
**ILLINOIS RIVER BASIN RESTORATION
SECTION 519**

**KANKAKEE RIVER MAINSTEM
CRITICAL RESTORATION PROJECT**

SUMMARY REPORT

SEPTEMBER 2014



**US Army Corps
of Engineers®**
Rock Island District

ILLINOIS RIVER BASIN RESTORATION SECTION 519

KANKAKEE RIVER MAINSTEM CRITICAL RESTORATION PROJECT

Summary Report

September 2014

1. STUDY AUTHORITY

The Rock Island, St. Louis, Chicago, and Detroit Districts of the US Army Corps of Engineers (USACE), along with the Illinois Department of Natural Resources as the non-Federal Sponsor (NFS) completed the *Illinois River Basin Restoration Comprehensive Plan with Integrated Environmental Assessment* (2007) that addresses two complementary authorities investigating the Federal and state interest in ecosystem restoration within the Illinois River Basin. A Reconnaissance Study identifying a Federal interest in restoration was completed in February of 1999. Study efforts were then initiated in the basin through the Illinois River Ecosystem Restoration Feasibility Study conducted under Section 216 of the 1970 Flood Control Act. That Study was initiated pursuant to the provision of funds in the Energy and Water Development Appropriations Act, 1998. The Study was authorized by Section 216 of the 1970 Flood Control Act and states:

The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significant changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest.

Congress provided additional authority for Illinois River Basin Restoration in Section 519 of the Water Resources Development Act (WRDA) 2000. Additional authority was provided in Section 5071 of WRDA 2007. Authority was granted in Sections (b) & (c) of Section 519 of WRDA 2000 (as amended; WRDA 2007) to complete a comprehensive plan and identify, evaluate, and implement critical restoration projects in the Illinois River Basin.

2. DESCRIPTION OF THE STUDY AREA

The Kankakee River Basin is located in northeastern Illinois and northwestern Indiana. The basin has a total area of approximately 5,800 square miles and encompasses portions of 22 counties in both states. The Kankakee River originates near South Bend, Indiana, and flows west for about 140 miles to its confluence with the Des Plaines River in Will County, Illinois. The confluence of the Des Plaines and Kankakee Rivers forms the Illinois River. The Kankakee's three principal tributaries are the Yellow River in Indiana and the Singleton Ditch and Iroquois River in Illinois and Indiana. The study area for this project is the mainstem of the Kankakee River in Illinois, upstream of the Kankakee Dam, which includes River Miles (RM) 33-58 (figure 1).

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140 miles to its confluence with the Des Plaines River in Will County, Illinois. The confluence of the Des Plaines and Kankakee Rivers forms the Illinois River. The Kankakee's three principal tributaries are the Yellow River in Indiana and the Singleton Ditch and Iroquois River in Illinois and Indiana. The study area for this project is the mainstem of the Kankakee River in Illinois, upstream of the Kankakee Dam, which includes RM 33-58.

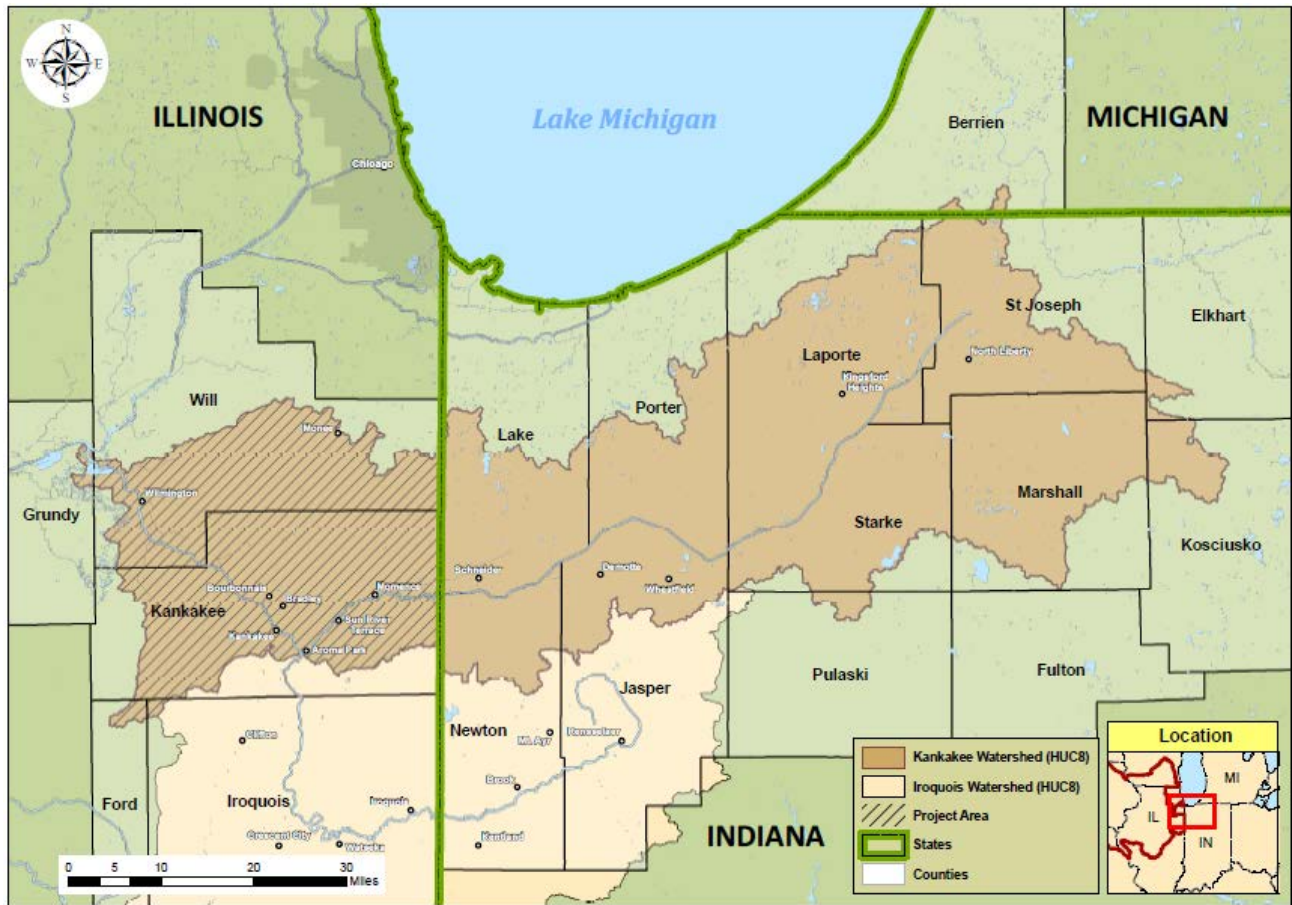


Figure 1: Kankakee River Basin

3. STUDY PURPOSE AND SCOPE

The purpose of ecosystem restoration activities is to restore significant ecosystem function, structure and dynamic processes that have been degraded. Ecosystem restoration planning involves a comprehensive examination of the problems contributing to the system degradation and the development of alternative solutions. The intent of ecosystem restoration is to partially or fully re-establish the attributes of a naturalistic, functioning and self-regulating system.

Sedimentation of important aquatic habitats is a major problem in the Kankakee River mainstem. The high mussel diversity and high biological stream characterization rating indicate the high quality of available aquatic habitat. Sand deposition threatens the quality of many of the high quality pool, riffle, and side channel habitats. Potential opportunities that could be addressed by USACE or in collaboration with the NFS and other Federal and local agencies are:

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- restore riffle, pool, and side channel habitats;
- increase suitable mussel habitat;
- increase submerged aquatic vegetation; and
- reduce sedimentation in pool, riffle, and side channel areas.

4. STUDIES, REPORTS, AND EXISTING WATER PROJECTS

Several Kankakee River Basin watershed planning documents were available for review. Summaries of one investigation and three USACE reports are provided here. Additional studies and reports are listed in Appendix B.

Kankakee River Basin Management Plan Feasibility. Prior to 2005, the Chicago District considered developing a management plan for the entire 5,167 square miles of the Kankakee River basin in terms of flood damage reduction, sediment management, and ecosystem restoration. A hydrologic model for the Kankakee River Basin in the Hydrologic Engineering Center's (HEC) Hydrologic Modeling System investigated several project alternatives in the basin for flood reduction. Different sediment management techniques were also evaluated. Separate analysis included riverine restoration, economics ecological/environmental, geotechnical, and civil engineering. Preliminary results indicated that flood damage reduction and main stem river sediment removal projects were unlikely to be justified as a Federal project. Further investigation using the Sediment Impacts Analysis Methods Model (SIAM) could evaluate projects providing ecosystem restoration and restoration of natural geomorphic systems.

Yellow River Watershed Draft Preliminary Reconnaissance Report. This Report examined the Yellow River Basin to determine problems in the watershed and potential restoration projects. The Yellow River drains 431 square miles and joins the Kankakee River approximately 99 miles upstream from the Kankakee / Des Plaines River confluence and 40 miles upstream from the Illinois Indiana state line. The Yellow River has been identified as the biggest contributor of sand sediment to the Kankakee River (USACE, ERDC, 2013). Most of the Yellow River's tributary streams and large portions of the main channel have been channelized and levied. According to the report, at several locations sand aggradation has raised streambed levels above the agricultural land behind levees resulting in isolation of the river and streams from their associated floodplains. The report recommends investigation of best management practice and stream re-meandering project alternatives with SIAM.

Draft Kankakee River Stateline Section 206 Study. This Study investigated sediment removal options at the Illinois Indiana Stateline with the HEC's Scour and Deposition in Rivers and Reservoirs model (HEC-6). Continuous removal and periodic removal options were evaluated. Results showed that both sediment removal methods had minimal effects on reducing downstream aggradation and recommended evaluation of a watershed based sediment management plan with tools such as SIAM. The study also proposed a potential wetland restoration project near the state line.

Draft Kankakee River Six-Mile Pool / Riffles Section 519 Study. As part of this Study, the hydraulic model HEC-6T was used to predict sediment transport and deposition trends on the Kankakee River between the Wilmington Dam and Momence, IL. The main objective of this modeling effort was to evaluate potential dredging projects upstream from the Kankakee Dam within the Six-Mile Pool that would reduce sediment transport in the Kankakee River Riffles Section. The riffles section of the Kankakee River, located downstream from the Kankakee Dam, is recognized by river scientists as a key

aquatic habitat in Illinois, due to its highly productive cobble and gravel substrates. The study used survey and cross section data to evaluate sedimentation trends and calibrate the sediment model. The results showed a decreased rate of sediment aggradation in the Six-Mile Pool in the period from 1999 to 2005 as compared to the period from 1980 to 1999. The sediment modeling of potential dredging projects in the Six-Mile Pool showed that potential dredging projects could reduce sand transport in the riffles section. However, initial analysis of the maintenance requirements and cost indicated that potential dredging projects would be infeasible. Investigation of project alternatives throughout the entire Kankakee River Basin with SIAM was recommended.

5. SUMMARY OF SYSTEM STUDY FOR PLAN FORMULATION

As noted in the Prior Federal Projects and Studies, numerous studies by Federal and state agencies and other organizations have addressed the Kankakee River's hydraulic and hydrologic characteristics and potential projects affecting these properties. These studies have all concluded that reducing the high rate of sediment transport and reducing the amount of sediment deposition is best addressed by reducing the amount of sediment input to the Kankakee River system and its tributaries instead of dredging and/or bed sediment removal. Separate USACE studies in 2004 and 2006 showed that main stem bed sediment removal and/or dredging would only provide benefits over a short reach downstream and/or require extremely high operation, maintenance, and disposal costs. The studies showed that dredging caused increased erosion, which limited its downstream effectiveness in reducing sediment transport. Each of these studies recommended a comprehensive investigation of the entire Kankakee River Basin with SIAM, the Sediment Impact Analysis Methods Model. SIAM analysis of the Kankakee River basin was completed by ERDC in 2013 (Little and Jonas, 2013) as part of the analysis for this project resulting in a report titled *Kankakee River Basin: Evaluation of Sediment Management Strategies* which can be found in Appendix A.

Kankakee River Basin: Evaluation of Sediment Management Strategies. This report (Little and Jonas, 2013), describes the use of the Sediment Impact Analysis Methods Model (SIAM) to evaluate sediment characteristics and potential projects in the Kankakee River Basin. The SIAM model defined 19 reaches for the Kankakee River Basin and used HEC-RAS to determine reach averaged Hydraulic properties. The hydraulics properties and sediment information determined the wash load/bed load division, transport capacity, and local balance for each reach. The sediment information was compiled from multiple sources and analyzed to determine average annual values of sub-basin sediment loads and grain size distribution within the Kankakee River watershed. The major sand contributors were the Yellow & Upper Kankakee (39% & 31%) compared to the Iroquois (22%). The major silt & clay contributor was the Iroquois (52%) compared to the combined Upper Kankakee & Yellow (23%). Sediment continuity was determined for base level conditions, then a matrix of management strategies for various sub-basins of the watershed were evaluated to determine the relative impact of each strategy on the system sediment balance. The matrix consisted of 35 sediment management strategies that encompassed combinations of watershed sediment source reductions (from 20% to 60%), channel re-meandering and flood plain reconnection, and dredging within Six-Mile Pool above Kankakee Dam. SIAM results for the alternatives were compared to existing condition results to determine relative effects on sediment continuity and total sediment load reduction within the basin. The Six-Mile Pool dredging option showed the potential to reduce sand load downstream from the Dam. Other options that affected bedload transport (remeandering) showed localized benefit, but limited effect downstream. The options that provided the most reduction in watershed total sediment (1E, 2J, & 3B) showed a significant positive

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effect throughout the downstream parts of the system and receiving streams in terms of reduction in total sediment load. The report recommended using a routing model to address potential projects that affect bedload transport.

6. CONCLUSION AND RECOMMENDATIONS

The 2013 SIAM analysis of the Kankakee River Basin showed the same findings as previous major USACE studies regarding main stem sand (bedload) removal. These studies found that bedload removal has localized benefits, but has limited effect on downstream parts of the system. The SIAM analysis found that projects addressing total and wash load in the watershed and tributaries have positive effect throughout the downstream parts of the system and receiving streams. SIAM is not a routing model - it does not measure changes in channel geometry for projects affecting bedload transport. The SIAM report recommended using a routing model to address potential projects that affect bedload transport. A routing model approach (HEC-6/HEC-6T) was used in USACE reports from 2004 and 2006. The 2004 USACE report showed that bedload removal at the state line has limited localized effect. The 2006 USACE report showed that dredging in the Six-Mile Pool would reduce sand concentrations in the riffle sections downstream, but preliminary cost analysis indicated that this type of project was infeasible. Costs to dredge would be nearly \$20 million, not including placement costs. It is estimated that recurring dredging would occur every 10 years or less adding to maintenance costs.

At this time there are no recommended viable projects in the Kankakee mainstem. Sand deposition threatens quality habitat but removing this sand from local areas on the mainstem is costly and does not reduce the high sediment load coming into the Kankakee Mainstem Area which shortens the time period of benefits. It is recommended that future focus include reducing sediment load into the system from the tributaries and watershed in the upper basin including the Iroquois River and Yellow River basins.

7. REFERENCES

- Illinois River Basin Restoration Comprehensive Plan With Integrated Environmental Assessment*, Main Report Final (USACE, Rock Island District. March, 2007. 1,229 pages)
<http://www.mvr.usace.army.mil/Portals/48/docs/Environmental/ILRBR/CompPlan/MAIN%20REPORT%20and%20APPENDICES%20-%20CD.pdf>
- Yellow River Watershed Draft Preliminary Reconnaissance Report* (U.S. Army Corps of Engineers, Detroit District, 2007)
- Draft Kankakee River Stateline 206 Study* (USACE, Rock Island District, 2004)
- Kankakee River Riffles Section 519 Critical Restoration Project* (USACE, Rock Island District, 2006)
- Kankakee River Basin: Evaluation of Sediment Management Strategies* (Little, Charles D. Jr. and Meg M. Jonas, 2013)

**ILLINOIS RIVER BASIN RESTORATION
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APPENDIX A

**KANKAKEE RIVER BASIN: EVALUATION OF SEDIMENT
MANAGEMENT STRATEGIES**

Charles D. Little, Jr., and Meg M. Jonas

September 2013



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Kankakee River Basin: Evaluation of Sediment Management Strategies

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Kankakee River Basin: Evaluation of Sediment Management Strategies

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Final report

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Abstract

The Kankakee River extends from South Bend, Indiana, to its confluence with the Illinois River near Wilmington, Illinois. The river has a 5,165-square-mile drainage area and a length of approximately 150 miles, reduced from approximately 250 miles, historically. The process of channelizing streams and draining the landscape has had impacts on the hydrology, hydraulics, sedimentation, and ecology of the watershed and channel network. Increased sediment loads associated with channelization and changed land use are a particular concern. A Section 519 Illinois River Basin Ecosystem Restoration Study is underway by the Sponsor to address these concerns, and the Kankakee River investigation reported herein was conducted in support of the restoration study.

Sediment data were compiled from multiple sources and analyzed to determine average annual values of sub-basin sediment loads within the Kankakee River watershed. The Sediment Impact Analysis Methods (SIAM) model was used for rapid screening of alternatives for sediment management on a watershed scale. Sediment continuity was determined for base level conditions; then, a matrix of management strategies for various sub-basins of the watershed was evaluated to determine the relative impact of each strategy on the system sediment balance. Results are useful for planners and sediment managers interested in creating an overall sediment management plan that meets the sediment reduction goals of the restoration project.

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Preface

This study was conducted for the US Army Engineer Rock Island District as a reimbursable project. The technical monitor for Rock Island District was Chris Haring.

The US Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL) conducted this study in two phases from July 2007 to January 2012. The principal investigators for this study were Charlie Little and Meg Jonas of the River Engineering Branch. The study was conducted under the direct supervision of Lisa Hubbard, Chief, River Engineering Branch; Bruce A. Ebersole, Chief, Flood and Storm Protection Division; and William Martin, Director, Coastal and Hydraulics Laboratory.

During the time of the study, COL Gary E. Johnston and COL Jeffrey R. Eckstein served as Commander and Executive Director of ERDC. Dr. James R. Houston and Dr. Jeffery P. Holland served as ERDC Director.

Unit Conversion Factors

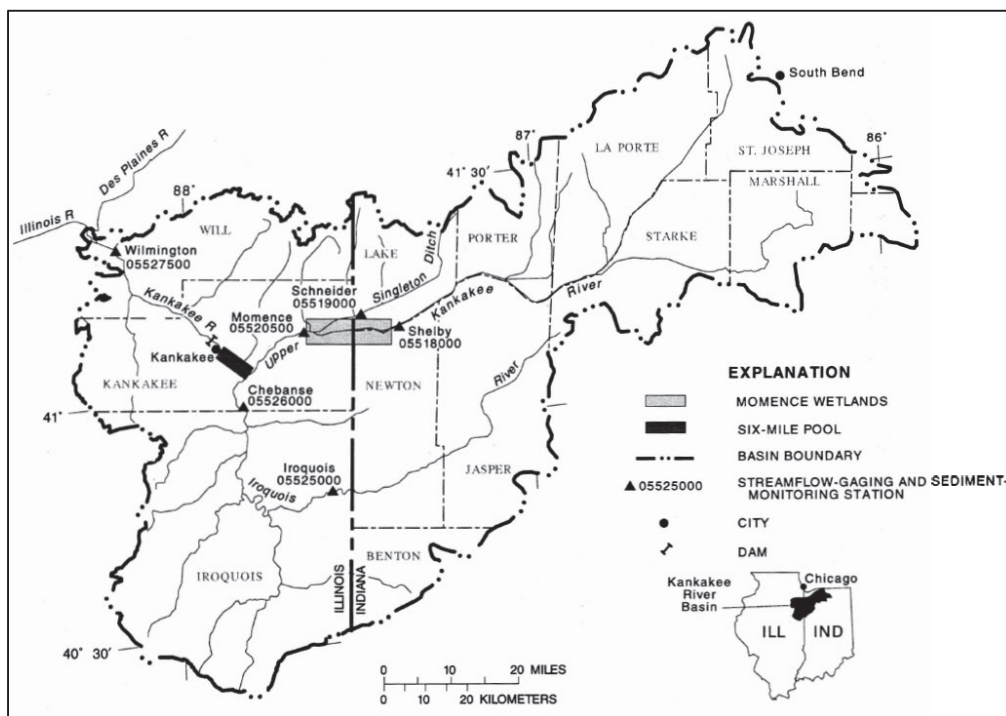
Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
miles (US statute)	1,609.347	meters
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
square miles	2.589998 E+06	square meters
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

1 Introduction

Background

The Kankakee River watershed extends from South Bend, Indiana, to its confluence with the Illinois River near Wilmington, IL (Figure 1.1). It has a 5,165-square-mile drainage area and a river length of approximately 150 miles, reduced from approximately 250 miles, historically. The watershed once included the Grand Kankakee Marsh, a 400,000-acre freshwater wetland system. The process of channelizing streams and draining the landscape has had impacts on the hydrology, hydraulics, sedimentation, and ecology of the watershed and channel network. Increased sediment loads associated with channelization and changed land use are of particular concern.

Figure 1.1 Kankakee River Basin.



The Kankakee River basin has a history of sediment concerns. The upstream portion of the watershed in Indiana was channelized by 1918 while the main stem of the river in Illinois was left in a largely natural alignment. Sites where concerns have been identified include the following:

1. wetland areas downstream of the Illinois state line
2. areas of gravel and cobble substrate downstream of Kankakee Dam (Illinois).
3. lower portion of the Yellow River (Indiana).

The lower portion of the Yellow River in Indiana has aggraded to the point where the elevation of the channel bed is above the adjacent floodplain and wetlands. The Yellow River drains an area of 435 square miles. Most of the Yellow River drainage area is overlain by sand-sized sediment.

The Rock Island, St. Louis, Chicago, and Detroit Districts collaborated to produce the Illinois River Basin Restoration Comprehensive Plan as authorized by Section 510 of Water Resources Development Act (WRDA) 2000 (USACE 2007). At the broadest level, the Comprehensive Plan seeks to develop, evaluate, and implement a collaborative and sustainable watershed-based approach to ecosystem restoration. Evaluation of potential sediment management strategies for the Kankakee River basin is a part of the comprehensive restoration plan and is the focus of the study reported herein.

Study Objectives

The objectives of the study were to estimate sub-basin sediment loads for the Kankakee River watershed and investigate 35 sediment management strategies proposed by the Rock Island District using the Sediment Impact Analysis Methods (SIAM) model. These objectives were accomplished through a field investigation and sample collection, analysis of existing sediment data from the basin, and development of a SIAM model from an existing US Army Corps of Engineers Hydrologic Engineering Center, River Analysis System (HEC-RAS) model provided by the Rock Island District.

2 Field Investigation

A field investigation of the Kankakee River basin was conducted with the purpose of identifying stream characteristics for both channelized and natural reaches, determining sediment sources and collecting sediment samples where necessary, and assessing the general morphology of the study area. The information obtained through the field investigation formed the basis for establishment of the sediment reaches incorporated in the SIAM model. The investigation was conducted with personnel from both ERDC and the Rock Island District. The investigation was limited to locations of easy access, such as road crossings, and was therefore not a comprehensive assessment of the complete stream network.

Kankakee River

The lower Kankakee River from the mouth upstream to the confluence of the Iroquois River is a fairly wide and shallow stream. Two low-head dams exist on this reach of river at Wilmington, IL, and Kankakee, IL. The lower Kankakee River contains sections that are flat in gradient as well as reaches of steep gradient. These steep gradient reaches contain a coarse bed material that acts as an armor layer and contains little loose-grained bed sediments. These reaches were designated as through-put reaches in the SIAM model. Steep reaches are located between Wilmington and the mouth and between Kankakee and Wilmington. Figure 2.1 shows the river conditions near Wilmington, where sediment deposition has formed low mid-channel islands. Figure 2.2 shows the reach of river near Kankakee River State Park, where the bed is coarse and the stream gradient is steeper.

The reach of the Kankakee River upstream of Kankakee to the IL/IN state line is somewhat narrower and more sinuous than the lower reach. The reach in the vicinity of the Iroquois River just upstream of Kankakee is influenced by pool effects from Kankakee Dam. Figure 2.3 shows sediment deposition that has occurred in this area. Upstream of the pool, the Kankakee River displays a pool/riffle sequence up to Momence, IL. Upstream of Momence, the river runs through the area known as the Momence Wetlands, and the river is narrow and sinuous with a milder gradient. Singleton Ditch is a major tributary to the Kankakee River in this reach. Singleton Ditch is a channelized stream throughout its entire length. Figure 2.4 shows the river conditions in the vicinity of the Momence Wetlands.

Figure 2.1. Kankakee River near Wilmington, IL.



Figure 2.2. Kankakee River near Kankakee River State Park.



Figure 2.3. Kankakee River near the confluence of the Iroquois River.



Figure 2.4. Kankakee River upstream of Mokence, IL, in the vicinity of the Mokence Wetlands.



The portion of the Kankakee River within Indiana upstream of the IL/IN state line is characterized by historic channelization that occurred in the early 1900s. The pattern of the river in this reach is much straighter than the river in Illinois. The straightened river channel in Indiana has contributed to increased sedimentation and flooding in the non-channelized reach in Illinois (Bhowmik et al. 1980). Figure 2.5 shows the channelized reach of the Kankakee River upstream of the IL/IN state line. Figure 2.6 shows a reach of the Kankakee River near Highway 231 in Indiana. Figure 2.7 shows the channelized Singleton Ditch in Indiana near Highway 41.

Iroquois River

The Iroquois River basin accounts for approximately 2,000 square miles of the Kankakee River basin in the southern and south-eastern portion of the basin. There is no significant channelization in the Iroquois River basin, but the basin is a major contributor of fine-grained suspended sediment. As much as twice the sediment is contributed from the Iroquois River as from the upper Kankakee River (Holmes 1997). The Iroquois River at Highway 41 in Indiana is shown in Figure 2.8. An upper reach of the Iroquois River near CR 55 is shown in Figure 2.9.

Figure 2.5. Kankakee River just upstream of the IL/IN state line.



Figure 2.6. Kankakee River near Highway 231 in Indiana.



Figure 2.7. Singleton Ditch near Highway 41 in Indiana.



Figure 2.8. Iroquois River at Highway 41 in Indiana.



Figure 2.9. Iroquois River near CR 55 in Indiana.



Yellow River

The Yellow River is a tributary to the upper Kankakee River in Indiana. It has a drainage basin area of approximately 425 square miles. The river has been channelized for the majority of the lower reach. The Yellow River is a significant producer of sand load to the Kankakee River. Extensive sand deposits are present in the lower reach of the Yellow River, resulting in the river being perched in relation to the adjacent flood plain. In addition, locations of minor to moderate bank erosion were observed along the upper portion of the Yellow River. The banks in these areas are composed of sand. An extensive sand delta at the confluence of the Yellow River with the Kankakee River is shown in Figure 2.10. An area of minor erosion in sandy banks located upstream of Knox, IN, is shown in Figure 2.11.

Several observations were made during the field investigation that was important in the development of the SIAM model and in the overall assessment of the various sediment management strategies evaluated. First, the lower Kankakee River downstream of Momence contains several reaches where the gradient is steep and the river bed is composed of coarse material. These reaches are considered through-put reaches that flush all sediment entering the reach downstream. These reaches were modeled as through-put reaches in the SIAM model. Additionally, the Yellow River is a major supplier of sand to the upper Kankakee River. The channelized sections of the Kankakee River in Indiana funnel an increased delivery of sand to the non-channelized river in Illinois. The sand deposits typically work their way through the system very slowly and can cause adverse impacts to the river for a lengthy period of time. Last, the Iroquois River is the major supplier of fine-grained suspended sediment to the Kankakee River. The Iroquois River also is a major contributor of water discharge, resulting in a significant suspended-sediment load to the lower Kankakee River. Annual suspended-sediment loads at Wilmington are four to five times the load at Momence due to the intervening contribution from the Iroquois River (Ivens et al. 1981). Unlike the sand load, which may take years or even decades to work through the system, the suspended-sediment load is generally passed completely through the system during a hydrograph cycle.

Figure 2.10. Sand deposit at the confluence of the Yellow River and the Kankakee River.



Figure 2.11. Yellow River bank erosion occurring upstream of Knox, IN.



3 Sediment Loads and Gradations

Sediment data have been compiled from multiple sources and analyzed to give average annual values of sediment loads as well as grain-size distributions. The data used as the basis for these estimates vary in time periods measured, analysis methods used, types of data collected, and variability of measured values over time.

Annual average sediment loads were first estimated from data on loads and yields from the Indiana and Illinois portions of the Kankakee River basin. Data on the relative percentages of fines (silts and clays) and sands (in the suspended load) were then used to refine these estimates. Particle-size distribution data were used to estimate percentages in each size class. Some estimates were made for sources and sinks of sediment in the reaches studied.

Data for average annual sediment loads in the Kankakee River basin were located from the review of existing reports. These data were required to run the SIAM model for existing conditions. Data were required for the main stem of the Kankakee River and major tributaries. Computed loads from different studies varied in time period covered, quantity of data, and units of the final output. Fortunately, there was relatively good coverage of the basin and good overlap of studies. The following discussion covers the data available, methods used to reduce data to average annual values, and recommended results for average annual sediment loads.

Data Sources

Although many reports were reviewed, data from three studies were used as primary sources: Demissie et al. (2004), Holmes (1997), and Crawford and Mansue (1996). Two additional sources, Bhowmik and Bogner (1981) and Demissie et al. (1983), were used for corroboration of suspended loads for water years 1979-1981 at Wilmington, Momence, Chebanse, and Iroquois.

Demissie et al. (2004) computed an average annual sediment load of 846,900 tons per year at the mouth of the Kankakee River. The load is an average over a 20-year period (1981-2000). This load was used to normalize the data from other studies.

Holmes (1997) computed total sediment loads (in tons) for the study period of three years (1993-1995) for six stations listed below. The last two stations (located in Indiana) overlap with the gauges included in Crawford and Mansue (1996):

1. Kankakee River near Wilmington, IL
2. Iroquois River near Chebanse, IL
3. Iroquois River at Iroquois, IL
4. Kankakee River at Momence, IL
5. Singleton Ditch at Schneider, IN
6. Kankakee River at Shelby, IN.

Crawford and Mansue (1996) estimated mean annual suspended sediment yield (tons per square mile per year) for seven stations in the Kankakee River basin (the study covers the entire state of Indiana). The estimates are described as imprecise. The bulk of the data were collected from 1978 to 1982. The seven stations are listed as follows:

1. Kankakee River at Shelby, IN
2. Singleton Ditch at Schneider, IN
3. Yellow River at Plymouth, IN
4. Kankakee River at North Liberty, IN
5. Cobb Ditch near Kouts, IN
6. Iroquois River near Foresman, IN
7. Iroquois River at Rosebud, IN.

Demissie et al. (2004) computed the average annual suspended sediment load for the Kankakee River at the mouth (5,165-square-mile drainage area) for 20 years of record (1981-2000). To compute the average annual sediment load at Wilmington, it was necessary to estimate (and subtract) the average annual yield for the 15 square miles of contributing drainage area downstream of Wilmington. Based on various estimates of yield for the lower Kankakee River, an average annual value of 307 tons per square mile was used. This gave an adjusted average annual value for the Kankakee River near Wilmington (5,150 square miles) of 842,300 tons per year.

The Holmes (1997) study measured sediment loads at multiple stations in the Kankakee River basin. The Wilmington gauge was the most downstream gauge, and the two most upstream gauges were the Kankakee River at Shelby, IN, and the Iroquois River at Iroquois, IL. Total sediment loads

(tons) were published for each gauge location for the measurement period, January 1993 through December 1995. Sediment loads were also computed for the contributing areas between gauge locations. For the Kankakee River near Wilmington, the Holmes (1997) study measured a sediment load of 2,010,000 tons for the 3-year study period. The computed average annual sediment load for the Kankakee River near Wilmington was 842,300 tons/year (as computed above, from the data in Demissie et al. 2004), giving a ratio of 0.42. The remaining loads in the Holmes study were multiplied by the same ratio (0.42) to convert the sediment loads to annual average values.

The estimated average annual yield for the Yellow River at Plymouth, IN, (86 tons per square mile: Crawford and Mansue 1996) was used to compute an average annual suspended load for the entire basin (430 square miles) of 37,000 tons from watershed sources. An estimate of sediment load from stream bank erosion (24,000 tons) was included because of the known presence of eroding banks. This material has a delivery ratio of 100 percent (USDA Soil Conservation Service 1971).

The Yellow River drains sandy glacial outwash in the lower third of the drainage basin (below Plymouth), with the upper two-thirds (above Plymouth) draining soils with considerably more clay (USACE 2006). The area of sandy glacial outwash covers the upper Kankakee River down to Momence (Ivens et al. 1981). The suspended sediment yields from the northern lake and moraine area of Indiana tend to be much less than yields from other physiographic regions, so low values are expected in the Kankakee River basin in Indiana (Crawford and Mansue 1996).

The Holmes (1997) and Crawford and Mansue (1996) studies overlap at two stations: Kankakee River at Shelby, IN, and Singleton Ditch at Schneider, IN. At the two locations where the studies overlap, the yield values from the Holmes (1997) study are 17 to 32 percent higher than the Crawford and Mansue (1996) values, which are described as imprecise. Information on bed load from studies throughout the basin is summarized as follows:

1. For the stations at Wilmington, Momence, Chebanse, and Iroquois, the measured suspended sediment loads should be close approximations of the total sediment load. For the gauges at Momence and Wilmington, this is because the river bed at both locations is rocky, and highly turbulent flows keep the sediment load in suspension at both of these stations

- (Bhowmik et al. 1980). At the Iroquois and Chebanse gauges, the suspended load should be close to the total sediment load since the sediment transported in the Iroquois River is mainly silt and clay (Bhowmik et al. 1980).
2. The Illinois State Water Survey analysis at the State Line estimated that 1.7 percent of the suspended load or 1.6 percent of the total load is transported as bed load (Bhowmik et al. 1980).
 3. Bhowmik et al. (2004) estimated bed load percentage as 5 to 10 percent of total load (for the Stateline Bridge to the Kankakee Dam).
 4. Sediment loads were not increased to account for bed load in this set of computations.

Ivens et al. (1981) summarizes substrate data from biological sampling done in 1979. These data were taken for the seven biological sampling stations on the Kankakee River main stem. The percentage of bed material that was gravel, cobble, or bedrock ranged from 0 to 80 percent of the substrate. These data are helpful in representing the portion of the substrate not included in collected bed material samples (e.g., bedrock and cobble).

General Procedure for Estimating Sediment Loads

The following procedure was used to estimate sediment loads and gradations for existing conditions in the Kankakee River basin:

1. The average annual suspended loads were estimated using the data and methods given above.
2. The percentages of sand and fines were estimated using available data from various sources. The loads were divided into sands and fines and were compared along the basin for reasonable values. The yields were determined for sands and fines as was the sand percent in the total load. These figures were compared with other available data.
3. Estimates of deposition were made for three locations: Yellow River above mouth; the Momence Wetlands; and the Six-Mile Pool.
4. Some data values were assumed to be fixed, i.e., the total average annual load at Wilmington. However, most data points could be modified within a range of reasonable values from the various data sources. The determination of the best estimates for the sediment loads and gradations was an iterative procedure.
5. After the loads, yields, and fine-sand split seemed reasonable for the entire basin, the entire particle size distribution was assigned. The ratio of clay to silt was determined. The percent of sand in the different size classes was

determined using appropriate sampled data. These percentages were used to distribute the loads and yields into individual grain size classes.

Estimates of Sediment Load

The analysis discussed above gives an evaluation of the sediment sources in the Kankakee River basin and provides estimates of the sediment loads from the various locations of the watershed. These sediment sources and gradations are used as input for the SIAM model to define the existing conditions of the basin.

The estimated average annual load of fine-grained sediment delivered to the Illinois River from the Kankakee River is approximately 770,000 tons and is delivered from the following locations within the watershed:

1. Contributing basin area downstream of the Iroquois River: 25 percent
2. Iroquois River basin: 52 percent
3. Kankakee River basin upstream of Iroquois River: 23 percent.

The estimated average annual load of sand delivered to the Illinois River from the Kankakee River basin is approximately 77,000 tons. The sand load is delivered from the following locations within the watershed:

1. Contributing basin area downstream of the Iroquois River: 8 percent
2. Iroquois River basin: 22 percent
3. Kankakee River basin upstream of Iroquois River (excluding the Yellow River basin): 31 percent
4. Yellow River basin: 39 percent.

Note that approximately 70 percent of the total sand load comes from the sand belt region of the Yellow River basin and the upper Kankakee River basin.

Given these estimates of the average annual loads for sand and fine-grained material, the average annual total sediment load for the Kankakee River is estimated at 847,000 tons per year. The sand load is approximately 9 percent of the estimated total sediment load. A graphic showing the estimated sediment loads and percentages by watershed locations is shown in Figure 3.1. A summary of the estimated sediment loads at major locations in the watershed is presented in Table 3.1.

Figure 3.1. Estimated sediment loads and percentages by location for the Kankakee River basin.

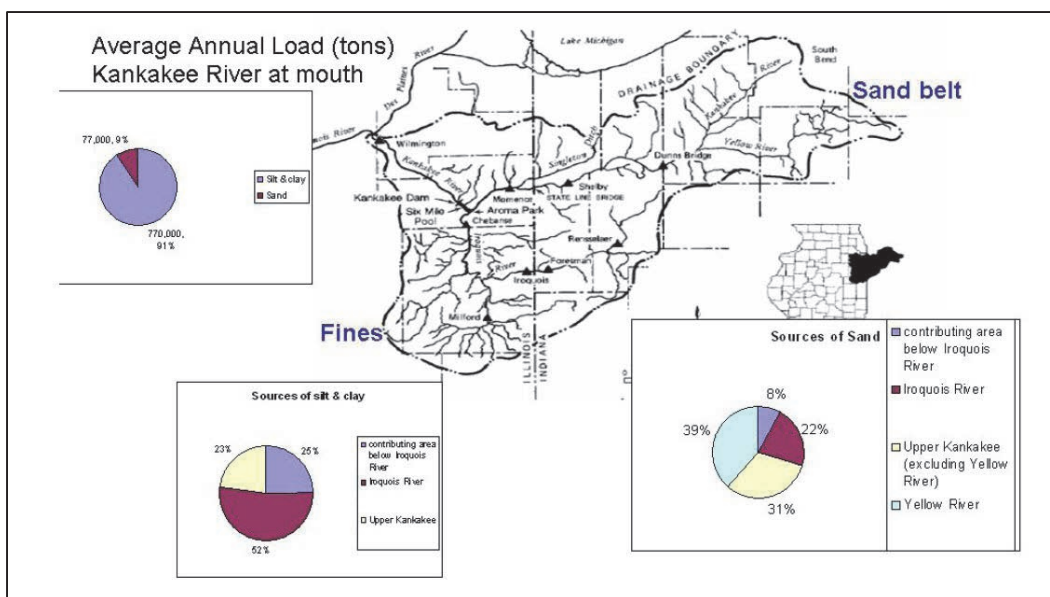


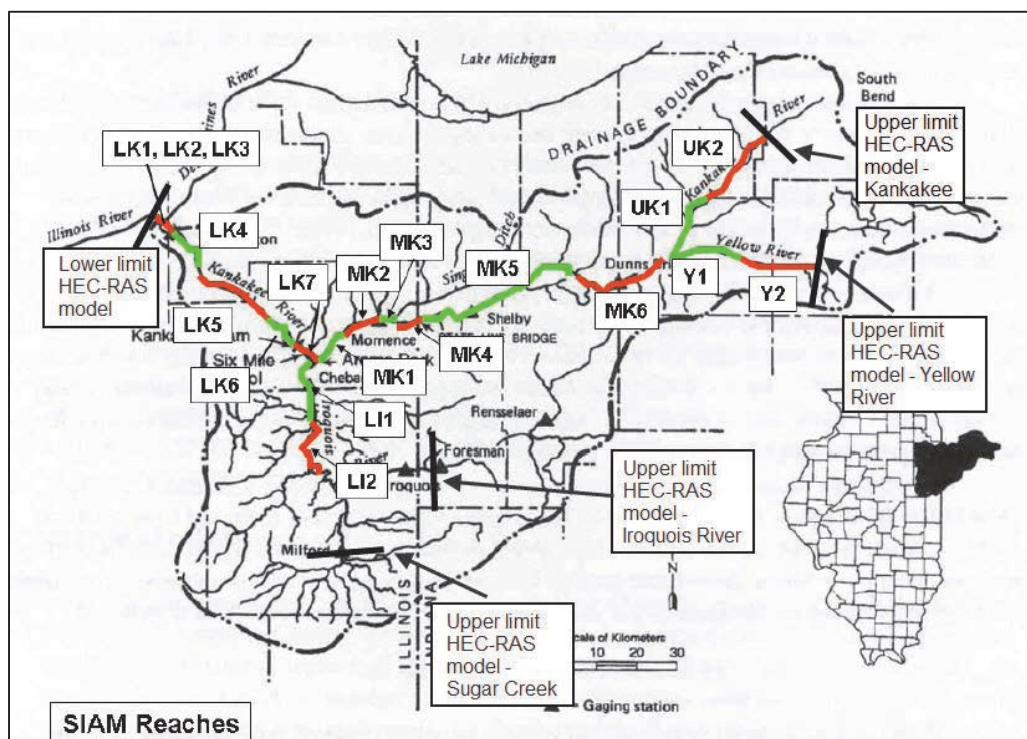
Table 3.1. Estimated annual sediment loads for the Kankakee River watershed.

Location	Basin area (miles ²)	Sediment Load (tons/year)		
		Total	Sand	Silt/Clay
Kankakee River at mouth	5,165	847,000	77,000	770,000
Kankakee River at Wilmington, IL	5,150	842,000	76,000	766,000
Kankakee River above Iroquois River	2,378	230,000	54,000	176,000
Kankakee River at Momence, IL	2,294	204,000	53,000	151,000
Kankakee River above Yellow River	670	27,400	11,000	16,400
Kankakee River at North Liberty, IN	174	8,400	3,400	5,000
Iroquois River at mouth	2,137	419,000	17,000	402,000
Iroquois River at Iroquois, IL	686	74,700	2,900	71,800
Yellow River at mouth	430	59,500	29,800	29,700
Yellow River at Plymouth, IN	294	25,000	2,500	22,500
Singleton Ditch at mouth	254	38,900	3,900	35,000

4 SIAM Model

A SIAM model was developed from an existing calibrated HEC-RAS model provided by the Rock Island District. The limits of the HEC-RAS model are shown in Figure 4.1. No further effort was made to verify the calibration of the HEC-RAS model. The estimated sediment loads were used to develop sediment source inputs that reflect existing conditions for the various sediment reaches of the model. The sediment source inputs were modified to reflect the anticipated impacts of proposed sediment management strategies in order to evaluate relative impacts with the SIAM model.

Figure 4.1. Sediment reaches for SIAM model of the Kankakee River.



Model Description

The SIAM model is available in the *Hydraulic Design* module of HEC-RAS. SIAM is a sediment budget tool that compares annualized reach-average sediment transport capacities to supplies and indicates reaches of overall sediment deficit or surplus. SIAM is a screening level tool to quickly compare relative responses to a range of alternatives in order to identify promising alternatives. The algorithms in SIAM evaluate sediment impact

caused by local changes on the system from a sediment continuity perspective. The results map potential imbalances and instabilities in a channel network and provide a first step in developing remediation features. The SIAM model does not predict intermediate or final morphological patterns and does not update cross-section geometry but rather indicates trends and locations in the system for potential sediment imbalances (USACE 2010).

Sediment Reaches

Development of the SIAM model from the existing calibrated HEC-RAS model involved establishing sediment reaches for the description of sediment inputs and interpretation of results. Sediment reaches were developed based on locations of morphological features within the watershed, such as reaches of similar slope, tributary points, and bed material composition. The intent of the sediment reach development was to delineate reaches with relatively consistent hydraulic, morphologic, and sediment properties. The sediment reaches adopted for the SIAM model are shown in Figure 4.1. Descriptions of the reaches are provided in Table 4.1.

Field investigation observations and bed material data were used to identify reaches that would be modeled as through-put reaches. Reaches acting as through-put reaches generally contain coarse bed material or bed rock and are steep in gradient and, therefore, pass all sediment entering the reach through to downstream reaches fairly quickly. Methods used to model the reaches as through-put are discussed later in this report. The sediment reaches that were identified as through-put reaches were LK1, LK3, LK5, LK6, and MK2.

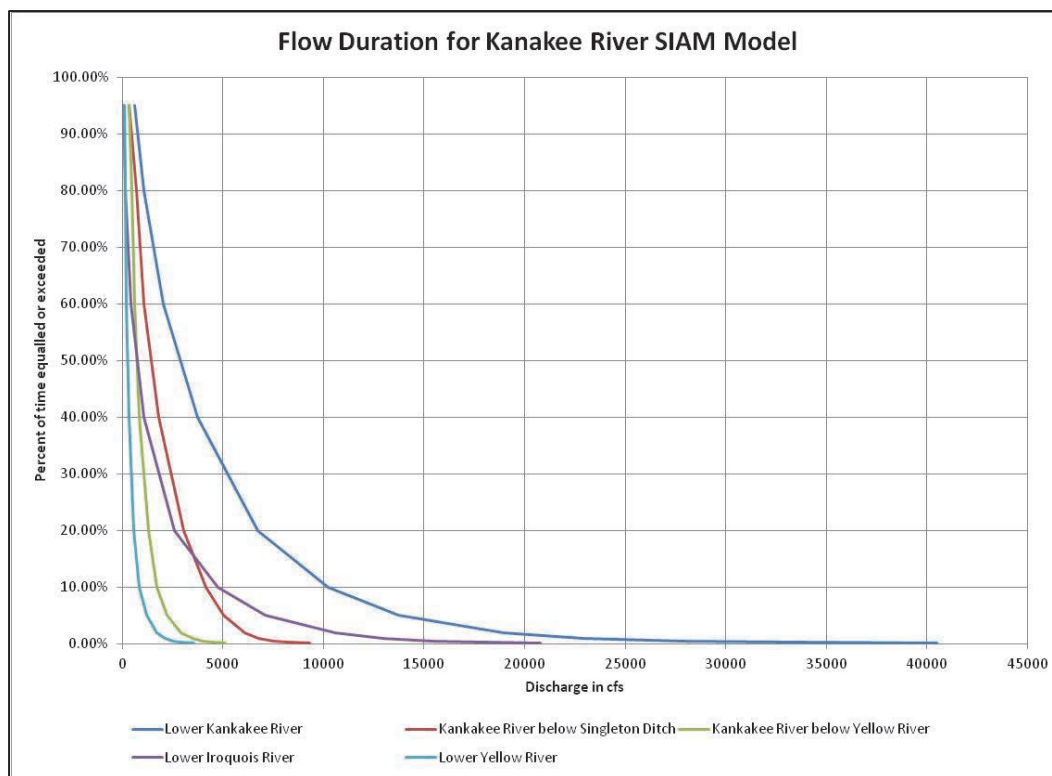
Input Data for Existing Conditions

User-supplied input data for the SIAM model included bed-material composition, flow duration, sediment controls such as threshold grain size and transport function, and sediment source loads and gradations. Reach-average hydraulic values used to compute transport capacities were obtained from the HEC-RAS hydraulic results.

Bed-material composition was determined from existing data or samples collected in the field. The bed-material grain size distribution for each sediment reach is shown in Table 4.2 (through-put reaches excluded).

Flow-duration curves for the SIAM model were obtained from data provided by the Rock Island District. The flow-duration curves at primary sites in the Kankakee River watershed are shown in Figure 4.2. Flow-duration curves at other required locations in the model were determined by interpolating based on watershed area. The flow-duration curves were input in the HEC-RAS model using 12 steady-state profiles corresponding to the following flow duration equaled or exceeded percentages: 0.1, 0.25, 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 40.0, 60.0, 80.0, and 95.0 percent.

Figure 4.2. Flow-duration curves input into the SIAM model.



The Laursen-Copeland sediment transport function was selected for the SIAM model based on its applicability to the range of sand to gravel that is found in the bed material. It should be noted that although other transport functions may yield different values of computed capacity, relative changes should be similar. The wash material threshold diameter was evaluated for each sediment reach (excluding through-put reaches) based on the D_{10} diameter of the bed material for the reach. Although the D_{10} of the bed material for some reaches was in the very fine sand range, trial runs of the SIAM model indicated that use of a threshold diameter corresponding to very fine sand (0.125 mm) resulted in an unreasonable magnitude of bed-material load. The adopted wash-load threshold value was 0.25 mm for

reaches on the Kankakee River and Yellow River and 0.5 mm for reaches on the Iroquois River. Sediment reaches designated as through-put reaches in the SIAM model were LK1, LK3, LK5, LK6 and MK2. Through-put reaches were modeled by setting the wash load threshold diameter to the maximum size allowed (128 mm), which is larger than any bed material size in the non-through-put reaches. This resulted in all sediment entering a through-put reach to be treated as wash load and delivered to the next downstream non-through-put reach by the SIAM model.

Sediment-source loads and grain-size distributions for each SIAM sediment reach were determined from the estimated sediment loads presented earlier. The majority of the sediment source used in the SIAM model was watershed contribution. The exceptions were a source for estimated bank erosion in the Yellow River reach Y1, a tributary source for Singleton Ditch for Kankakee River reach MK2, and incoming sediment loads for the most upstream reaches of the Kankakee, Iroquois and Yellow Rivers. Table 4.3 shows the estimated sediment source loads for specific areas of the watershed that were incorporated in the SIAM model for existing conditions. Table 4.4 shows the percentage (multiplier) of each sediment source that was applied to the individual SIAM sediment reaches for existing conditions.

Table 4.3. Sediment sources for existing conditions in the SIAM model.

Watershed location	Source type ¹	Sediment load (tons/yr) by grain size (mm)								
		0.004	0.008	0.016	0.032	0.063	0.125	0.25	0.5	1.0
Kankakee R. mouth to Wilmington	WS	3,680			736		184			
Wilmington to Kankakee Dam	WS	136,320			27,264		6,816			
Kankakee Dam to Iroquois R. confluence	WS	19,680			3,936		984			
Iroquois R. confluence to Momence	WS	20,800			4,160		1,040			
Momence to Shelby	WS	15,660			5,220		780	783	3,135	522
Shelby to Yellow R. confluence	WS	36,660			12,220		1,830	1833	7,335	1,222
Kankakee R. u/s Yellow R. confluence	WS	8,550			2,850		950	950	4,750	950
Upper Kankakee R.	US	3,780			1,260		420	420	2,100	420
Iroquois R. mouth to Chebanse	WS	11,280			2,256		564			

Watershed location	Source type ¹	Sediment load (tons/yr) by grain size (mm)								
		0.004	0.008	0.016	0.032	0.063	0.125	0.25	0.5	1.0
Iroquois R. Chebanse to Iroquois	WS	26,4400			52,880		13,220			
Iroquois R. Iroquois to Foresman	WS	36,400			7,280		1,820			
Upper Iroquois R.	US	22,800			4,845		855			
Yellow R. u/s of mouth	WS	5,400			1,800		600	600	3,000	600
Upper Yellow R.	US	17,000			5,500		500	500	750	750
Yellow R. bank erosion	BE							3,600	18,000	2,400
Singleton Ditch	TR	26,452			8,552		778	778	1,167	1,167

¹ WS=watershed contribution, US=upstream load, BE=bank erosion, TR=tributary load

Table 4.4. Percentage (multiplier) of sediment source for each SIAM sediment reach.

Watershed location	Sediment source percentage (multiplier) for individual sediment reaches																		
	LK1	LK2	LK3	LK4	LK5	LK6	LK7	MK1	MK2	MK3	MK4	MK5	MK6	UK1	UK2	LI1	LI2	Y1	Y2
Kankakee R. mouth to Wilmington	1.0																		
Wilmington to Kankakee Dam		0.12	0.04	0.42	0.19	0.23													
Kankakee Dam to Iroquois R. confluence							1.0												
Iroquois R. confluence to Momence								0.75	0.25										
Momence to Shelby										0.25	0.75								
Shelby to Yellow R. confluence												0.5	0.5						
Kankakee R. u/s Yellow R. confluence														1.0					
Upper Kankakee R.															1.0				
Iroquois R. mouth to Chebanse																1.0			
Iroquois R. Chebanse to Iroquois																0.5	0.5		

Watershed location	Sediment source percentage (multiplier) for individual sediment reaches																		
	LK1	LK2	LK3	LK4	LK5	LK6	LK7	MK1	MK2	MK3	MK4	MK5	MK6	UK1	UK2	LI1	LI2	Y1	Y2
Iroquois R. Iroquois to Foresman																	1.0		
Upper Iroquois R.																	1.0		
Yellow R. u/s of mouth																		1.0	
Upper Yellow R.																			1.0
Yellow R. bank erosion																		1.0	
Singleton Ditch									1.0										

The reach-average hydraulic values used to compute the sediment transport capacity for each sediment reach were obtained from the HEC-RAS computational results and are not tabulated in this report. The SIAM input data presented above were used to compute the sediment balance for existing conditions in the Kankakee River watershed. The SIAM results for existing conditions provide the baseline for the comparison of results from the various sediment management strategies presented later in this report.

5 Evaluation of Sediment Management Strategies

After the SIAM model results were computed for existing conditions in the Kankakee River watershed, various sediment management strategies were developed with the Rock Island District. Five trial sediment management alternatives were evaluated with the SIAM model for demonstration purposes. The trial alternatives involved removal of bank erosion sources, watershed sources, and simulation of channel re-meandering and flood plain reconnection on the Kankakee River from the IL/IN state line to Shelby, IN. The specific trial alternatives were as follows:

1. Trial Alternative 1: Remove bank erosion source from the Yellow River
2. Trial Alternative 2: Reduce watershed source loads from the Yellow River by 50 percent
3. Trial Alternative 3: Reduce watershed source loads from the Iroquois River by 50 percent
4. Trial Alternative 4: Reduce watershed source loads from the Kankakee River upstream of IL/IN state line by 50 percent
5. Trial Alternative 5: Simulate re-meandering of the Kankakee River reach from IL/IN state line through Shelby, IN.

The SIAM results from these trial alternatives were evaluated with the Rock Island District and formed the basis for development of a matrix of 35 sediment management strategies evaluated in this study. The results of these trial alternatives are not presented as part of the report but can be found in Jonas and Little (2010).

Sediment Management Strategies

Selected sediment management strategies were based on the assumption that restoration measures implemented in various watershed locations would result in a 20-percent reduction in sediment loads from watershed sources and bank erosion sources. Hence, the sediment load for each SIAM sediment reach listed for each sediment management strategy was reduced by 20 percent using the multiplication factor in the SIAM model. In addition to the reduction of sediment loads, some of the alternatives also addressed channel re-meandering and floodplain reconnection for the

Kankakee River reach upstream of the IL/IN state line and dredging of Six Mile Pool upstream of Kankakee Dam (Dredge Option 4 provided by the Sponsor).

The sediment management strategies were grouped according to application in the upper Kankakee River watershed in Indiana, the lower Kankakee River watershed in Illinois, and a miscellaneous combination of both areas. The sediment management strategies by groups of reaches (Figure 4.1 and Table 4.1) are as follows:

1. Upper Kankakee River basin (Indiana)

- a. UK1, UK2
- b. UK1, UK2, Y1, Y2
- c. UK1, UK2, Y1, Y2, MK6
- d. UK1, UK2, Y1, Y2, MK6, MK5
- e. UK1, UK2, Y1, Y2, MK6, MK5 + 20-percent reduction in Trial Alternative #3 (LI1, LI2)
- f. MK5 re-meander/reconnection of 40K acres in flood plain
- g. F. above + Y1, Y2
- h. F. above + Y1, Y2, UK1, UK2
- i. F. above + MK6 re-meander/reconnection of 60K acres in flood plain
- j. I. above + Y1, Y2
- k. I. above + Y1, Y2, UK1, UK2

2. Lower Kankakee River basin (Illinois)

- a. LI1, LI2
- b. LI1, LI2, MK1
- c. LI1, LI2, MK1, MK2
- d. LI1, LI2, MK1, MK2, MK3
- e. LI1, LI2, MK1, MK2, MK3 + 20-percent reduction in Singleton Ditch
- f. LI1, LI2, MK1, MK2, MK3 + 20-percent reduction in Singleton Ditch, MK4
- g. LI1, LI2, MK1, MK2, MK3, MK4
- h. LI1, LI2, MK1, MK2, MK3, MK4, LK6, LK7
- i. LI1, LI2, MK1, MK2, MK3, MK4 + Upper Kankakee Alt. D from above
- j. LI1, LI2, MK1, MK2, MK3, MK4 + Upper Kankakee Alt. D from above, LK6, LK7
- k. MK1
- l. MK1, MK2
- m. MK1, MK2, MK3

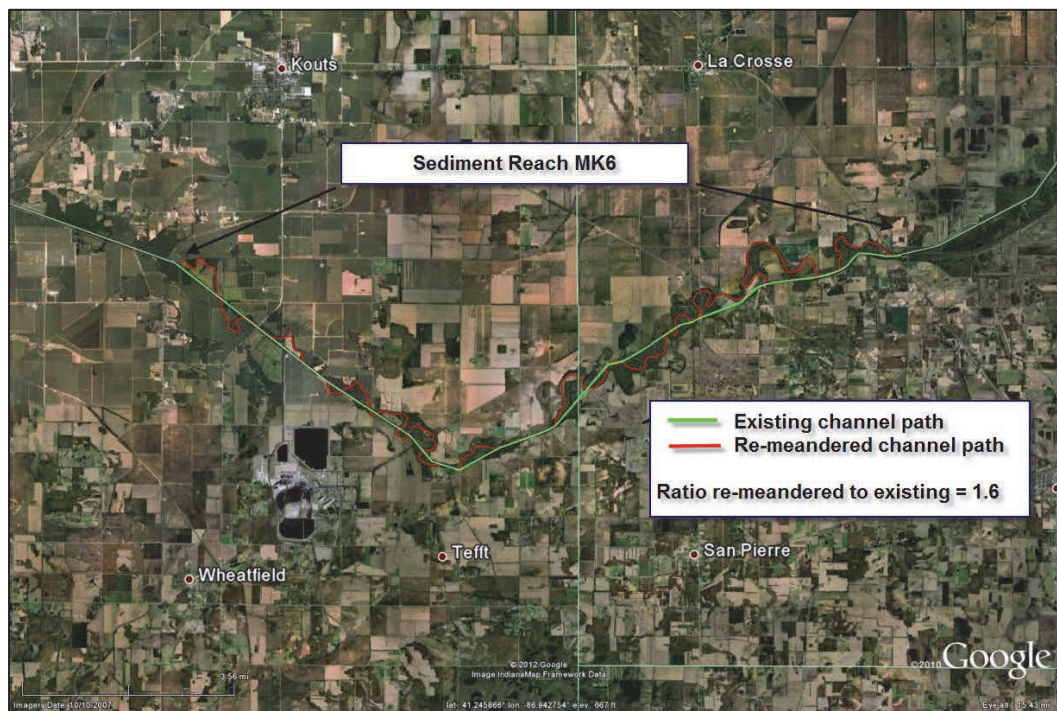
- n. MK1, MK2, MK3 + 20-percent reduction in Singleton Ditch
 - o. MK1, MK2, MK3 + 20-percent reduction in Singleton Ditch, MK4
 - p. MK1, MK2, MK3, MK4
 - q. MK1, MK2, MK3, MK4, LK6, LK7
 - r. MK1, MK2, MK3, MK4 + Upper Kankakee Alt. D from above
 - s. MK1, MK2, MK3, MK4 + Upper Kankakee Alt. D from above, LK6, LK7
 - t. LK7 Six Mile Pool dredging (Option 4)
 - u. LK7 Six Mile Pool dredging (Option 4), LK6
 - v. LK7 Six Mile Pool dredging (Option 4), MK3, MK4, LK6 + 20-percent reduction in Singleton Ditch
3. Miscellaneous Upper (Indiana) and Lower (Illinois) Kankakee River basin
- a. MK5 re-meander/reconnection of 40K acres in flood plain, LK7 Six Mile Pool dredging (Option 4)
 - b. MK5 re-meander/reconnection of 40K acres in flood plain, MK6 re-meander/reconnection of 60K acres in flood plain, UK1, UK2, Y1, Y2, LI1, LI2, MK1, MK2, MK3, MK4 + 20-percent reduction in Singleton Ditch.

A SIAM sediment reach listed in the above alternatives indicates that the total sediment source load for that reach is reduced by 20 percent from existing condition levels. It should be noted that alternative 1E contains a 20-percent reduction to the previous Trial Alternative 3, which included a 50-percent reduction in watershed sediment source. Therefore, alternative 1E results in an effective 60-percent reduction in watershed sediment source from existing conditions. For the alternatives involving channel re-meandering and flood plain reconnection in sediment reaches MK5 and MK6, the channel modifications were simulated by increasing the channel lengths in the HEC-RAS geometry file. The channel lengths were increased based on the ratio of re-meandered channel length to existing channel length as determined from measurements using Google Earth. The measured channel paths for existing and re-meandered conditions are shown in Figures 5.1 and 5.2 for sediment reaches MK5 and MK6, respectively. It should be noted that the re-meandered channel path was not based on any proposed plan but was determined from historic channel locations visible from the Google Earth imagery. As a result, the re-meandered channel path is subjective in nature. The ratio of the re-meandered channel length to the existing channel length for sediment reaches MK5 and MK6 was 1.37 and 1.6, respectively.

Figure 5.1. Assumed channel re-meander path for sediment reach MK5.



Figure 5.2. Assumed channel re-meander path for sediment reach MK6.



Management alternatives that involved Six Mile Pool dredging in sediment reach LK7 utilized a dredge plan Option #4 obtained from the Rock Island District. Dredge Option #4 involved dredging in Six Mile Pool above

Kankakee Dam from river mile 34.84 to 35.61. Dredge-cut elevations for this plan range from elevation 583.0 feet to 586.0 feet, and the dredge-cut width is approximately 400 feet. The dredge option was incorporated in the alternative by editing the appropriate cross sections in the HEC-RAS geometry file to reflect the dredge-cut geometry.

For reporting purposes, the numbering convention for each sediment management alternative combines the number and letter of the alternative from the list on pages 29 and 30. For example, alternative 1A refers to the Upper Kankakee River basin item A; 2T refers to the Lower Kankakee River basin item T; etc. All SIAM results herein utilize this numbering convention.

SIAM Results for Sediment Management Strategies

The matrix of 35 sediment management alternatives was evaluated with the SIAM model, and the results were compared to results for existing conditions in the Kankakee River watershed. The results are presented according to the basin location of the various management alternatives. The SIAM results presented include local sediment balance and total sediment load for each sediment reach. Local sediment balance is the difference between bed-material supply and transport capacity for a reach. A positive local balance indicates a surplus of bed-material supply for the reach and may be viewed as an indicator of potential sediment deposition. A negative local balance indicates an excess of transport capacity for the reach and may be an indicator of potential degradation. If the local sediment balance is within a specified tolerance, the reach is considered in relative equilibrium. The equilibrium tolerance adopted for this study is $\pm 1,000$ tons per year. The total sediment load reflects the sum of the bed-material supply and wash supply for each sediment reach.

It should be noted in evaluating the results for the alternatives that the SIAM model provides a picture of the relative sediment balance for the watershed for a given set of conditions. The model does not route sediment nor adjust channel geometry. Model output should be viewed as an indication of potential trends in sediment continuity as a result of the alternatives rather than an absolute quantitative assessment.

The SIAM local sediment balance results for the Upper Kankakee River (Indiana) alternatives 1A through 1K are shown in Table 5.1. Results are color-coded to indicate whether the local sediment balance is positive

(blue), negative (red), or in relative equilibrium (green). The local sediment balance for all through-put reaches is zero and, therefore, not color-coded.

Table 5.1. Local sediment balance for Upper Kankakee River (IN) alternatives 1A – 1K

Reach	Local sediment balance (tons/year) for Upper Kankakee River alternatives											
	Existing	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K
LK1	0	0	0	0	0	0	0	0	0	0	0	0
LK2	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507
LK3	0	0	0	0	0	0	0	0	0	0	0	0
LK4	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000
LK5	0	0	0	0	0	0	0	0	0	0	0	0
LK6	0	0	0	0	0	0	0	0	0	0	0	0
LK7	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300
MK1	-12,500	-12,500	-12,500	-12,500	-12,500	-12,500	-12,500	-12,500	-12,500	-12,500	-12,500	-12,500
MK2	0	0	0	0	0	0	0	0	0	0	0	0
MK3	-21,100	-21,100	-21,100	-21,100	-21,100	-21,100	-21,100	-21,100	-21,100	-21,100	-21,100	-21,100
MK4	2,081	2,081	2,081	2,081	2,081	2,081	-6,404	-6,404	-6,404	-6,447	-6,447	-6,447
MK5	-6,859	-6,859	-6,859	-6,859	-7,715	-7,715	866	866	866	-4,628	-4,628	-4,628
MK6	33,000	33,000	33,000	32,200	32,200	32,200	33,700	33,700	33,700	35,900	35,900	35,900
UK1	2,974	1,834	1,834	1,834	1,834	1,834	2,975	2,975	1,835	3,553	3,553	2,413
UK2	2,413	1,909	1,909	1,909	1,909	1,909	2,413	2,413	1,909	2,414	2,414	1,910
LI1	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900
LI2	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765
Y1	19,800	19,800	15,000	15,000	15,000	15,000	19,800	15,000	15,000	22,700	17,900	17,900
Y2	-30,900	-30,900	-31,200	-31,200	-31,200	-31,200	-30,900	-31,200	-31,200	-30,900	-31,200	-31,200

Surplus bed material supply (depositional trend)

Excess transport capacity (degradational trend)

Relative equilibrium

Alternatives 1A through 1E involve sediment-load reductions solely, and the impact on local sediment balance is manifested through the reduction in bed-material supply for the reaches where sediment source loads are reduced. The reduction in bed-material supply changes the local sediment balance for the reach by an equivalent amount. Alternatives 1F through 1K involve the channel re-meandering and floodplain reconnection for the Kankakee River in sediment reaches MK5 and MK6. The SIAM local sediment balance results for these alternatives indicate the effect of channel modifications on sediment-transport capacity. The increase in channel length associated with the re-meandered channel results in a

decrease in channel slope and, thus, an attendant decrease in available energy for sediment transport. This decrease in transport capacity affects local sediment balance in two ways: 1) the local balance for the reach is increased by an amount equal to the decrease in capacity, and 2) the local balance for the next downstream reach is decreased due to a reduction in bed-material supply equal to the decrease in capacity. For example, the existing-conditions local balance for reach MK5 is -6,800 tons per year, indicating an excess of transport capacity.

The channel re-meanders in alternatives 1F through 1H significantly decreased the reach-average transport capacity, resulting in a local sediment balance of approximately 860 tons per year for reach MK5, indicating a surplus bed-material supply. The local sediment balance for the next downstream reach, MK4, is approximately 2,080 tons per year for existing conditions, indicating a surplus of bed-material supply. However, the decrease in transport capacity for reach MK5 results in an equivalent decrease in bed-material supply to the downstream reach MK4. This changes the local sediment balance for reach MK4 to approximately -6,400 tons per year, or an excess of transport capacity. These results indicate the significant impact that channel modification can have on the system. Channel re-meandering and floodplain reconnection within a reach will tend to cause that reach to act as a sediment trap and likewise starve reaches immediately downstream of bed material. Because of the potential impacts of channel modification on the sediment regime of a reach, any alternative that involves such channel modifications should be fully evaluated with a sediment-routing model.

The SIAM local sediment balance results for the Lower Kankakee River (Illinois) alternatives 2A through 2V are shown in Tables 5.2 and 5.3.

The majority of the alternatives run for the lower Kankakee River in Illinois involved estimated reductions in sediment source loads from the watershed. A significant portion of these watershed sediment loads was fine material that was not found in significant amounts in the bed material, and reduction of the loads did not appreciably affect the local sediment balance. Reduction of these sediment loads did, however, affect the total sediment load as will be discussed later. Alternatives 2T through 2V were the exception, as they involved modification of the channel geometry of reach LK7 as a result of dredging in Six Mile Pool. Similar to the effects of channel re-meandering, geometry modification due to dredge cuts decreases sediment transport

Table 5.2. Local sediment balance for Lower Kankakee River (IL) alternatives 2A – 2K.

Reach	Local sediment balance (tons/year) for Lower Kankakee River alternatives											
	Existing	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K
LK1	0	0	0	0	0	0	0	0	0	0	0	0
LK2	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507	-4,507
LK3	0	0	0	0	0	0	0	0	0	0	0	0
LK4	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000	-124,000
LK5	0	0	0	0	0	0	0	0	0	0	0	0
LK6	0	0	0	0	0	0	0	0	0	0	0	0
LK7	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300	69,300
MK1	-12,500	-12,500	-12,500	-12,500	-12,500	-12,900	-12,900	-12,500	-12,500	-12,500	-12,500	-12,500
MK2	0	0	0	0	0	0	0	0	0	0	0	0
MK3	-21,100	-21,100	-21,100	-21,100	-21,300	-21,300	-21,300	-21,300	-21,300	-21,300	-21,300	-21,100
MK4	2,081	2,081	2,081	2,081	2,081	2,081	1,532	1,532	1,532	1,532	1,532	2,081
MK5	-6,859	-6,859	-6,859	-6,859	-6,859	-6,859	-6,859	-6,859	-6,859	-7,715	-7,715	-6,859
MK6	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	32,200	32,200	33,000
UK1	2,974	2,974	2,974	2,974	2,974	2,974	2,974	2,974	2,974	1,834	1,834	2,974
UK2	2,413	2,413	2,413	2,413	2,413	2,413	2,413	2,413	2,413	1,909	1,909	2,413
LI1	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900
LI2	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765
Y1	19,800	19,800	19,800	19,800	19,800	19,800	19,800	19,800	19,800	15,000	15,000	19,800
Y2	-30,900	-30,900	-30,900	-30,900	-30,900	-30,900	-30,900	-30,900	-30,900	-31,200	-31,200	-30,900

Surplus bed material supply (depositional trend)

Excess transport capacity (degradational trend)

Relative equilibrium

Table 5.3. Local sediment balance for Lower Kankakee River (IL) alternatives 2L – 2V.

[illegible]

Reach	Local sediment balance (tons/year) for Lower Kankakee River alternatives											
	Existing	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U	2V
MK3	-21,100	-21,100	-21,300	-21,300	-21,300	-21,300	-21,300	-21,300	-21,300	-21,100	-21,100	-21,300
MK4	2,081	2,081	2,081	2,081	1,532	1,532	1,532	1,532	1,532	2,081	2,081	1,532
MK5	-6,859	-6,859	-6,859	-6,859	-6,859	-6,859	-6,859	-7,715	-7,715	-6,859	-6,859	-6,859
MK6	33,000	33,000	33,000	33,000	33,000	33,000	33,000	32,200	32,200	33,000	33,000	33,000
UK1	2,974	2,974	2,974	2,974	2,974	2,974	2,974	1,834	1,834	2,974	2,974	2,974
UK2	2,413	2,413	2,413	2,413	2,413	2,413	2,413	1,909	1,909	2,413	2,413	2,413
LI1	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900	-18,900
LI2	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765	-1,765
Y1	19,800	19,800	19,800	19,800	19,800	19,800	19,800	15,000	15,000	19,800	19,800	19,800
Y2	-30,900	-30,900	-30,900	-30,900	-30,900	-30,900	-30,900	-31,200	-31,200	-30,900	-30,900	-30,900

Surplus bed material supply (depositional trend)

Excess transport capacity (degradational trend)

Relative equilibrium

capacity through reduction of channel velocity. The local sediment balance for reach LK7 (Six Mile Pool reach) was 69,300 tons per year for existing conditions, indicating a significant surplus of bed material supply on an annual basis. This bed-material surplus was the largest for all reaches and was indicative of the pool conditions above Kankakee Dam. For alternatives 2T through 2V, the decrease in transport capacity due to dredging in Six Mile Pool resulted in an increase in bed-material surplus of approximately 3,900 tons per year. This indicates, as expected, that the general effect of dredging in Six Mile Pool is an increased depositional trend in the reach, causing it to act as a sediment trap.

The local sediment balance results for the miscellaneous combinations of upper and lower Kankakee River basin alternatives are shown in Table 5.4. These results indicate the effect of combining the channel re-meandering in the Kankakee River reach in Indiana with the dredge option in Six Mile Pool, along with reduction of sediment loads for the upper and lower Kankakee River as well as the Iroquois and Yellow Rivers. Effects on the individual reaches where these alternatives are located are very similar to the previous results.

Whereas the local sediment balance results from SIAM indicate the effects of alternatives on the supply and transport of bed material for a given reach, comparison of total sediment load values gives an indication of the effect of the alternatives on the delivery of total sediment from the

Table 5.4. Local sediment balance for miscellaneous alternatives 3A & 3B.

Reach	Local sediment balance (tons/year) for Lower Kankakee River alternatives		
	Existing	3A	3B
LK1	0	0	0
LK2	-4,507	-4,507	-4,507
LK3	0	0	0
LK4	-124,000	-127,000	-124,000
LK5	0	0	0
LK6	0	0	0
LK7	69,300	73,200	69,300
MK1	-12,500	-13,400	-12,900
MK2	0	0	0
MK3	-21,100	-21,100	-21,300
MK4	2,081	-6,404	-6,996
MK5	-6,859	866	-4,628
MK6	33,000	33,700	35,900
UK1	2,974	2,975	2,413
UK2	2,413	2,413	1,910
LI1	-18,900	-18,900	-18,900
LI2	-1,765	-1,765	-1,765
Y1	19,800	19,800	17,900
Y2	-30,900	-30,900	-31,200

Surplus bed material supply (depositional trend)

Excess transport capacity (degradational trend)

Relative equilibrium

watershed. This may provide a better means for evaluating the alternatives and identifying the most effective sediment-management strategy. Total sediment load for each reach is computed by summing the bed-material supply and wash load. Results presented for all alternatives include average annual total sediment load in tons per year by reach and the magnitude and percentage change from existing conditions.

The total sediment load results for the upper Kankakee River alternatives 1A through 1K are presented in Table 5.5, and the change from existing conditions in magnitude and percent is shown in Tables 5.6 and 5.7. Negative magnitude and percent-change values indicate a decrease in total sediment load from existing conditions.

Table 5.5. Total sediment load for upper Kankakee River alternatives 1A – 1K.

Reach	Average annual total sediment load (tons/year) for Upper Kankakee River alternatives 1A – 1K											
	Existing	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K
LK1	950,000	946,000	939,000	933,000	928,000	677,000	950,000	942,000	939,000	950,000	942,000	939,000
LK2	1,075,000	1,072,000	1,065,000	1,059,000	1,054,000	803,000	1,075,000	1,068,000	1,065,000	1,075,000	1,068,000	1,065,000
LK3	920,000	916,000	909,000	904,000	899,000	647,000	920,000	913,000	909,000	920,000	913,000	909,000
LK4	799,600	795,600	788,600	783,600	778,600	527,600	799,600	792,600	788,600	799,600	792,600	788,600
LK5	718,000	714,000	707,000	701,000	696,000	445,000	718,000	711,000	707,000	718,000	711,000	707,000
LK6	685,000	681,000	674,000	669,000	664,000	413,000	685,000	678,000	674,000	685,000	678,000	674,000
LK7	714,900	711,900	703,900	698,900	693,900	442,900	714,900	707,900	703,900	714,900	707,900	703,900
MK1	285,800	281,800	274,800	269,800	264,800	264,800	285,800	278,800	274,800	285,800	278,800	274,800
MK2	220,000	216,000	209,000	203,000	198,000	198,000	220,000	212,000	209,000	220,000	212,000	209,000
MK3	153,400	149,400	142,400	136,400	131,400	131,400	153,400	146,400	142,400	153,400	146,400	142,400
MK4	148,500	144,500	137,500	132,500	127,500	127,500	140,100	133,100	129,100	140,000	133,000	129,000
MK5	121,900	117,900	111,200	105,900	99,900	99,900	121,200	114,200	110,500	115,665	108,665	104,965
MK6	124,700	120,800	113,700	107,600	107,600	107,600	124,700	117,600	113,700	121,300	114,200	110,300
UK1	25,007	19,967	19,967	19,967	19,967	19,967	25,007	25,007	19,967	25,006	25,006	19,966
UK2	8,400	6,720	6,720	6,720	6,720	6,720	8,400	8,400	6,720	8,400	8,400	6,720
LI1	420,765	420,765	420,765	420,765	420,765	168,765	420,765	420,765	420,765	420,765	420,765	420,765
LI2	239,000	239,000	239,000	239,000	239,000	95,700	239,000	239,000	239,000	239,000	239,000	239,000
Y1	91,900	91,900	80,000	80,000	80,000	80,000	91,900	80,000	80,000	91,900	80,000	80,000
Y2	25,000	25,000	20,000	20,000	20,000	20,000	25,000	20,000	20,000	25,000	20,000	20,000

Table 5.6. Change in total sediment load from existing conditions for upper Kankakee River alternatives 1A – 1K.

Reach	Total sediment load change (tons/year) from existing conditions for Upper Kankakee River alternatives 1A – 1K											
	Existing	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K
LK1	-----	-4,000	-11,000	-17,000	-22,000	-273,000	0	-8,000	-11,000	0	-8,000	-11,000
LK2	-----	-3,000	-10,000	-16,000	-21,000	-272,000	0	-7,000	-10,000	0	-7,000	-10,000
LK3	-----	-4,000	-11,000	-16,000	-21,000	-273,000	0	-7,000	-11,000	0	-7,000	-11,000
LK4	-----	-4,000	-11,000	-16,000	-21,000	-272,000	0	-7,000	-11,000	0	-7,000	-11,000
LK5	-----	-4,000	-11,000	-17,000	-22,000	-273,000	0	-7,000	-11,000	0	-7,000	-11,000
LK6	-----	-4,000	-11,000	-16,000	-21,000	-272,000	0	-7,000	-11,000	0	-7,000	-11,000
LK7	-----	-3,000	-11,000	-16,000	-21,000	-272,000	0	-7,000	-11,000	0	-7,000	-11,000
MK1	-----	-4,000	-11,000	-16,000	-21,000	-21,000	0	-7,000	-11,000	0	-7,000	-11,000
MK2	-----	-4,000	-11,000	-17,000	-22,000	-22,000	0	-8,000	-11,000	0	-8,000	-11,000
MK3	-----	-4,000	-11,000	-17,000	-22,000	-22,000	0	-7,000	-11,000	0	-7,000	-11,000
MK4	-----	-4,000	-11,000	-16,000	-21,000	-21,000	-8,400	-15,400	-19,400	-8,500	-15,500	-19,500
MK5	-----	-4,000	-10,700	-16,000	-22,000	-22,000	-700	-7,700	-11,400	-6,235	-13,235	-16,935

Reach	Total sediment load change (tons/year) from existing conditions for Upper Kankakee River alternatives 1A – 1K											
	Existing	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K
MK6	-----	-3,900	-11,000	-17,100	-17,100	-17,100	0	-7,100	-11,000	-3,400	-10,500	-14,400
UK1	-----	-5,040	-5,040	-5,040	-5,040	-5,040	0	0	-5,040	-1	-1	-5,041
UK2	-----	-1,680	-1,680	-1,680	-1,680	-1,680	0	0	-1,680	0	0	-1,680
LI1	-----	0	0	0	0	-252,000	0	0	0	0	0	0
LI2	-----	0	0	0	0	-143,300	0	0	0	0	0	0
Y1	-----	0	-11,900	-11,900	-11,900	-11,900	0	-11,900	-11,900	0	-11,900	-11,900
Y2	-----	0	-5,000	-5,000	-5,000	-5,000	0	-5,000	-5,000	0	-5,000	-5,000

Table 5.7. Percent change in total sediment load from existing conditions for upper Kankakee River alternatives 1A – 1K.

Reach	Percent change in total sediment load (tons/year) from existing conditions for Upper Kankakee River alternatives 1A – 1K											
	Existing	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K
LK1	-----	0%	-1.2%	-1.8%	-2.3%	-28.7%	0.0%	-0.8%	-1.2%	0.0%	-0.8%	-1.2%
LK2	-----	0%	-0.9%	-1.5%	-2.0%	-25.3%	0.0%	-0.7%	-0.9%	0.0%	-0.7%	-0.9%
LK3	-----	0%	-1.2%	-1.7%	-2.3%	-29.7%	0.0%	-0.8%	-1.2%	0.0%	-0.8%	-1.2%
LK4	-----	-1%	-1.4%	-2.0%	-2.6%	-34.0%	0.0%	-0.9%	-1.4%	0.0%	-0.9%	-1.4%
LK5	-----	-1%	-1.5%	-2.4%	-3.1%	-38.0%	0.0%	-1.0%	-1.5%	0.0%	-1.0%	-1.5%
LK6	-----	-1%	-1.6%	-2.3%	-3.1%	-39.7%	0.0%	-1.0%	-1.6%	0.0%	-1.0%	-1.6%
LK7	-----	0%	-1.5%	-2.2%	-2.9%	-38.0%	0.0%	-1.0%	-1.5%	0.0%	-1.0%	-1.5%
MK1	-----	-1%	-3.8%	-5.6%	-7.3%	-7.3%	0.0%	-2.4%	-3.8%	0.0%	-2.4%	-3.8%
MK2	-----	-2%	-5.0%	-7.7%	-10.0%	-10.0%	0.0%	-3.6%	-5.0%	0.0%	-3.6%	-5.0%
MK3	-----	-3%	-7.2%	-11.1%	-14.3%	-14.3%	0.0%	-4.6%	-7.2%	0.0%	-4.6%	-7.2%
MK4	-----	-3%	-7.4%	-10.8%	-14.1%	-14.1%	-5.7%	-10.4%	-13.1%	-5.7%	-10.4%	-13.1%
MK5	-----	-3%	-8.8%	-13.1%	-18.0%	-18.0%	-0.6%	-6.3%	-9.4%	-5.1%	-10.9%	-13.9%
MK6	-----	-3%	-8.8%	-13.7%	-13.7%	-13.7%	0.0%	-5.7%	-8.8%	-2.7%	-8.4%	-11.5%
UK1	-----	-20%	-20.2%	-20.2%	-20.2%	-20.2%	0.0%	0.0%	-20.2%	0.0%	0.0%	-20.2%
UK2	-----	-20%	-20.0%	-20.0%	-20.0%	-20.0%	0.0%	0.0%	-20.0%	0.0%	0.0%	-20.0%
LI1	-----	0%	0.0%	0.0%	0.0%	-59.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LI2	-----	0%	0.0%	0.0%	0.0%	-60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Y1	-----	0%	-12.9%	-12.9%	-12.9%	-12.9%	0.0%	-12.9%	-12.9%	0.0%	-12.9%	-12.9%
Y2	-----	0%	-20.0%	-20.0%	-20.0%	-20.0%	0.0%	-20.0%	-20.0%	0.0%	-20.0%	-20.0%

Since a large portion of the watershed sediment sources are wash-load, reduction of those sources through the various alternatives results in a decrease in total load for the entire Kankakee River basin. Exceptions are

alternatives 1F and 1I, which involve channel re-meandering in reaches MK5 and MK6 that only affects the bed-material load for that reach and the next reach downstream. Alternative 1E provides the most comprehensive reduction in total sediment load compared to existing conditions. Alternative 1E includes an effective 60-percent reduction in sediment sources from the Iroquois River basin in addition to the reductions from the upper Kankakee River basin, and is, therefore, a fairly comprehensive sediment control strategy. Total sediment load decrease for the entire Kankakee River basin resulting from alternative 1E is almost 29 percent.

The total sediment load results for the lower Kankakee River alternatives 2A through 2V are presented in Tables 5.8 and 5.9, and the change from existing conditions in magnitude and percent is shown in Tables 5.10 through 5.13.

Table 5.8. Total sediment load for lower Kankakee River alternatives 2A – 2K.

Reach	Average annual total sediment load (tons/year) for Lower Kankakee River alternatives 2A – 2K											
	Existing	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K
LK1	950,000	866,000	862,000	861,000	860,000	852,000	849,000	856,000	843,000	835,000	822,000	946,000
LK2	1,075,000	992,000	988,000	987,000	985,000	978,000	975,000	982,000	969,000	961,000	948,000	1,072,000
LK3	920,000	836,000	832,000	831,000	830,000	823,000	819,000	827,000	814,000	805,000	792,000	916,000
LK4	799,600	715,600	712,600	710,600	709,600	702,600	698,600	706,600	693,600	684,600	672,600	795,600
LK5	718,000	634,000	630,000	629,000	628,000	620,000	617,000	624,000	611,000	603,000	590,000	714,000
LK6	685,000	602,000	598,000	596,000	595,000	588,000	585,000	592,000	579,000	570,000	558,000	681,000
LK7	714,900	631,900	627,900	626,900	624,900	617,900	614,900	621,900	616,900	600,900	595,900	711,900
MK1	285,800	285,800	281,800	280,800	279,800	271,300	268,300	275,800	275,800	254,800	254,800	281,800
MK2	220,000	220,000	220,000	218,000	217,000	209,000	206,000	214,000	214,000	192,000	192,000	220,000
MK3	153,400	153,400	153,400	153,400	152,200	152,200	148,200	148,200	148,200	127,200	127,200	153,400
MK4	148,500	148,500	148,500	148,500	148,500	148,500	145,000	145,000	145,000	123,200	123,200	148,500
MK5	121,900	121,900	121,900	121,900	121,900	121,900	121,900	121,900	121,900	99,900	99,900	121,900
MK6	124,700	124,700	124,700	124,700	124,700	124,700	124,700	124,700	124,700	107,600	107,600	124,700
UK1	25,007	25,007	25,007	25,007	25,007	25,007	25,007	25,007	25,007	19,967	19,967	25,007
UK2	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	6,720	6,720	8,400
LI1	420,765	336,765	336,765	336,765	336,765	336,765	336,765	336,765	336,765	336,765	336,765	420,765
LI2	239,000	191,000	191,000	191,000	191,000	191,000	191,000	191,000	191,000	191,000	191,000	239,000
Y1	91,900	91,900	91,900	91,900	91,900	91,900	91,900	91,900	91,900	80,000	80,000	91,900
Y2	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	20,000	20,000	25,000

Table 5.9. Total sediment load for lower Kankakee River alternatives 2L – 2V.

Reach	Average annual total sediment load (tons/year) for Lower Kankakee River alternatives 2L – 2V											
	Existing	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U	2V
LK1	950,000	944,000	943,000	936,000	933,000	940,000	927,000	918,000	906,000	950,000	942,000	930,000
LK2	1,075,000	1,070,000	1,069,000	1,062,000	1,058,000	1,066,000	1,053,000	1,044,000	1,032,000	1,075,000	1,068,000	1,056,000
LK3	920,000	915,000	914,000	906,000	903,000	910,000	898,000	889,000	876,000	920,000	912,000	900,000
LK4	799,600	794,600	793,600	786,600	782,600	790,600	777,600	768,600	755,600	793,626	785,626	774,626
LK5	718,000	712,000	711,000	704,000	701,000	708,000	695,000	687,000	674,000	715,000	707,000	695,000
LK6	685,000	680,000	679,000	672,000	668,000	676,000	663,000	654,000	641,000	682,000	674,000	663,000
LK7	714,900	709,900	708,900	701,900	697,900	705,900	700,900	683,900	678,900	715,800	715,800	704,800
MK1	285,800	280,800	279,800	271,300	268,300	275,800	275,800	254,800	254,800	285,800	285,800	273,300
MK2	220,000	218,000	217,000	209,000	206,000	214,000	214,000	192,000	192,000	220,000	220,000	207,000
MK3	153,400	153,400	152,200	152,200	148,200	148,200	148,200	127,200	127,200	153,400	153,400	148,200
MK4	148,500	148,500	148,500	148,500	145,000	145,000	145,000	123,200	123,200	148,500	148,500	145,000
MK5	121,900	121,900	121,900	121,900	121,900	121,900	121,900	99,900	99,900	121,900	121,900	121,900
MK6	124,700	124,700	124,700	124,700	124,700	124,700	124,700	107,600	107,600	124,700	124,700	124,700
UK1	25,007	25,007	25,007	25,007	25,007	25,007	25,007	19,967	19,967	25,007	25,007	25,007
UK2	8,400	8,400	8,400	8,400	8,400	8,400	8,400	6,720	6,720	8,400	8,400	8,400
LI1	420,765	420,765	420,765	420,765	420,765	420,765	420,765	420,765	420,765	420,765	420,765	420,765
LI2	239,000	239,000	239,000	239,000	239,000	239,000	239,000	239,000	239,000	239,000	239,000	239,000
Y1	91,900	91,900	91,900	91,900	91,900	91,900	91,900	80,000	80,000	91,900	91,900	91,900
Y2	25,000	25,000	25,000	25,000	25,000	25,000	25,000	20,000	20,000	25,000	25,000	25,000

Table 5.10. Change in total sediment load from existing conditions for lower Kankakee River alternatives 2A – 2K.

Reach	Total sediment load change (tons/year) from existing conditions for Lower Kankakee River alternatives 2A – 2K											
	Existing	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K
LK1	-----	-84,000	-88,000	-89,000	-90,000	-98,000	-101,000	-94,000	-107,000	-115,000	-128,000	-4,000
LK2	-----	-83,000	-87,000	-88,000	-90,000	-97,000	-100,000	-93,000	-106,000	-114,000	-127,000	-3,000
LK3	-----	-84,000	-88,000	-89,000	-90,000	-97,000	-101,000	-93,000	-106,000	-115,000	-128,000	-4,000
LK4	-----	-84,000	-87,000	-89,000	-90,000	-97,000	-101,000	-93,000	-106,000	-115,000	-127,000	-4,000
LK5	-----	-84,000	-88,000	-89,000	-90,000	-98,000	-101,000	-94,000	-107,000	-115,000	-128,000	-4,000
LK6	-----	-83,000	-87,000	-89,000	-90,000	-97,000	-100,000	-93,000	-106,000	-115,000	-127,000	-4,000
LK7	-----	-83,000	-87,000	-88,000	-90,000	-97,000	-100,000	-93,000	-98,000	-114,000	-119,000	-3,000
MK1	-----	0	-4,000	-5,000	-6,000	-14,500	-17,500	-10,000	-10,000	-31,000	-31,000	-4,000
MK2	-----	0	0	-2,000	-3,000	-11,000	-14,000	-6,000	-6,000	-28,000	-28,000	0
MK3	-----	0	0	0	-1,200	-1,200	-5,200	-5,200	-5,200	-26,200	-26,200	0
MK4	-----	0	0	0	0	0	-3,500	-3,500	-3,500	-25,300	-25,300	0
MK5	-----	0	0	0	0	0	0	0	0	-22,000	-22,000	0

Reach	Total sediment load change (tons/year) from existing conditions for Lower Kankakee River alternatives 2A – 2K											
	Existing	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K
MK6	-----	0	0	0	0	0	0	0	0	-17,100	-17,100	0
UK1	-----	0	0	0	0	0	0	0	0	-5,040	-5,040	0
UK2	-----	0	0	0	0	0	0	0	0	-1,680	-1,680	0
LI1	-----	-84,000	-84,000	-84,000	-84,000	-84,000	-84,000	-84,000	-84,000	-84,000	-84,000	0
LI2	-----	-48,000	-48,000	-48,000	-48,000	-48,000	-48,000	-48,000	-48,000	-48,000	-48,000	0
Y1	-----	0	0	0	0	0	0	0	0	-11,900	-11,900	0
Y2	-----	0	0	0	0	0	0	0	0	-5,000	-5,000	0

Table 5.11. Change in total sediment load from existing conditions for lower Kankakee River alternatives 2L – 2V.

Reach	Total sediment load change (tons/year) from existing conditions for Lower Kankakee River alternatives 2L – 2V											
	Existing	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U	2V
LK1	-----	-6,000	-7,000	-14,000	-17,000	-10,000	-23,000	-32,000	-44,000	0	-8,000	-20,000
LK2	-----	-5,000	-6,000	-13,000	-17,000	-9,000	-22,000	-31,000	-43,000	0	-7,000	-19,000
LK3	-----	-5,000	-6,000	-14,000	-17,000	-10,000	-22,000	-31,000	-44,000	0	-8,000	-20,000
LK4	-----	-5,000	-6,000	-13,000	-17,000	-9,000	-22,000	-31,000	-44,000	-5,974	-13,974	-24,974
LK5	-----	-6,000	-7,000	-14,000	-17,000	-10,000	-23,000	-31,000	-44,000	-3,000	-11,000	-23,000
LK6	-----	-5,000	-6,000	-13,000	-17,000	-9,000	-22,000	-31,000	-44,000	-3,000	-11,000	-22,000
LK7	-----	-5,000	-6,000	-13,000	-17,000	-9,000	-14,000	-31,000	-36,000	900	900	-10,100
MK1	-----	-5,000	-6,000	-14,500	-17,500	-10,000	-10,000	-31,000	-31,000	0	0	-12,500
MK2	-----	-2,000	-3,000	-11,000	-14,000	-6,000	-6,000	-28,000	-28,000	0	0	-13,000
MK3	-----	0	-1,200	-1,200	-5,200	-5,200	-5,200	-26,200	-26,200	0	0	-5,200
MK4	-----	0	0	0	-3,500	-3,500	-3,500	-25,300	-25,300	0	0	-3,500
MK5	-----	0	0	0	0	0	0	-22,000	-22,000	0	0	0
MK6	-----	0	0	0	0	0	0	-17,100	-17,100	0	0	0
UK1	-----	0	0	0	0	0	0	-5,040	-5,040	0	0	0
UK2	-----	0	0	0	0	0	0	-1,680	-1,680	0	0	0
LI1	-----	0	0	0	0	0	0	0	0	0	0	0
LI2	-----	0	0	0	0	0	0	0	0	0	0	0
Y1	-----	0	0	0	0	0	0	-11,900	-11,900	0	0	0
Y2	-----	0	0	0	0	0	0	-5,000	-5,000	0	0	0

Table 5.12. Percent change in total sediment load from existing conditions for lower Kankakee River alternatives 2A – 2K.

Reach	Percent change in total sediment load (tons/year) from existing conditions for Lower Kankakee River alternatives 2A – 2K											
	Existing	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K
LK1	-----	-8.8%	-9.3%	-9.4%	-9.5%	-10.3%	-10.6%	-9.9%	-11.3%	-12.1%	-13.5%	-0.4%
LK2	-----	-7.7%	-8.1%	-8.2%	-8.4%	-9.0%	-9.3%	-8.7%	-9.9%	-10.6%	-11.8%	-0.3%
LK3	-----	-9.1%	-9.6%	-9.7%	-9.8%	-10.5%	-11.0%	-10.1%	-11.5%	-12.5%	-13.9%	-0.4%
LK4	-----	-10.5%	-10.9%	-11.1%	-11.3%	-12.1%	-12.6%	-11.6%	-13.3%	-14.4%	-15.9%	-0.5%
LK5	-----	-11.7%	-12.3%	-12.4%	-12.5%	-13.6%	-14.1%	-13.1%	-14.9%	-16.0%	-17.8%	-0.6%
LK6	-----	-12.1%	-12.7%	-13.0%	-13.1%	-14.2%	-14.6%	-13.6%	-15.5%	-16.8%	-18.5%	-0.6%
LK7	-----	-11.6%	-12.2%	-12.3%	-12.6%	-13.6%	-14.0%	-13.0%	-13.7%	-15.9%	-16.6%	-0.4%
MK1	-----	0.0%	-1.4%	-1.7%	-2.1%	-5.1%	-6.1%	-3.5%	-3.5%	-10.8%	-10.8%	-1.4%
MK2	-----	0.0%	0.0%	-0.9%	-1.4%	-5.0%	-6.4%	-2.7%	-2.7%	-12.7%	-12.7%	0.0%
MK3	-----	0.0%	0.0%	0.0%	-0.8%	-0.8%	-3.4%	-3.4%	-3.4%	-17.1%	-17.1%	0.0%
MK4	-----	0.0%	0.0%	0.0%	0.0%	0.0%	-2.4%	-2.4%	-2.4%	-17.0%	-17.0%	0.0%
MK5	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-18.0%	-18.0%	0.0%
MK6	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-13.7%	-13.7%	0.0%
UK1	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-20.2%	-20.2%	0.0%
UK2	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-20.0%	-20.0%	0.0%
LI1	-----	-20.0%	-20.0%	-20.0%	-20.0%	-20.0%	-20.0%	-20.0%	-20.0%	-20.0%	-20.0%	0.0%
LI2	-----	-20.1%	-20.1%	-20.1%	-20.1%	-20.1%	-20.1%	-20.1%	-20.1%	-20.1%	-20.1%	0.0%
Y1	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-12.9%	-12.9%	0.0%
Y2	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-20.0%	-20.0%	0.0%

Table 5.13. Percent change in total sediment load from existing conditions for lower Kankakee River alternatives 2L – 2V.

Reach	Percent change in total sediment load (tons/year) from existing conditions for Lower Kankakee River alternatives 2L – 2V											
	Existing	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U	2V
LK1	-----	-0.6%	-0.7%	-1.5%	-1.8%	-1.1%	-2.4%	-3.4%	-4.6%	0.0%	-0.8%	-2.1%
LK2	-----	-0.5%	-0.6%	-1.2%	-1.6%	-0.8%	-2.0%	-2.9%	-4.0%	0.0%	-0.7%	-1.8%
LK3	-----	-0.5%	-0.7%	-1.5%	-1.8%	-1.1%	-2.4%	-3.4%	-4.8%	0.0%	-0.9%	-2.2%
LK4	-----	-0.6%	-0.8%	-1.6%	-2.1%	-1.1%	-2.8%	-3.9%	-5.5%	-0.7%	-1.7%	-3.1%
LK5	-----	-0.8%	-1.0%	-1.9%	-2.4%	-1.4%	-3.2%	-4.3%	-6.1%	-0.4%	-1.5%	-3.2%
LK6	-----	-0.7%	-0.9%	-1.9%	-2.5%	-1.3%	-3.2%	-4.5%	-6.4%	-0.4%	-1.6%	-3.2%
LK7	-----	-0.7%	-0.8%	-1.8%	-2.4%	-1.3%	-2.0%	-4.3%	-5.0%	0.1%	0.1%	-1.4%
MK1	-----	-1.7%	-2.1%	-5.1%	-6.1%	-3.5%	-3.5%	-10.8%	-10.8%	0.0%	0.0%	-4.4%
MK2	-----	-0.9%	-1.4%	-5.0%	-6.4%	-2.7%	-2.7%	-12.7%	-12.7%	0.0%	0.0%	-5.9%

Reach	Percent change in total sediment load (tons/year) from existing conditions for Lower Kankakee River alternatives 2L – 2V											
	Existing	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U	2V
MK3	-----	0.0%	-0.8%	-0.8%	-3.4%	-3.4%	-3.4%	-17.1%	-17.1%	0.0%	0.0%	-3.4%
MK4	-----	0.0%	0.0%	0.0%	-2.4%	-2.4%	-2.4%	-17.0%	-17.0%	0.0%	0.0%	-2.4%
MK5	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-18.0%	-18.0%	0.0%	0.0%	0.0%
MK6	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-13.7%	-13.7%	0.0%	0.0%	0.0%
UK1	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-20.2%	-20.2%	0.0%	0.0%	0.0%
UK2	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-20.0%	-20.0%	0.0%	0.0%	0.0%
LI1	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LI2	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Y1	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-12.9%	-12.9%	0.0%	0.0%	0.0%
Y2	-----	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-20.0%	-20.0%	0.0%	0.0%	0.0%

Alternatives 2I and 2J result in the largest decrease in total sediment load from the entire Kankakee River basin for the lower-basin alternatives, and also provide the most comprehensive reduction in load for all reaches within the system. These alternatives combine sediment reduction from both the upper and lower Kankakee River basin but assume no channel modifications. The results of the lower-basin alternatives, as with the upper-basin alternatives, indicate that reduction of the watershed sources provides the greatest reduction of total sediment delivered from the entire basin; however, most of this sediment is fine-grained material.

The total sediment load results for the miscellaneous alternatives 3A and 3B are presented in Tables 5.14, and the changes from existing conditions in magnitude and percent are shown in Tables 5.15 and 5.16, respectively.

The results of average annual total sediment reduction for miscellaneous alternative 3A illustrate how the channel modifications from re-meandering and dredging have a local effect by decreasing bed-material supply to the downstream reaches but do not affect the total load from the entire watershed because there is no impact to the wash load. In comparison, the results for miscellaneous alternative 3B indicate the significant impact that a comprehensive sediment reduction plan can have on total sediment loads throughout the watershed.

Table 5.14. Total sediment load for miscellaneous alternatives 3A and 3B.

Reach	Average annual total sediment load (tons/year) for miscellaneous alternatives 3A & 3B		
	Existing	3A	3B
LK1	950,000	950,000	838,000
LK2	1,075,000	1,075,000	964,000
LK3	920,000	920,000	808,000
LK4	799,600	793,626	688,600
LK5	718,000	715,000	606,000
LK6	685,000	682,000	574,000
LK7	714,900	715,800	603,900
MK1	285,800	285,800	257,300
MK2	220,000	220,000	195,000
MK3	153,400	153,400	137,200
MK4	148,500	140,100	125,500
MK5	121,900	121,200	104,965
MK6	124,700	124,700	110,300
UK1	25,007	25,007	19,966
UK2	8,400	8,400	6,720
LI1	420,765	420,765	336,765
LI2	239,000	239,000	191,000
Y1	91,900	91,900	80,000
Y2	25,000	25,000	20,000

Table 5.15. Change in total sediment load from existing conditions for miscellaneous alternatives 3A & 3B

Reach	Total sediment load change (tons/year) from existing conditions for miscellaneous alternatives 3A & 3B		
	Existing	3A	3B
LK1	—	0	-112,000
LK2	—	0	-111,000
LK3	—	0	-112,000
LK4	—	-5,974	-111,000
LK5	—	-3,000	-112,000
LK6	—	-3,000	-111,000
LK7	—	9,00	-111,000
MK1	—	0	-28,500
MK2	—	0	-25,000

Reach	Total sediment load change (tons/year) from existing conditions for miscellaneous alternatives 3A & 3B		
	Existing	3A	3B
MK3	—	0	-16,200
MK4	—	-8,400	-23,000
MK5	—	-700	-16,935
MK6	—	0	-14,400
UK1	—	0	-5,041
UK2	—	0	-1,680
LI1	—	0	-84,000
LI2	—	0	-48,000
Y1	—	0	-11,900
Y2	—	0	-5,000

Table 5.16. Percent change in total sediment load from existing conditions for miscellaneous alternatives 3A & 3B

Reach	Percent change in total sediment load (tons/year) from existing conditions for miscellaneous alternatives 3A & 3B		
	Existing	3A	3B
LK1	—	0.0%	-11.8%
LK2	—	0.0%	-10.3%
LK3	—	0.0%	-12.2%
LK4	—	-0.7%	-13.9%
LK5	—	-0.4%	-15.6%
LK6	—	-0.4%	-16.2%
LK7	—	0.1%	-15.5%
MK1	—	0.0%	-10.0%
MK2	—	0.0%	-11.4%
MK3	—	0.0%	-10.6%
MK4	—	-5.7%	-15.5%
MK5	—	-0.6%	-13.9%
MK6	—	0.0%	-11.5%
UK1	—	0.0%	-20.2%
UK2	—	0.0%	-20.0%
LI1	—	0.0%	-20.0%
LI2	—	0.0%	-20.1%
Y1	—	0.0%	-12.9%
Y2	—	0.0%	-20.0%

Discussion of SIAM Results

Assessment of the SIAM results for the various sediment management alternatives must include a discussion of how the SIAM model accounts for bed-material supply and wash supply. Because SIAM is not a sediment routing model and only gives a balance for a given set of conditions, changes to bed-material supply to a reach are only observed in that particular reach. A change in bed-material supply for a given reach can occur from changes in local sediment sources for that reach, changes in wash supply from upstream reaches that transition into bed material in the reach, or changes in transport capacity for the reach or reaches immediately upstream. These bed-material changes will work through the system with time, but it could take years or even decades to pass completely through a system the size of the Kankakee River basin. The tracking of these bed-material changes can only be accomplished with a routing model that adjusts the channel geometry based on erosion and deposition. Therefore, the effect of the alternatives that modify the transport capacity of a reach can only be observed in the current reach and the reach downstream. Long-term impacts on bed-material delivery from the entire watershed cannot be determined from the SIAM results. However, the SIAM model does track wash supply throughout the entire system. The model accomplishes this through a *pseudo-routing* of the wash supply, in that the wash load delivered to downstream reaches is cumulative of all upstream reaches in the system. This gives a reasonable estimate of the total sediment load from the basin, although it mainly represents fine-grained material that has little interaction with the bed.

Given this understanding of the results of the SIAM model, the effects of the sediment management alternatives can be assessed in terms of the relative effect each would have on sediment continuity. In terms of effect on transport of bed material, alternatives such as 2F that involve channel modification through re-meandering significantly reduce the transport capacity of the reach and cause the reach to act as a sediment trap, thus decreasing the bed-material supply to the downstream reach. This reduction may be less from a percentage standpoint than reductions observed from alternatives that reduce the watershed sources, but the reduction reflects potential reductions in material that would tend to deposit in the downstream reach. Wash load reduction within the basin may not significantly affect reaches of deposition within the system, but does lower total sediment yield and may reduce deposition in receiving streams farther downstream.

In terms of reduction of total sediment load, the top three alternatives are 1E, 2J, and 3B. All of these alternatives involve a comprehensive reduction in watershed sources from the upper Kankakee River and the lower Kankakee River, including a 60-percent reduction from the Iroquois River basin.

6 Summary

An evaluation of existing sediment data from multiple sources was conducted for the Kankakee River basin, and an estimate of the average annual sediment load and grain-size distribution from various locations in the basin was made. These sediment sources were used as input to a SIAM model for existing conditions in the system. The SIAM model was developed from an existing calibrated HEC-RAS model provided by the Rock Island District. Based on a preliminary evaluation of trial sediment management schemes, a matrix of 35 sediment management strategies was developed and tested in the SIAM model. The alternatives encompassed combinations of watershed sediment source reductions, channel re-meandering and flood plain reconnection, and dredging within Six Mile Pool above Kankakee Dam. The results for the alternatives were compared to existing condition results to determine relative effects on sediment continuity and total sediment load reduction within the basin.

In terms of reduction in bed material, the alternatives that involve re-meandering of the Kankakee River upstream of the IL/IN state line indicate significant potential to decrease bed-material supply to downstream reaches that are currently experiencing adverse deposition. In terms of total sediment load reduction, alternative 1E indicates the greatest potential through a comprehensive reduction in watershed sources in the Kankakee, Yellow, and Iroquois Rivers. Various levels of total sediment load reduction are realized from the other alternatives with less aggressive management strategy. SIAM results for this matrix of alternatives provide an estimate of relative effects that can be used to identify potential sediment management strategies. A sediment routing model should be used to further evaluate promising alternatives regarding long-term sediment yield and channel impacts.

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14. ABSTRACT The Kankakee River extends from South Bend, Indiana to its confluence with the Illinois River near Wilmington, Illinois. The river has a 5,165 square mile drainage area and a length of about 150 miles, reduced from approximately 250 miles historically. The process of channelizing streams and draining the landscape has had impacts on the hydrology, hydraulics, sedimentation, and ecology of the watershed and channel network. Increased sediment loads associated with channelization and changed land use is a particular concern. A Section 519 Illinois River Basin Ecosystem Restoration Study is underway by the Sponsor to address these concerns, and the Kankakee River investigation reported herein was conducted in support of the restoration study. Sediment data were compiled from multiple sources, and analyzed to determine average annual values of sub-basin sediment loads within the Kankakee River watershed. The Sediment Impact Analysis Methods model was used for rapid screening of alternatives for sediment management on a watershed scale. Sediment continuity was determined for base level conditions, then a matrix of management strategies for various sub-basins of the watershed were evaluated to determine the relative impact of each strategy on the system sediment balance. Results are useful for planners and sediment managers interested in creating an overall sediment management plan that meets the sediment reduction goals of the restoration project.					
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**ILLINOIS RIVER BASIN RESTORATION
SECTION 519**

**KANKAKEE RIVER MAINSTEM
CRITICAL RESTORATION PROJECT**

APPENDIX B

LISTING OF PERTINENT WATERSHED PLANNING DOCUMENTS

**ILLINOIS RIVER BASIN RESTORATION
SECTION 519**

**KANKAKEE RIVER MAINSTEM
CRITICAL RESTORATION PROJECT**

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