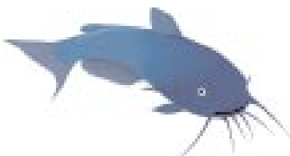
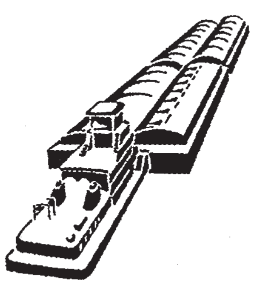
Interim Report For The Upper Mississippi River - Illinois Waterway System Navigation Study



Rates of Net Fine Sediment Accumulation in Selected Backwater Types of Pool 8, Upper Mississippi River



October 1997

Rock Island District
St. Louis District
St. Paul District

US Army Corps
of Engineers

Upper Mississippi River - Illinois Waterway System Navigation Study

ENV Report 2
October 1997

Rates of Net Fine Sediment Accumulation in Selected Backwater Types of Pool 8, Upper Mississippi River

by James T. Rogala

National Biological Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, WI 54650

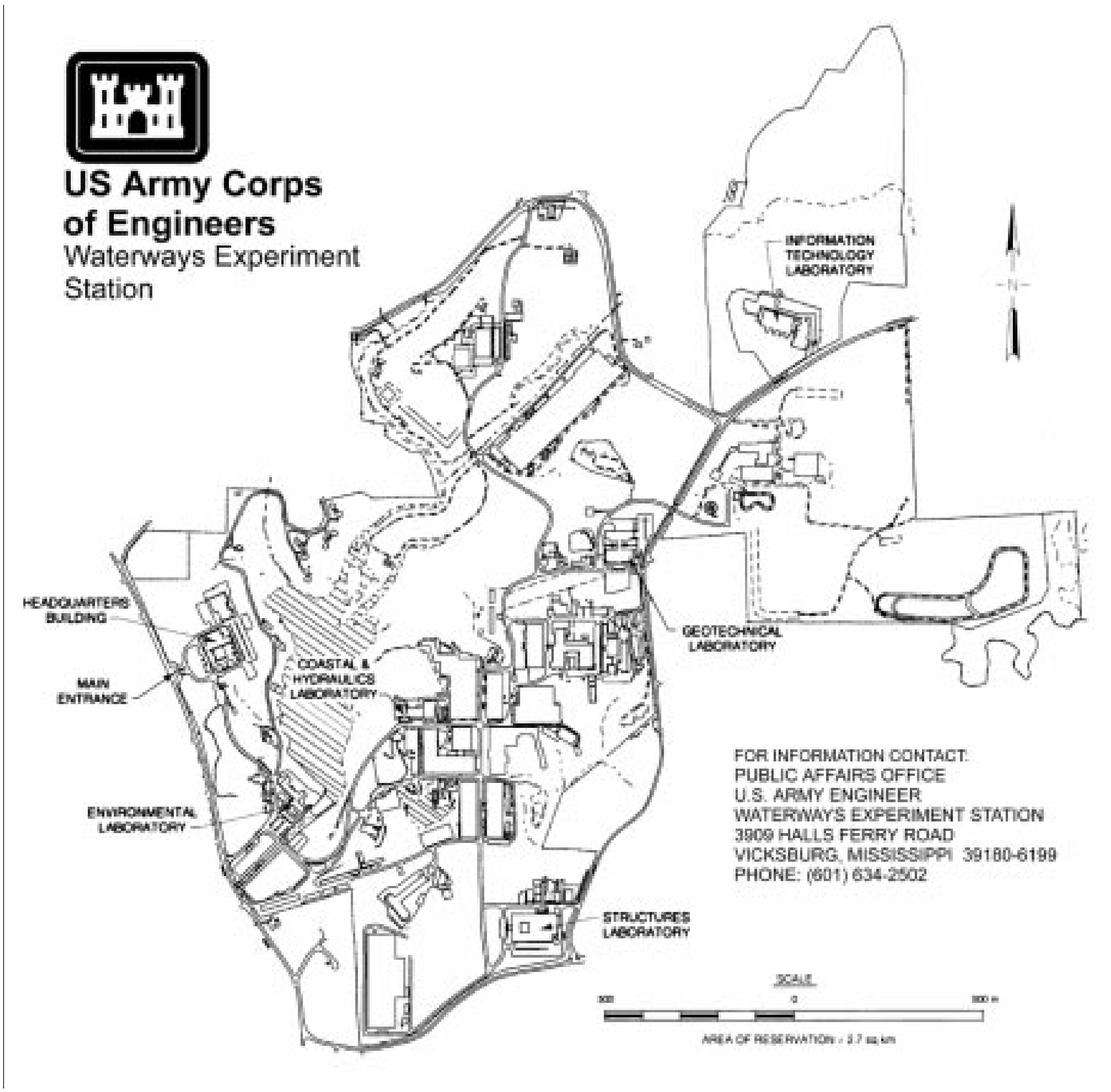
William F. James, Harry L. Eakin

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Interim report

Approved for public release; distribution is unlimited

Prepared for U.S. Army Engineer District, Rock Island
Rock Island, IL 61204-2004
U.S. Army Engineer District, St. Louis
St. Louis, MO 63103-2833
U.S. Army Engineer District, St. Paul
St. Paul, MN 55101-1638



Waterways Experiment Station Cataloging-in-Publication Data

Rogala, James T.

Rates of net fine sediment accumulation in selected backwater types of Pool 8, Upper Mississippi River / by James T. Rogala, William F. James, Harry L. Eakin ; prepared for U.S. Army Engineer District, Rock Island, U.S. Army Engineer District, St. Louis, U.S. Army Engineer District, St. Paul.

28 p. : ill. ; 28 cm.

“ENV report 2"

Includes bibliographic references.

1. Reservoir sedimentation — Mississippi River — Mathematical models. 2. Sedimentation and deposition — Mississippi River — Mathematical models. 3. Illinois Waterway (Ill.) I. James, William F. II. Eakin, Harry L. III. United States. Army. Corps of Engineers. Rock Island District. IV. United States. Army. Corps of Engineers. St. Louis District. V. United States. Army. Corps of Engineers. St. Paul District. VI. U.S. Army Engineer Waterways Experiment Station. VII. Upper Mississippi River-Illinois Waterway System Navigation Study. VIII. Title. IX. Title: Interim report for the Upper Mississippi River-Illinois Waterway System Navigation Study.

TA7 W3499 R5U7 ENV rept.2 1997

Contents

Preface

The work reported herein was conducted as part of the Upper Mississippi - Illinois Waterway (UMR-IWW) System Navigation Study. The information generated for this interim report will be considered as part of the plan formulation process for the System Navigation Study.

The UMR-IWW System Navigation Study is being conducted by the U.S. Army Engineer Districts of Rock Island, St. Louis, and St. Paul under the authority of Section 216 of the Flood Control Act of 1970. Commercial navigation traffic is increasing, and in consideration of existing system lock constraints, will result in traffic delays that will continue to grow into the future. The system navigation study scope is to examine the feasibility of navigation improvements to the Upper Mississippi River and Illinois Waterway to reduce delays to commercial navigation traffic. The study will determine the location and appropriate sequencing of potential navigation improvements for the 50-year planning horizon from 2000 through 2050. The final product of the System Navigation Study is a Feasibility Report, which is the decision document for processing to Congress.

The work described in this report was sponsored by the U.S. Army Engineer District, Rock Island, as part of the Environmental Plan of the Upper Mississippi River-Illinois Waterway System Navigation Feasibility Study.

The work was performed by personnel of the U.S. Army Engineer Waterways Experiment Station (WES), and the Environmental Management Technical Center (EMTC) of the Environmental Management Program s Long Term Resource Monitoring Program (LTRMP). The study was conducted under the direction of Dr. John W. Barko, Director, Center for Aquatic Plant Research and Technology, WES, and Scientific Technical Director, National Biological Service, EMTC, Onalaska, WI. This report was written by Messrs. James T. Rogala, EMTC, William F. James, WES, and Harry L. Eakin, WES.

Mr. Dale Dressel, Mr. Eugene Isherwood, and Mrs. Holly Wallace, Eau Galle Laboratory, and Ms. Sue Fox, AScI Corporation, performed the laboratory analyses. Messrs. Pete Boma, Bill Meier, and Randy Poelma of the LTRMP assisted in the sample collection. Dr. John Barko provided technical advice. Dr. Dave

Soballe, EMTC, and the staff of the U.S. Army Engineer District, St. Paul, Planning Division, provided review of a draft of this report.

At the time of publication of the report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

1 Introduction

The accumulation of sediments in off-channel areas (i.e., backwaters) of the Upper Mississippi River (UMR) is a major concern of river resource managers (Great River Environmental Action Team (GREAT) 1980; Fremling and Claflin 1984; Nielsen, Rada, and Smart 1984) because it can result in significant losses in water volume and habitat for fishes and waterfowl. Rates of net sediment accumulation of 1 to 2 cm/year and greater have been found using isotopic dating techniques in a few UMR backwaters with known high rates of sediment accumulation (McHenry et al. 1984, Eckblad et al. 1977). Similar rates have been found by comparing bed elevation changes over time (Claflin 1977, McHenry et al. 1984), although lower rates were found by Korschgen et al. (1987). However, because backwaters have diverse morphometric features and varying connections to the main river channel, there is a need to evaluate net sediment accumulation in differing backwater types over an entire navigation pool.

Different methods used for measuring sedimentation can provide different types of information on changes in an aquatic system. Bed elevation change provides the best overall estimate of net deposition and erosion. However, the historical elevation surveys of the UMR that are needed to detect changes are limited in spatial and temporal extent. In addition, these elevation survey comparisons provide no information on the type of sediment that is accumulating. In contrast, rates determined by isotopic dating can provide in most cases only estimates of net accumulation of fine sediment because the methods rely on markers adsorbed to fine sediments. However, these estimates of fine sediment accumulation provide unique information on the type of sediment that has accumulated in the UMR.

Isotopic dating techniques (i.e., cesium-137 or lead-210) are often used to estimate rates of fine sediment accumulation (Evans and Rigler 1980, McHenry et al. 1984) but are very expensive, and this expense limits the number of sites that can be evaluated. This technique can be inaccurate and, in some cases, inappropriate in dynamic systems such as the UMR because isotope-marked sediments can be resuspended and mixed with other sediments, making rate estimates biased. However, in impoundments/backwaters on the UMR and many reservoirs, sediment accumulation can be estimated by determining the depth of sediment overlying preimpoundment soil in a sediment core sample (James and Barko 1990). Although this method is subjective and limited to measuring fine sediment accumulation, it can greatly increase the sample size at relatively low expense as compared with isotopic dating.

Rates of net fine sediment accumulation were estimated over a wide range of backwater types in Pool 8 of the UMR using the depth to preimpoundment soil as a method for estimating sediment accumulation. Rates of net fine sediment accumulation were determined for 147 sediment cores collected from 25 backwater regions in this UMR pool. Correlations between these rates and backwater morphometric and sediment characteristics were determined to investigate the possibility of extrapolating the results from this study. In addition, comparisons of rates during the 58 years since impoundment estimated in this study to rates estimated during a 7-year period from 1989 to 1996 were made in selected backwaters to begin to investigate changes in rates through time.

Results from this study of rates of accumulation since impoundment are important in evaluating past accumulation of fine sediment and the variability of rates within and among backwaters. This information can be combined with studies of coarse sediment accumulation, studies of erosion, and studies of sedimentation in the other backwater types and channels to estimate total loss of water volume due to sedimentation in Pool 8. The rates determined in Pool 8 may not represent rates in other reaches of the UMR because of differences in sediment loading rates, source sediment characteristics, and hydraulic conditions.

2 Methods

Pool 8 is one in a series of 26 pools in the UMR formed by the construction of low-head dams in the 1930s for navigation. Pool 8 is 37 km long and, at low-water conditions, has a water surface area of 8,874 ha and a mean depth of 1.85 m. The area of Pool 8 that is aquatic at low discharge is composed of various geomorphic types including main channel, side channels, contiguous backwaters, and isolated backwater lakes. The focus of this study was contiguous backwater areas, excluding the large impounded backwater in the lower pool. These areas cover 1,980 ha and range in size from less than 0.1 ha to 256 ha (Figure 1). The backwater areas are shallow (mean depth of 0.67 m) and typically have low current velocities (median of 0.04 m/sec during the summer).

A geographical information system (GIS) was used to generate maps of all existing contiguous backwaters in Pool 8 (Owens and Rusher 1996). Backwater regions were defined as areas beyond the banks of the main or secondary channels (Wilcox 1993). A total of 337 distinct backwater areas were identified using these criteria. The study area did not include either backwater areas that have completely filled with sediment since impoundment or the impounded area as previously described. Estimates of sedimentation in the impounded area can be better obtained from elevation map comparisons using terrestrial preimpoundment elevation data. Many of the backwaters in the middle and upper portions of the pool were aquatic at the time of the preimpoundment terrestrial surveys and, therefore, the map comparisons cannot be done.

Backwater size (i.e., surface area, perimeter maximum, and effective fetch) and channel connection parameters (i.e., the number of channel connections, distance between connections to channels, and the size of the connections to channels) were used as criteria to stratify backwater selection. From this information, three general strata of backwaters were delineated: large backwaters, small, low-connectivity backwaters, and small, high-connectivity backwaters (Figure 2). A subset of backwaters was randomly selected from each stratum for sediment core sampling (Table 1, Figure 1).

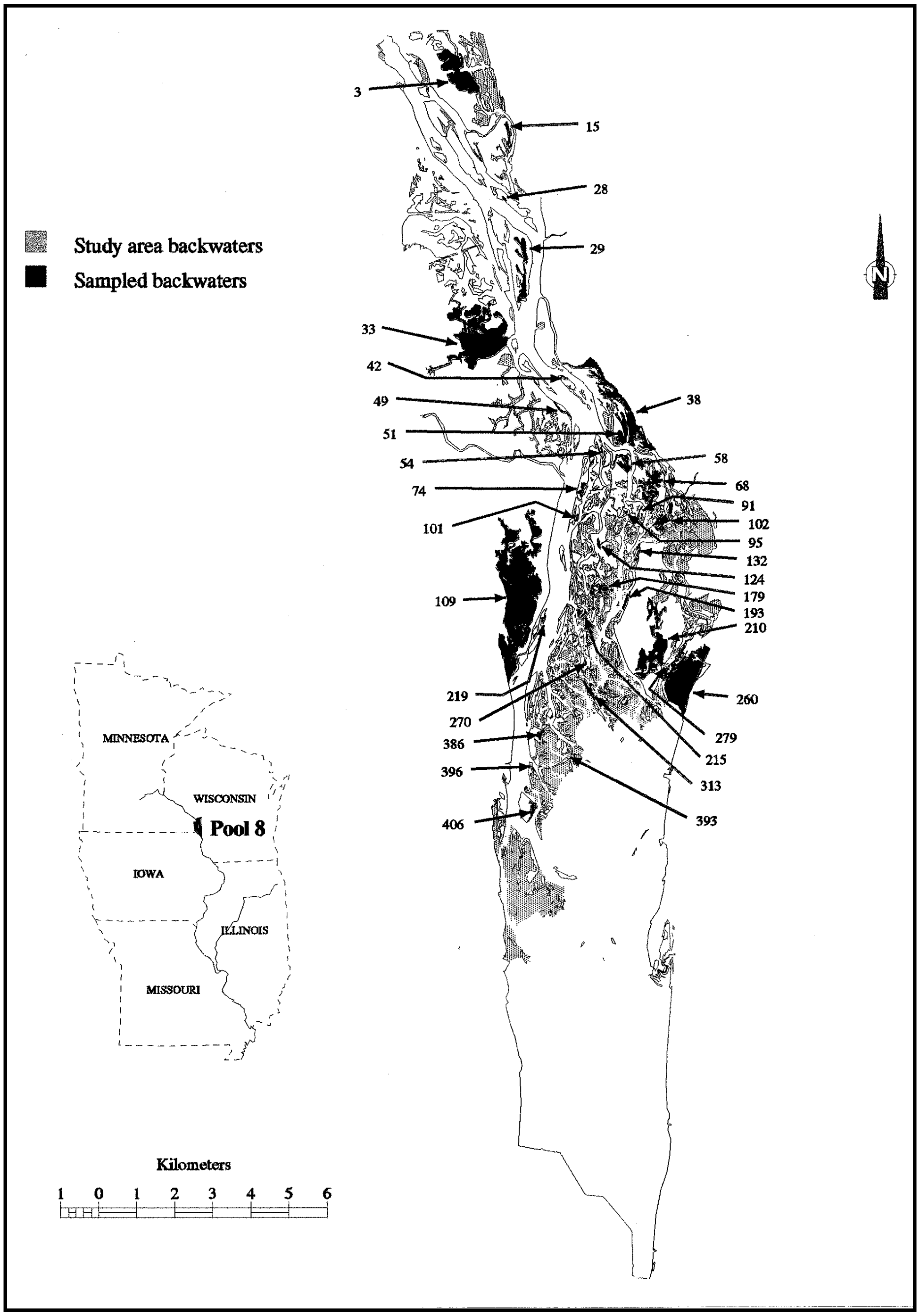
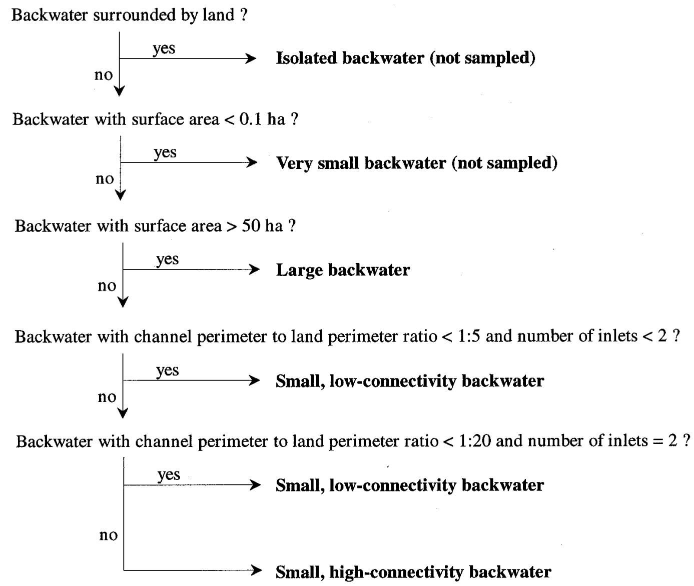


Figure 1. Map of the study area backwaters in Pool 8 and the location of the randomly selected backwaters selected for obtaining sediment cores

To select stations for sediment core collection, selected backwaters were further stratified by water depth, creating three depth strata to account for potential variance due to sediment focusing (Likens and Davis 1975, Håkanson 1977, Bellrose et al. 1983). Depth stratum 1 included depths less than the mean depth of the backwater (Figure 2). Depth stratum 2 included depths between the mean depth of the backwater and the mean depth plus 1 standard deviation (SD).



Depth class	Description
1	Depth less than the mean depth
2	Depth greater than the mean depth and less than the mean depth plus one standard deviation
3	Depth greater than the mean depth plus one standard deviation

Figure 2. Methods used to stratify sampling in Pool 8. (Flow chart illustrates criteria for classifying backwaters into three strata. Table shows the criteria for classifying depth ranges in each backwater based on mean depth and standard deviation of depth in each backwater)

Depth stratum 3 included depths greater than the mean depth plus 1 SD. In addition to randomly selected stations, sites along existing sediment range transects in Pool 8 were sampled to provide a comparison with rates of net sedimentation determined via changes in bed elevation since 1989 (Rogala and Boma 1996). These sites were not used in estimates of pool-wide fine sediment accumulation rates.

Sediment cores were obtained using a Wildco KB Sediment Core Sampler (Wildco Wildlife Supply) containing a plastic core liner (with an approximate 5-cm inside diameter and 50-cm length). The core was stored upright and transferred to the laboratory where it was sectioned at 10-cm intervals until preimpoundment material was encountered. Sections were weighed for moisture content determination and then dried to a constant weight at 105 ^{o}C (Håkanson 1977). Sediment density was estimated as dry mass of the section divided by its volume. Organic matter content in each core section was determined by loss on ignition at 550 ^{o}C (American Public Health Association 1992).

Table 1
Backwater Number, Area, Number of Sites Sampled with Coring Device, and Number of Sites Visited for Each Backwater Type. Total Number and Total Area of Each of the Four Backwater Types in Pool 8 are Shown in Parentheses

Backwater type (total no.) (total area)	Backwater number	Area (ha) of sampled backwater	Number of sites sampled	Number of sites visited
Large backwaters (10) (1065 ha)	3	54.65	15	15
	33	132.59	10	12
	38	60.42	10	10
	109	256.04	15	15
	210	53.19	14	15
	260	98.39	12	15
Total			76	82
Small, low-connectivity backwaters (89) (205 ha)	15	3.21	6	6
	28	0.49	2	2
	29	19.48	7	7
	42	0.71	3	3
	49	2.26	4	4
	51	12.67	9	9
	54	0.60	1	1
	58	7.67	6	6
	74	2.53	4	4
	91	0.55	3	3
	95	0.33	1	1
	101	0.61	1	1
	124	1.37	2	2
	219	0.90	1	1
	313	3.44	5	5
	396	0.16	1	1
Total			56	56
Small, high-connectivity backwaters (195) (706 ha)	68	21.63	8	9
	102	8.82	0	6
	132	2.18	0	4
	179	7.58	0	6
	193	2.89	0	6
	215	2.47	6	6
	270	0.18	1	3
	279	0.17	0	2
	386	1.83	0	3
	393	0.12	0	2
	406	4.33	0	6
Total			15	53
Very small backwaters (unsampled) (142) (4 ha)				
Total			147	191

Preimpoundment material was identified tactilely as an abrupt change in sediment density and/or texture. This determination was confirmed by examining differences in moisture content between the sections above and below the tactilely estimated preimpoundment interface, and by visual observations of differences in the composition of sediment. Other criteria were also used to arrive at a final estimate of the depth of preimpoundment material (see Figure 3).

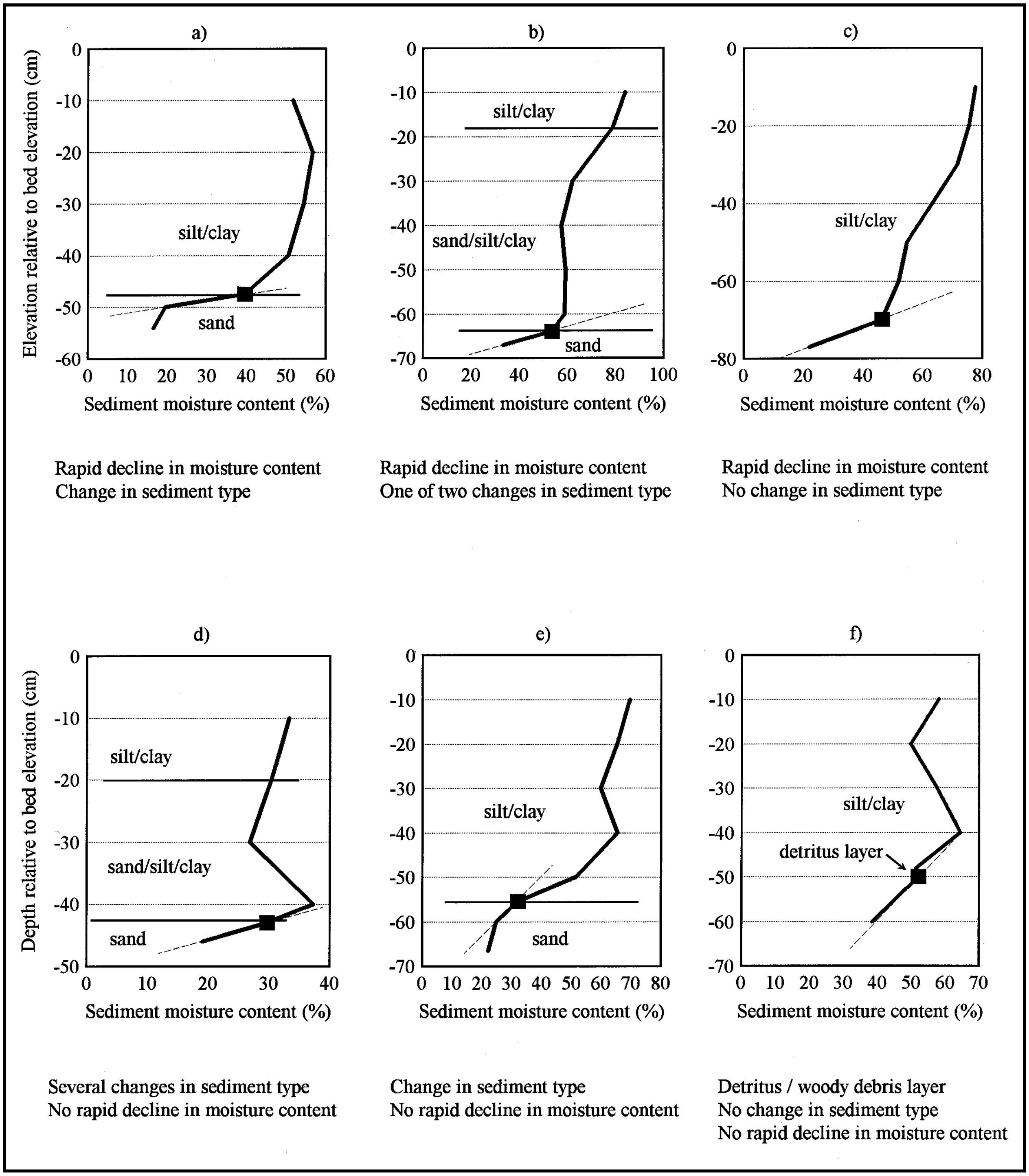


Figure 3. Examples of criteria used to identify preimpoundment sediment in the sediment cores. (Decline in moisture content is depicted by slope of dashed lime in each graph; more horizontal lines indicate a rapid decline in moisture content. Sediment types are labeled above and below the switch as marked with the solid horizontal lines)

Sediment cores were not collected at sample sites that were found to be channel-like, as determined by the presence of high-velocity and predominantly sand sediment during sampling. However, for the purposes of estimating fine sediment accumulation, these sites were considered to have no accumulation of fine sediment.

Rates of net fine sediment accumulation were calculated as the sediment depth above preimpoundment material divided by the time period since impoundment (58 years for Pool 8). Mean rates of net accumulation for each backwater were estimated by weighing rates within different depth strata by surface area. Similarly, rates of accumulation in the three backwater types were calculated based on surface area. Finally, a pool-wide mean (overall) net fine sediment accumulation rate for Pool 8 contiguous backwaters, excluding the impounded area, was estimated using the area-weighing approach. The Tukey s multicomparison test ($P = 0.05$) was used to test for significant differences.

3 Results and Discussion

Net fine sediment accumulation rates ranged from 0.017 to 1.36 cm/year over the 147 stations where some fine sediment accumulation was detected (Figure 4 and Appendix A). Mean rates of net fine sediment accumulation for the 33 backwaters sampled ranged from 0 to 0.82 cm/year (Table 2). However, no individual backwaters were found to be significantly different from each other, probably due to low sample sizes and highly variable accumulation rates among locations within backwaters (Figure 4). Overall means for the different backwater strata were 0.29 cm/year for the small, high-connectivity backwaters, 0.43 cm/year for the small, low-connectivity backwaters, and 0.57 cm/year for the large backwaters. Accumulation rates of fine sediment in large backwaters were found to be significantly different ($P > 05$) than rates in small, high-connectivity backwaters.

The estimate of a low mean rate of net sedimentation obtained for the small, high-connectivity backwaters suggests that these areas are channel-like. The majority of the areas that were not sampled due to the presence of flow and sand substrate were in this backwater stratum (Table 1). In addition, the coring sites in this stratum had accumulated sediments with low moisture content (<50 percent) as compared with the other two strata, which suggests that small, high-connectivity sites that had accumulated sediment were channel-like. Therefore, if accumulation has occurred in these areas, it may likely be due to sand accumulation and not fine sediment accumulation as measured in this study.

Rates of net fine sediment accumulation for the three depth strata were 0.50 cm/year for the shallowest depth stratum, 0.55 cm/year for the medium depth stratum, and 0.68 cm/year for the deepest depth stratum. However, no significant differences were found among the depth strata as a whole using Tukey s multicomparison testing. Significant differences were detected between the deepest and shallowest depth classes for the small, low-connectivity backwaters and within a few backwaters. Accumulation rates were highly variable in the depth classes selected; therefore, few differences could be detected. Also, because present-day depths were used to look at correlations, accumulation of sediments in areas that were deeper in the past may have masked any relationship between depth and accumulation.

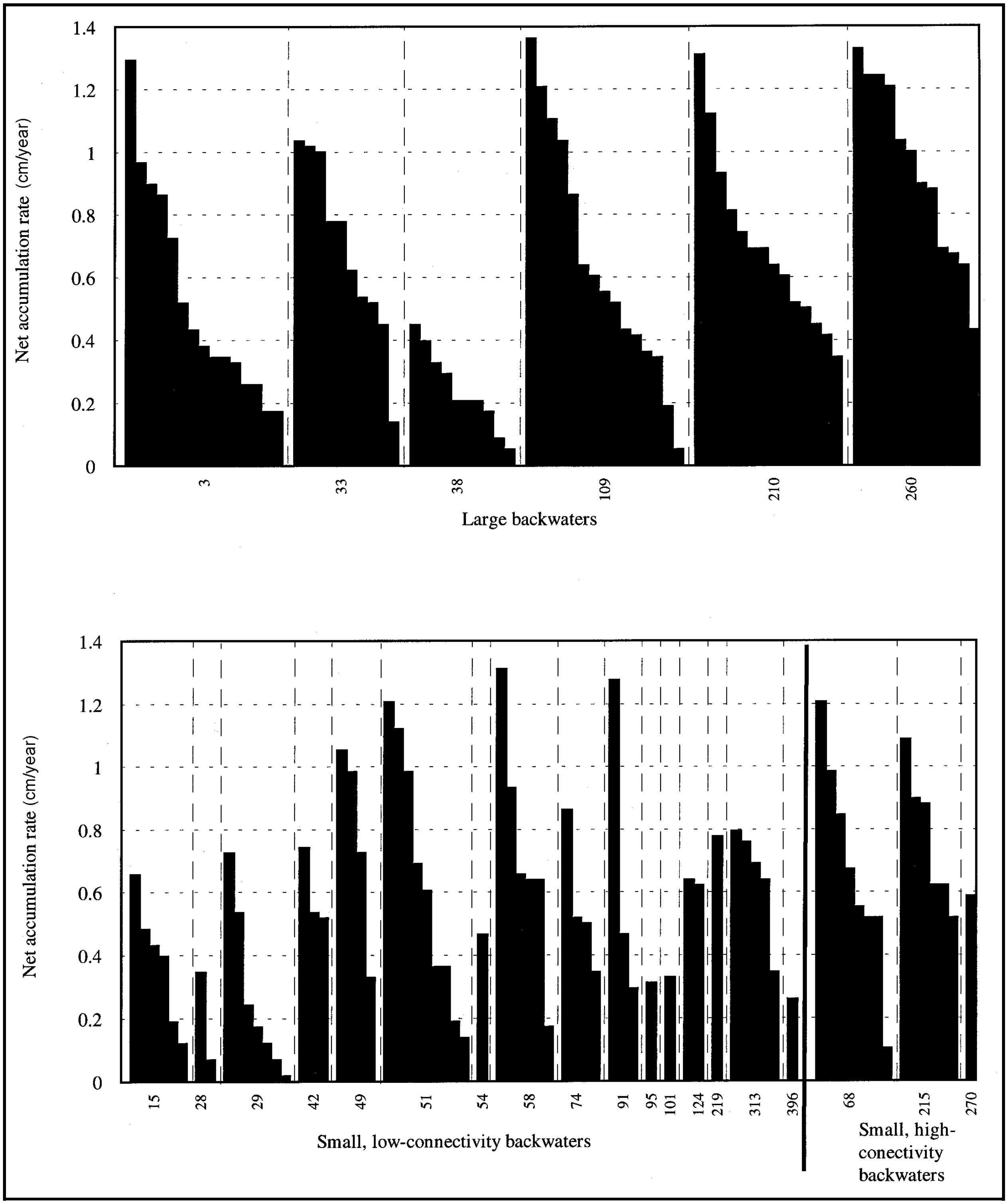


Figure 4. Net fine sediment accumulation rate as estimated by the depth to preimpoundment sediment for each sample site that fine sediment accumulation was found in Pool 8. (Sites grouped by backwater type and by individual backwater (separated by dashed lines))

Table 2
Mean Rate of Net Fine Sediment Accumulation For Each of the Sampled Backwaters, Sampled Backwater Types, And Sampled Overall Area of Pool 8

Backwater type	Backwater number	Accumulation rate (cm/year)	Backwater type accumulation rate (cm/year)	Pool 8 sampled area accumulation rate (cm/year)
Large backwaters	3	0.53	0.57	0.46
	33	0.48		
	38	0.25		
	109	0.66		
	210	0.62		
	260	0.64		
Small, low-connectivity backwaters	15	0.39	0.43	
	28	0.15		
	29	0.25		
	42	0.65		
	49	0.82		
	51	0.46		
	54	0.47		
	58	0.69		
	74	0.51		
	91	0.57		
	95	0.31		
	101	0.33		
	124	0.63		
	219	0.78		
	313	0.61		
	396	0.26		
Small, high-connectivity backwaters	68	0.58	0.29	
	102	0.00		
	132	0.00		
	179	0.00		
	193	0.00		
	215	0.76		
	270	0.20		
	279	0.00		
	386	0.00		
	393	0.00		
	406	0.00		

There were generally poor relationships between rates of net fine sediment accumulation at the 147 sample sites and variables describing backwater morphometry. For example, backwater size provided the strongest correlation with net accumulation rates, but the measure of the strength of correlation r^2 was less than 0.07. Similarly, measurements of various site-specific morphometry provided poor correlation with net accumulation rates, with site distance to a channel providing the strongest correlation with an r^2 of less than 0.05. These poor correlations suggest that extrapolation on the basis of these variables is not possible.

A wide range of surface (i.e., upper 10 cm) sediment characteristics (moisture content, sediment bulk density, and organic matter content) was observed over the 147 backwater station locations where cores were collected. Moisture content ranged between 17 and 84 percent; sediment bulk density ranged between 0.14 and 1.62 g/mL; and organic matter content ranged between 0.43 and 19.53 percent. In addition, significant differences ($P < 0.05$) in moisture content, sediment bulk density, and organic matter content were found among the three backwater strata. The large backwaters had surface sediment with the highest moisture and organic matter content, and lowest sediment bulk density; the small, high-connectivity backwaters had sediment with the lowest moisture and organic matter content and highest sediment bulk density; the small, low-connectivity backwaters were intermediate in sediment characteristics. The small, high-connectivity backwaters likely have sediments with lower moisture content overall than determined in this study, as suggested by the large number of sites unsampled with the coring device due to the presence of sand.

Poor correlations were found between surface sediment characteristics and net fine sediment accumulation rates for the 147 stations (Figure 5). Poor correlations were also found between surface sediment characteristics and net accumulation rates determined by changes in bed elevation during the period 1989 to 1996 (Rogala and Boma 1996). However, large variations in moisture content were often observed with sediment depth (Figure 3b). Although many stations exhibited a pattern of silt/clays over sands (Figure 3a), other patterns were observed such as distributions of silt/clays throughout the core (Figure 3c), mixtures of sand and silt/clay over sand (Figure 3b), thin layers of sand over silt/clays, and thin layers of detrital material (Figure 3f). These observations, coupled with generally low correlations between net sedimentation rates and surface sediment characteristics, suggest that some layering may result from episodic loading. These findings suggest that fine sediment accumulation cannot be predicted by surficial sediment characteristics.

Correlations were poor between net fine sediment accumulation rates over the last 58 years measured by coring in this study and bed elevation change measured by Rogala and Boma (1996) between 1989 and 1996 (Figure 6). The poor correlation was not due to accumulation of coarser sediments because all sites sampled contained only fine sediment. The poor correlation observed may be due to changes in accumulation rates over a long time (e.g., loss of trapping efficiency) or to episodic changes in rates over shorter time periods (e.g., effects of floods). Therefore, caution must be used when estimating present-day patterns of fine sediment accumulation using the historical rates obtained by this or other methods relying on long-term averages.

The pool-wide mean (overall) net fine sediment accumulation rate for the contiguous backwaters of Pool 8, excluding the impounded area, was 0.46 cm/year. This mean rate is lower than previously documented fine sediment accumulation rates in the UMR obtained from isotopic dating (McHenry et al. 1984, Eckblad et al. 1977). This may be due in part to differences in site selection and study area selection for the studies. Previous studies have focused sampling in large impounded areas and large backwater lakes, whereas this study excluded sampling in the impounded area and included small backwater areas for sampling. In addition, some previous studies focused site selection in deep areas and areas of known fine sediment deposition, which may have provided overestimates of accumulation for backwaters as a whole. The positive correlation observed

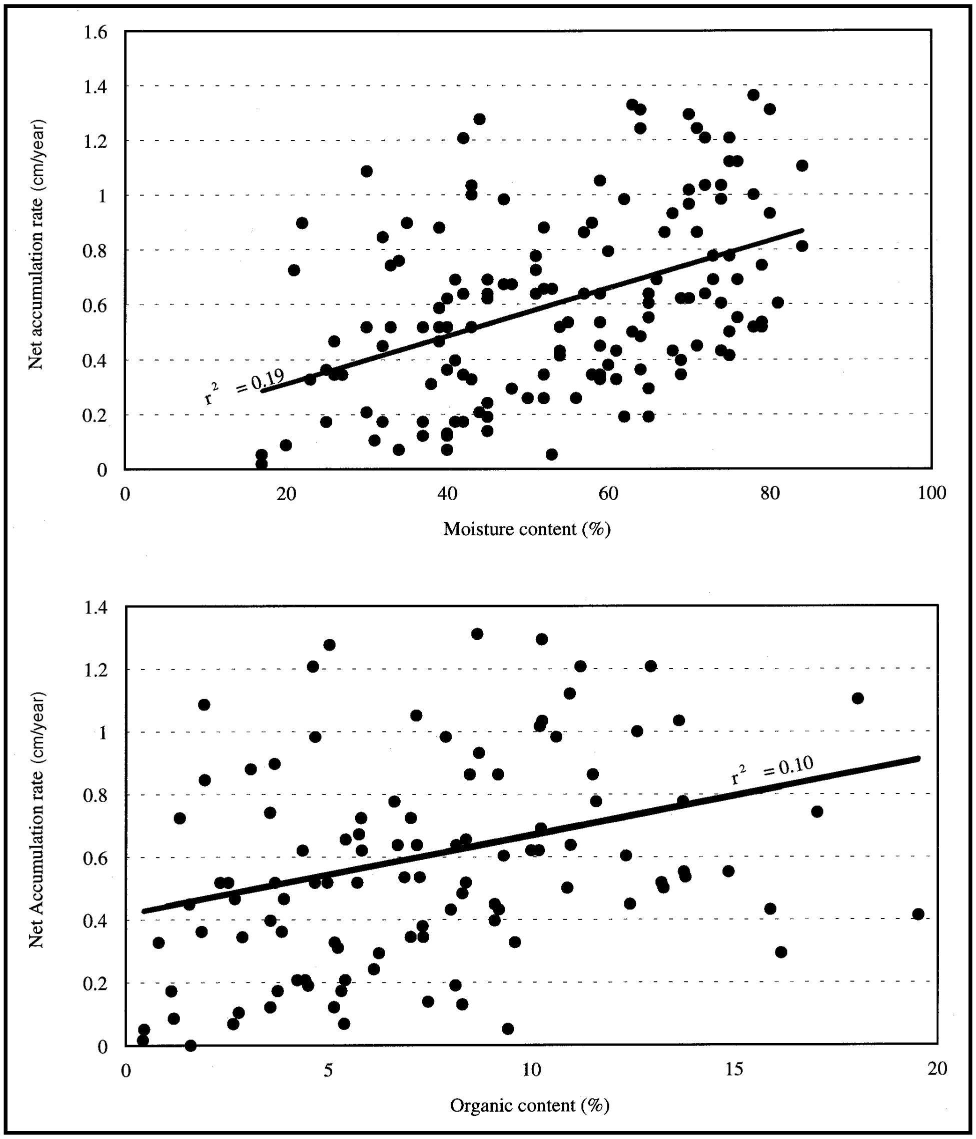


Figure 5. Correlation between surficial sediment characteristics (moisture content and organic content) and net accumulation rates for the 147 sites sampled in Pool 8

between depth strata and fine sediment accumulation rates in this study suggests higher rates would be obtained from sampling exclusively in deeper areas. In this study, locations were randomly selected across the selected backwater area of Pool 8, thus providing unbiased site selection and a better estimate of the overall mean rate of fine sediment accumulation for the study area.

The variability in accumulation rates of fine sediment in Pool 8 backwaters was, for the most part, uncorrelated to the factors investigated in this study. In general, backwater type and depth strata accounted for some variability in accumulation rates, but overall the predictive capability was poor. Backwater characteristics related to exchange of water in backwaters with channels provide very poor correlation with accumulation rates. A more holistic investigation of

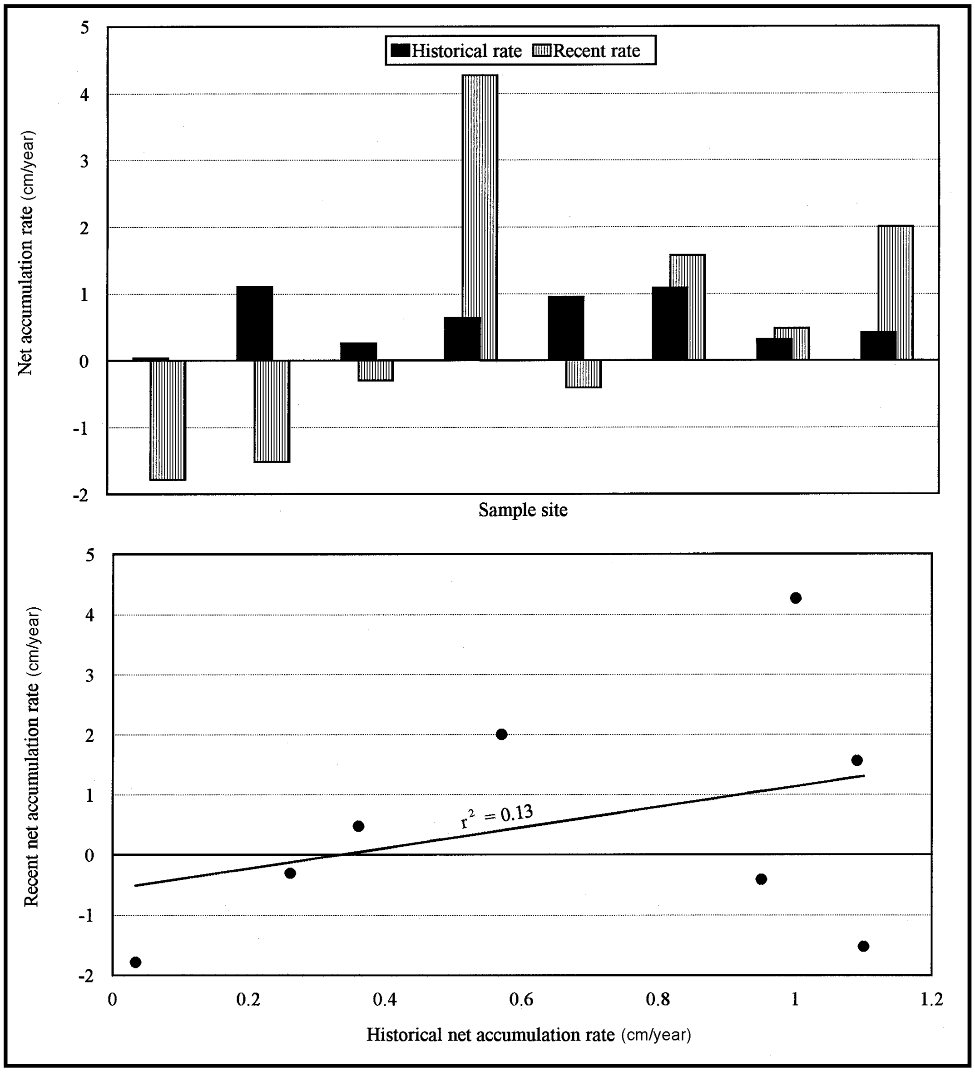


Figure 6. The comparison of historical and recent accumulation rates. (Upper graph illustrates the comparison of historical net accumulation rates as determined by the depth to impoundment sediment (historical rate) to more recent net sedimentation rates determined from sediment ranges surveyed between 1989 to 1996 (recent rates). Lower graph illustrates the regression line from the comparison of the rates for the two time periods)

sedimentation including accumulation of coarse sediments and erosion of sediments may provide for better predictive capabilities. However, this study effectively illustrates high variability in accumulation rates of fine sediments in backwaters that would suggest high variability in sedimentation rates also likely exist in these areas.

References

American Public Health Association. (1992). *Standard methods for the examination of water and wastewater.* 18th ed. American Public Health Association.

Bellrose, F. C., Havera, S. P., Paveglio, F. L., and Steffeck, D. W. (1983). “The fate of lakes in the Illinois River valley,” *Illinois Natural History Survey*. Biological Notes No. 119.

Claflin, T. O. (1977). “Project report - Lake Onalaska rehabilitation feasibility study,” River Studies Center, University of Wisconsin-La Crosse.

Eckblad, J. W., Petersen, N. L., Ostlic, K., and Tempte, A. (1977). “The morphometry, benthos, and sedimentation rates of a floodplain lake in Pool 9 of the Upper Mississippi River,” *American Midland Naturalist* 97, 433-43.

Evans, R. D., and Rigler, F. H. (1980). “Measurement of whole lake sediment accumulation and phosphorus retention using lead-210 dating,” *Canadian Journal of Fisheries and Aquatic Sciences* 37, 817-22.

Fremling, C. R., and Claflin, T. O. (1984). “Ecological history of the Upper Mississippi River,” *Contaminants in the Upper Mississippi River*. J. G. Wiener, R. V. Anderson, and D. R. McConville, eds., Butterworth Publishers, Stoneham, MA. 5-24.

Great River Environmental Action Team. (1980). “GREAT I: Study of the Upper Mississippi River; Technical Appendix H, Fish and Wildlife,” vol 5. U.S. Army Corps of Engineers, St. Paul, MN.

Håkanson, L. (1977). “The influence of wind, fetch, and water depth on the distribution of sediment in Lake Vanern, Sweden,” *Canadian Journal of Earth Sciences* 14, 397-412.

James, W. F., and Barko, J. W. (1990). "Macrophyte influences on the zonation of sediment accretion and composition in a north-temperate reservoir." *Archiv für Hydrobiologie* 120, 129-42.

Korschgen, C. E., Jackson, G. E., Muessig, L. F., and Southworth, D. C. (1987). "Sedimentation in Lake Onalaska, Navigation Pool 7, Upper Mississippi River, since impoundment," *Water Resources Bulletin* 23, 221-26.

Likens, G. E., and Davis, M. B. (1975). "Post-glacial history of Mirror Lake and its watershed in New Hampshire, USA: An initial report," *Int. Ver. Theor. Angew. Limnol.* 19, 982-93.

McHenry, J. R., Ritchie, J. C., Cooper, C. M., and Verdon, J. (1984). "Recent rates of sedimentation in the Mississippi River," *Contaminants in the Upper Mississippi River*. J. G. Wiener, R. V. Anderson, and D. R. McConville, eds. Butterworth Publishers, Stoneham, MA. 99-117.

Nielsen, D. N., Rada, R. G., and Smart, M. M. (1984). "Sediments of the Upper Mississippi: Their sources, distribution, and characteristics," *Contaminants in the Upper Mississippi River*. J. G. Wiener, R. V. Anderson, and D. R. McConville, eds. Butterworth Publishers, Stoneham, MA. 67-98.

Owens, T., and Ruhser, J. J. (1996). "Long term monitoring program standard operating procedures: Aquatic areas database production," LTRMP 95-P008-6, National Biological Service, Environmental Management Technical Center, Onalaska, WI.

Rogala, J. T., and Boma, P. J. (1996). "Rates of sedimentation along selected backwater transects in Pools 4, 8, and 13 of the Upper Mississippi River," LTRMP 96-T005, U.S. Geological Survey, Environmental Management Technical Center, Onalaska, WI.

Wilcox, D. B. (1993). "An aquatic habitat classification system for the Upper Mississippi River System," EMTC 93-T003, U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, WI.

Appendix A
Sediment Information

Sample site ID	Backwater ID	X coordinate (UTM zone 15, NAD27)	Y coordinate (UTM zone 15, NAD27)	Net accumulation rate (cm/yr)	Moisture content (%)	Bulk density (g/mL)	Organic content (%)
1	3	637608	4857933	1.29	70	0.35	10.26
2	3	637933	4857783	0.52	30	1.27	2.53
3	3	637758	4857608	0.86	67	0.42	9.18
4	3	637933	4857358	0.72	21	1.44	1.33
5	3	637808	4857283	0.34	58	0.56	7.34
6	3	638008	4857233	0.38	60	0.54	7.32
7	3	638308	4857233	0.43	61	0.51	8.02
8	3	638183	4857208	0.97	70	0.37	9.65
9	3	638333	4857183	0.33	61	0.49	7.58
10	3	637783	4857158	0.26	50	0.71	8.18
11	3	638183	4857133	0.9	22	1.25	1.23
12	3	638208	4857008	0.17	37	1.05	3.34
13	3	638483	4856983	0.17	32	1.22	2.32
14	3	638333	4856933	0.26	52	0.71	5.8
15	3	638408	4856908	0.34	26	1.37	1.32
37	33	639108	4850683	0.78	75	0.28	13.74
38	33	638358	4850383	0.53	79	0.21	13.8
39	33	638658	4850333	0.78	73	0.3	11.6
40	33	639283	4850333	*	29	1.28	2.59
41	33	638708	4850308	0.62	70	0.35	10
42	33	639183	4850233	0.52	39	0.97	3.68
43	33	638358	4850208	1	78	0.24	12.61
45	33	638533	4850108	1.03	72	0.34	10.27
46	33	638283	4850008	0.45	59	0.49	9.1
47	33	638508	4849908	1.02	70	0.36	10.21
48	33	638458	4849808	0.13	40	0.24	8.3
54	38	641608	4849383	0.21	44	0.91	5.41
58	38	641783	4849158	0.4	41	1.03	3.57
59	38	641758	4848958	0.21	44	0.84	4.43
60	38	642133	4848933	0.17	25	1.31	1.13
61	38	642208	4848683	0.29	65	0.4	16.16
68	38	642483	4848183	0.09	20	1.41	1.19
72	38	642458	4847983	0.33	23	1.31	0.81
74	38	642483	4847908	0.45	32	1.11	1.57
80	38	642933	4847483	0.21	30	1.11	4.23
81	38	643008	4847408	0.05	17	1.26	0.46
118	109	640058	4844783	1.03	74	0.28	13.64
121	109	639783	4844658	0.41	75	0.27	19.53
124	109	639258	4844233	0.43	74	0.28	15.89

Sample site ID	Backwater ID	X coordinate (UTM zone 15, NAD27)	Y coordinate (UTM zone 15, NAD27)	Net accumulation rate (cm/yr)	Moisture content (%)	Bulk density (g/mL)	Organic content (%)
128	109	639758	4843708	0.6	74	0.29	12.34
132	109	639258	4843558	1.1	84	0.14	18.04
133	109	639583	4843533	0.64	65	0.41	8.15
139	109	639358	4843333	0.05	53	0.72	9.43
140	109	639658	4843258	0.86	71	0.34	11.52
145	109	639633	4843058	1.21	75	0.26	12.94
147	109	639733	4843008	0.52	79	0.21	13.21
151	109	639508	4842808	0.55	76	0.24	13.76
155	109	639033	4842358	1.36	78	0.22	14.04
156	109	639608	4842333	0.36	64	0.45	13.52
160	109	639308	4842158	0.34	42	0.85	4.61
162	109	639308	4842108	0.19	65	0.43	8.39
152	210	643083	4842608	0.5	75	0.25	13.26
153	210	643258	4842508	0.45	71	0.34	12.44
154	210	643283	4842483	0.74	79	0.22	17.04
157	210	643208	4842308	0.81	84	0.16	18.32
158	210	643183	4842208	0.6	81	0.2	16.56
159	210	643283	4842208	1.31	80	0.21	14.94
161	210	643183	4842133	0.41	54	0.61	6.06
163	210	643108	4842058	0.34	69	0.36	9.31
165	210	642883	4841908	0.52	78	0.23	13.57
166	210	642958	4841908	0.69	41	0.92	3.5
167	210	643108	4841833	*	39	0.86	5.44
170	210	642758	4841783	0.93	80	0.2	12.58
172	210	642808	4841733	0.69	76	0.25	11.68
174	210	642808	4841683	1.12	76	0.26	10.91
180	210	642833	4841358	0.64	72	0.32	11.06
173	260	644258	4841733	0.9	58	0.56	6.45
177	260	643808	4841583	0.69	45	0.86	4.59
179	260	643733	4841408	0.64	42	0.89	4.81
181	260	643908	4841308	0.67	48	0.76	5.39
183	260	643633	4841258	1	43	0.85	5.38
184	260	644158	4841258	1.21	72	0.33	10.94
186	260	644108	4841183	1.24	71	0.35	10.58
188	260	643833	4841058	0.88	52	0.69	6.49
193	260	643533	4840858	1.03	43	0.83	5.4
194	260	643908	4840708	1.33	63	0.47	8.22
195	260	643883	4840608	1.24	64	0.45	8
196	260	643858	4840533	0.43	54	0.64	6.49

Sample site ID	Backwater ID	X coordinate (UTM zone 15, NAD27)	Y coordinate (UTM zone 15, NAD27)	Net accumulation rate (cm/yr)	Moisture content (%)	Bulk density (g/mL)	Organic content (%)
16	15	639258	4855933	0.48	64	0.44	8.3
17	15	639283	4855908	0.43	68	0.39	9.2
18	15	639308	4855883	0.12	40	0.92	5.14
19	15	639308	4855783	0.4	69	0.38	9.1
20	15	639308	4855733	0.19	62	0.47	8.13
21	15	639358	4855708	0.66	53	0.63	8.39
22	28	639183	4854058	0.34	27	0.83	2.88
23	28	639233	4854008	0.07	34	1.06	2.66
25	29	639733	4852733	0.53	59	0.48	7.25
27	29	639733	4852383	0.02	17	1.61	0.43
28	29	639708	4852133	0.07	40	0.88	5.39
30	29	639608	4851558	0.12	37	0.91	3.57
31	29	639658	4851483	0.17	41	0.88	5.32
32	29	639758	4851458	0.72	51	0.62	7.03
33	29	639558	4851308	0.24	45	0.74	6.12
55	42	640733	4849308	0.53	55	0.58	6.87
56	42	640783	4849308	0.74	33	1.07	3.56
57	42	640808	4849283	0.52	43	0.85	4.97
62	49	640483	4848658	*	43	0.81	6.13
63	49	640558	4848583	*	41	0.91	4.96
64	49	640683	4848408	0.98	62	0.48	7.89
65	49	640708	4848408	1.05	59	0.53	7.16
66	49	640883	4848308	0.72	51	0.68	5.8
67	49	640933	4848233	0.33	43	0.84	5.15
69	51	642358	4848133	0.98	74	0.29	10.62
70	51	642383	4848108	0.6	65	0.42	9.32
71	51	642333	4848033	0.36	25	1.4	1.87
73	51	642383	4847933	0.69	73	0.31	10.24
75	51	642308	4847883	0.14	45	0.8	7.46
76	51	642333	4847883	1.12	75	0.29	10.95
77	51	642333	4847858	1.21	75	0.29	11.21
78	51	642383	4847658	0.19	45	0.82	4.5
79	51	642283	4847608	0.36	40	0.92	3.85
82	54	641758	4847383	0.47	26	1.33	2.69
83	58	642183	4847108	0.64	59	0.52	10.97
84	58	642408	4847033	0.17	42	0.89	3.75
85	58	642183	4847008	0.64	57	0.57	7.18
86	58	642258	4846958	0.93	68	0.4	8.71

Sample site ID	Backwater ID	X coordinate (UTM zone 15, NAD27)	Y coordinate (UTM zone 15, NAD27)	Net accumulation rate (cm/yr)	Moisture content (%)	Bulk density (g/mL)	Organic content (%)
87	58	637608	4857933	1.31	64	0.43	8.7
88	58	637933	4857783	0.66	52	0.7	5.4
94	74	638183	4857208	0.52	37	0.99	4.7
96	74	637783	4857158	0.86	57	0.53	8.5
97	74	638183	4857133	0.5	63	0.45	10.9
98	74	638208	4857008	0.34	52	0.64	7
106	91	639308	4855733	0.47	39	0.92	3.9
107	91	639358	4855708	0.29	48	0.69	6.2
108	91	639183	4854058	1.28	44	0.77	5
103	95	639283	4855908	0.31	38	1.01	5.2
105	101	639308	4855783	0.33	59	0.52	9.6
115	124	637808	4851683	0.62	69	0.35	10.2
119	124	639558	4851308	0.64	45	0.75	6.7
148	219	640483	4848658	0.78	51	0.58	6.6
185	313	642883	4846283	0.69	66	0.42	12.7
187	313	642808	4846108	0.34	59	0.49	9.2
189	313	642358	4845733	0.79	60	0.48	8.5
190	313	643533	4845733	0.64	51	0.61	7.3
191	313	641108	4845683	0.76	34	1.04	4.4
202	396	642708	4844833	0.26	56	0.55	8
89	68	637758	4857608	0.55	65	0.41	14.9
90	68	637933	4857358	0.52	33	1.14	2.3
91	68	637808	4857283	1.21	42	0.92	4.6
92	68	638008	4857233	0.98	47	0.77	4.7
93	68	638308	4857233	0.52	54	0.59	8.4
95	68	638333	4857183	*	28	1.27	1.6
99	68	638483	4856983	0.1	31	1.23	2.8
100	68	638333	4856933	0.67	47	0.79	5.8
101	215	638408	4856908	0.84	32	1.12	2
142	215	640783	4849308	0.62	40	0.92	4.4
143	215	640808	4849283	0.52	40	0.92	5.7
144	215	641783	4849158	0.88	39	0.92	3.1
146	215	642133	4848933	1.09	30	1.23	1.9
149	215	640558	4848583	0.62	45	0.78	5.8
150	215	640683	4848408	0.9	35	1.02	3.7
168	270	641758	4847383	0.59	39	0.71	2.5
169	270	642183	4847108	*	21	1.56	1.5
171	270	642183	4847008	*	18	1.62	1

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1997	Interim report

4. TITLE AND SUBTITLE
Rates of Net Fine Sediment Accumulation in Selected Backwater Types of Pool 8, Upper Mississippi River

5. FUNDING NUMBERS

6. AUTHOR(S)
James T. Rogala, William F. James, Harry L. Eakin

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Biological Service, Environmental Management Technical Center
575 Lester Avenue, Onalaska, WI 54650;
U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER

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

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
ENV Report 2

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT ***Maximum 200 words***

Estimates of accumulation rates provide valuable information needed for projecting future conditions of backwaters in the Upper Mississippi River (UMR), either with or without changes in the use of resources. Net fine sediment accumulation rates since impoundment were estimated from sediment cores collected in selected backwater types of Pool 8. Net fine sediment rates at 147 depositional sites were calculated from the depth of sediment overlying pre-impoundment sediment and ranged from 0.017 to 1.36 cm/year. Mean rates for the 33 backwaters sampled in Pool 8 ranged from 0 to 0.82 cm/year. Large backwaters had the highest accumulation rate (0.57 cm/year); small, low-connectivity backwaters had the lowest rate (0.29 cm/year); and small, low-connectivity backwaters had an intermediate rate (0.43 cm/year). The overall mean rate of net accumulation for Pool 8 backwaters was 0.46 cm/year. Deeper areas within backwater regions tended to have higher accumulation rates than shallower areas, suggesting sediment focusing. Relationships were weak between accumulation rates and other parameters such as surficial sediment characteristics, backwater characteristics, and sedimentation measured during bed elevation surveys between 1989 and 1996.

14. SUBJECT TERMS
Fine sediment
Moisture content
Sediment
Sedimentation

15. NUMBER OF PAGES
28

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		

9. (Concluded).

U.S. Army Engineer District, Rock Island, Clock Tower Building, P.O. Box 2004, Rock Island, IL 61204-2004
U.S. Army Engineer District, St. Louis, 1222 Spruce Street, St. Louis, MO 63103-2833
U.S. Army Engineer District, St. Paul, Army Corps of Engineers Centre, 190 5th Street East, St. Paul, MN 55101-1638