American Goldfinch	abundant
Chipping Sparrow	common
Tree Sparrow	common, spring
Field Sparrow	common
Song Sparrow	abundant

Table A-109

Check list of amphibians and reptiles observed in the Upper Mississippi River Wildlife and Fish Refuge (Pool 9) during spring and summer of 1973.

	Frogs
Spring Peeper	Hyla crucifer
Gray Tree Frog	Hyla versicolor
Bullfrog	Rana catesbetana
Green Frog	Rana clamitans
Leopard Frog	Rana pipiens
	Toads
American Toad	Bufo americanus
	Turtles
Snapping Turtle	Chelydra serpentina
Map Turtle	Graptemys geographica
False Map Turtle	Graptemys pseudogeographica
Painted Turtle	Chrysemys picta
Spiny Softshell	Trionyx spinifer
	Lizards
Six-Lined Racerunner	Cnemidophorus sexlineatus
	Snakes
Northern Water Snake	Natrix sipedon sipedon
Brown (DeKay's) Snake	Storeria dekayi
Eastern Garter Snake	Thamnophis sirtalis sirtalis
Fox Snake	Elaphe vulpina
Timber Rattlesnake	Crotalus horridus horridus

Table A-110

Check list of mammal species observed in the Upper Mississippi River Wildlife and Fish Refuge (Pool 9) during spring and summer of 1973

Species	
Virginia Opossum	Didelphis marsupialis
Masked Shrew	Sorex cinereus
Eastern Cottontail	Sylvilagus floridanus
Woodchuck	Marmota monax
Thirteen-Lined Ground Squirrel	Citellus tridecemlineatus
Eastern Chipmunk	Tamias striatus
Eastern Gray Squirrel	Sciurus carolinensis
Eastern Fox Squirrel	Sciurus niger
Beaver	Castor canadensis
Deer Mouse	Peromyscus maniculatus
White-footed Mouse	Peromyscus kucopus
Meadow Vole	Microtus pennsylvanicus
Muskrat	Ondatra zibethicus
Red Fox	Vulpes fulva
Gray Fox	Urocyon cinereozrgenteus
Raccoon	Procyon lotor
White-tailed Deer	Odocoileus virginianus

REFERENCES

APHS. 1971. Standard methods for the examination of water and waste water. 13th ed. Amer. Pub. Health Association, Washington, D.C.

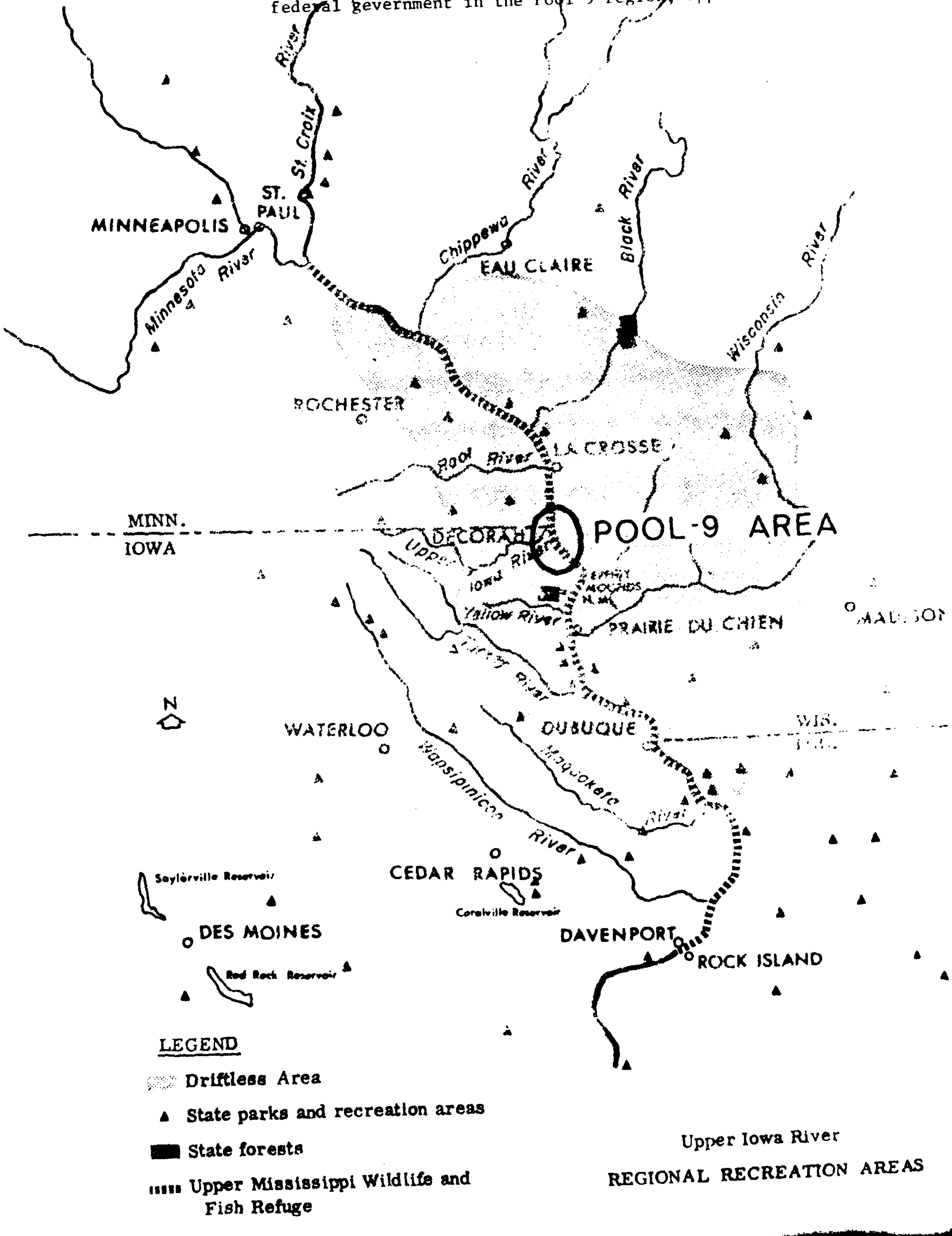
Cottam, G. and J. T. Curtis. 1956. The use of distance measures in Phytosociological sampling. Ecology 37:451-460.

Giles, Robert. 1971. Wildlife management techniques. 3rd ed. The Wildlife Society, Inc., Washington, D.C.

10. APPENDIX B

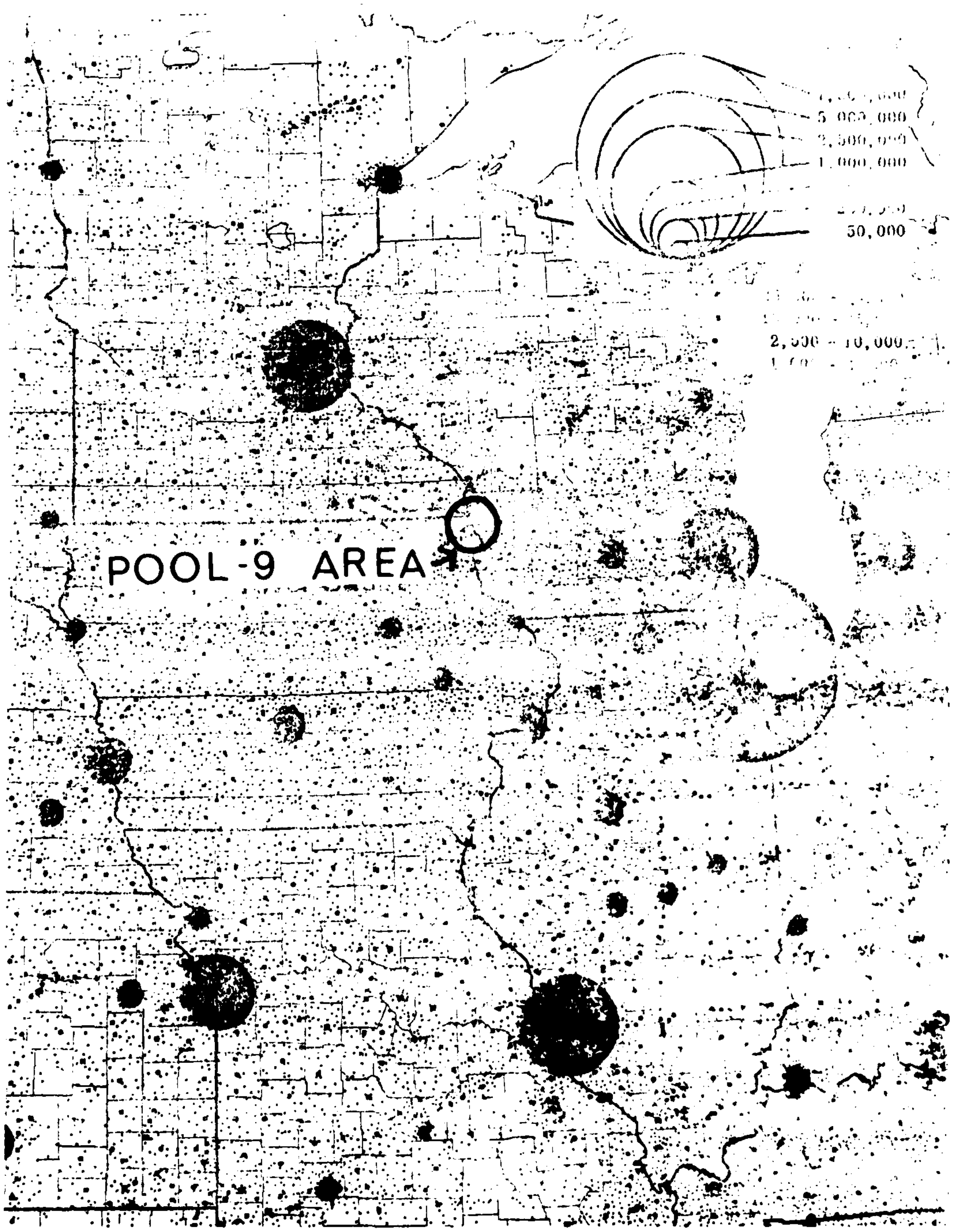
This brief section contains three figures which illustrate the the state and federally operated recreation areas, and the population distribution, in the Pool 9 region.

Figure B-1. Forest and recreation areas currently operated by state and federal government in the Pool 9 region, Upper Mississippi River



Upper Iowa River

REGIONAL RECREATION AREAS



Source data:
U.S. Bureau of the Census **1960 REGIONAL POPULATION DISTRIBUTION**

Figure B-2. Population distribution of approximately 20,000,000 people within a 250 mile radius of Pool 9, Upper Mississippi River.

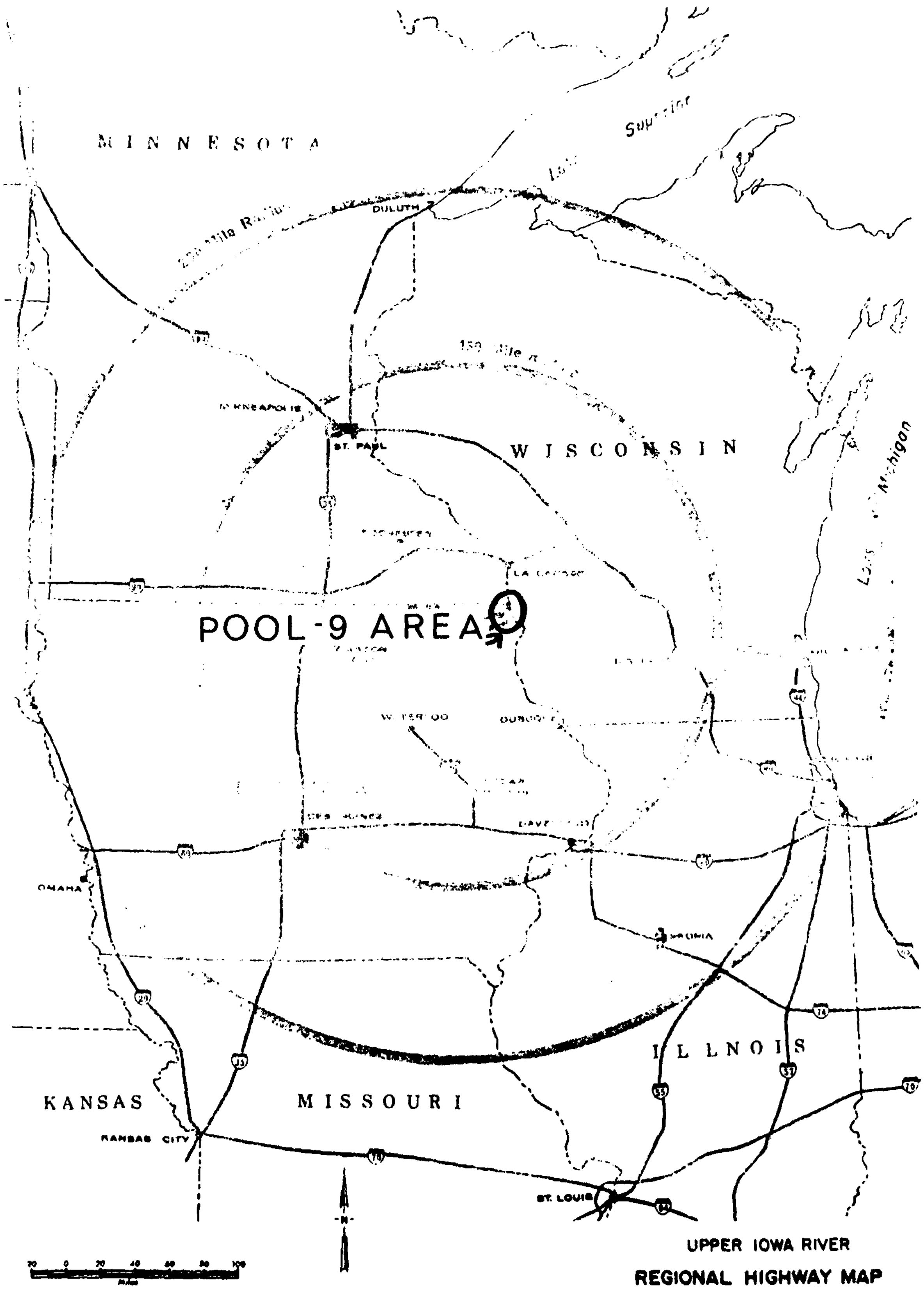


Figure B-3. Location of Pool 9, Upper Mississippi River, with respect to major population centers of Upper Midwest.

11. APPENDIX C: ARCHAEOLOGICAL BACKGROUND INFORMATION

Archaeological and historic sites of importance consist of such diverse elements as prehistoric village sites, petroglyphs (rock pictures), burial mounds, log cabins, forts, and so forth. Sites of significance may date from thousands of years ago to very recent times. Interest in studying elements of human history also varies as much with the times as interest in studying elements of natural history.

STUDIES IN THE LATE 1800's: THE LEWIS AND HILL SURVEY

Fortunately for our study now there was a strong interest in the late 19th Century in burial mounds; a massive study was pursued for approximately 20 years by Alfred J. Hill and Theodore H. Lewis. The extent of their work is best understood by examining a few of their manuscripts, a few samples of which are reproduced in this report. In 1928, Charles R. Keyes wrote of their accomplishments:

> "The great extent of the archeological survey work accomplished by Lewis and Hill cannot be appreciated except through an extended examination of the large mass of manuscript material that has been preserved. This consists approximately of the following forty leather-bound field notebooks well filled with the original entries of the survey; about a hundred plats of mound groups drawn on a scale of one foot to two thousand; about eight hundred plats of effigy mounds (animal-shaped mounds from Minnesota, Wisconsin, Iowa, and Illinois) on a scale of one foot to two hundred; about fifty plats of "forts" (largely village sites of the Mandan type) and other inclosures on a scale of one foot to four hundred; about a hundred large, folded tissue-paper sheets of original, full-size petroglyph rubbings with from one to six or more petroglyphs on each; about a thousand personal letters of Lewis to Hill; four bound "Mound Record" books made by Hill and in his handwriting; eight large, well filled scrapbooks of clippings on archeological matters made by Lewis; numerous account books, vouchers, and other miscellany...

WISCONSIN

Early Archaeology

Increase A. Lapham recorded the results of Wisconsin archaeological research which he began in 1836 in The Antiquities of Wisconsin, published in 1850. Although his work was extensive and continued until his death in 1875, if focused on areas other than the Mississippi River Valley. He described sites along the Mississippi River as far north as the La Crosse River; then concluded: "Only an occasional mound was observed along the valley of the La Crosse River; and it is believed that no works of any considerable extent exist above this point on the Mississippi." See Figure 1.

A review of the publications of Lapham, Robert Ritzenthaler, and Charles E. Brown reveal that Wisconsin archaeological and historic sites, especially burial mounds, were extensive. The number of mounds in Wisconsin were estimated to number 15,000. Sites occurred on and near the shores on nearly every stream and lake. In addition to burial mounds, "sites of native villages, camps and workshops; plots of corn hills and garden beds; enclosures; burial places and cemeteries; refuse heaps and pits; cave shelters; shrines; pictograph rocks; boulder mortars, sources of flint, quartz, quartzite and pipestone; lead diggings; copper mining pits; stone heaps and circles; cairns; and trails" are of interest to the Wisconsin archaeologist. Burial mounds, village sites, forts, and pictographs are found in the Mississippi River Valley. See Figure 2.

Recent Archaeology

An important discovery was made in 1945 by two Mississippi River fishermen who "saw some aritfacts projecting from the bank which had been undercut by the action of the River." The "Osceola Site" in Grant County is located two miles south of Potosi on the Mississippi River bank. (NW 1/4 of Sec. 14 T.2, N. Range 3, W. of 4th Principal Meridian). Excavation of the burial mound revealed copper implements, as well as projectile points and banner stones. The copper implements provide evidence of the presence of Indians belonging to the "Old Copper Culture" who probably arrived in the State about 3000 B. C.

The site had been damaged, however, by rising river water. Ritzenthaler who described the site in 1946 stated:

> Up to 8 years ago this was the bank of the Grant River, but the installation of a dam at Dubuque raised the water and widened the Mississippi at this point. . . . Test pits revealed that the burial pit extended about 70 feet along the bank, and was about 20 feet wide at this time, but it must have been considerably wider originally judging from the amount of material washed into the river.

No mention was made about intended future disposition of the site. Ritzenthaler also mentioned that another site, Raisbeck, in Grant County had been excavated, but he did not give an exact location. Other mounds were located on the Mississippi River bluffs above Potosi and were mentioned in the 1927 edition of Scenic and Historic Wisconsin.

Dr. Freeman stated that an extensive survey of sites was conducted in Crawford County when the St. Feriole Island buildings were recommended for inclusion in the National Register of Historic Places. St. Feriole Island was originally a prairie between the Mississippi River and the bluffs of Prairie du Chien. It contained many burial mounds which were not effigy shaped.

An article in 1853 by Lapham stated that the mounds "are so near the river that their bases are often washed by floods." During the highest known flood--1826--only the mounds could be seen above the surface of the water. The first fort was built on an Indian mound, as were several French homes. Lapham stated that the mound was excavated but that no remains were found in it. He did note some remains of an "American fort taken by the British in the War of 1812." Lapham, in visiting the mounds in 1852, found them "almost entirely obliterated due to cultivation and the light sandy nature of the materials."

In Pepin County, Ritzenthaler reported the existence of an Indian village site, 2 miles east of Pepin, along a wide terrace to the Mississippi. Pepin is also mentioned as the site of French forts including St. Antoine, built in 1686, above the mouth of Bogus Creek. In Trempealeau County, Nicolls Mound, the Schwert Mounds, and the Trowbridge site have been excavated. Perrot State Park in Trempealeau contains Indian mounds and the site of a log fort erected by N. Perrot, a French explorer, in 1685-6. Indian mounds are also preserved in La Crosse.

In an article published in 1950, "Wisconsin Petroglyphs and Pictographs" Ritzenthaler enumerated the existence of the following petrographs. He did not specify their exact location. Their condition had been unchecked since 1929. Exact location and current condition should be checked with the state archaeologist. In Vernon, La Crosse, Crawford, and Trempealeau Counties, sandstone and limestone cliffs and caves with petrographs were recorded. Larson Cave in Vernon County contained petroglyphs described as being in excellent condition in 1929, Samual's Cave, La Crosse County, containing petroglyphs and pictographs was first investigated in 1879--and was still in excellent condition in 1929. Galesbluff, La Crosse County, contained petroglyphs carved on soft limestone. Nearly all of the petroglyphs in Trempealeau County in the Trempealeau and Galesville rock shelters have been destroyed--either by road builders, erosion, or tourists. Pictographs were described by L. H. Bunnell in 1897, "a short distance above Prairie du Chien." Ritzenthaler did not report their present condition.

Future Studies

Dr. Freeman mentioned specific sites which have been flooded are located on Lake Pepin, at Trempealeau, and at Wyalusing. In the limited time available, this author could not locate any current publication describing the extent or present condition of sites known to have existed in Wisconsin. The *Wisconsin Archaeologist*, if reviewed issue by issue, would reveal considerably more data on the above mentioned sites, as well as other, perhaps more important, sites. However, lack of time precluded that examination. An examination of that publication, a review of the files in the historical society, and on-site visits would be required before one could be assured of an accurate analysis of the present condition of the sites.

National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The *Register* is an official statement of properties which merit preservation.

The only Wisconsin archaeological or historic site bordering the Mississippi or St. Croix rivers listed in the Register is in Crawford County on St. Feriole Island in the Mississippi River, at Prairie du Chien.

Astor Fur Warehouse, Brisbois House, Dousman Hotel, Second Fort Crawford, Villa Louis

All of the above structures are remains of the early establishment of Prairie du Chien as an early fur trade, steamship, and railroad center. They were constructed between 1808 and 1864 and most are still under private ownership.

References

Lapham, Increase, A., 1953. The Antiquites of Wisconsin. Smithsonian Contribution to Knowledge.

Brown, Charles, E., 1927. Scenic and Historic Wisconsin. Wisconsin Archaeological Society, Madison, Wisconsin.

Brown, Charles, E., 1933. Wisconsin Indians, Wisconsin Archaeological Society, Madison, Wisconsin.

Ritzenthaler, Robert, E., and Pat. 1970. The Woodland Indians of the Western Great Lakes. Natural History Press, Garden City, New York.

Ritzenthaler, Robert, E., 1950. "Wisconsin Petroglyphs and Pictographs". Wisconsin Archaeologist, Vol. 31, #4, 1950.

Ritzenthaler, Robert, E., 1953. Prehistoric Indians of Wisconsin. Popular Science Handbook Series #4, Milwaukee Public Museum.

Ritzenthaler, Robert, E., 1946. The Osceola Site--on "Old Copper" Site near Potosi, Wisconsin. Wisconsin Archaeologist 27 (3).

IOWA

According to Marshall McKusick, Iowa State Archaeologist, there were perhaps 30,000 Indian burial mounds in Iowa. Most of them lay on prominent ridges or bluffs along all of the rivers and larger streams. The mounds occur in clusters or groups; a single site sometimes contains more than 100 mounds. Mounds are in three forms: conical (round), linear (long), and effigy. The effigy mounds are large, elaborately shaped animal forms which may measure as many as 100 feet across.

Early Survey Work

The original survey work on Iowa mounds was conducted in the late 19th Century by Lewis and Hill. Records detail legal location by township, range, and 1/16 sections; thus locations are recorded to the nearest 40 acres. Nearly all of the sites have subsequently been destroyed by farming.

In Alamakee and Clayton Counties, 132 and 44 archaeological sites respectively have been surveyed. These sites contain effigy mounds which were built along the Mississippi River bluffs and on the river flats. The Effigy Mounds National Monument in Alamakee County, just north of McGregor has been created to preserve the effigy mounds on the Mississippi River bluffs. Only by checking the site locations filed in the Archaeological Laboratory, University of Iowa, Iowa City, and by on-site inspections could we determine exactly how many sites are or were found along the river flats (and thus subject to damage by the Corps of Engineers).

Charles R. Keyes, in an article about the Hill-Lewis archaeological survey (1928) wrote:

> ". . . Lewis visited on May 4, 1892, the 'prairie,' or terrace, on which stood the village of Harper's Ferry in Alamakee County, Iowa. This area is rather level and extends along one of the secondary channels of the Mississippi for about three miles, with a width between the river and the bluffs of from half a mile to a mile. He found nearly all of the terrace under cultivation and made an actual survey of only five mounds, four bear effigies and one conical mound. He did, however, make a count of mounds still discernible and he entered his count in a penciled note: This group consisted of 107 tailless animal[s] [*probably bear mounds*], 67 birds, 98 embankments that were probably animals, 154 embankments [*linear mounds*] and 240 round mounds the largest of which is now about 6 feet high. Total number of effigies in sight including surveyed, 671. Add 229 small round mounds (estimated) that have been destroyed by cultivation makes a total of 900 mounds of all classes. This note may be the record of the largest mound group ever erected by the prehistoric inhabitants of America. On August 20, 1927, the writer walked over the entire extent of this terrace and was able to count only eighteen mounds, a few even of these rather doubtful. The soil of the terrace is quite sandy, and once deprived of their covering of vegetation and put under the plow the mounds disappear in a few years."

Recent Studies

McKusick reports that very little substantial excavation of Iowa effigy mounds has been completed. He mentions in Men of Ancient Iowa that Ellison Orr excavated a bear effigy mound which is part of a group known as Brazells Island Mound Group, located on an island in the Mississippi River opposite Harper's Ferry in Alamakee County. More recently excavations were conducted in the Sny Magill Mound Group in Clayton County and in Mound 2 of the Harvey Island Mound Group, also in Clayton County. Petroglyphs (rock carvings) were found by Lewis and Hill on the sides of rocky outcrops which are most common along the Mississippi River bluffs in Alamakee and Clayton counties. Sites mentioned by Lewis and Hill and later rechecked by Ellison Orr were found to have weathered badly, or to have disappeared entirely [due to their being on sandstone]. Rock slides protected a few sites by sealing them off and thus preventing weathering.

Future Studies Needed

McKusick mentions other archaeological sites found in Iowa: camps, villages, forts, cemeteries, fish dams, and rock quarries. Individual site records would have to be checked and on-site visits made to determine which sites were located along the Mississippi and whether or not Crops of Engineers activity specifically affected any of them.

National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The Register is an official statement of properties which merit preservation. The only site on the river in Iowa listed in the Register is:

Effigy Mounds National Monument - located in Alamakee and Clayton Counties, three miles north of Marquette, Iowa. The National Monument preserves traces of Indians living there about 1000 years ago. It is an area of 1,467 acres divided by the Yellow River which flows into the Mississippi. It is most significant for its effigy mounds which provide information on the burial customs of prehistoric and historic Indians. Further information on the area is found in the Iowa report.

1973 Summer Survey

During the summer of 1973 an extensive survey of Iowa Effigy Mounds was conducted by R. Clark Mallam (Luther College Archaeological Research Center). The following mounds in the Pool 9 region were identified in his report submitted to the State Historic Preservation Program.

13 AM 32 Waukon Junction Mound Group

Located on a high bluff overlooking the Mississippi River to the east and Paint Creek to the south. Originally consisted of 1 bear effigy, 1 bird effigy, 5 conicals and 9 linears. Only 3 conicals remain, both effigies and the 9 linears have been destroyed.

13 AM 69 Keller Mound Group

Located on a terrace overlooking the Mississippi River and immediately adjacent to the Lansing Interstate Public Power Plant. Originally consisted of 3 bear effigies, 23 conicals and 4 linears. Currently there are 2 bear effigies remaining besides 15 conicals and 2 linears. The Luther College Archaeological Research Center has received a verbal committment from the Interstate Public Power Corporation that they will not destroy the mound group. Efforts are being made to encourage the I.P.P.C. to construct a public park from the remaining mounds.

13 AM 202 Capoli Bluff Mound Group

Located in a small valley facing the Mississippi River approximately 2-1/2 miles south of Lansing. The mound group consists of 4 bear effigies, 4 bird effigies, 6 conicals and 1 linear. Except for the conicals, all are in a good state of preservation.

No Number Hemminway Mound Group

Located on a terrace adjacent to the Mississippi River within the town limits of Lansing. It orginally consisted of 2 bears and 1 conical. All the mounds have been partially destroyed and the effigies are so in-distince as to eliminate the possibility of obtaining valid outlines. The group was surveyed by Lewis in 1885 but the mounds were already indistinct at that time.

References

McKusick, Marshall. 1964. Men of Ancient Iowa; as Revealed by Archaeological Discoveries, Iowa State University Press.

Hill, A. J. 1894. Mounds in Dakota, Minnesota, and Wisconsin in Vol. 6, collections of Minnesota Historical Society. The Pioneer Press Co., State Printers.

M.O.R.R.C. Minnesota Outdoor Recreation Resources Commission, Report #2. 1965. A Historic Sites Program for Minnesota. State Capitol, St. Paul.

National Register of Historic Places. 1968 and 1972 editions. National Park Service, Department of the Interior, Washington, D. C.

Holmquist, June Drenning and Jean A Brookins. 1963. Minnesota's Major Historic Sites: A Guide.

Fridley, Russell W. 1960. "Preserving and Interpreting Minnesota's Historic Sites" Minnesota History, 37.

Meyer, Roy W. 1961. "The Prairie Island Community -- A Remnant of the Minnesota Sioux" Minnesota History, 37 (7).

Winchell, Newton H. 1911. The Aborigines of Minnesota, The Pioneer Company Publisher for the Minnesota Historical Society, St. Paul, Minnesota.

Keyes, Charles, R. 1928. Hill-Lewis Archaeological Survey. In Volume IX, Minnesota History. Blegen, Theodore C., ed. Minnesota Historical Society, St. Paul, Minnesota.

12 APPENDIX D - GLOSSARY

Alleguanian Life Zone - One of the divisions of Merriam's Austral Life Zones comprising most of the non-montane United States and Mexico with distinctive faunal and floral characteristics.

alluvial material - sediment, usually fine material, deposited on land by flowing water.

backwaters - an older term now divided into sloughs and lakes and ponds.

benthic invertebrates - animals lacking a spinal column living in the benthic zone.

benthic zone - refers to the bottom region of any body of water.

BSFW - Bureau of Sport Fisheries and Wildlife.

c.f.s. - cubic feet per second; equivalent to 7.48 gallons per second.

chute - an inclined plane, sloping channel, or passage down or through which things may pass; a quick descent in a river.

coulee - steep-sided tributary valleys, commonly used in Wisconsin.

coves - precipitously walled opening at head of small stream valley produced by erosion; alluvial fill common in valley making it u-shaped.

drawdown - a process of lowering the water level of an impoundment.

Driftless Area - the portion of southwestern Wisconsin, southeastern Minnesota, and northeastern Iowa which was virtually untouched by the last advance of the Pleistocene glaciers (i.e., Wisconsin Glacier).

fluviatile dams - dams produced by stream action.

formation - a uniform or uniformly varying rock unit occurring over a wide geographic area; it may not be of the same age throughout its extent.

JTU - Jackson Turbidity Unit - arbitrarily defined units used as a standard for measuring water turbidity.

LACBWR - LaCrosse Boiling Water Reactor is the main condenser of the Dairyland Power Station at Genoa; it draws its cooling water from the Mississippi River.

lake and pond - open areas with little or no current. They are formed behind fluviatile dams, on mature flood-plains, and in areas where higher organisms, particularly beavers are active.

macroinvertebrates - collectively, all invertebrate organisms visible with the unaided eye.

main channel - the portion of the river used for navigation by large commercial craft. A minimum depth of 9 feet and a minimum width of 400 feet were established by the lock and dam system and are maintained by periodic dredging.

main channel border - the water zone between the main channel boundary and the main river bank, islands, or now sub-merged cha-nel boundaries. Wing dam are located in this zone.

MRRC - Mississippi River Research Consortium

MRRPC - Mississippi River Regional Planning Commission

mussels - bivalves, clams.

physiography - a branch of science that deals with the physical features of the earth.

phytoplankton - collectively, all those microscopic plants suspended in the water of aquatic habitat.

piezometric surface - surface to which water of a given water bearing rock unit will rise under its full head.

planktonic organism - passively floating or weakly swimming animal and plant life of a body of water.

Quaternary Era - latest geologic period of Cenozoic era which began about 1 million years ago.

riprap - rock fortifications on the sides of the river opposite wing dams. These protect the bank from erosion by water rushing around the dams. There are 17 miles of riprap bank in Pool 9.

river miles - miles above the entrance of the Ohio River at Cairo, Illinois measured on the river.

rock closing dam - low rock dams extending across side channels. These were constructed to divert water from side channels to the main channel during low water periods.

roller gates - moveable structure of dams which can be ad-justed to affect water flow and its level.

side channel - departures from the main channel or main channel border. At normal river stage, a current occurs in these channels.

slough - bodies of water through which there is no current at normal river stage. Muck bottoms and an abundance of submergent and emergent vegetation are characteristic. The slough category lies somewhere between the side channel and lake and pond categories.

tailwaters - water areas immediately below the dams. They are affected by the movement of water through the gates and locks and change in size in response to changing water levels.

tainter gates - moveable structure of dams which can be ad-justed to affect water flow and its head.

UMRCBS - Upper Mississippi River Comprehensive Basin Study.

UMRCC - Upper Mississippi River Conservation Committee.

wing dams - low structures extending radically from shore into the river for varying distances to constrict low water flows. They were constructed of rocks and brush to establish a main channel depth of 4½ feet. Sixty such dams occur in Pool 9.

zone of mixing - an area of interaction, i.e., mixing water of differing temperature to prevent stratification.

zooplanktonic - animal life of plankton.