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SURFACE WATER SECTION
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SEDIMENTATION OF POOL 19 ON THE MISSISSIPPI RIVER NEAR HAMILTON, ILLINOIS: BACKGROUND ANALYSIS

by
Nani G. Bhowmik and J. Rodger Adams

Champaign, Illinois
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Introduction

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The city of Hamilton, Illinois, is located on the east bank of the Mississippi River near Lock and Dam 19 (figure 1). The city is dependent on the Mississippi River for its water supply, and it also maintains public access to the river from its park system located on the east bank of the river just upstream of Lock and Dam 19. Excessive sedimentation over the years has virtually choked the city's water intake and has made it almost impossible for its citizens to enter the main channel of the river from its public docking facilities near the mouth of Cheney Creek. The city is now contemplating asking the U.S. Army Corps of Engineers to consider keeping some of the gates on Lock and Dam 19 near the east bank of the river open, with the hope that increased flow near the east bank would scour and transport some of the deposited sediment from upstream of the dam in the downstream direction. This increased scouring might help to maintain a deep channel near the east bank of the river, which is essential for recreational access to the river by the local communities.

After a discussion with the Office of the Mayor of Hamilton, Illinois, representatives of the Department of Conservation, and other interested public officials, it was decided that a background report outlining the available information on the sedimentation patterns upstream of Lock and Dam 19 would be extremely useful for the development of a management alternative for this reach of the river. Also it was felt that

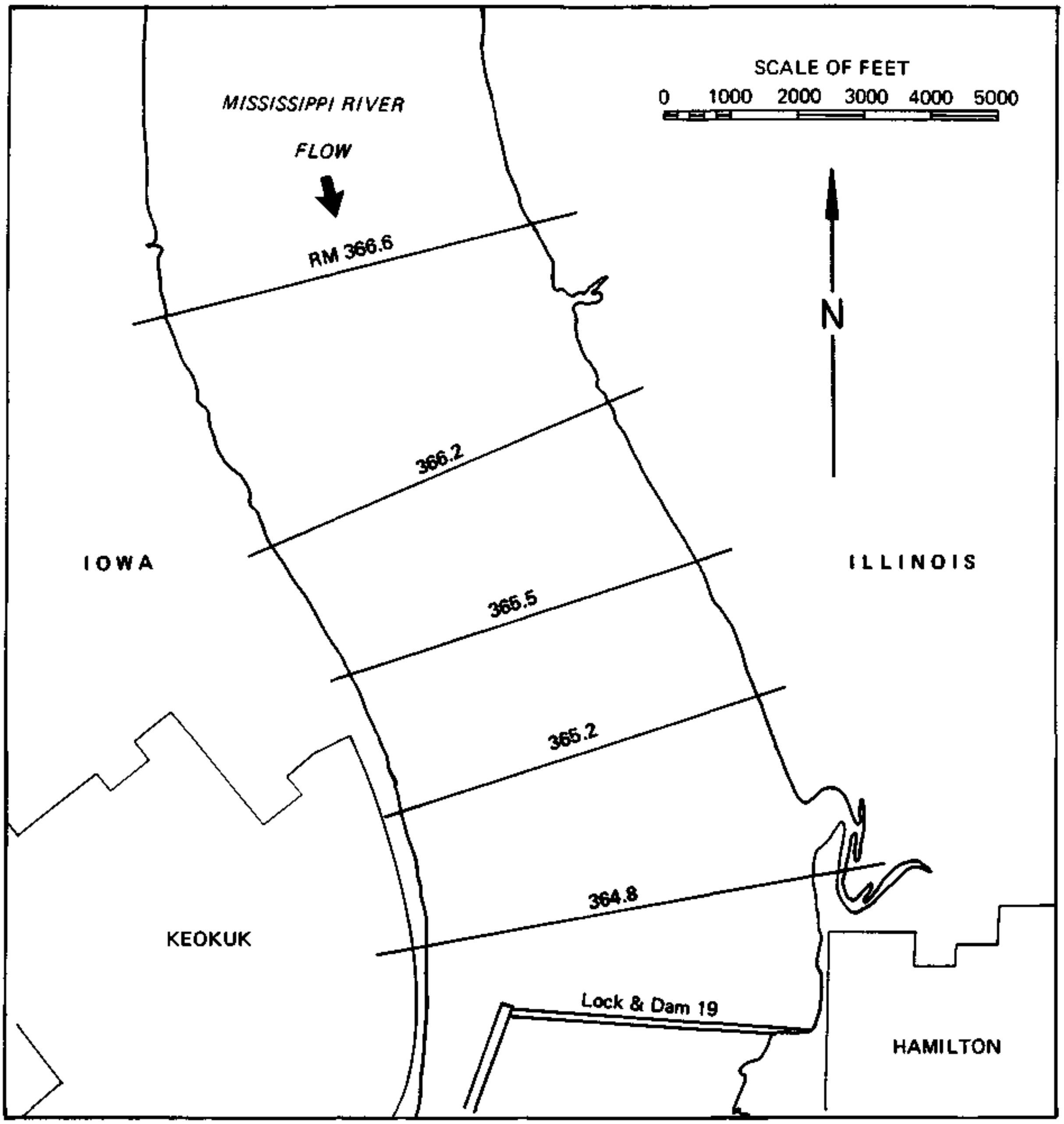


Figure 1. Lower portion of Pool 19 on the Mississippi River

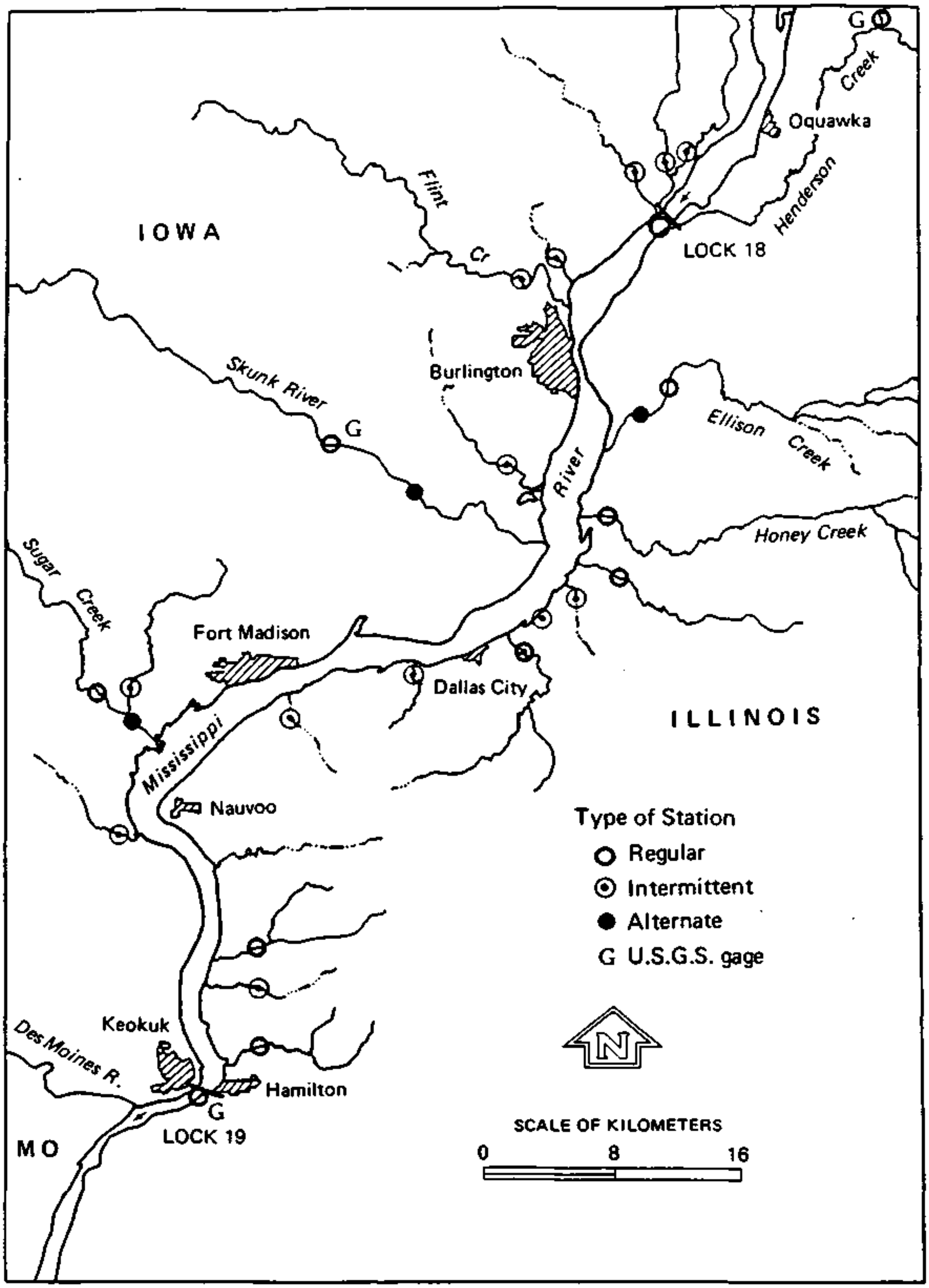
if a demonstration project such as this one is initiated, in which some of the gates are kept open to scour and move the sediment, then a scientific and engineering evaluation must be made. Such an evaluation would determine if such an alternative is feasible and how these results could be used on a semi-permanent basis not only for Pool 19 but also for other similar areas along the Mississippi, Illinois, and many other rivers with dams in Illinois. This report has been prepared to address these and other related topics.

Background

Pool 19 extends from Keokuk, Iowa, past Burlington, Iowa, for a distance of 74.5 km. Lock and Dam 19, constructed in 1913 to facilitate navigation past the Des Moines Rapids, is the oldest and highest lock and dam (11.6 m) along the river. Pool 19 is the longest pool of the entire navigation channel. At the flat pool elevation, the head on the dam is 11.64 m, which is the highest head differential on the Mississippi River except for that at the Upper St. Anthony Falls lock, which has substandard width. This lock and dam also includes a hydroelectric power plant. The tailwater level fluctuations are limited to a maximum daily value of 0.6 m, and the gates are operated to maintain a nearly constant level above the dam.

Figure 2 is a plan view of Pool 19, including most of the tributary streams. At normal pool level of 157.95 m above sea level, the surface area of the navigation channel is about 9 million m^2, and there are another 116 million m^2 of water outside the navigation channel (U.S. Army Corps of Engineers, 1981). The average slope of the thalweg is about 0.076 mkm^{-1}. The depth to bedrock in the river valley varies from 4 to 48 meters. Deposits from glacial action raised the river bottom by about 30 meters above the pre-glacial elevation. The upstream part of the pool has 11-km-wide floodplains which are protected by levees. The narrowest section of the floodplain near Nauvoo (figure 2) is about 3 km wide.

The mean annual precipitation on the Pool 19 drainage area is about 0.82 m and the average temperature is about 11 C. The mean annual runoff of the river at Lock and Dam 19 is about 18 mm. The channel is maintained at a minimum dredged width of 122 meters, and the navigation depths vary from 2.75 m near the upper reaches to 11 m near Lock and Dam 19. The



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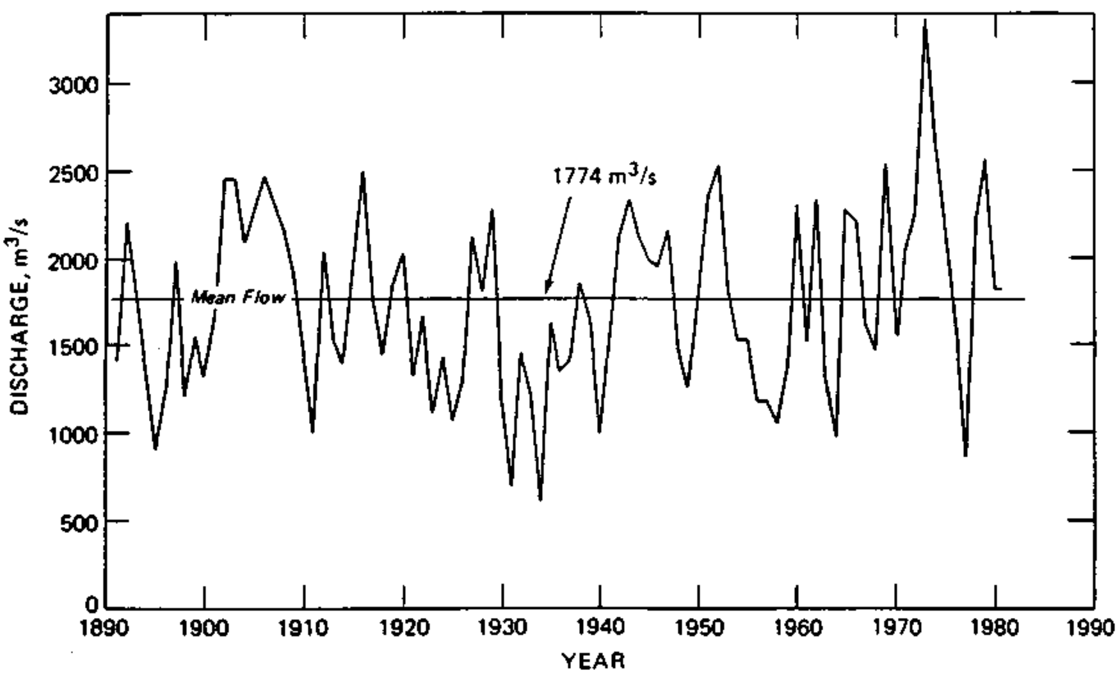
The low flow period of 1977 had a significant impact on the sediment movement in this pool. From figure 4, it is clear that the sediment



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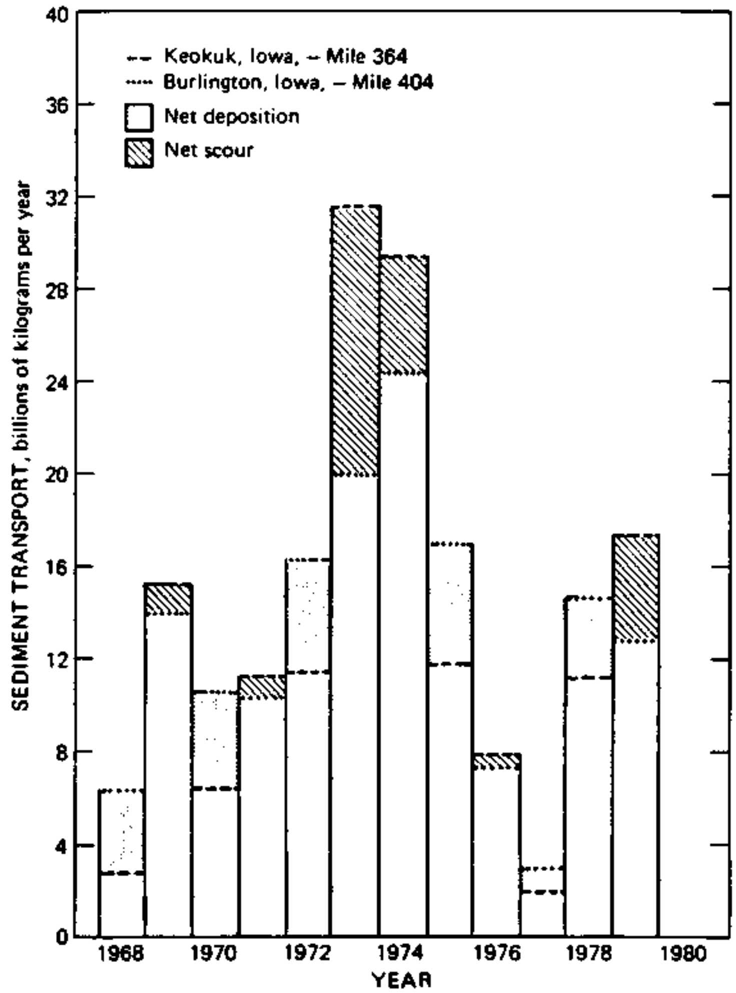

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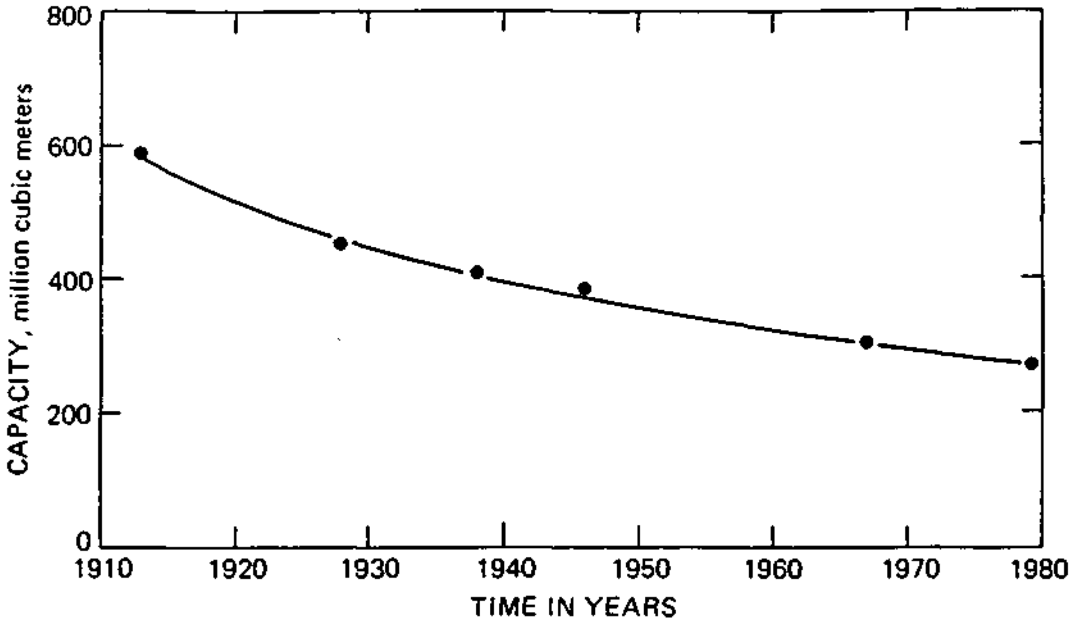
The highest sedimentation rates within the pool have been observed on the Illinois side just upstream of Lock and Dam 19 (see figures 1 and 2). The lock Is located on the Iowa shore near Keokuk, and the navigation channel is close to the Iowa shore. The release of water through the turbines and the lock prevents sediment deposition near the Iowa shore. However, since most of the gates are closed for much of the year, the water upstream of the dam near the Illinois shore remains almost stagnant, increasing the sediment deposition rate at this location. From the plot of a cross section just upstream of the dam (figure 6), it seems probable that about 60% of the width of the river from the Illinois shore has reached an elevation that will not change significantly with time. The sedimentation rate at this location has been about 44 mm/yr since 1946.

This sand bar or impending island formation extends for about 3 to 5 km upstream of the dam. The navigation channel shifts toward the Illinois



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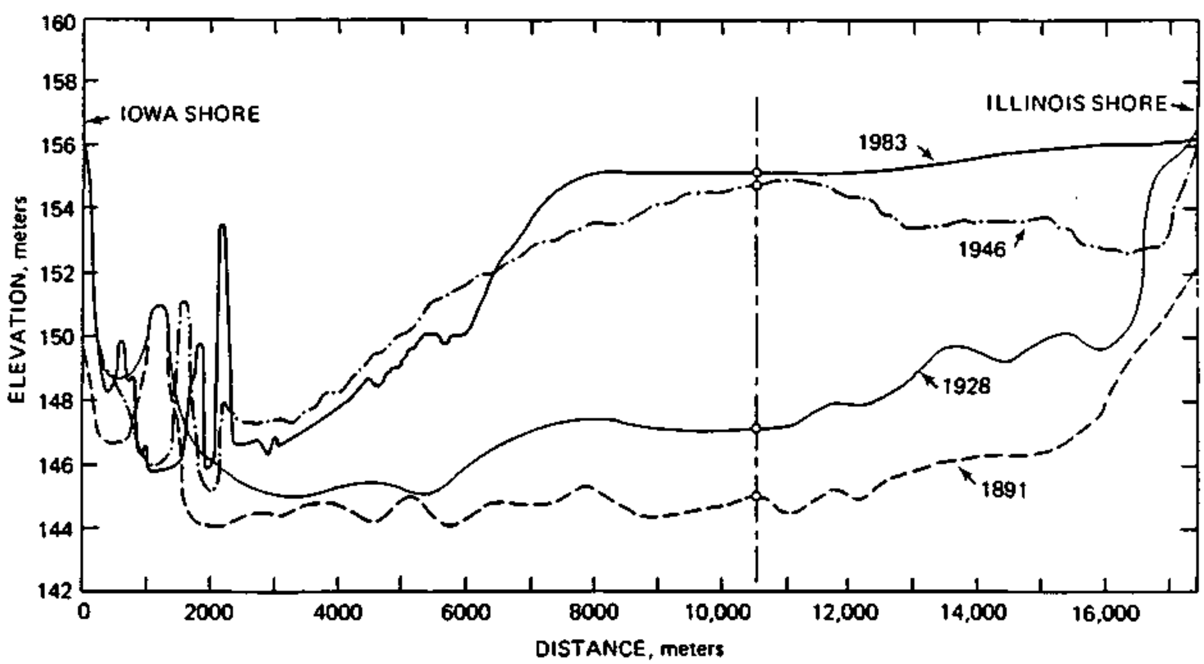

Figure 6. Variation of the Mississippi River cross section at river mile 364.8, just upstream of Lock and Dam 19

shore about 5 km upstream of the dam. The navigation channel remains fairly clear of sediment deposition.

The sedimentation pattern upstream of the lock and dam can further be illustrated with a set of river cross sections given in figures 7 and 8. The locations of these cross sections are given in figure 1. An examination of these figures indicates that the deposition of sediment near the Illinois shore has extended up to river mile 366.6, and other data have shown that this massive bar extends close to river mile 367.3. Buildup of this bar from 1946 through 1984 is again demonstrated in figure 9.

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<u>Proposed Action by Local Citizens/State</u>

The extensive sedimentation of the river near the Illinois shore led to the natural conclusion by local interested citizens that an attempt must be made to remove this massive sediment bar and restore this river to a state close to its original condition, or at least to develop and maintain a deep channel at this location. One of the suggestions that is being pursued actively is to initiate a scouring action of the deposited sediment by the increased velocity that will develop when some of the gates of the dam near the Illinois shores are kept open. It is hoped that this scouring of the sediment will maintain a deeper channel near the city of Hamilton. It should be noted here that scouring of the deposited sediment by sluicing is quite feasible. As a matter of fact, during the 1973 flood, most of the crest gates on Lock and Dam 19 were kept open to allow the passage of flood flows. During this event, the high velocity flow scoured and transported downstream almost one year's equivalent sediment load of the Mississippi River at this location (Bhowmik and Adams, 1986). Figure 4

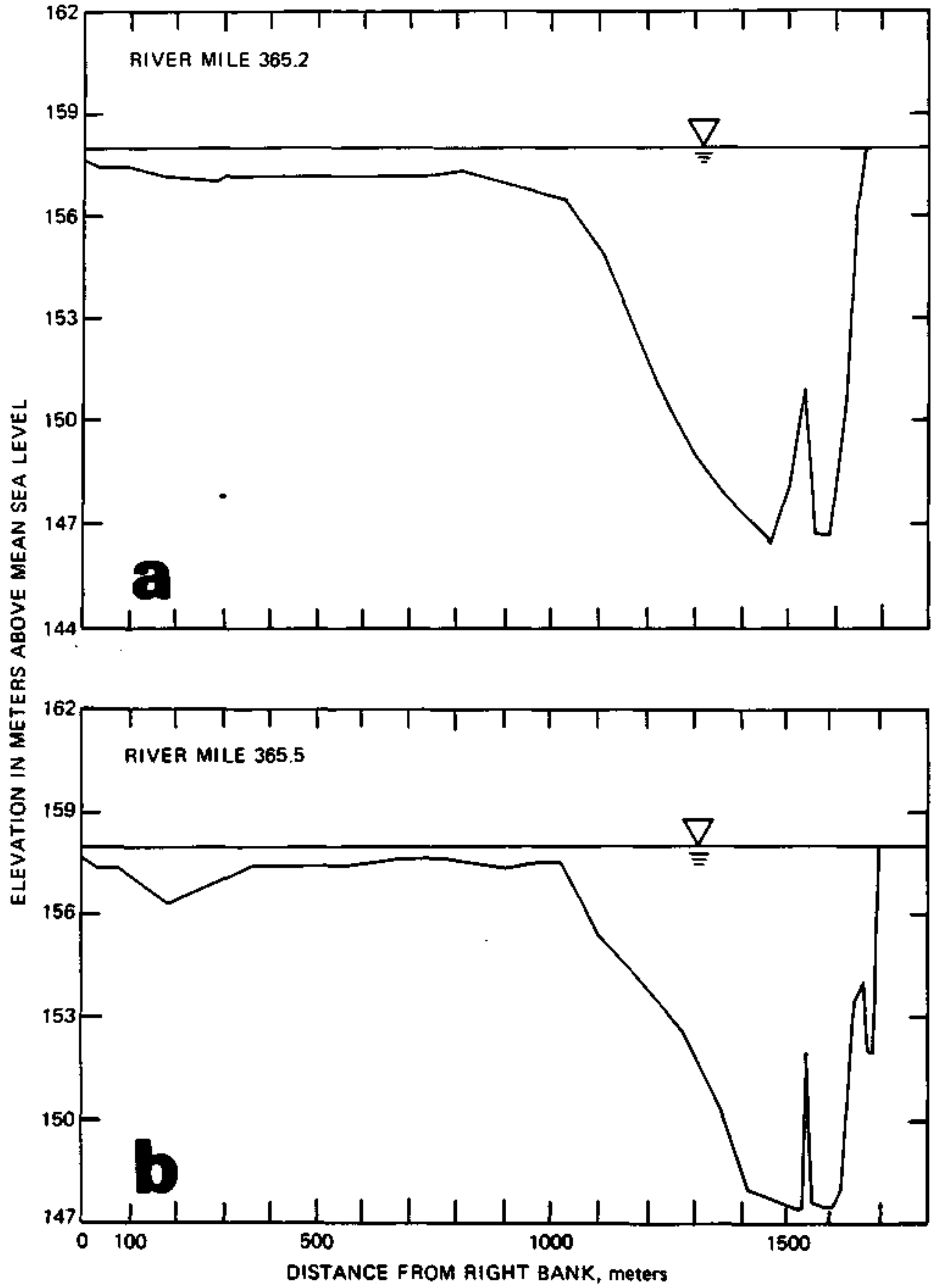

Figure 7. 1984 cross sections at a) river mile 365.2 and b) river mile S6S.S

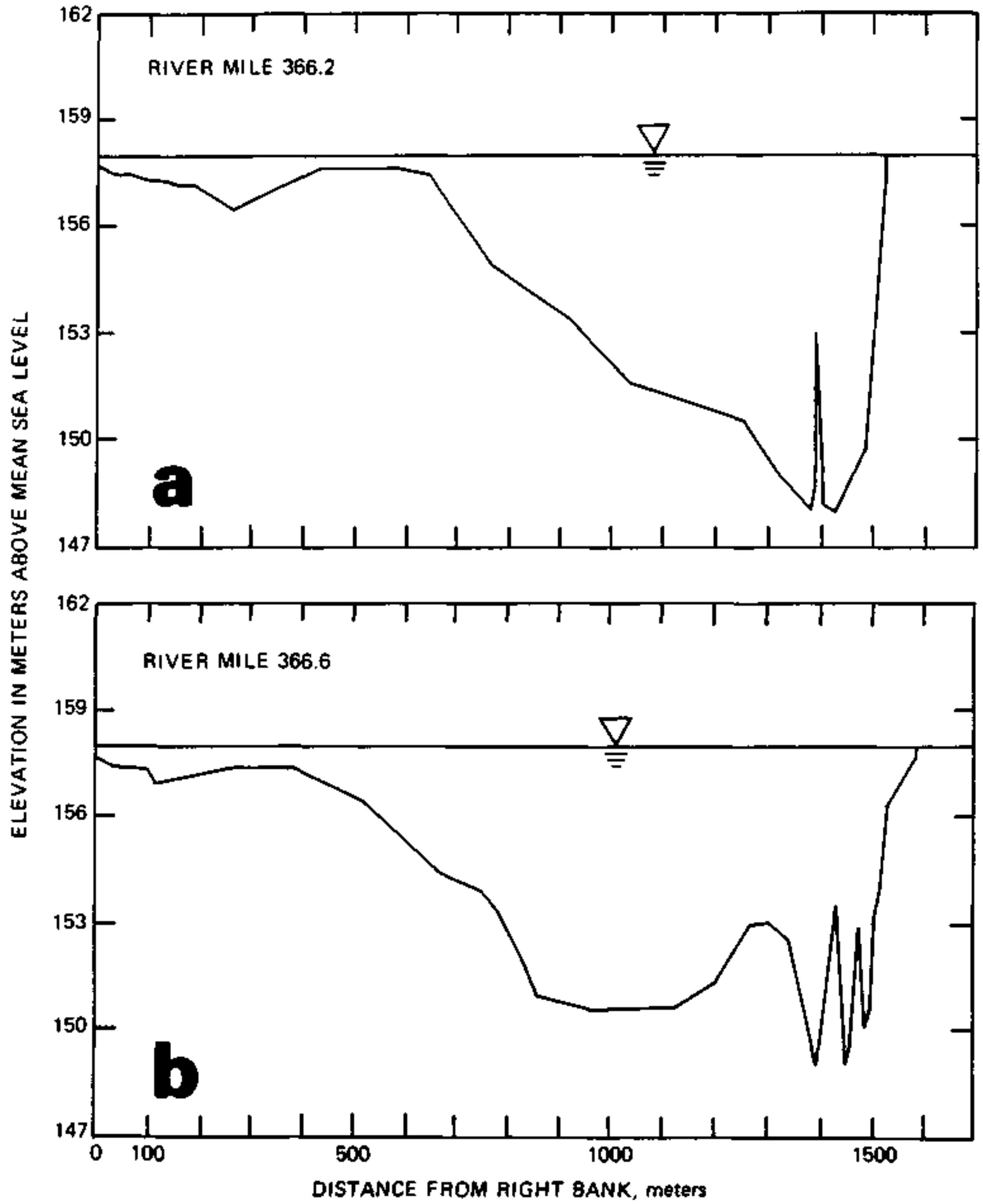

Figure 8. 1984 cross sections at a) river mile 266.2 and b) river mile 366.6

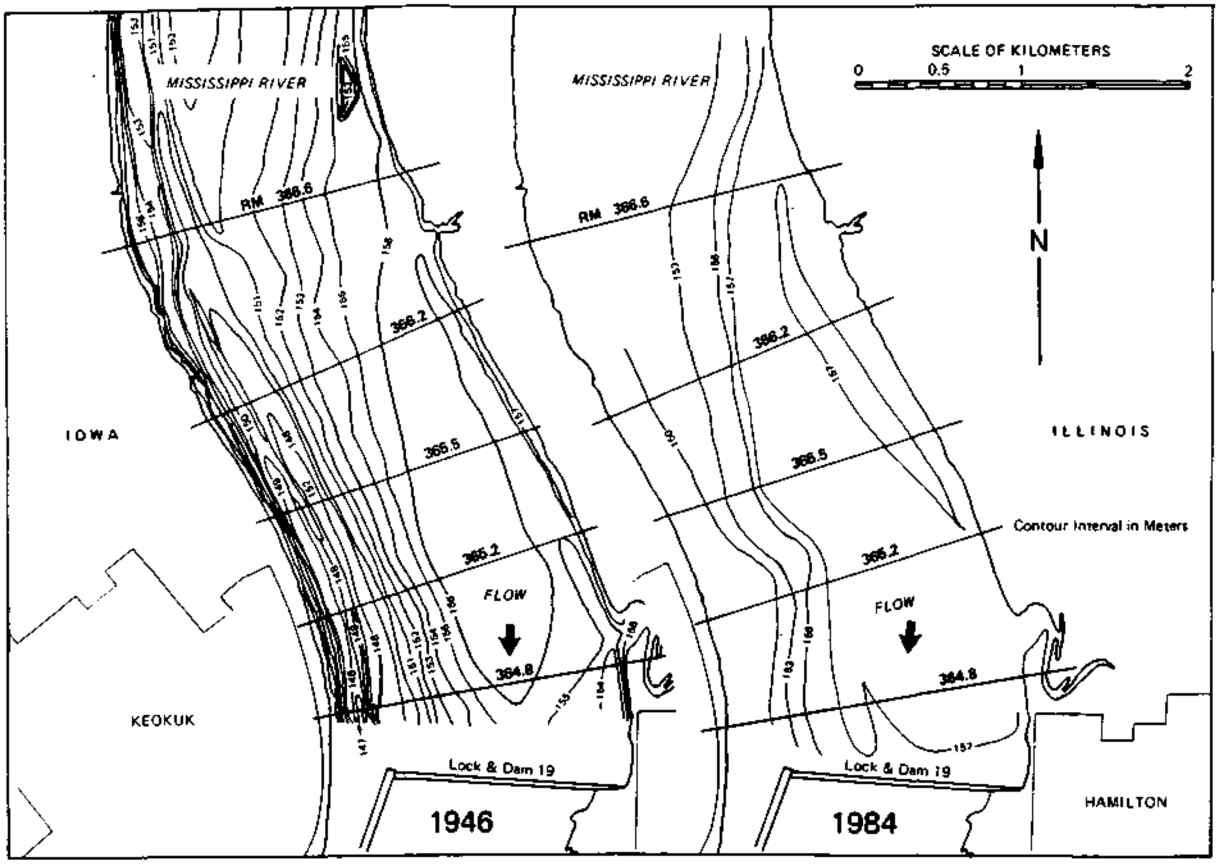

Figure 9. 1946 and 1984 bed contours of the Mississippi River above Look and Dam 19

also illustrates the effect of this scour during the 1973-1974 season. Therefore, with a proper design and plan, it is quite feasible to scour some of the deposited sediment from above the dam by opening the crest gates during high and median flows on the Mississippi River. Sluicing of the deposited sediment by opening gates or bottom sluices has been practiced in various parts of the world (USDA, 1942; Jiahua, 1960; Jiahua and Rujin, 1980; Parhami, 1986).

Knowledge of the hydraulics of flow of the Mississippi River and the sediment transport and sedimentation within a reservoir indicates that attempts can be made to determine if opening the gates will have the desirable impact of resuspending some of the deposited sediment. However, before such an attempt is made, a plan should be developed and implemented to evaluate the effectiveness of such a demonstration project.

Evaluation and Proposed Recommendations

It is recommended that a demonstration project be evaluated, with a follow-up report indicating the usefulness of such an operation. The evaluation will include an analysis of the existing data, collection and analyses of field data during the demonstration, and preparation of a report. An evaluation is essential in order to determine whether or not such an operation on a semi-permanent basis will have the desired effect of keeping a deeper channel open near the Illinois shore close to the city of Hamilton.

Data collection for such a project will include: bed elevation measurements at various cross sections before, during, and after the gates have been opened; suspended sediment load measurements at upstream and downstream sections during the demonstration project (to determine the net volume of sediment being scoured from above the dam); sediment analyses to determine particle size distribution and quality; and a determination of the discharges when the gates are opened.

On the basis of the analyses of the existing and collected data and also from an intimate knowledge of the hydraulics of flow and sediment transport characteristics of the Mississippi River, a set of recommendations will be made for implementation by the concerned agencies/authorities which will be useful in maintaining a deep channel near the city of Hamilton. It should be noted that such an alternative solution may also be quite feasible for many lakes and reservoirs in Illinois where excessive sedimentation is a major problem.

Time and Cost: The project will last for about 12 months with a total initial cost of about $45,000.

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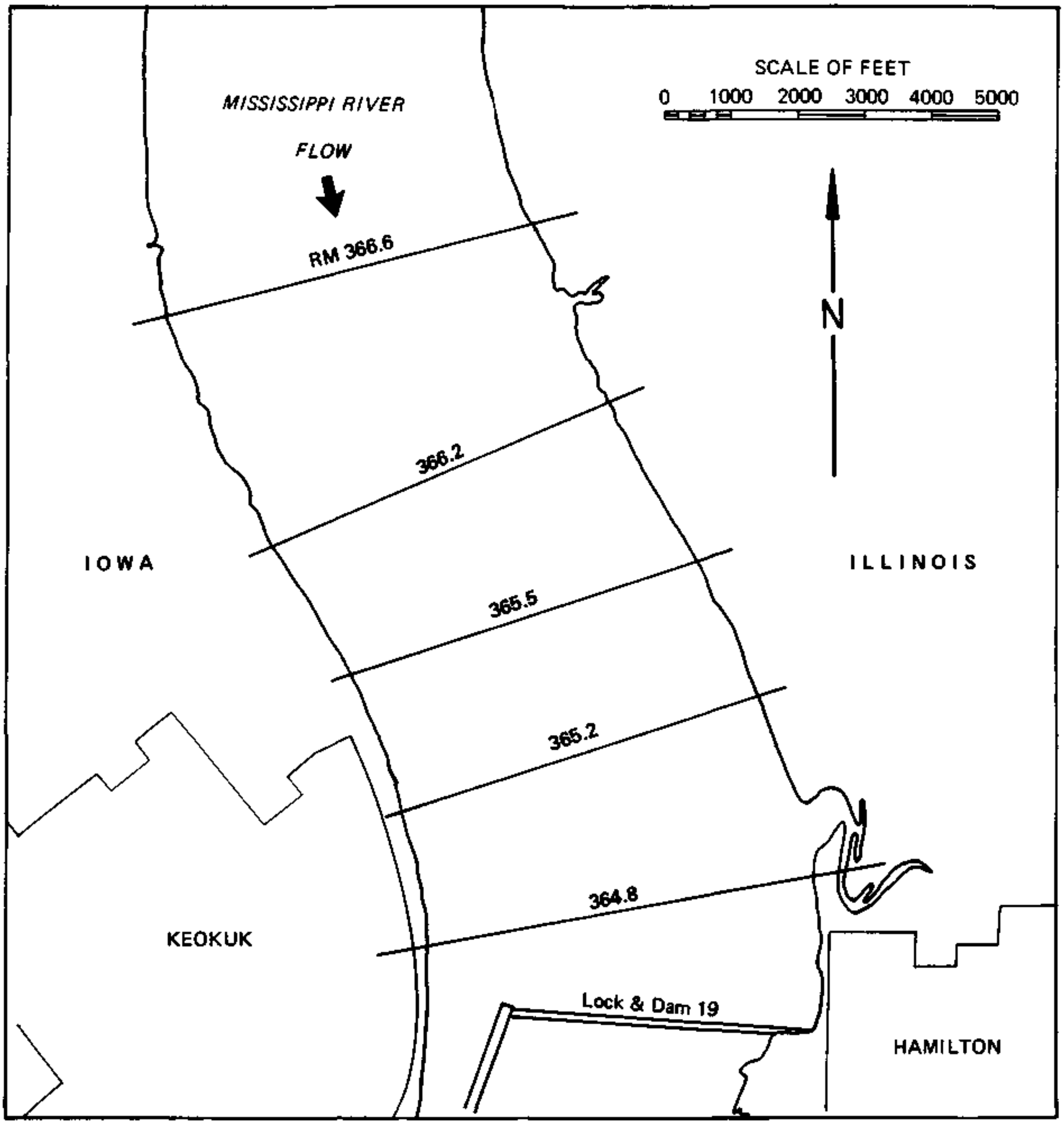

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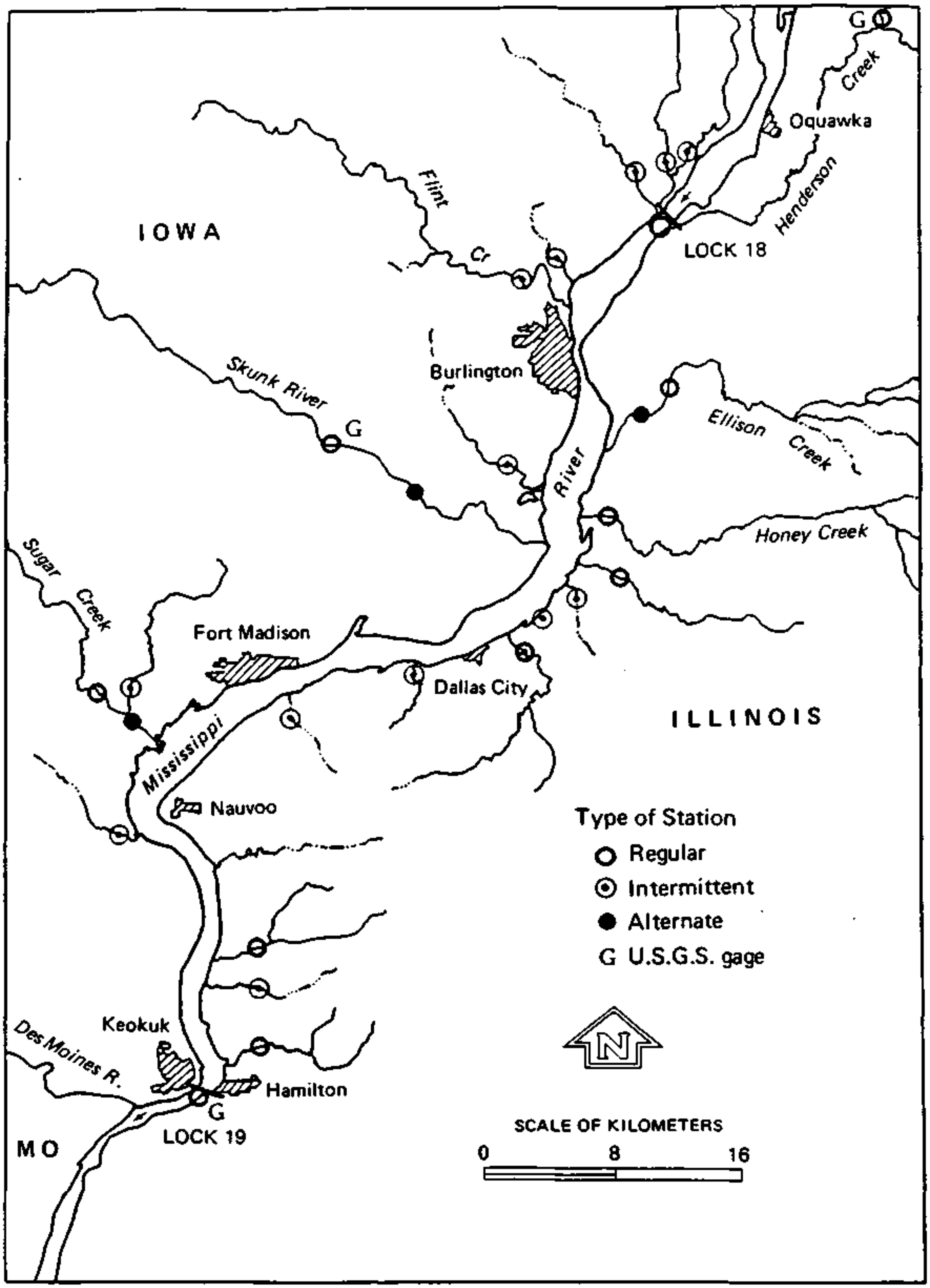

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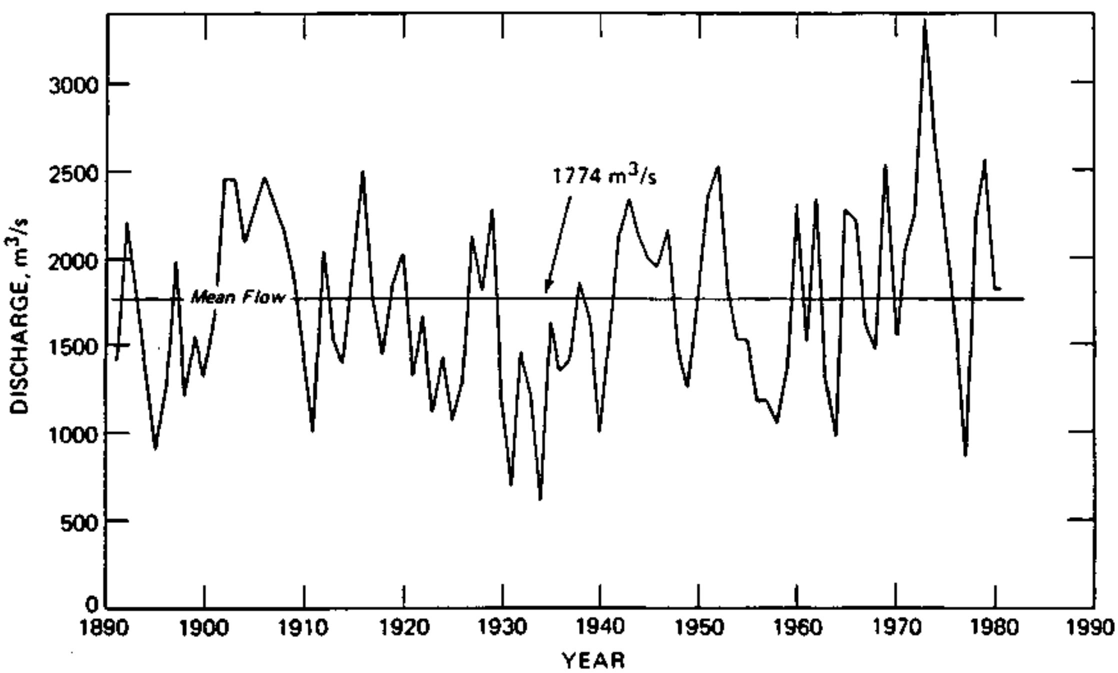

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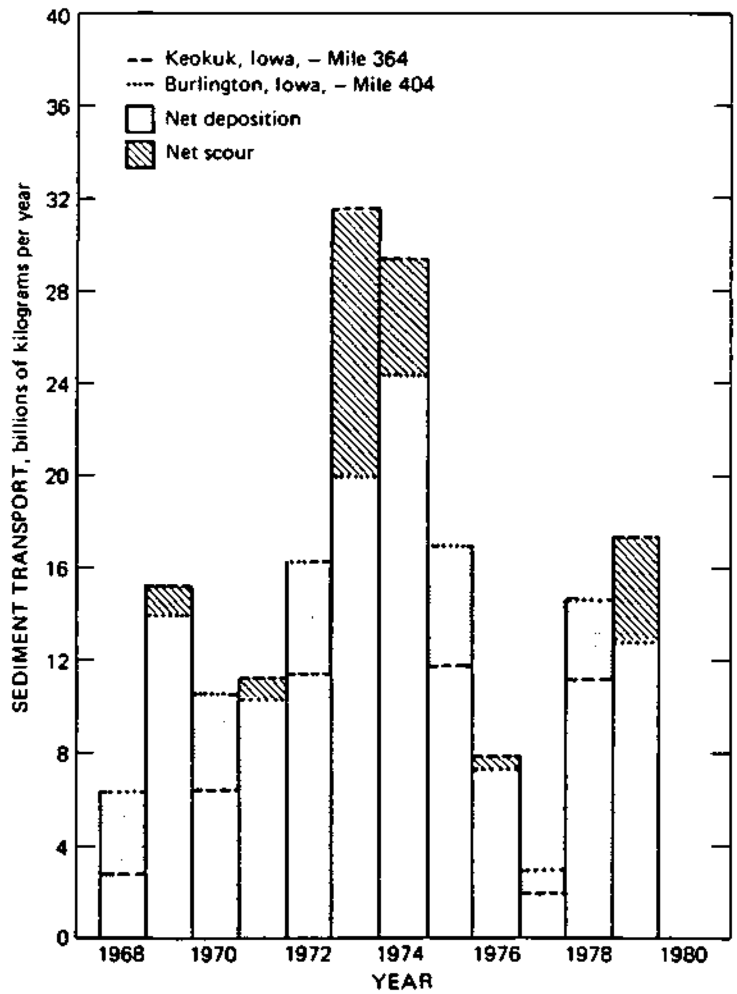

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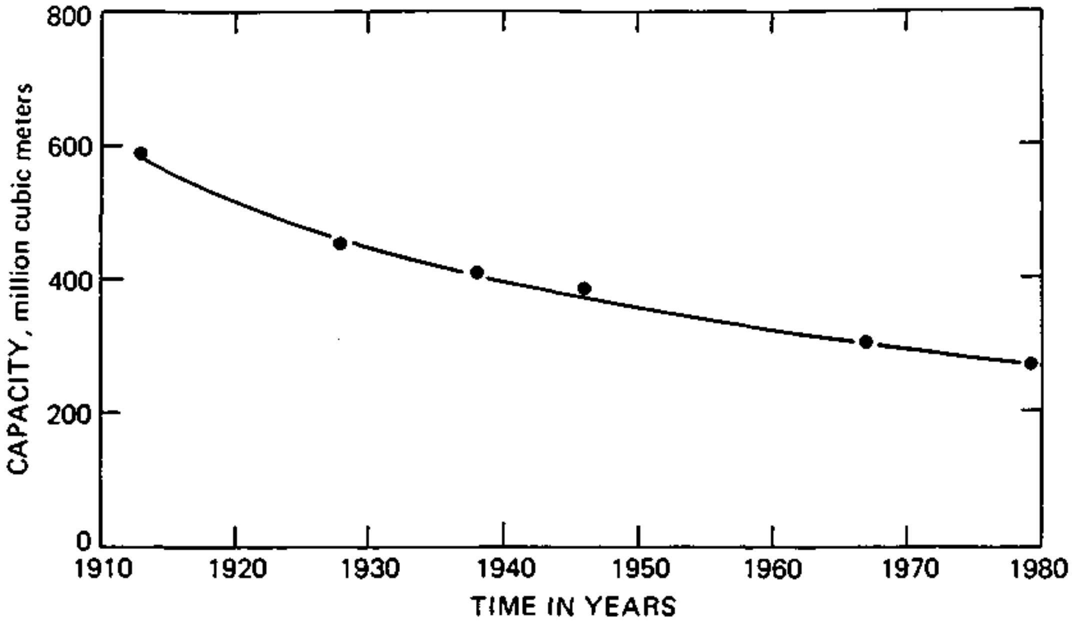

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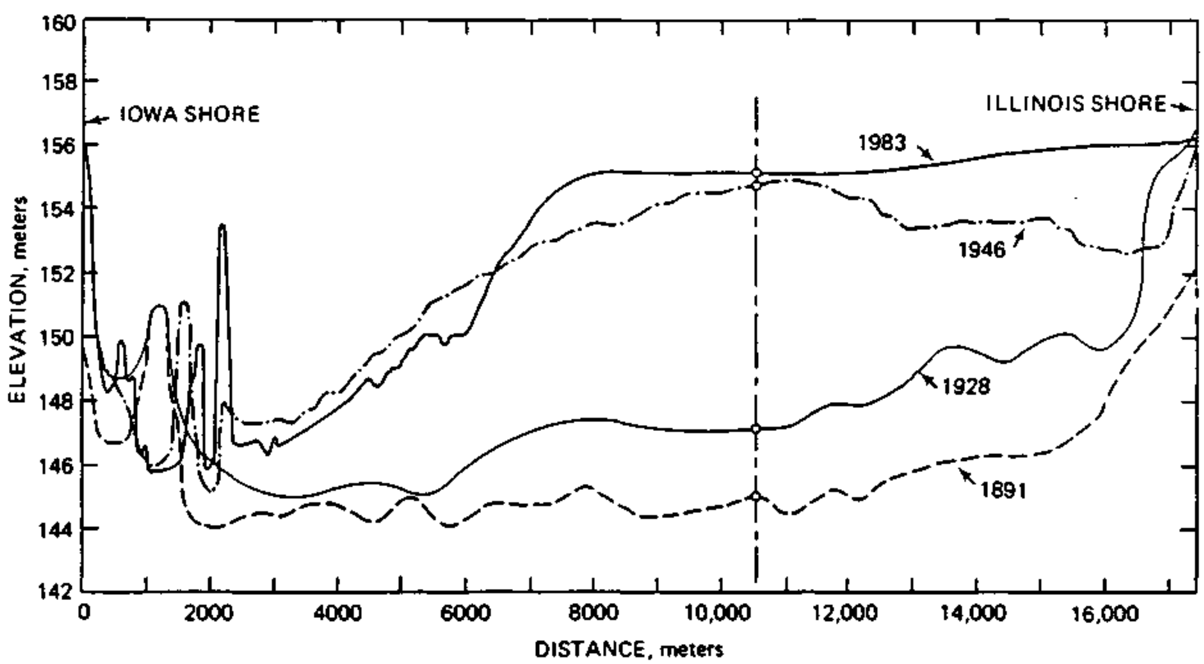

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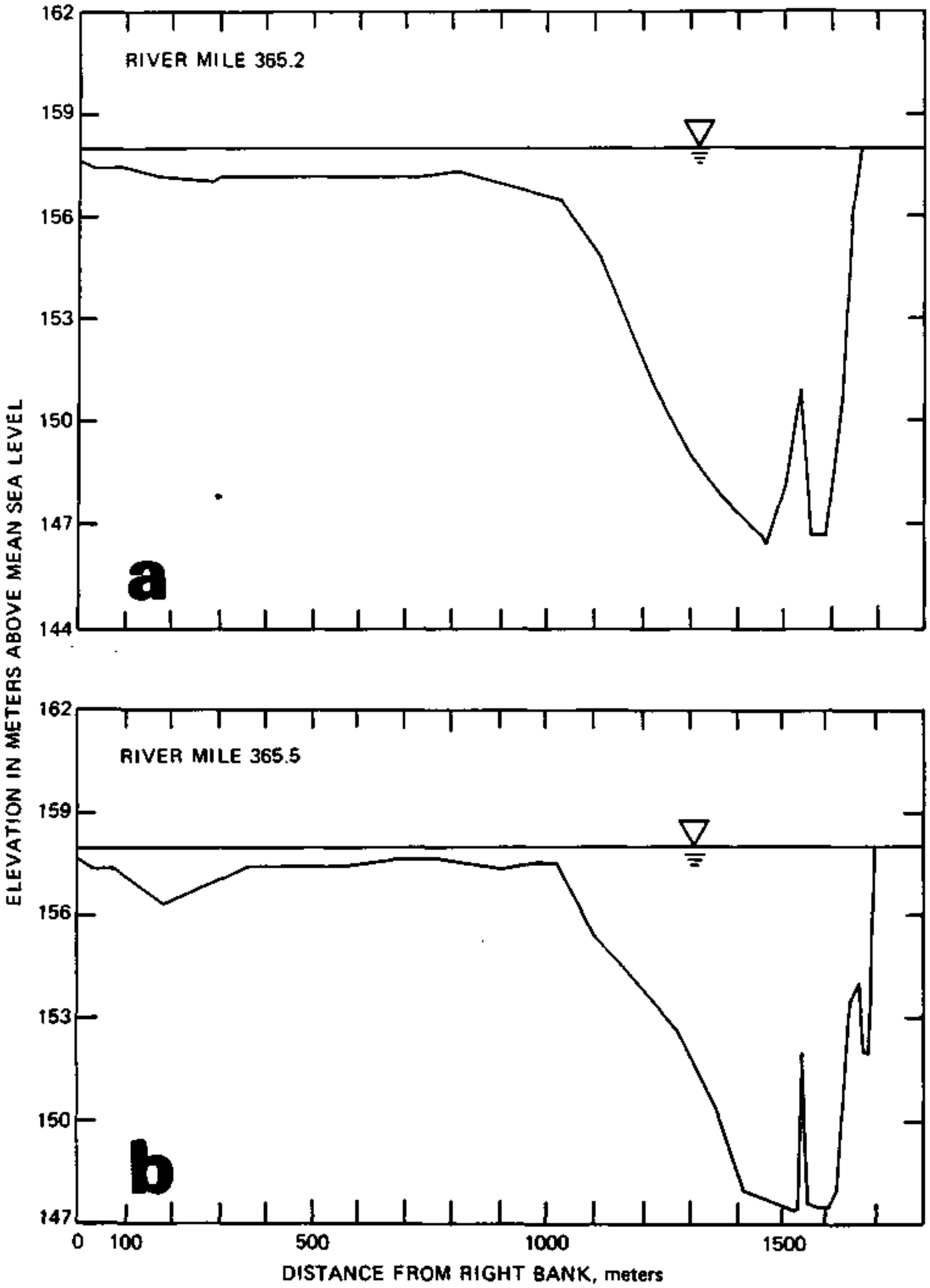

Figure 7. 1984 cross sections at a) river mile 365.2 and b) river mile S6S.S

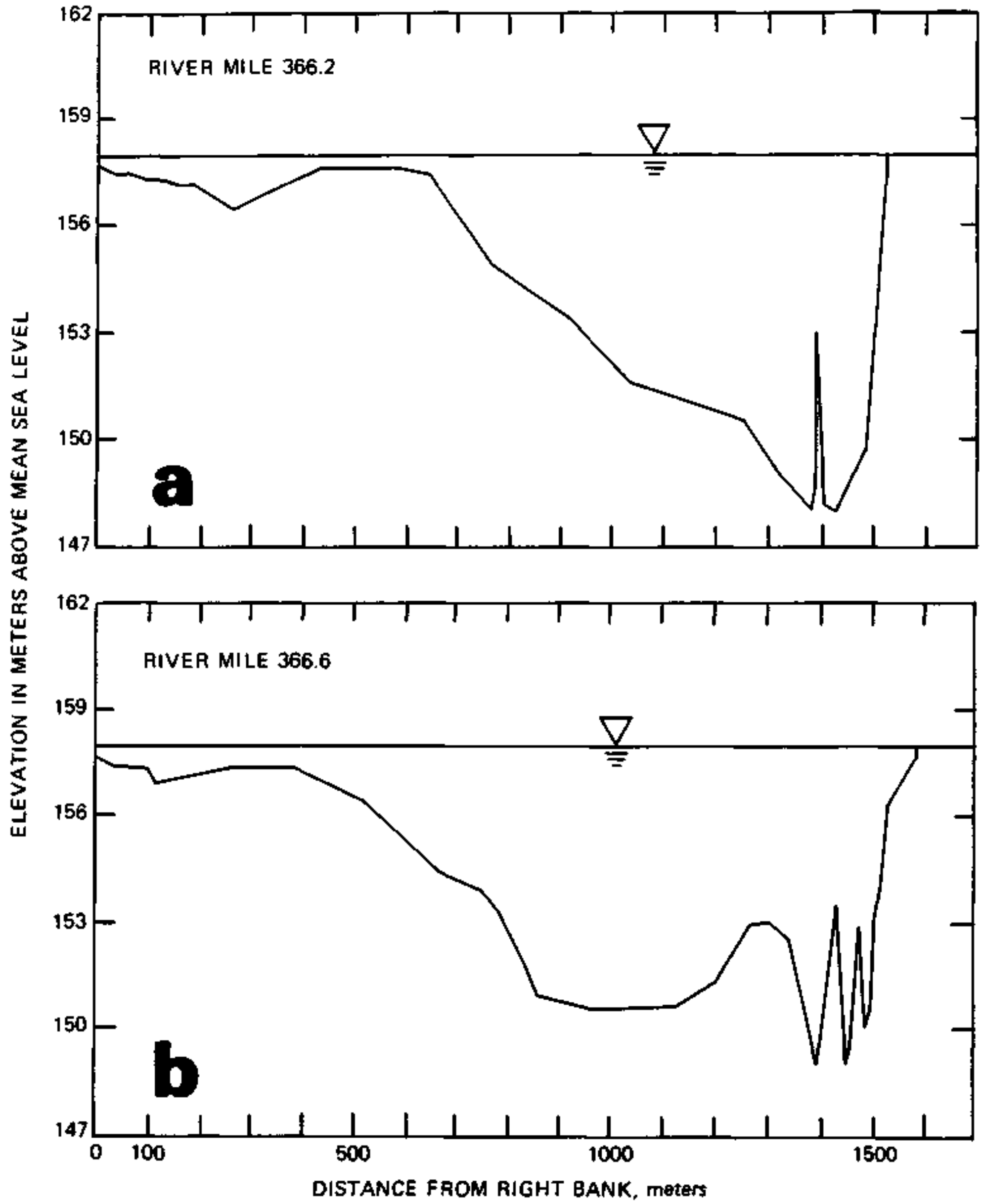

Figure 8. 1984 cross sections at a) river mile 266.2 and b) river mile 366.6

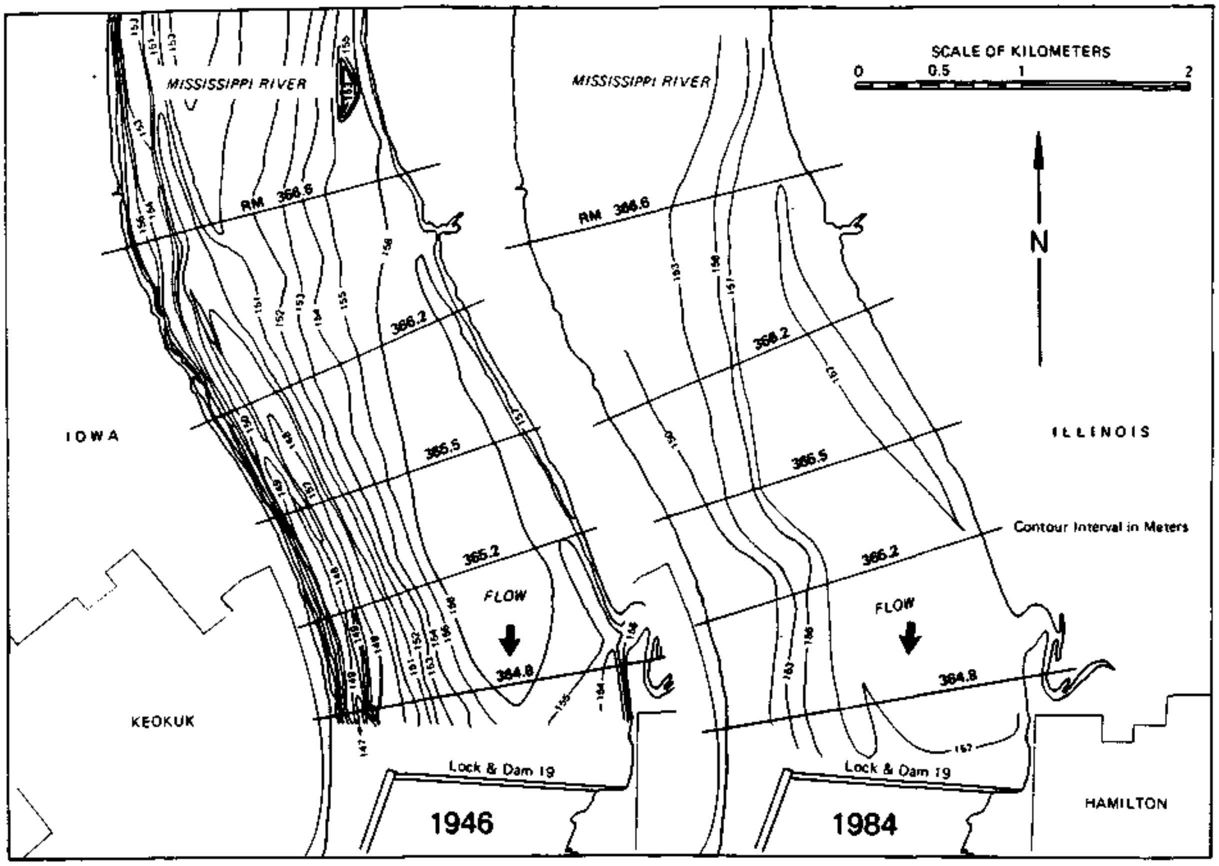

Figure 9. 1946 and 1984 bed contours of the Mississippi River above Look and Dam 19

also illustrates the effect of this scour during the 1973-1974 season. Therefore, with a proper design and plan, it is quite feasible to scour some of the deposited sediment from above the dam by opening the crest gates during high and median flows on the Mississippi River. Sluicing of the deposited sediment by opening gates or bottom sluices has been practiced in various parts of the world (USDA, 1942; Jiahua, 1960; Jiahua and Rujin, 1980; Parhami, 1986).

Knowledge of the hydraulics of flow of the Mississippi River and the sediment transport and sedimentation within a reservoir indicates that attempts can be made to determine if opening the gates will have the desirable impact of resuspending some of the deposited sediment. However, before such an attempt is made, a plan should be developed and implemented to evaluate the effectiveness of such a demonstration project.

Evaluation and Proposed Recommendations

It is recommended that a demonstration project be evaluated, with a follow-up report indicating the usefulness of such an operation. The evaluation will include an analysis of the existing data, collection and analyses of field data during the demonstration, and preparation of a report. An evaluation is essential in order to determine whether or not such an operation on a semi-permanent basis will have the desired effect of keeping a deeper channel open near the Illinois shore close to the city of Hamilton.

Data collection for such a project will include: bed elevation measurements at various cross sections before, during, and after the gates have been opened; suspended sediment load measurements at upstream and downstream sections during the demonstration project (to determine the net volume of sediment being scoured from above the dam); sediment analyses to determine particle size distribution and quality; and a determination of the discharges when the gates are opened.

On the basis of the analyses of the existing and collected data and also from an intimate knowledge of the hydraulics of flow and sediment transport characteristics of the Mississippi River, a set of recommendations will be made for implementation by the concerned agencies/authorities which will be useful in maintaining a deep channel near the city of Hamilton. It should be noted that such an alternative solution may also be quite feasible for many lakes and reservoirs in Illinois where excessive sedimentation is a major problem.

Time and Cost: The project will last for about 12 months with a total initial cost of about $45,000.

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