Contract Report 554

Horseshoe Lake Sedimentation and Sediment Detention Basin Project

by Ming T. Lee
Office of Spatial Data Analysis & Information

Prepared for the
Illinois Department of Conservation
and
U.S. Fish and Wildlife Service
Department of the Interior

July 1993

Illinois State Water Survey
Hydrology Division
Champaign, Illinois

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HORSESHOE LAKE SEDIMENTATION AND SEDIMENT DETENTION BASIN PROJECT

Final Report F-109R
April 15, 1990 through April 14, 1993

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DISCLOSURE

Research Project F-109, the Horseshoe Lake Sedimentation and Detention Basin Project was conducted with funding from the Federal Aid in Sport Fish Restoration Act (Dingell-Johnson Program) — a cooperative program between the states and the U.S. Fish and Wildlife Service. The form, content, and interpretations of data are the responsibility of the University of Illinois at Urbana-Champaign, Illinois, and not of the Illinois Department of Conservation or cooperative agencies/organizations.

EXECUTIVE SUMMARY

In recent years, Horseshoe Lake's sedimentation problems have caused frequent severe fish mortality. The key to preserving the future sport fishery at Horseshoe Lake is to prevent the total mortality of the fish there. Ensuring adequate water depths, at least in the southern half of the deeper portion of the lake, will significantly reduce the opportunities for total fish mortality. Proposed alternatives for maintaining adequate water depth are: 1) incremental lake-level raising and 2) watershed protection to reduce sediment yield.

Based on the most recent lake sediment survey, it is projected that in the next 20 years about half of the lake capacity will be lost and the average water depth will be reduced from 2.6 feet to 1.8 feet. If the water level were raised 10 inches, the lake capacity could increase by 33 percent. This additional water depth would maintain a deeper water than the present depth for the next 20 years. Additionally, due to lower sedimentation rates in the deeper segments at the southern half of the lake, the incremental lake-level raising would prevent total fish kills in the next 30 years.

The watershed management alternative was studied. To reduce sediment delivery to the lake, a watershed treatment program and sediment detention basins feasibility study were initiated. The Illinois Department of Conservation and U.S. Soil Conservation Service are working together to encourage landowners to implement sheet erosion control. Streambank/bed erosion sources, which produce about 40 percent of sheet erosion, are also being considered.

A feasibility study that uses sediment detention basins to control lake sedimentation was also conducted. Two alternatives schemes were investigated: 1) construction of one large sediment detention basin near the discharge point of Black Creek and Pigeon Roost Creek or 2) construction of two small sediment detention basins in upland watersheds. The results indicate that the large sediment detention basin would detain about 5,455 tons of sediment per year versus 3,539 tons for the two smaller detention basins. The effectiveness and associated costs of these two approaches were also compared with those of land treatment only.

The Water Survey collected data on precipitation, streamflow, suspended sediment concentration, and groundwater data from 1984-1986 and 1990-1992 in Horseshoe Lake. These data were used to support the development of the proposed solutions. The data analysis provides information to the Illinois Department of Conservation's Horseshoe Lake Task Force to assess the impacts of the proposed solutions.

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INTRODUCTION

Sedimentation has reduced the water depth in Horseshoe Lake. The foremost concern is the fishery resource, however, because the lake apparently no longer has sufficient depth to prevent winter and summer fish mortality. Several severe fish kills have occurred in the last three years, which indicate that the quality of fish habitat in the lake is declining. The reduced water depth in turn reduces the lake's ability to moderate temperature increases during the summer. The resulting higher summer water temperature has caused phytoplankton die-off, which depletes oxygen during plankton decomposition and results in fish kills. Winter kills have also occurred during extended periods of cold weather, depleting oxygen to phytoplankton, when ice and snow cover have prevented sun penetration. Losses of phytoplankton reduce oxygenation required for fish survival. Sedimentation may also kill beneficial trees in portions of the lake. These trees prevent extreme temperature increases in the lake water.

Sedimentation problems in Horseshoe Lake and its watershed have been previously studied (Bogner et al., 1985; Lee et al., 1986; Blakley and Lee, 1987; Brown and Giese, 1988). Recently, the Illinois Department of Conservation (IDOC) reviewed the results of the past studies. A series of management alternatives was evaluated and proposed (Mike Carter, personal communication, 1988). The alternatives included: 1) diverting the stream away from the lake to prevent sedimentation from the contributing watersheds, 2) using part of the lake as a sediment detention basin, 3) dredging the lake, 4) increasing the lake water level through spillway modification, and 5) do nothing. The effectiveness and costs of these five alternatives were compared, and the results were submitted to IDOC.

IDOC determined that the short-term, least costly solution was to raise the level of the lake through dam modification. However, the higher water level may affect the growth of cypress and tupelo trees in and around the lake. As a result, a separate study was conducted to learn more about cypress and tupelo growth in the lake.

Additional concerns are the impacts of the high lake level to the ground-water table in the Nature Preserve area at the southern tip of the peninsula. A separate ground-water monitoring program was conducted (Blakley and Lee, 1987).

The long-term solution for the sedimentation problem in Horseshoe Lake is to reduce erosion and sediment yield from the contributing watersheds. A feasibility study of sediment detention basins was conducted (Lee, 1992).

Acknowledgments

This investigation, sponsored and financially supported by the Illinois Department of Conservation and the U.S. Fish and Wildlife Service, Department of Interior, was conducted under the general supervision and guidance of John O'Connor (Chief), Nani Bhowmik (Acting Head, Hydrology Division), and Michael Terstriep (Director, Office of Spatial Data Analysis & Information), Illinois State Water Survey. Richard Allgire, Laura Keefer, and Misganaw Demissie, Office of Sediment & Wetland Studies, assisted with field data collection and analysis. Amelia Greene, Robert Sinclair, and Jack Drobisz digitized the soil map. Linda Hascall prpared the graphics. Becky Howard formatted the camera-ready copy, and Eva Kingston edited the report.

IDOC's Horseshoe Lake Task Force provided general guidance for this investigation. Bill Boyd served as the project coordinator. Mike Sweet and Larry Dunham served as federal aid coordinators. The U.S. Soil Conservation Service provided technical assistance. Gary Barnett (District Conservationist, Euley Simington and Michael Harvell (Field Technicians, Pulaski-Alexander Counties) and James Evans (Assistant State Conservation Engineer) assisted with field data collection and selection of the sediment detention basin sites.

DESCRIPTION OF STUDY AREA

Location

Horseshoe Lake lies within the Horseshoe Lake State Fish and Wildlife Management Area, two miles south of Olive Branch, Illinois, 15 miles northwest of Cairo, Illinois, in Alexander County, and about 15 miles southeast of Cape Girardeau, Missouri. Figure 1 shows the regional location.

History

Before the 18th century, the area was traversed by Indians, hunters, trappers, and explorers. Such noted historical figures as the Spanish explorer de Soto (14th

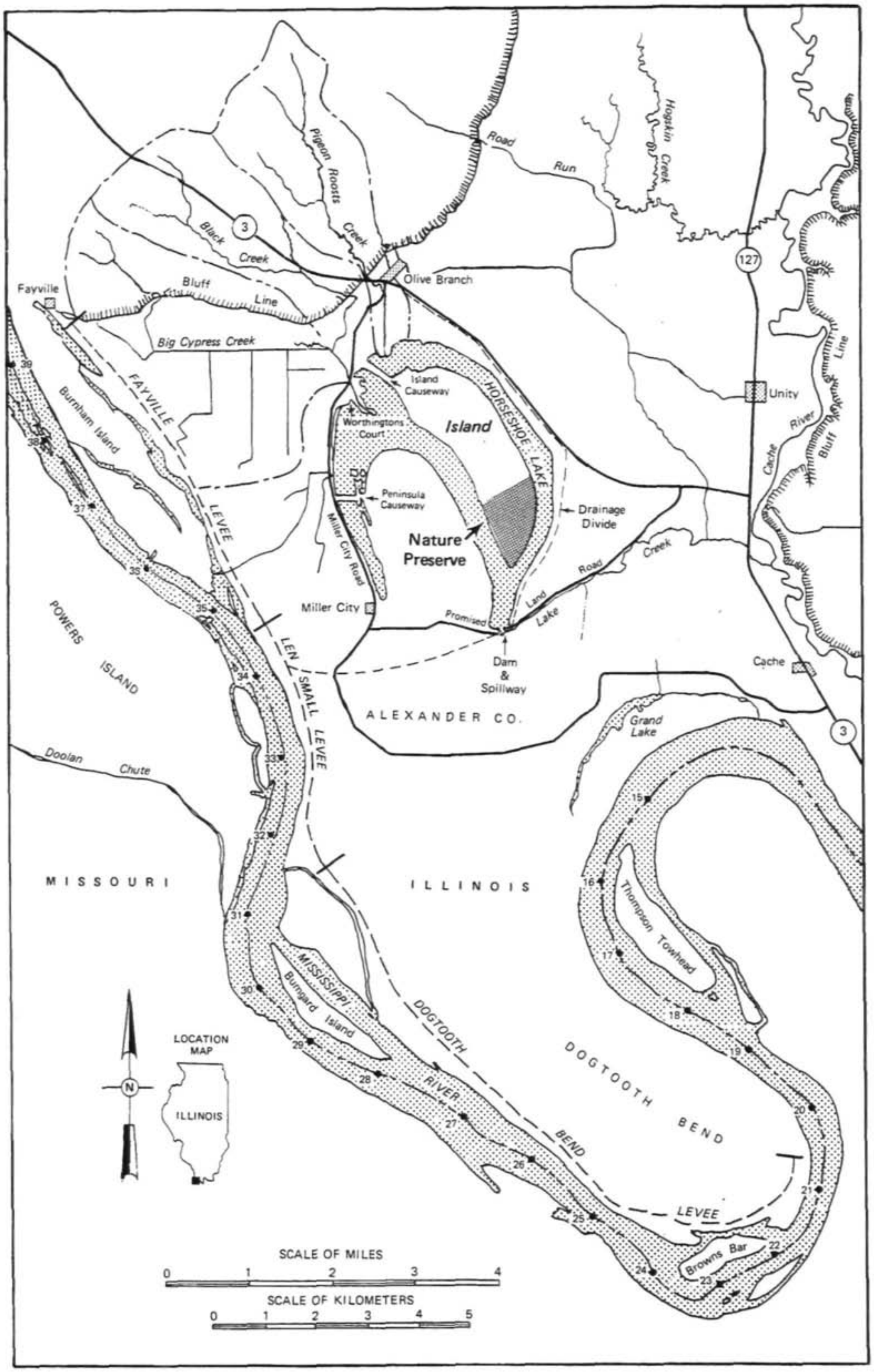

Figure 1. Location map for Horseshoe Lake, Alexander County, Illinois (after Lee et al., 1986)

century), French explorers Marquette and Joliet (15th century), and George Rogers Clark (18th century) possibly passed through or near the area.

In 1803, the federal government purchased southern Illinois from the Kaskaskia Indians, who controlled the area after the Revolutionary War. Illinois gained statehood in 1818, and in 1827 the federal government transferred the land to Alexander County. Between 1900 and 1904, the county sold the area to Dr. F.M. Harrel of Cairo, Illinois. Harrel unsuccessfully attempted to drain the lake for two years; however, it nearly dried up several times due to drought conditions while under his ownership.

Harrel owned the lake through 1920. Between 1905 and 1920, he purchased the Horseshoe Lake island from C.P. Lawrence. In the early 1920s, A.P. Green of Indiana purchased the lake and the island property from Harrel for $1. Under Green's ownership, Horseshoe Lake was used as a private duck-hunting club. The island supported several small orchards but was primarily used for hay production and pasture.

During these pre-state-ownership years, Horseshoe Lake existed as a shallow bottomland cypress swamp and was highly dependent on annual precipitation and river floodwaters for its water supply. Black Creek was the only stream feeding the lake, while Pigeon Roost Creek flowed parallel to the northeast and east sides of the lake to the Richland Slough, and eventually into the lower Cache River. Pigeon Roost Creek was diverted into Horseshoe Lake sometime prior to 1927, possibly in conjunction with construction of old Illinois Route 3.

The southwest arm of the lake, known locally as the Miller City arm, was in forage crops prior to state ownership. Other areas within the lake were logged for the cypress and tupelo lumber as evidenced by remnant stump fields in the Worthington's Court area, north of the spillway, and on both sides of the island causeway (figure 1).

In 1927, the State of Illinois began purchasing properties in the Horseshoe Lake area with the intent of establishing a state conservation area. An initial purchase of 49.05 acres on the Horseshoe Lake island was made in April 1927, and property acquisition continued throughout the rest of the year. The majority of the private land holdings belonged to A.P. Green, who sold approximately 3,176 acres to the state by the end of 1927. This acreage included both the Horseshoe Lake island and the lake. By the end of 1927, nearly 3,600 acres of land and water had been relinquished to state control. After the lake had been acquired, plans were formulated to stabilize the lake pool.

In 1929 IDOC completed construction of a stop-log spillway and dam at the intersection of Lake Creek and Promised Land Road at the southern tip of Horseshoe

Lake (figure 1). Although the wooden spillway was structurally adequate to withstand water pressure exerted by impounded water, the design did not take into account the water pressure exerted on the structure by Mississippi River floodwater flowing over the spillway into the lake. Consequently, in spring 1930, the spillway was washed into the lake by incoming floodwater. As the floodwaters receded, Horseshoe Lake drained and lay partially dry for one year.

Construction of a controllable concrete spillway was started. This spillway was completed in 1931, just prior to the first attempt at stocking fish in the lake. Retaining walls were added to the dam in 1933. These walls extended east and west from the spillway wing walls and were two feet higher than normal lake pool elevation.

The controllable spillway functioned for eight years before being altered to a fixed concrete structure in 1939 (IDOC, 1972). The 1939 spillway was not keyed to a sea level datum, but current calculations based on the original spillway blueprints indicate that the 1940 elevation was approximately 322 feet above mean sea level (msl).

After final spillway construction was completed, the lake level rose approximately 4.5 feet above its pre-1939 stage. This rise in elevation inundated more than 600 acres of topographically low land adjacent to the lake. Included in this acreage were the areas known as Worthington's Court and the Miller City arm (figure 1). Although the majority of the flooded land belonged to the state, several private holdings were also flooded. Some of these properties are still under private ownership and are still under water today. Prior to stabilizing the lake pool at a higher elevation, the state secured flood easements.

In the mid-1940s, the area north of the mouth of Black Creek was a privately owned duck-hunting club. By the early 1960s, this property and much of the current holdings had been acquired by the state through direct purchase or other methods of land transferal, which allowed development of the state park facilities. By the early 1960s, it became evident to the state and local citizens that the main channel of Black Creek was becoming log-choked and silted in. In 1963, IDOC dredged the channel to within 500 feet of the lake. The last 500 feet of dense vegetation and shallow water was then blasted open and dredged to promote better drainage and to provide continued access to the lake for property owners along this stretch of the creek.

Prior to 1969, only portions of the Mississippi River levee system had been completed. The completed levees in the Horseshoe Lake area functioned as barriers to overland flow in Dogtooth Bend south of the lake. This area, which is primarily cropland, experienced severe scour and fill prior to construction of the Len Small Levee in 1943 and the Dogtooth Bend Levee prior to 1943. The northern end of the levee system, the Fayville Levee, was not completed until 1969 after which it effectively prevented overland flow to the lake. Local residents attribute the aggregation of the Black Creek delta and general siltation of the Big Pocket-Worthington's Court area to the completion of the levee.

Physical Characteristics

General

The Horseshoe Lake State Fish and Wildlife Management Area is a floodplain wetland on the floodplain of the Mississippi River. The area occupies 9,570 acres, which includes the 2007-acre Horseshoe Lake, and exhibits wetland characteristics common to more southerly wetland environments. Many of these characteristics, such as area species of plants and animals, cannot be found in more northern latitudes of the state. A detailed description of these characteristics may be found in the IDOC Master Management Plan for Horseshoe Lake (ibid.).

Wetland habitat similar to that at Horseshoe Lake is commonly found along the Mississippi River. Oxbow lakes are remnants of river channels that were abandoned as the river migrated laterally through its floodplain. Horseshoe Lake is a prime example of this type of shallow-water, oxbow lake habitat.

The primary sources of water for oxbow lakes may be seasonal flooding by rivers, continuous supply from tributary streams that empty into the lake, or both. Horseshoe Lake receives its water from both of these sources. The two streams that provide a continuous supply of water to the lake are Black Creek, which drains an area of 9.86 square miles west and northwest of the lake, and Pigeon Roost Creek, which originates north of the lake and drains an area of 3.78 square miles (figure 1). Both streams are subject to flash flooding during intense rainfall and are the primary source of water and sediment for the lake (SCS, 1983). The Mississippi River, which floods Horseshoe Lake on an average of two out of every three years, is a secondary but important source of water for the lake.

Oxbow-lake hydrologic characteristics such as sources and amount of recharge, flooding frequency, and storage capacity influence the flora and fauna of the area and the type of habitat available for biological communities inhabiting the wetland. If the area is managed for specific interests, whether state or private, the management objectives may be formulated on the basis of these biotic characteristics. At Horseshoe Lake, the following management objectives have been implemented: to provide a winter refuge for the Illinois flock of the Mississippi valley population of migratory Canadian geese; to preserve the natural character of the area; to provide for fishing, hunting, camping, and sightseeing activities; to provide forest management; and to preserve the Horseshoe Lake Island Nature Preserve and the Horseshoe Lake Forest Nature Preserve (IDOC, 1972).

Soils

Soils in the Horseshoe Lake watershed are generally silty loams that have developed in bottomland alluvium, on remnant terrace deposits, and in upland loess deposits. Problems commonly associated with these soils include low fertility, erodibility, and poor drainage.

Three soil associations cover the Horseshoe Lake watershed: the Ginat-Weinbach-Sciotoville association, Alvin-Roby-Ruark association, and Kamak-Darwin association (SCS, 1968).

Land Use

A land use map was obtained from the Alexander County Soil and Water Conservation District. The 1:24,000 scale map was digitized as shown in figure 2. The land use breakdowns in the Horseshoe Lake watershed are listed in table 1. The largest acreage is used for cropland, which covers 7,280 acres or 48.6 percent. Forests cover 4,168 acres or 27.8 percent. Water and wetlands cover 2,005 acres or 13.4 percent. Pasture covers 1,059 acres or 7.1 percent. Smaller acreages are used for urban areas, highway construction, and forest preserves.

Table 1. Land Use in the Horseshoe Lake Watershed

Land use	*Acreage*	*Percent*
Cropland	7,280	48.6
Forest	4,168	27.8
Water and wetlands	2,005	13.4
Pasture	1,059	7.1
Urban	162	1.1
Highway construction	32	0.2
Forest preserve	266	1.8
Total	14,973	100.0

Other detailed physical descriptions of the area can be found in previous reports (Bogner et al., 1985; Lee et al., 1986; Blakley and Lee, 1987).

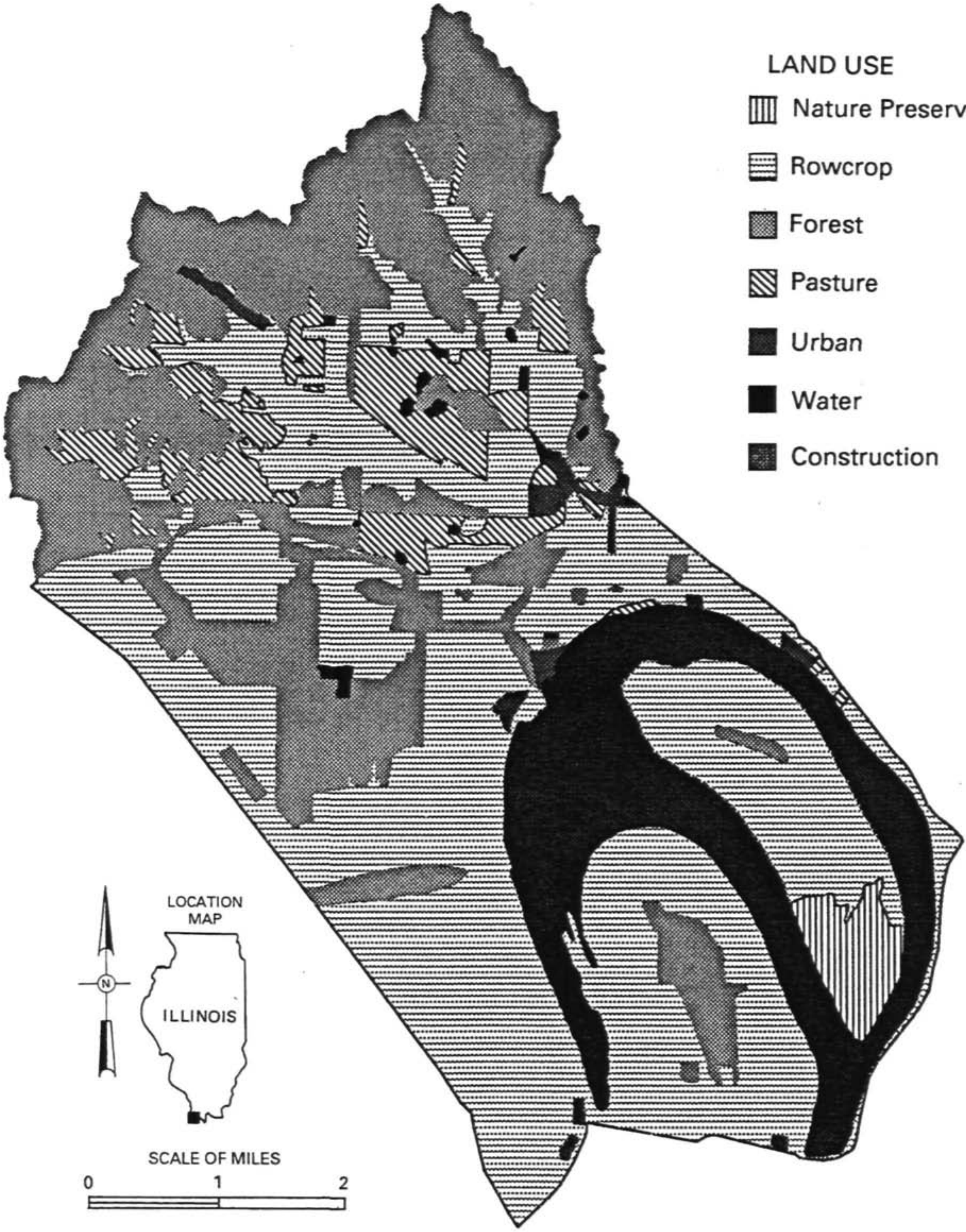

Figure 2. Land use map of Horseshoe Lake

RELATED STUDIES

In 1980, Mr. O.M. Price conducted a lake sounding of Horseshoe Lake. The Illinois State Water Survey conducted a lake sediment survey in 1984 and a lake management study in 1986 (Lee et al., 1986). In 1988, Brown and Giese conducted a study on the bottomland swamp in the Cache River basin and Horseshoe Lake.

The Water Survey also conducted a diagnostic and feasibility study of sediment management for Horseshoe Lake in 1986 (ibid.). The study was organized into five components:

1) Determination of the sedimentation rate at Horseshoe Lake;
2) Analysis of pertinent lake water quality parameters;
3) Development of a lake hydrologic budget;
4) Identification of major sources of sedimentation, using sediment budget analysis techniques; and
5) Development and evolution of various sediment management plans on the basis of new data and existing information.

On the basis of the feasibility study, three recommendations were made:

1) Watershed management has the potential to reduce the gross erosion to the level of 40 percent of the current. However, to achieve this, a long-range plan and full cooperation of the landowners in the watershed are absolutely necessary.
2) The in-stream management techniques that were considered included four stream diversion alternatives. From the preliminary cost estimate, however, the in-stream management alternatives are significantly more expensive than other alternatives.
3) In-lake management included both raising the lake level and increasing the water depth by removing sediment. The most economic alternative is to raise the lake level.

In 1990, Watwood and Heavener, Inc (1990) conducted a study to investigate the possibility of increasing the depth of Horseshoe Lake, while raising the crest of the existing spillway incrementally. The study results showed that: "If the raise in the spillway does cause the lake to exceed its shoreline limits, the extent of inundated land will be examined for corrective measures such as raising or roadways, flood easements or land purchase." Five levels of spillway increment were considered. For a 10-inch increment, the flat pool will inundate 400 feet of road, 4.06 acres of land, and a 100-year flood will increase those numbers by an additional 6,100 feet of road and 650.7 acres of land.

In 1991 the Illinois Natural History Survey did additional soundings of Horseshoe Lake. But the results were not compared with those of the earlier surveys.

In 1992 a study was conducted to assess the potential for oxygen-related fish kill in Horseshoe Lake (Heidinger, 1992). The study concluded that:

"Due to the shallowness of the lake and its eutrophic nature, ice with 4-6 inches of snow cover for three or four weeks would likely lead to a localized or a complete fish kill. Sport species tend to be more vulnerable to low oxygen conditions than nonsport fish species, such as carp, buffalo, gar, etc."

In 1992, a sediment detention basin feasibility study (Lee, 1992) was conducted, and two alternative schemes were developed: 1) construction of one large sediment detention basin near the discharge point of Black Creek and Pigeon Roost Creek or 2) construction of two smaller sediment detention basins in upstream watersheds. The cost and effectiveness of the two alternatives were compared.

NEEDS

Lake Sedimentation

The results of the 1985 report of the lake sediment survey (Bogner et al., 1985) showed that the lake had accumulated 2,808 acre-feet of sediment from 1951 to 1984. Analysis of particle sizes of sediments in Horseshoe Lake shows a preponderance of clay materials. The average composition of all sediment samples analyzed was 70 percent clay, 25 percent silt, and 5 percent sand. The analysis of organic content of the Horseshoe Lake sediments shows that the organic input to the lake is very high. (10 percent of the sediment material). The high organic input is the result of the large goose population and the large stands of cypress and tupelo trees in the lake. A calculation of the sediment rates in Horseshoe Lake showed that the water volume of the lake is being replaced by sediment at the rate of 78.6 acre-feet per year. This represents an average loss of depth in the lake of about 0.5 inches per year.

Impacts to Fisheries

At present, the foremost concern is the fishery resource of this lake. Horseshoe Lake apparently no longer has sufficient depth to ensure that winter and summer fish mortalities can be prevented. Several severe fish kills have occurred in the past five years indicating that the quality of fish habitat in the lake is declining. Sedimentation has reduced the lake water depth, which in turn reduces the lake's ability to moderate temperature increases during the summer. The resulting high summer water temperature has caused phytoplankton die-offs resulting in fish kills.

OBJECTIVES

The overall purpose of the project was to develop lake management alternatives that can minimize the potential risk of sport fish kill.

The specific objectives were:

1) To collect necessary hydrologic and sediment data to support the lake management alternatives developed; and

(2) To develop watershed management recommendations, including ones for sediment detention basins, and to identify land uses in the watershed that contribute excessive sediment yields.

DATA COLLECTION

The job number indicated in the subtitle is the same as that of the work plan.

Precipitation (Job B5)

Precipitation initiates the inflow process to the lake, directly or indirectly. In this report, precipitation includes rain and snow, although the significant precipitation events are usually rain in the Horseshoe Lake area.

Between August 1990 and October 1992, precipitation data for 28 months were collected at Horseshoe Lake. A standard weighting bucket raingage was used to measure rainfall. Daily data were recorded and tabulated as shown in appendix A. Rainfall was previously measured at the same site from March 1984-April 1985.

Table 2 summarizes the monthly totals from August 1990-October 1992 at Horseshoe Lake and the adjacent station (about 15 miles northwest) at Cape Girardeau, Missouri. The data show that less rainfall was observed at Horseshoe Lake than at the Cape Girardeau station. Note that the Cape Girardeau site is a long-term U.S. Weather Bureau station while the Horseshoe Lake station was established specifically for the project. Table 3 provides precipitation data for 1984 and part of 1985 for Cairo and other stations in the basin.

Table 2. Monthly Rainfall Data at Horseshoe Lake

Date		*Horseshoe Lake (inches)*	*Cape Girardeau (inches)*	*Differences (inches)*
1990	Aug	1.35	1.61	-0.26
	Sep	0.30	1.79	-1.49
	Oct	3.25	5.21	-1.96.
	Nov	1.90	3.54	-1.64
	Dec	7.65	9.16	-1.51
1991	Jan	2.54	3.56	-1.02
	Feb	2.37	2.69	-0.32
	Mar	2.81	3.17	-0.36
	Apr	3.52	5.87	-2.35
	May	2.12	4.37	-2.25
	Jun	1.29	1.05	+0.24
	Jul	0.56	2.93	-2.37
	Aug	0.94	4.84	-3.90
	Sep	1.44	2.58	-1.14
	Oct	2.97	5.19	-2.22
	Nov	3.85	8.39	-4.51
	Dec	3.75	5.14	-1.39
1992	Jan	1.97	2.37	-0.40
	Feb	3.16	2.98	-0.18
	Mar	2.61	3.41	-0.80
	Apr	2.59	2.70	-0.11
	May	1.19	2.31	-1.12
	Jun	1.99	3.70	-1.71
	Jul	4.73	3.80	+0.93
	Aug	5.51	2.08	+3.43
	Sep	4.16	5.28	-1.12
	Oct	3.70*	3.38	+0.32

Note:

* incomplete monthly data

Table 3. Monthly Precipitation (inches)

Date	*Cairo*[1]	*Departure from normal*	*RGl*[2]	*RG2*[3]	*NWS*[4] *Olive Branch*	*Average*
1984						
January	1.25	-2.22	1.33	1.33		
February	3.16	-0.26	3.97	3.97		
March	4.89	-0.07	6.36	6.36		
April	6.40	1.96	0.13*	1.48*	4.94	4.33
May	4.88	-0.02	2.55*	5.00	4.50	4.15
June	1.71	-2.65	2.06	1.57	1.93*	2.10
July	5.79	1.83	1.23*	3.46	2.74	2.89
August	1.05	-2.92	0.86	0.94	1.35	1.05
September	4.40	0.90	5.37	5.80	4.98	5.41
October	7.89	5.35	11.77	10.08	9.80*	10.67
November	4.33	0.36	4.34*	4.97	7.41	6.19
December	10.07	5.91	5.91*	7.58	5.98*	7.98
1985						
January	*	*	0.90*	1.31*	1.52	1.64
February	3.27	-0.15	2.61*	2.31*	4.19	4.03
March	4.83	-0.13	5.07*	5.12*	5.66	5.75
April	7.29	2.85	5.29	5.85	6.53	5.99
Totals	71.21	+10.74	48.09	55.46	69.00	73.84

Notes:

1 National Oceanic and Atmospheric Administration data

2 RG1 is located along the east arm of the lake

3 RG2 is located near the spillway

4 NWS is located along Route 3 in the northwest portion of the watershed

* Missing or incomplete data

The data show that the wet season at Horseshoe Lake is from December through May. The site generally received less rainfall during the summer months. When comparing rainfall data for the Horseshoe Lake and Cape Girardeau sites, the results indicate that the precipitation measurements at Horseshoe Lake are consistently lower than the measurements at the Cape Girardeau raingage. The results show a great spatial variation of precipitation in the region, but it is possible that data were missing or that measuring errors had occurred.

The maximum monthly precipitation of the observation period, 7.65 inches at Horseshoe Lake, occurred in December 1990. The Cape Girardeau precipitation station recorded 9.16 inches during the same month. The lowest monthly precipitation, 0.30 inches, was measured in September 1990 while the Cape Girardeau station measured 1.79 inches. The temporal distribution of the observed monthly precipitation data is illustrated in figure 3.

Lake Level (Job B4)

A water-level staff gage was installed near the spillway. Weekly lakewater-level data were collected from June, 1990-October 16, 1992 (figure 4). The staff gage was read to the accuracy of one hundredth of a foot. Water-level data were also previously collected from February 1984-July 1986.

The fluctuation in lake stage over the observation periods is presented in figure 4. The maximum lake stage, about 1 foot above the spillway crest, occurred in December 1990. The lowest stage, about 1.5 feet below the spillway crest, occurred in summer 1991.

Comparing lake-level data between 1984-1985 and 1990-1992 as shown in figures 4 and 5, the results show that 1984-1985 had higher lake peak stages in early spring due to the high backwater from the Mississippi River. The data clearly indicate the annual cycle of lake-level fluctuation. The stage rises from the winter to the spring and peaks with the backwater flooding. The summer and early autumn months experience a drop in stage so that the lake level falls below the spillway.

Runoff and Streamflow Measurement (Job B2)

The portion of the precipitation that falls on the land surface and is not lost to interception, evapotranspiration, depression storage, or infiltration enters the lake as runoff from a defined streamchannel or directly overland. Since it is not feasible to monitor every source of runoff into the lake, two streamgaging stations were selected to measure runoff: Pigeon Roost Creek and Black Creek.

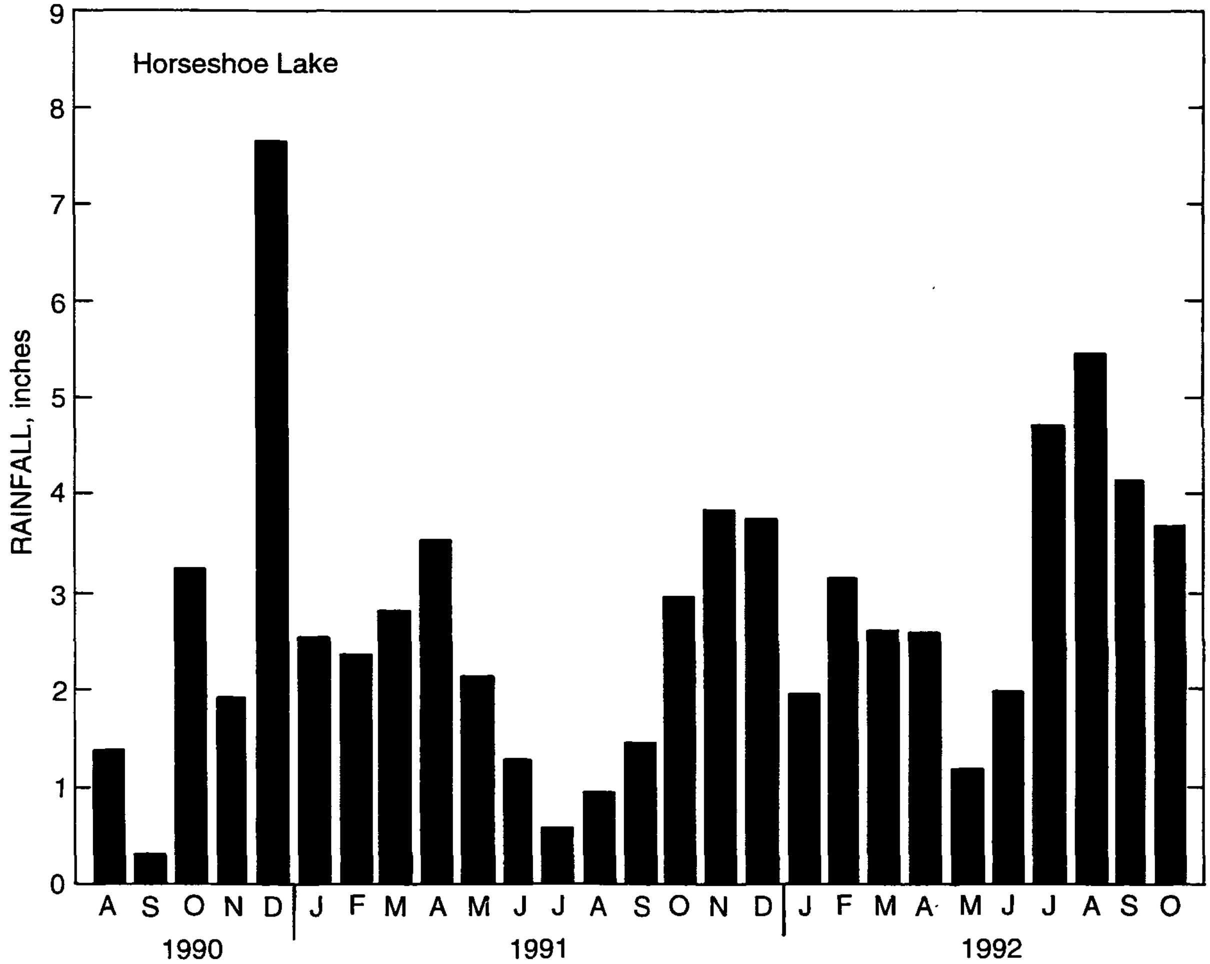

Figure 3. Monthly precipitation data for Horseshoe Lake, Alexander County, Illinois

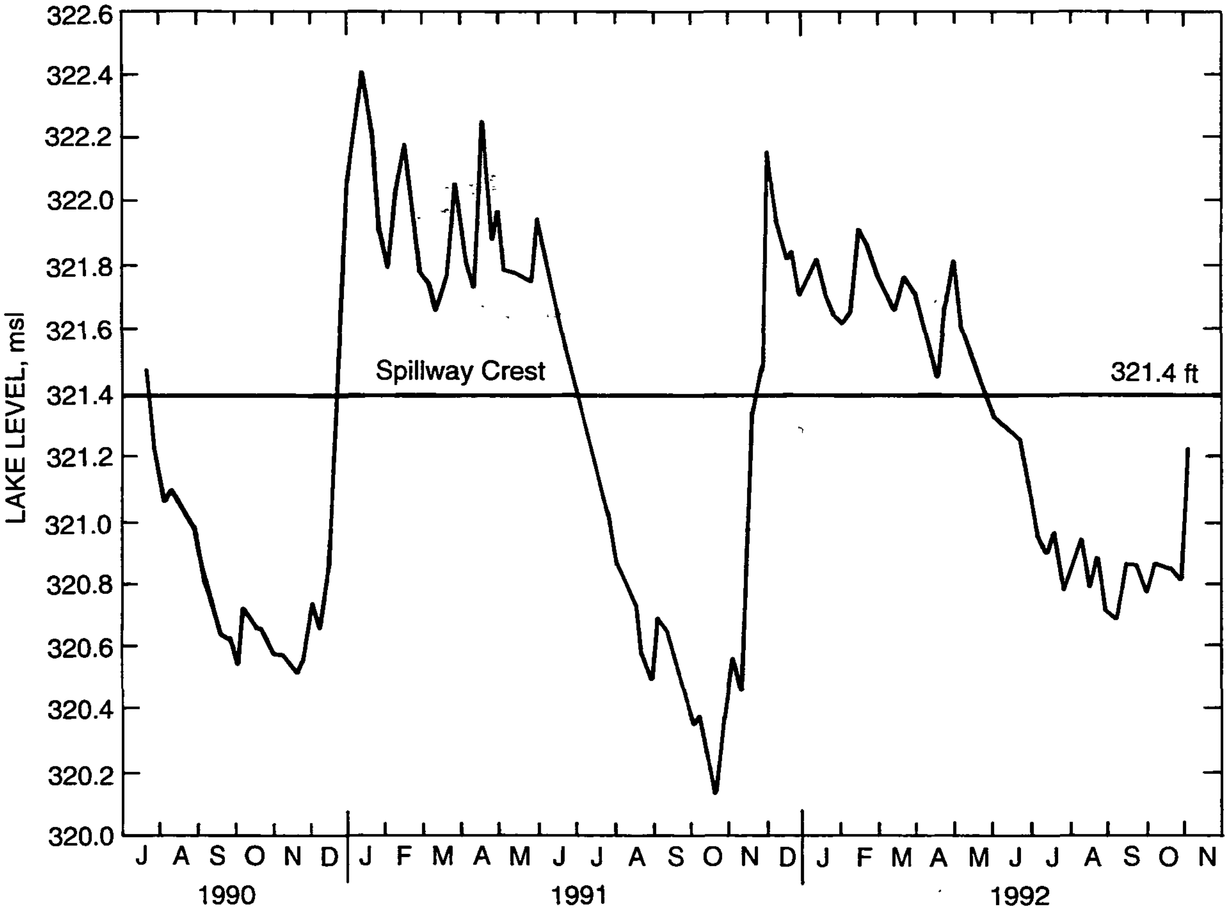

Figure 4. Lake level of Horseshoe Lake, June 1990-October 1992

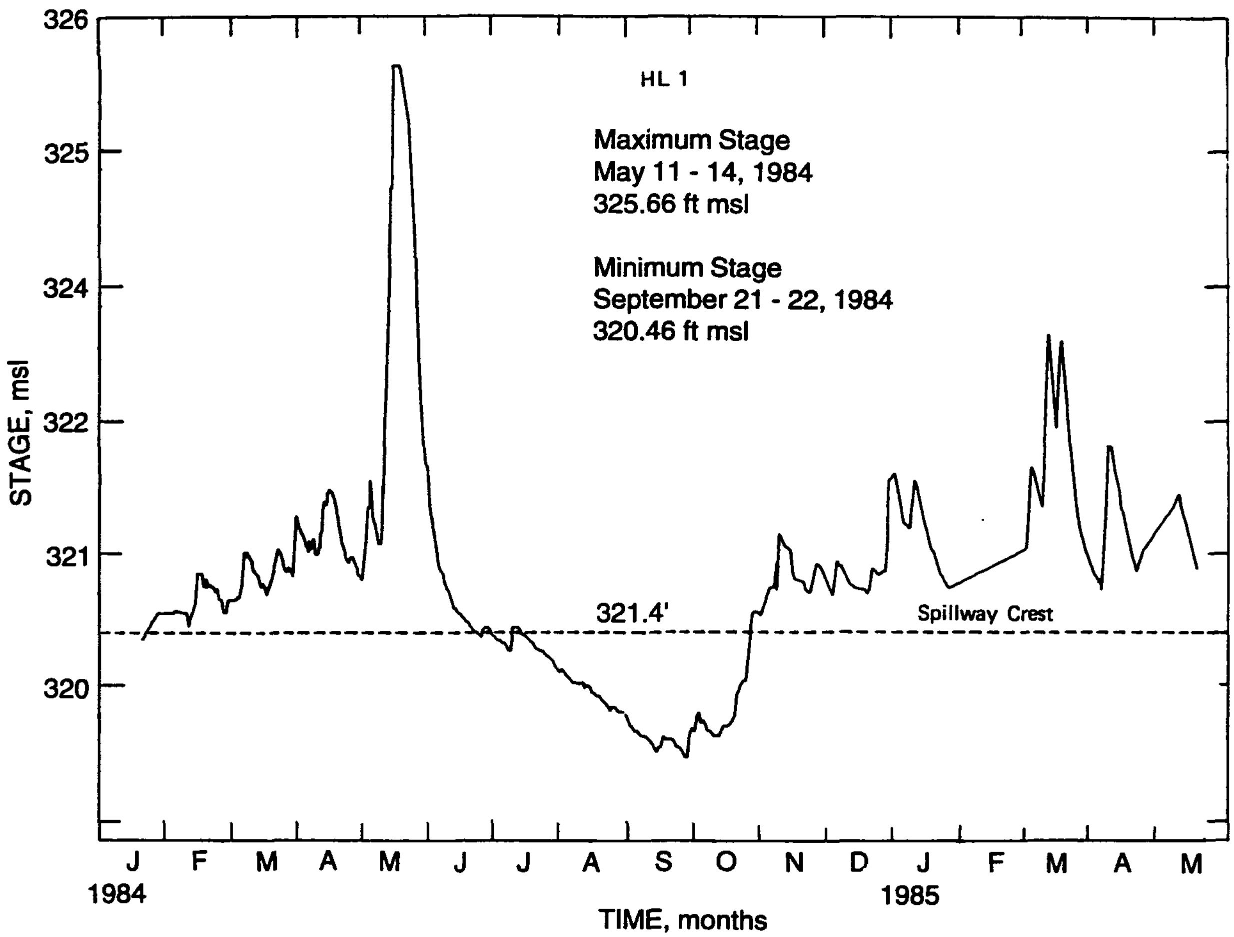

Figure 5. Water level at Horseshoe Lake, January 1984-May 1985

Each streamgaging station had a continuous water level recorder (Leupold and Stevens, Type A, Model 71) installed on top of a stilling well constructed of 24-inch corrugated metal pipe. The pipe, with its longitudinal axis oriented vertically, was bolted to a bridge. The lower end was buried in the streambank and the bottom 2-3 feet were below the normal water surface so that low flow stages could be obtained.

The stage-discharge relationship, also called the stage-discharge rating curve, was obtained for the gaging station sites by discharge measurement. The streamflow was then calculated by using the recorded stage levels and the stage-discharge rating curve.

The stage-discharge rating curves of the Pigeon Roost Creek and Black Creek streamgaging stations were shown in figures 6 and 7. The daily streamflow data of the two gaging stations are shown in appendices B and C. The monthly streamflow data of the 1984-1986 and 1990-92 periods are tabulated in table 4.

The results indicate that Pigeon Roost Creek has higher stream runoff than Black Creek. For the 1990-1992 observed data at Pigeon Roost Creek, the maximum monthly stream runoff, 8.68 inches, occurred in December 1990. For Black Creek, the maximum monthly stream runoff, 4.97 inches, occurred the same month. As expected, low stream runoff occurred in summer months. During some of the summer, the streambed was almost dry. In general, the 1984-1986 and 1990-1992 streamflows have similar trends, as do precipitation and the lake-level cycle.

Suspended Sediment Measurement (Job B1)

Data were collected on suspended sediment concentration at two streamgaging stations located at Pigeon Roost Creek (147 samples) and Black Creek (184 samples) from June 1990-October 1992. Figures 8 and 9 show the suspended concentration at Pigeon Roost Creek and Black Creek, respectively. The high suspended concentrations were induced by the heavy rainfall in late winter and early spring. The concentrations can reach as high as 35,000 milligrams per liter (mg/L). During low flow, however, the average sediment concentration is below 100 mg/L.

Shallow Ground-Water Table Measurement (Job B4)

The purpose of monitoring the ground-water level is to determine if a higher lake level would cause a rise in ground-water elevation beneath the Horseshoe Lake Island Nature Preserve.

Three observation wells were installed along an east-west transect of the island along the northern boundary of the nature preserve (see figure 10). The wells were

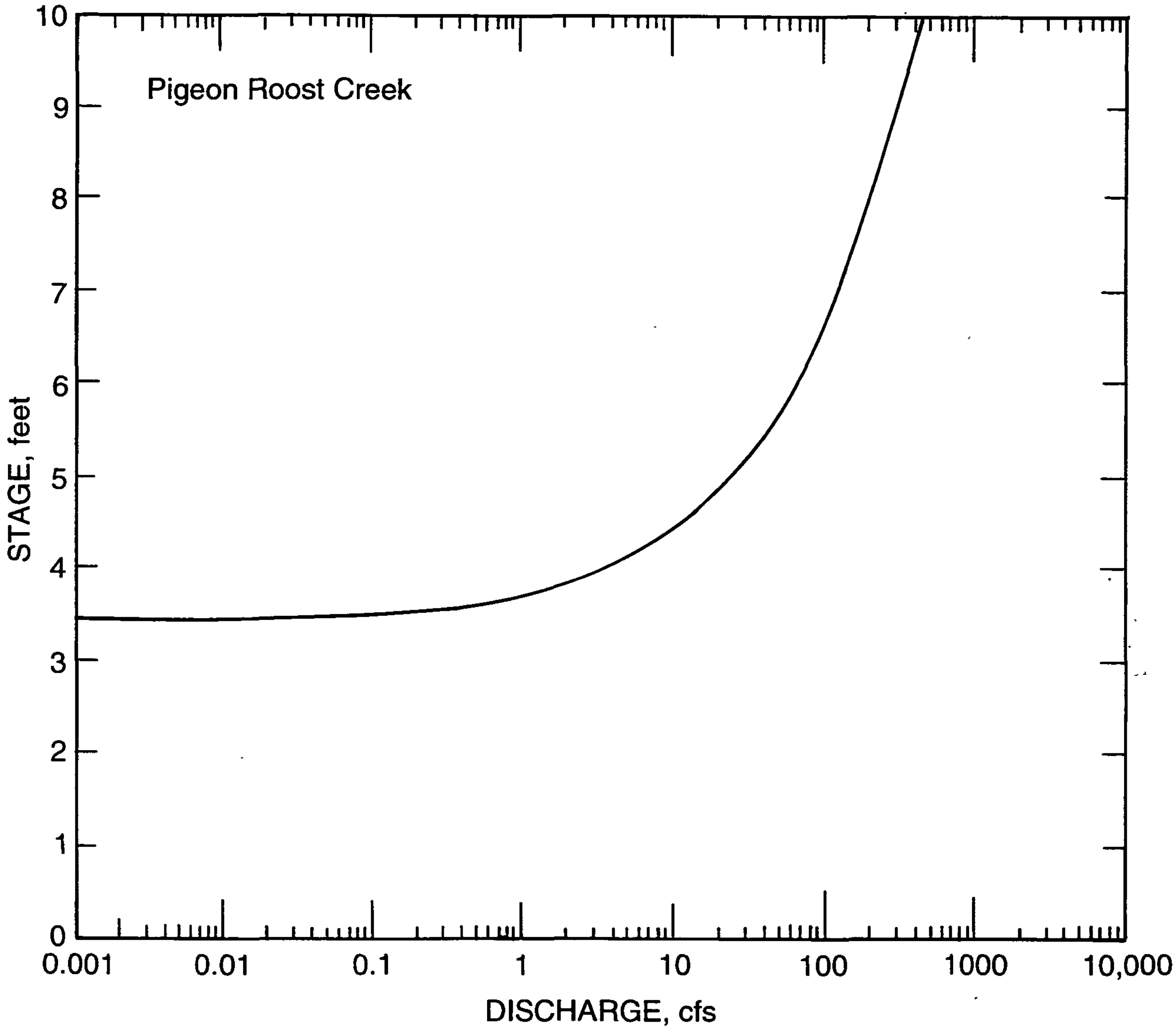

Figure 6. Stage-discharge rating curve at Pigeon Roost Creek, Horseshoe Lake, Alexander County, Illinois

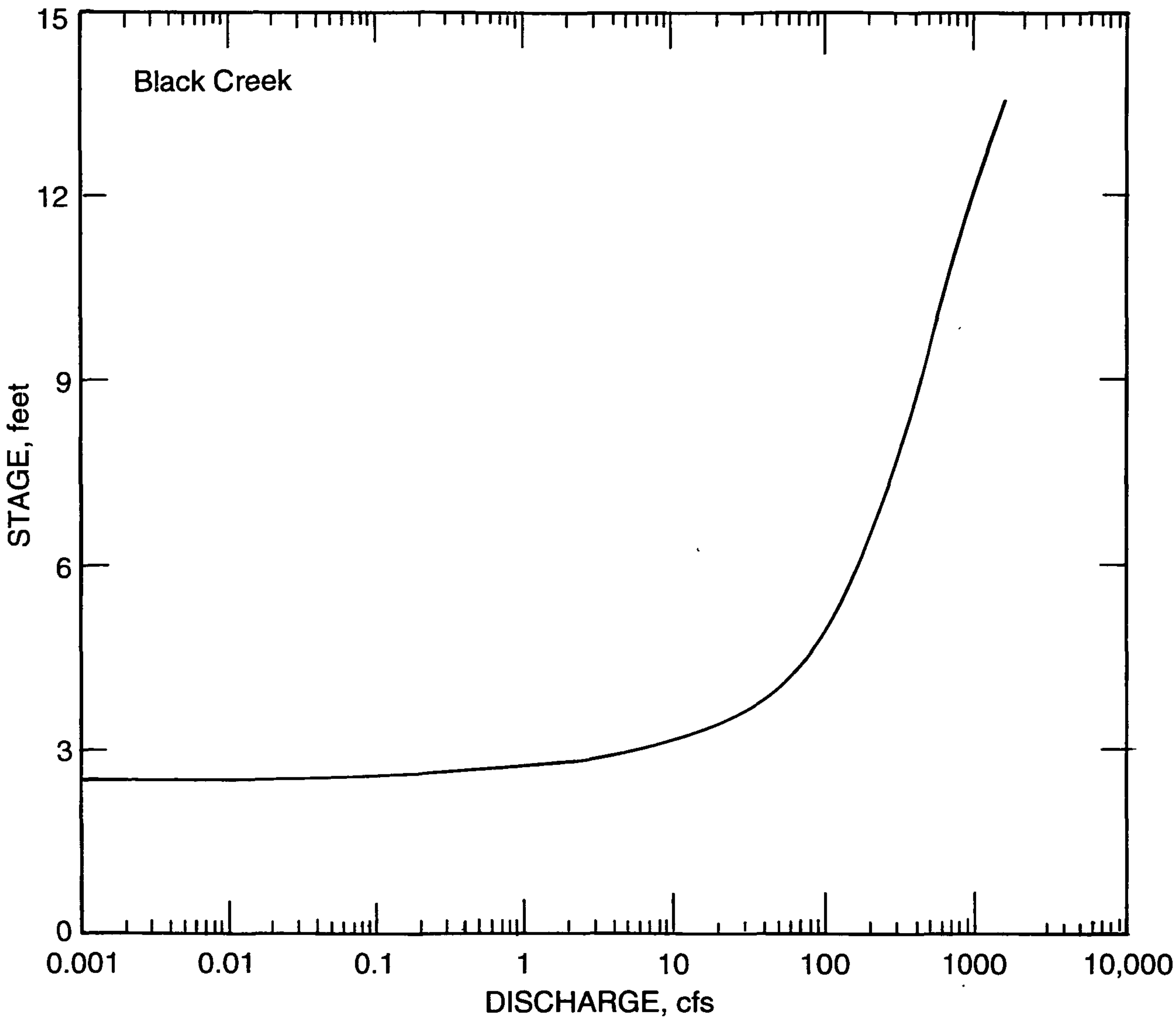

Figure 7. Stage-discharge rating curve at Black Creek, Horseshoe Lake, Alexander County, Illinois

Table 4. Monthly Streamflow Data Horseshoe Lake

Date		Black Creek *(cfsd)*	Black Creek *(inches)*	Pigeon Roost Creek *(cfsd)*	Pigeon Roost Creek *(inches)*
1984	Mar	229.44	2.33	279.88	2.99
	Apr	133.92	1.36	150.71	1.61
	May	163.46	1.66	151.64	1.62
	Jun	13.79	0.14	6.55	0.07
	Jul	14.77	0.15	9.36	0.10
	Aug	0.00	0.00	0.94	0.01
	Sep	7.88	0.08	8.42	0.09
	Oct	171.34	1.74	83.31	0.89
	Nov	329.88	3.35	246.18	2.63
	Dec	499.26	5.07	367.86	3.93
1985	Jan	40.37	0.41	15.91	0.17
	Feb	318.07	3.23	263.03	2.81
	Mar	294.43	2.99	271.46	2.90
	Apr	219.59	2.23	214.36	2.29
1990	Jul	21.90	0.22	41.70	0.45
	Aug	1.40	0.01	37.20	0.40
	Sep	0.20	0.00	37.00	0.40
	Oct	21.90	0.22	55.00	0.59
	Nov	29.80	0.30	53.30	0.57
	Dec	490.00	4.97	812.50	8.68
1991	Jan	462.90	4.69	192.20	2.10
	Feb	281.90	2.86	161.70	1.73
	Mar	237.70	2.41	133.80	1.43
	Apr	270.80	2.75	183.80	1.96
	May	123.60	1.25	116.20	1.24
	Jun	9.30	0.09	38.40	0.41
	Jul	1.90	0.02	16.80	0.18
	Aug	4.50	0.05	35.30	0.38
	Sep	9.40	0.10	32.90	0.35
	Oct	31.80	0.32	50.90	0.54
	Nov	286.60	2.91	193.90	2.07
	Dec	286.30	2.90	243.40	2.60
1992	Jan	134.40	1.36	126.80	1.36
	Feb	171.60	1.74	127.60	1.36
	Mar	114.30	1.16	152.70	1.63
	Apr	74.30	0.75	128.70	1.38
	May	1.60	0.02	50.10	0.54
	Jun	0.80	0.01	31.20	0.33
	Jul	25.00	0.25	27.80	0.30
	Aug	32.70	0.33	60.70	0.65
	Sep	21.60	0.22	39.50	0.42
	Oct	168.80	1.71	57.70	0.62

Note:
* cfsd = mean flow in cubic feet per second times the number of days in the month

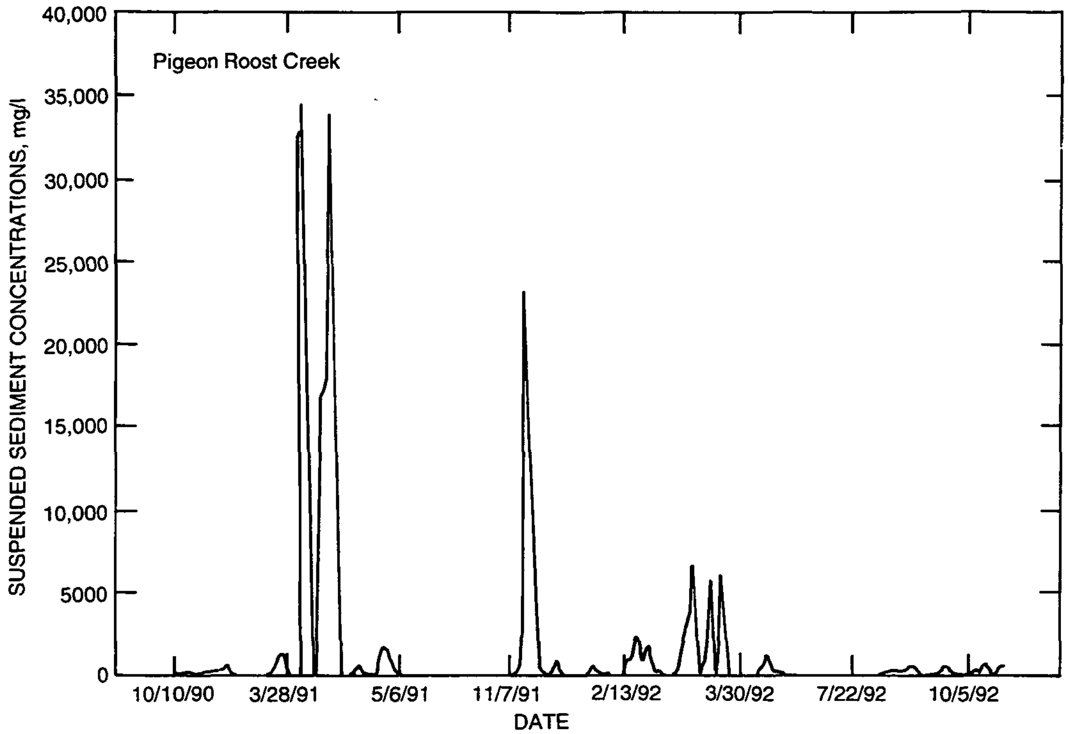

Figure 8. Total suspended sediment measurements at Pigeon Roost Creek, June 1990-October 1992

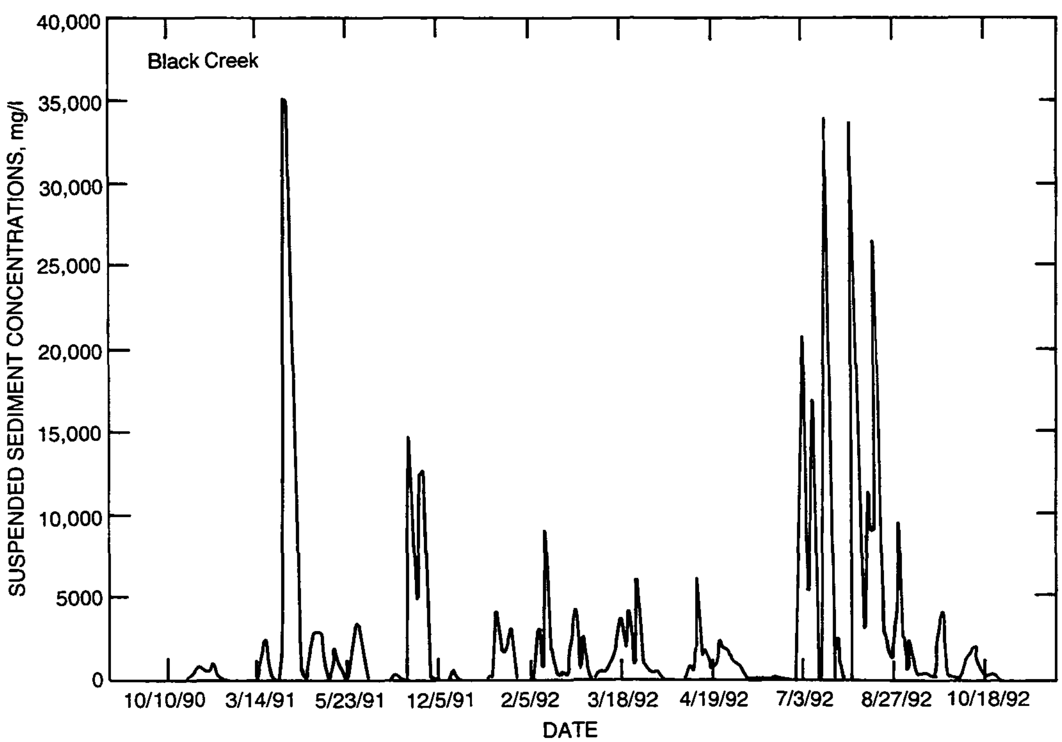

Figure 9. Total suspended sediment measurements at Black Creek, June 1990-October 1992

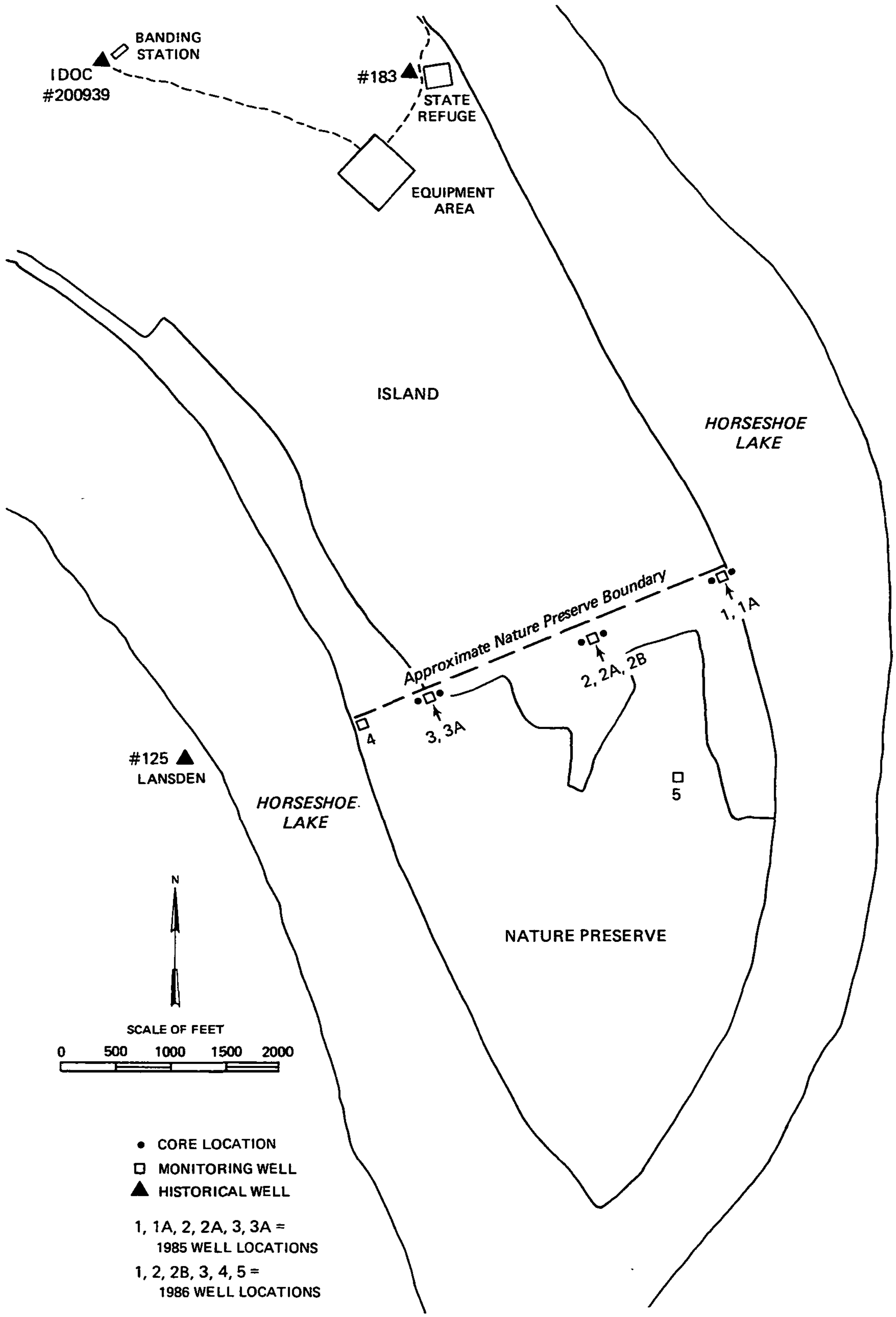

Figure 10. Positions of original and relocated monitoring wells

located on low ridges between swales in an attempt to improve accessibility during wet periods. The relatively straight-line transect allowed development of a two-dimensional water-level profile beneath the island. The observation wells were constructed from 5-foot sections of 1-1/2-inch diameter galvanized steel pipe fitted with 36-inch-long stainless steel sandpoints with 60-gauze screen.

The hydrogeology of the island is probably a remnant of point bar construction and vertical floodplain accretion that occurred during the river's meandering process. The elevation of the Horseshoe Lake island and surrounding floodplain are similar, primarily in the range of 328 to 332 feet above mean sea level. The island has a typical sequence of alluvial deposits beneath it. Soil test data conducted by the Illinois Department of Transportation indicate an upper unit of soft to stiff gray silts and clay overlying a lower sand unit in the shallow aquifer under the island as shown in figure 11.

The three observation wells shown in figure 10 were measured weekly. The 1990-1992 data of well #2 are plotted in figure 12.

The results show that the ground water table fluctuated in a similar mode to the lake level and precipitation annual cycle but with a larger magnitude. The highest ground-water table measurement reached was about the same as the lake level, which occurred in early spring. The lowest ground-water table measurement reached 5 feet below the spillway level and occurred in summer. The fluctuation patterns of the ground-water table indicated that the rise and fall are induced by infiltration mainly attributed to rainfall. Lateral inflow to or outflow from the lake water are slow and consequently a minor contribution. Clearly the lake level affecting the ground-water table's rise or fall is much smaller than that induced by direct precipitation and surface infiltration. Thus the higher lakewater level does not cause a rise in ground water beneath the Nature Preserve area at Horseshoe Lake Island.

LAKE MANAGEMENT ALTERNATIVES

Introduction

The sediment survey at Horseshoe Lake conducted by Bogner et al. (1985) showed that sedimentation had slowly reduced the water depth since the dam was constructed in 1939. A study conducted by Lee et al. (1986) compared all possible lake management alternatives and illustrated that a short-term solution for the sedimentation problem was to raise the lakewater level by constructing water-level control gates at the spillway. Due to the large surface area and shallow water depth of

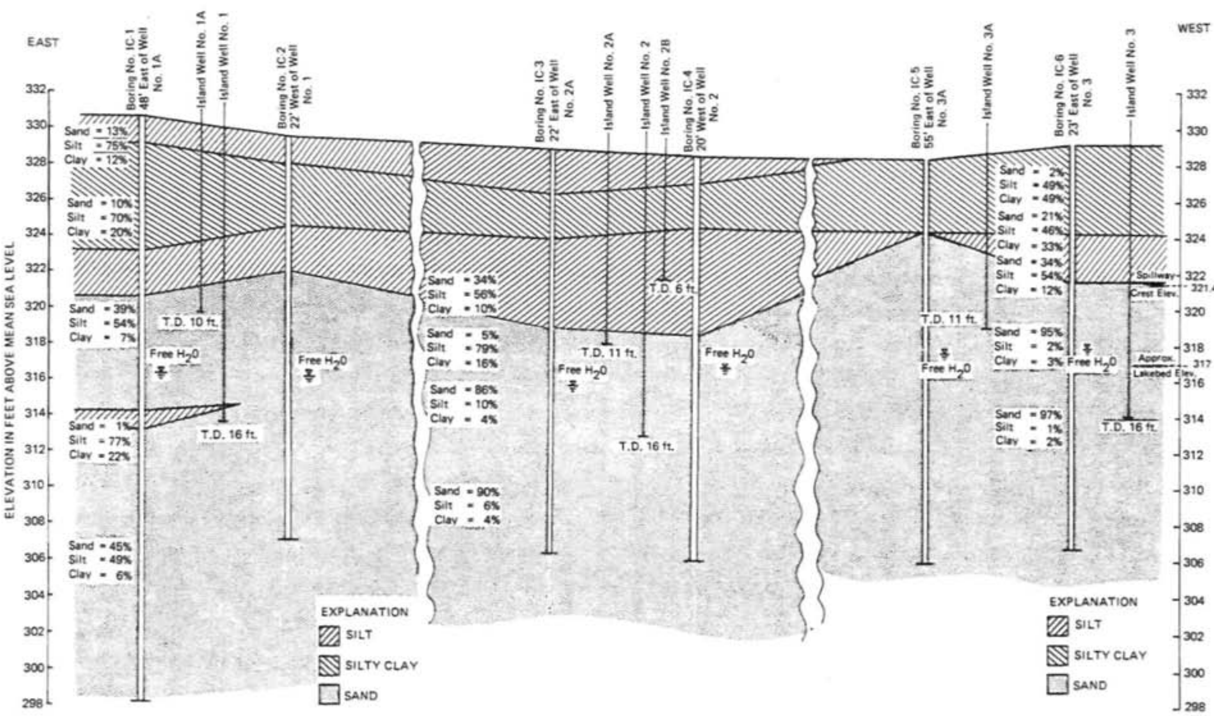

Figure 11. Stratigraphy of monitoring wells

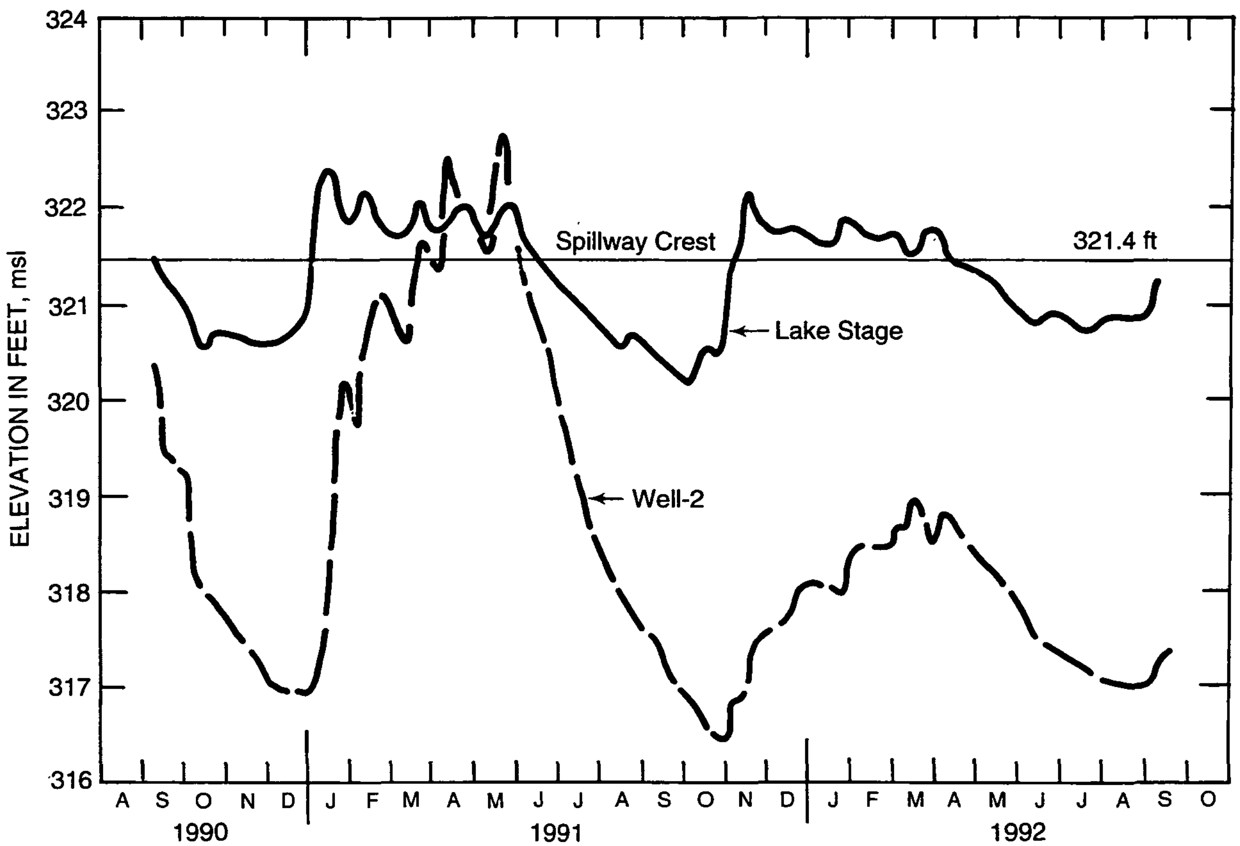

Figure 12. Ground-water table at Nature Preserve near south end of peninsula

the lake, raising the lake level a foot would increase the lake volume by about one third. Immediate concerns are the impacts of the higher water level as it relates to sport fishery. For the long-term solution to the sediment problem, an aggressive lake watershed management study was recommended and initiated. This section discusses the available sediment and hydrologic data that may be useful for predicting the possible effects of lake-level increases, watershed management, and ground-water table effects near the Natural Preserve area as they relate to sport fishery.

Incremental Lake-Level Raising (Job B3)

Based on the most recent lake sediment survey (Bogner et al., 1985), the lake volume was 5,947 acre-feet in 1984, and the annual sedimentation rate was 78 acre-feet per year or about 0.5 inches. Past research shows that the future sedimentation rate will vary with the rainfall, lake sediment trap efficiency, and soil erosion rates from contributing watersheds. For a simplified analysis, if the sedimentation rate is assumed to be the same as for 1951-1984, the projected future lake volumes and average water depth for the next 25 years are listed in table 5.

Table 5. Projected Lake Volume and Water Depth in Next 25 Years

	Present spillway level		*Raised 10-inches*	
Year	*Volume (acre-feet)*	*Depth (feet)*	*Volume (acre-feet)*	*Depth (feet)*
1984	5,947	2.9	N.A	N.A.
1993	5,239	2.6	6,912	3.44
1998	4,846	2.4	6,519	3.25
2003	4,453	2.2	6,126	3.05
2008	4,060	2.0	5,733	2.86
2013	3,667	1.8	5,340	2.66
2018	3,274	1.6	4,947	2.46

Note:
NA = not applicable

The results show that 25 years from now (in the year of 2018) about half of the lake capacity will be lost and the average water depth will be reduced from 2.6 feet to 1.6 feet. If the water level is raised 10 inches, the average water depth will increase to 3.44 feet and the lake capacity to 6,912 acre-feet. This 10-inch increase would maintain a deeper water depth than the present 2.6 feet for the next 20 years (to the year of 2013) as shown in table 5.

The spatial distribution of the sedimentation rates of 15 lake segments in Horseshoe Lake varies. The past and projected water depths for each segment are shown in table 6 and figure 13. The results show that the highest sedimentation rates at lake segments near the north end of the lake, which decreased toward the spillway. Near the north end at the outlets of Pigeon Roost and Black Creeks, the annual sedimentation rates are in the range of 0.56-0.75 inches. Near the southern end at the spillway of the lake, the annual sedimentation rates are in the range of 0.12-0.27 inches.

Table 6. Volumes, Surface Areas and Projected Water Depths of 15 Segments in Horseshoe Lake

Segment	*Volume (acre-feet)*	*Area (acres)*	*1984* (feet)*	*1983** (feet)*	*2018*** (feet)*	*Sediment rate (inch/year)*	*Sediment**** tonnages (1,000 tons)*
1	49.2	21.1	2.33	2.24	1.99	0.12	2.3
2	265.8	82.3	3.23	3.03	2.46	0.27	20.3
3	606.7	160.5	3.78	3.48	2.65	0.40	55.4
4	533.5	138.2	3.86	3.55	2.70	0.41	28.6
5	733.4	180.2	4.07	3.71	2.71	0.48	45.6
6	498.4	147.9	3.37	2.89	1.56	0.64	64.9
7	347.7	150.5	2.31	1.74	0.16	0.75	123.7
8	19.8	10.9	1.82	1.40	0.23	0.56	11.9
9	449.9	113.6	3.96	3.71	3.00	0.34	36.0
10	708.6	183.1	3.87	3.59	2.82	0.37	66.2
11	1,395.9	601.7	2.32	1.90	0.73	0.56	468.0
12	105.8	65.3	1.62	1.17	0.00	0.60	87.7
13	42.6	26.3	1.62	1.23	0.15	0.52	30.5
14	99.4	64.1	1.55	1.22	0.30	0.44	63.1
15	90.7	61.3	1.48	1.21	0.46	0.36	50.2

* Water depth based on 1984 lake sediment survey (Bogner et al., 1985

** Estimated water depths based on the segment sedimentation rates

*** Segment numbers are shown in figure 13

**** More details of lake sedimentation, see appendix D

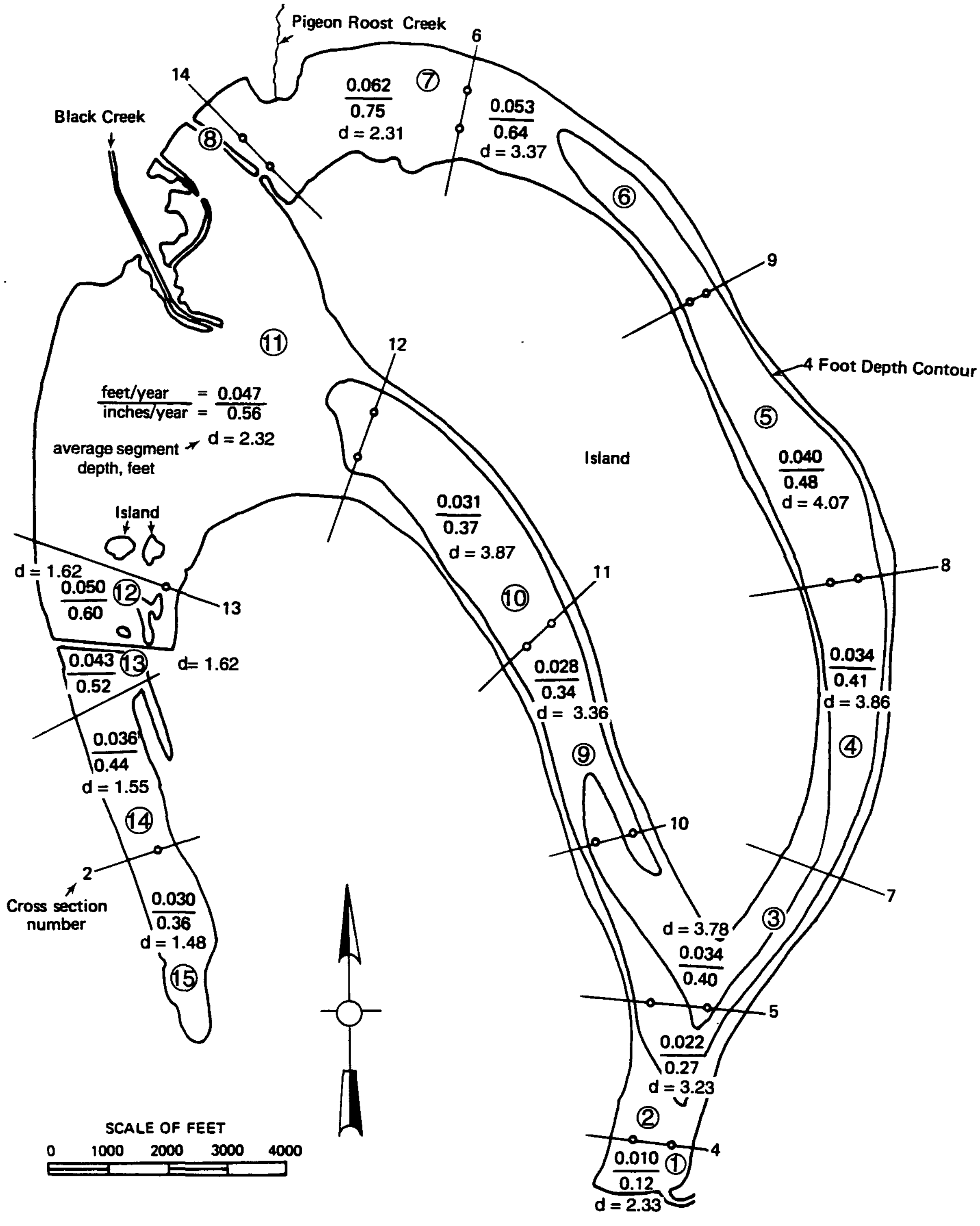

Figure 13. Horseshoe Lake sedimentation rates with 4-foot depth contour

In recent years, partial fish kills have become more common due to decreased depth from sedimentation. This is especially true in the upper (north) arms of the lake. For example (table 6, figure 13) segments 6-8, 11, and 13-15, consist of 1,062 surface acres of water containing 812,300 tons of sediment (Bogner, 1985) while segments 1-5 and 9-10 consist of 879 surface acres of water containing 203,400 tons of sediment. This means that 54.7 percent of the lake volume traps 79.1 percent of the sediment while deeper lake areas contain 45.2 percent of the water but only trap 19.9 percent of the sediment. The key to preserving future sport fishery at Horseshoe Lake is to prevent a "total fish mortality." Ensuring adequate water depths in the southern half of the lake, will significantly reduce the opportunities for total fish mortality. It is believed that partial fish mortalities will occasionally occur, especially in the north arms, regardless of any actions taken short of raising the spillway 4 feet or more. In regard to the relationship between fish kills and water depth, a report on potential for oxygen-related fishkill in Horseshoe lake (Heidinger, 1992) described that "Obviously, in regard to oxygen kills, there are potential trade-offs for raising the elevation of the spillway. Increased water depth during the winter would decrease the likelihood of fishkills in a large area of the lake. During the summer, higher water levels in some areas of the lake may actually have an increased likelihood for a fishkill, while other areas that were very shallow would tend to have a decreased probability of a summer fishkill. It is clear that siltation will continue to decrease the water depth in Horseshoe Lake to a point where a major or complete fishkill will occur. No one can predict exactly when this will take place but the outcome is inevitable."

To reduce the likelihood of total fish mortality an initial increase in spillway elevation 10, 16, or 22 inches will dramatically increase opportunities for sport fish survival in the southern half of the lake (segments 1-5 and 9-10) due to lower sedimentation rates. This will result in increased water depths over present levels for a minimum of 30, 48, 66 years, respectively. While increased water depth beyond the above recommendation has been studied, it is recommended that increased water levels occur incrementally so that any impacts to fish and other natural resources can be monitored.

The secret to preserving the integrity of the sport fishery at Horseshoe Lake is not dependent on eliminating partial fish mortality. It is to reduce the probability of total fish mortality which can only be accomplished by an increase in spillway elevation.

According to a report prepared by Watwood & Heavener, Inc. (1990), the flooding impacts due to raising five selected water levels are tabulated in table 7.

Table 7. Flooding due to Raising Lake Level

Spillway incremental raising	*Normal pool*		*100-year flood*	
	Road (feet)	*Land (acres)*	*Road (feet)*	*Land (acres)*
10-inch (322.0 msl)	400	4	6,100	651
16-inch (322.5 msl)	400	13	8,500	760
22-inch (323.0 msl)	800	27	9,100	921
28-inch (323.5 msl)	1,600	153	10,200	1,048
34-inch (324.0 msl)	3,250	310	10,800	1,171

The flooding impacts to the surrounding areas were addressed for normal pool and 100-year flooding conditions. Under normal pool conditions, when the lake was raised from 10 inches to 34 inches, the affected roads increased from 400 feet to 3,250 feet, and at the same time, the flooded land increased from 4 to 310 acres. For a 100-year flooding event, when the lake level increased from 10 inches to 34 inches, 6,100 to 10,800 feet of roads and 651 to 1,171 acres of land will be flooded.

Watershed Protection and Management

The land uses of the Horseshoe Lake watershed (Lee, 1992) are croplands (48.6 percent), forest (27.8 percent), water and wetlands (13.4 percent), pasture (7.1 percent), and urban use and highways (3.1 percent). To reduce sediment delivery to the lake, a land treatment program and sediment detention basins must be considered. The Illinois Department of Conservation and the Soil Conservation Service are working together to encourage the landowners to implement soil conservation practices to reduce the soil erosion rates. Approximately 56 landowner/operators exist in the Horseshoe Lake watershed. Thirty percent of these individuals have highly erodible land *(EEL)*. Twenty-seven percent of these individuals are actively applying conservation system practices on their land. Therefore sheet erosion in HEL lands is nearly under control. Another erosion source is from streambanks/beds. According to the 1992 SCS field measurement at Black Creek and Pigeon Roost Creek, streambank/bed erosion was about 40 percent of the total gross erosion (ibid.). Consequently, the streambank/bed conservation should also be considered.

Another approach is to build sediment detention basins in the upland watersheds. In 1992, two alternative sediment detention basins plans were considered and evaluated for use in the Pigeon Roost Creek and Black Creek watershed (ibid.). Because of limitations of the sub-watershed drainage areas, installation of sediment detention basins alone can achieve lake sediment reduction of about 16 percent per year. The construction cost will be about $570,000.

Soil conservation measures reduce the sedimentation rate and are good long-term sustaining practices for Horseshoe Lake. This effort requires the cooperation of all landowners, the Soil Conservation Service, and the Illinois Department of Conservation. The sediment detention basins alone in Pigeon Roost Creek and Black Creek have only limited ability to reduce the lake sedimentation.

A feasibility study of using sediment detention basins to control lake sedimentation was also conducted. Two alternatives schemes were investigated: 1) construction of one large sediment detention basin near the discharge point of Black Creek and Pigeon Roost Creek or 2) construction of two small sediment detention basins in upland watersheds. The results indicated the large sediment detention basin will detain about 5,455 tons of sediment per year versus 3,539 tons for the two smaller detention basins. The effectiveness and associated costs of these two approaches were also compared with those of land treatment only. A detailed report on sediment detention basin was submitted to IDOC in 1992 (Lee, 1992).

Ground-Water Table and Lake Water Level

The Illinois Nature Preserve maintains a section of land at the southern tip of the peninsula. One of the concerns is that raising the lake level will raise the ground-water table in the natural preserve area. The ground-water levels were monitored in 1987 and again in 1990-1992. The data show that in most months the ground-water table is below the lake-water level. During high rainfall months (December-May), rainfall and surface recharge raised the ground-water table. Without precipitation, however, the interactions between lake level and ground-water level are relatively limited.

SUMMARY AND CONCLUSIONS

Summary

Horseshoe Lake and its watersheds are unique cypress wetlands in Illinois. To protect and maintain these natural resources for future generations is a vital responsibility of IDOC. In recent years, a sedimentation problem in Horseshoe Lake has been identified. The history of Horseshoe Lake revealed the difficulties of managing the lake for multiple purposes such as wildlife, fishery, nature preserve, and state park. This report briefly describs the physical characteristics of the lake and its contributing watersheds. Related past studies were also reviewed. Based on the past literature and site-specific reports, the present sedimentation problems and their relationship to lake fishery are a major concern.

Two solutions for preventing total fish mortality were selected for further evaluation in this report: raising the lakewater level and (2) implementing a watershed management approach. The objectives of this project were to collect hydrologic and sediment data to support the assessment of the proposed raising of the lake-water level for fishery management and to conduct a feasibility study in which sediment detention basins were used to reduce lake sedimentation. Detailed objectives include: 1) determining the amount of sediment load from contributing watersheds, 2) determining the relationship between rainfall and lake level, 3) determining the relationship between lake level and the ground-water table under the Nature Preserve area near the lake, and 4) determining the value of sediment detention basins to reduce lake sedimentation.

Data on precipitation, streamflow, suspended sediment, lake stage, and shallow groundwater levels were collected from June 1990-October 1992. The previous databases and recent data illustrate that lake-level fluctuations were caused by an annual wet/dry cycle of rainfall-runoff processes from contributing watersheds, and backwater of the high-water stage from the Mississippi River during spring flood seasons. Based on the previous lake sediment survey and recent suspended sediment data, it is calculated that in the next 25 years about half of the lake capacity will be lost and the average depth will be reduced from 2.6 feet to 1.6 feet. The ground-water table level near the Nature Preserve area in the peninsula showed that the rise and fall of shallow ground-water tables are induced by direct rainfall and surface infiltration rather than lateral inflow to or outflow from the lake water.

The proposed incremental lake-level increase of 10-inches will increase the lake volume to 6,912 acre-feet and will maintain a deeper water than the present 2.6 feet for the next 20 years. Additionally, since the deeper segments (southern half) of the lake received less sedimentation, the 10-inch incremental lake level raising will prevent total fish kill in the next 30 years.

A feasibility study of using sediment detention basins to control lake sedimentation was also conducted. Two alternatives schemes were investigated: 1) construction of one large sediment detention basin near the discharge point of Black Creek and Pigeon Roost Creek or 2) construction of two small sediment detention basins in upland watersheds. The results indicate that the large sediment detention basin will detain about 5455 tons of sediment per year versus 3,539 tons for the two smaller detention basins. The effectiveness and associated costs of these two approaches were also compared with those of land treatment only (Lee, 1992).

Conclusions

- Based on the recent lake sediment survey, it is projected that about half of the lake capacity will be lost and the average depth will be reduced from 2.6 feet to 1.6 feet in the next 25 years.
- The key to preserving future sport fishery at Horseshoe Lake is to prevent total fish mortality. The proposed incremental lake raising by 10 inches will increase lake capacity by 32 percent. The additional water depth would maintain a deeper water than the present depth for the next 20 years.
- The sediment detention basin was found to reduce lake sedimentation by about 16 percent. The main reason is that the best sites for the sediment detention basins only control a limited portion of the lake's watershed.
- The fluctuation of the ground-water table at the Nature Preserve was induced by direct rainfall and surface infiltration rather than lateral inflow to or outflow from the lake.

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Appendix A:

Daily Precipitation Data, June 1990-October 1992

Appendix A. Daily Precipitation Data, June 1990-October 1992

Mo/yr	***Days***	***1 +***	***2 +***	***3 +***	***4 +***	***5+***	***6+***	***7+***	***8 +***	***9 +***	***70 +***	***31st***	***Inches***
5-90	1-10	md	md	md	md	md							
	11-20												
	21-30												**0**
6-90	1-10							*md	*md	*md	*md		
	11-20	*md	*md	*md	*md	*md	*md	*md	*md	*md	*md		
	21-31	*md	*md	*md	*md								**1.7**
7-90	1-10				0.75	0.45							
	11-20			0.1			0.05						
	21-31												**1.35**
8-90	1-10		md	md	md	md							
	11-20												
	21-30	0.3											**0.3**
9-90	1-10			0.4	0.3			0.85	1.2	0.1			
	11-20							0.1					
	21-31	0.2	0.1										**3.25**
10-90	1-10					0.1							
	11-20												
	21-30		1.05					0.75					**1.9**
11-90	1-10		0.2	0.1									
	11-20					0.2	0.3	1.1	0.65				
	21-31	2.7	0.7					0.3		0.5	0.9		**7.65**
12-90	1-10					0.2	1.15				0.27		
	11-20	0.4				0.37							
	21-31									0.15			**2.54**
2-91	1-10	-	-	-	-	0.93	0.34	-	-	-	-		
	11-20	-	-	0.6	0.27	-	-	0.02	0.03	-	-		
	21-28	-	-	-	-	-	-	-	-				**2.37**
3-91	1-10	0.13	-	-	-	-	-	-	-	-	-		
	11-20	-	-	-	-	-	-	0.04	-	-	-		
	21-31	0.5	2.14	-	-	-	-	-	-	-	-	-	**2.81**
4-91	1-10	-	-	-	0.04	-	-	-	0.04	-	-		
	11-20	-	-	1.97	0.22	-	-	-	-	-	-		
	21-30	-	-	-	-	-	-	-	0.1	1.15	-		**3.52**

Appendix A: (continued)

Mo/yr	***Days***	***7 +***	***2 +***	***3 +***	***4 +***	***5+***	***6+***	***7 +***	***8 +***	***9 +***	***10 +***	***31st***	***Inches***
5-91	1-10	-	-	0.03	-	-	-	-	-	-	-		
	11-20	-	-	-	-	0.17	0.27	-	-	-	0.41		
	21-31	-	-	-	0.55	0.69	-	-	-	-	-	-	**2.12**
6-91	1-10	0.07	-	-	-	-	-	-	-	-	-		
	11-20	0.77	0.45	-	-	-	-	-	-	-	-		
	21-30	-	-	-	-	-	-	-	-	-	-		**1.29**
7-91	1-10	-	-	-	-	-	-	-	-	0.17	-		
	11-20	-	-	-	-	-	-	-	-	-	-		
	21-31	-	-	-	0.34	0.05	-	-	-	-	-	-	**0.56**
8-91	1-10	-	-	-	-	-	0.05	-	0.04	-	-		
	11-20	-	-	-	-	-	-	-	-	-	-		
	21-30	-	-	-	-	-	-	-	0.2	0.65	-	-	**0.94**
9-91	1-10	-	-	0.41	0.98	-	-	-	-	-	-		
	11-20	-	-	-	-	-	-	-	-	-	-		
	21-30	-	0.05	-	-	-	-	-	-	-	-		**1.44**
10-91	1-10	-	-	-	-	0.13	-	-	-	-	-		
	11-20	-	-	-	0.04	-	-	-	-	-	-		
	21-31	-	-	-	-	0.11	0.3	0.5	0.67	0.32	0.9	-	**2.97**
11-91	1-10	0.45	-	-	-	-	-	-	-	-	-		
	11-20	-	-	-	-	-	-	-	0.2	2.95	0.25		
	21-30	-	-	-	-	-	-	-	-	-	-		**3.85**
12-91	1-10	0.91	1.8	-	-	-	-	-	-	*md	-		
	11-20	-	0.05	-	-	-	-	-	-	-	0.25		
	21-31	0.25	0.15	0.19	-	-	-	-	0.15	-	-	-	**3.75**
1-92	1-10	0.1	0.38	-	-	-	-	-	0.8	-	-		
	11-20	-	0.15	0.53	-	-	-	-	-	-	-		
	21-31	-	0.11	-			-	-	-	-	-	-	**1.97**
2-92	1-10	-	-	-	-	-	-	-	-	-	-		
	11-20	0.05	0.48	0.31	1.12	-	-	0.25	-	-	-		
	21-29	-	-	0.95	-	-	-	-	-	-			**3.16**
3-92	1-10	-	-	-	-	-	-	-	-	0.35	0.21		
	11-18	-	-	-	-	-	-	-	1.39	0.05	-		
	21-31	-	-	-	0.08	0.18	-	-	-	0.15	0.2	-	**2.61**

Appendix A: (concluded)

Mo/yr	***Days***	**7 +**	**2 +**	***3 +***	**4 +**	***5 +***	***6+***	**7 +**	***8 +***	***9 +***	**70 +**	***31st***	***Inches***
4-92	1-10	-	-	-	-	-	-	-	-	0.04	-		
	11-20	-	-	-	-	-	0.43	0.11	1.3	0.48	0.23		
	21-30	-	-	-	-	-	-	-	-	-	-		**2.59**
4-92	1-8	-	0.13	-	-	0.06	-	-	-	-	-		
	11-18	-	-	-	-	-	-	0.13	0.12	0.25	-		
	21-31	-	-	0.31	-	-	-	-	-	0.19	-	-	**1.19**
5-92	1-8	-	-	0.88	-	-	0.35	-	-	-	-		
	11-18	-	-	-	-	-	-	-	-	-	-		
	21-30	-	-	-	0.15	0.13	-	-	-	-	0.48		**1.99**
6-92	1-8	-	-	0.75	0.58	-	-	-	-	-	-		
	11-18	-	-	-	0.71	-	1.08	-	0.68	-	-		
	21-31	0.05	-	0.13	-	-	0.65	0.1	-	-	-	-	**4.73**
7-92	1-8	-	-	-	-	-	-	-	-	-	2.31		
	11-18	-	-	-	-	-	-	-	-	-	-		
	21-31	-	0.07	0.73	-	-	-	2.4	-	-	-	-	**5.51**
8-92	1-8	-	0.36	-	-	-	0.85	-	0.15	-	0.41		
	11-18	-	-	-	-	-	-	-	-	-	1.25		
	21-30	0.19	-	-	-	-	0.95	-	-	-	-		**4.16**
9-92	1-8	-	-	-	-	-	-	-	-	-	-		
	11-14	-	-	-	-	1.70	2.00						**3.70**

Appendix B:

Daily Stage and Streamflow Data, June 1990-October 1992: Black Creek Gaging Station, Alexander County, Illinois

Appendix B. Black Creek Stage and Discharge Data

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Stage At Gaging Station HL2 -- Black Creek
Feet Above Mean Sea Level -- WY90

								1990			
DAY	***OCT***	***NOV***	***DEC***	***JAN***	***FES***	***MAR***	***APR***	***MAY***	***JUN***	***JUL***	***AUG***	***SEP***
1	-	-	-	-	-	-	-	-	-	**2.56**	**2.52**	**2.51**
2	-	-	-	-	-	-	-	-	-	**2.56**	**2.53**	**2.51**
3	-	-	-	-	-	-	-	-	-	**2.58**	**2.51**	**2.51**
4	-	-	-	-	-	-	-	-	-	**2.58**	**2.55**	**2.51**
5	-	-	-	-	-	-	-	-	-	**2.58**	**2.61**	**2.51**
6	-	-	-	-	-	-	-	-	-	**2.57**	**2.55**	**2.51**
7	-	-	-	-	-	-	-	-	-	**2.58**	**2.52**	**2.50**
8	-	-	-	-	-	-	-	-	-	**2.57**	**2.51**	**2.50**
9	-	-	-	-	-	-	-	-	-	**2.57**	**2.50**	**2.50**
10	-	-	-	-	-	-	-	-	-	**2.56**	**2.52**	**2.50**
11	-	-	-	-	-	-	-	-	-	**2.59**	**2.53**	**2.50**
12	-	-	-	-	-	-	-	-	-	**2.61**	**2.55**	**2.50**
13	-	-	-	-	-	-	-	-	-	**2.58**	**2.62**	**2.50**
14	-	-	-	-	-	-	-	-	-	**2.57**	**2.65**	**2.50**
15	-	-	-	-	-	-	-	-	**2.66**	**2.58**	**2.57**	**2.50**
16	-	-	-	-	-	-	-	-	**2.64**	**2.56**	**2.53**	**2.50**
17	-	-	-	-	-	-	-	-	**2.62**	**2.54**	**2.55**	**2.50**
18	-	-	-	-	-	-	-	-	**2.61**	**2.55**	**2.54**	**2.50**
19	-	-	-	-	-	-	-	-	**2.60**	**2.54**	**2.54**	**2.51**
20	-	-	-	-	-	-	-	-	**2.61**	**2.51**	**2.54**	**2.51**
21	-	-	-	-	-	-	-	-	**2.63**	**2.59**	**2.53**	**2.53**
22	-	-	-	-	-	-	-	-	**2.62**	**3.25**	**2.53**	**2.54**
23	-	-	-	-	-	-	-	-	**2.61**	**2.61**	**2.53**	**2.51**
24	-	-	-	-	-	-	-	-	**2.60**	**2.56**	**2.52**	**2.50**
25	-	-	-	-	-	-	-	-	**2.59**	**2.54**	**2.51**	**2.50**
26	-	-	-	-	-	-	-	-	**2.58**	**2.53**	**2.52**	**2.50**
27	-	-	-	-	-	-	-	-	**2.58**	**2.53**	**2.52**	**2.50**
28	-	-	-	-	-	-	-	-	**2.57**	**2.53**	**2.52**	**2.50**
29	-	-	-	-		-	-	-	**2.57**	**2.53**	**2.51**	**2.50**
30	-	-	-	-		-	-	-	**2.56**	**2.52**	**2.50**	**2.50**
31	-		-	-		-		-		**2.52**	**2.50**	

Appendix B. (continued)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Stage At Gaging Station HL2 -- Black Creek
Feet Above Mean Sea Level -- WY91

			1990	*1991*								
DAY	*OCT*	*NOV*	*DEC*	*JAN*	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*
1	2.50	2.56	2.61	3.25	3.12	3.10	2.72	2.89	2.67	2.58	2.53	2.46
2	2.50	2.56	2.60	3.17	3.11	3.00	2.71	2.81	2.65	2.58	2.53	2.51
3	2.54	2.56	2.70	3.11	3.12	2.84	2.70	2.77	2.63	2.58	2.52	2.62
4	3.00	2.57	2.67	3.10	3.12	2.81	2.88	2.80	2.75	2.55	2.52	2.88
5	2.55	2.67	2.64	3.24	3.47	2.80	2.82	2.83	2.70	2.55	2.52	2.58
6	2.50	2.63	2.64	4.98	4.01	2.80	2.79	2.73	2.63	2.54	2.53	2.48
7	2.71	2.60	2.64	3.45	3.13	2.75	2.80	2.71	2.59	2.54	2.56	2.46
8	2.63	2.59	2.63	3.21	2.95	2.73	2.86	2.70	2.58	2.54	2.52	2.62
9	2.90	2.59	2.61	3.13	2.88	2.74	2.83	2.71	2.58	2.58	2.58	2.58
10	2.81	2.63	2.61	3.78	2.85	2.74	2.77	2.70	2.58	2.63	2.54	2.48
11	2.62	2.64	2.61	3.80	2.80	2.75	2.79	2.78	2.68	2.58	2.54	2.48
12	2.59	2.63	2.61	3.19	2.80	2.79	2.90	2.83	2.73	2.57	2.53	2.47
13	2.57	2.62	2.60	3.15	4.40	2.80	4.65	2.85	2.69	2.56	2.53	2.47
14	2.56	2.61	2.60	3.15	3.37	2.77	3.81	2.77	2.65	2.55	2.53	2.47
15	2.54	2.61	2.83	3.28	2.96	2.74	3.20	2.89	2.62	2.55	2.54	2.46
16	2.55	2.60	2.71	3.17	2.92	2.73	2.95	3.31	2.56	2.55	2.54	2.46
17	2.54	2.60	3.02	3.13	3.02	2.91	2.88	2.92	2.56	2.54	2.55	2.47
18	2.66	2.60	3.98	3.13	3.20	2.85	2.85	2.81	2.57	2.54	2.55	2.47
19	2.59	2.61	2.97	3.12	3.16	2.78	2.83	2.77	2.58	2.54	2.56	2.46
20	2.57	2.62	2.80	3.14	2.96	2.79	2.81	2.74	2.59	2.53	2.55	2.46
21	2.56	2.62	6.19	3.14	2.89	2.79	2.79	2.73	2.59	2.53	2.55	2.46
22	2.57	3.10	3.62	3.15	2.86	5.34	2.78	2.71	2.58	2.54	2.56	2.46
23	2.59	2.68	3.00	3.14	2.83	3.31	2.78	2.70	2.58	2.53	2.56	2.45
24	2.59	2.62	2.91	3.12	2.81	3.05	2.77	3.76	2.58	2.52	2.55	2.45
25	2.59	2.61	2.88	3.12	2.81	2.95	2.78	3.23	2.58	2.56	2.54	2.45
26	2.58	2.60	2.88	3.13	2.78	2.88	2.77	2.97	2.58	2.53	2.52	2.45
27	2.57	2.69	2.89	3.13	2.78	2.83	2.81	2.83	2.58	2.54	2.48	2.44
28	2.56	3.11	2.93	3.13	2.77	2.80	3.07	2.75	2.57	2.54	2.48	2.45
29	2.56	2.69	4.59	3.13		2.78	4.02	2.73	2.57	2.54	2.76	2.46
30	2.56	2.63	4.53	3.13		2.73	2.98	2.71	2.58	2.53	2.52	2.46
31	2.56		3.38	3.12		2.72		2.68		2.53	2.48	

Appendix B. (continued)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Stage At Gaging Station HL2 -- Black Creek
Feet Above Mean Sea Level -- WY92

DAY	1991 OCT	NOV	DEC	1992 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.46	2.98	3.90	2.77	2.74	2.81	2.77	2.65	2.48	2.45	2.42	2.49
2	2.46	2.65	5.61	3.10	2.73	2.77	2.74	2.61	2.51	2.42	2.42	2.58
3	2.46	2.57	3.19	2.99	2.75	2.76	2.73	2.53	2.65	2.89	2.42	2.47
4	2.46	2.54	2.93	2.86	2.74	2.75	2.72	2.60	2.55	2.55	2.41	2.46
5	2.49	2.56	2.93	2.83	2.74	2.74	2.68	2.58	2.51	2.59	2.40	2.44
6	2.47	2.57	2.91	2.83	2.75	2.74	2.70	2.56	2.52	2.54	2.38	2.55
7	2.47	2.57	2.88	2.82	2.75	2.73	2.81	2.54	2.55	2.51	2.37	2.62
8	2.47	2.57	2.82	3.61	2.74	2.74	2.81	2.51	2.50	2.47	2.38	2.54
9	2.46	2.54	2.82	3.08	2.71	2.79	2.68	2.49	2.50	2.46	2.39	2.48
10	2.46	2.54	2.78	2.91	2.72	3.06	2.67	2.58	2.51	2.45	2.52	2.71
11	2.45	2.54	2.75	2.85	2.73	2.83	2.66	2.55	2.51	2.42	2.49	2.50
12	2.45	2.54	3.00	2.89	2.87	2.81	2.65	2.52	2.50	2.39	2.48	2.47
13	2.45	2.54	3.09	3.18	3.08	2.78	2.65	2.52	2.49	2.38	2.46	2.44
14	2.45	2.54	2.88	3.28	4.01	2.77	2.66	2.52	2.47	2.46	2.44	2.43
15	2.45	2.55	2.81	2.91	3.28	2.76	2.68	2.52	2.47	2.50	2.41	2.42
16	2.44	2.55	2.79	2.84	2.96	2.76	2.68	2.51	2.47	2.66	2.39	2.41
17	2.45	2.55	2.79	2.82	2.99	2.77	2.82	2.53	2.48	2.59	2.38	2.39
18	2.45	2.55	2.76	2.79	3.04	3.77	2.75	2.54	2.46	2.71	2.35	2.41
19	2.45	5.63	2.73	2.77	2.87	3.05	3.47	2.56	2.45	2.62	2.30	2.43
20	2.45	3.87	2.75	2.78	2.81	2.87	3.50	2.55	2.44	2.55	2.21	3.00
21	2.46	3.05	3.05	2.79	2.79	2.87	2.98	2.53	2.43	2.60	2.15	2.64
22	2.46	2.98	2.90	2.83	2.78	2.91	2.82	2.51	2.43	2.47	2.17	2.58
23	2.46	2.93	3.07	2.85	3.51	2.89	2.72	2.51	2.44	2.45	2.62	2.54
24	2.44	2.88	2.90	2.77	3.11	2.83	2.66	2.51	2.46	2.45	2.55	2.48
25	2.45	2.84	2.82	2.77	2.97	2.86	2.63	2.46	2.47	2.45	2.45	2.48
26	2.46	2.80	2.80	2.74	2.90	2.83	2.60	2.43	2.45	2.54	2.43	2.68
27	2.62	2.75	2.79	2.76	2.87	2.82	2.57	2.47	2.44	2.71	3.23	2.73
28	2.99	2.73	2.81	2.76	2.85	2.81	2.65	2.50	2.43	2.47	2.52	2.51
29	2.76	2.74	2.83	2.76	2.82	2.83	2.63	2.52	2.42	2.46	2.49	2.49
30	3.43	3.63	2.79	2.76		2.98	2.62	2.51	2.45	2.45	2.48	2.46
31	2.72		2.77	2.76		2.82		2.49		2.44	2.50	

Appendix B. (continued)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Stage At Gaging Station HL2 -- Black Creek
Feet Above Mean Sea Level -- WY93

DAY	OCT	NOV	1992 DEC	JAN	FEB	MAR	APR	1993 MAY	JUN	JUL	AUG	SEP
1	2.44	-	-	-	-	-	-	-	-	-	-	-
2	2.44	-	-	-	-	-	-	-	-	-	-	-
3	2.44	-	-	-	-	-	-	-	-	-	-	-
4	2.44	-	-	-	-	-	-	-	-	-	-	-
5	2.44	-	-	-	-	-	-	-	-	-	-	-
6	2.44	-	-	-	-	-	-	-	-	-	-	-
7	2.43	-	-	-	-	-	-	-	-	-	-	-
8	2.42	-	-	-	-	-	-	-	-	-	-	-
9	2.40	-	-	-	-	-	-	-	-	-	-	-
10	2.37	-	-	-	-	-	-	-	-	-	-	-
11	2.35	-	-	-	-	-	-	-	-	-	-	-
12	2.32	-	-	-	-	-	-	-	-	-	-	-
13	2.25	-	-	-	-	-	-	-	-	-	-	-
14	2.21	-	-	-	-	-	-	-	-	-	-	-
15	3.51	-	-	-	-	-	-	-	-	-	-	-
16	5.27	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-		-	-	-	-	-	-	-
30	-	-	-	-		-	-	-	-	-	-	-
31	-		-	-		-		-		-	-	

Appendix B. (continued)

Horseshoe Lake Project - Illinois State Water Survey
Average Daily Discharge At Gaging Station HL2 - Black Creek
Cubic Feet Per Second -- WY90

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	1990 JUN	JUL	AUG	1990 SEP
1	-	-	-	-	-	-	-	-	-	0.10	0.00	0.00
2	-	-	-	-	-	-	-	-	-	0.10	0.00	0.00
3	-	-	-	-	-	-	-	-	-	0.10	0.00	0.00
4	-	-	-	-	-	-	-	-	-	0.10	0.10	0.00
5	-	-	-	-	-	-	-	-	-	0.10	0.20	0.00
6	-	-	-	-	-	-	-	-	-	0.10	0.10	0.00
7	-	-	-	-	-	-	-	-	-	0.10	0.00	0.00
8	-	-	-	-	-	-	-	-	-	0.10	0.00	0.00
9	-	-	-	-	-	-	-	-	-	0.10	0.00	0.00
10	-	-	-	-	-	-	-	-	-	0.10	0.00	0.00
11	-	-	-	-	-	-	-	-	-	0.20	0.00	0.00
12	-	-	-	-	-	-	-	-	-	0.20	0.10	0.00
13	-	-	-	-	-	-	-	-	-	0.10	0.20	0.00
14	-	-	-	-	-	-	-	-	-	0.10	0.30	0.00
15	-	-	-	-	-	-	-	-	0.40	0.10	0.10	0.00
16	-	-	-	-	-	-	-	-	0.30	0.10	0.00	0.00
17	-	-	-	-	-	-	-	-	0.20	0.00	0.10	0.00
18	-	-	-	-	-	-	-	-	0.20	0.10	0.10	0.00
19	-	-	-	-	-	-	-	-	0.20	0.10	0.00	0.00
20	-	-	-	-	-	-	-	-	0.20	0.00	0.10	0.00
21	-	-	-	-	-	-	-	-	0.20	0.80	0.00	0.10
22	-	-	-	-	-	-	-	-	0.20	18.80	0.00	0.10
23	-	-	-	-	-	-	-	-	0.20	0.20	0.00	0.00
24	-	-	-	-	-	-	-	-	0.20	0.10	0.00	0.00
25	-	-	-	-	-	-	-	-	0.20	0.00	0.00	0.00
26	-	-	-	-	-	-	-	-	0.10	0.00	0.00	0.00
27	-	-	-	-	-	-	-	-	0.10	0.00	0.00	0.00
28	-	-	-	-	-	-	-	-	0.10	0.00	0.00	0.00
29	-	-	-	-		-	-	-	0.10	0.00	0.00	0.00
30	-	-	-	-		-	-	-	0.10	0.00	0.00	0.00
31	-		-	-		-		-		0.00	0.00	
TOTAL:												
(cfs-day)									*3.00*	*21.90*	*1.40*	*0.20*
(inches)									*0.03*	*0.22*	*0.01*	*0.00*

Appendix B. (continued)

Horseshoe Lake Project ~ Illinois State Water Survey
Average Daily Discharge at Gaging Station HL2-- Black Creek
Cubic Feet Per Second -- WY91

	1990		1990	1991								
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	0.10	0.20	12.40	8.90	10.10	0.70	3.60	0.40	0.10	0.00	0.00
2	0.00	0.10	0.20	10.50	8.80	6.20	0.60	2.10	0.30	0.10	0.00	0.40
3	0.50	0.10	0.60	8.60	9.00	2.80	0.60	1.30	0.20	0.10	0.00	0.30
4	8.80	0.10	0.40	8.30	8.90	1.90	3.60	1.90	2.40	0.10	0.00	6.70
5	0.10	0.50	0.30	13.00	24.40	1.80	2.10	2.60	0.60	0.10	0.00	0.20
6	0.00	0.30	0.30	98.70	48.40	1.80	1.60	0.80	0.20	0.10	0.00	0.00
7	2.00	0.20	0.30	19.90	9.20	1.00	1.70	0.60	0.20	0.00	0.10	0.00
8	0.30	0.20	0.20	11.40	4.90	0.80	3.00	0.50	0.10	0.00	0.00	1.60
9	4.90	0.20	0.20	9.40	3.50	0.90	2.40	0.60	0.10	0.20	0.20	0.20
10	2.40	0.20	0.20	37.60	2.90	0.80	1.30	0.60	0.10	0.30	0.10	0.00
11	0.20	0.30	0.20	36.80	1.80	1.00	1.80	1.70	0.70	0.10	0.00	0.00
12	0.20	0.20	0.20	11.00	1.80	1.70	3.80	2.90	1.30	0.10	0.00	0.00
13	0.10	0.20	0.20	10.00	71.70	1.80	104.30	2.70	0.50	0.10	0.00	0.00
14	0.10	0.20	0.20	9.90	18.10	1.20	37.60	1.30	0.30	0.10	0.00	0.00
15	0.10	0.20	2.60	14.30	5.20	0.90	11.30	7.80	0.20	0.10	0.00	0.00
16	0.10	0.20	0.70	10.50	4.40	0.80	4.90	16.20	0.10	0.10	0.10	0.00
17	0.00	0.20	6.50	9.30	6.50	4.30	3.50	4.40	0.10	0.10	0.10	0.00
18	0.40	0.20	45.10	9.20	11.20	2.80	3.00	2.10	0.10	0.00	0.10	0.00
19	0.20	0.20	5.40	9.20	10.20	1.30	2.40	1.30	0.10	0.00	0.10	0.00
20	0.10	0.20	1.80	9.70	5.00	1.50	1.90	0.90	0.20	0.00	0.10	0.00
21	0.10	0.20	197.10	9.80	3.70	1.60	1.60	0.80	0.20	0.00	0.10	0.00
22	0.10	10.80	29.20	10.00	3.20	152.60	1.40	0.60	0.10	0.00	0.10	0.00
23	0.20	0.50	6.10	9.80	2.30	15.40	1.40	0.60	0.10	0.00	0.10	0.00
24	0.20	0.20	4.00	9.10	2.00	7.00	1.30	42.90	0.10	0.00	0.10	0.00
25	0.20	0.20	3.60	8.90	1.90	5.00	1.40	12.10	0.10	0.10	0.10	0.00
26	0.10	0.20	3.50	9.20	1.40	3.60	1.20	5.40	0.10	0.00	0.00	0.00
27	0.10	1.90	3.60	9.40	1.40	2.50	2.00	2.50	0.10	0.00	0.00	0.00
28	0.10	11.00	4.50	9.40	1.20	1.70	9.30	1.00	0.10	0.00	0.00	0.00
29	0.10	0.50	80.60	9.30		1.40	53.50	0.80	0.10	0.00	3.10	0.00
30	0.10	0.20	75.30	9.20		0.80	5.60	0.60	0.10	0.00	0.00	0.00
31	0.10		16.70	9.10		0.70		0.40		0.00	0.00	
TOTAL:												
(cfs-day)	21.90	29.80	490.00	462.90	281.90	237.70	270.80	123.60	9.30	1.90	4.50	9.40
(inches)	0.22	0.30	4.97	4.69	2.86	2.41	2.75	1.25	0.09	0.02	0.05	0.10

Appendix B. (continued)

Horseshoe Lake Project - Illinois State Water Survey
Average Daily Discharge At Gaging Station HL2 -- Black Creek
Cubic Feet Per Second -- WY92

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	7.10	42.00	1.20	0.90	1.80	1.20	0.40	0.00	0.00	0.00	0.00
2	0.00	0.30	147.50	8.70	0.80	1.20	0.90	0.30	0.00	0.00	0.00	0.30
3	0.00	0.10	11.60	5.80	0.90	1.10	0.80	0.00	0.60	9.60	0.00	0.00
4	0.00	0.00	4.60	3.20	0.90	1.00	0.70	0.20	0.10	0.10	0.00	0.00
5	0.00	0.10	4.40	2.50	0.90	0.90	0.50	0.10	0.00	0.20	0.00	0.00
6	0.00	0.10	4.10	2.50	1.00	0.90	0.50	0.10	0.00	0.00	0.00	1.40
7	0.00	0.10	3.50	2.10	1.00	0.80	2.40	0.00	0.10	0.00	0.00	0.70
8	0.00	0.10	2.20	31.70	0.90	0.90	2.30	0.00	0.00	0.00	0.00	0.10
9	0.00	0.00	2.20	7.90	0.60	1.70	0.50	0.00	0.00	0.00	0.00	0.00
10	0.00	0.10	1.30	4.20	0.70	8.40	0.40	0.10	0.00	0.00	0.80	2.20
11	0.00	0.00	1.00	3.00	0.80	2.50	0.40	0.10	0.00	0.00	0.00	0.00
12	0.00	0.00	6.30	3.80	3.30	1.90	0.30	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	8.40	13.70	8.30	1.40	0.30	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	3.50	15.00	55.70	1.30	0.40	0.00	0.00	0.00	0.00	0.00
15	0.00	0.10	2.00	4.10	14.50	1.10	0.40	0.00	0.00	0.00	0.00	0.00
16	0.00	0.10	1.60	2.60	5.20	1.10	0.50	0.00	0.00	3.90	0.00	0.00
17	0.00	0.10	1.60	2.20	6.10	1.20	2.20	0.00	0.00	0.70	0.00	0.00
18	0.00	0.10	1.10	1.60	7.00	41.10	1.00	0.10	0.00	7.60	0.00	0.00
19	0.00	173.40	0.80	1.20	3.30	7.50	24.30	0.10	0.00	0.50	0.00	0.00
20	0.00	44.10	1.00	1.40	1.90	3.30	23.90	0.10	0.00	0.10	0.00	14.10
21	0.00	7.00	7.40	1.60	1.50	3.40	5.70	0.00	0.00	0.20	0.00	0.40
22	0.00	5.60	3.80	2.40	1.40	4.10	2.20	0.00	0.00	0.00	0.00	0.10
23	0.00	4.50	7.80	2.90	27.80	3.70	0.70	0.00	0.00	0.00	9.30	0.00
24	0.00	3.40	3.90	1.30	8.70	2.30	0.40	0.00	0.00	0.00	0.10	0.00
25	0.00	2.60	2.10	1.30	5.30	3.10	0.30	0.00	0.00	0.00	0.00	0.00
26	0.00	1.70	1.80	0.90	3.80	2.30	0.20	0.00	0.00	0.70	0.00	0.80
27	0.70	1.10	1.60	1.10	3.30	2.10	0.10	0.00	0.00	1.40	22.50	1.50
28	6.90	0.80	1.90	1.10	2.90	2.00	0.30	0.00	0.00	0.00	0.00	0.00
29	1.60	0.90	2.50	1.10	2.20	2.30	0.30	0.00	0.00	0.00	0.00	0.00
30	21.70	33.10	1.50	1.20		5.70	0.20	0.00	0.00	0.00	0.00	0.00
31	0.90		1.30	1.10		2.20		0.00		0.00	0.00	
TOTAL:												
(cfs-day)	*31.80*	*286.60*	*286.30*	*134.40*	*171.60*	*114.30*	*74.30*	*1.60*	*0.80*	*25.00*	*32.70*	*21.60*
(inches)	*0.32*	*2.91*	*2.90*	*1.36*	*1.74*	*1.16*	*0.75*	*0.02*	*0.01*	*0.25*	*0.33*	*0.22*

Appendix B. (concluded)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Discharge At Gaging Station HL2 - Black Creek
Cubic Feet Per Second - WY93

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	-	-	-	-	-	-	-	-	-	-	-
2	0.00	-	-	-	-	-	-	-	-	-	-	-
3	0.00	-	-	-	-	-	-	-	-	-	-	-
4	0.00	-	-	-	-	-	-	-	-	-	-	-
5	0.00	-	-	-	-	-	-	-	-	-	-	-
6	0.00	-	-	-	-	-	-	-	-	-	-	-
7	0.00	-	-	-	-	-	-	-	-	-	-	-
8	0.00	-	-	-	-	-	-	-	-	-	-	-
9	0.00	-	-	-	-	-	-	-	-	-	-	-
10	0.00	-	-	-	-	-	-	-	-	-	-	-
11	0.00	-	-	-	-	-	-	-	-	-	-	-
12	0.00	-	-	-	-	-	-	-	-	-	-	-
13	0.00	-	-	-	-	-	-	-	-	-	-	-
14	0.00	-	-		-	-	-	-	-	-	-	-
15	49.50	-	-	-	-	-	-	-	-	-	-	-
16	119.30	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-		-	-	-	-	-	-	-
30	-	-	-	-		-	-	-	-	-	-	-
31	-		-	-		-		-		-	-	
TOTAL:												
(cfs-day)	*168.60*											
(inches)	*1.71*											

Appendix C:

Daily Stage and Streamflow Data, June 1990-October 1992: Pigeon Roost Creek Gaging Station, Alexander County, Illinois

Appendix C. Pigeon Roost Creek Stage and Discharge Data

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Stage at Gaging Station HL3 -- Pigeon Roost Creek
Feet Above Mean Sea Level -- WY90

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	-	-	-	-	-	-	-	-	-	3.70	3.70	3.72
2	-	-	-	-	-	-	-	-	-	3.70	3.70	3.72
3	-	-	-	-	-	-	-	-	-	3.70	3.70	3.72
4	-	-	-	-	-	-	-	-	-	3.70	3.70	3.72
5	-	-	-	-	-	-	-	-	-	3.70	3.70	3.72
6	-	-	-	-	-	-	-	-	-	3.70	3.70	3.72
7	-	-	-	-	-	-	-	-	-	3.70	3.70	3.72
8	-	-	-	-	-	-	-	-	-	3.70	3.71	3.72
9	-	-	-	-	-	-	-	-	-	3.70	3.71	3.72
10	-	-	-	-	-	-	-	-	-	3.70	3.71	3.72
11	-	-	-	-	-	-	-	-	-	3.70	3.71	3.71
12	-	-	-	-	-	-	-	-	-	3.70	3.71	3.71
13	-	-	-	-	-	-	-	-	-	3.70	3.71	3.71
14	-	-	-	-	-	-	-	-	-	3.70	3.71	3.71
15	-	-	-	-	-	-	-	-	3.70	3.70	3.71	3.71
16	-	-	-	-	-	-	-	-	3.70	3.70	3.71	3.71
17	-	-	-	-	-	-	-	-	3.71	3.70	3.71	3.71
18	-	-	-	-	-	-	-	-	3.73	3.70	3.71	3.71
19	-	-	-	-	-	-	-	-	3.75	3.70	3.71	3.70
20	-	-	-	-	-	-	-	-	3.76	3.70	3.71	3.70
21	-	-	-	-	-	-	-	-	3.75	3.72	3.71	3.70
22	-	-	-	-	-	-	-	-	3.74	4.09	3.71	3.70
23	-	-	-	-	-	-	-	-	3.74	3.70	3.71	3.70
24	-	-	-	-	-	-	-	-	3.73	3.70	3.71	3.70
25	-	-	-	-	-	-	-	-	3.73	3.70	3.71	3.70
26	-	-	-	-	-	-	-	-	3.70	3.70	3.71	3.70
27	-	-	-	-	-	-	-	-	3.70	3.70	3.71	3.70
28	-	-	-	-	-	-	-	-	3.70	3.70	3.71	3.70
29	-		-	-		-	-	-	3.70	3.70	3.71	3.70
30	-	-	-	-		-	-	-	3.70	3.70	3.71	3.70
31	-		-	-		-		-		3.70	3.71	

Appendix C. (continued)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Stage at Gaging Station HL3 -- Pigeon Roost Creek
Feet Above Mean Sea Level -- WY91

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.70	3.75	3.87	4.23	3.86	3.95	3.87	4.00	3.93	3.60	3.62	3.66
2	3.70	3.75	3.84	4.11	3.83	3.94	3.89	3.97	3.93	3.60	3.63	3.67
3	3.77	3.75	3.82	4.09	3.83	3.88	3.89	3.96	3.93	3.60	3.63	3.68
4	4.08	3.76	3.82	4.04	4.19	3.86	3.89	3.96	3.89	3.57	3.63	3.69
5	3.78	3.76	3.79	4.05	4.95	3.85	3.89	4.00	3.75	3.56	3.65	3.66
6	3.75	3.75	3.77	5.72	4.19	3.84	3.89	3.95	3.72	3.56	3.67	3.65
7	3.80	3.74	3.75	4.63	4.06	3.84	3.91	3.95	3.72	3.56	3.69	3.65
8	3.86	3.74	3.75	4.23	4.03	3.83	3.92	3.94	3.72	3.56	3.73	3.66
9	4.00	3.74	3.76	4.13	3.97	3.84	3.91	3.95	3.72	3.56	3.72	3.66
10	3.96	3.74	3.76	4.60	3.93	3.84	3.92	3.94	3.72	3.60	3.72	3.65
11	3.85	3.74	3.76	4.77	3.90	3.83	3.94	3.97	3.72	3.61	3.72	3.64
12	3.82	3.74	3.75	4.24	3.89	3.83	3.98	3.99	3.72	3.62	3.72	3.63
13	3.79	3.74	3.75	4.09	5.14	3.83	5.32	3.98	3.72	3.63	3.71	3.64
14	3.79	3.74	3.74	4.03	4.50	3.82	4.37	3.96	3.72	3.63	3.70	3.65
15	3.78	3.74	3.80	4.09	4.19	3.84	4.13	4.02	3.72	3.63	3.70	3.65
16	3.78	3.75	3.82	4.09	4.11	3.86	4.08	4.26	3.69	3.62	3.71	3.65
17	3.77	3.75	3.98	3.98	4.05	3.88	4.09	4.05	3.68	3.61	3.71	3.67
18	3.76	3.75	4.90	3.94	4.16	3.90	3.96	3.99	3.66	3.62	3.71	3.68
19	3.76	3.74	4.10	3.92	4.13	3.92	3.91	3.95	3.66	3.62	3.71	3.67
20	3.77	3.74	3.96	3.94	4.06	3.91	3.89	3.91	3.66	3.62	3.71	3.66
21	3.77	3.75	9.02	3.92	4.00	3.89	3.87	3.89	3.66	3.62	3.71	3.67
22	3.78	4.09	4.56	3.91	3.96	5.56	3.86	3.88	3.66	3.63	3.70	3.67
23	3.78	3.85	4.16	3.89	3.93	4.25	3.89	3.86	3.66	3.63	3.70	3.72
24	3.77	3.82	4.15	3.87	3.90	4.01	3.90	4.51	3.65	3.63	3.70	3.74
25	3.75	3.81	4.12	3.86	3.88	3.92	3.94	4.34	3.65	3.62	3.70	3.74
26	3.74	3.79	4.10	3.86	3.85	3.89	3.97	4.11	3.64	3.60	3.69	3.74
27	3.74	3.81	4.14	3.87	3.83	3.88	3.95	4.01	3.63	3.60	3.69	3.73
28	3.73	4.13	4.09	3.90	3.82	3.86	4.10	3.93	3.60	3.61	3.69	3.72
29	3.73	3.87	5.15	3.88		3.84	4.95	3.93	3.60	3.61	3.74	3.71
30	3.74	3.86	5.44	3.92		3.83	4.11	3.93	3.60	3.61	3.64	3.70
31	3.74		4.33	3.89		3.83		3.93		3.62	3.64	

Appendix C. (continued)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Stage at Gaging Station HL3 -- Pigeon Roost Creek
Feet Above Mean Sea Level -- WY92

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.70	4.02	4.80	4.00	3.86	3.93	3.92	3.81	3.60	3.70	3.68	3.81
2	3.70	3.91	6.37	4.02	3.85	3.89	3.91	3.80	3.68	3.69	3.67	3.81
3	3.71	3.91	4.52	4.04	3.86	3.85	3.94	3.78	3.68	4.24	3.65	3.80
4	3.72	3.88	4.29	4.09	3.86	3.84	3.96	3.75	3.71	3.80	3.64	3.80
5	3.78	3.75	4.18	4.10	3.86	3.85	4.10	3.74	3.72	3.59	3.64	3.79
6	3.82	3.72	4.10	4.11	3.87	3.86	4.12	3.72	3.72	3.60	3.64	3.78
7	3.79	3.72	3.93	4.10	3.86	3.88	4.11	3.70	3.72	3.60	3.65	3.77
8	3.75	3.70	3.90	4.52	3.86	3.95	4.10	3.69	3.69	3.61	3.66	3.76
9	3.75	3.69	3.88	4.27	3.87	3.96	4.07	3.67	3.67	3.61	3.67	3.75
10	3.75	3.68	3.88	4.02	3.86	3.99	4.05	3.66	3.65	3.61	3.75	3.74
11	3.74	3.62	3.89	3.95	3.86	4.01	3.95	3.65	3.64	3.59	3.70	3.73
12	3.74	3.63	3.93	3.94	3.87	4.03	3.93	3.64	3.64	3.59	3.67	3.72
13	3.74	3.64	4.06	4.06	4.09	4.05	3.89	3.65	3.65	3.58	3.67	3.70
14	3.74	3.62	4.01	4.20	4.87	4.10	3.84	3.65	3.65	3.58	3.67	3.69
15	3.74	3.62	3.98	4.05	4.40	4.10	3.80	3.65	3.66	3.58	3.66	3.68
16	3.74	3.62	3.98	4.15	4.10	4.11	3.76	3.65	3.66	3.59	3.66	3.67
17	3.73	3.62	3.98	4.23	4.06	4.11	3.75	3.65	3.65	3.60	3.75	3.66
18	3.73	3.62	3.98	4.11	4.12	4.93	3.74	3.65	3.64	3.60	3.86	3.66
19	3.72	5.84	3.97	4.06	3.87	4.47	4.82	3.67	3.64	3.60	3.96	3.65
20	3.73	4.95	3.96	3.98	3.88	4.20	4.75	3.68	3.63	3.60	3.98	4.02
21	3.73	4.11	3.98	3.90	3.92	4.12	4.32	3.68	3.63	3.60	4.00	3.83
22	3.73	4.02	3.98	3.93	3.95	4.09	4.12	3.66	3.62	3.60	4.02	3.62
23	3.73	3.97	4.20	3.94	4.42	4.08	3.95	3.84	3.71	3.61	3.98	3.59
24	3.74	3.94	4.22	3.94	4.16	4.05	3.87	4.24	3.71	3.61	3.89	3.63
25	3.74	3.93	4.20	3.93	4.08	4.03	3.80	4.21	3.70	3.62	3.80	3.64
26	3.75	3.93	4.18	3.91	4.02	4.02	3.80	4.20	3.70	3.63	3.71	3.64
27	3.75	3.93	4.16	3.90	4.01	4.02	3.80	3.61	3.70	3.70	4.25	3.63
28	3.76	3.94	4.13	3.87	3.99	4.01	3.99	3.60	3.70	3.71	3.92	3.61
29	3.73	3.94	4.04	3.87	3.95	4.00	3.90	3.61	3.69	3.70	3.81	3.62
30	4.32	4.49	4.01	3.86		3.95	3.81	3.61	3.69	3.69	3.81	3.62
31	3.93		4.00	3.86		3.92		3.60		3.69	3.81	

Appendix C. (continued)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Stage At Gaging Station HL2 -- Pigeon Roost Creek
Feet Above Mean Sea Level -- WY93

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.63	-	-	-	-	-	-	-	-	-	-	-
2	3.63	-	-	-	-	-	-	-	-	-	-	-
3	3.63	-	-	-	-	-	-	-	-	-	-	-
4	3.63	-	-	-	-	-	-	-	-	-	-	-
5	3.63	-	-	-	-	-	-	-	-	-	-	-
6	3.63	-	-	-	-	-	-	-	-	-	-	-
7	3.65	-	-	-	-	-	-	-	-	-	-	-
8	3.65	-	-	-	-	-	-	-	-	-	-	-
9	3.65	-	-	-	-	-	-	-	-	-	-	-
10	3.65	-	-	-	-	-	-	-	-	-	-	-
11	3.65	-	-	-	-	-	-	-	-	-	-	-
12	3.65	-	-	-	-	-	-	-	-	-	-	-
13	3.62	-	-	-	-	-	-	-	-	-	-	-
14	3.63	-	-	-	-	-	-	-	-	-	-	-
15	4.15	-	-	-	-	-	-	-	-	-	-	-
16	5.28	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-		-	-	-	-	-	-	-
30	-	-	-	-		-	-	-	-	-	-	-
31	-		-	-		-		-		-	-	

Appendix C. (continued)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Discharge at Gaging Station HL3 -- Pigeon Roost Creek
Cubic Feet Per Second -- WY90

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
2	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
3	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
4	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
5	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
6	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
7	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
8	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
9	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
10	-	-	-	-	-	-	-	-	-	1.20	1.20	1.30
11	-	-	-	-	-	-	-	-	-	1.20	1.20	1.20
12	-	-	-	-	-	-	-	-	-	1.20	1.20	1.20
13	-	-	-	-	-	-	-	-	-	1.20	1.20	1.20
14	-	-	-	-	-	-	-	-	-	1.20	1.20	1.20
15	-	-	-	-	-	-	-	-	1.20	1.20	1.20	1.20
16	-	-	-	-	-	-	-	-	1.20	1.20	1.20	1.20
17	-	-	-	-	-	-	-	-	1.20	1.20	1.20	1.20
18	-	-	-	-	-	-	-	-	1.30	1.20	1.20	1.20
19	-	-	-	-	-	-	-	-	1.40	1.20	1.20	1.20
20	-	-	-	-	-	-	-	-	1.50	1.20	1.20	1.20
21	-	-	-	-	-	-	-	-	1.40	1.30	1.20	1.20
22	-	-	-	-	-	-	-	-	1.40	5.60	1.20	1.20
23	-	-	-	-	-	-	-	-	1.40	1.20	1.20	1.20
24	-	-	-	-	-	-	-	-	1.30	1.20	1.20	1.20
25	-	-	-	-	-	-	-	-	1.30	1.20	1.20	1.20
26	-	-	-	-	-	-	-	-	1.20	1.20	1.20	1.20
27	-	-	-	-	-	-	-	-	1.20	1.20	1.20	1.20
28	-	-	-	-	-	-	-	-	1.20	1.20	1.20	1.20
29	-	-	-	-		-	-	-	1.20	1.20	1.20	1.20
30	-	-	-	-		-	-	-	1.20	1.20	1.20	1.20
31	-		-	-		-		-		1.20	1.20	
TOTAL:												
(cfs-day)									*20.60*	*41.70*	*37.20*	*37.00*
(inches)									*0.22*	*0.45*	*0.40*	*0.40*

Appendix C. (continued)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Discharge at Gaging Station HL3 -- Pigeon Roost Creek
Cubic Feet Per Second -- WY91

DAY	*OCT*	*NOV*	*DEC*	*JAN*	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*
1	1.20	1.40	2.'20	6.50	2.10	3.40	2.20	3.50	2.70	0.50	0.70	1.00
2	1.20	1.40	2.00	5.10	1.90	2.80	2.30	3.10	2.70	0.50	0.70	1.10
3	1.90	1.40	1.90	4.80	1.90	2.20	2.30	3.00	2.70	0.50	0.80	1.10
4	4.80	1.50	1.80	4.00	8.30	2.10	2.30	3.00	2.40	0.30	0.80	1.20
5	1.60	1.50	1.60	4.20	25.00	2.00	2.30	3.50	1.40	0.30	0.90	1.00
6	1.50	1.50	1.50	51.40	6.10	2.00	2.30	2.90	1.30	0.30	1.10	1.00
7	1.70	1.40	1.40	13.50	4.40	2.00	2.50	2.90	1.30	0.30	1.20	1.00
8	2.10	1.40	1.40	6.50	3.90	1.90	2.60	2.80	1.30	0.20	1.30	1.00
9	3.60	1.40	1.50	5.40	3.10	2.00	2.50	2.90	1.30	0.20	1.30	1.00
10	3.10	1.40	1.50	14.80	2.70	1.90	2.60	2.80	1.30	0.50	1.30	1.00
11	2.00	1.40	1.50	18.00	2.50	1.90	2.80	3.10	1.30	0.50	1.30	0.90
12	1.80	1.40	1.40	6.70	2.40	1.90	3.30	3.40	1.30	0.70	1.30	0.80
13	1.70	1.40	1.40	4.80	36.00	1.90	63.60	3.20	1.30	0.70	1.20	0.90
14	1.60	1.40	1.40	3.90	11.20	1.80	8.80	3.10	1.30	0.70	1.20	1.00
15	1.60	1.40	1.80	4.70	6.00	1.90	5.30	3.80	1.30	0.70	1.20	0.90
16	1.60	1.40	1.80	4.80	5.10	2.10	4.70	7.20	1.20	0.60	1.20	1.00
17	1.50	1.40	3.30	3.30	4.20	2.20	4.80	4.10	1.10	0.60	1.30	1.10
18	1.50	1.40	21.60	2.80	5.60	2.40	3.10	3.40	1.10	0.60	1.30	1.10
19	1.50	1.40	4.90	2.60	5.30	2.60	2.60	2.90	1.00	0.60	1.20	1.10
20	1.50	1.40	3.00	2.80	4.30	2.50	2.30	2.50	1.00	0.60	1.20	1.00
21	1.50	1.40	623.10	2.60	3.50	2.40	2.20	2.30	1.00	0.70	1.20	1.10
22	1.60	4.90	14.20	2.50	3.10	62.10	2.10	2.30	1.00	0.80	1.20	1.10
23	1.60	2.00	5.60	2.30	2.70	7.00	2.40	2.10	1.00	0.80	1.20	1.30
24	1.50	1.80	5.50	2.20	2.50	3.70	2.40	14.80	1.00	0.80	1.20	1.40
25	1.50	1.70	5.30	2.10	2.20	2.60	2.80	8.20	1.00	0.60	1.20	1.40
26	1.40	1.70	4.90	2.10	2.00	2.30	3.20	5.00	0.90	0.50	1.20	1.40
27	1.40	1.80	5.50	2.20	1.90	2.30	2.90	3.60	0.70	0.50	1.20	1.30
28	1.40	5.40	4.80	2.40	1.80	2.10	4.80	2.70	0.50	0.50	1.20	1.30
29	1.30	2.20	33.50	2.30		2.00	30.70	2.70	0.50	0.50	1.50	1.20
30	1.40	2.10	43.30	2.60		1.90	5.10	2.70	0.50	0.60	0.90	1.20
31	1.40		7.90	2.30		1.90		2.70		0.60	0.80	
TOTAL:												
(cfs-day)	*55.00*	*53.30*	*812.50*	*196.20*	*161.70*	*133.80*	*183.80*	*116.20*	*38.40*	*16.80*	*35.30*	*32.90*
(inches)	*0.59*	*0.57*	*8.68*	*2.10*	*1.73*	*1.43*	*1.96*	*1.24*	*0.41*	*0.18*	*0.38*	*0.35*

Appendix C. (continued)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Discharge at Gaging Station HL3 -- Pigeon Roost Creek
Cubic Feet Per Second -- WY92

DAY	*OCT*	*NOV*	*DEC*	*JAN*	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*
1	1.20	3.80	18.70	3.50	2.10	2.70	2.60	1.70	0.40	1.20	1.10	1.70
2	1.20	2.50	100.60	3.70	2.10	2.30	2.50	1.70	1.10	1.20	1.10	1.70
3	1.20	2.50	11.20	4.00	2.10	2.00	2.80	1.60	1.10	6.90	1.00	1.70
4	1.30	2.30	7.40	4.80	2.10	1.90	3.00	1.40	1.20	1.90	0.90	1.70
5	1.60	1.40	5.90	5.00	2.10	2.00	4.90	1.40	1.30	0.40	0.80	1.60
6	1.80	1.30	4.90	5.00	2.20	2.10	5.20	1.30	1.30	0.40	0.90	1.60
7	1.70	1.30	2.70	5.00	2.10	2.30	5.10	1.20	1.30	0.50	1.00	1.50
8	1.40	1.20	2.40	13.10	2.10	2.90	4.90	1.10	1.20	0.60	1.00	1.50
9	1.40	1.10	2.30	7.00	2.20	3.00	4.50	1.10	1.10	0.60	1.10	1.40
10	1.40	1.10	2.20	3.80	2.10	3.30	4.10	1.00	1.00	0.60	1.70	1.40
11	1.40	0.70	2.40	2.90	2.10	3.50	2.90	1.00	0.90	0.40	1.20	1.30
12	1.40	0.80	2.70	2.70	2.20	3.80	2.70	0.90	0.90	0.40	1.10	1.30
13	1.40	0.80	4.30	4.40	4.80	4.20	2.40	1.00	1.00	0.40	1.10	1.20
14	1.40	0.70	3.60	6.30	29.60	5.00	2.00	1.00	1.00	0.30	1.10	1.20
15	1.40	0.60	3.20	4.10	9.30	5.00	1.70	1.00	1.00	0.30	1.10	1.10
16	1.40	0.60	3.20	5.50	4.90	5.10	1.50	1.00	1.00	0.40	1.00	1.10
17	1.30	0.60	3.20	6.50	4.20	5.10	1.40	1.00	1.00	0.50	1.40	1.00
18	1.30	0.60	3.20	5.10	5.10	36.30	1.40	1.00	0.90	0.50	2.20	1.00
19	1.30	99.40	3.10	4.30	2.20	11.00	24.30	1.10	0.80	0.50	3.00	1.00
20	1.30	29.50	3.00	3.20	2.30	6.20	17.70	1.10	0.80	0.50	3.20	5.20
21	1.30	5.00	3.20	2.40	2.60	5.20	7.80	1.10	0.70	0.50	3.50	2.10
22	1.30	3.70	3.30	2.70	2.90	4.90	5.10	1.00	0.70	0.50	3.80	0.60
23	1.30	3.10	6.20	2.80	10.20	4.70	2.90	2.90	1.30	0.50	3.30	0.40
24	1.40	2.80	6.40	2.80	5.70	4.20	2.20	6.60	1.20	0.60	2.40	0.80
25	1.40	2.70	6.10	2.70	4.70	3.90	1.70	6.30	1.20	0.60	1.70	0.90
26	1.40	2.70	5.90	2.50	3.80	3.80	1.70	6.10	1.20	0.70	1.20	0.80
27	1.40	2.70	5.60	2.40	3.60	3.70	1.70	0.50	1.20	1.20	9.80	0.80
28	1.50	2.80	5.30	2.20	3.30	3.60	3.60	0.50	1.20	1.20	2.70	0.60
29	1.30	2.80	4.10	2.20	2.90	3.50	2.60	0.50	1.10	1.20	1.80	0.60
30	8.10	12.80	3.60	2.10		2.90	1.80	0.50	1.10	1.20	1.80	0.70
31	2.70		3.50	2.10		2.60		0.50		1.10	1.70	
TOTAL:												
(cfs-day)	*50.90*	*193.90*	*243.40*	*126.80*	*127.60*	*152.70*	*128.70*	*50.10*	*31.20*	*27.80*	*60.70*	*39.50*
(inches)	*0.54*	*2.07*	*2.60*	*1.36*	*1.36*	*1.63*	*1.38*	*0.54*	*0.33*	*0.30*	*0.65*	*0.42*

Appendix C. (concluded)

Horseshoe Lake Project -- Illinois State Water Survey
Average Daily Discharge At Gaging Station HL3-- Pigeon Roost Creek
Cubic Feet Per Second -- WY93

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.80	-	-	-	-	-	-	-	-	-	-	-
2	0.80	-	-	-	-	-	-	-	-	-	-	-
3	0.70	-	-	-	-	-	-	-	-	-	-	-
4	0.70	-	-	-	-	-	-	-	-	-	-	-
5	0.80	-	-	-	-	-	-	-	-	-	-	-
6	0.80	-	-	-	-	-	-	-	-	-	-	-
7	1.00	-	-	-	-	-	-	-	-	-	-	-
8	1.00	-	-	-	-	-	-	-	-	-	-	-
9	1.00	-	-	-	-	-	-	-	-	-	-	-
10	1.00	-	-	-	-	-	-	-	-	-	-	-
11	1.00	-	-	-	-	-	-	-	-	-	-	-
12	1.00	-	-	-	-	-	-	-	-	-	-	-
13	0.70	-	-	-	-	-	-	-	-	-	-	-
14	0.80	-	-	-	-	-	-	-	-	-	-	-
15	9.70	-	-	-	-	-	-	-	-	-	-	-
16	35.90	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-		-	-	-	-	-	-	-
30	-	-	-	-		-	-	-	-	-	-	-
31	-		-	-		-		-		-	-	
TOTAL:												
(cfa-day)	57.70											
(inches)	0.62											

Appendix D:

Summary of Lake Sedimentation Results

Appendix D. Horseshoe Lake - Alexander County
Summary of Lake Sedimentation Results
(after Bogner et al., 1985)

Segment[1]	*1984 Volume (acre-feet)*	*Sediment volumes (acre-feet)* 1951-1984	0000-1951[2]	0000-1984[3]	*Sediment tonnages (1000 tons)* 1951-1984	0000-1951[2]	0000-1984[3]	*Unit weights (pounds per cubic foot)* Area (acres)	1951-1984	0000-1951
1	49.2	7.1	26.2	33.3	2.3	18.5	20.8	21.1	14.9	32.5
2	265.8	62.6	162.9	225.5	20.3	115.3	135.6	82.3	14.9	32.5
3	606.7	183.0	545.7	728.7	55.4	324.5	379.9	160.5	13.9	27.3
4	533.5	160.3	569.3	729.6	28.6	249.2	277.8	138.2	8.2	20.1
5	733.4	243.3	697.4	940.7	45.6	264.3	309.9	180.2	8.6	17.4
6	498.4	266.2	393.5	659.7	64.9	144.8	209.7	147.9	11.2	16.9
7	347.7	319.0	138.5	457.5	123.7	151.1	274.8	150.5	17.8	50.1
8	19.8	23.9	-	23.9	11.9	-	11.9	10.9	22.9	-
9	449.9	107.9	397.6	505.5	36.0	224.3	260.3	113.6	15.3	25.9
10	708.6	192.3	574.9	767.2	66.2	411.7	477.9	183.1	15.8	32.8
11	1395.9	950.7	631.8	1582.5	468.0	836.6	1304.6	601.7	22.6	60.8
12	105.8	110.3	-	110.3	87.7	-	87.7	65.3	36.5	-
13	42.6	38.4	-	38.4	30.5	-	30.5	26.3	36.5	-
14	99.4	79.4	-	79.4	63.1	-	63.1	64.1	36.5	-
15	90.7	63.2	-	63.2	50.2	-	50.2	61.3	36.5	-
Total	5947	2808	4139	6946	1154	2740	3894	2007		
		Average unit weight (pounds per cubic foot)			18.9	30.4	25.7			

Drainage area 23.72 square miles
15,177 acres

Area excluding lake 13,170 acres

Sediment delivery to lake 2.58 tons/acre

Note: 0000 represents the maximum penetration of the sounding pole in 1984. No date can be applied.

[1] Refer to figure 5 for segment location

[2] Accumulated sediment up to 1951

[3] Accumulated sediment up to 1984