Contract Report 2001-17

Benchmark Sedimentation Survey of the Lower Cache River Wetlands

by

Richard L. Allgire

Illinois State Water Survey

and

Richard A. Cahill

Illinois State Geological Survey

Prepared for the
Illinois Department of Natural Resources

December 2001

Illinois State Water Survey
Watershed Science Section
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

Benchmark Sedimentation Survey of the Lower Cache River Wetlands

by
Richard L. Allgire
Illinois State Water Survey

and

Richard A. Cahill
Illinois State Geological Survey

Illinois State Water Survey
2204 Griffith Drive
Champaign, IL

Illinois State Geological Survey
615 E. Peabody
Champaign, IL

Prepared for the
Illinois Department of Natural Resources

December 2001

Benchmark Sedimentation Survey of the Lower Cache River Wetlands

by
Richard L. Allgire
Illinois State Water Survey

and

Richard A. Cahill
Illinois State Geological Survey

Abstract

The Cache River located in the southernmost part of Illinois flows through an area containing the Cache River Wetlands. These unique and important wetlands were designated as a Ramsar Site in 1996. Drainage activities divided the Cache River in half in the early 1900s, effectively separating the river into the Upper and Lower Cache Rivers. The Lower Cache River contains a remnant of a vast wetland system called the Lower Cache River State Natural Area (LCRSNA), commonly referred to as Buttonland Swamp. Sediment inflow from several tributary streams has an impact on the wetland. Previous research has determined that 217,000 tons of sediment were deposited in Buttonland Swamp between 1986 and 1988.

The wetlands of the Lower Cache River have been targeted for preservation and restoration by state, federal, and private environmental organizations. A program to monitor the sediment deposition rate within the wetland area at regular intervals would be useful in evaluating and guiding preservation and restoration efforts. This project established a benchmark measure of the deposition rates and cross-sectional profiles at selected locations in the LCRSNA wetland.

Contents

Page

Benchmark Sedimentation Survey of the Lower Cache River Wetlands

by
Richard L. Allgire
Illinois State Water Survey

and

Richard A. Cahill
Illinois State Geological Survey

Introduction

The Cache River watershed covers parts of the six southernmost Illinois counties (Johnson, Pulaski, Alexander, Union, Massac, and Pope) and has a total drainage area of 737 square miles. The Cache River has been the subject of numerous flow control projects since 1900. The primary purpose of those projects was to drain wetlands and create new agricultural lands. The most significant projects were the construction of the Post Creek Cutoff in 1915 and the construction of the Cache River Levee in 1952. These two projects cut the Cache River in half, forming what is commonly referred to as the Upper Cache and Lower Cache Rivers. Figure 1 depicts the location of the Cache River and its primary watershed features. Table 1 lists the year of implementation of important water control projects that had impacts on the Cache River (Demissie et al., 1990).

The Upper Cache River has a 368-square-mile watershed that drains entirely into the Ohio River at River Mile 957.8 through the Post Creek Cutoff. The Upper Cache River is 57 miles long with a gradient of 1-1.5 feet per mile (Muir et al., 1995). As a result of the shortened distance to the Ohio River, the Upper Cache River experiences increased flow velocities resulting in erosion and channel entrenchment in the Post Creek Cutoff as far upstream as the Heron Pond Nature Preserve.

Table 1. Water Control Projects Influencing the Cache River

Year	*Activity*
1915	Post Creek Cutoff and Forman Floodway constructed
1930s	Channelization of Lower Cache River
1950	Lower Cache River outlet diverted to Mississippi River
1952	Reevesville and Cache River Levees constructed
1960s	Dredging and clearing of Lower Cache River in Buttonland Swamp
1982	Low-head channel dam built in Buttonland Swamp by Citizens Committee to Save the Cache, Inc.

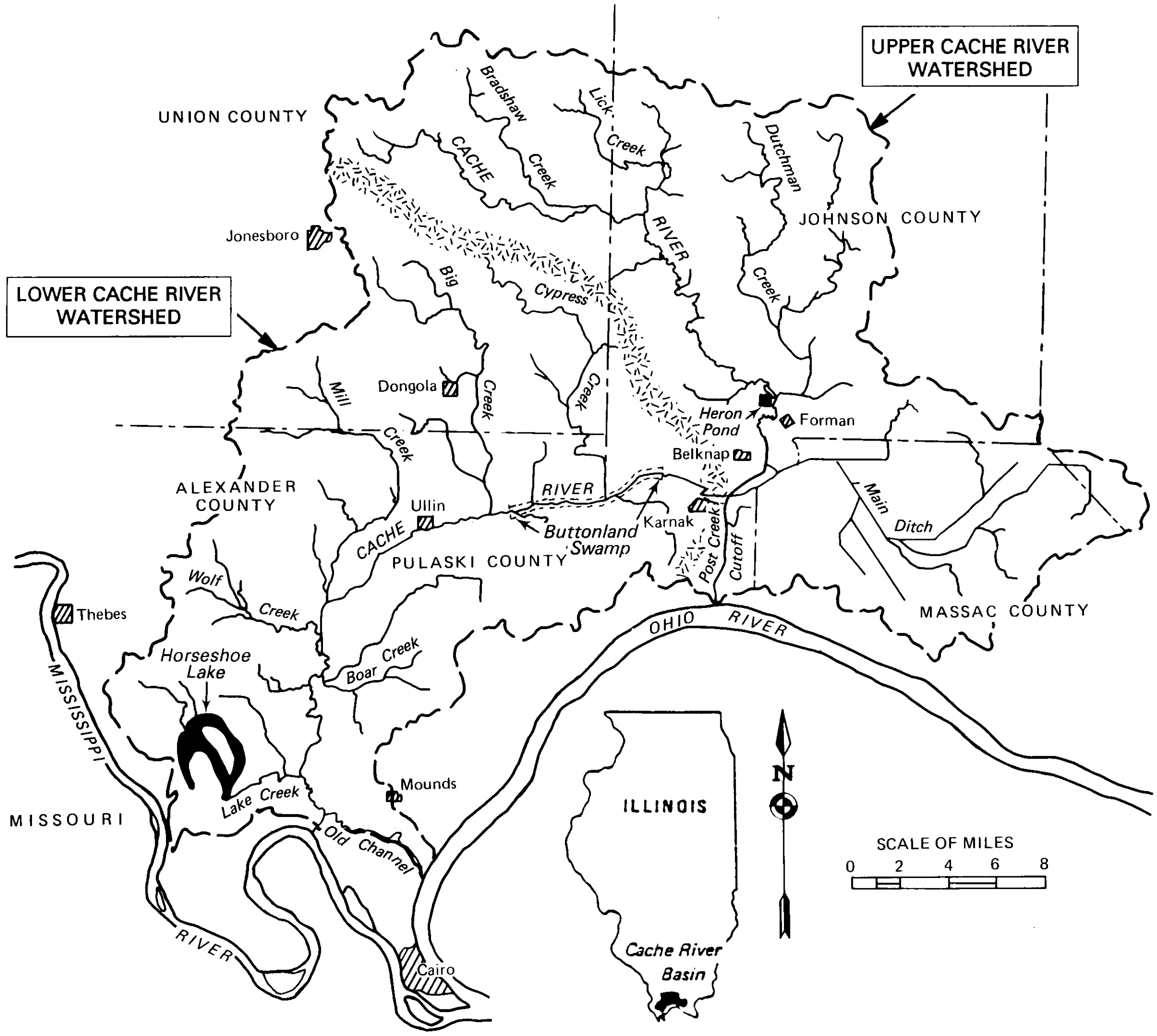


Figure 1. Location of the Cache River

The Lower Cache River, which consists of the western half of the original river basin with a drainage area of 358 square miles, drains into the Mississippi River at River Mile 13.2. The Lower Cache River is about 36 miles long with a flat gradient in the wetlands of 0.2-0.3 feet per mile to 1 foot per mile lower in the watershed. A small fluctuating percentage of the flow in the Lower Cache River Wetlands, commonly referred to as Buttonland Swamp, continues to pass through a flow control structure in the Cache River Levee into the Post Creek Cutoff. The east-west division of flow in Buttonland Swamp fluctuates depending upon the water level in the swamp and the contribution of inflow from the Big Creek and Cypress Creek tributaries, as well as from the local agricultural drainage ditches. A more thorough discussion of the influence Big Creek and other tributaries of the Lower Cache River have on Buttonland Swamp can be found in the report *Hydrology of the Big Creek Watershed and Its Influence on the Lower Cache River* by Demissie et al. (2001).

The two halves of the Cache River have very different problems associated with the altered drainage patterns as a result of the water control projects. While the Upper Cache has entrenchment and erosion problems, the Lower Cache River experiences the opposite. The straightened and channelized tributary creeks and drainage ditches have sharply steeper hydrographs than the meandering stream channels of pre-settlement times. Thus, the Lower Cache River Wetland fills rapidly with sediment-laden floodwaters from its tributaries and slowly releases the water downstream to the Mississippi River. This detention and slow release of floodwaters is similar to a flood control reservoir that stores and gradually releases upstream floodwaters. The subsequent decrease in velocity of the floodwaters as they fill the wetland complex enables the suspended sediment to drop out of suspension.

Acknowledgments

This report was funded by the Illinois Department of Natural Resources' Conservation 2000 Ecosystem Partnership Program. The views expressed in this report are those of the authors and do not necessarily reflect the views of the sponsor or the Illinois State Water Survey (ISWS) or Illinois State Geological Survey (ISGS).

This project was conducted by the authors as part of their regular duties at the Illinois State Water Survey and the Illinois State Geological Survey under the administrative guidance of Derek Winstanley, Chief (ISWS), and Misganaw Demissie, Head of the Watershed Science Section (ISWS). Bill Bogner (ISWS), who assisted with field data collection, was instrumental in guiding and developing survey techniques used in this project. Yi Han analyzed unit weight and particle size samples at the ISWS Sediment Laboratory. Ray Henderson, Gary Salmon, John Steele, and Yanhong Zhang of the ISGS Applied Geochemistry Section provided the radiometric dating and sediment composition analyses.

Becky Howard prepared the camera-ready copy of the report, Eva Kingston edited the report, and Linda Hascall assisted with preparation of the graphics.

The Nature Conservancy's Southern Illinois Field Office staff and the managers of the U.S. Fish and Wildlife Service's Cypress Creek National Wildlife Refuge and the Illinois Department of Natural Resources Lower Cache River State Natural Area provided assistance in formulating the project plan, site information for access, and storage access for boats and equipment.

Project Background

A data collection study was initiated in 1985-1988 as part of a project to investigate and quantify the hydrology and sediment transport of the Cache River basin (Demissie et al., 1990). The project established streamgaging stations on the Cache River and its tributaries. Demissie et al. (1990) analyzed the two major tributaries contributing flow and sediment to the Lower Cache River State Natural Area (LCRSNA), Big Creek and Cypress Creek, and the outflow of the Cache River mainstem downstream at Ullin to quantify the sediment contribution to the swamp. This is a mass balance approach of monitoring inflow and outflow to determine a sediment budget. The monitoring program determined that the annual sediment trap efficiency for Buttonland Swamp for the 1985-1988 period was 84 percent, 78 percent, and 69 percent, respectively (Demissie, 1989).

However, monitoring sediment transport loads does not give any insight into the spatial deposition that may occur over a large area such as Buttonland Swamp. Any water body has some bottom locations that may experience higher sedimentation rates than others. For example, river channels will experience different sedimentation rates than backwater sloughs and side channel areas.

An additional component of the 1985-1988 project included collecting bed material cores from the swamp at several locations and analyzing them for sedimentation rates using a radiometric dating technique. These cores were collected in 1988. Through this aspect of the project the depositional rates obtained by the mass balance model were compared with the sedimentation rates determined by radiometric dating of cores from select locations. Sedimentation rates for each of these methods were extrapolated to the surface area of sediment deposition (Demissie et al., 1992). The sedimentation rates determined from the cores collected for the current project will be compared to the rates determined from the limited number of cores collected and analyzed in 1988.

Land use in the Cache River basin has changed since the 1985-1988 project ended. The U.S. Fish and Wildlife Service (USFWS) established the Cypress Creek National Wildlife Refuge (CCNWR), and The Nature Conservancy (TNC) and the Illinois Department of Natural Resources (IDNR) have acquired large tracts of former agricultural land. These tracts have been allowed to revert to a more natural condition in an effort to restore old ecosystems and reduce sediment transport into the wetlands.

Sediment transport data collection for the LCRSNA was terminated in 1988. Therefore, sediment transport rates within Buttonland Swamp have not been measured for the past ten years. The benchmark sedimentation survey of Buttonland Swamp project was designed to measure existing bed elevations, establish sediment deposition rates at select locations using radiometric dating, and establish a systematic reproducible system to regularly measure future sediment deposition rates. The transect line survey and sediment core samples for the project were collected between February 2000 and May 2001.

Project Design

The purpose of this study was to provide a benchmark bathymetric survey of the Lower Cache River Wetland that can be used with future resurveys to evaluate the impacts of changes in land use, erosion control measures, and watershed restoration. The ISWS has used well-documented location and elevation data throughout Illinois to measure changes in lake storage capacity and sediment deposition.

Buttonland Swamp, the area of interest for this study, extends from near Cache Chapel Road on the west to the Section 8 Woods Nature Preserve adjacent to Route 37 on the east end of the swamp. Ten transect lines were laid out at approximately equidistant intervals throughout the swamp. Figure 2 shows a map of the swamp survey area and the approximate locations of the transect lines. Transect lines and endpoints were numbered beginning with R1-R2 near Cache Chapel Road near the west end of the swamp and progressing eastward. The odd-numbered endpoints (R1, R3, R5, etc.) are generally located on the southern side of the river and swamp, and the even-numbered endpoints (R2, R4, R6, etc.) on the northern side.

Several transect lines were first located in areas of significant interest such as Eagle Pond, Goose Pond, Short Reach, and Section 8 Woods. An attempt was made to locate several of these transect lines near areas where sediment cores were collected during the earlier study conducted in 1988. While the exact locations of the 1988 cores were not documented, general location information was available and used to locate some of the transect lines in the same general area. The remaining transect lines were then spaced at approximately equidistant intervals throughout Buttonland Swamp. The transect lines were then marked with 4-foot green t-post monuments on two points along each transect line.

Ideally, the monument points were located at each end of the transect line at or above the normal static water level. However, for each cross section transect line located east of Cypress Creek, one monument post was set on the dredge berm adjacent to the river channel. Each transect line was examined to determine the most useful locations along the line to set the monument posts. Various reasons for not siting the monuments at the ends of the transect lines included timber harvesting adjacent to the swamp in the desired endpoint location, difficulty in navigating to and locating the desired endpoint location, and private property concerns. Monument post locations were documented using Global Positioning System (GPS) coordinates to facilitate relocating the transect lines for future resurveys. All coordinates and positions were determined using a Leica 9600 system. The GPS monument positions were corrected using Radio Technical Commission for Maritime Services (RTCM) signals from the U.S. Coast Guard in St. Louis, Missouri. The GPS coordinates for the monument points are given in table 2 and are reported in feet as Illinois State Plane East 1927 Coordinates.

Table 2. Transect Line Monument Locations in Illinois State Plane East 1927 Coordinates

Monument number	*East (feet)*	*North (feet)*	*Monument number*	*East (feet)*	*North (feet)*
R1	274519	225620	R11	291466	228315
R2	274113	226624	R12	290982	230469
R3	280116	226593	R13	294139	229451
R4	280178	228960	R14	293692	231403
R5	283541	228350	R15	296468	230493
R6	283097	229636	R16	295546	232214
R7	285954	228352	R17	298831	232698
R8	285962	229830	R18	297719	233928
R9	288529	228205	R19	300555	234490
R10	288356	229951	R20	300250	235018

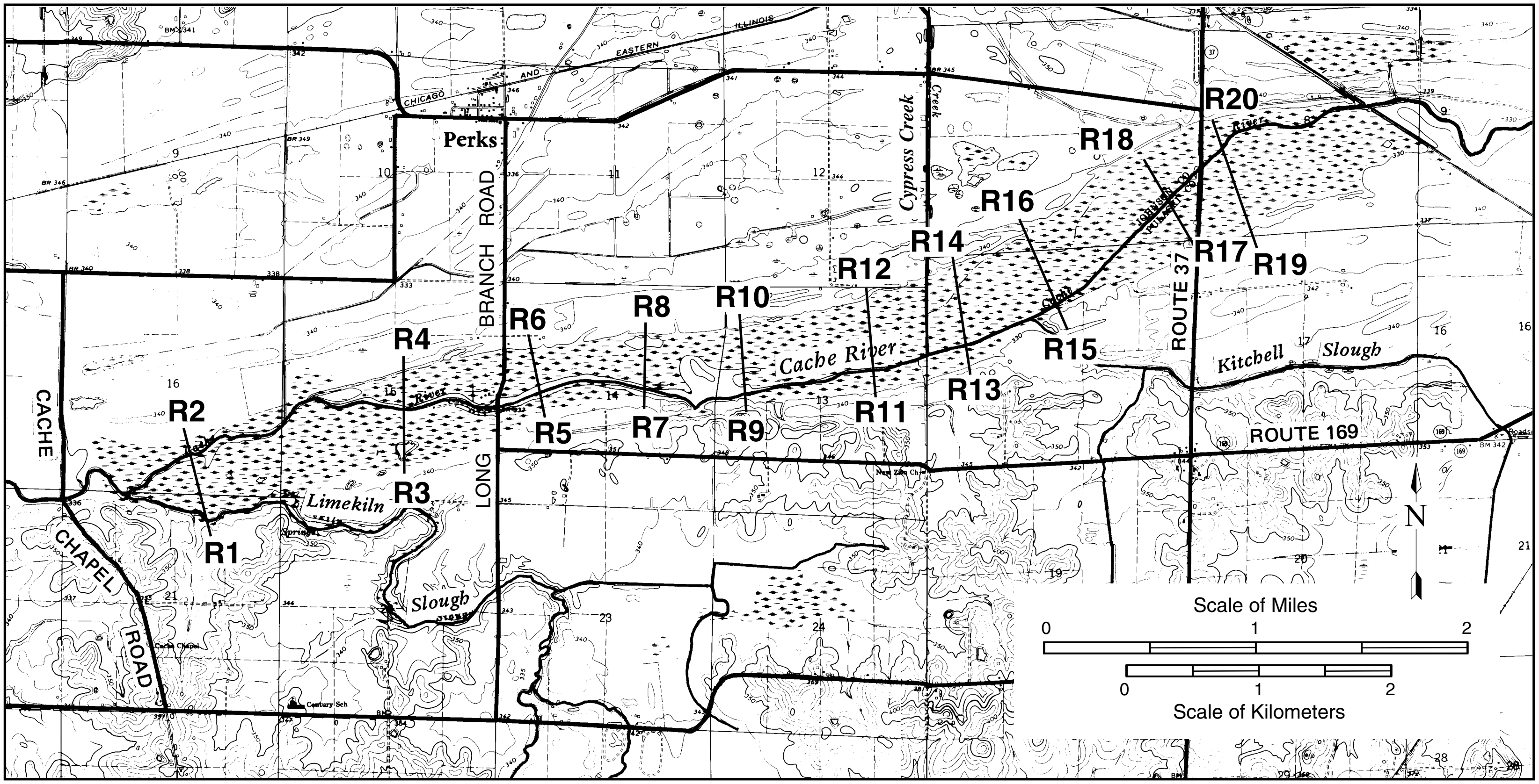


Figure 2. Lower Cache River State Natural Area (Buttonland Swamp)
approximate locations of survey transect lines

Data Collection Techniques

Transect Line Survey

The monument post coordinates were entered into HyPack hydrographic survey software on a laptop computer and operated in conjunction with the GPS system. This navigation mapping system enabled the survey boat to maneuver along the transect line. The program would locate the survey boat position relative to the transect line and distance from the known monument post. The positioning program was especially useful in the realm of Buttonland Swamp where extensive vegetative growth such as buttonbush created substantial survey line obstacles. The extensive length of the transect lines across the swamp, coupled with the reduced distance visibility, also made traditional transect line measurements such as those used in lake sedimentation surveying impractical. The positioning program allowed the survey boat to leave the transect line to navigate survey obstacles and realign on the transect line. The positioning program also was used in the core sampling component of the project to relocate along the transect line and give a precise location of the cores for future use.

Water depths along the transect lines were measured using a 2-inch diameter sounding pole. The elevation of the water level in Buttonland Swamp was used as a vertical control along the transect line with the exception of transect R1-R2. Water elevation measurements were made several times during the workday at known reference benchmarks to ensure accuracy of the vertical control. Differential levels also were surveyed on side channels, sloughs, and floodplains to account for ponding effects in various sections of the swamp. The bed profile of the swamp was measured along the transect line using the sounding pole and positioning system at various intervals as necessary to produce a bed profile along the transect line. Bed profiles for each of the transect lines are shown in appendix A. Because this was the first time the ISWS has established and surveyed transect lines across the entire width of Buttonland Swamp, no prior data were available for comparison. Therefore, no conclusions on sedimentation rates can be based upon the transect information to date. Future resurveys along these same transect lines will show the variations in deposition locations and rates, however.

Transect line cross sections varied considerably and ranged in length from 1,080 feet for transect R1-R2 to 2,900 feet for transect R17-R18. Transect line plots shown in appendix A include a water elevation of 328.4 feet above mean sea level (ft-msl). This water elevation is the targeted baseline water elevation in Buttonland Swamp controlled by the two low-head channel dams located west of Long Reach Road and west of Highway Route 37.

Sediment Core Collection

Sediment cores were collected along cross section transect lines established earlier in the study. The approximate locations of the sediment cores collected are included in the transect line plots (appendix A). Sediment cores were collected in areas deemed representative of the swamp along established transect lines. Sediment cores were collected away from areas suspected or known to have been dredged or otherwise artificially disturbed in the past. Such artificial disturbances have the potential to bias sedimentation rate measurements based on radiometric data.

Some transect line cores were collected in two locations to better define the sedimentation rates for different spatial and habitat considerations. However, even though core locations were representative of the surrounding swamp, the results of the core analysis are generally applicable only to the immediate area of the core sample. Extrapolation of the core analysis data beyond the immediate area of the individual sampling sites should be done with caution because sediment deposition does not occur uniformly across an expanse of wetland or floodplain. Core and transect line data from a project such as this can give insights into the deposition rates at selected locations and serve as a benchmark used to monitor future deposition rate changes. Additionally, some differences in depositional rates can be determined by comparing the rates from the limited core information collected in 1988 and the data from this survey. Future transect resurveys coupled with core analysis will provide more detail on depositional patterns within the swamp.

Three types of core samplers were used to collect the sediment cores: a 3-foot long, 2-inch diameter piston-type core sampler, a 4-foot long, 2-inch diameter Wildco gravity core sampler, and a 1.3-foot long 1-inch diameter stainless steel soil probe.

The piston-type core sampler was used to collect cores for unit weight, particle size, and chemistry analyses. These sediment cores were sub-sampled in the field and stored in labeled bags that identified the date, transect number, sample number, and sub-sample section.

The Wildco gravity core sampler with lexan core tubes was used to collect sediment cores for sedimentation rate measurements using the Cesium-137 (^{137}Cs) technique. These sediment core tubes were cut off near the sediment water interface, capped at both ends, sealed with duct tape, and labeled in the field.

The piston-type and Wildco gravity core samplers were used in areas of the swamp that were accessible by boat. The stainless steel soil probe was used in areas that were not accessible by boat such as transect R1-R2 or portions of the swamp that were dry at the time of core sampling. Sediment cores on transect R13-R14 east of Cypress Creek and R19-R20 in the Section 8 Woods Nature Preserve were sampled using the soil probe during periods when the location was dry, enabling the collection of longer cores. By carefully withdrawing the probe, succeeding core samples from deeper in the sediment column could be extracted by reinserting the probe in the open core hole.

Cores collected using the soil probe were sub-sampled in the field and placed in labeled bags for storage and transport to the laboratory. Table 3 lists general information about the core sampling locations.

Table 3. Core Sample Location Information

Transect line	*Description of sampling location*	*Distance from endpoint (ft)*	*Bed elevation (ft-msl)*
R1-R2	Open pond wetland	495	327.6
R3-R4	Forested wetland	940	326.6
R3-R4	Open water wetland area (Goose Pond)	479	324.6
R5-R6	North side of river channel	185	326.2
R5-R6	Forested wetland	901	325.5
R7-R8	North side of river channel	132	324.4
R7-R8	Open water wetland area (Eagle Pond)	1,189	323.9
R9-R10	Side channel slough (Short Reach)	667	324.4
R11-R12	Side channel slough	278	326.0
R13-R14	Forested floodplain	280	328.4
R15-R16	Forested floodplain	696	327.1
R17-R18	Forested floodplain	404	327.5
R19-R20	Forested floodplain (Section 8 Woods)	200	328.1

Data Analysis Results

Transect Line Survey

Transect line surveys were designed to develop a cross-sectional profile of the swamp bed. The profile of each transect line represents only the actual swamp bed elevation on that particular survey line. Extrapolation of the profile data between discrete transect lines is not valid due to the extreme variations in the swamp profiles from place to place, the presence of remnants of old dredge berms, trees, and vegetation, and the distance between transect lines.

Because no previous transect surveys were conducted in the study area, sediment deposition rates cannot be accurately estimated from changes in profiles over time. Transect line data constitute a benchmark starting point from which to measure future deposition or erosion along the transects.

The transect line survey showed great variations in bed profile configurations across Buttonland Swamp. Results of the transect line surveys are shown in appendix A. In general, the survey plots show a relatively flat profile outside the Cache River channel. The river channel is generally deeper with spoil piles deposited along the channel that are associated with the dredging activities in the 1960s.

Notable deepwater areas occur along some transect lines such as Goose Pond on transect R3-R4, Eagle Pond on transect R7-R8, and Short Reach on transect R9-R10. Water depths along the various transect lines outside the river channel and even the notable deeper water habitats are generally less than 2 feet deep. This illustrates the impact that continued, unmitigated sediment deposition may have in future decades in the wetland complex. The six transects west of the Cypress Creek confluence generally had a lower bed elevation than the four transects east of Cypress Creek. All transect line plots use the same water elevation reference of 328.4 ft-msl for illustration purposes. This should not be interpreted as a static water elevation that is maintained throughout Buttonland Swamp especially in the swamp areas north and south of the river channel in the section east of Cypress Creek. The water elevation reference was chosen for the transect plots based on the target water elevation for the primary section of Buttonland Swamp between the in-stream rock dam west of Long Reach Road and Cypress Creek to the east. The top of the rock dam has a target elevation of 328.4 feet-msl. Transect lines east of Cypress Creek generally showed much shallower water depths than the transect lines west of Cypress Creek.

Sediment Core Analysis

Sediment cores collected were analyzed for unit weight, particle size, and radiometric dating. Additional core samples were collected at several sampling locations and analyzed for sediment composition and total recoverable metals concentrations. Although this sediment analysis was not part of the project proposal, it is being included in this report to provide additional background information to document current environmental conditions in the Cache River Wetland.

Sediment Density and Particle Size

Sedimentation rates can be discussed in terms of sediment volume or volume capacity loss or as sediment mass. A water body could have a high volume loss and a low sediment mass or vice versa. Various factors can influence the volume-weight relationship of sediment, including drying, compaction, organic content, and sediment particle sizes. Buttonland Swamp has experienced periods when portions of the swamp have gone dry for various reasons, including the river channel dredging in the 1960s and periods of extreme drought such as experienced in the late 1980s.

Particle size information was obtained on selected sub-samples from the sediment cores. Generally the particle sizes tested were clay size fractions (<0.004 millimeters or mm) with very little sand size particles (>0.62 mm). Silt size sediment predominates at R1-R2 (64%), R5-R6 (79%), and R13-R14 (69%). Table 4 lists the average sediment densities and particle sizes for the transect core locations. Table 4 also lists the core sub-sample depths for each of the density and particle size samples analyzed.

Because transect line profile data had not been collected prior to this project, it is not possible to determine the sediment mass deposited in the entire swamp. Future resurveys of the transect lines will permit calculations of the sediment mass deposited along the transect lines. Unit weight and particle size samples collected from the cores during this project give some indications about the spatial variability of sediment characteristics throughout the swamp. Sediments that have been exposed to air generally compact and exhibit higher unit weights than sediments that remain submerged or saturated. Locations with bulk densities of approximately 60 pounds per cubic foot (lb/ft^3), such as those on transect R13-R14 and R19-R20, indicate that these areas have experienced periodic drying and compaction. Consequently, these sediments are more dense than the recent sediments on transect R7-R8 in Eagle Pond that exhibit densities of 30 lb/ft^3.

Cesium-137 Analysis Procedures

Sediment cores for radiometric analysis were returned to the ISGS laboratories and refrigerated until they were extruded and sub-sampled. Sediment cores were cut into detailed 5-centimeter (cm) intervals for ^{137}Cs analysis. The texture, presence of organic matter or shells, and other prominent sample features were recorded in a laboratory notebook. Sediments were weighed and then air-dried in a Class 100 laminar-flow clean bench. Sediment sub-samples were ground using a ceramic mortar and pestle and sieved to pass a 1.0-mm stainless steel sieve. Ten grams (g) of sediment were weighed into a 50- x 9-mm disposable polystyrene petri dish with lid, which was then sealed with tape. Any remaining sediment was stored in pre-cleaned bottles for later analysis.

The long radioactive half-life (30.174 years) and the distinct pattern of ^{137}Cs introduction into the environment make it a very useful tracer of recent atmospheric, hydrologic, and sedimentologic processes. The atmospheric testing of nuclear weapons produced ^{137}Cs (an unnaturally occurring isotope that began to be deposited in significant quantities in 1952). About 90 percent of the total flux of ^{137}Cs in the Northern Hemisphere was deposited between 1954 and

Table 4. Core Sample Densities and Particle Sizes

Transect line	*Description of sampling location*	*Sub-sample Depth (cm)*	*Unit weight (lb/ft^3)*	*Particle size (%)*		
				Sand	*Silt*	*Clay*
R1-R2	Open pond wetland	12 – 21	76.11	0.7	64.1	35.2
R3-R4	Forested wetland	24 – 33		3.7	7.5	88.8
		34 – 43	78.7			
R3-R4	Open water wetland area (Goose Pond)	0 – 9		0.1	0.6	99.3
		9 – 18	21.6			
		34 – 43		0.1	3.0	96.9
		43 – 52	39.5			
R5-R6	North side of river channel	0 – 9		1.0	68.0	31.0
		12 – 21	64.38	0.5	78.4	21.1
		21 – 30	75.5			
		37 – 46		0.4	79.6	20.0
		46 – 55	68.46			
R5-R6	Forested wetland	15 – 24	31.4			
		24 – 34		0.1	1.7	98.2
		34 – 43	65.4			
R7-R8	North side of river channel	0 – 9		0.3	17.0	82.7
		9 – 18	32.8			
		34 – 43		0.1	4.9	95.0
		43 – 52	37.5			
R7-R8	Open water wetland area (Eagle Pond)	0 – 12		0.4	3.9	95.7
		12 – 21	25.1			
		34 – 43		0.2	4.3	95.5
		43 – 52	38.0			
R9-R10	Side channel slough (Short Reach)	0 – 9		0.3	12.1	87.6
		9 – 18	28.7			
		18 – 27		0.1	12.4	87.5
		43 – 52	25.5			
R11-R12	Side channel slough	3 – 12	35.8			
		18 – 27		0.2	14.7	85.1
		34 – 43	58.7			
		43 – 52		1.8	15.6	82.6

Table 4. (concluded)

Transect line	*Description of sampling location*	*Sub-sample depth (cm)*	*Unit weight (lb/ft³)*	*Particle size (%)*		
				Sand	*Silt*	*Clay*
R13-R14	Forested floodplain	6 – 15		0.5	69.1	30.4
		15 – 24	63.4			
R15-R16	Forested floodplain	15 – 24	33.0			
		24 – 30		0.0	0.8	99.2
		31 – 40	50.4			
R17-R18	Forested floodplain	6 – 15	48.8			
		15 – 21		0.2	0.6	99.2
		21 – 30	63.7			
R19-R20	Forested floodplain	6 – 12		0.2	35.9	63.9
	(Section 8 Woods)	12 – 21	65.9			

1963, prior to the signing of the Limited Nuclear Test Ban Treaty of 1963. Despite sporadic inputs in recent years, the amount of ^{137}Cs in the atmosphere has decreased since 1966 to near zero (Ritchie and McHenry, 1990).

Crickmore et al. (1990), Ritchie and McHenry (1990), and Santschi and Honeyman (1989) critically reviewed the effectiveness of ^{137}Cs in the study of sedimentation processes in aquatic environments. Brown et al. (1981, Lance et al. (1986), and McHenry et al. (1973) demonstrated the application of ^{137}Cs to measuring sediment accumulation patterns in small watersheds, and Kadlec and Robbins (1984) demonstrated this in a wetland area. The technique has been successfully used in Illinois to study sedimentation processes in lakes associated with the Illinois and Mississippi Rivers (Cahill and Steele, 1986; Cahill and Autrey, 1987), and to study deposition processes in Lake Michigan (Robbins and Edgington, 1975; Christensen and Goetz, 1987).

The key assumption made when using ^{137}Cs to measure depositional processes is that following deposition, there is no significant movement of ^{137}Cs as a result of chemical, physical or biological processes. Critical evaluations by Ritchie and McHenry (1990) and Santschi and Honeyman (1989) indicate that ^{137}Cs is strongly adsorbed on clay materials and would not migrate under normal conditions. Cerling et al. (1990), and Sobocinski et al. (1990) have measured ^{137}Cs contamination from nuclear facilities to track contamination in streams. These studies found that ^{137}Cs adsorption on sediments was essentially irreversible and that the ^{137}Cs was immobile.

Gamma activity of sediment samples was measured using high-purity germanium and lithium-drifted germanium [Ge (Li)] crystals. One detector was 59 mm in diameter and 77 mm long with a warranted resolution of 1.90 kiloelectron volts (keV) at 1.33 million electron volts (MeV) of cobalt-60 (^{60}Co) and a relative efficiency of 40.6 percent. The second detector was 60 mm in diameter and 80 cm long with a warranted resolution of 1.95 keV at 1.33 MeV of ^{60}Co and a relative efficiency of 40.0 percent. Signals were processed using Ortec Model 572 amplifiers, Canberra Model 579 analog-to-digital converters, and Canberra AccuSpect B Multichannel Analyzer (MCA) acquisition interface boards installed in an IBM-compatible personal computer. Canberra Genie-2000 spectroscopy software was used to acquire and analyze the spectra from the MCA. Sediment samples were counted for an average of 45 hours and a minimum of 24 hours.

The software peak analysis option was used to make a spectral plot of the 661.6 keV peak of ^{137}Cs, which was used to calculate peak centroids, peak energy, net peak area, and net peak uncertainty in the collected spectra. The region in the spectra for the 661.64 keV peak of ^{137}Cs also was defined manually, and the software was used to calculate centroid, peak area, peak error, and peak resolution. In addition to the ^{137}Cs peak, areas and errors associated with the 609.2 and 665.5 keV of bismuth-214 (^{214}Bi), and the 1460.8 keV peaks of potassium-40 (^{40}K) also were recorded as a check of spectroscopy system performance. A Microsoft Excel 2000 spreadsheet program was used to calculate disintegrations per minute (DPM), sample activity (relative to NIST 4350B) in milli-becquerel per gram (mBq/g), peak-to-background ratio, percent error of peak fit, and also to plot the results.

The ^{137}Cs activity versus depth was plotted in each core to select the position in the sedimentation record when fallout from testing of nuclear weapons in the atmosphere began to be deposited in significant quantities (1954) or the peak time of fallout from nuclear testing (1963). Sedimentation rates then were calculated with these dates as a marker. All sedimentation rates obtained by this technique are based on the assumption of a constant rate of sedimentation over the time interval of interest (37 or 46 years). The extent of agreement between the two rate values (based on the onset of and peak activity of atmospheric fallout) can be used to assess the uniformity of sedimentation rates in an area.

Determining the exact location of the 1954 event horizon was often difficult. Much smaller amounts of ^{137}Cs were deposited in 1954 than in the peak years of atmospheric testing, 1961-1963. More than one half-life has passed since 1954, thereby reducing the amount of ^{137}Cs present by more than 50 percent due to radioactive decay. The limit of detection was, however, variable, depending on operating conditions. Use of a counting period longer than 24 hours, and a high efficiency detector improved the limit of detection. In some cases, counts of up to three days were used. Detection of ^{137}Cs occurred if the results for a sediment interval met the following criteria: (1) the peak-to-background ratio was greater than 1; (2) the error associated with computer software fitting the peak was less than 30 percent; and (3) the sediment interval was counted for a minimum of 24 hours. The lowest specific activity that could be detected in a 10-g sample by using a 48-hour counting time on a 40-percent efficient Ge (Li) detector was approximately 0.003 mBq/g.

The ^{137}Cs measurements were checked by analysis of duplicate core samples and reference samples. Reference samples used include National Institute of Standards and Technology Standard Reference Material (NIST) 4350B Columbia River Sediment, SRM 4353 Rocky Flats Soil Number 1, SRM 4354 Freshwater Lake Sediment, SRM 4355 Peruvian Soil, and SRM 4357 Ocean Sediment.

Chemical Analysis Procedures

Sediments sub-sampled in the field were air dried in a Class 100 laminar-flow clean bench. Dried sediment samples were then ground using a SPEX 8505 alumina ceramic grinding container in a SPEX 8500 Shatterbox. Samples were ground to pass a 100-mesh stainless steel sieve.

Procedures were the same as those used in previous studies on the Illinois River (Cahill and Steele, 1986; Cahill, 2001). The technique used and the total metal concentrations determined were as follows: cold vapor atomic absorption: mercury; X-ray fluorescence spectrometry: silicon, aluminum, iron, calcium, magnesium, potassium, sodium, titanium, phosphorous, sulfur, barium, strontium, and zirconium; coulometric method: total carbon, inorganic carbon, and organic carbon (by difference); and gravimetric method: loss on ignition.

Metals also were determined with inductively coupled plasma emission spectrometry according to U.S. Environmental Protection Agency (EPA) method 6010. This method is not a total digestion procedure, but results in “total recoverable metal concentrations” for aluminum, arsenic, boron, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, potassium, lanthanum, lithium, magnesium, manganese, molybdenum, sodium, nickel, lead, antimony, scandium, selenium, silicon, strontium, titanium, thallium, vanadium, and zinc.

Calibration standards used in each analytical method were prepared from either NIST Standard Reference materials or carefully mixed from stock solutions prepared by commercial vendors. Standard Reference Materials were analyzed as unknowns as a check for proper instrument calibration. The ISGS Applied Geochemistry Section's established Quality Assurance Plan was followed.

Cesium-137 Results

The ^{137}Cs results are summarized in table 5. A total of 20 cores were collected at 13 sampling locations during the 2000 project. Additional cores were collected in October at some locations to obtain longer cores, and to confirm results from cores collected in March. Duplicate cores were collected at two locations (transects R1-R2 and R9-R10). The gamma activity profiles for the 20 cores are presented in appendix B in which shaded bars represent detectable levels of ^{137}Cs activity and unshaded bars represent undetectable levels of ^{137}Cs.

Sedimentation rates vary according to the depositional environment. Small changes in elevation relative to the river as well as latitudinal distances and flow pattern regimes within the wetland complex are important. Additionally, the accuracy of the field sampling and analytical methods must be considered. Table 6 summarizes the average long-term (37-year) sedimentation rates by location type and transect location.

The sedimentation rates based on the sediment budget project for 1985-1988 ranged from 0.15 to 0.33 cm/yr based on sediment bulk density of 800 kilograms per cubic meter (kg/m^3) and based on an estimated wetland area of 1,200 hectares at 330 ft msl (Demissie et al., 1992). These rates were measured during a period with two dry years, so the rates were expected to be less than long-term averages.

Table 7 gives ^{137}Cs sediment rate results for the cores collected in 1988. Five cores were reanalyzed as part of this study. Several of the cores from the 1988 study were located in the general vicinity of several of the transect lines from this 2000 survey and are noted in the table 7 data. Reanalyzing five of the cores from 1988 changed the sedimentation rate slightly for the two cores near transect line R19-R20. This is attributed to the more advanced laboratory equipment now available providing more accurate counts. Gamma activity profiles for four of the cores are included in appendix B. Two of the reanalyzed 1988 cores are from the same general vicinity of transect R19-R20 of the 2000 survey. The 1988 core A was located closer to the 2000 transect line and therefore only the plot for core A was included in appendix B.

Table 5. Summary of ^{137}Cs Sedimentation Rate Estimates for the Cache River Wetland

Sample ID	*Transect line*	*Depth to peak activity (cm)*	*Max activity (mBq/g)*	*1963 sedimentation rate (cm/yr)*	*Depth to no activity (cm)*	*1954 Sedimentation rate (cm/yr)*
Cs-13*	R1-2	13	0.042	0.4	*	*
Cs-15*	R1-2	28	0.043	0.8	*	*
Cs-16	R1-2	23	0.024	0.6	37	0.8
Cs-6	R3-4	18	0.042	0.5	28	0.6
Cs-5	R3-4	28	0.079	0.8	38	0.8
Cs-7*	R5-6	47	0.015	>1.3	*	*
Cs-17*	R5-6	72	0.015	>2	*	*
Cs-8	R5-6	18	0.118	0.5	23	0.5
Cs-3	R7-8	33	0.093	0.9	43	0.9
Cs-4	R7-8	28	0.098	0.8	38	0.8
Cs-2*	R9-10	53	0.118	1.4	*	*
Cs-18	R9-10	53	0.081	1.4	58	1.3
Cs-19	R9-10	47	0.081	1.3	63	1.4
Cs-1	R11-12	32	0.067	0.9	38	0.8
Cs-9*	R13-14	26	0.013	>0.7	*	*
Cs-20	R13-14	68	0.102	1.8	85	1.8
Cs-10	R15-16	8	0.042	0.2	18	0.4
Cs-12	R17-18	13	0.075	0.4	23	0.5
Cs-11*	R19-20	15	0.057	0.4	*	*
Cs-14	R19-20	15	0.041	0.4	35	0.8

Note: *Depth to no detectable activity not reached in this core.

Table 6. Summary of Average Sedimentation Rates for 2000 Cores

Core ID	*Location type*	*Transect line*	*1963 sedimentation rate (cm/yr)*
Cs-13, Cs-15, Cs-16	Open pond wetland	R1-R2	0.6
Cs-5	Open water wetland area (Goose Pond)	R3-R4	0.8
Cs-6	Forested wetland	R3-R4	0.5
Cs-7,Cs-17	North side of river channel	R5-R6	>2
Cs-8	Forested wetland	R5-R6	0.5
Cs-3	North side of river channel	R7-R8	0.9
Cs-4	Open water wetland (Eagle Pond)	R7-R8	0.8
Cs-2, Cs-18, Cs-19	Side channel slough (Short Reach)	R9-R10	1.4
Cs-1	Side channel slough	R11-R12	0.9
Cs-9, Cs-20	Forested floodplain (N)	R13-R14	1.8
Cs-10	Forested floodplain (N)	R15-R16	0.2
Cs-12	Forested floodplain (S)	R17-R18	0.4
Cs-11, Cs-14	Forested floodplain (S)	R19-R20	0.4

Table 7. Summary of Sedimentation Rates Determined in 1988 Cores Based on ^{137}Cs

Core ID (approximate 2000 cross section)	*Location type*	*1963 sedimentation rate (1988) (cm/yr)*	*1963 sedimentation rate (recount of same cores) (cm/yr)*
J (R1-R2)	Wetland meadow	0.5	0.5
I	Wetland meadow	1.6	
C (R7-R8)	Eagle Pond	1.4	
D (R7-R8)	Eagle Pond	1.4	
E	Side channel slough	1.1	1.1
F (R9-R10)	Short reach	2.8	
H	Backwater slough	1.6	
G	Backwater slough	0.5	0.5
B (R19-R20)	Floodplain	0.3	0.5
A (R19-R20)	Floodplain	0.3	0.6

Summary of Sedimentation Rates

Transect R1-R2, described during the 1988 coring as a seasonal wetland meadow, appeared during the 2000 survey as an open pond area. As listed in table 7, the 1988 cores I and J were collected in the same general area. The 1988 core J is closer to the 2000 survey locations than core I. The 2000 survey analyzed three cores fro m this location. The average sedimentation rate for the 2000 survey as shown in table 6 for the three cores was 0.6 cm/yr. Therefore, the 1988 and 2000 sedimentation rates are similar.

Transect R3-R4 was not sampled in 1988. A sedimentation rate of 0.8 cm/yr was measured in the 2000 core.

Transect R5-R6 also was not sampled in 1988. The sediment deposition at this core location is theorized to be significantly influenced by Big Creek floodwaters flowing east through the constriction of the Long Reach Road bridge and entering the large open swampland. As the flow velocity decreases after passing through the bridge constriction, a larger percentage of suspended sediment will fall out of suspension and deposit in the immediately adjacent reach. Additional information on the influence that Big Creek has on the lower Cache River can be found in the report by Demissie et al. (2001).

The sedimentation rate for transect R7-R8 in Eagle Pond appears to have decreased from 1.4 cm/yr in 1988 to 0.8 cm/yr in 2000. The two cores collected in 1988 had a suspected loss of 9 and 14 cm of the top fluff layer. If no loss is assumed for these cores, and the position of the peak activity is adjusted, then the rate in 1988 would be 0.9 – 1.0 cm/yr. The 1988 cores were collected in the east and west thirds while the 2000 cores were collected near the center of the pond.

Transect R9-R10 is the Short Reach Slough or side channel near the location where 1988 core F was collected. The sedimentation rate from the 1988 core was 2.8 cm/yr whereas the rate measured in this study was 1.4 cm/yr. Sedimentation rates appear to have decreased since 1988. However, as stated earlier, sedimentation rates vary according to the depositional environment, location, and flow patterns within the wetland complex. Therefore, the different locations of the two cores may be critical in determining the validity of comparing these two sedimentation rates.

Transects R11-R12, R13-R14, R15-R16, and R17-R18 are forested floodplain sites on both sides of the river. None of these locations had any data from the 1988 sampling project. Sedimentation rates for this study ranged from 0.2 to 1.8 cm/yr. Sedimentation rates for the 1988 core G, a backwater slough 150 feet north of river, was 0.5 cm/yr, and the rate for the 1988 core H, collected 225 feet south of the river, was 1.6 cm/yr. Once again, the locations of the 1988 cores relative to the 2000 core locations would be critical in determining whether any differences in sedimentation rates are valid. The influence of floods from Cypress Creek would be reflected here.

Transect R19-R20 through the Section 8 Woods Nature Preserve showed the same long-term sedimentation rates as core samples collected in the same vicinity in 1988.

Chemical Analysis Results

The composition of the sediments of the Cache River Wetland was not tested in the previous 1988 study. For the present study, lateral variations in the compositions or the wetland sediments were examined. The compositional changes with depth (age) also were analyzed in the sediments from Eagle Pond.

Twelve sediment sub-samples from cores collected for bulk density and particle size, and ten sub-samples from cores collected in Eagle Pond were chemically analyzed. All 22 samples were tested for total carbon, inorganic carbon, organic carbon, and total recoverable metals concentrations. Twelve sediment sub-samples from the cores also were tested for major and minor trace elements by X-ray fluorescence. Tables 8 and 9 show the results, which are reported as oxides.

Lateral Variations. The composition of the sediments in the Lower Cache River Wetland were generally uniform. Organic carbon was greater in the forested floodplain samples (peaty layers and vegetation observed) and silicon dioxide (SiO_2) was elevated in two samples, including one sample near the Long Reach Road. The concentrations of compounds associated with carbonate minerals (CaO, MgO, and inorganic carbon) were low relative to other river sediments (Cahill, 2001). Manganese concentrations were elevated in the Eagle Pond sediments. Trace elements (copper, nickel, and zinc) were generally uniform, but zinc levels were greater in Eagle Pond for an undetermined reason. No lead or selenium was detected in the core samples. The source of metals in the sediments could be from atmospheric deposition from two coal-burning power plants on the Ohio River at Joppa, Illinois, and Paducah, Kentucky, although this also could not be determined from the currently available data.

Depth (Age) Variations in Eagle Pond. An additional core was collected from the Eagle Pond site for chemical analysis based on core depth. This information gives insight regarding the chemical deposition within the sediments over time.

The composition of the sediments in Eagle Pond were generally uniform with depth. Organic carbon was greater in the upper 10 cm of the core, as were boron and sulfur, whereas concentrations of barium, chromium, nickel, and zinc were somewhat greater in the deeper, older sediments.

Comparison of Lower Cache River Sediment Composition Concentrations with Other Studies. Table 10 compares the concentrations of major and trace elements in sediments of the Lower Cache River Wetland to concentrations observed in Little Grassy Lake, Campus Lake at Southern Illinois University in Carbondale, and Peoria Lake. Dreher et al. (1977) included Little Grassy Lake in a study of lakes in southern Illinois. Muchmore sampled Campus Lake in 1998 (unpublished results). Peoria Lake results were from samples collected in 1998 (Cahill, 2001). All of the major elemental analyses were done using X-ray fluorescence spectroscopy. The methods used for the trace element analyses are noted in the table.

The concentration of silicon dioxide was lower in the Lower Cache River samples than those for Little Grassy Lake or Campus Lake, which reflected a larger component of sand or

Table 8. Composition of Sediments Collected in Lower Cache River Wetland, March 2000

	Depth (cm)					
Sub-sample	*18-33* *R3-4* *Goose Pond*	*18-27* *R3-4* *Flood-plain*	*0-12* *R5-6* *Edge of channel*	*0-15* *R5-6* *Flood-plain*	*21-33* *R7-8* *Edge of channel*	*21-33* *R7-8* *Eagle Pond*
Tot. Carbon (%)	2.48	2.97	1.63	4.68	1.43	2.25
Inc. Carbon (%)	0.06	0.03	0.03	0.02	0.03	0.03
Org.Carbon (%)	2.42	2.94	1.60	4.66	1.40	2.22
SiO_2 (%)	54.0	55.8	75.8	53.7	61.8	53.1
Al_2O_3 (%)	19.7	19.3	10.1	18.5	17.0	19.8
Fe_2O_3 (%)	8.82	6.79	3.58	6.50	6.82	8.96
CaO (%)	0.58	0.72	0.63	0.75	0.62	0.68
MgO (%)	1.49	1.52	0.62	1.42	1.26	1.49
K_2O (%)	2.41	2.36	2.02	2.28	2.40	2.32
Na_2O (%)	0.26	0.35	0.99	0.34	0.57	0.28
TiO_2 (%)	0.88	0.87	0.76	0.83	0.87	0.85
P_2O_5 (%)	0.44	0.32	0.22	0.35	0.29	0.44
MnO (%)	0.10	0.08	0.07	0.09	0.11	0.14
Sr	87	99	120	99	97	85
Ba	753	896	626	764	822	812
Hg	0.080	0.085	0.060	0.090	0.070	0.090
Zr	121	128	350	115	150	111
Total Recoverable Concentrations (ICP)						
Si (%)	208	245	264	236	187	167
Al (%)	7.11	7.08	2.61	6.32	5.51	7.79
Fe (%)	5.75	4.47	2.35	4.33	4.62	6.21
Ca (%)	0.38	0.48	0.28	0.51	0.40	0.47
Mg (%)	0.77	0.79	0.32	0.73	0.65	0.81
K (%)	0.80	0.80	0.34	0.66	0.60	0.93
Na	<50	<50	<50	<50	<50	<50
Ti	804	882	525	722	701	934
Mn	770	520	514	691	789	1120
S	964	923	480	1700	574	880
As	<75	<75	<75	<75	<75	<75
B	39	46	40	42	39	48
Be	1.67	1.79	0.71	1.66	1.35	1.87
Ba	376	449	162	374	323	420
Cd	<5	<5	<5	<5	<5	<5
Co	18	17	11	19	19	22
Cr	36	41	17	38	32	41
Cu	38	32	16	37	30	38
La	31.5	35.7	26.8	32.7	32.5	33.8
Li	46	47	18	40	36	50
Mo	<10	<10	<10	<10	<10	<10
Ni	48	50	23	48	42	55
Pb	<25	<25	<25	<25	<25	<25
Sb	<25	<25	<25	<25	<25	<25
Sc	11	11	5	10	9	12
Se	<50	<50	<50	<50	<50	<50
Sr	40.1	51.8	24.8	47.1	36.1	45.3
Tl	<100	<100	<100	<100	<100	<100
V	73	85	37	81	63	82
Zn	178	170	73	179	148	195

Table 8. (concluded)

	Depth (cm)					
Sub-sample	*18-33 R3-4 Goose Pond*	*18-27 R3-4 Flood-plain*	*0-12 R5-6 Edge of channel*	*0-15 R5-6 Flood-plain*	*21-33 R7-8 Edge of channel*	*21-33 R7-8 Eagle Pond*
Tot. Carbon (%)	1.79	1.56	1.67	8.05	2.77	1.39
Inc. Carbon (%)	0.03	0.06	0.03	0.03	0.02	0.02
Org. Carbon (%)	1.76	1.50	1.64	8.02	2.75	1.37
SiO_2 (%)	56.4	62.7	76.1	52.9	58.9	63.8
Al_2O_3 (%)	19.2	16.4	10.0	16.3	18.0	16.4
Fe_2O_3 (%)	8.18	6.43	3.03	5.59	6.25	5.75
CaO (%)	0.69	0.58	0.62	0.68	0.59	0.61
MgO (%)	1.46	1.19	0.62	1.25	1.33	1.16
K_2O (%)	2.41	2.43	2.00	2.18	2.35	2.31
Na_2O (%)	0.36	0.59	1.01	0.40	0.43	0.57
TiO2 (%)	0.88	0.91	0.80	0.78	0.89	0.91
P_2O_5 (%)	0.36	0.26	0.14	0.26	0.29	0.25
MnO (%)	0.13	0.11	0.05	0.06	0.07	0.09
Sr	88	99	118	95	86	107
Ba	808	763	647	700	769	746
Hg	0.080	0.070	0.040	0.080	0.060	0.060
Zr	123	153	346	127	156	195
Total Recoverable Concentrations (ICP)						
Si (%)	170	133	218	150	226	198
Al (%)	6.77	5.83	2.60	6.05	6.37	5.84
Fe (%)	5.52	4.43	2.00	3.68	4.08	3.75
Ca (%)	0.48	0.37	0.30	0.46	0.38	0.38
Mg (%)	0.76	0.66	0.33	0.65	0.68	0.62
K (%)	0.74	0.75	0.35	0.78	0.74	0.73
Na	<50	<50	<50	<50	<50	<50
Ti	780	817	486	767	830	764
Mn	994	836	407	494	519	685
S	726	272	239	2240	520	255
As	<75	<75	<75	<75	<75	<75
B	36	44	43	49	43	45
Be	1.67	1.45	0.71	1.38	1.72	1.50
Ba	382	370	178	346	340	342
Cd	<5	<5	<5	<5	<5	<5
Co	21	17	9	15	15	16
Cr	36	34	19	38	38	37
Cu	34	28	15	37	28	26
La	33.8	36.9	27.6	30.3	33.6	35.5
Li	44	41	18	39	42	41
Mo	<10	<10	<10	<10	<10	<10
Ni	49	42	21	42	44	41
Pb	<25	<25	<25	<25	<25	<25
Sb	<25	<25	<25	<25	<25	<25
Sc	11	10	5	10	10	10
Se	<50	<50	<50	<50	<50	<50
Sr	42.7	42.5	26.6	39.7	38.5	39.4
Tl	<100	<100	<100	<100	<100	<100
V	71	66	33	77	79	72
Zn	171	140	67	152	150	132

Note: All values in ppm unless otherwise noted.

Table 9. Composition of Sediments Collected in Eagle Pond, March 2000

	Depth (cm)									
Sub-sample	*0-5*	*5-10*	*10-15*	*15-20*	*20-25*	*25-30*	*30-35*	*35-40*	*40-45*	*45-50*
Tot. C (%)	6.95	5.33	3.02	2.20	2.24	2.56	3.09	2.56	2.46	2.80
Inc. C (%)	0.05	0.04	0.03	0.03	0.04	0.03	0.07	0.04	0.05	0.04
Org. C (%)	6.90	5.29	2.99	2.17	2.20	2.53	3.02	2.52	2.41	2.76
Total Recoverable Concentrations (ICP)										
Si (%)	174	212	198	255	259	202	142	132	230	240
Al (%)	5.44	5.84	6.04	5.77	5.92	6.76	6.07	6.99	7.15	7.08
Fe (%)	4.15	5.51	5.61	5.25	5.56	5.73	5.21	5.09	4.64	4.11
Ca (%)	0.55	0.56	0.46	0.44	0.44	0.46	0.46	0.41	0.40	0.41
Mg (%)	0.65	0.65	0.68	0.67	0.68	0.74	0.68	0.76	0.74	0.73
K (%)	0.69	0.72	0.74	0.56	0.69	0.57	0.57	0.60	0.57	0.59
Na	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40
Ti	636	596	625	598	645	794	608	831	884	870
Mn	992	1180	1120	1010	1050	1130	1210	642	603	600
S	2340	1540	1015	650	850	980	1110	780	460	550
As	<75	<75	<75	<75	<75	<75	<75	<75	<75	<75
B	30	22	11	9	10	16	<5	12	12	15
Be	1.6	1.7	1.9	1.9	1.9	1.9	2.0	1.9	2.1	1.9
Ba	332	300	322	333	345	377	346	486	400	475
Cd	7	<5	<5	<5	<5	<5	<5	<5	<5	<5
Co	20	19	22	21	21	20	23	28	21	21
Cr	33	30	31	31	32	37	31	42	44	44
Cu	50	34	36	34	35	34	41	43	47	41
La	30	28	31	32	30	31	32	35	36	36
Li	36	39	40	39	40	45	41	47	48	48
Mo	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ni	45	45	49	51	49	52	52	57	56	59
Pb	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Sb	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Sc	9	9	10	10	11	10	12	12	11	12
Se	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Sr	42	41	38	37	38	41	39	43	40	41
Tl	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
V	65	51	54	53	55	67	46	72	75	76
Zn	163	174	180	184	184	192	200	201	185	190

Note: All values in ppm unless otherwise noted.

Table 10. Comparison of Mean Concentration in Sediments from Lower Cache River, Little Grassy Lake, Campus Lake (SIU), and Peoria Lake

Sub-sample	*Lower Cache*	*Little Grassy Lake (Dreher et al., 1977)*	*Campus Lake (SIU) (Muchmore, 1998)*	*Peoria Lake (Cahill, 2001)*
Tot. C (%)	2.72	0.65	1.85	4.17
Inc. C (%)	0.03	0.04	0.02	1.31
Org. C (%)	2.69	0.61	1.83	2.86
Method	XRF	XRF	XRF	XRF
SiO_2 (%)	60.4	78.14	73.87	56.5
Al_2O_3 (%)	16.7	10.86	10.85	12.7
K_2O (%)	2.29	1.82	1.95	2.75
CaO (%)	0.65	0.42	0.63	5.10
MgO (%)	1.23	0.48	0.74	2.74
Fe_2O_3 (%)	6.39	3.68	3.53	5.20
Na_2O (%)	0.51		0.93	0.59
TiO_2 (%)	0.85	0.79	0.77	0.66
MnO (%)	0.09	0.06	0.08	0.09
P_2O_5 (%)	0.30	0.10	0.12	0.35
Hg	0.07			0.34
Ba	759		537	488
Sr	98		119	126
Zr	173		312	132
Method	ICP	OED	XRF	ICP
Si	200			213
Al (%)	5.82			3.53
Fe (%)	4.27			3.41
Ca (%)	0.41			2.55
Mg (%)	0.65			1.48
K (%)	0.69			0.72
Na	<50			431
Ti	751			402
Mn	695			628
S	814			1426
As	<75			<50
B	43	81		56
Be	1.5	3		1.2
Ba	339			211
Cd	<5		<15	5.5
Co	17	11		14
Cr	34	50	62	59
Cu	30	14	50	48
Li	39			36
Ni	42	28	28	62

Table 10. (concluded)

Sub-sample	*Lower Cache*	*Little Grassy Lake (Dreher et al., 1977)*	*Campus Lake (SIU) (Muchmore, 1998)*	*Peoria Lake (Cahill, 2001)*
Pb	<25		43	51
Sb	<25			<25
Se	<50			<50
Sr	40	96		59
V	68	70	79	35
Zn	146	78	72	303

Notes: ICP = Inductively coupled plasma emission spectrometry. Total Recoverable Concentration determined by according to USEPA Method 6010 (Cahill, 2001).
OED = Direct-reading optical emission spectrometric method. Total metal concentrations. (Dreher et al., 1977).
XRF = X-ray fluorescence spectrometry. Total metal concentrations (Cahill, 2001).
All values in mg/kg unless otherwise noted.

quartz in lake sediments. The concentrations of organic carbon, iron, aluminum, and phosphorous were higher in the Lower Cache sediments than in those for Little Grassy Lake or Campus Lake, probably reflecting more silt- and clay-sized sediments in the Lower Cache River than in the lakes. Concentrations of inorganic carbon, calcium, and magnesium were greater in Peoria Lake sediments than in the Lower Cache, Little Grassy Lake, or Campus Lake sediments. Trace element concentrations were generally uniform, although zinc and lead were somewhat greater in the Peoria Lake sediments due, in part, to the urban nature of the area and contributing watershed.

Summary

The Illinois State Water Survey in conjunction with the Illinois State Geological Survey designed and conducted a sedimentation survey of the Lower Cache River State Natural Area in 2000. The project goal was to design a sedimentation survey of the Lower Cache River swamp that would enable future surveys to monitor changes in the sediment deposition rates within the swamp regime.

A series of transect lines was designated, and the endpoint locations were monumented for use in future surveys. The bed profile was surveyed across the width of the swamp along each transect line. The plots of the transect line surveys show the complete bed profile across the width of the swamp along each particular survey line. The bed profile generally shows little variation laterally with baseline water depths generally less than 2 feet outside the immediate river channel. The greatest use of the transect line data will be in future resurveys that will show changes in the swamp bed profile and subsequent sediment deposition patterns along the surveyed line.

Sediment cores were collected in selected locations along the transect lines and analyzed for radiometric dating, density, and particle size. While not a component of the original project proposal, 13 additional core samples were collected from selected sites and analyzed for major, minor, and trace element composition. Radiometric dating uses ^{137}Cs from the aboveground nuclear testing in the late 1950s and early 1960s as a tracer to map the amount of sediment deposition since 1954 and 1963. The sedimentation rate in Buttonland Swamp based on this technique ranged from a low of 0.2 cm per year in the forested floodplain near Highway Route 37 to a high range of greater than 2 cm per year in the edge of the river channel in the Long Reach area. Sedimentation rates from several cores collected randomly in 1988 and compared to the cores collected during the 2000 survey show that the long-term sedimentation rates in locations such as Eagle Pond and the Section 8 Woods Nature Preserve have not changed significantly.

References

Brown, R.B., G.F. Kling, and N.H. Cutshall. 1981. Agricultural Erosion Indicated by ^{137}Cs Redistribution: II. Estimates of Erosion Rates. *Soil Science Society of America Journal* 45:1191-1197.

Cahill, R.A. 2001. *Assessment of Sediment Quality in Peoria Lake: Results from the Chemical Analysis of Sediment Core Samples Collected in 1998, 1999, and 2000.* Illinois State Geological Survey Open File Series 2001-4.

Cahill, R. A., and A.D. Autrey. 1987. Measurement of ^{210}Pb and ^{137}Cs, Organic Carbon and Trace Elements in Sediments of the Illinois and Mississippi Rivers. *Journal of Radioanalytical and Nuclear Chemistry* 110:197-205.

Cahill, R. A., and J.D. Steele. 1986. *Inorganic Composition and Sedimentation Rates of Backwater Lakes Associated with the Illinois River*. Illinois State Geological Survey Environmental Geology Notes 115.

Christensen, E.R., and R.H. Goetz, 1987. Historical Fluxes of Particle-Bound Pollutants Form Deconvolved Sedimentary Records. *Environmental Science and Technology* 21:1088-1096.

Crickmore, M. J., G.S. Tazioli, P.G. Appleby, and F. Oldfield. 1990. *Radioisotope Studies of Recent Lake and Reservoir Sedimentation*. The Use of Nuclear Techniques in Sediment Transport and Sedimentation Problems, IHP-III Project 5.2, pp. 131-167. Paris: UNESCO.

Demissie, M. 1989. *Sediment Yield and Accumulation in the Lower Cache River*. Illinois State Water Survey Miscellaneous Publication 108.

Demissie, M., W.P. Fitzpatrick, and R.A. Cahill. 1992. *Sedimentation in the Cache River Wetland: Comparison of Two Methods*. Illinois State Water Survey Miscellaneous Publication 129.

Demissie, M., H.V. Knapp, P. Parmar, and D.J. Kriesant. 2001. *Hydrology of the Big Creek Watershed and Its Influence on the Lower Cache River*. Illinois State Water Survey Contract Report 2001-06.

Demissie, M., T.W. Soong, R.L. Allgire, L. Keefer, and P. Makowski. 1990. *Cache River Basin: Hydrology, Hydraulics, and Sediment Transport. Volume 1: Background, Data Collection, and Analysis*. Illinois State Water Survey Contract Report 484.

Dreher, G.B., C.B. Muchmore, and D.W. Stover. 1977. *Major, Minor, and Trace Elements of Bottom Sediments in Lake DuQuoin, Johnston City Lake, and Little Grassy Lake in Southern Illinois*. Illinois State Geological Survey Environmental Geology Notes 82.

Kadlec, R.H., and J.A. Robbins. 1984. Sedimentation and Sediment Accretion in Michigan Coastal Wetlands (U.S.A.). *Chemical Geology* 44:119-150.

Lance, J.C., S.C. McIntyre, J.W. Naney, and S.S. Rousseva. 1986. Measuring Sediment Movement at Low Erosion Rates Using ^{137}Cs. *Soil Science Society of America Journal* 50:1303-1309.

McHenry, J.R., J.C. Ritchie, and A.C. Gill 1973. Accumulation of Fallout ^{137}Cs in Soils and Sediments in Selected Watersheds. *Water Resources Research* 9:676-686.

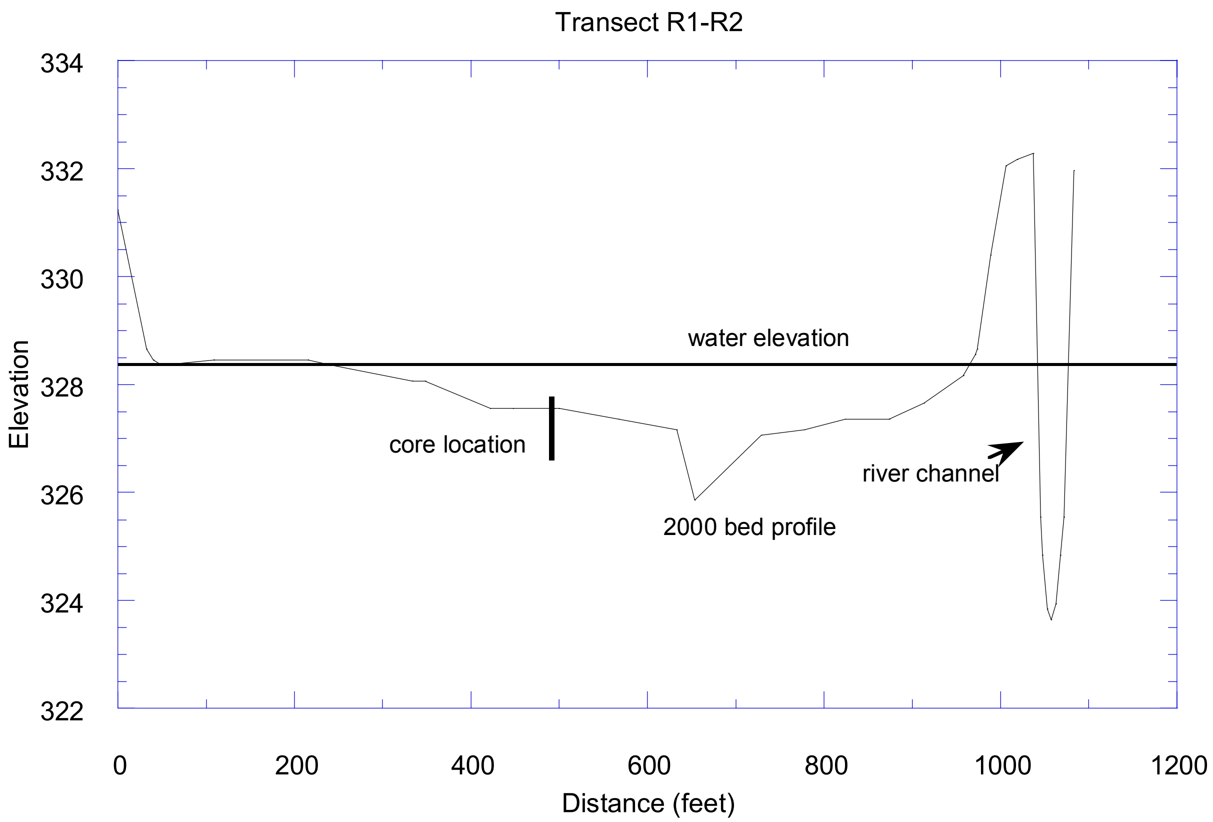
Muir, D.B., R.L. Hite, M.M. King, and M.R. Matson. 1995. *An Intensive Survey of the Cache River Basin, Summer 1992*. Illinois Environmental Protection Agency. IEPA/WPC/95-013, Springfield, IL.

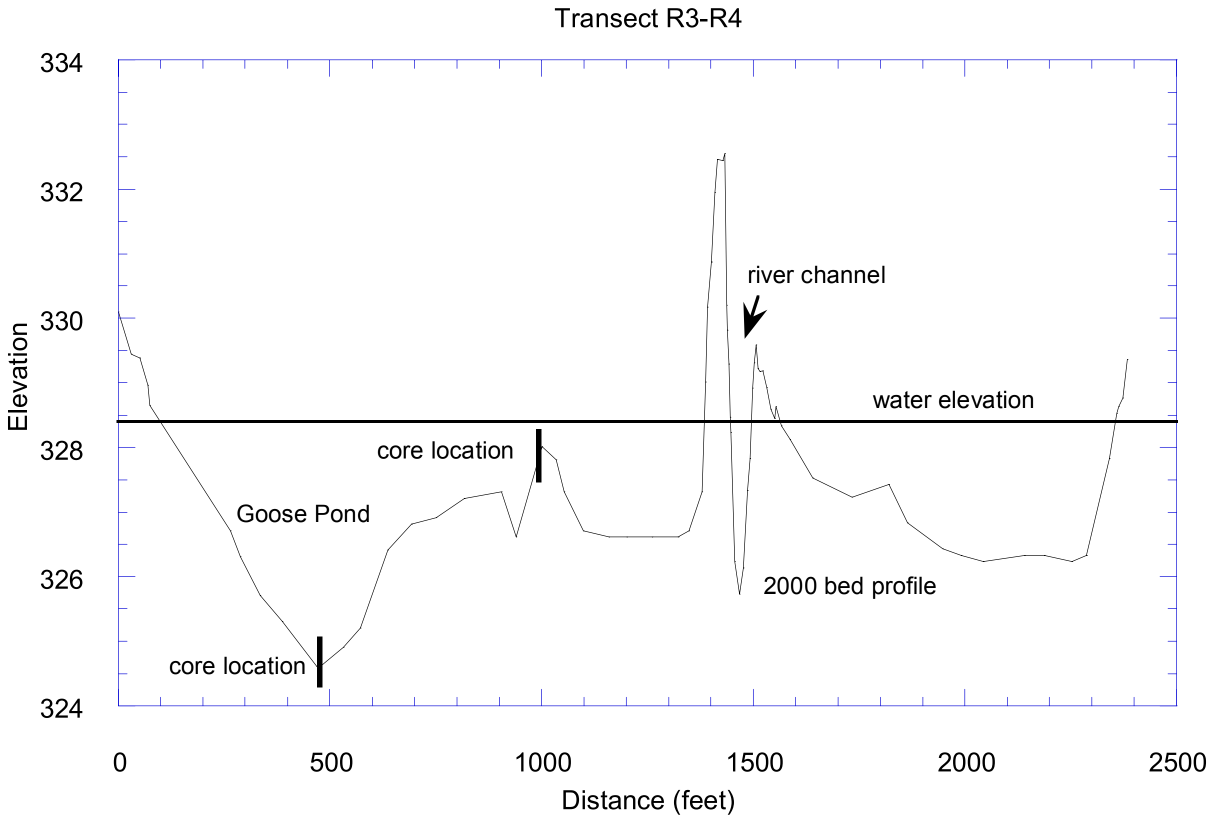
Ritchie, J.C., and J.R. McHenry. 1990. Application of Radioactive Fallout ^{137}Cs for Measuring Soil Erosion and Sediment Accumulation Rates and Patterns; A Review. *Journal of Environmental Quality* 19:215-233.

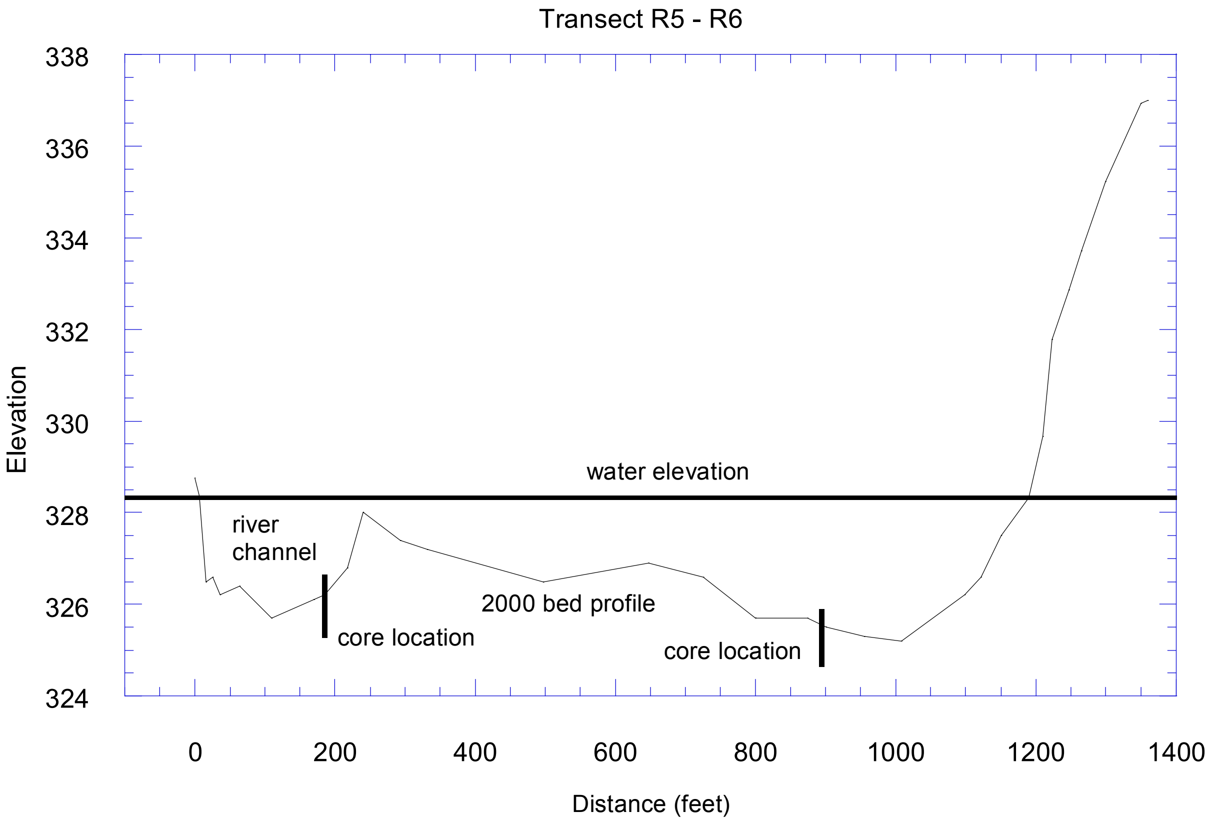
Robbins, J.A. and D.N. Edgington. 1975. Determination of Recent Sedimentation Rates in Lake Michigan using ^{210}Pb and ^{137}Cs. *Geochimica and Cosmochimica Acta*. 39: 285-304.

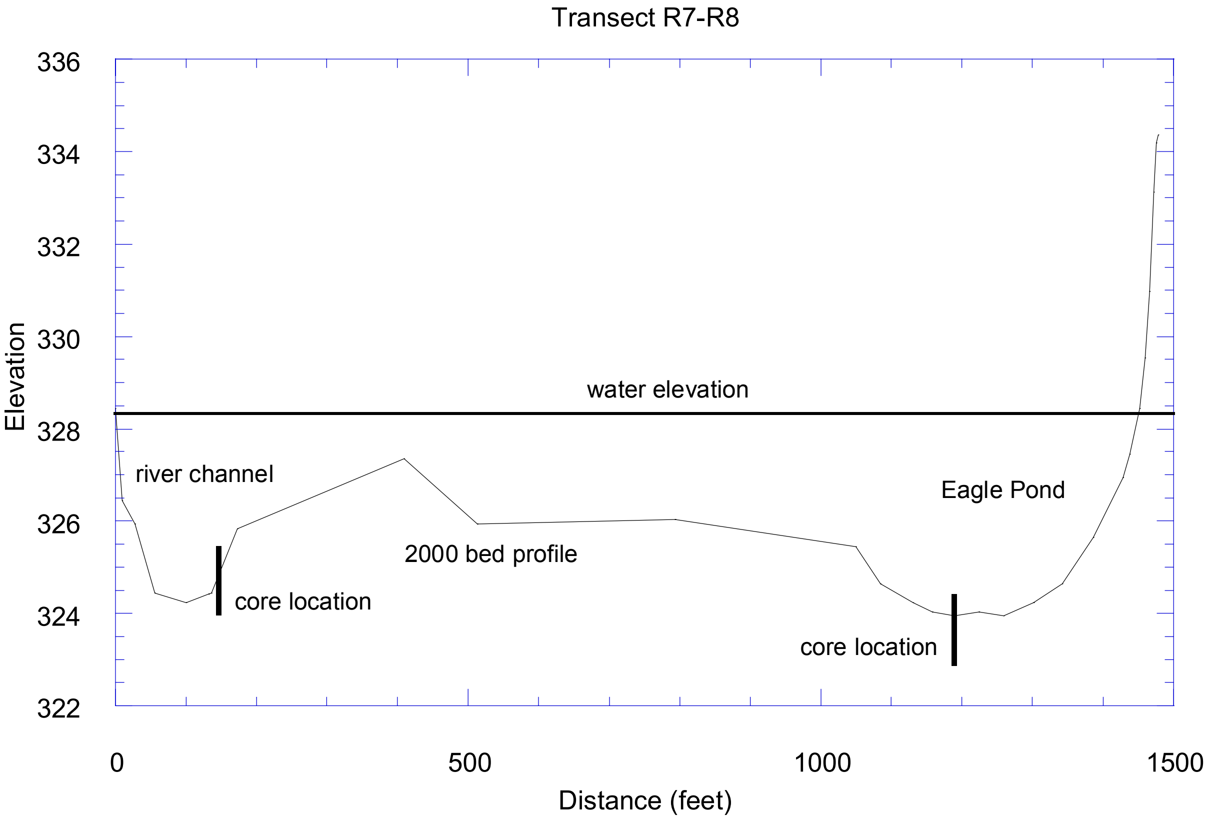
Santschi, P.H., and B.D. Honeyman. 1989. Radionuclides in Aquatic Environments. *International Journal of Radiation and Applied Instrumentation* 34:213-240. ILENR/RE-WR-92/07.

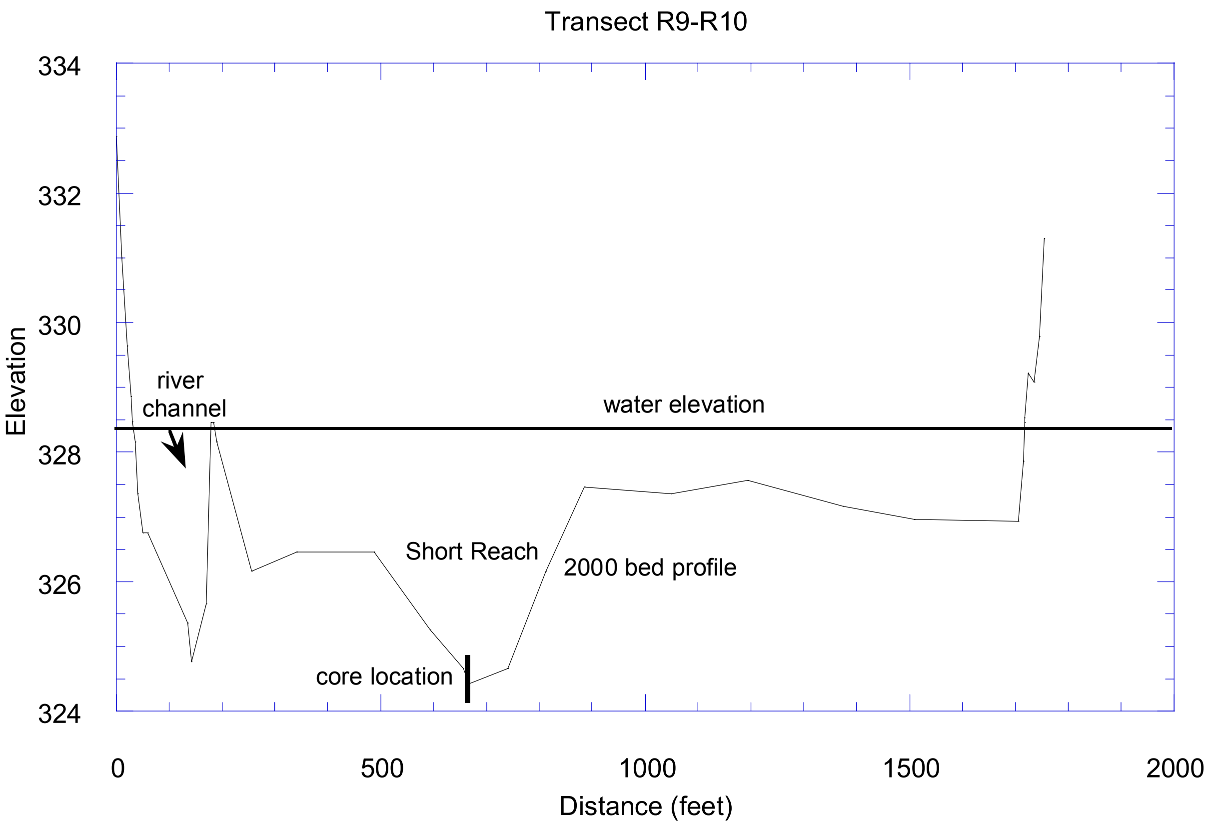
Appendix A: Plots of Transect Line Survey

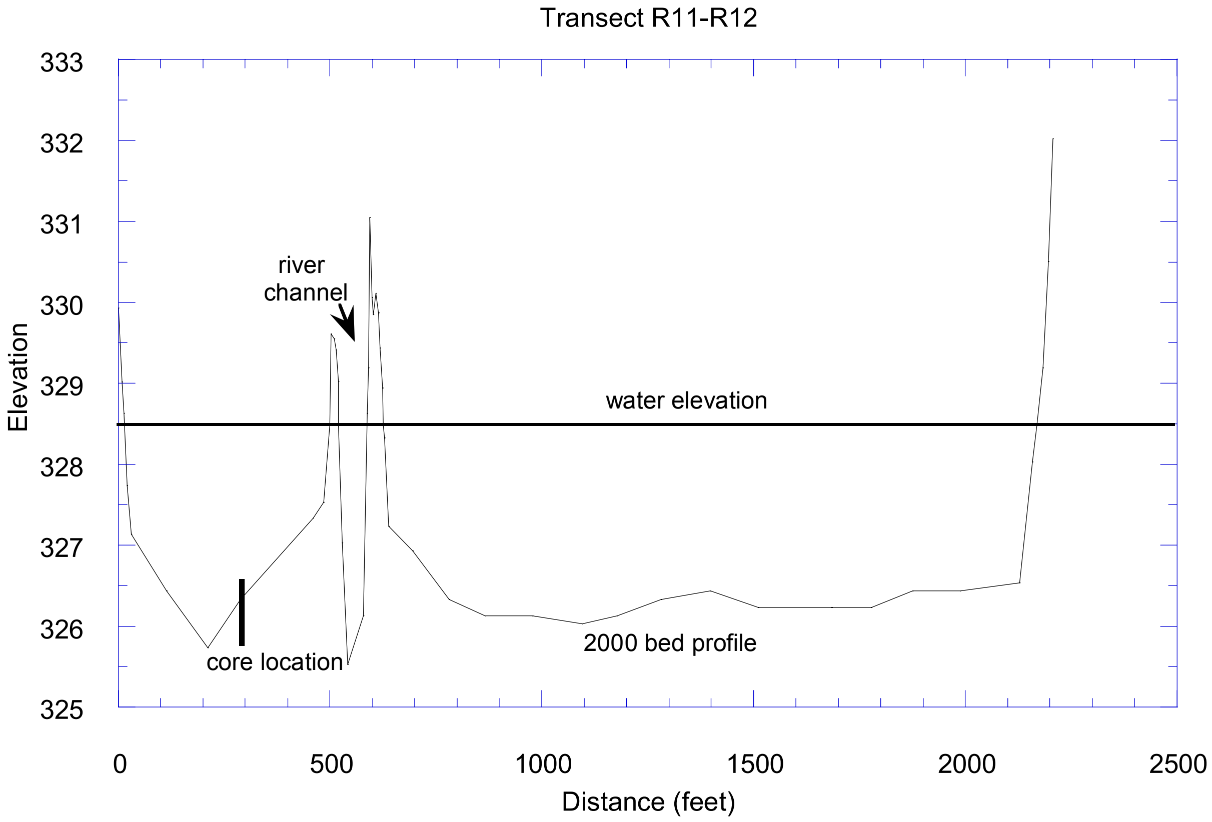

Transect R1-R2
334
332
330
328
326
324
322
Elevation
0
200
400
600
800
1000
1200
Distance (feet)
water elevation
core location
river channel
2000 bed profile

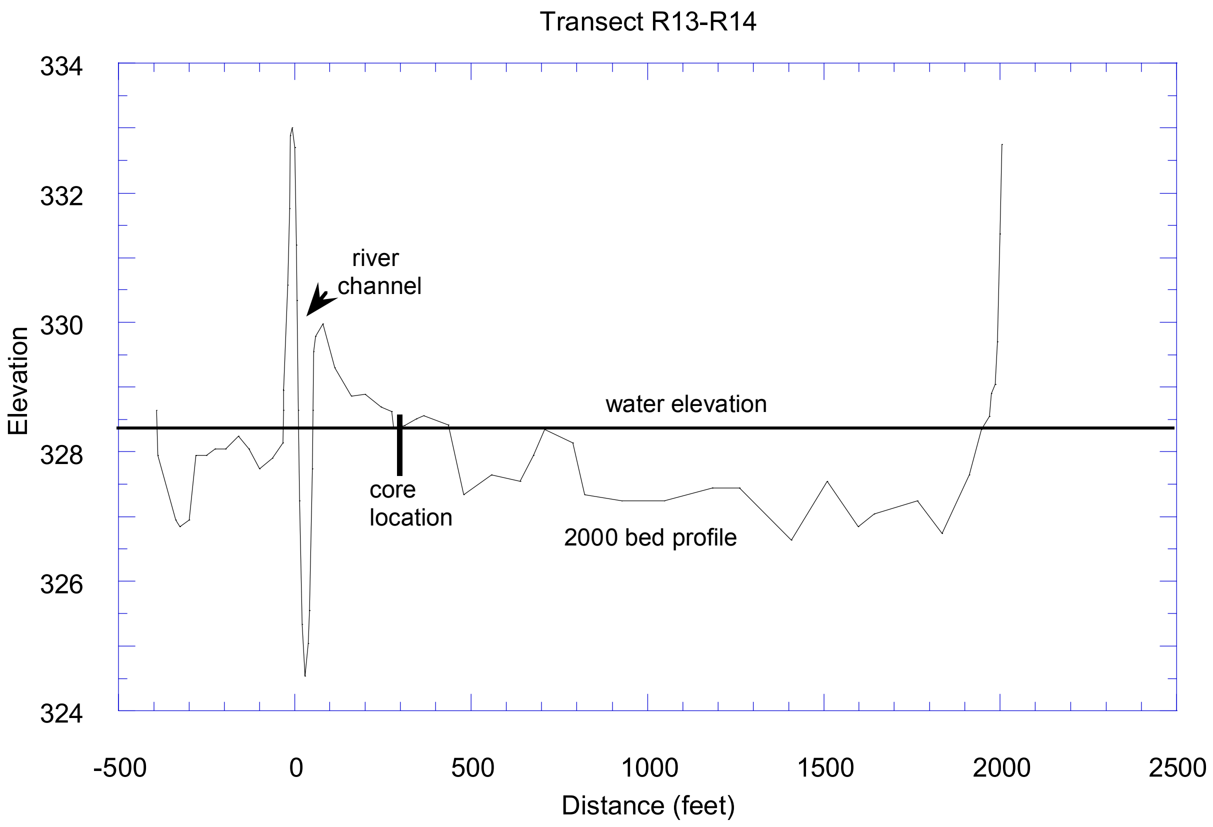

Transect R3-R4
334
332
330
328
326
324
Elevation
0
500
1000
1500
2000
2500
Distance (feet)
river channel
water elevation
core location
Goose Pond
2000 bed profile
core location

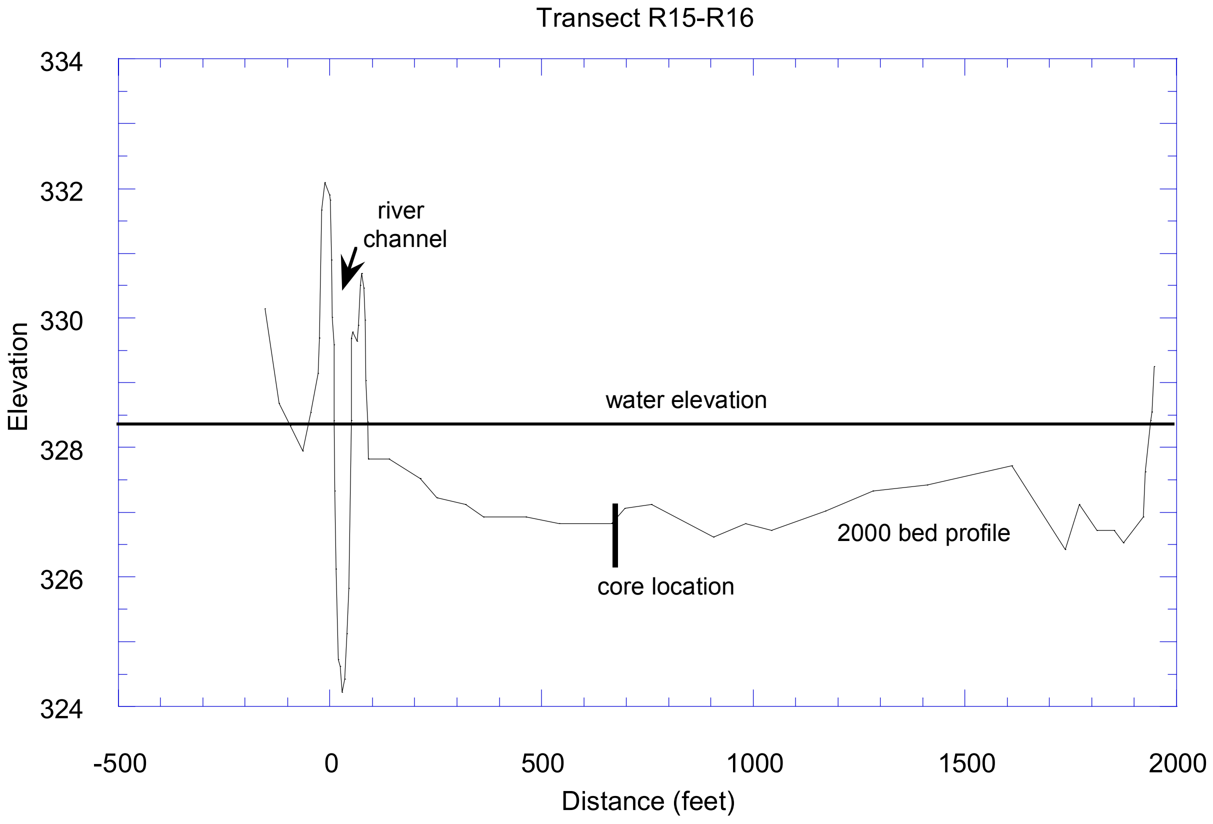

Transect R5 - R6
Elevation
338
336
334
332
330
328
326
324
0
200
400
600
800
1000
1200
1400
Distance (feet)
water elevation
river
channel
core location
2000 bed profile
core location

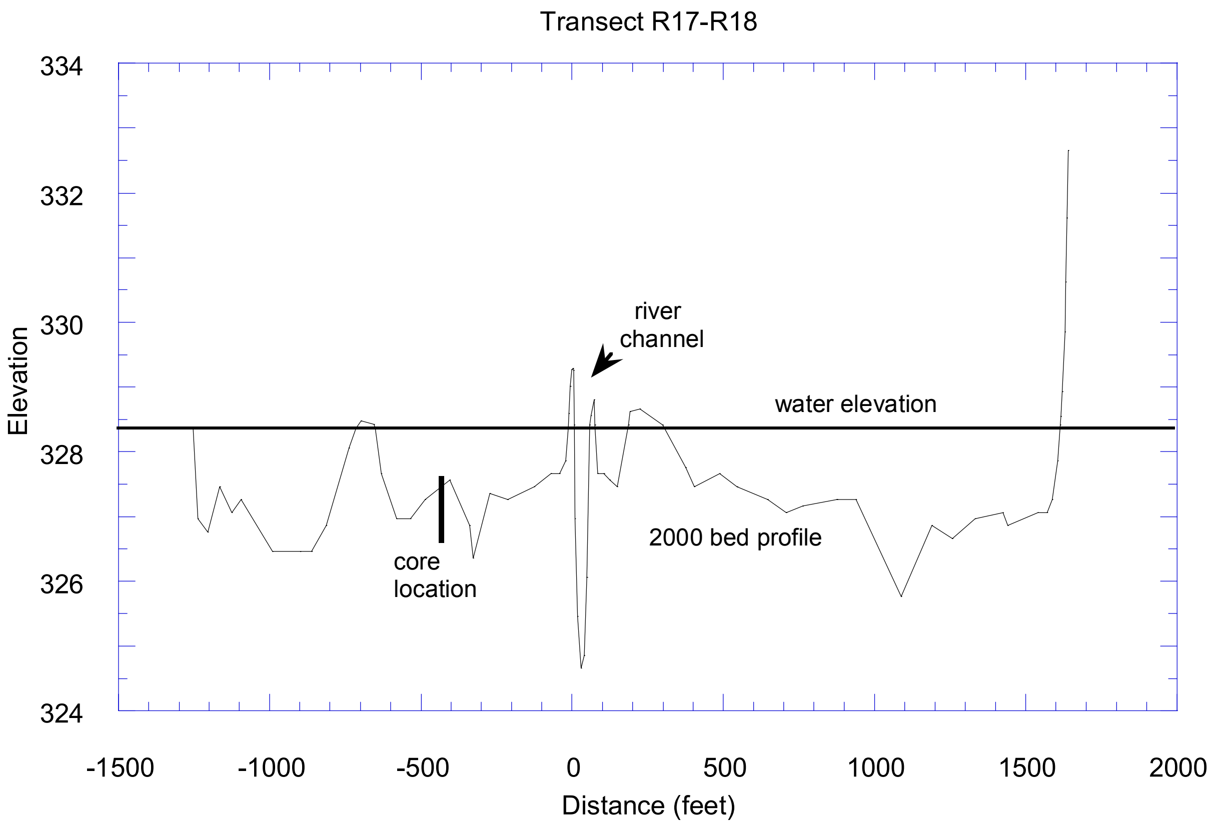

Transect R7-R8
Elevation
336
334
332
330
328
326
324
322
0
500
1000
1500
Distance (feet)
water elevation
river channel
core location
2000 bed profile
Eagle Pond
core location

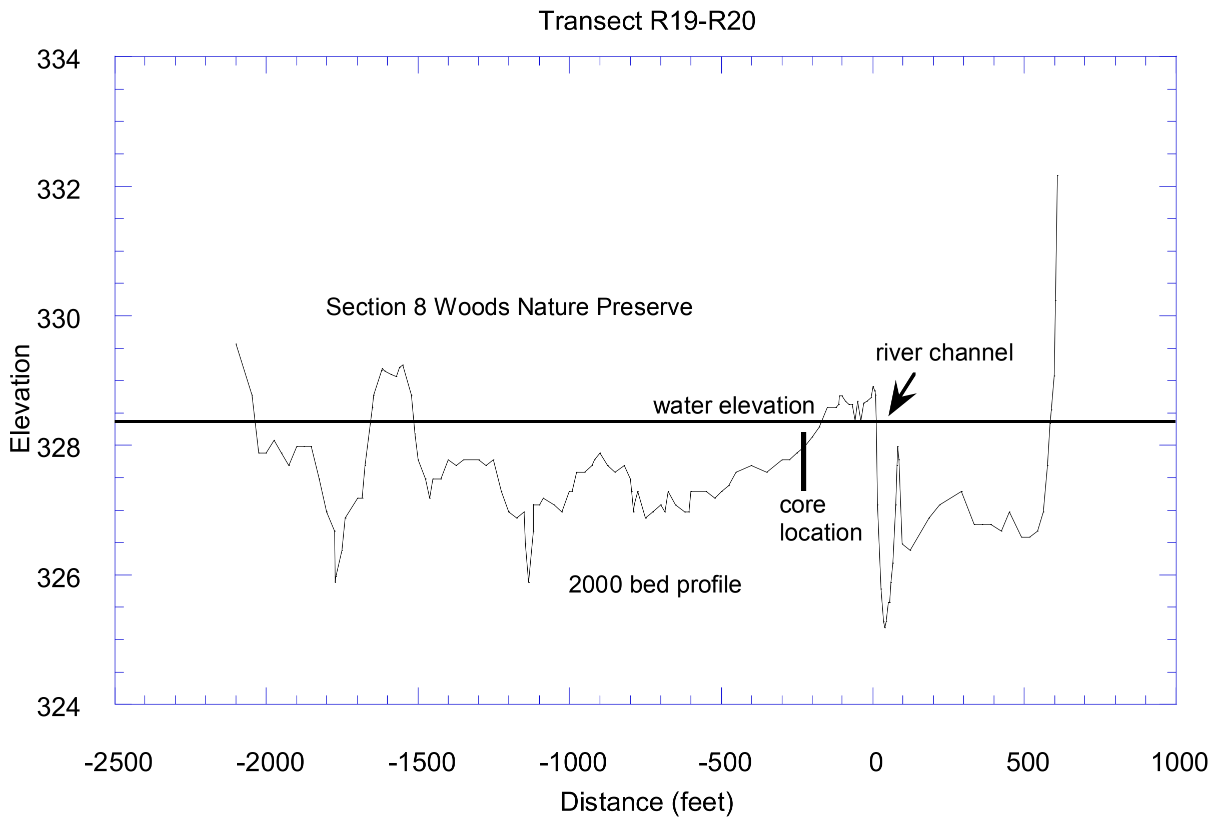

Transect R9-R10
334
332
330
328
326
324
Elevation
river channel
water elevation
Short Reach
2000 bed profile
core location
0
500
1000
1500
2000
Distance (feet)


Transect R11-R12
333
332
331
330
329
328
327
326
325
Elevation
river channel
water elevation
2000 bed profile
core location
0
500
1000
1500
2000
2500
Distance (feet)

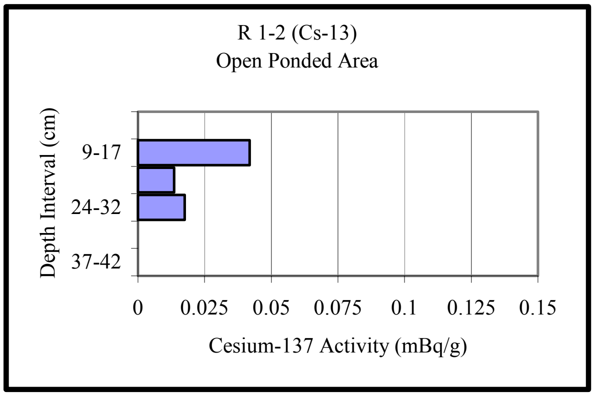

Transect R13-R14
334
332
330
328
326
324
Elevation
-500
0
500
1000
1500
2000
2500
Distance (feet)
river channel
water elevation
core location
2000 bed profile

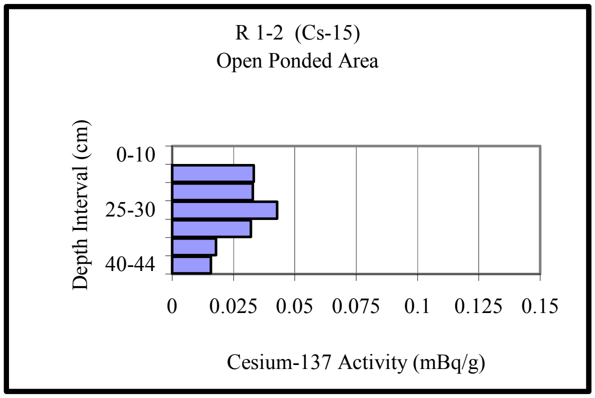

Transect R15-R16
334
332
330
328
326
324
Elevation
-500
0
500
1000
1500
2000
Distance (feet)
river channel
water elevation
2000 bed profile
core location

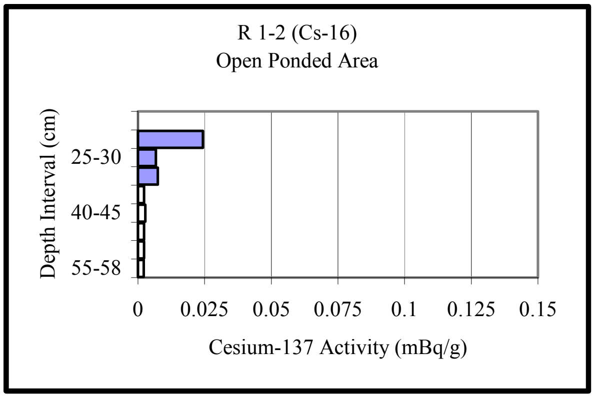

Transect R17-R18
334
332
330
328
326
324
Elevation
-1500
-1000
-500
0
500
1000
1500
2000
Distance (feet)
river
channel
water elevation
core
location
2000 bed profile

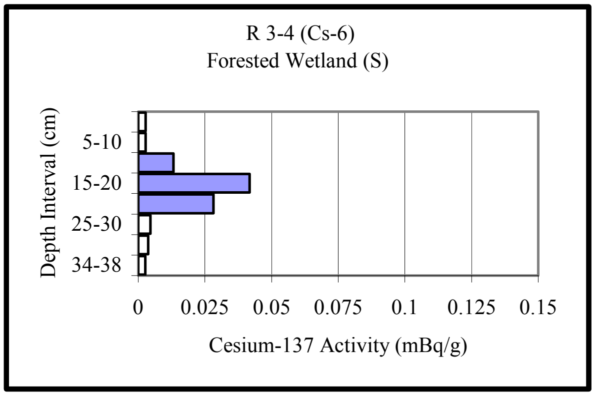

Transect R19-R20
334
332
330
328
326
324
Elevation
-2500
-2000
-1500
-1000
-500
0
500
1000
Distance (feet)
Section 8 Woods Nature Preserve
river channel
water elevation
core
location
2000 bed profile

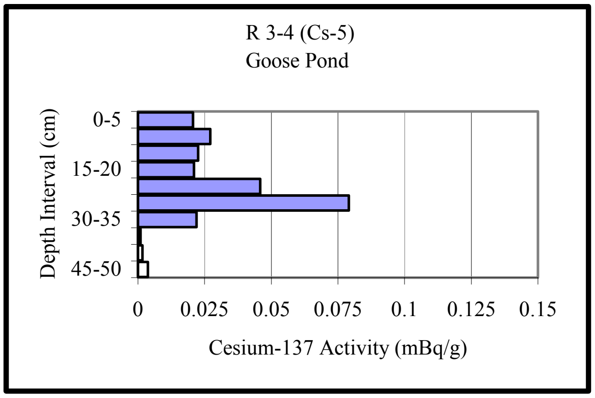
Appendix B: Plots of Cesium-137 Laboratory Analysis

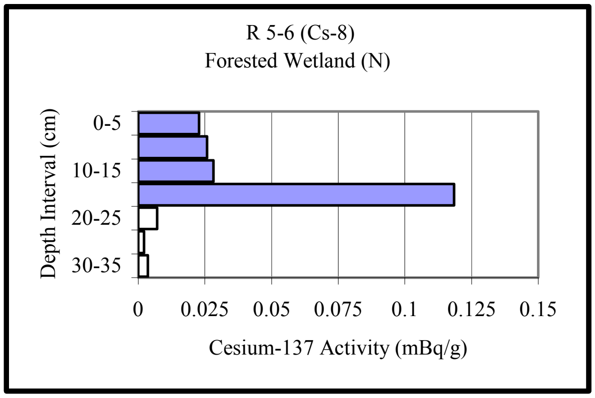

R 1-2 (Cs-13)
Open Ponded Area
Depth Interval (cm)
9-17
24-32
37-42
0
0.025
0.05
0.075
0.1
0.125
0.15
Cesium-137 Activity (mBq/g)

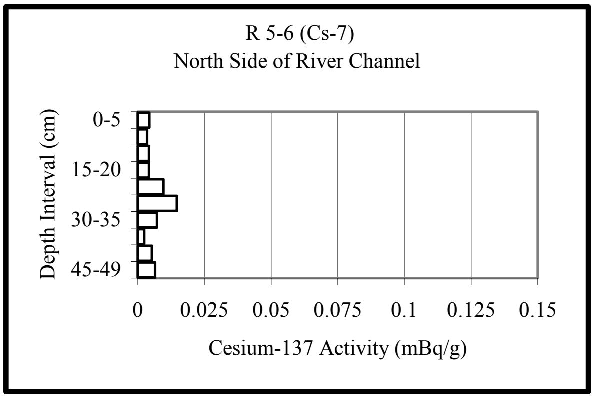

R 1-2 (Cs-15)
Open Ponded Area
Depth Interval (cm)
0-10
25-30
40-44
0
0.025
0.05
0.075
0.1
0.125
0.15
Cesium-137 Activity (mBq/g)

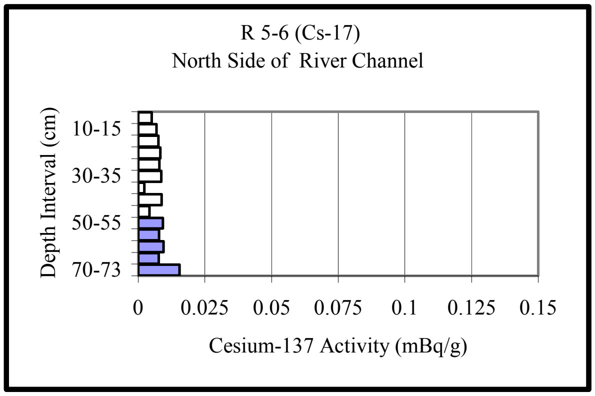

R 1-2 (Cs-16)
Open Ponded Area
Depth Interval (cm)
25-30
40-45
55-58
0
0.025
0.05
0.075
0.1
0.125
0.15
Cesium-137 Activity (mBq/g)

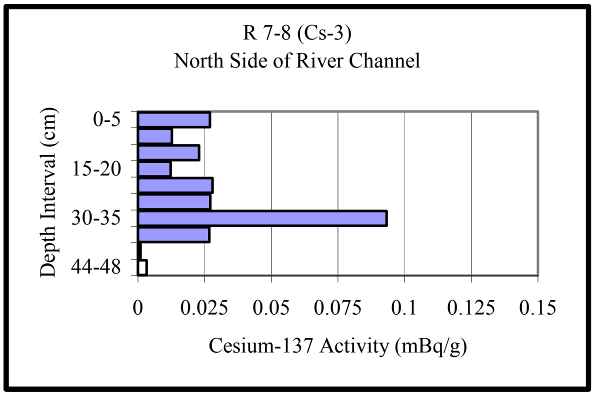

R 3-4 (Cs-6)
Forested Wetland (S)
Depth Interval (cm)
5-10
15-20
25-30
34-38
0
0.025
0.05
0.075
0.1
0.125
0.15
Cesium-137 Activity (mBq/g)

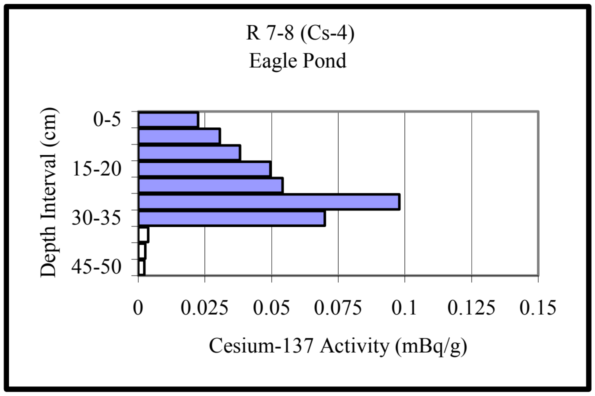

R 3-4 (Cs-5)
Goose Pond
Depth Interval (cm)
0-5
15-20
30-35
45-50
0
0.025
0.05
0.075
0.1
0.125
0.15
Cesium-137 Activity (mBq/g)

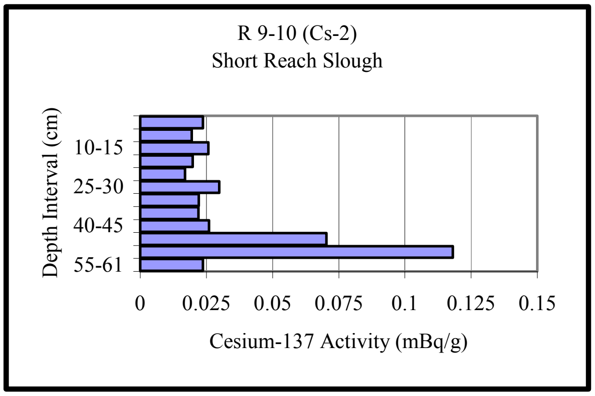

R 5-6 (Cs-8)
Forested Wetland (N)
Depth Interval (cm)
0-5
10-15
20-25
30-35
0
0.025
0.05
0.075
0.1
0.125
0.15
Cesium-137 Activity (mBq/g)

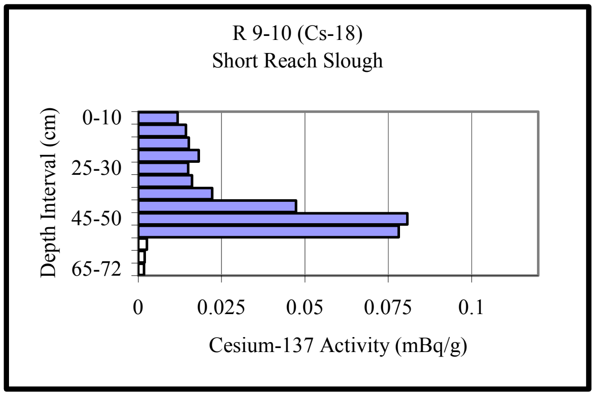

R 5-6 (Cs-7)
North Side of River Channel
Depth Interval (cm)
0-5
15-20
30-35
45-49
0
0.025
0.05
0.075
0.1
0.125
0.15
Cesium-137 Activity (mBq/g)

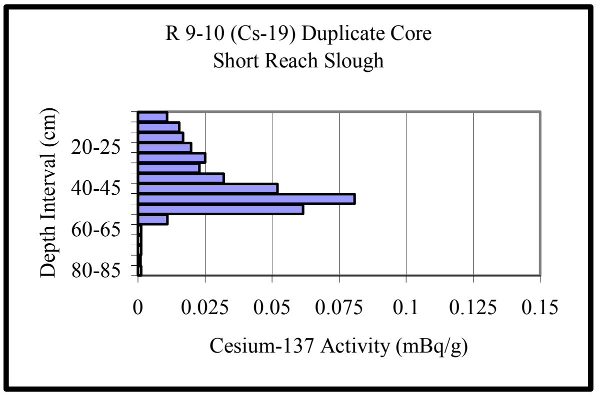

R 5-6 (Cs-17)
North Side of River Channel
Depth Interval (cm)
10-15
30-35
50-55
70-73
0
0.025
0.05
0.075
0.1
0.125
0.15
Cesium-137 Activity (mBq/g)

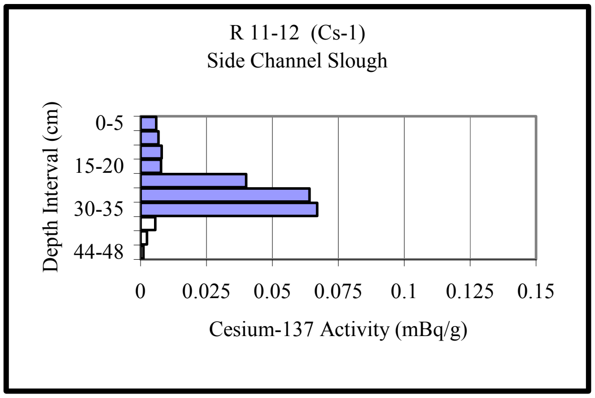

R 7-8 (Cs-3)
North Side of River Channel

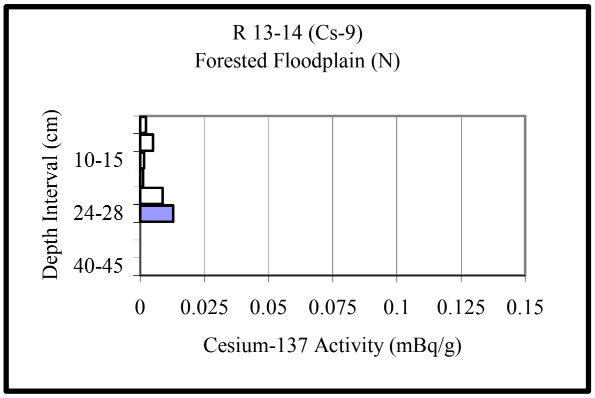

R 7-8 (Cs-4)
Eagle Pond

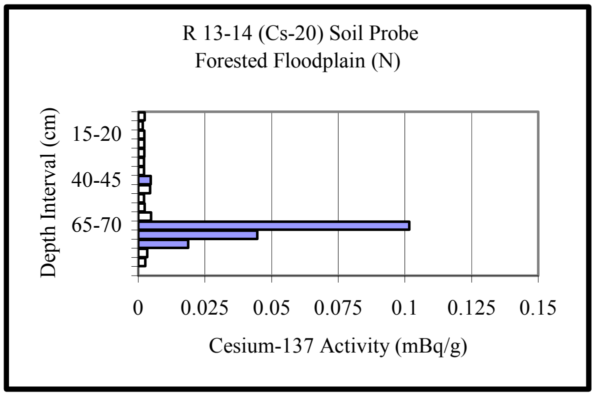

R 9-10 (Cs-2)
Short Reach Slough

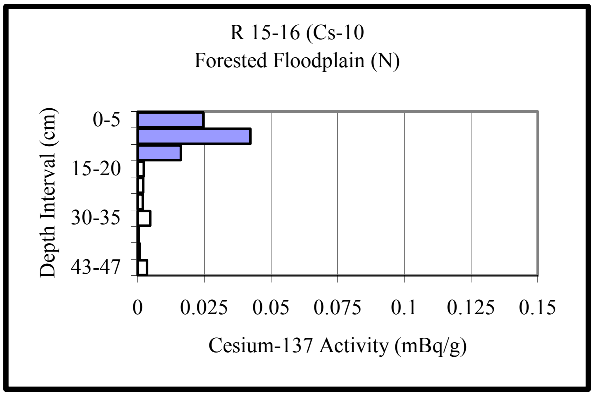

R 9-10 (Cs-18)
Short Reach Slough

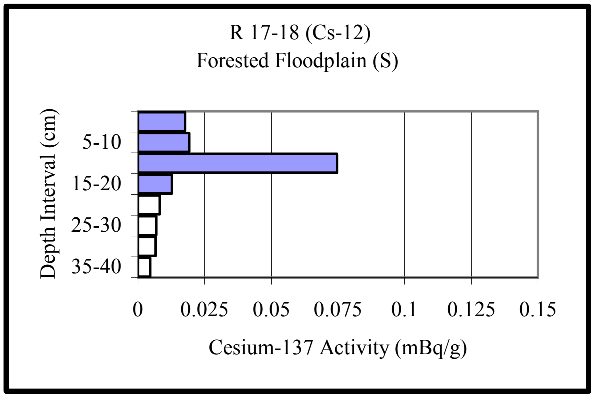

R 9-10 (Cs-19) Duplicate Core
Short Reach Slough

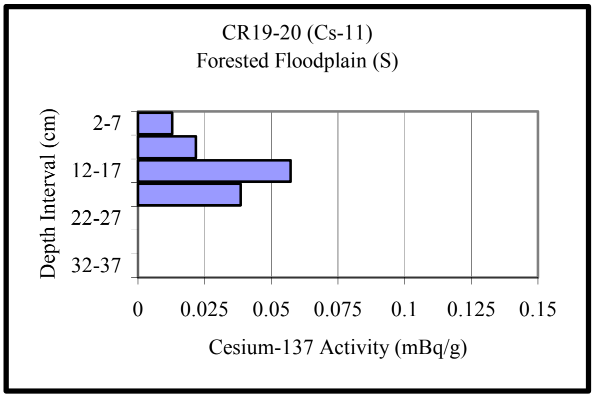

R 11-12 (Cs-1)
Side Channel Slough

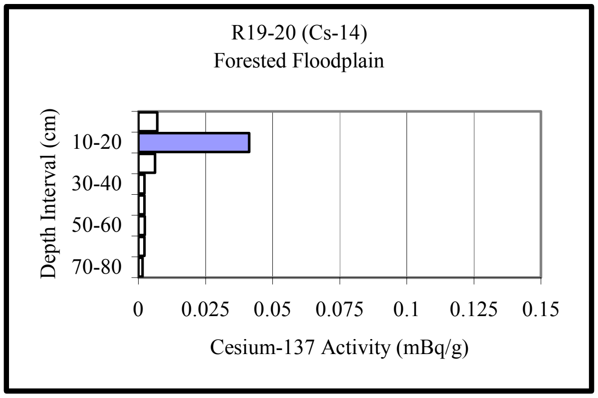

R 13-14 (Cs-9)
Forested Floodplain (N)

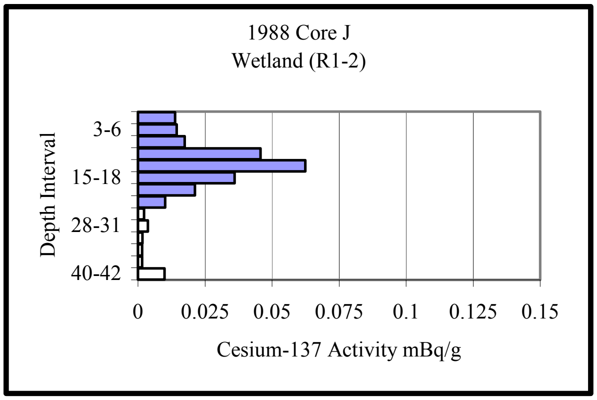

R 13-14 (Cs-20) Soil Probe
Forested Floodplain (N)

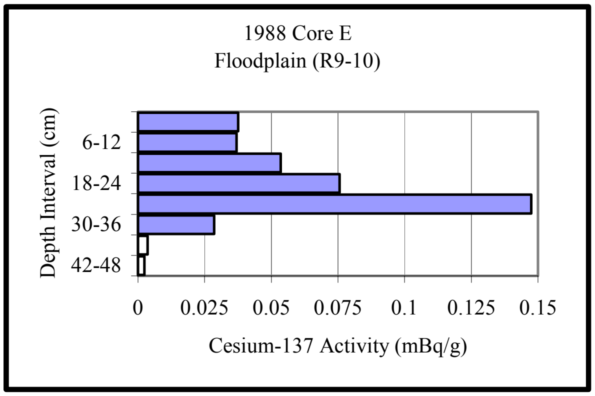

R 15-16 (Cs-10
Forested Floodplain (N)

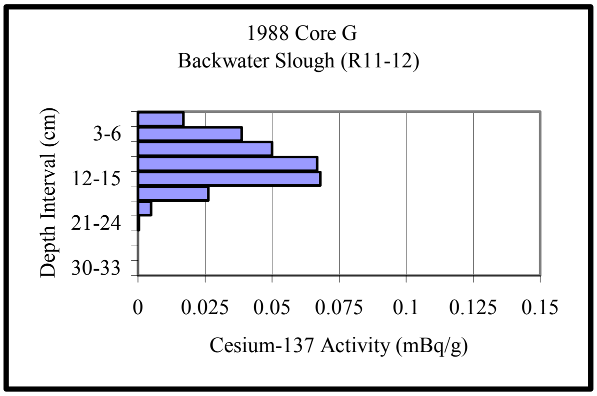

R 17-18 (Cs-12)
Forested Floodplain (S)

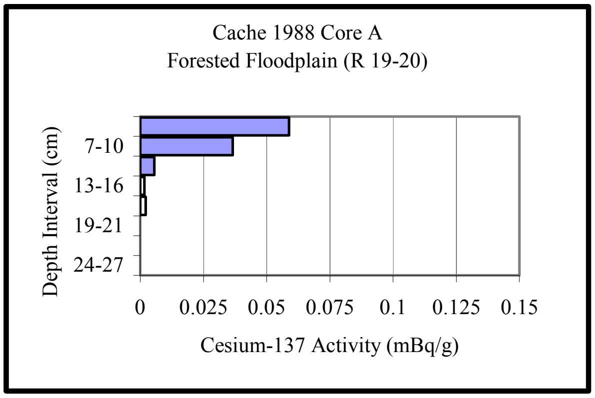

CR19-20 (Cs-11)
Forested Floodplain (S)


R19-20 (Cs-14)
Forested Floodplain


1988 Core J
Wetland (R1-2)


1988 Core E
Floodplain (R9-10)


1988 Core G
Backwater Slough (R11-12)


Cache 1988 Core A
Forested Floodplain (R 19-20)

ILLINOIS
DEPARTMENT OF
NATURAL
RESOURCES