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QUINCY BAY: BACKGROUND ANALYSIS AND A PROPOSED PLAN OF ACTION

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Introduction

Quincy Bay is a complex backwater along the Mississippi River adjacent to the City of Quincy, Illinois. Hunting, fishing, and boating are common in the bay. Sediment accumulation in Quincy Bay has been a concern for many years. The change in water flow patterns and sediment deposition following the opening of a small boat access channel in the late 1960's has increased the concern. Local citizens have requested corrective action since 1975.

This report presents a summary of existing data, some of which has been provided by a citizens group. The available information is not adequate to determine the best means of alleviating the sedimentation problem. Thus, this report outlines a proposal to conduct a complete study of the hydraulics and sedimentation of Quincy Bay. This study would produce recommendations to alleviate the sedimentation problem.

Description of Quincy Bay

On most maps (USGS, 1971; Corps of Engineers, 1978) Quincy Bay is a 3-mile long by 400 to 2000 ft wide body of water extending north along the bluff line in Illinois from mile 327 above Cairo, Illinois on the Upper Mississippi River. The City of Quincy is located near the bay outlet. An associated complex of interconnected channels and small bays lies to the west of Quincy Bay proper. In this report, Quincy Bay refers to the entire area. The bay area is located in Adams County, Illinois and occupies all or portions of several townships in Township 1 south and Range 9 west. The bay outlet is at latitude 39°56'9" north and longitude 91°25' west.

The overall bay area is about four miles long by two miles wide, as shown in figure 1. The land areas are less than 10 ft above normal pool level and covered with willows and other scrubby trees. The total water surface area is about 525 acres. Triangle Lake contains 220 acres, of which about half is water and the rest is brush-covered dry land. Figure 1 was traced from the appropriate plates in "Soil Survey of Adams County, Illinois" (Bushue, 1979). This publication identifies soil types by drainage characteristics, parent rock, slope, and agricultural productivity. Erosion potential on the tributary watersheds can be estimated using this information.

Major tributaries include Cedar Creek, Frazier Creek, and Bear Creek which is the main ditch in the Indian Grave Drainage District. Drainage areas in acres are: Cedar Creek, 5100; Frazier Creek, 10,700; Indian Grave Drainage District, 17,700; and direct drainage, 2640. The direct runoff areas, Cedar Creek, and Homan Creek, a tributary of Frazier Creek with a drainage area of 4900 acres, are in the City of Quincy or residential areas north of Quincy. The remainder of the Frazier Creek watershed is rural. Most of the area of these watersheds is on top of bluffs which are about 100 to 150 feet high. A portion of the area is on the steep bluffs. The drainage district is entirely level bottomland in agricultural use and is leveed for flood protection. The outflow from the drainage district is pumped into Triangle Lake.

History

Indian Grave Drainage District was chartered in 1880. Its 17,900 acres included the area now in Triangle Lake. The USGS 15 minute

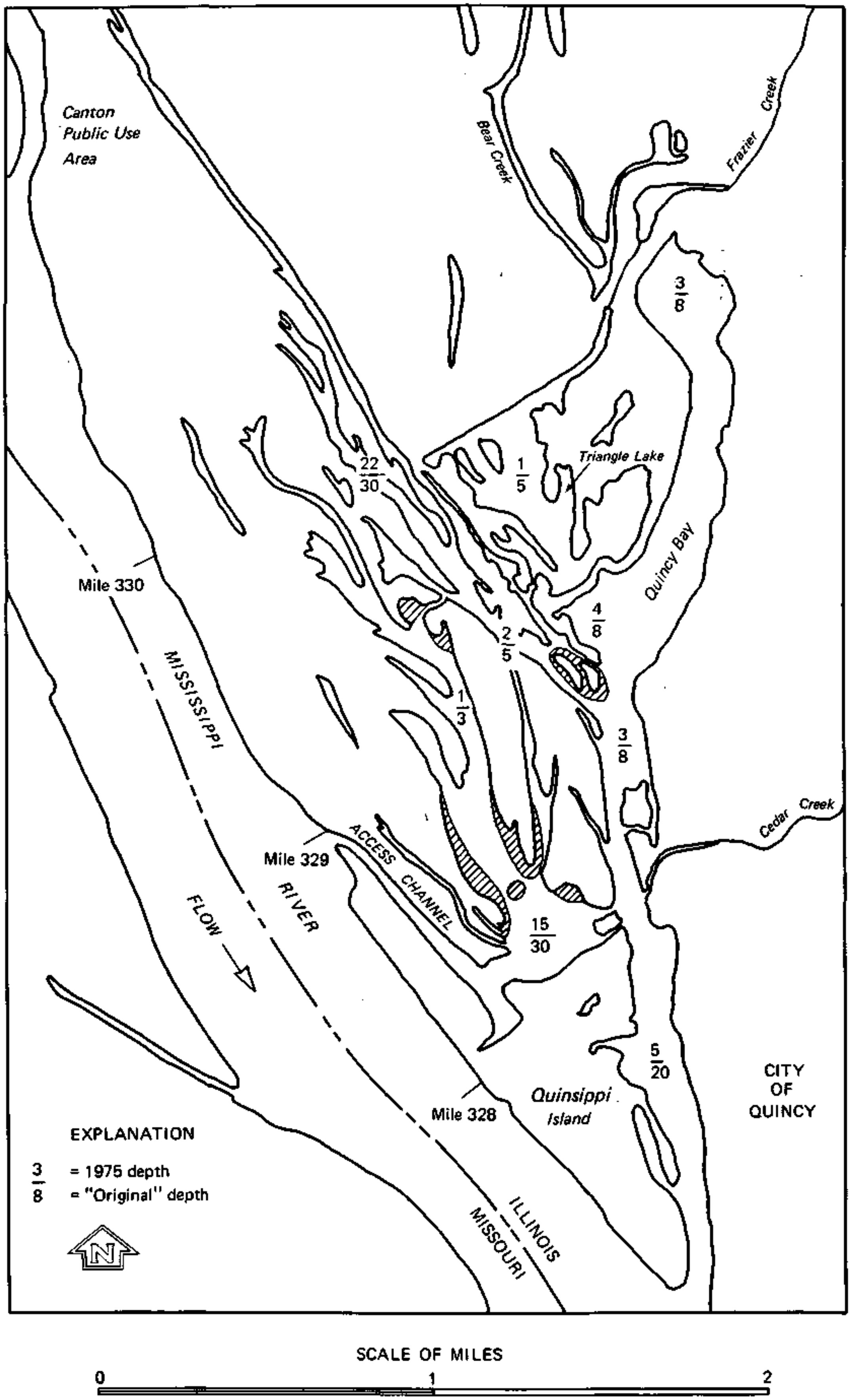

Figure 1. Map of Quincy Bay Area

quadrangle maps of 1925 and 1944 both show this location for the drainage district levees. Quincy Bay proper extends from the present outlet to the levee. None of the connected backwaters are shown on either map, even though the 1944 map was published 6 years after Lock and Dam 21 was placed in service in July, 1938. This navigation structure established a flat pool water surface elevation of 470 ft msl with a lift of 10.5 ft in the lock. With the lock and dam in operation, Quincy Bay became a backwater of the Mississippi River rather than the outlet channel for Bear Creek and Frazier Creek. Sedimentation in the upper part of Quincy Bay became a serious problem with average depths reduced from 8 ft to 3 ft by 1956 (Lymenstull, 1975). The 1944 topographic map shows Frazier Creek outside the Indian Grave Drainage District levee where the 1925 map shows Homan Creek entering the drainage district. Quincy Bay is about 1000 ft shorter on the 1944 map than on the 1925 map. To control this sedimentation problem, two new levees were constructed; one, within the drainage district, cut Triangle Lake off from the drained area. The pumping station discharge was diverted into Triangle Lake. The other new levee diverted the Frazier Creek outlet from Quincy Bay to Triangle Lake. Triangle Lake is a sediment trap for these inflows to the upper end of Quincy Bay, and the outlet from the lake enters the bay proper about a mile south of the discharge point before this change in flow pattern in the bay. This has slowed the sedimentation rate in the upper bay, but Triangle Lake has nearly filled with sediment since 1956.

In 1960, a new railroad crossing was built with high, fixed-span bridges over Quincy Bay and the Mississippi River. This new bridge across Quincy Bay is 1500 ft north of the old bridge which has been retained for access to a park area on Quinsippi Island. The new Mississippi River bridge is 500 ft north of the old bridge which was removed. The navigation channel was moved from the Missouri shore to the Illinois shore, requiring dredging 902,000 cubic yards of sand. The railroad grade was raised to an elevation near 535 ft above mean sea level (msl). Fill for the high embankment across Quinsippi Island was obtained from the backwater of Quincy Bay directly north of the railroad alignment. This left a hole with a water depth of about 30 ft.

In 1966 two recreation projects were undertaken. Squaw Chute small boat harbor was constructed on Quinsippi Island. The small boat channel called Quincy Bay Access was opened in 1966 (GREAT II, 1980). Since it was opened in 1966, the Quincy Bay Access Channel has been dredged as follows:

Year	Cubic Yards Dredged
1968	6741
1971	6053
1972	8028
1973	5063

This location is classified as a recurrent dredging site, and future dredging requirements are estimated to be 2500 cubic yards every three years. The work group report states: "Sedimentation in this channel is due to sediment flowing from the Mississippi River into the Quincy Bay Access where the water velocity is considerably slower. The reduction in the velocities causes sediment accretion and reduces the access channel depth." As described in the next section, this channel changed the pattern of water movement in Quincy Bay and the sedimentation problem is not limited to the channel itself, but occurs throughout the backwaters of the bay.

Since 1975, local boaters, fishermen, and duck hunters have been concerned about the rapid rate of shoaling in many chutes, bays, and sloughs within the entire Quincy Bay area. In 1975 they conducted a detailed hydrographic survey of Quincy Bay. The numbers on figure 1 are adopted from this effort (Lymenstull, 1975). The upper number is the average depth in 1975 and lower number is the original depth. The hatched areas in figure 1 were filled to above normal pool elevation of 470 ft msl. Several of the shallow areas, to the access channel and the railroad bridges, can be clearly seen in figure 2, which is a portion of one of the plates in Bushue (1979).

Hydrology and Hydraulics

The Mississippi River has a drainage area of 135,000 square miles at Lock and Dam 21. The average discharge is 68,150 cfs. The 1973 flood which has a recurrence period of about 200 years, set the record daily discharge of 408,000 cfs. Major tributaries to the Mississippi in Pool 21 are the Wayconda River in Missouri, drainage area 458 square miles and Bear Creek in Illinois, drainage area 349 square miles. The average flow in these two rivers totals about 450 cfs.

Quincy Bay receives water from 56.5 square miles of drainage area. Prior to opening the Small Boat Access Channel, this water flowed into the Mississippi through the bay outlet channel at low or normal stages. The access channel allows water to enter the bay complex two miles upstream of the outlet. This influx of Mississippi River water carries sediment into the bay which is deposited in various locations as the water flows through the complex of interconnected channels. Before the access channel was constructed, river stages less than elevation 474 ft msl caused water to

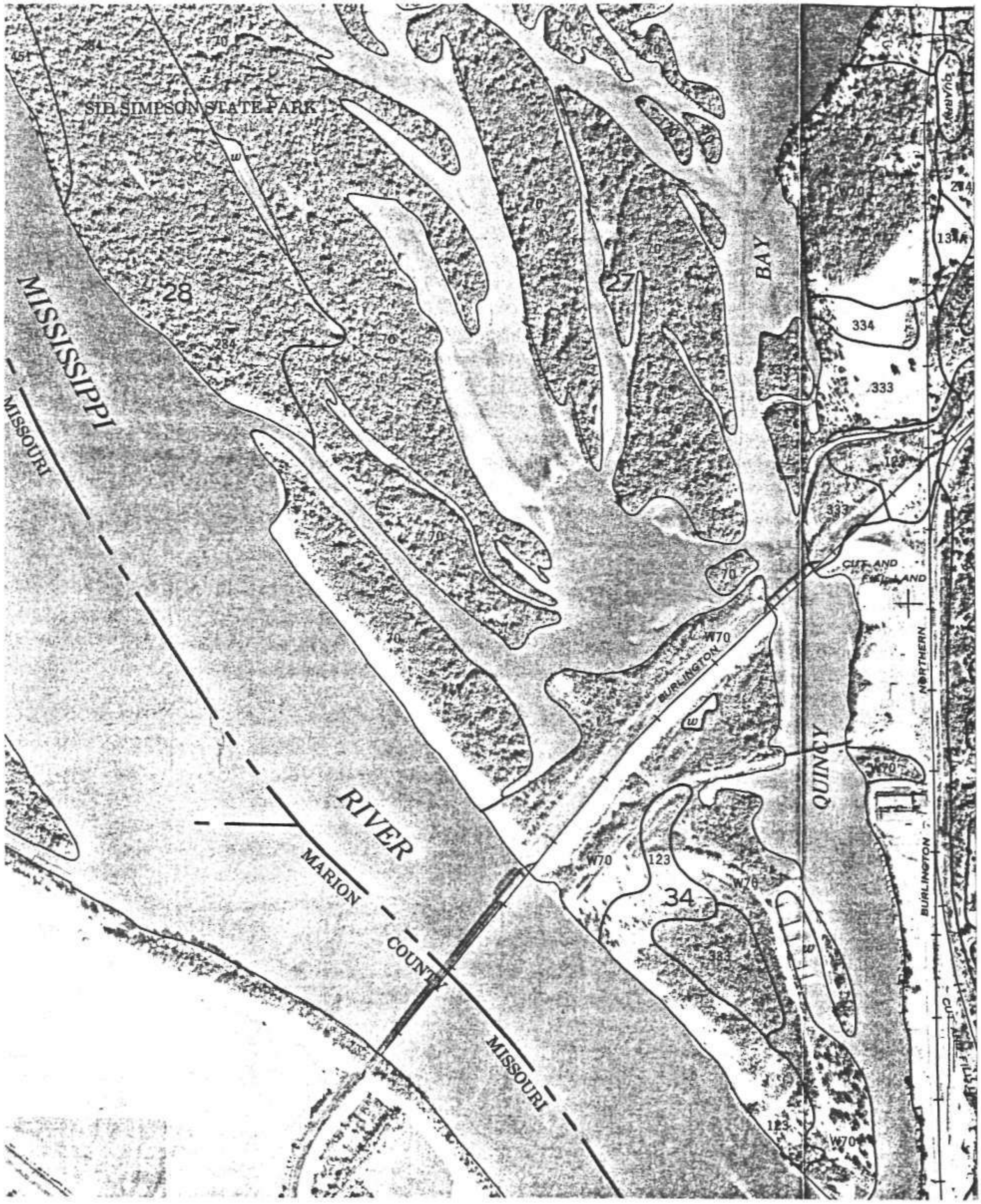

Figure 2. Aerial Photograph of Quincy Bay
(from Bushue, 1979)

flow into the bay through the outlet channel. For stages over 474 ft above msl at mile 332, river water flows into the Quincy Bay area near the Canton Chute Public Use Area (also called Knapheide Landing). According to stage-duration information (U.S. Army Engineer District, Rock Island, 1980) such conditions occur about 10 percent of the time. Thus, during major floods on the Mississippi River, the entire area is under water and scour and deposition may occur throughout Quincy Bay. The most likely areas for sediment deposition during floods are Triangle Lake and the upper portion of Quincy Bay proper and near the railroad embankment on Quinsippi Island.

The tributary flows and sediment transport into the bay are estimated from available data. The four nearby stream gage records in table 1 (USGS, 1981) were used to determine this relation between mean annual discharge and drainage area:

$$Q = 1.007\ A^{0.902}$$

in which Q is the discharge in cubic feet per second and A is the drainage area in square miles.

Table 1. Gaging Station Data

Stream	Location	Drainage area (sq mi)	Average discharge (cfs)	Length of record (years)
Bear Creek	Marcelline	349	197	36
Hadley Creek	Kinderhook	73	53	41
Bay Creek	Pittsfield	39	26	41
Bay Creek	Nebo	161	96	41

This equation yields average discharges of 13 cfs for Frazier Creek 20 cfs for Indian Grave Drainage District (Bear Creek), and 6 cfs for Cedar Creek.

The sediment load has not been measured for many Illinois streams. A sediment budget study on the Mississippi River has been done by the Iowa Institute of Hydraulic Research (Nakato, 1981). Nakato gives an annual sediment discharge of 18,200 tons for Bear Creek near Marcelline. This is 521 tons per year per sq mi. He discusses sediment yield ratios, and found that the average sediment load was about 7 percent of the Soil Conservation Service Erosion Estimate for the drainage basin. This delivery ratio is important if a detailed erosion estimate is made and used to determine the sediment load in a stream. Since determining the soil erosion potential is well beyond the scope of this report, a regional estimate of sediment yield was used. The Upper Mississippi River Comprehensive Basin Study (1970) presents a relationship between average annual sediment yield in tons per square mile and drainage area for areas with different erosion potential because of soil type, slope, cover, and precipitation. Using the information in this report (UMRCBS-CC, 1970), the estimated annual sediment yields are: 1100 tons per sq mi, or 18,900 tons for Frazier Creek and 8800 tons for Cedar Creek; and 2200 tons per sq mi, or 65,000 tons for Indian Grave Drainage District. Using the exponent from the UMRCBS report and the Bear Creek annual sediment yield in tons per square mile for its drainage area, another set of estimates of annual sediment yields are: Frazier Creek, 775 tons per sq mi and 12,900 tons; Cedar Creek, 850 tons per sq mi and 6800 tons; and Indian Grave Drainage District, 725 tons per sq mi and 20,100 tons. This range of estimates is typical rather than unusual for sediment yield computations. Thus, field data are necessary to determine the sediment yield closely enough to develop a mitigation or improvement plan.

The approximately 4 sq mi draining directly to Quincy Bay probably contributes about 4 cfs on a yearly average. However, much of this area, as well as part of the Cedar Creek drainage area, is in the City of Quincy. Thus, runoff and sediment yield estimates are extremely difficult to make and are affected by the storm sewer system and the amount of impervious area. Using the same sources as above, the annual sediment yield from this area is probably between 900 and 2200 tons per sq mi or between 3200 and 9000 tons.

These estimates of water and sediment fluxes into Quincy Bay are accurate within the limitations of hydrologic computations for ungaged streams. There is no way to estimate the water or sediment movement in the bay area during a flood on the Mississippi River which inundates most of the lowland area within the bay area. The diversion of Frazier and Bear Creeks into Triangle Lake has reduced the rate of deposition in the upper portion of Quincy Bay proper but has deposited sufficient sediment in Triangle Lake to convert about half of it to dry land at normal pool elevation. The access channel has changed the water and sediment flow patterns in much of the bay and has resulted in rapid accumulation of sediment in places where the water velocity reduces or eddies are formed.

The limited amount of data available limit us to only rough estimates of the sources, quantities, and deposition of sediments in the bay. Hence, it is difficult to make specific recommendations to solve the problem. In fact, there is a chance that only temporary, or even ineffective measures would be proposed and executed. For example, dredging might be required every few years, or a change in flow pattern could move the problem to a new location. The choice of a permanent, hydraulically and ecologically sound solution depends on accurate data.

Proposed Plan of Study

Several types of investigation would contribute to our understanding of the hydrology and sedimentation of Quincy Bay. The studies outlined here may be done individually or as components of a comprehensive research project. Depending on the completeness of the investigations, remedial or mitigative measures can be recommended. Three studies, each labeled as a "component", are described in the order of necessity to resolve the questions about the sedimentation in Quincy Bay.

A precise sediment survey will clearly identify areas which need to be dredged and areas which can be protected from future sediment deposition. This can be combined with the data collected by concerned sportsmen (Lymanstull, 1975) and, if obtainable, data collected by investigators from Quincy College to determine sedimentation rates and the loss of volume since these surveys were conducted. The second component would be the suspended sediment transport study. It would be the longest and most expensive. Suspended sediment transport rates would be measured for 20 months on the major tributaries to Quincy Bay and in the access channel and outlet channel. This would allow determination of the amount of suspended sediments entering the bay from each source, the amount leaving the bay, and the amount deposited or scoured in the bay. The third component would be the erosion potential study. In it, we would identify land areas where land management practices should be improved to reduce the sediment flow into the bay. In conjunction with the suspended sediment study, this will determine sediment delivery ratios for the tributary watersheds.

Component A: Sedimentation Survey

Standard State Water Survey methods which follow Soil Conservation Service procedures (1968) would be used to measure the depth of water on about 125 cross sections in Quincy Bay. About 260 points would be surveyed and monumented to mark these cross sections. Sixty monuments will be permanent concrete markers which will be the basis for possible future sedimentation surveys. The remainder of the points will be marked temporarily because of the nature of the land in Quincy Bay and to reduce costs.

In addition to determining the hydrography of Quincy Bay, bed material samples will be obtained. Bed material particle size distributions and unit weights will be determined by the Water Survey's Sediment and Materials Laboratory. Particle size distributions will indicate the type and likely source of the bed material. Unit weights will be determined at several depths along a core sample of the upper one meter of the sediment to show the amount of compaction which has taken place.

This investigation will take six months. If the cross sections were determined and surveyed beginning in July 1983, the final report would be completed by the end of December 1983. Using students from Quincy College as field assistants, the sedimentation survey is estimated to cost $26,642. This includes indirect costs of 10 percent, which assumes funding from the State of Illinois. The Water Survey would contribute $8000 in personnel and use of equipment. If federal funds were available instead of state funds, the indirect costs would be 42.4% of the direct costs.

Component B: Suspended Sediment Transport

The sedimentation survey will determine the present water volume of Quincy Bay and the sediment deposition which has occurred since 1975.

However, this sedimentation is the end result of a continuous process of movement of sediment into, through, and out of the bay. In some areas, the usual condition involves deposition, in others scour takes place, and in others the net result of alternate periods of scour and deposition is a fairly constant average bed elevation. This study of the rate at which suspended sediment enters and leaves Quincy Bay will provide a quantitative determination of the sources of sediment entering the bay. Erosion and transport of soil particles by fluvial processes is a major problem in Illinois, yet very little quantitative information is available.

This component is planned for two years. Field data collection will be scheduled to include two springs when high discharges of water and sediment occur. Where bridges are available, depth-integrating, isokinetic suspended sediment samplers will be installed to be used by local observers. The four bridge sampling sites will be on Bear Creek, Frazier Creek, Cedar Creek, and the old railroad bridge across Quincy Bay proper. A bridge location might also be located on Homan Creek to separate the Frazier and Homan Creek sediment loads. Ideally, three sampling sites would be located on Frazier and Homan Creeks: one on each creek above the confluence and one below the confluence. The one site on Frazier Creek below Homan Creek is sufficient for this study of sediment transport into Quincy Bay. The access channel and bay outlet will be sampled using similar equipment mounted in a boat.

Samples will be collected daily for 90 days in the spring and weekly throughout the year. Ice in the winter and major floods will prevent sampling. Local observers will be instructed in proper sampling techniques and all equipment and supplies will be provided by the Water Survey. Observers are reimbursed for each sample collected. The stipend for sampling from a boat is intended to cover boat operating expenses. A skilled technician will install the sampler and staff gage on each bridge. He will also measure water and sediment discharge at each site approximately monthly. All samples will be analyzed for suspended sediment concentration by the Water Survey Sediment Laboratory. When practical, samples for particle size distribution analysis will also be obtained by the technician. The annual number of samples collected and analyzed is expected to be 1500 for concentration and 50 for particle size. The methods used by the Water Survey follow U.S. Geological Survey standard practice (Guy and Norman, 1970).

Recommended timing would begin the project in September 1983. The sampling sites would be selected and sampling equipment installed. Observers would be hired and trained. Weekly sampling would begin and continue until freeze-up. Sampling would begin in spring 1984 as soon as the ice has melted and the river is safe for small boats. Sample collection would continue until the end of May 1985. A progress report would be prepared in August 1984 and a final report would be prepared in August 1985.

As outlined, this project would cost $82,119. The value of personnel and equipment contributed by the Water Survey would total $25,278.

Component C: Watershed Erosion Potential

Erosion of soil particles from the land surface by rainfall and sheet or rill flow is the beginning of sediment transport. The Universal Soil Loss Equation (Wischmeier and Smith, 1974) is generally used to estimate the soil erosion from a given parcel of land or watershed. A technial note details use of this equation in Illinois and will be a primary source of methodology for this study (Soil Conservation Service, 1974). The data needed to use this method is available in Bushue (1979) and climate data summaries. Land use will be verified by field inspection. The necessary data will be entered into computer files for application of the equation. This is a six month project and the results will be presented in report. This estimate of soil erosion potential and the suspended sediment load measurements in Component B will yield an accurate sediment yield ratio for the watersheds which drain to Quincy Bay. The project cost is $5837 and the Water Survey contribution of personnel is $3760. July 1, 1984 to December 31, 1984 will be the time period for this component.

Discussion

The Water Survey believes that the background information presented and interpreted in this brief report are very important. They highlight the fact that a detailed investigation of the sediment transport and deposition in Quincy Bay is needed in order to wisely resolve the sediment problems. Unfortunately, such an investigation cannot be undertaken by the Water Survey with our present resources. Additional funding would be required to initiate the studies outlined herein. If this proposed plan of action appears viable, Water Survey engineers and scientists will prepare a formal proposal for submittal to an appropriate sponsoring agency.

REFERENCES

Bushue, L.J., 1979. "Soil Survey of Adams County, Illinois," U.S. Department of Agriculture, Soil Conservation Service and Illinois Agricultural Experiment Station.

GREAT II, 1980. "Dredging Requirements Work Group Appendix."

Guy, Harold P. and Vernon W. Norman, 1980. "Field Methods for Measurement of Fluvial Sediment," Book 3, Chapter C2 in Techniques of Water Resources Investigations, U.S. Geological Survey.

Lymenstull, A.J., 1975. "Priorities on Quincy Bay Area," prepared for a meeting on June 17, 1975.

Nakato, Tatsuaki, 1981. "Sediment-Budget Study to the Upper Mississippi River, Great II Reach," Iowa Institute of Hydraulic Research, Report No. 227.

Rock Island District, U.S. Army Engineers, 1980. "Lock and Dam No. 21," Appendix 21, Master Reservoir Regulation Manual.

Soil Conservation Service, 1968. "Sedimentation," Chapters 1, 2, and 7; in National Engineering Handbook, Section 3, U.S. Department of Agriculture.

Soil Conservation Service, 1974. "Resource Conservation Planning Technical Note-IL-4, Universal Soil Loss Equation.

U.S. Geological Survey, 1981. "Water Resources Data for Illinois, Volume 1. - Illinois except Illinois River Basin," Water Data Report IL-80-1.

Upper Mississippi River Comprehensive Basin Study Coordinating Committee, 1970. Volume III, Appendix 6: "Fluvial Sediment."

Wischmeler, W.H. and D.D. Smith, 1978. "Predicting Rainfall Erosion Losses - A guide to Conservation Planning." U.S. Department of Agriculture, Agricultural Handbook. No. 537.