Long Term Resource Monitoring Program

Technical Report
2004-T004

A Suspended Sediment Budget for Pool 13 and La Grange Pool of the Upper Mississippi River System

September 2004

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A Suspended Sediment Budget for Pool 13 and La Grange Pool of the Upper Mississippi River System

by

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Final Report to
U.S. Army Corps of Engineers
Rock Island, Illinois

for
Long Term Resource Monitoring Program
Scope of Work 3.4
(Suspended Sediment Budgets for Pool 13 and La Grange Pool)

September 2004

Suggested citation:

Gaugush, R. F. 2004. A suspended sediment budget for Pool 13 and La Grange Pool of the Upper Mississippi River System. Final report to U.S. Army Corps of Engineers. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. September 2004. LTRMP 2004-T004. 13 pp. + Appendixes A–D.

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Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Upper Midwest Environmental Sciences Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This report supports LTRMP Operating Plan (U.S. Fish and Wildlife Service 1993) Task 1.2.1.2 *Select Processes for Research*, and Tasks 1.2.1.3, *Establish Experimental Design*, under Strategy 1.2.1, *Determine Effects of Sedimentation and Sediment Transport Processes on the Upper Mississippi River System Ecosystem.* This report was developed with funding provided by the Long Term Resource Monitoring Program.

A Suspended Sediment Budget for Pool 13 and La Grange Pool of the Upper Mississippi River System

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(Suspended Sediment Budgets for Pool 13 and La Grange)

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Abstract: The suspended sediment budget for Pool 13 of the Mississippi River and La Grange Pool of the Illinois River was examined over a 3-yr period (October 1995 through September 1997). Pool 13 output was between 3.07 and 3.64 million t (metric tons) of suspended sediment annually during the study period. Loads to Pool 13 were dominated by those delivered by the Mississippi River (76%, 74%, and 66% in the 1995, 1996, and 1997 water years, respectively). Pool 13 exhibited sediment export (output greater than input) in 1995, a balance in 1996, and marked sediment trapping (output less than input) in 1997. Within the three study years, Pool 13 received its highest water and sediment loads during spring (March through May) and this period was marked by sediment export. Suspended sediment loads were trapped during the remainder of the year. La Grange Pool output was between 3.71 and 5.04 million t of suspended sediment annually during the 1995–97 water years. The Illinois River accounted for less than 50% of the suspended sediment load to the pool (19%, 25%, and 45% in the 1995, 1996, and 1997 water years, respectively. La Grange Pool exhibited considerable sediment trapping in 1995 whereas the 1996 and 1997 water years were much closer to a balance wherein output was within 5% of input. Generally, La Grange Pool received its largest water and sediment loads during the late spring–early summer period (April through June), but in 1997 the late winter loads predominated. In all years, La Grange Pool trapped the sediments during these high discharge, high loading periods and exported suspended sediments for the remainder of the year. The distinct differences in the manner in which these pools process suspended sediment loads may be related to the considerable differences between the morphometry of these pools.

Key words: La Grange, Mississippi River, Pool 13, river, sediment budget, sediment load

Introduction

The Upper Mississippi River System (UMRS), defined as the navigable portions of the Mississippi and Illinois Rivers, has been directly affected by human activities (activities in the river channel itself, rather than in the watershed) such as the construction of wing dams and side channel closing structures for at least 120 yrs, but the most severe alteration occurred with the construction of a series of locks and dams in the late 1930s. Initially, impoundment of these rivers created a very diverse mosaic of physical features such as islands, braided channels, and backwater lakes. On the Mississippi River, the construction of the navigation system created a series of shallow impoundments occupying most of the floodplain. Whereas the initial filling of these areas was seen as a boon to the overall physical heterogeneity, it was soon apparent that the hydrological changes brought about by impoundment were having considerable effects on sedimentation processes (Fremling and Claflin 1984). A general pattern was observed involving island loss and excessive backwater sedimentation. This erosion of high points and filling in of low points led to a considerable loss of physical heterogeneity. Essentially the same process (impoundment) that led to their creation would also be responsible for the demise of the islands, braided channels, and backwater lakes. Similar changes have been observed in the Illinois River (Sparks 1984). Increased sedimentation, primarily in off-channel areas, has for some time been recognized as a major concern and has been identified as one of the primary threats to the ecological resources of the Upper Mississippi River (Great River Environmental Action Team 1980).

Most previous sediment budget studies on the Mississippi and Illinois Rivers have focused on large-scale (a long reach or the entire river) and have been based on relatively few data. Nakato (2000) assembled the available data and developed a sediment budget, which included estimates of bedload, for Pools 11–26 on the Mississippi River for two long periods: post-impoundment to the mid-1950s and mid-1950s to the present. A major finding of Nakato's study (2000) was that sediment loading is lower in the more recent period. Demissie et al. (2003) produced a sediment budget for the Illinois River for 1981–94. Data from the Illinois River indicated that, on the average, 12.4 million t (metric tons; 1 metric ton = 1,000 kg) of sediment are delivered to the system every year and the system exports an average of 5.3 million t. Approximately 7.2 million t are stored in the system.

A workshop held in 1994 identified the serious need to develop pool-scale sediment budgets for the navigation pools of the UMRS (Gaugush and Wilcox 1994). Pool-scale budgets wherein the in-pool processes were viewed as a "black box" were seen, collectively, as a necessary first step in developing an understanding of sediment processing in the UMRS. Pool 13 on the Mississippi River and La Grange Pool on the Illinois River were chosen as the first sites for this type of study. The objectives of this study were to

1. determine the suspended sediment budget in two distinctly different navigation pools of the UMRS;
2. determine if the budgets were dominated by sediment storage (input greater than output), a quasi-equilibrium (input ≈ output), or export (output greater than input); and
3. examine the relation between sediment mass flux and the annual dynamics of water discharge.

Study Area

Pool 13

Pool 13 is between river miles 522.5 and 556.8 (measured from the confluence with the Ohio River) on the Mississippi River (Figure 1). Pool 13 is 1 of 26 pools formed by a series of locks and dams constructed in the late 1930s to maintain a 9-foot channel as an aid to commercial navigation. Construction of Lock and Dam 13 was completed in 1938 and placed in operation in 1939 (U.S. Army Corps of Engineers 1980). Four small rivers discharge into Pool 13: the Maquoketa and Elk Rivers on the Iowa (western) side of the pool and the Apple and Plum Rivers on the Illinois (eastern) side. Eight additional minor streams also discharge into Pool 13. Mean discharge

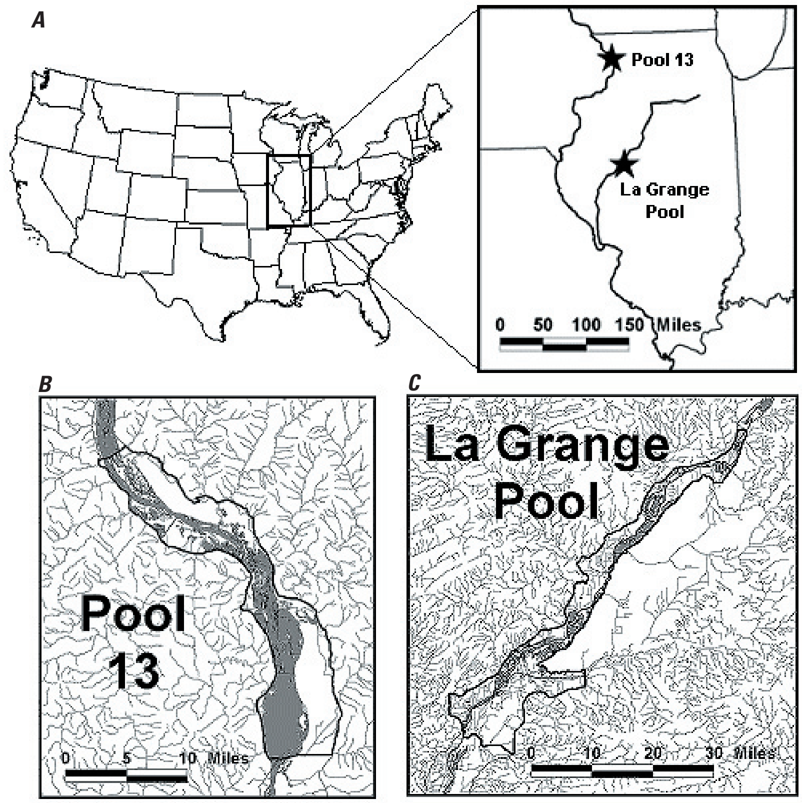

Figure 1. Map of the Upper Mississippi River System: (*A*) location of the two pools in the upper Midwest of the United States; (*B*) Pool 13; and (*C*) La Grange Pool.

from Pool 13 is 1379 m^3 s^{-1} for the period of record (1873–1997) and time of travel for water is approximately 10 h during normal operation. Pool 13 is in an extended valley segment, the walls of which are erosion resistant limestone and dolomite formations (Knox 2000). A narrow bedrock gorge ends in the upper reach of Pool 13. The generally flat floodplain is 2.4 km wide at the upper end of Pool 13 and widens to almost 6.4 km at the lock and dam.

La Grange Pool

La Grange Pool is between Illinois River miles 80.2 and 157.7 (measured from the confluence with the Mississippi River; Figure 1). La Grange Pool is one of six pools on the Illinois River formed by impoundment with locks and dams to support commercial navigation. As with the system on the Mississippi River, these structures were constructed to aid in the maintenance of a 9-foot navigation channel. The Illinois Waterway serves to provide a commercial navigation connection between the Mississippi River and Lake Michigan. The lock and dam that forms La Grange Pool is the most downstream of the nine locks and dams forming the Illinois Waterway. La Grange Lock and Dam were constructed and put into operation in 1939 (U.S. Army Corps of Engineers 1986). Four significant rivers enter La Grange Pool: the Spoon and La Moine Rivers on the northern side and the Mackinaw and Sangamon Rivers on the southern side. Mean discharge for the period of record (1939–97) is 645 m^3 s^{-1} and the mean travel time for water is 24–36 hours. La Grange Pool occupies the ancient course of the Mississippi River, which accounts for its low gradient and large valley width (Knox 2000). The main channel is relatively narrow and uniform with only a slight widening at the lock and dam. An extensive series of levees separate most of the floodplain from the Illinois River.

Methods

Pool 13 was allocated six gaging sites, one upstream of the pool on the Mississippi River, one downstream of the pool, and one each for the four major tributaries to the pool (Figure 1). Gaging stations (Table 1) were established on the Mississippi River at the next upstream lock and dam, the Apple and Plum Rivers on the Illinois (eastern) side, the Maquoketa and Elk Rivers on the Iowa (western) side, and the Mississippi River below Lock and Dam 13. Drainage area is 221,695 km^2 at the most downstream station, 96.3% of which is contributed by the Mississippi River and less than 2.5% by the four gaged tributaries (Table 2). Only 1.3% of the drainage area was not gaged.

La Grange Pool was allocated six gaging sites, one upstream of the pool on the Illinois River, one downstream of the pool, and one each

Table 1. U.S. Geological Survey station names and station codes for the gaging stations used in developing the suspended sediment budget for Pool 13.

Station name	Station code
Mississippi River at Lock & Dam 12 at Bellvue, Iowa	05416100
Apple River near Hanover, Illinois	05419000
Plum River at Savanna, Illinois	05420100
Maquoketa River near Maquoketa, Iowa	05418500
Elk River near Altmont, Iowa	05420300
Mississippi River at Clinton, Iowa	05420500

Table 2. U.S. Geological Survey station names and station codes for the gaging stations used in developing the suspended sediment budget for La Grange Pool.

Station name	Station code
Illinois River at Pekin, Illinois	05563800
Mackinaw River near Green Valley, Illinois	05568500
Spoon River at Seville, Illinois	05570000
Sangamon River near Oakford, Illinois	05583000
La Moine River at Ripley, Illinois	05585000
Illinois River at Valley City, Illinois	05586100

Table 3. Drainage areas for Pool 13.

Source	Drainage area (km2)	Proportion of total (%)
Mississippi River above Pool 13	213,408	96.3
Apple River	640	0.3
Plum River	707	0.3
Maquoketa River	4,022	1.8
Elk River	145	0.1
Total gaged input	218,920	98.8
Ungaged	2,772	1.3
Output for Pool 13	221,695	

Table 4. Drainage areas for La Grange Pool.

Source	Drainage area (km2)	Proportion of total (%)
Illinois River above La Grange Pool	37,775	54.5
La Moine River	3,349	4.8
Mackinaw River	2,779	4.0
Sangamon River	13,190	19.0
Spoon River	4,237	6.1
Total gaged input	61,330	88.5
Ungaged	7,932	11.5
Output for La Grange Pool	69,262	

for the four major tributaries to the pool (Figure 1). Gaging stations (Table 3) were established on the Illinois River below the next upstream lock and dam, the Spoon and La Moine Rivers on the northern side of the pool, the Sangamon and Mackinaw Rivers on the southern side of the pool, and the Illinois River below the La Grange Lock and Dam. Drainage area is 69,262 km^2 at the most downstream station, of which 54.5% is contributed by the Illinois River above La Grange Pool and 34% by the four gaged tributaries (Table 4). Approximately 11.5% of the drainage was not gaged and represents the area between the tributary gaging stations and the pool, ungaged tributaries, and direct drainage into the pool.

At both pools, discharge gaging and suspended sediment sampling were conducted by the U.S. Geological Survey according to established U.S. Geological Survey/Water Resources Division (USGS/WRD) methods (Buchanon and Somers 1969; Guy and Norman 1982). Suspended sediment sampling at each gaging site consisted of approximately 250 samples per year with the samples taken weekly during base flow conditions and more frequent sampling during storm events. Discharge measurements were recorded continuously by automated equipment. This study was initiated in 1994 with site preparation and gage installation. Actual data collection began in October 1995. Sampling was terminated at the end of September 1997 after 3 yrs of data collection.

The USGS/WRD uses the continuous discharge data and the instantaneous suspended sediment concentration data to compute mean daily water discharge and daily suspended sediment loads for each gaging station. These mean daily data were used in this study to develop the water and suspended sediment budgets for Pool 13 and La Grange Pool. These data have been published in annual water data reports for Illinois and Iowa (May et al. 1996, 1997, 1998; Wicker et al. 1996, 1997, 1998).

Results and Discussion

Pool 13

The drainage area of Pool 13 is dominated by that area drained by the Mississippi River that contributes just over 96% of the total area. Of the remaining 3.7%, 2.5% is contributed by the four gaged tributaries of this study and 1.2% is ungaged. The predominance of the Mississippi River in terms of its contribution to the overall drainage area would suggest that the water and sediment budgets for Pool 13 will be influenced primarily by events or conditions above the pool and conditions directly surrounding the pool will have a lesser effect.

The water years of 1995, 1996, and 1997 were generally wetter than the long-term (1873–1997) average (Figure 2, upper), but still considerably drier than the major flood year of 1993. Discharges from the pool were greater than 125% of the mean daily discharge for the period of record. Input of water to Pool 13 is provided predominantly (generally about 95% of the amount discharged from the pool) by the Mississippi River. The gaged tributaries provide only about 3%.

As with most water budgets, there are some unknown (i.e., unmeasured) sources and losses of water from the pool. A typical assumption in the absence of data is that precipitation and evaporation are in balance (the amount input by precipitation equals the amount lost to evaporation). Another unknown source is the sum of all inputs from ungaged tributaries and direct runoff from the land adjacent to the pool and not drained by a stream. To estimate this source, one might assume that the ungaged contribution is directly proportional to the ungaged drainage area. This requires one further assumption, that the nature of the ungaged area (its land use, soil types, slopes, etc.) is similar to the features of the gaged tributaries. Given these assumptions, an export coefficient (amount of material exported divided by the drainage area) for the gaged tributaries can be calculated. This export coefficient multiplied by the ungaged drainage area provides an estimate of the ungaged contribution to the budget.

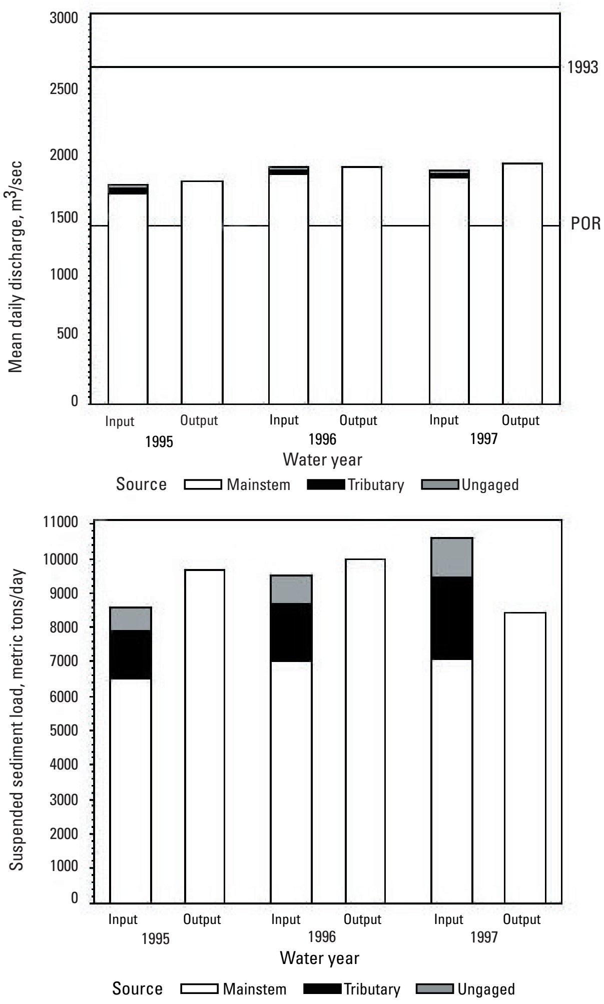

Figure 2. Annual water budgets (*upper*) and annual suspended sediment budgets (*lower*) for Pool 13. Horizontal reference lines indicate mean daily discharge at the downstream end of the Pool 13 study area for the period of record (POR, 1873–1997) and for the 1993 flood (1993).

Generating ungaged estimates in the above manner results in a water budget in balance (inputs = outputs) for all water years. There is less than a 1% difference between water input and water output for the 3 yrs studied (Figure 2, upper). Developing a water budget that is in balance (given the assumptions made) suggests that the sampling design and sample allocation should also provide adequate estimates for the suspended sediment budget.

Pool 13 exported between 8,500 and 10,000 t of suspended sediment on a daily basis during the 1995–97 water years (Figure 2, lower). The majority (76% in 1995, 74% in 1996, and 66% in 1997) of the sediment input to Pool 13 is supplied by the Mississippi River. Whereas the gaged tributaries only accounted for about 3% of the drainage area and discharge, they provided a greater portion (16% in 1995, 17% in 1996, and 22% in 1997) of the suspended sediment load. These loads are more than five times greater than would be expected based solely on these tributaries' contribution to the overall drainage area or water input.

The observation that the gaged tributaries contributed more to the sediment budget than would be expected based on either their drainage area or their water discharge suggests a difference in the relation between drainage area and sediment delivery. In other words, the local drainage area has a greater sediment delivery per unit area than the drainage area above the pool. This is not an unexpected result because, though the local drainage area (that area drained by tributaries that enter Pool 13) has a predominantly agricultural land use, the area above Pool 13 drained by the Mississippi River is more forested with lesser agricultural use (Table 5).

Table 5. Land use (expressed as percent of the total drainage area) in the watersheds of Pool 13 and La Grange Pool.

Land Cover/Use	Pool 13	La Grange Pool
Agriculture	57.9	83.6
Deciduous forest	13.1	5.8
Evergreen forest	2.2	0.1
Forested wetland	5.5	0.5
Mixed forest	13.4	0.1
Other	7.9	9.9

The same assumptions used to estimate the contribution of water from the ungaged areas were used to estimate the contribution of those areas to the suspended sediment load. Ungaged estimates were half (8% in 1995, 8% in 1996, and 11% in 1997) the sediment contribution from the gaged tributaries because the ungaged drainage area was approximately 50% of the gaged tributary drainage area.

Typically when budgets show a difference of about 5% or less they are said to be in balance. Errors associated with the data and the estimation of ungaged sources cannot distinguish differences at that level. Differences greater than 5% are usually indicative of real differences in the budget (i.e., input greater than output or input less than output).

Given the relative similarity in the water budget for the 3 yrs studied, there are considerable differences between years in the suspended sediment budgets. The data suggest sediment export (output greater than input) in 1995, a balance in 1996, and marked sediment trapping (output less than input) in 1997. Two processes in water year 1997 result in a positive sediment budget (material is stored in the pool). First, tributary loads (and, as a result, the ungaged contribution) are somewhat greater than the previous 2 yrs. Second, the pool output is considerably lower than the previous 2 yrs. This observation suggests that Pool 13 may process tributary loads in a manner different from mainstem loads.

The nature of the observed change in the 1997 suspended sediment loading cannot be derived from a simple examination of the annual estimates. Determining why Pool 13 apparently trapped sediments in 1997 will require a closer examination of the dynamics and timing of events within the year. The pattern of changing conditions during the year most likely will affect the annual estimate. For example, the timing of large loading events (when they occur within the year, such as in spring instead of summer or fall) may have a large effect on whether the suspended load is trapped by the system or passed through it.

The Mississippi River and gaged tributaries to Pool 13 exhibited the expected annual patterns of water discharge and suspended sediment loads. Discharges were at their lowest in the winter (December through February), rose to their peak in the spring (April and May), fell through the summer (June through September), and generally rose to a smaller peak in the fall (October and November) before dropping back to the winter minimum (Figure 3; upper, middle, and lower left). Suspended sediment loads, not surprisingly, followed the same general pattern through the year (Figure 3; upper, middle, and lower right). Sediment loads from the Mississippi River generally exceeded the contribution of sediments from the tributaries, but there were three exceptions to this general behavior, all of which occurred in the 1997 water year. The month of February 1997 was marked by an extremely large sediment load from the tributaries. The months of March and June 1997 were also months of high tributary sediment loading. These same months (February, March, and June 1997) also showed larger than usual tributary contributions to the water load. Suspended sediment discharged from Pool 13 generally followed the same patterns as input sediment loads and water discharge.

The pattern of sediment storage and export in Pool 13 is more clearly illustrated by examining the net flux (input minus output) behavior in terms of metric tons per day and the net flux expressed as a percentage of the input (Figure 4; upper and lower, respectively). A value of zero for the net flux indicates that the inputs (Mississippi River, four gaged tributaries, and the ungaged estimate) and the downstream output are in balance (i.e., as much is leaving as is entering). A positive value for the net flux means that inputs exceed the output and the pool is trapping or storing sediment. A negative net flux occurs when output exceeds inputs, which then implies that the pool is actually mobilizing previously stored sediment and exporting it from the system. Pool 13 exported sediment (output is greater than input) during the major high flow, high load months of the year during all 3 yrs of the study. The periods of peak discharge and peak loads (April and May in all years) all have negative values for net flux. During these months, the pool exports from 125% to 175% of the suspended sediment input. In the

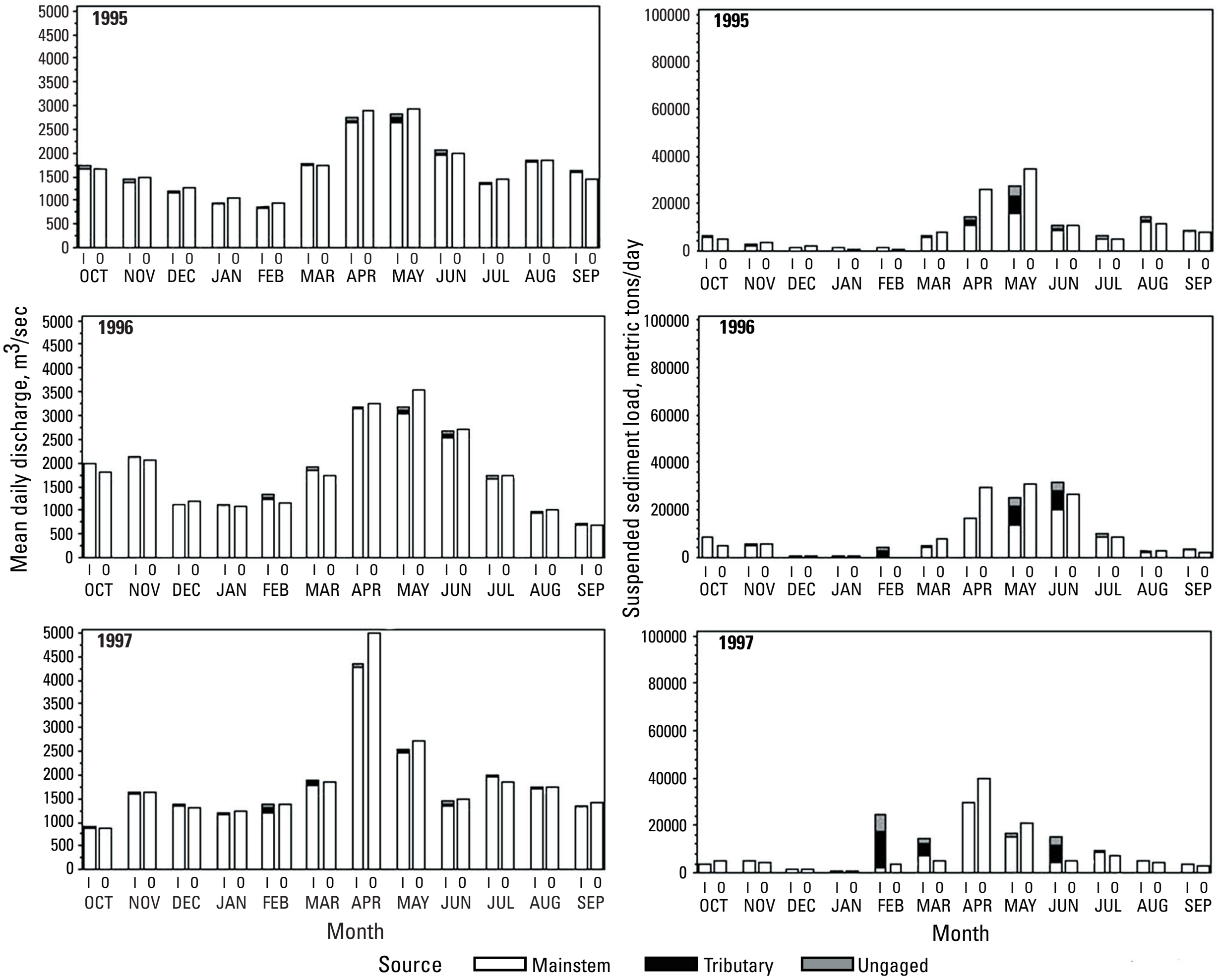

Figure 3. Pool 13 monthly water (*left*) and suspended sediment budgets (*right*) for the 1995 (*upper*), 1996 (*middle*), and 1997 (*lower*) water years. "I" refers to input to Pool 13 and "O" refers to outputs.

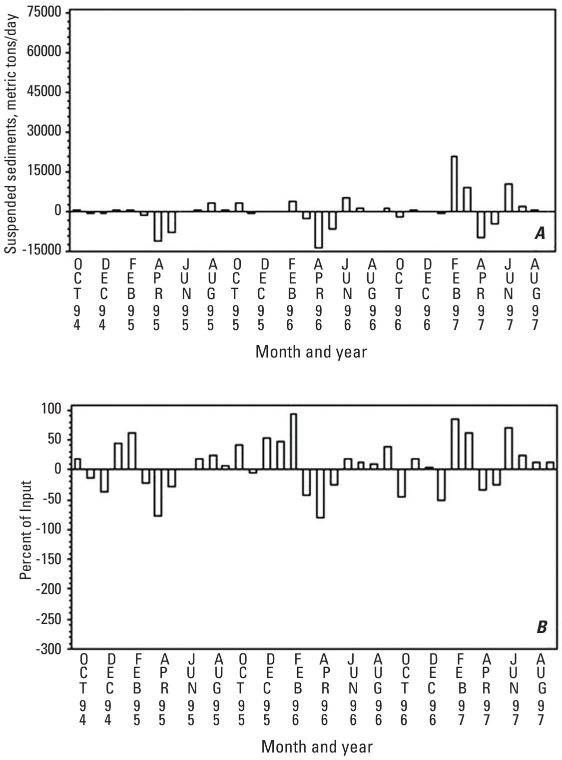

Figure 4. Pool 13 suspended sediment balance (sum of inputs minus output) expressed as (*A*) the metric tons per day of sediment storage (positive values, inputs exceed output) and export (negative values, outputs exceed inputs) and (*B*) the percentage of the input sediment load that is stored or exported.

remaining months of the year, Pool 13 traps from a few to as much as 90% of the input sediment load.

La Grange Pool

The drainage area of La Grange Pool is almost evenly split between the area drained by the Illinois River and the "local" drainage (area between the upstream and downstream ends of the pool). The Illinois River drains 55% of the pool's total drainage area and the remaining 45% (34% gaged tributaries and 11% ungaged) is local or direct. This implies that the water and sediment budgets for La Grange Pool will be much more influenced by local conditions (storms, land use patterns, etc.) than a pool where the mainstem might account for most (> 90%) of the input of water and sediment.

The 1995 water year was considerably wetter than the long-term (1939–97) average (Figure 5, upper) but the 1996 and 1997 water years were very close to normal. Discharge in 1995 was almost 130% of the mean daily discharge for the period of record. The Illinois River contributes the majority of the water input (58% in 1995, 66% in 1996, and 72% in 1997) to La Grange Pool.

Ungaged contributions to the La Grange Pool water budget were estimated in the same manner described above for Pool 13. Generating ungaged estimates in the above manner results in a water budget that is in balance (input equals output) for all water years. There is less than a 1% difference between water input and water output for the 3 yrs studied. Again, these results for the water budget suggest that the sampling design and sample

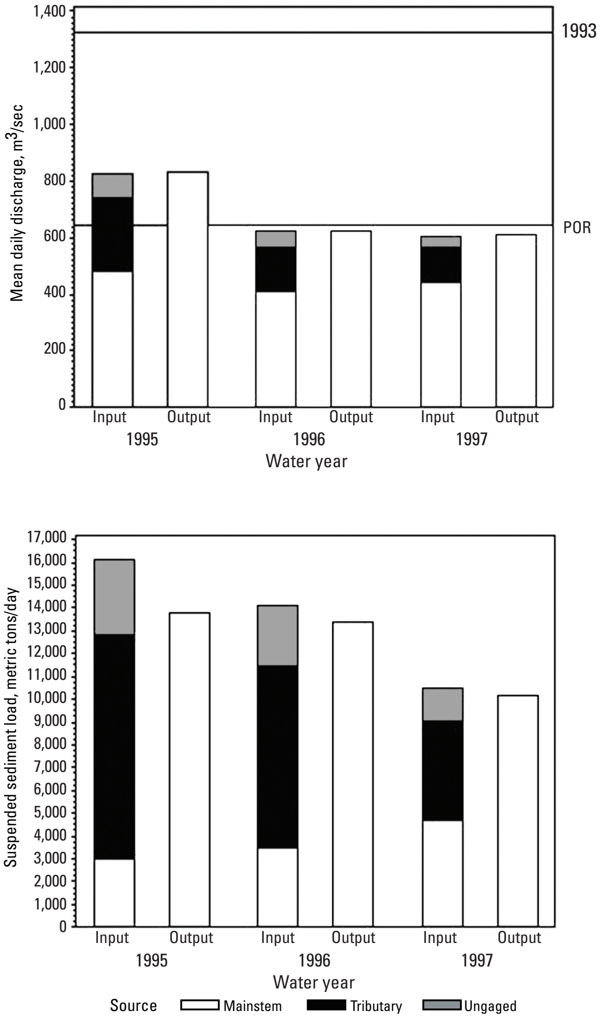

Figure 5. Annual water budgets (*upper*) and annual suspended sediment budgets (*lower*) for La Grange Pool. Horizontal reference lines indicate mean daily discharge at the downstream end of the La Grange Pool study area for the period of record (POR 1938–1997) and for the 1993 flood (1993).

allocation should also provide adequate estimates for the suspended sediment budget.

La Grange Pool annually exported between 10,000 and 14,000 t of suspended sediment on a daily basis during the 1995–97 water years (Figure 5, lower). In all years, the Illinois River above La Grange Pool accounted for less than 50% of the suspended sediment load to the pool (19% in 1995, 25% in 1996, and 45% in 1997). The gaged tributaries accounted for only 34% of the total drainage area, but they account for a much greater portion of the sediment load (61% in 1995, 56% in 1996, and 41% in 1997). These loads are from 1.2 to 2 times higher than would be expected based solely on these tributaries' contribution to the overall drainage area or water input. This greater than expected contribution from the gaged tributaries implies that the local watershed has a greater sediment delivery per unit area than the drainage area above the pool.

The same assumptions used to estimate the contribution of water from the ungaged areas were used to estimate the contribution of these areas to the suspended sediment load. Ungaged loads were estimated to be 34% of the sediment contribution from the gaged tributaries because the ungaged drainage area was approximately 34% of the gaged tributary drainage area.

The wet year of 1995 is associated with considerable sediment trapping (input greater than output) whereas the water years of 1996 and 1997 seem to be in balance (less than a 5% difference between input and output; Figure 5, lower). These data suggest that La Grange Pool traps sediment during flood years but is nearly in balance in more hydrologically normal years.

The Illinois River and the gaged tributaries to La Grange Pool exhibited annual patterns of water discharge and suspended sediment loads that were different from those observed in Pool 13. In the 1995 and 1996 water years, discharges were at their lowest in the late summer–early fall (September and October), slowly rose to their peak in the late spring–early summer (May and June), and then slowly fell to the fall minimum (Figure 6, upper and middle left). The 1997 water year exhibited a late winter–early spring (February and March) peak discharge with only a slight increase in flows in June (Figure 6, lower left). During all periods of peak discharge, the tributary and the estimated ungaged contributions make up a large proportion of the total water load to La Grange Pool. In May of 1995 and 1996, these contributions exceed those of the Illinois River. Suspended sediment loads followed the same general pattern through the year (Figure 6; upper, middle, and lower right) as water discharge. Sediment loads from the tributaries and the estimated ungaged loads generally exceeded the contribution of sediments from the Illinois River. Illinois River loads were greater than these other sources during those periods when both discharges and loads were relatively small (late summer through early winter). Suspended sediment discharged from La Grange Pool generally followed the same patterns as input sediment loads and water discharge, but during the periods of high tributary loading (May in 1995 and 1996; February in 1997) the sediment export peaks were much smaller in magnitude than the input peaks.

The pattern of sediment storage and export in La Grange Pool is clarified by examining the net flux (input - output) behavior in terms of metric tons per day and the net flux expressed as a percentage of the input (Figure 7; upper and lower, respectively). La Grange Pool stored sediment (inputs greater than output) during the major high flow, high load months of the year during all 3 yrs of the study. The periods of peak discharge and peak loads (May in 1995 and 1996; February in 1997) all have positive values for net flux. During these months, the pool stores from 25% to 75% of the suspended sediment input. The height, or relative magnitude of the storage events exceeds the sum of all the negative events, which implies that La Grange Pool is, on the whole, trapping sediments over the course of a year. On the other hand, on a temporal basis, the pool is most often mobilizing and exporting sediments (negative net flux periods) and it is only during the few large loading periods that tip the scale toward net sediment storage.

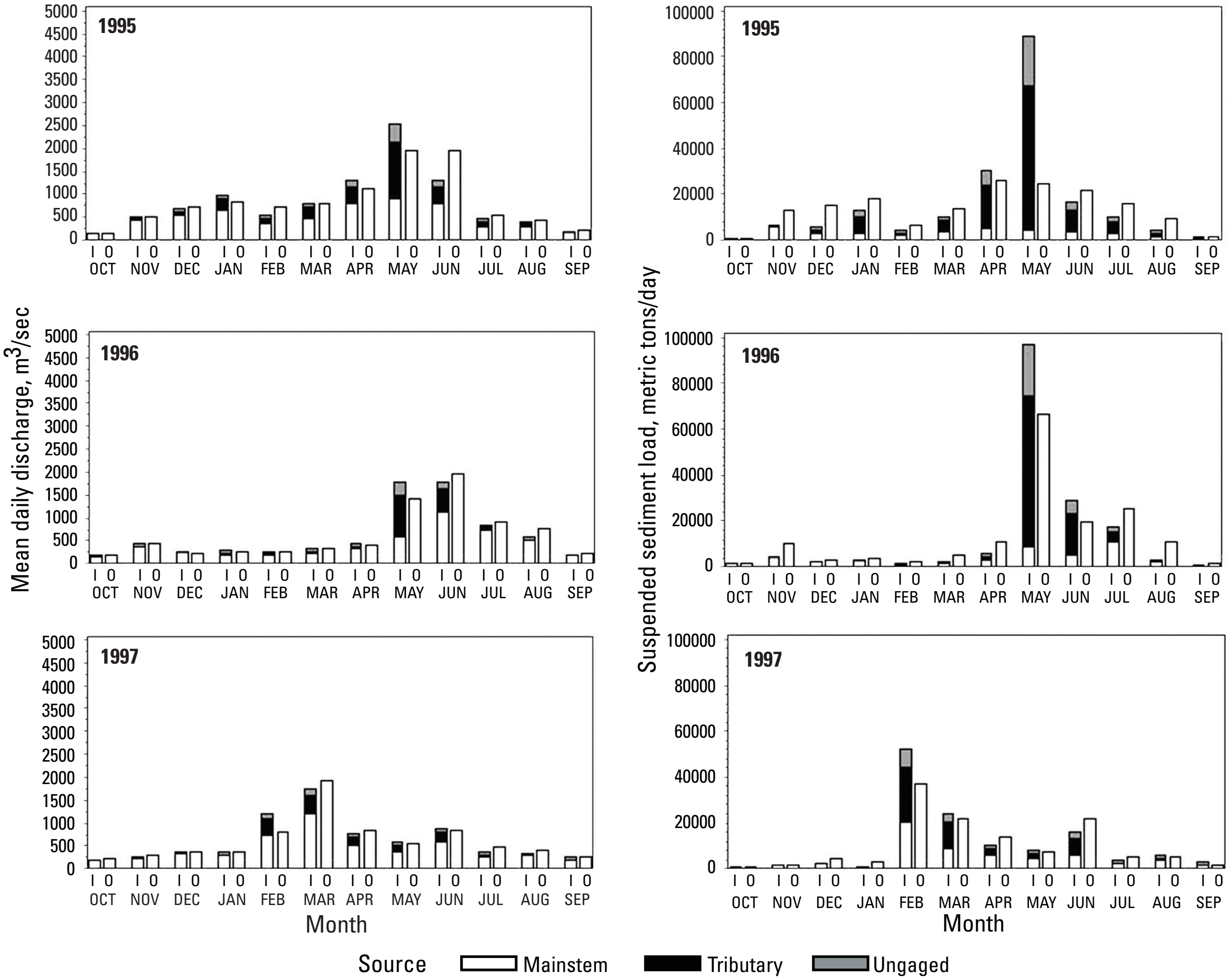

Figure 6. La Grange Pool monthly water (*left*) and suspended sediment budgets (*right*) for the 1995 (*upper*), 1996 (*middle*), and 1997 (*lower*) water years. "I" refers to input to La Grange Pool and "O" refers to outputs.

Comparison of Pool 13 and La Grange Pool

Pool 13 and La Grange Pool sit on vastly different rivers, have different hydrological settings with respect to those rivers, and have very different watersheds. The relative influence of the mainstem river (the Mississippi or Illinois River) is the first distinction between these two pools. In Pool 13, the Mississippi River dominates both the hydrology of the pool and the sediment loading. In La Grange Pool, however, the Illinois River is a major contributor of both water and sediment but it does not dominate the budget. The Mississippi River at Pool 13 is a much larger river in terms of land area drained and average flow than the Illinois River at La Grange Pool. The Mississippi River at Pool 13 drains over three times the land area than does the Illinois River at La Grange Pool. For the period of record, the mean daily flow in the Mississippi River is twice that in the Illinois River. The second distinction lies in the differences in sediment delivery by these rivers. Whereas the Mississippi River drains more land and has greater flows, its sediment supply to Pool 13 is considerably less than what the Illinois River supplies to La Grange Pool. The sediment export rate (calculated on an areal basis) for the watershed above Pool 13 is less than one-fourth the rate observed for the La Grange Pool watershed. The difference in sediment export rates are understandable given that the La Grange Pool watershed sits in one of the most fertile agricultural basins in the world; in contrast, much of the Pool 13 watershed is dominated by second-growth hardwood and coniferous forest (Table 5).

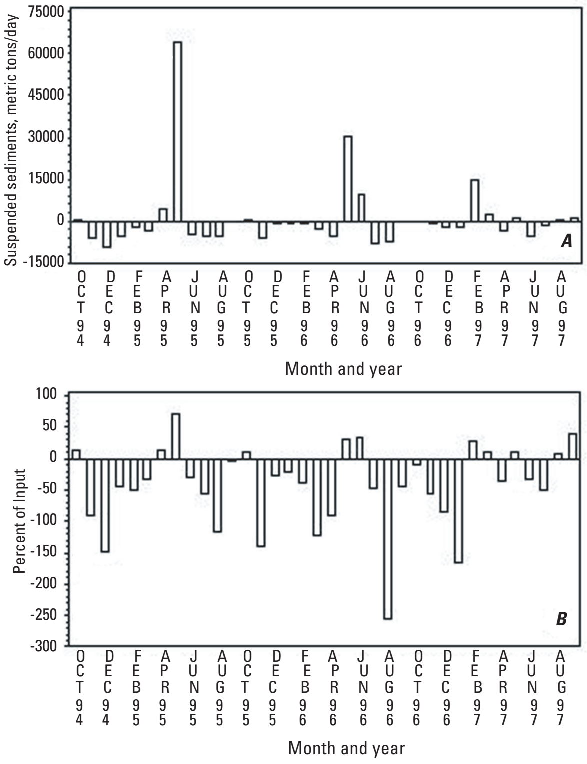

Figure 7. La Grange Pool suspended sediment balance (sum of inputs minus output) expressed as: (*A*) the metric tons per day of sediment storage (positive values, inputs exceed output) and export (negative values, outputs exceed inputs); (*B*) the percentage of the input sediment load that is stored or exported.

The most striking difference between these pools is the manner in which they store and export suspended sediments. Pool 13 exported sediments during high flow-high load periods and stored them during the remainder of the year while La Grange Pool exhibited the opposite. In La Grange Pool, sediments are trapped during high flow-high load periods of the year and exported the rest of the time. The explanation for this striking difference in behavior may lie in the considerable difference between the morphometries of these two pools. Pool 13 can be characterized as having a very riverine section for approximately 24 km; a transition zone, which is a more braided channel area, for the next 21 km; and a wide, open, and relatively shallow (1.0–1.5 m, other than the main channel) impounded area for the remaining 10.5 km. In contrast, La Grange Pool is essentially riverine for its entire length (124.7 km) and has an extensive levee system.

In Pool 13, the open area, sufficiently shallow to allow wind-generated waves to resuspend sediment and be subject to advective currents, may allow for the net export of suspended sediments during high flow-high load periods of the year. Periods of high flow will be associated with relatively higher current velocities both in the main channel and across the impounded area (Hendrickson, personal communication). The spring high-flow period is also associated with the passage of relatively frequent weather fronts that lead to the higher water inputs and may generate wind conditions that act to resuspend previously deposited sediments in the impounded area. The combination of resuspension and higher advective current velocities may be acting to allow the net export of suspended sediments. During the remainder of the year, when flows are lower, current velocities are reduced across the impounded area. Lower current velocities should result in less sediment being transported out of the system and could result in the net trapping of sediments.

In La Grange Pool, during high flow-high load periods of the year, the river may spread out onto what floodplain is still accessible (inside the levees) and allow material to settle out of suspension, thereby trapping sediments during these periods. During the remainder of the year when flows are lower in magnitude, the river may act as a more efficient conduit (flow and suspended sediment remain in the channel) for water and suspended material and result in a net export of suspended sediment.

Conclusion

The present study of the suspended sediment budgets of two navigation pools indicates that even more than 60 yrs after the construction of locks and dams to regulate these two rivers, these pools are still strikingly dynamic in the manner in which they process suspended sediments. Rather than being simple sediment sinks, net sediment exporters, or in some sort of equilibrium with their sediment loads, these pools exhibit all of these conditions over the course of a given year.

Not only does the mode of processing suspended sediments change in response to changes in hydrology, but the processes are completely different between the two pools.

Acknowledgments

This study was a cooperative effort between the U.S. Geological Survey Biological Division's Upper Midwest Environmental Sciences Center, the U. S. Geological Survey Water Resources Division's Water Districts of Wisconsin, Illinois, and Iowa, and the States of Wisconsin, Illinois, and Iowa.

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Appendix A

Summary Water and Suspended Sediment Data for Pool 13

Table A-1. Pool 13 water budget (unless otherwise indicated values are m^3/sec)

		River									
Water year	**Mississippi (above Pool 13)**	**Apple**	**Plum**	**Maquoketa**	**Elk**	**Total gaged input**	**Total gaged tributary input[a]**	**Gaged export coefficient (m^3/sec/km^2)[b]**	**Ungaged estimate[c]**	**Total input[d]**	**Output from Pool 13**
1995	1,636.7	5.8	7.0	32.4	1.4	1,683.3	46.6	0.0085	23.6	1,706.9	1,726.7
1996	1,779.0	5.7	7.2	25.8	1.1	1,818.8	39.7	0.0072	20.0	1,838.8	1,834.5
1997	1,755.1	4.1	4.7	30.5	1.1	1,795.5	40.4	0.0073	20.2	1,815.7	1,870.2

[a] Sum of the discharge from the Apple, Plum, Maquoketa, and Elk Rivers

[b] Gaged export coefficient = (total gaged triputary input)/(watershed area of gaged tributaries [5,514 km^2])

[c] Ungaged estimate = (ungaged watershed area [2,772 km^2]) x (gaged export coefficient)

[d] Total input = total gaged input + ungaged estimate

Table A-2. Pool 13 suspended sediment budget (unless otherwise indicated values are metric tons/day)

		River									
Water year	**Mississippi (above Pool 13)**	**Apple**	**Plum**	**Maquoketa**	**Elk**	**Total gaged input**	**Total gaged tributary input[a]**	**Gaged export coefficient (kg/km^2/yr)[b]**	**Ungaged estimate[c]**	**Total input[d]**	**Output from Pool 13**
1995	6,526	146	155	1,058	18	7,903	1,377	91.2	692	8,595	9,692
1996	7,012	230	151	1,167	112	8,672	1,660	109.9	834	9,506	9,977
1997	7,076	119	169	2,075	61	9,500	2,363	156.4	1,187	10,687	8,412

[a] Sum of the load from the Apple, Plum, Maquoketa, and Elk Rivers

[b] Gaged export coefficient = (total gaged tributary input)/(watershed area of gaged tributaries [5,514 km^2])

[c] Ungaged estimate = (ungaged watershed area [2,772 km^2]) x (gaged export coefficient)

[d] Total input = total gaged input + ungaged estimate

Appendix B

Summary Water and Suspended Sediment Data for La Grange Pool

Table B-1. La Grange Pool water budget (unless otherwise indicated values are m^3/sec)

		River									
Water year	**Illinois (above La Grange Pool)**	**Lamoine**	**Mackinaw**	**Sangamon**	**Spoon**	**Total gaged input**	**Total gaged tributary input[a]**	**Gaged export coefficient (m^3/sec/km^2)[b]**	**Ungaged estimate[c]**	**Total input[d]**	**Output from La Grange Pool**
1995	482.4	43.8	30.5	132.6	49.7	739.0	256.5	0.0109	86.5	825.5	832.9
1996	409.2	30.6	11.8	87.9	28.8	568.3	159.1	0.0068	53.9	622.2	623.3
1997	439.7	20.4	12.0	61.6	29.3	563.0	123.3	0.0052	41.2	604.2	610.4

[a] Sum of the discharge from the Lamoine, Mackinaw, Sangamon, and Spoon Rivers

[b] Gaged export coefficient = (total gaged triputary input)/(watershed area of gaged tributaries [23,555 km^2])

[c] Ungaged estimate = (ungaged watershed area [7,932 km^2]) x (gaged export coefficient)

[d] Total input = total gaged input + ungaged estimate

Table B-2. La Grange Pool suspended sediment budget (unless otherwise indicated values are metric tons/day)

		River									
Water year	**Illinois (above La Grange Pool)**	**Lamoine**	**Mackinaw**	**Sangamon**	**Spoon**	**Total gaged input**	**Total gaged tributary input[a]**	**Gaged export coefficient (kg/km^2/yr)[b]**	**Ungaged estimate[c]**	**Total input[d]**	**Output from La Grange Pool**
1995	3,017	1,761	1,536	3,061	3,438	12,813	9,796	151.8	3,299	16,112	13,819
1996	3,522	1,982	752	2,625	2,551	11,432	7,910	122.6	2,664	14,096	13,390
1997	4,685	901	364	1,266	1,792	9,008	4,323	67.0	1,456	10,464	10,178

[a] Sum of the load from the Lamoine, Mackinaw, Sangamon, and Spoon Rivers

[b] Gaged export coefficient = (total gaged triputary input)/(watershed area of gaged tributaries [23,555 km^2])

[c] Ungaged estimate = (ungaged watershed area [7,932 km^2]) x (gaged export coefficient)

[d] Total input = total gaged input + ungaged estimate

Appendix C

Monthly Summaries of Water and Suspended Sediment Data for Pool 13

Table C-1. Monthly means for discharge (ft^3 sec^{-1}) for the Mississippi River at Lock and Dam 13 at Bellevue, Iowa. U.S. Geological Survey station code 0541600.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	59,367.7	49,076.7	40,422.6	30,451.6	29,453.6	61,061.3	93,146.7	92,751.6	68,916.7	46,845.2	63,677.4	56,796.7
1996	69,593.5	73,436.7	38,967.7	36,774.2	42,379.3	65,619.4	111,273.3	107,767.7	889,96.7	59,012.9	33,335.5	24,823.3
1997	30,919.4	57,063.3	47,845.2	39,967.7	42,442.9	62,996.8	151,233.3	87,312.9	47,796.7	69,209.7	60,816.1	45,936.7

Table C-2. Monthly means for sediment load (tons day^{-1}) for the Mississippi River at Lock and Dam 13 at Bellevue, Iowa. U.S. Geological Survey station code 0541600.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	6689.0	2724.3	1355.0	1318.5	1408.4	6250.1	11757.3	17525.8	9653.3	5332.6	13169.4	8715.0
1996	9252.0	5839.7	588.3	508.6	866.3	4963.4	18022.6	15240.3	21788.7	9716.7	2549.7	3308.4
1997	3635.2	5356.3	1266.5	595.9	2140.3	7905.5	32403.3	16631.0	4809.0	9626.5	5515.2	3656.0

Table C-3. Monthly means for discharge (ft^3 sec^{-1}) for the Apple River near Hanover, Illinois. U.S. Geological Survey station code 0541900.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	111.7	155.4	169.8	141.7	108.0	141.2	360.6	658.5	282.8	149.4	100.7	78.7
1996	83.8	125.9	82.9	178.7	455.9	80.4	94.1	443.6	587.0	142.7	81.6	58.5
1997	59.3	60.2	63.3	104.3	396.2	233.3	126.8	205.3	227.5	130.4	68.2	83.0

Table C-4. Monthly means for sediment load (tons day^{-1}) for the Apple River near Hanover, Illinois. U.S. Geological Survey station code 0541900.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	15.7	28.6	11.8	11.9	4.8	10.6	103.5	1596.4	72.8	22.4	11.5	10.4
1996	14.3	10.2	2.4	27.5	756.7	8.2	13.2	1393.1	782.9	31.4	13.1	5.6
1997	5.5	5.3	2.9	6.0	837.6	385.8	14.9	28.1	298.8	42.6	4.6	3.7

Table C-5. Monthly means for discharge (ft^3 sec^{-1}) for the Elk River near Altmont, Iowa. U.S. Geological Survey station code 05420300.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	20.2	35.9	34.8	27.6	34.5	40.0	84.4	121.6	53.7	55.3	41.3	22.7
1996	20.1	26.2	16.6	16.8	24.3	14.5	17.6	143.7	94.1	36.1	28.0	18.7
1997	29.7	21.2	24.3	23.8	178. 8	42.5	31.9	39.8	31.2	23.9	16.3	13.3

Table C-6. Monthly means for sediment load (tons day^{-1}) for the Elk River near Altmont, Iowa. U.S. Geological Survey station code 05420300.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	0.6	20.3	1.3	1.3	2.9	1.8	68.5	102.2	6.1	5.1	23.7	3.4
1996	1.2	3.0	1.0	3.4	26.3	0.5	0.5	1093. 5	327.4	5.5	1.9	0.5
1997	44.5	1.2	1.0	15.7	694.3	58.6	2.6	10.0	18.3	11.1	6.6	0.5

Table C-7. Monthly means for discharge (ft^3 sec^{-1}) for the Maquoketa River near Maquoketa, Iowa. U.S. Geological Survey station code 05418500.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	913.4	795.2	892.3	637.8	747.1	929.5	2046.5	2698.7	1699.0	969.8	874.0	517.3
1996	514.4	647.3	451.4	431.8	981.4	808.9	576.4	1826.6	2522.0	1080.2	607.1	466.9
1997	499.2	587.0	558.0	538.7	2721.1	1837.7	1020.3	1529.3	1808.7	891.6	542.7	529.8

Table C-8. Monthly means for sediment load (tons day^{-1}) for the Maquoketa River near Maquoketa, Iowa. U.S. Geological Survey station code 05418500.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	255.5	288.4	258.4	102.0	174.7	520.3	2361.8	5494.9	1308.1	978.2	1897.2	245.1
1996	141.8	179.9	41.8	37.7	1519.1	467.3	142.4	4408.1	7552.3	625.3	265.7	121.9
1997	153.7	94.6	60.2	47.6	13985.4	4389.9	196.6	1183.6	7489.5	648.9	164.3	125.2

Table C-9. Monthly means for discharge (ft^3 sec^{-1}) for the Plum River at Savanna, Illinois. U.S. Geological Survey station code 05420100.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	92.1	192.5	179.7	197.3	151.0	151.6	422.8	863.8	343.4	169.1	122.0	81.6
1996	91.6	179.9	130.5	176.5	317.4	113.5	145.0	731.5	750.4	209.9	110.0	75.5
1997	81.2	82.6	71.1	88.5	658.3	332.5	133.4	189.9	166.5	90.2	61.7	74.1

Table C-10. Monthly means for sediment load (tons day^{-1}) for the Plum River at Savanna, Illinois. U.S. Geological Survey station code 05420100.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	11.0	64.7	51.4	49.6	23.7	20.0	437.4	1054.1	154.8	89.8	46.2	29.5
1996	23.5	45.2	21.2	65.4	103.4	34.0	30.1	1252.7	201.2	149.4	35.0	13.0
1997	28.2	25.9	8.8	15.6	1223.7	560.3	23.4	104.3	270.8	36.5	13.1	15.9

Table C-11. Monthly means for discharge (ft^3 sec^{-1}) for the Mississippi River at Clinton, Iowa. U.S. Geological Survey station code 05420500.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	59464.5	52313.3	44693.5	36187.1	33210.7	61774.2	101706.7	103551.6	70260.0	51045.2	65061.3	50693.3
1996	73333.3	42051.6	36935.5	39817.2	61574.2	114783.3	125377.4	95753.3	61438.7	35951.6	24343.3	73333.3
1997	57226.7	46667.7	41774.2	49382.1	65722.6	175856.7	96429.0	52006.7	65951.6	60974.2	50206.7	57226.7

Table C-12. Monthly means for sediment load (tons day^{-1}) for the Mississippi River at Clinton, Iowa. U.S. Geological Survey station code 05420500.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	5847.7	3788.3	2506.1	877.0	663.5	8631.9	28520.0	38171.0	11847.7	5705.2	12478.7	8517.0
1996	5602.9	6552.8	316.5	379.4	239.7	8239.0	32808.0	34187.1	29060.0	9503.5	2706.1	2183.0
1997	5808.1	4543.3	1330.1	1097.1	3805.7	5955.5	43623.3	23251.0	5271.7	8224.2	5053.9	3420.0

Appendix D

Monthly Summaries of Water and Suspended Sediment Data for La Grange Pool

Table D-1. Monthly means for discharge (ft^3 sec^{-1}) for the Illinois River at Pekin, Illinois. U.S. Geological Survey station code 05563800.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	4990.0	15441.7	19468.7	21843.9	13232.5	16579.7	28096.7	31603.2	27703.3	10024.2	10271.3	5057.3
1996	6112.6	13369.7	7577.7	7077.1	6898.6	8330.0	11310.3	21001.0	40450.0	25427.4	18898.4	6446.3
1997	6232.6	8257.0	12245.2	10767.1	26341.1	43103.2	18676.0	13674.2	21307.7	9710.3	10075.5	6719.0

Table D-2. Monthly means for sediment load (tons day^{-1}) for the Illinois River at Pekin, Illinois. U.S. Geological Survey station code 05563800.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	1043.8	6407.0	3211.3	3300.0	2012.1	3710.0	5333.3	4884.5	4052.3	3105.8	1671.0	1164.9
1996	1356.1	3958.0	2278.5	2241.9	672.1	1531.5	3703.1	9367.3	5581.5	11684.9	2842.3	989.8
1997	1116.3	1308.8	2453.9	1061.4	22108.0	9414.5	6910.1	4797.0	6387.9	2300.5	4006.3	1600.1

Table D-3. Monthly means for discharge (ft^3 sec^{-1}) for the La Moine River at Ripley, Illinois. U.S. Geological Survey station code 05585000.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	24.8	198.3	510.7	806.9	669.2	623.7	2988.1	9257.5	1847.2	723.2	705.3	92.1
1996	121.2	321.2	107.5	377.9	511.8	420.3	394.5	7027.8	2402.0	918.1	188.9	65.0
1997	35.5	48.7	48.2	56.6	2187.4	1727.2	1379.0	1205.3	1663.7	210.4	131.4	86.6

Table D-4. Monthly means for sediment load (tons day^{-1}) for the La Moine River at Ripley, Illinois. U.S. Geological Survey station code 05585000.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	4.1	65.7	740.0	1091.7	769.2	280.0	4843.8	11518.0	2300.1	495.0	1013.2	38.8
1996	66.2	157.7	14.3	179.0	443.5	137.5	211.0	20613.4	3110.4	875.1	44.0	14.7
1997	3.6	3.7	2.5	8.3	4112.5	1704.9	1287.1	1621.7	3256.4	99.3	105.3	28.6

Table D-5. Monthly means for discharge (ft^3 sec^{-1}) for the Mackinaw River near Green Valley, Illinois. U.S. Geological Survey station code 05568500.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	50.2	119.4	446.1	1208.9	359.9	909.3	2379.8	5494.7	1169.0	405.2	203.0	82.6
1996	73.6	201.1	102.4	150.0	108.2	185.5	254.9	2084.4	1350.9	262.9	126.7	58.1
1997	49.0	60.4	88.4	148.9	1390.3	1413.9	755.1	370.5	468.5	152.5	172.9	101.4

Table D-6. Monthly means for sediment load (tons day^{-1}) for the Mackinaw River near Green Valley, Illinois. U.S. Geological Survey station code 05568500.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	4.0	11.2	152.9	1228.4	30.5	595.3	5249.1	11722.0	873.5	211.2	47.3	16.3
1996	18.2	32.1	13.3	27.1	14.8	24.7	51.1	8362.5	1131.1	81.8	30.3	10.4
1997	4.1	7.9	8.0	19.9	3388.7	1108.7	191.8	51.7	207.5	38.6	28.4	16.0

Table D-7. Monthly means for discharge (ft^3 sec^{-1}) for the Sangamon River near Oakford, Illinois. U.S. Geological Survey station code 05583000.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	389.3	974.9	1937.6	5913.9	2711.1	5951.0	4799.3	20541.6	8033.3	2290.3	1814.0	511.1
1996	437.9	700.8	606.0	1036.9	843.9	1575.8	2272.3	17811.3	9188.3	1475.8	677.3	384.1
1997	323.6	406.8	438.3	931.1	3883.9	8208.1	2383.7	2444.8	4300.7	1515.6	688.5	702.3

Table D-8. Monthly means for sediment load (tons day^{-1}) for the Sangamon River near Oakford, Illinois. U.S. Geological Survey station code 05583000.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	40.4	98.4	510.4	4709.3	448.9	4291.4	2627.2	21172.2	3896.2	1391.2	716.4	81.0
1996	67.8	145.6	28.7	244.6	113.6	451.0	1385.9	25246.6	5933.6	510.7	135.6	51.8
1997	16.3	9.4	5.8	97.8	4727.7	5879.7	589.4	1265.5	3172.6	806.9	227.9	224.0

Table D-9. Monthly means for discharge (ft^3 sec^{-1}) for the Spoon River at Seville, Illinois. U.S. Geological Survey station code 05570000.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	56.4	725.1	1138.5	978.5	1072.5	1097.9	3136.8	8015.5	2548.3	1477.5	591.1	148.9
1996	161.6	457.9	246.7	373.6	520.5	405.7	371.1	4214.3	3936.7	1058.3	303.1	100.5
1997	92.4	144.9	131.0	170.4	4231.6	2554.0	1548.4	908.7	1117.7	348.4	802.6	668.2

Table D-10. Monthly means for sediment load (tons day^{-1}) for the Spoon River at Seville, Illinois. U.S. Geological Survey station code 05570000.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	8.8	622.8	1254.8	751.6	719.0	572.8	8192.9	24984.4	3357.3	3958.6	638.5	26.7
1996	66.4	195.4	97.1	103.6	202.3	180.7	164.9	18705.2	9545.0	4006.3	144.9	29.3
1997	12.2	23.0	10.1	30.8	14240.7	4326.4	1285.9	401.4	1828.3	237.3	1572.5	797.5

Table D-11. Monthly means for discharge (ft^3 sec^{-1}) for the Illinois River at Valley City, Illinois. U.S. Geological Survey station code 05586100.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	5743.2	17847.3	25925.8	29041.9	25167.9	28283.9	39610.0	69683.9	68616.7	19912.9	15992.9	7209.7
1996	7301.3	15500.0	8478.4	9311.0	9459.0	11991.0	14570.3	50274.2	69130.0	31719.4	26783.5	8698.0
1997	8632.6	10684.7	13184.5	12241.9	27975.0	67580.6	29200.0	19545.2	29403.3	17090.3	14063.9	9403.0

Table D-12. Monthly means for sediment load (tons day^{-1}) for the Illinois River at Valley City, Illinois. U.S. Geological Survey station code 05586100.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1995	982.8	14240.7	16855.2	19617.7	6972.9	15143.9	28579.0	26898.7	23544.3	17379.7	10550.3	1448.7
1996	1464.3	11247.3	3167.8	3620.2	2342.9	5758.4	11751.9	73178.1	21651.7	27817.4	11772.5	1649.4
1997	1274.2	2138.9	4632.4	3379.5	40895.7	24109.2	15329.3	8282.2	23738.6	5828.0	6036.5	1794.1

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 2004	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE A suspended sediment budget for Pool 13 and La Grange Pool of the Upper Mississippi River System	5. FUNDING NUMBERS
6. AUTHOR(S) Robert F. Gaugush	
7. PERFORMING ORGANIZATION NAME AND ADDRESS Upper Midwest Environmental Science Center, 2360 Fanta Reed Road, La Crosse, Wisconsin 54603	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Geological Survey Upper Midwest Environmental Sciences Center 2630 Fanta Reed Road La Crosse, Wisconsin, 54603	10. SPONSORING/MONITORING AGENCY REPORT NUMBER 2004-T004

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT Release unlimited. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (1-800-553-6847 or 703-487-4650). Also available to registered users from the Defense Technical Information Center, Attn: Help Desk, 8725 Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218 (1-800-225-3842 or 703-767-9050).	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The suspended sediment budget for Pool 13 of the Mississippi River and La Grange Pool of the Illinois River was examined over a 3-yr period (October 1995 through September 1997). Pool 13 output was betwee
by those delivered by the Mississippi River (76%, 74%, and 66% in the 1995, 1996, and 1997 water years, respectively). Pool 13 exhibited sediment export (output greater than input) in 1995, a balance in 1996, and marked sediment trapping (output less than input) in 1997. Within the three study years, Pool 13 received its highest water and sediment loads during spring (March through May) and this period was marked by sediment export. Suspended sediment loads were trapped during the remainder of the year. La Grange Pool output was between 3.71 and 5.04 million t of suspended sediment annually during the 1995–97 water years. The Illinois River accounted for less than 50% of the suspended sediment load to the pool (19%, 25%, and 45% in the 1995, 1996, and 1997 water years, respectively. La Grange Pool exhibited considerable sediment trapping in 1995 whereas the 1996 and 1997 water years were much closer to a balance wherein output was within 5% of input. Generally, La Grange Pool received its largest water and sediment loads during the late spring–early summer period (April through June), but in 1997 the late winter loads predominated.

14. SUBJECT TERMS La Grange, Mississippi River, Pool 13, river, sediment budget, sediment load	15. NUMBER OF PAGES 13 pp. + Appendixes A–D
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT

The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.