Long Term Resource Monitoring Program

Program Report

94-P004

DO NOT REMOVE
LAST COPY

Planning Document:

Investigate Sediment Transport/Deposition and Predict Future Configuration

of UMRS Channels and Floodplain

December 1994

Planning Document:

Investigate Sediment Transport/Deposition and Predict Future Configuration of UMRS Channels and Floodplain

by

Robert F. Gaugush
National Biological Survey
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

and

Daniel B. Wilcox
St. Paul District, U.S. Army Corps of Engineers
Army Corps of Engineers Centre
190 Fifth Street East
St. Paul, Minnesota 55101-1638

December 1994

Planning Document:

Investigate Sediment Transport/Deposition and Predict Future Configuration of UMRS Channels and Floodplain

by

Robert F. Gaugush
National Biological Survey
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

and

Daniel B. Wilcox
St. Paul District, U.S. Army Corps of Engineers
Army Corps of Engineers Centre
190 Fifth Street East
St. Paul, Minnesota 55101-1638

December 1994

The Environmental Management Technical Center issues LTRMP Program Reports to provide Long Term Resource Monitoring Program partners with programmatic documentation, procedures manuals, training manuals, and geographic information systems applications.

National Biological Survey
Environmental Management
Technical Center

CENTER DIRECTOR
Robert L. Delaney

DEPUTY CENTER DIRECTOR
Barry W. Drazkowski

SCIENCE TECHNICAL DIRECTOR
John W. Barko

TECHNICAL DIRECTOR FOR
INFORMATION SYSTEMS
Norman W. Hildrum

REPORT EDITOR
Terry D'Erchia

The National Biological Survey . . . gathering, analyzing, and sharing the biological information necessary to support the wise stewardship of the Nation's natural resources.

Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center (EMTC), an office of the National Biological Survey, in cooperation with the five Upper Mississippi River System states, Illinois, Iowa, Minnesota, Missouri, and Wisconsin, with guidance and Program responsibility provided by the U.S. Army Corps of Engineers.

The mission of the LTRMP is to provide decision makers with information to maintain the Upper Mississippi River System as a viable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and impacts, develop management alternatives, manage information, and develop useful products.

This report supports LTRMP Operating Plan (USFWS 1992) Task 1.2.1.2, *Select Processes for Research*, and Task 1.2.1.3, *Establish Experimental Design*, under Strategy 1.2.1, *Determine Effects of Sedimentation and Sediment Transport Processes on the Upper Mississippi River System Ecosystem.* Work proposed in this report would support all tasks under Strategy 2.2.5, *Monitor and Evaluate Sediment Composition*, all tasks under Strategy 2.2.6, *Monitor and Evaluate Aquatic and Floodplain Habitat*, and all strategies under Objective 3.1, *Develop Alternative Management Objectives*.

This report was developed with funding provided by the Long Term Resource Monitoring Program.

Additional copies of this report may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

This report should be cited as:

Gaugush, R. F., and D. B. Wilcox. 1994. Planning Document: Investigate sediment transport/deposition and predict future configuration of UMRS channels and floodplain. National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, December 1994. LTRMP 94-P004. 9 pp. + Appendixes A-E

Table of Contents

Background

The template for the mosaic of habitats in the Upper Mississippi River System (UMRS) is the configuration of the channels and floodplain. This template of river configuration is formed by the fluvial processes of erosion, sediment transport, and deposition (Meade et al. 1990). Previous investigations of sediment in the UMRS have addressed upland erosion (Brown and Nygard 1941; Happ 1944; Brune 1948; Knox et al. 1975; Knox 1977, 1989; Trimble and Lund 1982; Trimble 1983; Hawkins and Stewart 1990), sediment discharge of tributaries (Lane 1938; Tornes 1986; Rose 1992), and sediment transport processes and deposition within the floodplain (McHenry et al. 1976; Simons and Chen 1979; Chen and Simons 1986; Bhowmik et al. 1989; Demissie et al. 1992), but have not resulted in a quantitative and spatially complete forecast of future changes in the geometry of UMRS channels and floodplain.

Prediction of the future geometry of UMRS channels and floodplain is needed for managing UMRS natural resources and the Mississippi River and Illinois Waterway navigation system. Development of plans for managing the UMRS ecosystem will require prediction of future condition of the river system under various management alternatives. Prediction of future geomorphology of the system will be essential for predicting future amounts and spatial distribution of floodplain vegetation, aquatic habitats, water quality conditions, and recreational opportunities. Evaluation of the impacts of increased navigation and planning of long-term navigation channel maintenance activities will require prediction of future channel geometry and dredging requirements. A quantitative understanding of sediment transport and contaminant fate processes will be needed to manage contaminants.

The proposed investigations of sediment transport processes and future condition of UMRS channels and floodplain would provide information needed to meet a number of objectives described in the Long Term Resource Monitoring Program (LTRMP) Operating Plan, including Strategy 1.2.1, *Determine Effects of Sedimentation and Sediment Transport Processes*, Strategy 1.2.2, *Determine the Effects of Navigation*, Strategy 2.2.1, *Monitor and Evaluate Floodplain Elevation*, Strategy 2.2.3, *Monitor and Evaluate Water Quality*, Strategy 2.2.6, *Monitor and Evaluate Floodplain Habitat*, and Strategy 3.1.2, *Predict Future Conditions*.

Problem Statement

Sedimentation of backwater areas is considered by many to be the most severe environmental problem on the UMRS (GREAT I 1980a; Problem Identification and Analysis Work Group 1987; Hawkins and Stewart 1990; USFWS 1992). The main source of fine-grained sediment filling UMRS backwaters is soil eroded from upland areas within the basin (Nielsen et al. 1984; Chen and Simons 1986; Demissie et al. 1992; Bhowmik et al. 1993).

Land use and land management practices within the basin have greatly increased upland erosion rates and discharge of sediment from tributaries to the UMRS over presettlement rates (Knox et al. 1975; Knox 1977; Demissie et al. 1992). Upland erosion and UMRS tributary sediment yields were highest during periods of intensive farming and runoff during the 1850s through the 1940s, with erosion rates declining since then due to improved land management practices (Knox et al. 1975; Trimble and Lund 1982; Trimble 1983). Despite improved land management practices and reduced upland erosion rates, sediment discharge from tributaries to the UMRS continues to be influenced by sediment historically deposited in tributary valleys and by historical changes in the channel geometry of the tributary stream network (Knox 1977, 1987, 1989).

Channel maintenance dredging has been estimated to remove a major fraction of the total river bedload transport in the upper pools of the Mississippi River (GREAT I 1980b). Disposal of dredged material has created numerous channel border islands (Simons and Chen 1979; GREAT I 1980b). Future channel maintenance will require additional placement of dredged material in the floodplain, despite increased efforts to place material out of the floodplain for beneficial use as fill and for winter road sanding.

Navigation dams, channel training structures, levees, and channel maintenance dredging have altered river hydraulic characteristics, sediment transport processes, and the pattern of sediment deposition within the UMRS floodplain (Lee and Stall 1976; Simons and Chen 1979; Bhowmik and Adams 1986; Chen and Simons 1986; Bhowmik et al. 1989). Navigation dams have increased sediment trapping efficiency of river reaches that are now navigation "pools" (Simons and Chen 1979; Bhowmik and Adams 1986; Bhowmik et al. 1989, 1993; Bhowmik and Demissie 1989; Demissie et al. 1992). Impoundment of the UMRS navigation pools has raised the base elevation of some of the UMRS tributaries, resulting in changes in delta formation at their confluences with the main stem (J. C. Knox, Geography Department, University of Wisconsin, MI, personal communication, 1994). An average of 2-3 cm/year of fine sediment was estimated to accumulate in backwater areas of Pools 4 through 10, changing aquatic areas into marsh and floodplain terrestrial habitat (McHenry et al. 1976). Both Peoria Lake on the Illinois River and Pool 19 on the Mississippi River have lost more than half of their volume to sediment deposition since dam construction (Demissie and Bhowmik 1986; Bhowmik and Adams 1989; Demissie et al. 1992; Bhowmik et al. 1993).

Bank revetments, wing dams, and closing dams constructed to maintain the navigation channel have constrained the main channel, reduced flows to secondary channels and backwaters, prevented lateral channel migration, and have prevented the creation of new fluvial landforms (Simons et al. 1974, 1981; Simons and Chen 1979; Chen and Simons 1986). Levees have sequestered the floodplain from the main channel in much of the lower UMRS, raising flood stages (Kazmann 1972; Belt 1975) and allowing conversion of natural floodplain areas to agricultural and urban use.

Navigation traffic has been found to resuspend bottom sediments in some river reaches and to exert erosive forces on river shorelines (Bhowmik et al. 1981; Simons et al. 1981). Simons et al. (1981) predicted ranges of increased sediment inflow to backwater areas that would be produced by increased vessel traffic on the UMRS. Wake waves generated by commercial (Bhowmik et al. 1990) and recreational craft (Bhowmik et al. 1992) have accelerated shoreline erosion in some reaches of the UMRS (S. Johnson, Minnesota Department of Natural Resources, Lake City, MN, personal communication,1994).

Continuous inundation by the navigation dams has prevented the annual dewatering of extensive floodplain areas and the associated consolidation and oxidation of sediments by seasonally fluctuating water levels. The configuration of the UMRS floodplain has been changed since dam construction by island and shoreline erosion from wind-driven and vessel wake waves, increased sediment trapping by vegetation, wind-driven sediment resuspension, and littoral drift (Simons and Chen 1979; USACE 1989). Extensive areas of formerly vegetated shallow aquatic habitat interspersed with islands have degraded to open windswept shallow areas with no vegetation (USACE 1989).

The geometry of UMRS channels and floodplain will change through both fluvial processes and human intervention. A quantitative understanding of sediment transport processes and prediction of future floodplain geometry is essential to management of UMRS natural resources and the navigation system.

Approach

The proposed approach involves an expansion of LTRMP research in sediment transport and depositional processes. The proposed research will include literature review and data compilation, surveys of present floodplain elevation and geomorphology, expansion of the sediment monitoring network, interdisciplinary investigations into tributary sediment discharge, sediment transport processes within the UMRS floodplain, sediment budgets of backwater areas, estimation of bedload transport, and forecast of future configuration of channels and floodplain.

The first stage (Tasks 1 and 2, below) will include a literature review and acquisition of existing data. The Scope of Work for subsequent tasks (3 through 9) will be developed in greater detail following acquisition and evaluation of existing data.

Some of the tasks will be accomplished as part of the Corps Navigation Study. Some investigations of backwater sediment processes have already been initiated by the Environmental Management Technical Center (EMTC) and the Corps' St. Paul District as part of Environmental Management Program research in support of Habitat Rehabilitation and Enhancement Projects. Much research of this kind has been conducted on the Illinois River by the Illinois State Water Survey. The proposed research will require significant expansion of LTRMP research in this field and a cooperative effort on the part of a number of agencies involved in the water resources of the Upper Mississippi River Basin.

Sediment erosion, transport, and deposition in the UMRS basin is driven by climate and human activities. Precipitation and runoff events cause sedimentation to be very episodic. Forecasts of fluvial geomorphic processes are generally made over longer time scales. Interest in future configuration of UMRS channels and floodplain for management purposes requires forecasting over a shorter, decadal time scale. The inherent uncertainties of such forecasting will be reduced by attention to historical trends, quantification of geomorphic processes affecting the UMRS channels and floodplain, and simulation of alternative outcomes under different climatic and management scenarios.

Task 1. Literature Review

Literature pertaining to the fluvial geomorphology of the UMRS will be reviewed. A narrative report will be prepared, summarizing the literature on land use in the basin, upland erosion, sediment delivery through the tributary stream network, sediment transport and depositional processes within the channels and floodplain, and geomorphology of the UMRS.

Task 2. Compilation and Review of Existing Hydraulic, Sediment, and Geomorphic Data

Existing data on historical land use, upland erosion, sediment transport and depositional processes, hydraulic conditions, and geomorphology of the UMRS will be compiled. Data acquired from State and Federal agencies and educational institutions will be cataloged and curated for future use at the EMTC. A report update of Simons et al. 1981 will be prepared to evaluate and document the availability and quality of land use, sediment, hydraulic, and geomorphic data on the UMRS.

Task 3. Obtain Floodplain Elevation Data

A comprehensive elevation survey of the UMRS floodplain will be conducted, including channels, backwater areas, and floodplain terrestrial areas. A geographic information system (GIS) database of floodplain elevation will be developed.

Task 4. Map the Geomorphology of the UMRS Floodplain

A comprehensive set of maps of the geomorphology of the UMRS floodplain will be developed using aerial photographs, floodplain elevation coverage, and field reconnaissance as necessary. A standard nomenclature for geomorphic units of the UMRS floodplain will be used. The present pattern and genesis of geomorphic units throughout the system will be interpreted in a narrative report. A set of GIS coverages of geomorphology of UMRS pools and river reaches will be developed.

Task 5. Establish an Expanded Sediment Monitoring Network

Strategically placed stations will be established, augmenting the existing set of stations to provide a more complete network for monitoring suspended sediment movement in the UMRS and tributaries. A series of elevation survey transects will be established, monumented, and documented for long-term monitoring of sedimentation in the lower reaches of UMRS tributaries and at key locations along the UMRS. Where possible, these elevation survey transects will be located where previous elevation surveys have been conducted.

Task 6. Estimate Tributary Sediment Discharge

UMRS tributary watersheds will be classified by their size, hydrology, and geomorphic characteristics. Available data on sediment delivery of tributary watersheds to the UMRS will be evaluated. Models for estimating sediment discharge of ungaged tributaries will be identified and evaluated. Using available sediment discharge data from gaging stations and appropriate models for estimating suspended and bedload sediment discharge, annual sediment discharge from tributary watersheds to the UMRS will be estimated. Models for estimating the relationships between upland erosion and land use will be identified and evaluated for application to the UMRS. Hydraulic characteristics of tributary channels and historical data on sedimentation in tributary valleys will be evaluated to interpret trends in sediment conveyance conditions of tributary channels. By applying appropriate upland erosion and land use models, the change in sediment discharge from each tributary over the next 50 years will be estimated, based on ongoing geomorphic processes in tributary channels and expected changes in land management practices and land use.

Task 7. Investigate and Quantify Sediment Transport and Depositional Processes within the UMRS Floodplain

Hydraulic models for predicting sediment transport and depositional processes will be identified from the literature, evaluated for application to the UMRS, and calibrated and verified through field and laboratory investigations. The sediment transport and depositional processes that will be investigated include:

Subtask 7a. Wave Effects

Model(s) applicable to the UMRS for predicting wave energy and spatial and temporal occurrence of wind-driven and vessel-generated waves will be identified. Field investigations with measurements of wind speed, direction, and wave height will be conducted at several sites. Predictive models of wind-generated wave action will be calibrated and verified using the resulting time series data.

Model(s) applicable to the UMRS for predicting shoreline erosion rates by wave action will be identified and evaluated for application to the UMRS. Historical shoreline erosion rates will be estimated using available elevation survey data and aerial photography. Reaches of UMRS shorelines that are subject to wave-induced erosion will be identified and shoreline erosion rates will be estimated.

Subtask 7b. Resuspension

A numerical hydraulic modeling capability will be developed to estimate shear stress exerted on the river bed by passing commercial vessels. Field measurements and physical hydraulic model experiments will be conducted to calibrate and verify predictive models. Data on channel configuration and channel sediment physical properties will be used to model the increase in suspended solids concentration in the main channels of the UMRS due to resuspension by commercial traffic.

Model(s) applicable to the UMRS for predicting sediment resuspension by advective (gravity) flow will be identified. Field measurements of current velocity, sediment physical properties, and suspended solids will be conducted. Critical shear stress and associated current velocities for mobilizing for different types of UMRS sediments will be identified. Field measurements and possibly laboratory experiments will be used to calibrate and verify predictive models.

Subtask 7c. Bedload Transport and Deposition

Bedload transport will be measured at a number of strategically located stations in the UMRS. Hydraulic data will be obtained from the same sites to develop numerical hydraulic model estimates of bedload transport (e.g., Rose 1992). The primary tributary bedload delta areas and areas of bedload accumulation outside the main and secondary channels in the UMRS will be identified using aerial photography, floodplain elevation data, and field reconnaissance. Corps of Engineers historical dredging and placement records will be used to evaluate the influence of dredging on bedload movement in different reaches of the UMRS.

Task 8. Backwater Areas Sediment Budgets

Backwater areas of the UMRS will be classified according to their size and geomorphic and hydraulic characteristics. A number of representative backwater areas on the UMRS will be selected for sediment budget studies. Two-dimensional numerical hydraulic models of the backwater areas will be developed to predict flow patterns and velocity distributions at different levels of river discharge. Suspended sediment inflow and discharge will be monitored. The relationships between the gradation of inflowing suspended materials and season and river discharge will be determined. The fate of inflowing materials and their depositional pattern within the backwaters will be estimated using coring techniques, depositional layer markers, sediment traps, and grain size analysis of bed material samples. Sediment resuspension by waves and advective flow will be modeled. The range of fine sediment water content and density with depth of accumulation will be investigated. A sediment budget for each study area will be developed based on historical changes discernible from aerial photography, estimates of sediment loadings and export, and models of water flow and sediment erosional and depositional processes. Rates and the spatial patterns of fine sediment accumulation within each study area will be estimated using sediment budget, substrate, and hydraulic information. A model system for estimating sediment budgets for other UMRS backwater areas will be developed, based on findings of the backwater sediment budget studies.

Task 9. Synthesis and Estimation of Future Configuration of UMRS Channels and Floodplain

A synthesis analysis will be conducted to summarize findings of the foregoing investigations. Historical changes in the configuration of UMRS channels and floodplains will be evaluated using historical elevation surveys and aerial photography. A forecasting approach will be developed to simulate future configuration of the channels and floodplain of the UMRS over the next 50 years, making use of present-day geomorphic patterns, estimates of future land use changes and sediment discharge to the river, and findings of the foregoing investigations of sediment transport and depositional processes in the UMRS. A series of forecast scenarios will be developed for alternative future conditions with and without changes in land use, river management, and climate.

References

Belt, C. B. 1975. The 1973 flood and man's constriction of the Mississippi River. Science 189:681-684.

Bhowmik, N. G., and J. R. Adams. 1986. The hydrologic environment of Pool 19 of the Mississippi River. Hydrobiologia 136:21-30.

Bhowmik, N. G., and J. R. Adams. 1989. Successional changes in habitat caused by sedimentation in navigation pools. Hydrobiologia 176/177:17-27.

Bhowmik, N. G., J. R. Adams, A. P. Bonini, C. Y. Guo, D. J. Kisser, and M. A. Sexton. 1981. Resuspension and lateral movement of sediment by tow traffic on the Upper Mississippi and Illinois Rivers. Illinois State Water Survey Contract Report 269.

Bhowmik, N. G., J. R. Adams, and M. Demissie. 1989. Sedimentation in four reaches of the Mississippi and Illinois Rivers. Pages *21-29 in* Proceedings of the Porto Alegre Symposium. IAHS Publication No. 174.

Bhowmik, N. G., W. C. Bogner, J. A. Slowikowski, and J. R. Adams. 1993. Source monitoring and evaluation of sediment inputs for Peoria Lake. Illinois Water Survey, Champaign, Illinois. Illinois Department of Energy and Natural Resources Report ILENR/RE-WR-93-01. Reprinted by the National Biological Survey Environmental Management Technical Center, Onalaska, Wisconsin, October 1993. EMTC 93-R016. 60 pp. (NTIS PB93-188472)

Bhowmik, N. G., and M. Demissie. 1989. Sedimentation in the Illinois River Valley and backwater lakes. Journal of Hydrology 105:187-195.

Bhowmik, N. G., A. C. Miller, and B. S. Payne. 1990. Techniques for studying the physical effects of commercial navigation traffic on aquatic habitats. U.S. Army Waterways Experiment Station, Vicksburg, Mississippi. Technical Report EL-90-10.

Bhowmik, N. G., T. W. Soong, W. F. Reichelt, and N. M. L. Seddik. 1992. Waves generated by recreational traffic on the Upper Mississippi River System. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, in fulfillment of Project Number FWS14-16-0003-80-973, November 1992. EMTC 92-S003. 68 pp. (NTIS #PB92-161868)

Brown, M. H., and I. J. Nygard. 1941. Erosion and related land use conditions in Winona County, Minnesota. U.S. Department of Agriculture Soil Conservation Service Erosion Survey 17. 33 pp.

Brune, G. M. 1948. Rates of sediment production in the Midwestern United States. U.S. Department of Agriculture Soil Conservation Service, Milwaukee, Wisconsin. SCS-TP-65.

Chen, Y. H., and D. B. Simons 1986. Hydrology, hydraulics, and geomorphology of the Upper Mississippi River System. Hydrobiologia 136:5-20.

Demissie, M., and N. G. Bhowmik. 1986. Peoria Lake sediment investigation. Illinois State Water Survey Contract Report 371.

Demissie, M., L. Keefer, and R. Xia. 1992. Erosion and sedimentation in the Illinois River Basin. Illinois State Water Survey, Champaign, Illinois. ILENR/RE-WR-92/04.

GREAT I. 1980a. Great River Environmental Action Team Study of the Mississippi River. Volume 7. Public Participation and Plan Formulation. 62 pp.

GREAT I. 1980b. Great River Environmental Action Team Study of the Mississippi River. Volume 4. Water Quality, Sediment, and Erosion. 126 pp.

Happ, S. C. 1944. Effect of sedimentation on floods in the Kickapoo Valley, Wisconsin. Journal of Geology 52:53-68.

Hawkins, A. S., and J. L. Stewart. 1990. Pilot project on the Middle Branch of the Whitewater River. U.S. Fish and Wildlife Service, Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota. 34 pp.

Kazmann, R.G. 1972. Modern Hydrology. Edition 2. Harper and Row. New York.

Knox, J. C. 1977. Human impacts on Wisconsin stream channels. Annals of the Association of American Geographers 67:323-342.

Knox, J. C. 1987. Historical valley floor sedimentation in the Upper Mississippi Valley. Annals of the Association of American Geographers 77(2):224-244.

Knox, J. C. 1989. Long- and short-term episodic storage and removal of sediment in watersheds of southwestern Wisconsin and northwestern Illinois. Pages 157-164 *in* Sediment and the environment, Proceedings of the Baltimore Symposium, May 1989. IAHS Publication No. 184.

Knox, J. C., P. J. Bartlein, K. K. Hirschboek, and R. J. Muckenhirn. 1975. The response of floods and sediment fields to climatic variation and land use in the Upper Mississippi Valley. University of Wisconsin-Madison, Institute for Environmental Studies. Report 52. 76 pp.

Lane, E. W. 1938. Report on investigation of sediment carried by rivers of St. Paul, U.S. Engineer District 1937 and 1938. Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa. 42 pp.

Lee, M. T., and J. B. Stall. 1976. Sediment conditions in backwater lakes along the Illinois River - Phase I. Illinois State Water Survey Contract Report 371. 73 pp.

McHenry, J. R., J. C. Richie, and J. Verdon. 1976. Sedimentation rates in the Upper Mississippi River. Proceedings of the Symposium on Inland Waterways for Navigation, Flood Control, and Water Diversions. Colorado State University, Fort Collins, Colorado, August 10-12, 1976.

Meade, R. H., T. R. Yuzyk, and T. J. Day. 1990. Movement and storage of sediment in rivers of the United States and Canada. Pages 255-280 *in* M. G. Wolman and H. C. Riggs, editors. Volume 0-1, Surface Water Hydrology. The Geology of North America Geological Society of America, Boulder, Colorado.

Nielsen, D. N., R. Rada, and M. M. Smart. 1984. Sediments of the Upper Mississippi River: Their sources, distribution, and characteristics. Pages 67-98 *in* J. G. Wiener, R. V. Anderson, and D. R. McConville, editors. Contaminants in the Upper Mississippi River. Proceedings of the 15th

Annual Meeting of the Mississippi River Research Consortium. Butterworth Publishers, Boston Massachusetts.

Problem Identification and Analysis Work Group. 1987. Environmental Management Program Problem Identification and Analysis Action Plan Report. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 30 pp.

Rose, W. J. 1992. Sediment transport, particle sizes, and loads in lower reaches of the Chippewa, Black, and Wisconsin Rivers in western Wisconsin. U.S. Geological Survey, Madison, Wisconsin. Water Resources Investigations Report 90-4124.

Simons, D. B., and Y. H. Chen. 1979. A geomorphic study of Pools 5 through 8 in the Upper Mississippi River System. Report prepared by Colorado State University, Fort Collins, Colorado, for the St. Paul District, U.S. Army Corps of Engineers, Department of Civil Engineering. Report CER79-89DBS-YHC19.

Simons, D. B., Y. H. Chen, R. M. Li, and S. S. Ellis. 1981. Summary report of assistance in evaluation of the existing river environment and in assessment of the impacts of navigation activity on the physical and biological environment in the Upper Mississippi River System. Report by Simons, Li, and Associates Inc., Fort Collins Colorado, for the Upper Mississippi River Basin Commission, Minneapolis, Minnesota. 34 pp.

Simons, D. B., S. A. Schumm, and M. Stevens. 1974. Geomorphology of the Middle Mississippi. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Tornes, L. H. 1986. Suspended sediment in Minnesota streams. U.S. Geological Survey Water Resources Investigations Report 85-4312. 33 pp.

Trimble, S. W. 1983. A sediment budget for Coon Creek Basin in the Driftless Area, Wisconsin, 1853-1977. American Journal of Sciences 283:454-474.

Trimble, S. W., and S. W. Lund. 1982. Soil conservation and the reduction of erosion and sedimentation in the Coon Creek Basin, Wisconsin. U.S. Geological Survey, Washington, D.C. Professional Paper 1234. 35 pp.

U.S. Army Corps of Engineers (USACE). 1992. Definite Project Report - Pool 8 Islands Construction Habitat Rehabilitation and Enhancement Project, Upper Mississippi River, Vernon County, Wisconsin. St. Paul District, St. Paul, Minnesota.

U.S. Fish and Wildlife Service (USFWS). 1992. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised October 1993. EMTC 91-P002. 179 pp. (NTIS #PB94-160199)

Appendix A

Amendment to FY 1994 Annual Work Plan

Supplement to Strategy 1.2.1, *Determine Effects of Sedimentation and Sediment Transport Processes* - Task 1.2.1.2, Select Processes for Research - Work Unit A: Identify Approaches and Develop Scope of Work

Background:

The fluvial processes of sediment transport and alluviation determine the configuration of Upper Mississippi River System (UMRS) channels and floodplain. This configuration, in turn, provides the template for the mosaic of habitats found in the system. Previous studies of sediment and sediment processes in the UMRS have addressed many topics but have not resulted in quantitative and spatially complete estimates of changes in the geometry of UMRS channels and floodplain. This quantitative information is needed to predict future conditions in the river under various management alternatives and thus guide development of plans for managing the UMRS ecosystem. Current Long Term Resource Monitoring Program (LTRMP) efforts do not provide information at the level of detail or spatial extent required; augmentation of LTRMP sediment-related activities is consistent with Objectives 1.2, 1.3, and 3.3 (and inclusive strategies and tasks) of the Operating Plan.

Approach:

Early in 1994, the Environmental Management Technical Center will sponsor the formation of a Sediment Transport/ Geomorphology Working Group that will develop a detailed description of initial activities (to be carried out over the next 3 to 5 years) needed to understand sediment transport processes and the changing geomorphology of the UMRS. This Working Group will consist of a limited number of recognized scientists from the Federal, State, and private sectors. Issues to be considered by this group include estimations of tributary sediment discharge, acquisition of floodplain elevation data, prioritization and measurement of sediment transport and depositional processes, estimation of sediment budgets for UMRS pools and river reaches, mapping of UMRS geomorphology, and prediction of future changes in the geomorphology of the UMRS. Other activities will include a literature review, identification of existing data, and initial site selection for sediment transport studies.

Appendix B

Members of the Sedimentation/Geomorphology Working Group

Nani Bhowmik, PhD
Illinois State Water Survey
2204 Griffith Drive
Champaign, IL 61820

Robert F. Gaugush, PhD
National Biological Survey
Environmental Management Technical Center
575 Lester Avenue
Onalaska, WI 54650

Jon Hendrickson, PE
U.S. Army Corps of Engineers, St. Paul District
Army Corps of Engineers Centre
190 Fifth Street East
St. Paul, MN 55101

James Knox, PhD
Department of Geography
Science Hall
550 North Park Street
University of Wisconsin-Madison
Madison, WI 53706

Robert Meade, PhD
U.S. Geological Survey
Stop 413
Box 25046
Denver, CO 80255

Thomas Pokrefke, PE
U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180

Daniel B. Wilcox
U.S. Army Corps of Engineers, St. Paul District
Army Corps of Engineers Centre
190 Fifth Street East
St. Paul, MN 55101

Other members of the Environmental Management Technical Center staff, Dr. John Barko, Dr. David Soballe, Mr. Jim Rogala, and Mr. Thomas Kirkeeng, took part in some Working Group discussions.

Appendix C

Draft Planning Document

Investigate Sediment Transport Processes and Sedimentation; Predict Future Configuration of UMRS Channels and Floodplain

Background

The template for the mosaic of habitats in the Upper Mississippi River System (UMRS) is the configuration of the channels and floodplain formed by the fluvial processes of sediment transport and alluviation. Previous investigations of sediment in the UMRS have addressed upland erosion (Brown and Nygard 1941; Happ 1944; Knox et al. 1975; Knox 1977, 1989; Trimble and Lund 1982; Trimble 1983; Hawkins and Stewart 1990), sediment discharge of tributaries (Lane 1938; Tornes 1986), and sediment transport processes and deposition within the floodplain (McHenry et al. 1976; Simons and Chen 1979; Chen and Simons 1986; Bhowmik et al. 1989) but have not resulted in quantitative and spatially complete estimates of future changes in the geometry of UMRS channels and floodplain.

Prediction of the future geometry of the UMRS channels and floodplain is needed for managing the UMRS natural resources and the Mississippi River and Illinois Waterway navigation system. Development of plans for managing the UMRS ecosystem will require prediction of future condition of the river system under various management alternatives. Prediction of future geomorphology of the system will be essential for predicting future amounts and spatial distribution of floodplain vegetation, aquatic habitats, water quality conditions, and recreational opportunities. Evaluation of the impacts of increased navigation and planning of long-term navigation channel maintenance activities will require prediction of future channel geometry and dredging requirements. Quantitative understanding of sediment transport and contaminant fate processes will be needed to manage contaminants.

The proposed investigations of sediment transport processes and future condition of UMRS channels and floodplain would provide information needed to meet a number of objectives described in the LTRMP Operating Plan, including Strategy 1.2.1, *Determine Effects of Sedimentation and Sediment Transport Processes*, Strategy 1.2.2, *Determine the Effects of Navigation*, Strategy 2.2.1, *Monitor and Evaluate Floodplain Elevation*, Strategy 2.2.3, *Monitor and Evaluate Water Quality*, Strategy 2.2.6, *Monitor and Evaluate Floodplain Habitat*, and Strategy 3.1.2, *Predict Future Conditions*.

Problem Statement

Sedimentation of backwater areas is considered by many to be the most severe environmental problem on the UMRS (GREAT I 1980a; Problem Identification and Analysis Work Group 1987; Hawkins and Stewart 1990; USFWS 1992). The main source of fine-grained sediment filling UMRS backwaters is soil eroded from upland areas within the basin (Chen and Simons 1986).

Land use and land management practices within the basin have greatly increased upland erosion rates and discharge of sediment from tributaries to the UMRS over presettlement rates (Knox et al. 1975; Knox 1977). Upland erosion and UMRS tributary sediment yields were highest during periods of intensive farming and runoff during the 1850s through the 1940s, with erosion rates declining since then due to improved land management practices (Knox et al. 1975; Trimble and Lund 1982; Trimble 1983). Despite improved land management practices and reduced upland erosion rates, tributary sediment discharge to the UMRS continues to be influenced by sediment historically deposited in tributary valleys (Knox 1989).

Channel maintenance dredging has been estimated to remove a major fraction of the total river bedload transport in the upper pools of the Mississippi River (GREAT I 1980b). Disposal of dredged material has created numerous channel border islands (Simons and Chen 1979; GREAT I 1980b). Future channel maintenance will require additional placement of dredged material in the floodplain, despite increased efforts to place material out of the floodplain for beneficial use as fill and for winter road sanding.

Navigation dams, channel training structures, levees, and channel maintenance dredging have altered river hydraulic characteristics, sediment transport processes, and the pattern of sediment deposition within the UMRS floodplain (Lee and Stall 1976; Simons and Chen 1979; Bhowmik and Adams 1986; Chen and Simons 1986; Bhowmik et al. 1989). Navigation dams have increased sediment trapping efficiency of river reaches that are now navigation pools" (Simons and Chen 1979; Bhowmik and Adams 1986; Bhowmik and Demissie 1989; Bhowmik et al. 1989). An average of 2-3 cm/year of fine sediment was estimated to accumulate in backwater areas of Pools 4 through 10, changing aquatic areas into marsh and floodplain terrestrial habitat (McHenry et al. 1976). Both Peoria Lake on the Illinois River and Pool 19 on the Mississippi River have lost more than half of their volume to sediment deposition since dam construction (Demissie and Bhowmik 1986; Bhowmik and Adams 1989).

Bank revetments, wing dams, and closing dams constructed to maintain the navigation channel have constrained the main channel, reduced flows to secondary channels and backwaters, prevented lateral channel migration, and have prevented the creation of new fluvial landforms (Simons et al. 1974, 1981; Simons and Chen 1979; Chen and Simons 1986). Levees have sequestered the floodplain from the main channel in much of the lower UMRS, raising flood stages (Kazmann 1972; Belt 1975) and allowed conversion of natural floodplain areas to agricultural and urban use.

Navigation traffic has been found to resuspend bottom sediments in some river reaches and exert erosive forces on river shorelines (Bhowmik et al. 1981; Simons et al. 1981). Simons et al. (1981) predicted ranges of increased sediment inflow to backwater areas that would be produced by increased vessel traffic on the UMRS.

Continuous inundation by the navigation dams has prevented the annual dewatering of extensive floodplain areas and the associated consolidation and oxidation of sediments by seasonally fluctuating water levels. The configuration of the UMRS floodplain has been changed since dam construction by island and shoreline erosion from wind-driven and vessel wake waves, increased sediment trapping by vegetation, wind-driven sediment resuspension and littoral drift (Simons and Chen 1979; USACE 1989). Extensive areas of formerly vegetated shallow aquatic habitat interspersed with islands have degraded to open windswept shallow areas with no vegetation (USACE 1989).

The geometry of the UMRS channels and floodplain will change through both fluvial processes and human intervention. Quantitative understanding of sediment transport processes and prediction of future floodplain geometry is essential to management of the UMRS natural resources and the navigation system.

Approach

The proposed approach involves an expansion of the present LTRMP research into sediment transport and depositional processes. The proposed research would include interdisciplinary investigations into tributary sediment discharge, sediment transport processes within the UMRS floodplain, sediment budgets of backwater areas and navigation pools, a comprehensive survey of present floodplain geometry, and prediction of future floodplain configuration under different management scenarios. Some of the tasks will be accomplished as part of the Corps Navigation Study. Some tasks have already been initiated by the Environmental Management Technical Center and the Corps St. Paul District as part of ongoing Environmental Management Program research. The proposed additional work will require significant expansion of ongoing efforts.

Task 1. Literature Review

A review of sedimentological and geomorphological literature pertaining to the UMRS will be conducted, and a narrative review of the existing information will be prepared.

Task 2. Review of Existing Hydraulic, Sediment, and Geomorphic Data

An update of Simons et al. (1981) will be performed, to evaluate the availability of hydrologic, hydraulic, sediment, and geomorphic data on the UMRS.

Task 3. Estimate Tributary Sediment Discharge

Many UMRS tributaries are being routinely monitored for water and sediment discharge by the U.S. Geological Survey (USGS). Models for estimating sediment discharge of ungaged tributaries will be identified and evaluated. Using available sediment discharge data from USGS, Corps of Engineers, and Illinois State Water Survey gaging stations and appropriate models for estimating both wash load and bedload sediment discharge, estimate annual sediment discharge and sediment yield from each basin tributary to the UMRS. Models for estimating the relationships between sediment yield and land use will be identified and evaluated for application to the UMRS. Applying appropriate sediment yield and land use models, estimate the change in sediment discharge from each tributary over the next 50 years, based on ongoing geomorphic processes and expected changes in land management practices and land use.

Task 4. Obtain Floodplain Elevation Data

In partnership with the Corps of Engineers, conduct a comprehensive elevation survey of the UMRS floodplain, including channels, backwater areas, and floodplain terrestrial areas. Develop a geographic information system (GIS) database of floodplain elevation.

Task 5. Investigate Sediment Transport and Depositional Processes within the UMRS Floodplain

Hydraulic models for predicting sediment transport and depositional processes will be identified from the literature, evaluated for application to the UMRS, and calibrated and verified through field and laboratory investigations. The sediment transport and depositional processes that will be investigated include as follows:

Subtask 5a. Wind-driven waves

Review the literature, identify appropriate model(s) for application to the UMRS for predicting wave energy and spatial and temporal occurrence of wind-driven waves. Conduct field investigations with measurements of wind speed, direction, and wave height at several sites. Calibrate and verify predictive models using the resulting time series data.

Subtask 5b. Vessel wake waves (Corps of Engineers - Navigation Study)

Review the literature, identify appropriate model(s) for predicting wake waves generated by classes of commercial and recreational vessels operating at different speeds. Measure wake waves generated under controlled conditions, in the field and/or with a physical hydraulic model. Calibrate and verify the predictive models using observational data.

Subtask 5c. Wave energy regime (Corps of Engineers - Navigation Study)

Using land:water GIS coverage of the UMRS, vessel traffic projections, monthly wind rose data, and models of wind- and vessel-generated wave action, predict and compare wind-generated and vessel-generated wave action.

Subtask 5d. Shoreline erosion by waves (Corps of Engineers Navigation Study)

Review the literature, identify appropriate model(s) for predicting shoreline erosion rates by wave action that are appropriate for application to the UMRS. Using the spatial extrapolations of wind- and vessel-generated wave energy, and aerial photography, identify areas of UMRS shoreline that are subject to erosion by wave action, and estimate erosion rates.

Subtask 5e. Sediment resuspension by waves

Review the literature, identify model(s) for predicting sediment resuspension by wave action that are appropriate for application to the UMRS. Conduct field measurements of wind speed, direction, wave height, sediment physical properties, and suspended solids to generate time series data sets for calibration and verification of predictive hydraulic model(s).

Subtask 5f. Sediment resuspension by navigation traffic (Corps of Engineers - Navigation Study)

Review the literature, identify appropriate model(s) for predicting sediment resuspension by wave action that are appropriate to apply to the UMRS. Conduct field measurements and physical hydraulic model experiments to calibrate and verify predictive models. Using existing data on channel configuration and channel sediment physical properties, model the increase in suspended solids concentration due to resuspension by commercial traffic.

Subtask 5g. Sediment resuspension by advective flow

Review the literature, identify appropriate model(s) for predicting sediment resuspension by advective (gravity) flow. Conduct field measurements and laboratory experiments to calibrate and verify predictive models.

Subtask 5h. Bedload transport and deposition

Review the literature and compile existing information on bedload transport and channel maintenance dredging in the UMRS. Identify appropriate model(s) for estimating bedload discharge at various points in the UMRS. Obtain the hydraulic and sediment gradation data necessary for estimating bedload transport. Using aerial photography, floodplain elevation data, and field reconnaissance, identify the primary tributary bedload delta areas and areas of bedload accumulation outside the main and secondary channels in the UMRS. Using side channel inlet geometry and estimates of flow rates, estimate rates of bedload delivery to off-channel areas. Using estimates of tributary bedload discharge, estimate rates of tributary delta building. Evaluate Corps dredging records and placement locations. Develop a bedload budget for each UMRS pool.

Subtask 5i. Suspended sediment transport and deposition

Using findings from the investigations of erosional processes, identify the range of conditions where fine sediment deposition occurs. Investigate the mass exchanges between main channel, channel border areas, and off-channel areas. Using floodplain geometry, aerial photography, and hydraulic data, identify areas of fine-grained sediment deposition.

Task 6. Backwater Areas Sediment Budget

Select three to five representative backwater areas on the UMRS. Develop two dimensional numerical hydraulic models of the backwater areas to predict flow patterns and velocity distributions at different levels of river discharge. Monitor suspended sediment inflow and export. Model sediment resuspension by waves and advective flow. Monitor sediment accumulation using depositional layer markers. Measure the range of fine sediment water content and density with depth of accumulation. Develop a sediment budget for each study area based on estimates of sediment loadings and export, and sediment erosional and depositional processes. Estimate rates and the spatial patterns of fine sediment accumulation within each study area using sediment budget and hydraulic information. Develop a model system for predicting sediment budgets for other UMRS backwater areas, based on findings of the backwater sediment budget studies.

Task 7. Sediment Budget of UMRS Pools and River Reaches

Evaluate the available data on hydraulic and geomorphic conditions. Estimate sediment loadings, deposition, and export for each pool and river reach.

Task 8. Map the Geomorphology of the UMRS Floodplain

Review the literature, compile existing geomorphic maps and information on the UMRS. Adopt a standard nomenclature for geomorphic units of the UMRS floodplain. Using aerial photographs, floodplain elevation coverage, and field reconnaissance as necessary, develop a comprehensive map of the geomorphology of the UMRS floodplain. Interpret and evaluate the present pattern and genesis of geomorphic units throughout the system.

Task 9. Predict Configuration of the UMRS Floodplain

Conduct a spatial survey of UMRS aquatic areas to relate velocity regime with bed form and sediment physical properties. Develop a predictive model of sediment type distribution and accumulation rates based on position within the floodplain. Using available hydraulic and sediment budget data, estimate change in floodplain configuration over the next 50 years. Develop GIS elevation coverages for future floodplain configuration.

References

Belt, C. B. 1975. The 1973 flood and man's constriction of the Mississippi River. Science 189:681-684.

Bhowmik, N. G., and J. R. Adams. 1986. The hydrologic environment of Pool 19 of the Mississippi River. Hydrobiologia 136:21-30.

Bhowmik, N. G., and J. R. Adams. 1989. Successional changes in habitat caused by sedimentation in navigation pools. Hydrobiologia 176/177:17-27.

Bhowmik, N. G., J. R. Adams, A. P. Bonini, C. Y. Guo, D. J. Kisser, and M. A. Sexton. 1981. Resuspension and lateral movement of sediment by tow traffic on the Upper Mississippi and Illinois Rivers. Illinois State Water Survey Contract Report 269.

Bhowmik, N. G., J. R. Adams, and M. Demissie. 1989. Sedimentation in four reaches of the Mississippi and Illinois Rivers. Pages *21-29 in* Proceedings of the Porto Alegre Symposium. IAHS Publication No. 174.

Bhowmik, N. G., and M. Demissie. 1989. Sedimentation in the Illinois River Valley and backwater lakes. Journal of Hydrology 105:187-195.

Brown, M. H., and I. J. Nygard. 1941. Erosion and related land use conditions in Winona County, Minnesota. U.S. Department of Agriculture Soil Conservation Service Erosion Survey 17. 33 pp.

Chen, Y. H., and D. B. Simons 1986. Hydrology, hydraulics, and geomorphology of the Upper Mississippi River System. Hydrobiologia 136:5-20.

Demissie, M., and N. G. Bhowmik. 1986. Peoria Lake sediment investigation. Illinois State Water Survey Contract Report 371.

GREAT I. 1980a. Great River Environmental Action Team Study of the Mississippi River. Volume 7. Public Participation and Plan Formulation. 62 pp.

GREAT I. 1980b. Great River Environmental Action Team Study of the Mississippi River. Volume 4. Water Quality, Sediment, and Erosion. 126 pp.

Happ, S. C. 1944. Effect of sedimentation on floods in the Kickapoo Valley, Wisconsin. Journal of Geology 52:53 68.

Hawkins, A. S., and J. L. Stewart. 1990. Pilot project on the Middle Branch of the Whitewater River. U.S. Fish and Wildlife Service, Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota. 34 pp.

Kazmann, R. G. 1972. Modern Hydrology. Edition 2. Harper and Row. New York.

Knox, J. C. 1977. Human impacts on Wisconsin stream channels. Annals, Association of American Geographers 67:323-342.

Knox, J. C. 1989. Long- and short-term episodic storage and removal of sediment in watersheds of southwestern Wisconsin and northwestern Illinois. Pages 157-164 *in* sediment and the environment, Proceedings of the Baltimore Symposium, May 1989. IAHS Publication No. 184.

Knox, J. C., P. J. Bartlein, K. K. Hirschboek, and R. J. Muckenhirn. 1975. The response of floods and sediment fields to climatic variation and land use in the Upper Mississippi Valley. University of Wisconsin-Madison, Institute for Environmental Studies. Report 52. 76 pp.

Lane, E. W. 1938. Report in investigation of sediment carried by rivers of St. Paul, U.S. Engineer District 1937 and 1938. Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa. 42 pp.

Lee, M. T., and J. B. Stall. 1976. Sediment conditions in backwater lakes along the Illinois River - Phase I. Illinois State Water Survey Contract Report 371. 73 pp.

McHenry, J. R., J. C. Richie, and J. Verdon. 1976. Sedimentation rates in the Upper Mississippi River. Proceedings of the Symposium on Inland Waterways for Navigation, Flood Control, and Water Diversions. Colorado State University, Fort Collins, Colorado, August 10-12, 1976.

Problem Identification and Analysis Work Group 1987. Environmental Management Program Problem Identification and Analysis Action Plan Report. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 30 pp.

Simons, D. B., and Y. H. Chen. 1979. A geomorphic study of Pools 5 through 8 in the Upper Mississippi River System. Report prepared by Colorado State University, Fort Collins, Colorado, for the St. Paul District, U.S. Army Corps of Engineers, Department of Civil Engineering. Report CER79-89DBS-YHC19.

Simons, D. B., Y. H. Chen, R. M. Li, and S. S. Ellis. 1981. Summary report of assistance in evaluation of the existing river environment and in assessment of the impacts of navigation activity on the physical and biological environment in the Upper Mississippi River System. Report by Simons, Li, and Associates Inc., Fort Collins Colorado, for the Upper Mississippi River Basin Commission, Minneapolis, Minnesota. 34 pp.

Simons, D. B., S. A. Schumm, and M. Stevens. 1974. Geomorphology of the middle Mississippi. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Tornes, L. H. 1986. Suspended sediment in Minnesota streams. U.S. Geological Survey Water Resources Investigations Report 85-4312. 33 pp.

Trimble, S. W. 1983. A sediment budget for Coon Creek basin in the Driftless Area, Wisconsin, 1853-1977. American Journal of Sciences 283:454 474.

Trimble, S. W., and S. W. Lund. 1982. Soil conservation and the reduction of erosion and sedimentation in the Coon Creek Basin, Wisconsin. U.S. Geological Survey, Washington, D.C. Professional Paper 1234. 35 pp.

U.S. Army Corps of Engineers (USACE). 1992. Definite Project Report Pool 8 Islands Construction Habitat Rehabilitation and Enhancement Project, Upper Mississippi River, Vernon County, Wisconsin. St. Paul District, St. Paul, Minnesota.

U.S. Fish and Wildlife Service (USACE). 1992. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised October 1993. EMTC 91-P002. 179 pp. (NTIS #PB94-160199)

Appendix D

Working Group Meeting

The materials that follow are not verbatim transcripts of the discussions. Rather, the materials come from notes taken by the authors and, as such, represent a distillation of the discussions that occurred during the Working Group meeting. Information from particular members of the Working Group is attributed directly to them. However, general discussions are attributed to the Working Group (indicated as "WG") as a whole. A listing of acronyms utilized in the discussions appears at the end of this appendix.

Gaugush: This Working Group was assembled to respond to and modify the draft Scope of Work, "Investigate Sediment Transport Processes and Sedimentation and Predict Future Configuration of UMRS Channels and Floodplain," which was sent to all of the participants. What I hope we can accomplish during this meeting is outlined in the Agenda [Appendix E]. What are the data requirements to accomplish the proposed tasks? What kind and amount of data have already been collected in the area of sedimentation and geomorphology? Are there necessary tasks that have not been included in the proposed work? Will any of these tasks be addressed by the Corps Navigation Study? How can we prioritize the proposed work efforts? Dan Wilcox can provide some background on what led to development of the Scope of Work.

Wilcox: Sedimentation has been identified as one of the most severe problems occurring on the UMRS. Research into sediment processes is a major part of the LTRMP. There is a growing need for quantitative information on sediment transport processes and an ability to forecast future configuration of the UMRS channels and floodplain. Planning for ecosystem management and the Corps of Engineers Navigation Study will require information of this kind. It became apparent that there is a pressing need to accelerate LTRMP sediment-related research. We realized early on that greatly expanded research into UMRS sediment processes will require an infusion of expertise, an interagency cooperative effort, and funding. So, we prepared a strawman planning document, and invited you to this workshop to gain your insights.

Meade: Just what are you interested in? Before the locks and dams, the river existed as a channel with a seasonally wet-dry floodplain. Eventually, the river will again be a channel with a seasonally wet-dry floodplain. What are you trying to do?

WG: Long-term activities would be directed at the maintenance or enhancement of as much physical diversity as possible. Physical diversity refers to the geomorphology of the river and we assume that the maintenance of structural diversity will tend to support biological diversity as well.

Meade: People don't remember what the river looked like before the locks and dams. The river was structurally simpler prior to construction of the navigation system and much of what we now see was created by the impoundment of the river.

This was followed by some considerable discussion about how the river is currently handling and/or transporting sediments.

Meade: Our [USGS] recent work has involved an examination of the sediments in the lower pools of Pools 1-26 (except for Pool 17). In each of the navigation pools, 15-20 sediment grab samples from the lower portion of the pool were taken and then composited for analysis. Composited samples were analyzed for percent clay, percent organic carbon, total PCBs, lead, and coprostanol (a sewage indicator). These data indicate that the system restarts below Pool 4 (Lake Pepin), which acts as a deep sediment trap for a large proportion of the material from above Pool 4. Does Pool 19 (a deeper pool built for hydropower) act to reset the system in a similar fashion?

Hendrickson: Coarse materials may be more important than fines. Secondary side channels have enlarged since inundation. These create deltas with their relatively large amounts of bedload. Fines may reach an equilibrium state when depths reach about 1.5 m (4-5 ft). At this point, in many backwaters wind action is sufficient to resuspend fine particulate matter at these depths. Once wind action can act on the fines, backwater lakes may export as much fine particulate matter as they receive.

Knox: Large events account for an extremely large proportion of sediment transport. On the Grant River in southeastern Wisconsin, four floods accounted for 37% of the 3.5 m of sediments in the floodplain. There is also a difference in the timing of floods between the main stem and the tributaries that has resulted from impoundment and development with the UMRS basin. The main stem peaks earlier due to wetland drainage, increased surface runoff from impervious areas, and faster flood routing. As a result, the location of fine sediment deposition has changed as well. Very little deposition occurs on the top of the older islands.

Wilcox: There are two factors that are leading to the concern over sedimentation and the future geomorphology of the UMRS. First, there is a public perception of a decrease in the quality and quantity of aquatic habitat. Second, resource managers need to actively manage the river system to attain a desirable future condition.

Knox: How old are the geomorphological features we are looking at? The river may have been much less dynamic than we have assumed.

Gaugush: What are our needs? What will the river look like if we continue to manage the river as we are now? This is the major question, but we don't have major answers. The future state of the river will also dictate the management opportunities.

Pokrefke: The various agencies, Federal and State, will need to state what they want for the river. It will be most important for these management agencies to state what they want in quantifiable terms. River managers would like to maintain or enhance aquatic habitat, but how would it be quantified?

Meade: Conditions will be very different on different scales. On a pool scale, the river is in a disequilibrated state.

Gaugush: When a system is perturbed (by establishing a navigation system with the use of locks and dams), it moves away from some quasi-equilibrium state and begins to operate under a new set of conditions. This new set of conditions and the system's behavior comprises the disequilibrium state, which will continue until the system attains some new quasi-equilibrium. If the perturbation can be considered to be the construction of the locks and dams, what then was the old state and what will be the new state? We also have to remember that there were numerous interventions prior to construction of the locks and dams. Maintenance activities (e.g., snagging and the construction of wing dams and closing dams) were carried out in support of the 6-ft navigation channel.

We don't even know where we are at on the curve between the old and the new equilibrium states. We can illustrate some of the changes that have occurred since the impoundment of the UMRS. One major change is the observed loss in structural diversity in the lower (downstream) portions of the navigation pools. GIS-based studies of the changes in the lower portion of Pool 8 from 1939 to 1989 demonstrate the loss of islands over this time period.

Wilcox: The overall objective of any work effort must be to determine or forecast the future geomorphology of the river.

This statement of the primary objective was followed by a lengthy discussion of a number of tasks that would contribute to meeting that objective.

Meade: Aerial photography provides a 50-year story for the main stem of the river. A primary question is: What is happening on the river regardless of the tributary sediment inputs? Secondary question: What are the effects of the tributary inputs? The aerial photographs can be used to review historical changes. For example, the photographs could be used to track the changes in the total area represented by islands or the upstream boundary of open water such as is seen in the changes in lower Pool 8.

Hendrickson: Suspended sediment data should be collected in backwater areas to develop relationships between suspended sediment concentrations and various levels of river discharge.

Gaugush: Sediment mass balance budgets need to be determined on a pool scale. Studies such as these can tell us where we are on the curve from one equilibrium state to another. Are the navigation pools still trapping sediments? Are they anywhere near a new equilibrium state?

Knox and Meade: Re-run the old survey transects for elevation changes. In a number of the navigation pools, sedimentation ranges were established when the locks and dams were constructed.

Gaugush: Many of the pools do not have established sedimentation ranges. In many cases, sedimentation ranges were planned but never run.

Bhowmik: Gather all available data on sediments, sedimentation, geomorphology, etc. for the Upper Mississippi River System.

Pokrefke: Two-dimensional modeling, on a more limited scale, can answer some of the questions about what the river will do in the next 50-100 years.

Wilcox: The Corps Navigation Study will address the effects of vessel-induced resuspension of particulate matter.

Knox: What are the Corps' long-term plans for the navigation system on the Upper Mississippi River?

Wilcox: The Corps of Engineers is engaged in a Navigation Study for the Mississippi River and Illinois Waterway to determine the need for and feasibility of expanding navigation system capacity. The study could lead to construction of larger locks at some of the dams downriver toward St. Louis. The Corps is also engaged in long-term planning for channel maintenance, to reduce dredging requirements and to find cost-effective and environmentally acceptable ways to dredge and place dredged material. The Corps is developing a system-wide hydrologic model to assist in river regulation decisionmaking. There is consideration of changing the present system of river regulation to take advantage of habitat management opportunities through water control actions. This could involve shifting water level control points from mid-pool to the dam at some of the navigation dams. There are no plans to replace entire dams or to increase the depth of the 9-ft navigation channel.

Knox: We would also need to consider the effects of the projected global change in climate. The area of the UMRS is projected to become warmer and wetter. Very minor changes in climate can have profound impacts on the hydrology of both the main stem of the river and its tributaries. The magnitude of floods is sensitive to modest changes in climate. In the warmer and drier period, 3300-5000 B.P., the largest, extremely rare floods were relatively small. Floods were of the size that now have a recurrence interval of 50 years. After 3300 B.P., the climate became cooler and wetter and produced a shift in flood behavior. There were frequent large floods which now occur only once every 500 years or more. Still larger floods occurred between 1250 and 1450 A.D., during the transition from the medieval warm interval to the cooler Little Ice Age. These changes were associated with changes in mean annual temperature of only about 1-2 °C and changes in mean annual precipitation of less than 10% to 20%.

Pokrefke: The Mississippi River is part of the global climate change study being conducted by NASA and the USGS.

Meade: Is there any plan to develop a UMRS-scale sediment routing model? This would require extensive and detailed bathymetric data. Should this be a basic element of the studies being proposed?

Knox: Is the Brown Survey sufficient data for at least a first cut at developing a sediment routing model?

Bhowmik: You will need to use a set of representative pools, collect data, and model with either HEC-2 or FastTABS (hydrodynamic models developed by U.S. Army Corps of Engineers).

WG: How would predictions be made using these models?

Bhowmik: Peoria Lake on the Illinois River and Pool 19 on the Mississippi River had sufficient repetitions of cross-sectional data to make statements about loss in volume over time.

WG: That kind of data does not provide information on overall changes in geomorphology other than the statement that areas will be shallower over time.

Meade: It will be necessary to develop a set of monumented transects throughout all of the UMRS. These transects will be used to document elevation across the floodplain and will serve as baseline data for future changes. These data won't help our study very much but will help the working group that meets 50 years from now. The information concerning the location of these transects must be published with the elevation data.

WG: Once such transects are established, other investigators will probably use them for vegetation, invertebrate, and sediment surveys. The transects would provide common locations for a variety of studies that require some level of positional accuracy and will involve repetitive sampling.

The EMTC must play a curatorial role in regard to hydrological and geomorphological data. With the passage of time, more and more data are being lost. The EMTC should make the effort to locate and obtain all data pertinent to the geomorphology of the UMRS. This effort could be based on an update of the Master Plan treatment. The UMRS Master Plan identified most of the major data sources as of 1980. That work could serve as a starting point for the collection and storage of available data.

Meade: The data acquisition phase will require numerous meetings with the various agencies to determine just what is available.

Bhowmik: It is important that the EMTC make the long-term commitment. Such a commitment would include the establishment of elevation survey cross-sections and the establishment of suspended sediment sampling stations on both the Mississippi and Illinois Rivers as well as on their major tributaries.

There is a basic need to classify aquatic areas (main channel, channel border, off channel, etc.). As part of the Navigation Study, scientists and engineers will be meeting at the Waterways Experiment Station to begin formation of a classification scheme. There is a need to extrapolate effects of navigation spatially throughout the system.

WG: There is a need to develop a set of measures or metrics to define representative backwaters or classes of backwaters. These metrics, such as morphometry, residence time, advective effects, and vegetation, could eventually be related to sedimentation.

Given how important episodic events will be in determining the features and dynamics of backwater lakes, annual averages may not be sufficient to describe or classify backwater areas. Events of relatively short duration may dictate long-term behavior. Do episodic floods or seasonal high water events contribute to or remove sediments? This question may not be answered by annual averages of sediment loads and sediment outputs from backwater lakes.

Wilcox: We need to consider a requirement that can be used to define the research tasks of interest. This effort should eventually provide resource managers our best estimate of what the UMRS will look like in the next 50 years, given the present system of river regulation and channel maintenance practices.

Bhowmik: Land use has greatly influenced sediment delivery to the river. We can explain 80% of the variance in sediment delivery (suspended sediment load at gaging stations) with drainage area alone.

Knox: Our work indicates that land use poorly predicts sediment delivery to channels. There is a need to link land use with the changing hydraulics of channels with sediment delivery to the river. It can be dangerous to use historical data to develop land use-export relationships because channel form changes over time. Land use practices in some UMRS tributary watersheds have resulted in tributary channel form changes that have greatly increased their sediment conveyance efficiency.

Pokrefke: It will be necessary to obtain maps of land use and soil types for the entire basin. It may be necessary to depict pre-project (locks and dams), present, and projected land use maps.

Gaugush: Many of those maps have already been compiled. The Soil Conservation Service has soil type maps for the entire UMRS basin. Land use maps are also being produced by other agencies.

Bhowmik: If large-scale sediment transport is to be understood on the Mississippi and Illinois Rivers, there is a need to do the following:

1. Locate and collect all available data on sediment processes and geomorphology of the UMRS.

2. Identify and execute tasks possible with the existing data (e.g., preliminary sediment budgets).

3. Identify data needs and collect the data necessary to develop sediment budgets for the LTRMP pools.

4. Benchmark cross-section elevation data for the entire UMRS.

5. Establish additional suspended sediment sampling stations on the main stems of the Mississippi and Illinois Rivers.

Meade: There will be an eventual need for a sediment routing model for the entire UMRS. This model might not be obtainable for 50 to 100 years, but some data could be collected in support of this goal. These data could be used to develop a first approximation or "back of the envelope" calculations of sediment routing. Calculation of reliable estimates of pool volumes would be an initial step toward the goal of a sediment routing model. The eventual development of the sediment routing model would be dependent on knowledge of pool volume which would, in turn, allow for the calculation of residence time.

Wilcox: The Corps is developing a system hydrologic model for river regulation purposes. This model may aid the development of a system sediment routing model.

WG: Acquisition of elevation data for the channels and floodplain is an essential but costly task. A low density of survey points may be sufficient to gain information to estimate water body volumes with acceptable accuracy.

Hendrickson: As an aside to this discussion, siltation ranges were established on the lower ends of tributaries to the Mississippi River. These ranges were initially run prior to impoundment and some were done again in 1945. It would be useful to re-run these ranges.

WG: How many transects would be required to calculate the volume in a given pool to within 5% or 10% of the actual value?

This could be addressed with the Pool 8 bathymetric data that have been collected by the EMTC bathymetry crew. The high-resolution data collected by the EMTC could be used to determine the number of transects required to adequately estimate pool volume. The determination of volume could be based on the selection of *n* transects through the bathymetric surface created from the EMTC's data. Pool volume would be calculated from the *n* transects and compared with the volume calculated from the high resolution data. This would be repeated for various values of *n* to develop a relationship between the number of transects and the error associated with the calculated volume. This exercise would provide an indication of the number of transects required to estimate pool volume within some specified percent of the actual value.

Can the Illinois River act as a predictor of the fate of the Mississippi River? In many people's minds the historical changes in the Illinois River illustrate the eventual state of the Upper Mississippi River. How accurate is this view?

Knox: The Illinois River has always (in a geological sense) been a very different river when compared to the Mississippi River. The Illinois River is a loess-dominated river, whereas the Mississippi River is dominated by a much larger size fraction of particulate material.

WG: Sediment mass balances for a set of (5 or 6) representative pools should be developed. Pools could be classified on the basis of the level of tributary inputs. An initial "first-cut" at sediment budgets for particular pools might be possible by using currently available data. Locating and obtaining these data would also serve to identify data gaps. Pools 4 and 19 would have to be addressed separately because these pools are not comparable to any others in the UMRS.

Meade: For the above task, it will be necessary for the project leader to evaluate the available data, pool by pool, and determine the data's adequacy for developing sediment budgets. The project leader will have to be responsible for much of the work involved with locating data and its compilation so that he is aware of all of the data's possibilities and shortcomings.

Pokrefke: It may be necessary to form a multi-agency team to identify and collect all the available data. The team would have to have members from the EMTC, U.S. Fish and Wildlife Service, Corps, and State representatives.

WG: Long (1-2 m) sediment cores could be used in an attempt to develop an average sedimentation rate in various areas of the UMRS. Areas that were not continuously inundated prior to impoundment but are currently covered with water for all or most of the year could be compared with areas that were inundated prior to impoundment. Such a comparison might allow identification of a pre-impoundment layer in the sediment core. Identification of such a layer would then support the calculation of an average sedimentation rate (cm/year) without relying on the use of expensive radioactive dating techniques.

An extensive annotated bibliography on sediment transport/deposition and geomorphology should be also developed. This should include a review of the open literature as well as of the "grey" literature (State and Federal reports, dissertations, and theses). The work of Simons et al. (1981) for the Upper Mississippi River Basin Commission could provide a basis for this work.

The above discussion ended the first day of the Working Group meeting. Research tasks identified by the Group included the following:

1. Collect and analyze all of the available aerial photography for the UMRS.

2. Re-run the old sedimentation range surveys.

3. Locate and collect all available data on sediments, hydrology, and geomorphology of the UMRS and develop a curatorial role at the EMTC for these data.

4. 2-D modeling.

5. Develop a set of monumented transects.

6. Develop a set of measures (morphometry, advective effects, residence time, etc.) that can be used to classify backwaters that could eventually be related to sedimentation.

7. Large-scale acquisition of floodplain elevation data in support of the eventual development of a system-scale sediment routing model for the UMRS.

8. Re-survey the siltation ranges on the lower ends of tributaries emptying into the UMRS.

9. Develop sediment mass balance budgets for representative pools.

10. Develop an annotated bibliography covering the topic areas of sediment transport/deposition and the geomorphology of rivers.

Many of the above tasks appeared in the draft planning document provided to the Working Group prior to the meeting. The above list of research tasks was not compiled during the meeting; it is simply a list of those topics that received considerable discussion. The second day of the Working Group meeting was involved with a task-by-task discussion of the draft planning document that had been sent to all of the members prior to the meeting. Tasks that were discussed during the first day of the meeting are indicated as such.

Task 1. Literature Review

Discussed during the first day of the meeting.

Task 2. Review of Existing Hydraulic, Sediment, and Geomorphic Data

This task needs to include the acquisition of available data and its storage at the EMTC. The EMTC must also make a definite commitment to a curatorial role.

Task 3. Estimate Tributary Sediment Discharge

This task would also contribute to Task 7. How would bedload be handled? Both Meade and Knox felt that estimates of bedload are about as accurate as actual measurements of bedload.

Task 4. Obtain Floodplain Elevation Data

This task would support many other activities (vegetation surveys, navigation studies, habitat studies, etc.) at the EMTC. Work under this task would include the establishment of a number of monumented and well described cross-sections.

Task 5. Investigate Sediment Transport and Depositional Processes within the UMRS Floodplain

Subtask 5a. Wind-driven waves

Subtask 5b. Vessel wake waves (Corps of Engineers-Navigation Study)

Subtask 5c. Wave energy regime (Corps of Engineers-Navigation Study)

Subtask 5d. Shoreline erosion by waves (Corps of Engineers-Navigation Study)

Subtask 5e. Sediment resuspension by waves

Subtask 5f.	Sediment resuspension by navigation traffic (Corps of Engineers-Navigation Study)
Subtask 5g.	Sediment resuspension by advective flow
Subtask 5h.	Bedload transport and deposition
Subtask 5i.	Suspended sediment transport and deposition

Combine Subtasks 5a-d into a Wave Effects subtask, Subtasks 5e-g into a Resuspension subtask, and Subtasks 5h and i into a Sediment Transport and Deposition subtask.

Task 6. Backwater Areas Sediment Budget

This task should be performed on a set of different classes of backwaters. A rigorous classification scheme for different types of backwaters will be required for this task. As a part of planning for the Navigation Study, the Math Modeling Group is working on development of such a classification scheme.

Task 7. Sediment Budget of UMRS Pools and River Reaches

Discussed during the first day of the meeting.

Task 8. Map the Geomorphology of the UMRS Floodplain

This task will require the acquisition of extensive elevation coverages, available boring log data from the floodplain, and use of a set of defined types of geomorphic units.

Task 9. Predict Configuration of the UMRS Floodplain

This task is a major objective of the research effort and all of the previous tasks feed into this one.

Acronyms

EMTC	Environmental Management Technical Center
GIS	Geographic Information Systems
LTRMP	Long Term Resource Monitoring Program
NASA	National Aeronautics and Space Administration
UMRS	Upper Mississippi River System
USGS	U.S. Geological Survey

Appendix E

Sediment Transport/Geomorphology Working Group

Location: Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

Date: January 19-20, 1994

AGENDA

1. Introduction/Purpose/Outcome - Gaugush
2. Background - Wilcox
3. Identification of Needs
4. Available Data
5. Identification of Tasks
6. Tasks Associated with Navigation Study
7. Task Prioritization

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, D.C. 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE December 1994	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE

Planning Document: Investigate sediment transport/deposition and predict future configuration of UMRS channels and floodplain

5. FUNDING NUMBERS

6. AUTHOR(S)

Robert F. Gaugush[1] and Daniel B. Wilcox[2]

7. PERFORMING ORGANIZATION NAME AND ADDRESS

[1]National Biological Survey, Environmental Management Technical Center, 575 Lester Avenue, Onalaska, Wisconsin 54650 and [2]St. Paul District, U.S. Army Corps of Engineers, Army Corps of Engineers Centre, 190 Fifth Street East, St. Paul, Minnesota 55101-1638

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Biological Survey
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

94-P004

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Release unlimited. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

In late November 1993, discussions at the Environmental Management Technical Center concerning the addition of an initiative in the area of sediment transport and deposition led to the inclusion of a new work unit in the FY 1994 Annual Work Plan. This work unit was to form a Sediment Transport/ Geomorphology Working Group to develop a detailed set of initial tasks to be carried out over the next 3-5 years. The Working Group consisted of a limited number of scientists from the National Biological Survey, the U.S. Army Corps of Engineers, the U.S. Geological Survey, the Illinois State Water Survey, and the University of Wisconsin-Madison. Members of the Working Group were sent a draft planning document for their review prior to the meeting of the Working Group January 19-20, 1994. The Working Group met to discuss the draft planning document and to identify any gaps in its approach. The discussions and suggestions of the Working Group were used to revise the draft document. The planning document serves to include consideration of the influence of sediment transport and deposition on the future geomorphology of the Upper Mississippi River System in the Long Term Resource Monitoring Program.

14. SUBJECT TERMS

sediment, sedimentation, sediment transport, geomorphology, floodplain, backwaters, Mississippi River, Illinois River

15. NUMBER OF PAGES

9 pp. + Appendixes A-E

16. PRICE CODE

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