CHANNEL CHANGES ALONG A MODIFED FLOODPLAIN: LEAF RIVER, MISSISSIPPI

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ABSTRACT

As part of a larger study involving a geomorphic assessment of the Pascagoula drainage in Mississippi, this paper discusses the preliminary interpretations of channel changes on the Leaf River from a cross-sectional perspective, based primarily on historic USGS data. The continuous gage stations on the Leaf River were evaluated for trends indicating aggradation or degradation using discharge summary data. Several stations have data collected before 1940. Historic cross sections were plotted at both these continuous and a few other discontinuous gage locations with sufficient data. Research on spatial patterns and temporal relationships of channel changes is important because channel instability has numerous ramifications to the environment and private and public properties. Elucidating and quantifying these relationships can assist in defining and refining state regulations regarding floodplain activities, including those associated with deforestation, agriculture, mining and development.

Of the four continuous locations on the Leaf River, the two upstream sites show some (Collins) to pronounced (Hattiesburg) decreases of about 1 and 2m in mean bed elevation and 0.5 and 4m in thalweg elevation. Hattiesburg also shows an increase in maximum depth of about 1.5m, changing most rapidly during the 1970s, and stabilizing since then, possibly due to in-channel mining in the Bowie River, a tributary that joins it just upstream of the gage site. Other types of geomorphic changes are not pronounced and inconsistent. The two downstream sites (New Augusta, McLain) show increases in mean bed elevation of 1m and thalweg elevation to 3m, increases in width and larger increases width-depth ratio.

This study also characterizes several episodes of possible lateral migration and other changes identified from plots of historic cross sections. Several possible changes are listed, and through continuing work more evidence and analysis will help to establish which of these occurred and to gather further information about the timing and magnitude of these possible changes in planform and profile.

INTRODUCTION

While becoming increasingly common, the ramifications associated with river instability are numerous (Bull, 1973, Graf, 1979, Kondolf, 1994, Mossa, 1995, Mossa and McLean, 1997). Problems include: bank erosion and riparian property disputes associated with channel shifting, which sometimes leads to litigation; structural problems associated with undermining or filling at bridges and reservoirs; changes in channel capacity which affect flood patterns and increases the need for flood control; changes in floodplain habitat and effects to aquatic biota; and reductions in the quantity and diversity of fishes and mussels (e.g. Allan and Flecker, 1993; Brim Box and Mossa, 1999). Thus, it is important to riparian property owners, state and federal regulators, local communities and governments, industries, as well as other scientists and other individuals, to understand spatial and temporal variations of river channels, and how various factors contribute to instability and channel change.

This paper describes preliminary findings of channel changes interpreted from historical cross-section data along the Leaf River. Using U.S. Geological Survey discharge measurements at various locations, this paper describes which of these sites shows channel change, discusses the types and magnitude of channel change such as degradation or aggradation and widening or narrowing, discusses the timing of these changes, and where possible, if it might be connected to historical activities, such as land use changes. Two major types of data were used: 1) instantaneous measurements or cross sections; and 2) discharge summary measurements. Although not intended for geomorphology, discharge measurements contain much surrogate information that can assist in characterizing changes in channel form (e.g. Leopold and Maddock, 1953; Leopold and others, 1964; Gregory and Walling, 1973; Knighton, 1974, 1975). Discussed herein are interim findings based on work conducted exclusively in the first year of a three-year project. As with other secondary historical data sources, the inferences are made from the available information to-date, and more understanding will likely be garnered as the project progresses as more relevant data are gathered and analyses are performed towards the objectives of this study.

STUDY AREA

The Leaf River occupies the northwestern portion of the Pascagoula basin and drains about 9280 km2 (3580 mi2) (Fig. 1-1). The Pascagoula River drains southward into the Mississippi Sound, which is a portion of the Gulf of Mexico. The longitudinal profile of the Leaf River shows differences between high and low water, major knickpoints and the declining slopes in the Pascagoula (Pat Harrison Waterway District, 1973) (Fig. 1-2). The topography is generally rolling to hilly with low to moderate relief, with the highest elevations in the basin exceeding 500 ft (160m) (Fig.1-3). The basin has a varied geology of Cenozoic sediments and sedimentary rocks further characterized in Li and Maylen (1994) and Maylen and Li (1995). The state of Mississippi has abundant rainfall, with different locations in the basin averaging from 1300 to over 1700 mm (52 to 68 in) annually, yet some years average four times the flow as other years (Lamonds and Boswell, 1985). The land cover/land use throughout the basin is largely forested, both in silviculture and national forest, with some areas of pasture, farming, residential areas, and mining (Slack, 1991). In general, the basin is generally considered to have much less human alteration than most basins of this size. There are comparatively few large impoundments in the basin compared to the region or country as a whole. However, there are numerous small farm impoundments, privately-built dams, and recreational impoundments or water parks (Bowen, personal comm.), but most streams in the basin are largely unregulated (Lamonds and Boswell, 1985).

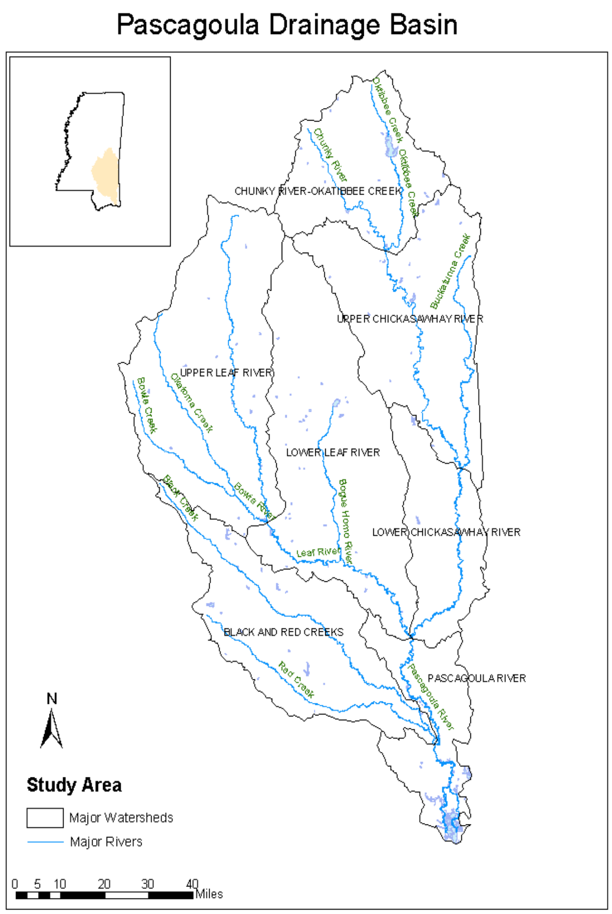


Figure 1-1. Major subbasins of the Pascagoula Basin.

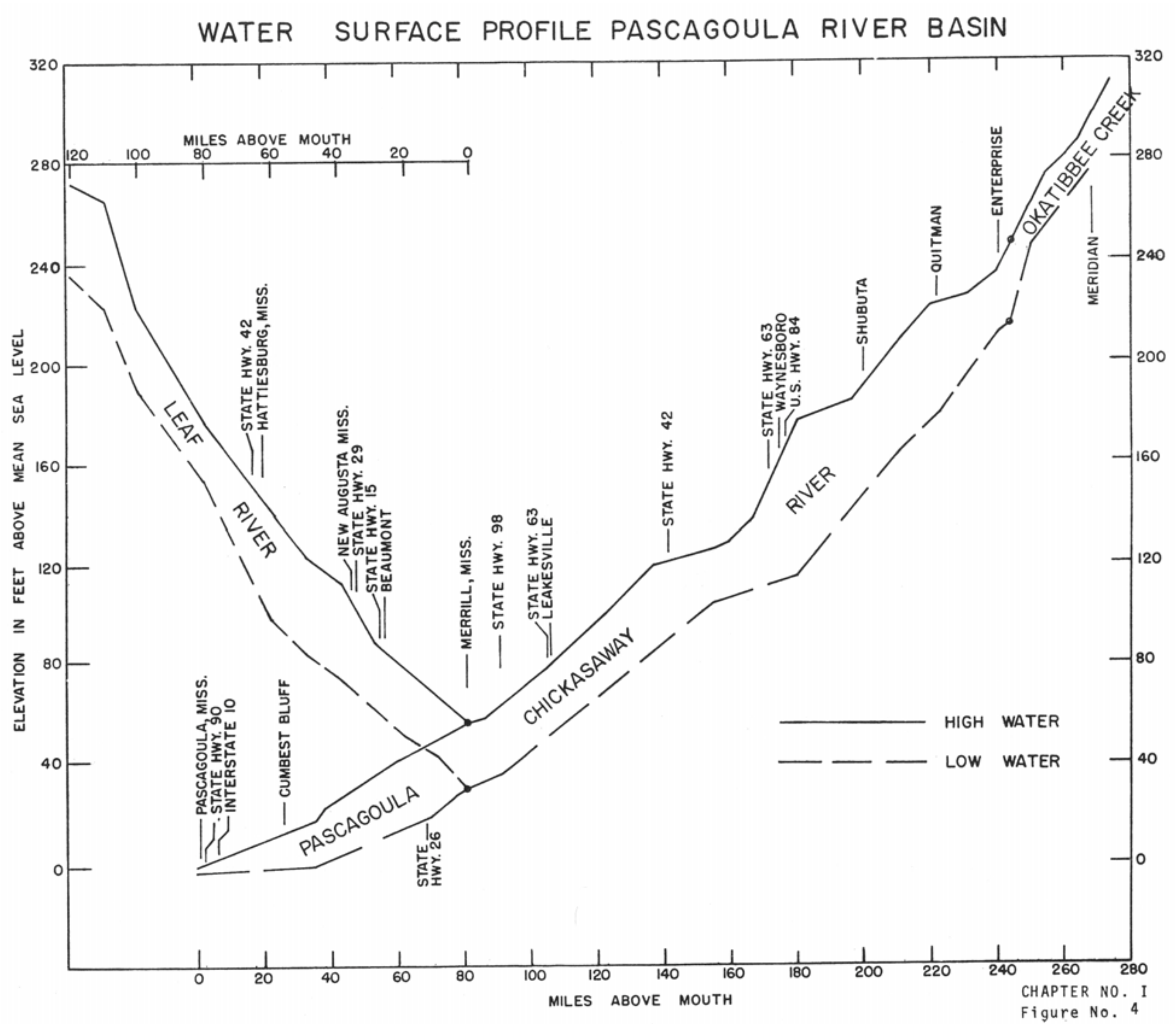


Figure 1-2. Longitudinal profile of the Leaf, Chickasawhay and Pascagoula Rivers, showing differences between high and low water, major knickpoints and the declining slope in the Pascagoula (from Pat Harrison Waterway District, 1973).

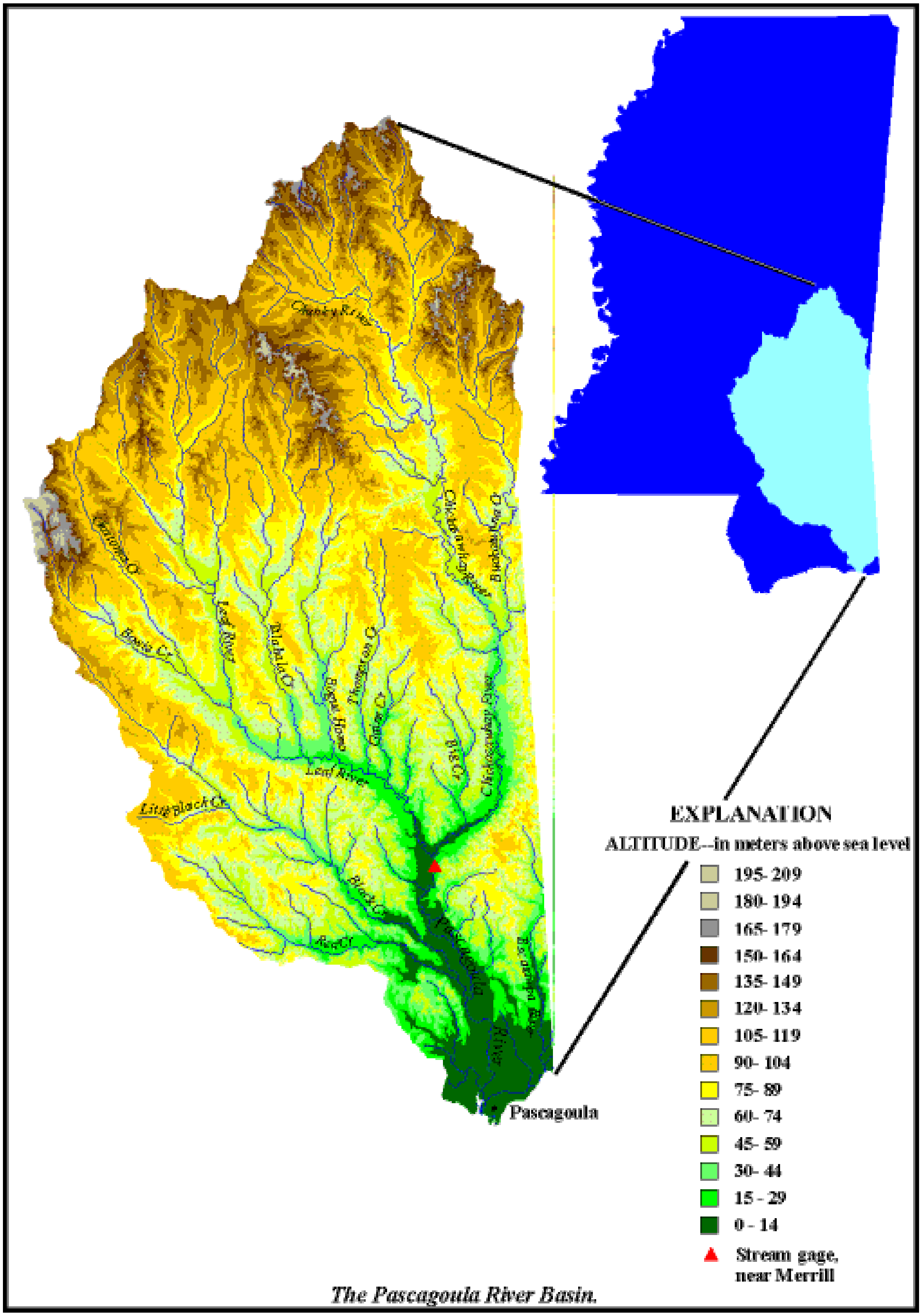


Figure 1-3. Elevations in the Pascagoula River Basin
(from http://wwwmswater.usgs.gov/ms_proj/eric/pasca.html)

TERMINOLOGY AND TYPES OF GEOMORPHIC CHANGE

Because rivers are three-dimensional, but are most easily depicted in two dimensions, there are three different geometric perspectives from which rivers are examined through time or space. The type of geomorphic change that can be documented depends upon the type of data available for comparisons. One view is the cross-sectional perspective, which shows the bed elevation and channel depths versus the distance across the valley, floodplain, or channel (x versus z) (Fig. 1-4). This perspective can illustrate varied changes that include channel widening, narrowing, deepening or filling. Another is the planform perspective, such as from a map, aerial photograph, or a bird-eye view, which shows distance along and distance across the valley, floodplain or channel (x versus y). This can show changes in channel position, meander cutoffs, changes in channel form such as widening or narrowing, changes in sinuosity, and various forms of lateral migration. The third perspective is the longitudinal profile, which shows water or bed surface elevation versus distance along the channel or valley (y versus z). This perspective best illustrates various types of knickpoints, including waterfalls and rapids (Fig. 1-2), and at the reach scale it can show bed variations such as riffles, which are local shallow areas, and pools, which are locally deep. The planform dimensions are linked to the longitudinal and cross-sectional dimensions, where bendways generally correspond with pools and straight reaches with riffles in meandering rivers. Of course, some combination of these changes may occur, as well as no change that is discernible, documentable or observable, at least from that perspective at that particular location with the available data. It is particularly difficult to make interpretations or conclusions if the historical data are short-term (<20 years) and/or collected infrequently, or have large time gaps where the data were not collected or collected in a different manner (e.g., only during floods).

If appropriate data are available it is generally a straightforward process to document the types and magnitude of geomorphic changes. However, determining the causes of change is more complicated. Degradation and aggradation may be caused by natural factors or may be the result of one or more direct stream alterations or basin modifications, including land use activities. Factors that may affect long-term bed elevation changes are dams and reservoirs located either upstream or downstream of the bridge, change in watershed land use (urbanization, deforestation, etc.), channelization, cutoffs of meander bends (natural or human-induced), changes in the downstream base level, in-channel or floodplain sand and gravel mining, flow diversions, lowering of the entire system in response to regional uplift, and bridge location with respect to stream planform and subsequent stream movement in relation to the crossing (Richardson et al., 1991).

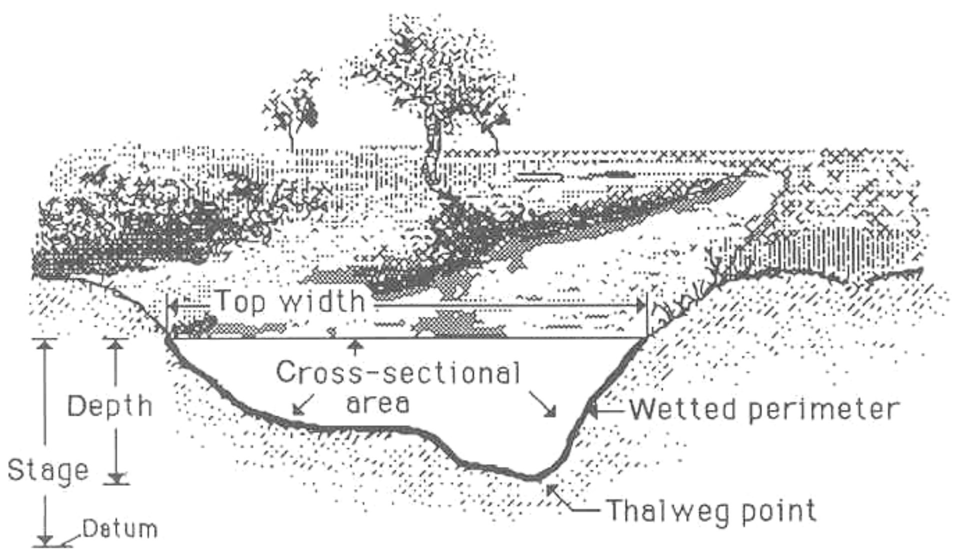


Figure 1-4. A generalized diagram of measurement of a stream cross section showing some of the variables that can be characterized from this perspective (from Gordon and others, 1992).

RELEVANT PRIOR WORK

Only few studies have evaluated geomorphology or channel change at sites in the Leaf River basin. Although this study has more analysis than prior works, the conclusions and interpretations of others reported in this section generally agree with the findings of this study.

Turnipseed (1993) examined channel changes at the Leaf River near McLain, using both historic cross sections and aerial photographs to evaluate planform change in the vicinity of the bridges (Figs.1-5 and 1-6). He documented some changes in meanders, but none located near either the existing or proposed bridges. No lateral movement was detected at the bridge sites, but a maximum of 440 ft of westward movement on the east bank and about 120 ft of westward movement of the west bank occurred upstream of the proposed Hwy 98 crossing on the Leaf River near McLain. There was also significant scouring of the thalweg, about 2.5m (7 to 8 ft), during floods.

As part of a larger study of scour at bridges, Wilson (1995) evaluated 4 sites on the Leaf. He plotted minimum bed elevations or thalweg elevations vs. time for the Leaf River at Hattiesburg, which showed large variation 9.5 m (29 ft) in thalweg elevation and a trend of declining average thalweg elevations throughout the period of record of about 1.5 m (5 ft) (Fig. 1-7). This large quantity of change was unexpected and attributed to mining of the Bowie River.

Brown and Mitchell (1995) examined two sites to examine impacts of American Sand and Gravel mining operations on the Bowie River. The most pertinent data analyzed in the study were annual minimum elevations on the Bowie River at U.S. Highway 49 and the Leaf River at U.S. Highway 11, both in Hattiesburg. Evaluating one point annually from 1961, when this company was actively mining the river, to the late 1980s, when the evaluation period ended, they determined that there was no discernible change at the Bowie River gage and that has been channel deepening on the Leaf River on the order of 0.3 m (1 ft) for every 10 years in the nearly 30-year period (Fig.1-8).

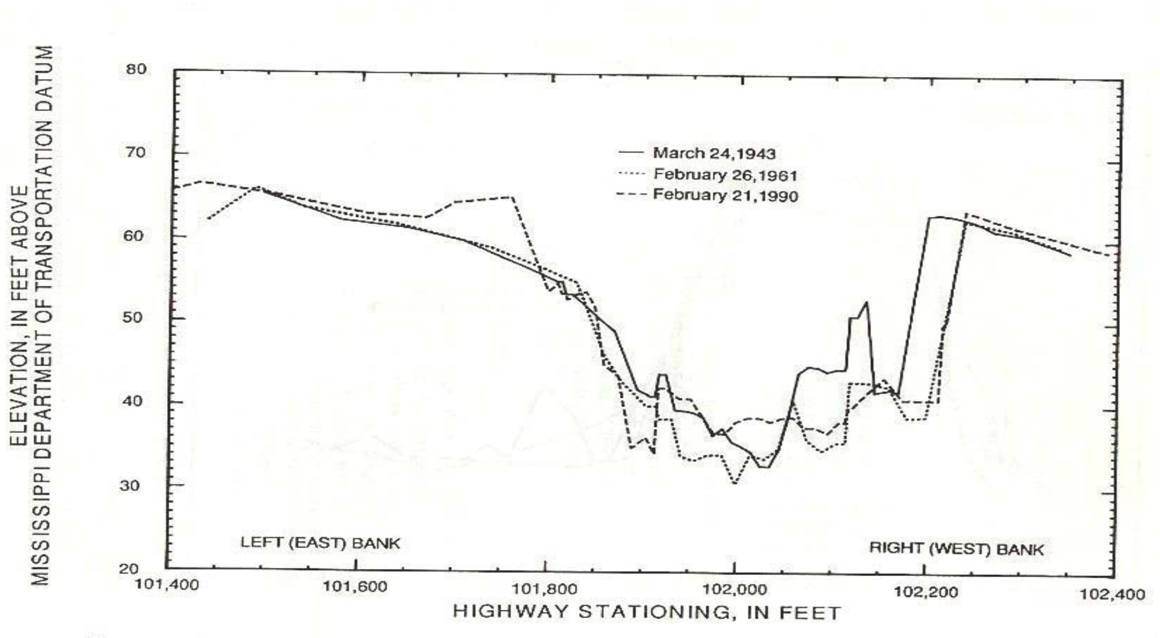


Figure 1-5. Cross-sectional changes at the Leaf River near McLain, Mississippi (from Turnipseed, 1993).

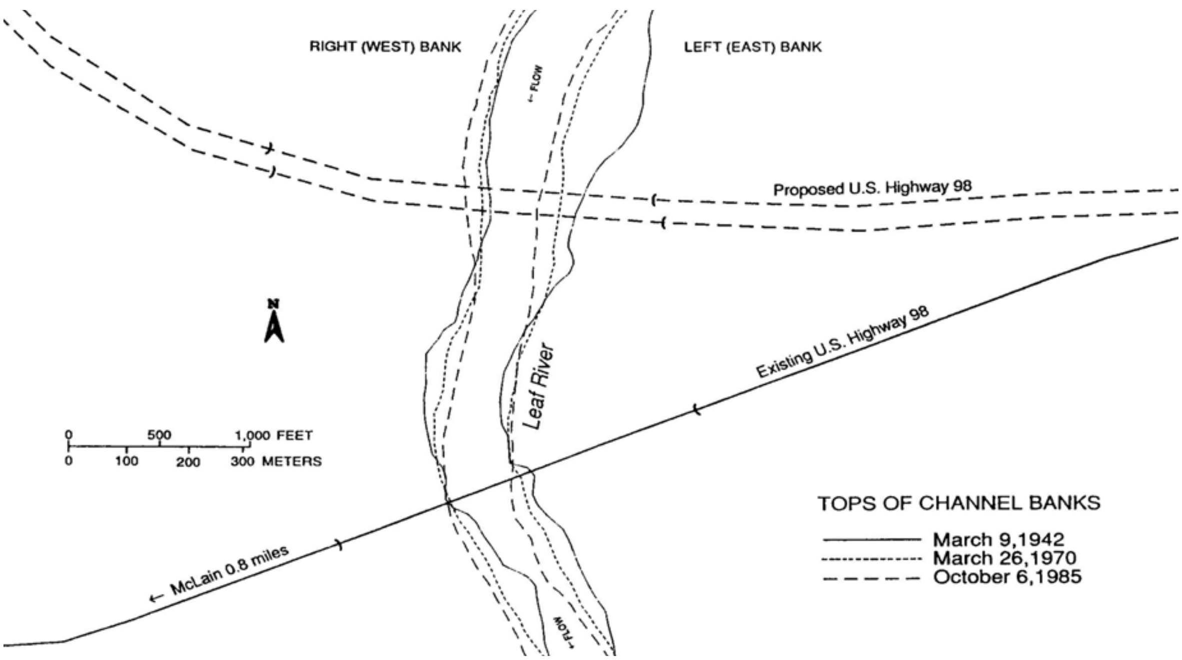


Figure 1-6. Planform channel changes in the vicinity of the bridge at the Leaf River near McLain, Mississippi (from Turnipseed, 1993).

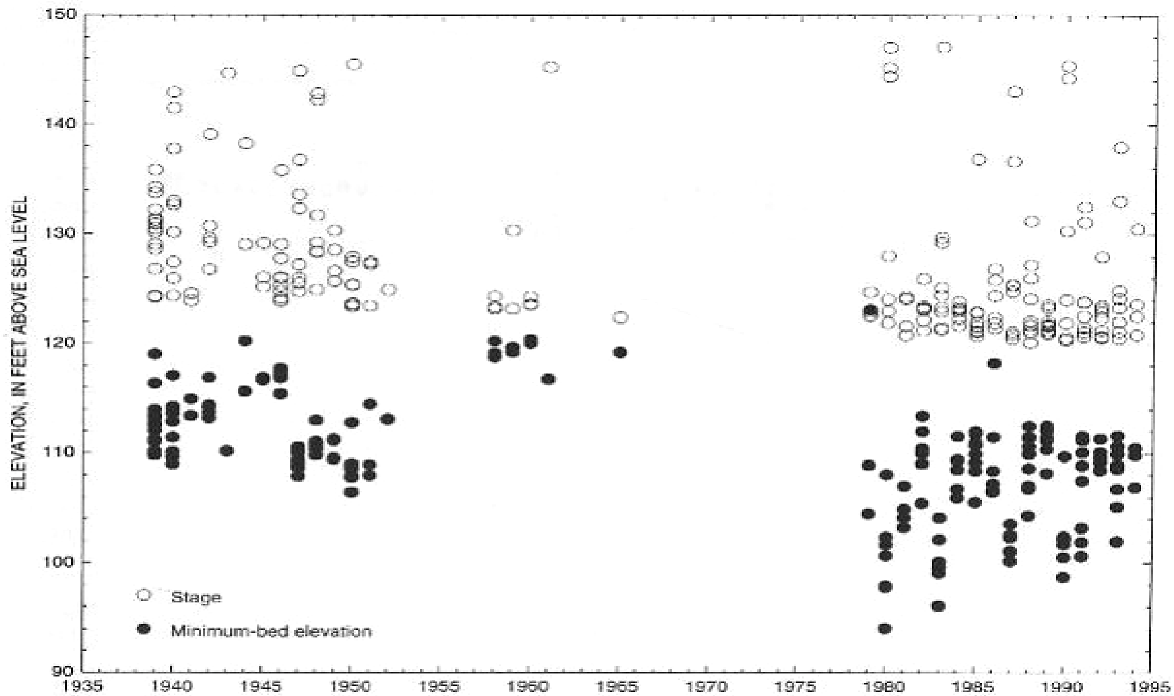


Figure 1-7. Changes in adjusted stage and minimum bed elevation with time for the Leaf River at Hattiesburg, Mississippi (from Wilson, 1995).

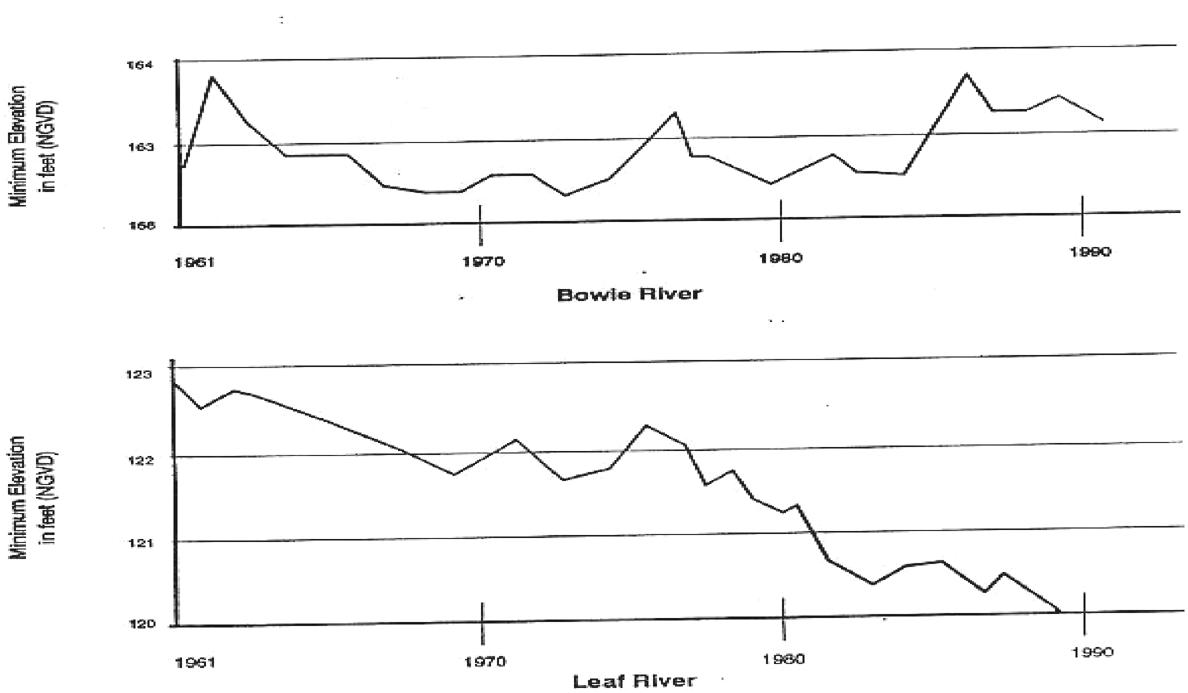


Figure 1-8. Changes in annual minimum bed elevation with time for the Bowie River near Hattiesburg and the Leaf River at Hattiesburg, Mississippi (from Brown and Mitchell, 1995).

METHODS

The use of historical secondary data sources is an established approach for understanding rivers and their changes (Trimble and Cooke, 1991). One of the most useful types of secondary data for evaluation of channel changes are cross sectional discharge measurements collected by the U.S. Geological Survey, Water Resources Division. Advantages of such data include the ability to monitor changes over reasonably long time periods, and a better temporal resolution than many data sets, including data collection during floods.

Site selection was limited to stations located at bridges where measurements were collected at least through some time in the last decade. Sites with continuous data included Collins, Hattiesburg, New Augusta, and McLain (Fig. 1-9; Figs. 2-1 to 2-6, 3-1 to 3-6, 4-1 to 4-6 and 5-1 to 5-6). For all locations data go back to 1938, except for New Augusta where data collection began in 1983. At continuous sites, discharge data were collected about 6 to 12 times annually in the field using the velocity-area method (Buchanan and Somers, 1969), as on most rivers throughout the United States. These field data are known as instantaneous measurements or cross-sectional measurements. They are used to develop stage-discharge relationships, which are used with daily stage data to derive daily discharge measurements. Because the velocity-area technique requires that discharge be computed by adding the discharge in multiple trapezoids, there are repeated measurements of depth and velocity at various distances across the channel. Each trapezoid ideally contains less than 5% of the total flow, thus there are a minimum of twenty, and typically more than thirty, depth measurements made across the channel. Two additional sites with partial data on the Leaf River near Raleigh and Taylorsville were examined. Both have some data at least through the 1990s (Figures 6-1 and 7-1) and are monitored usually only occasional floods or once every several years for other reasons.

Cross-Sectional Comparisons

The discharge measurements collected from rivers in Mississippi are stored in USGS file cabinets in a district office in Pearl, a suburb of Jackson, from which selected historic cross sections were copied. Figure 1-10 shows the cover sheet of a discharge measurement, and Figure 1-11 shows several of the individual distance and depth values associated with an individual discharge measurement.

The objective was to assess and compare the general configuration of the channel at the same transect over long time periods. To maximize information, yet keep the graphs somewhat uncluttered, measurements collected from bridges about every 10 years were selected. Cross sections at higher flow levels were chosen, where possible, so that changes in both channel and floodplain morphology could be examined over decadal timescales. Distance and depth data from these cross sections were input into spreadsheets, comparing distance across the channel and converting the numerous depth measurements across the channel to bed elevations by subtracting depth from adjusted stage for multiple cross sections on a single plot. Locations of cross sections compared were largely from the same side of the bridge because wading and boat measurements are collected at inconsistent locations. Data

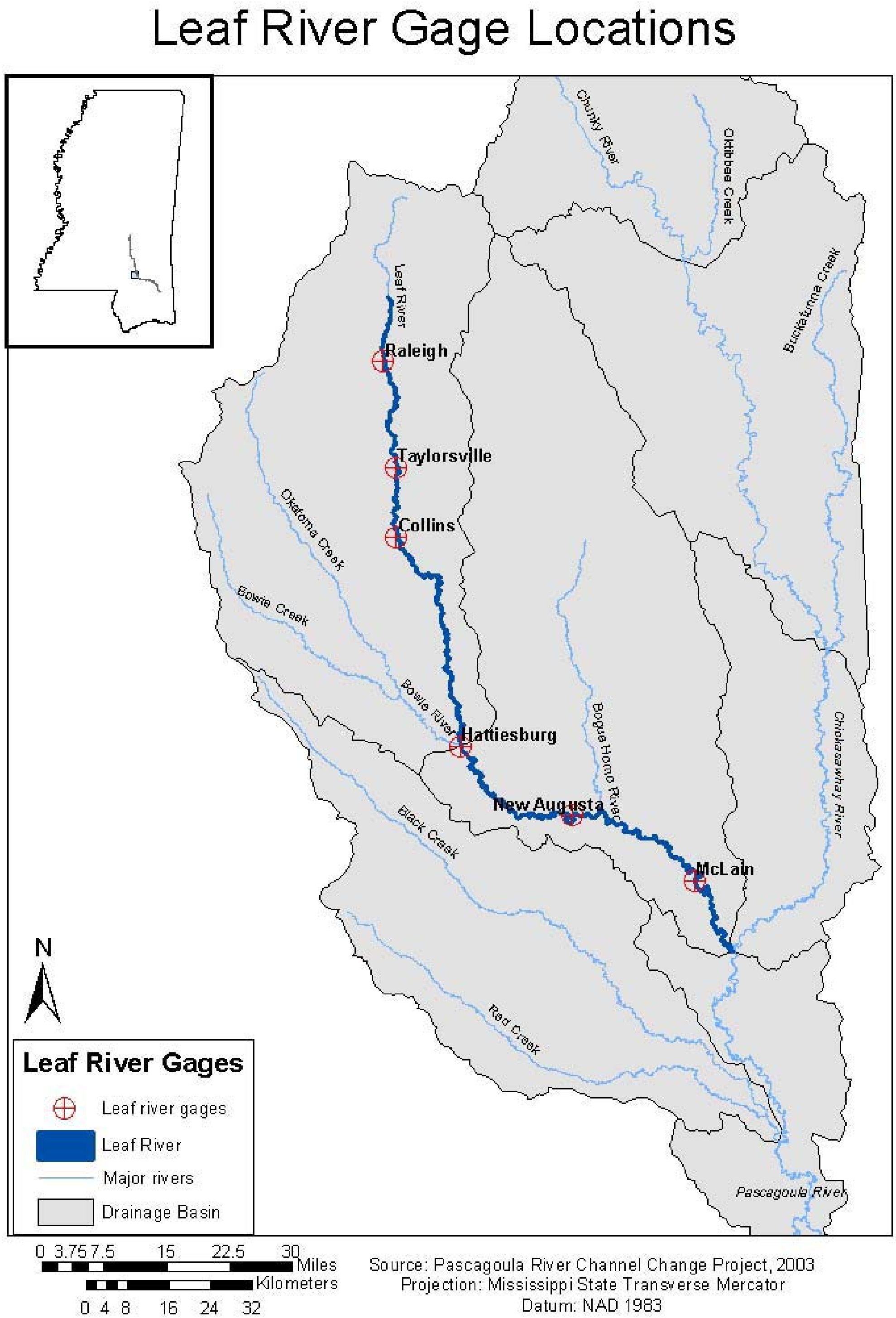
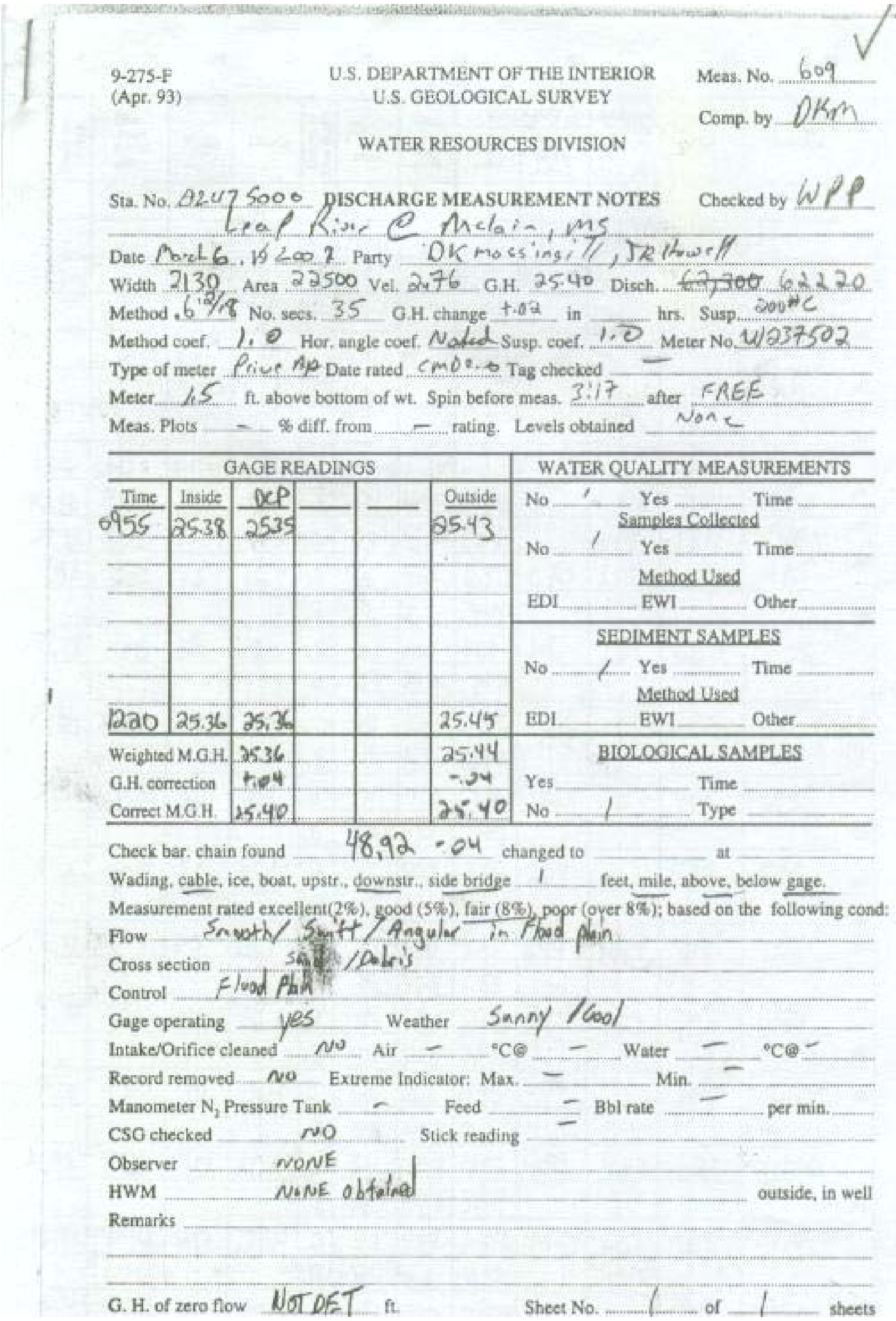


Figure 1-9. USGS gage sites on the Leaf River. The two upstream sites (Raleigh, Taylorsville) only have occasional or partial data whereas the other four sites are monitored continuously.



9-275-F
(Apr. 93)

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

WATER RESOURCES DIVISION

Meas. No. 609
Comp. by DKM

Sta. No. 02475000 DISCHARGE MEASUREMENT NOTES Checked by WPP

Leaf River @ McLain, MS

Date March 6, 19 2007 Party DK Mossingill, JR Howell

Width 2130 Area 22500 Vel. 2.76 G.H. 25.40 Disch. ~~62,300~~ 62220

Method .6 .2/.8 No. secs. 35 G.H. change +.02 in ___ hrs. Susp. 200#C

Method coef. 1.0 Hor. angle coef. Noted Susp. coef. 1.0 Meter No. W037502

Type of meter Price AA Date rated CMDO.0 Tag checked —

Meter 1.5 ft. above bottom of wt. Spin before meas. 3:17 after FREE

Meas. Plots — % diff. from — rating. Levels obtained None

GAGE READINGS					
Time	Inside	DCP			Outside
0955	25.38	25.35			25.43
1220	25.36	25.36			25.45
Weighted M.G.H.		25.36			25.44
G.H. correction		+.04			-.04
Correct M.G.H.		25.40			25.40

WATER QUALITY MEASUREMENTS
No ✓ Yes ___ Time ___
Samples Collected
No ✓ Yes ___ Time ___
Method Used
EDI ___ EWI ___ Other ___

SEDIMENT SAMPLES
No ✓ Yes ___ Time ___
Method Used
EDI ___ EWI ___ Other ___

BIOLOGICAL SAMPLES
Yes ___ Time ___
No ✓ Type ___

Check bar. chain found 48.92 -.04 changed to ___ at ___

Wading, cable, ice, boat, upstr., downstr., side bridge 1 feet, mile, above, below gage.

Measurement rated excellent(2%), good (5%), fair (8%), poor (over 8%); based on the following cond:

Flow Smooth/ Swift / Angular in Flood plain

Cross section Sand /Debris

Control Flood Plain

Gage operating yes Weather Sunny /Cool

Intake/Orifice cleaned NO Air — °C@ — Water — °C@ —

Record removed NO Extreme Indicator: Max. — Min. —

Manometer N_2 Pressure Tank — Feed — Bbl rate — per min.

CSG checked NO Stick reading —

Observer NONE

HWM NONE obtained outside, in well

Remarks

G. H. of zero flow NOT DET ft. Sheet No. 1 of 1 sheets

Figure 1-10. The cover sheet of a discharge measurement shows characteristics including the date and time of the measurement, the measurement party, the equipment used, the channel conditions and summary measurements, and the estimated quality of the measurement overall.

.0 .10 .20 .30 .40 .50 .60 .70 .75

River at—

Angle coefficient	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY At point	VELOCITY Mean in vertical	Adjusted for hor. angle or --------	Area	Discharge	
												.80
			No		Flow	IN	Left		Box	Culvert		.85
(3100)							.5 mile	from	left	abutment		
	STP	1015	Box	Culvert			Right	of	Bridge	full +		.90
			Flowing.									.92
												.94
LWE	50	125	0		V=0					0	0	
↖ .80	300	175	5.6	.6	24	40.1	1.34		1.07	980	1050	.96
↗ .92	400	100	7.3	.6	23	41.2	1.25		1.15	730	840	.97
↗ .93	500	75	16.7	.2	46	40.5	2.52	1.70	1.58	1250	1975	.98
				.8	16	40.7	.884					.99
↗ .94	550	50	13.0	.2	29	40.1	1.61	1.16	1.09	650	708	
				.8	13	41.0	.717					
↗ .96	600	50.	13.7	.2	18	40.7	.993	.786	.755	685	517	1.00
				.8	11	43.3	.578					
↗ .98	650	50	14.1	.2	11	41.2	.606	.568	.557	705	393	
				.8	10	43.1	.529					.99
↑ 1.0	700	35	15.1	.2	23	40.9	1.26	1.09		528	576	.98
				.8	17	41.3	.925					.97
↖ .99	720	20	15.9	.2	25	40.0	1.40	1.46	1.44	318	458	.96
				.8	28	40.4	1.53					
↖ .98	740	30	16.7	.2	46	40.5	2.52	2.34	2.29	501	1150	.94
				.8	39	40.0	2.17			776	2297	.92
↑ 1.0	780	40	19.4	.2	50	40.3	2.75	2.96		~~788~~	~~2330~~	.90
				.8	58	40.7	3.16					
↖ .98	820	30	20.7	.2	86	40.3	4.72	4.23	4.14	621	2570	
				.8	68	40.3	3.74					.85
↖ .98	840	20	23.4	.2	92	40.4	5.04	4.60	4.51	468	2110	
				.8	76	40.3	4.17					
Boiling	860	20	27.4	.2	52	40.2	2.87	3.16		548	1730	.80
				.8	63	40.3	3.46			8772	16407	

.0 .10 .20 .30 .40 .50 .60 .70 .75

Figure 1-11. The following sheets of a discharge measurement show several of the individual distance and depth values from water's edge on the left bank onwards to the other water's edge. On this sheet the maximum depth is 27.4 ft, but the data continue to the next page.

Discharge Measurement Summary Data

Derived from, but stored, copied and analyzed separately from, cross-sectional measurements are discharge measurement summary data. Because direct use of cross-sections requires much photocopying and inputting, and because it would be difficult to discern differences with more than ten cross sections on a graph, this summarized source provides higher temporal resolution of aggradation and degradation at gaging sites. Such data are listed on the cover sheet of a cross section (Fig. 1-10) and then each of several hundred measurements is transferred onto a summary sheet (Fig. 1-12). Such data are now available on the internet for most locations in the basin. Most of the following are typically recorded on discharge summary measurement sheets: discharge measurement number, date, measurement team, width, area, mean velocity, gage height, discharge, method, measured sections, gage height change (during recording), recording time, rating of measurement (excellent to poor), and transect method (bridge, wading, boat) (Figs. 1-10 and 1-12). The method used also may contain some information regarding approximate distance from the gage location. Associated with the fact that the river has multiple channels during floods (typically listed as “channels” on the measurement summary sheets), some data were either missing or irregular. In such cases, where numbers were given, it was not clear whether they characterized the entire system or the main channel. Determination of this would require detailed scrutinizing of cross sections in the district office.

Besides those variables on the summary data sheets, maximum depth was recorded as an additional variable by reviewing the listing of depth measurements for several selected historic cross sections in the USGS office. The probability of obtaining a value representative or close to the true maximum depth was considered high because there were numerous (usually > 30) depth measurements across the channel. Depth typically was measured at close intervals near the edges of piers and in zones of highest velocity, which often coincided with deepest points.

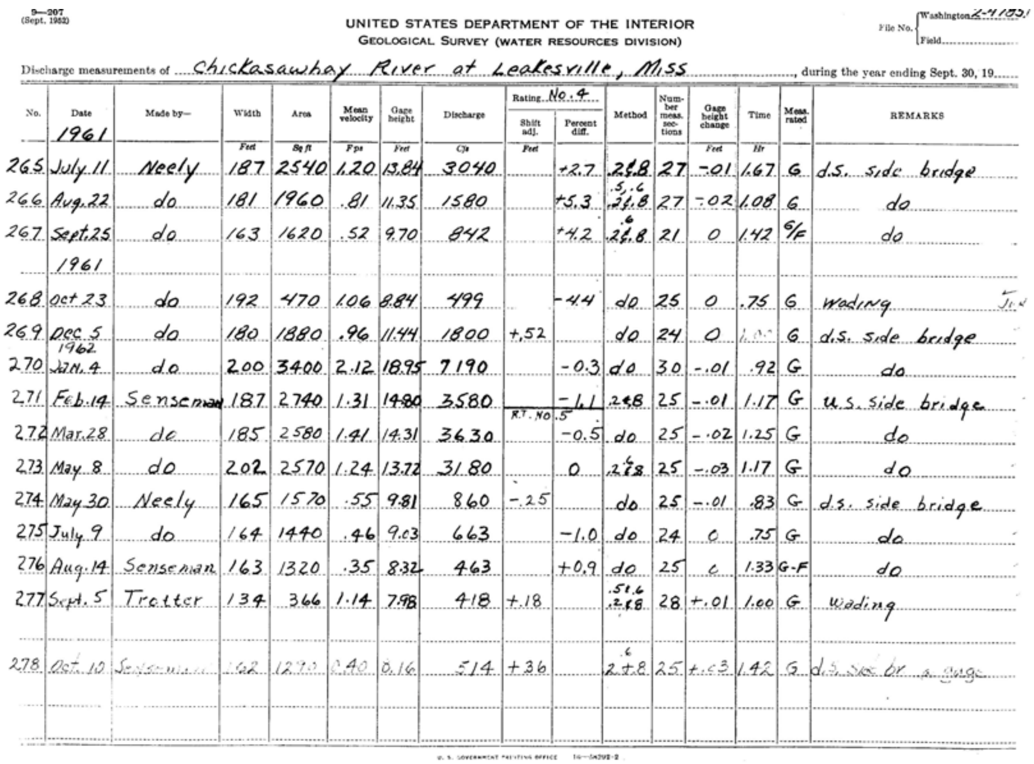
Some additional variables were derived or adjusted from the recorded variables. The gage height was adjusted according to changes in the datum of the local gage over the period of record, using information found in USGS publications such as Water Resources Data (e.g. Morris and others, 2002). Mean depth is computed by dividing the area by the width, and then mean bed elevation is computed by subtracting the mean depth from the adjusted stage. Mean depth trends show whether the cross-section is getting deeper or shallower, but also rises and falls with high and low flow. Mean bed elevation is considered a better measure of channel change than mean depth, because the scatter associated with stage or water levels is subtracted out of this variable, characterizing form changes such as aggradation or degradation more directly. The thalweg elevation is the deepest point in a given cross section, and reflects the bottom stability of a particular cross section. It is computed by subtracting the maximum depth from the adjusted stage or gage height. In some reports (e.g. Wilson, 1995), this variable is called minimum bed elevation. As mean bed elevation is a better measure of channel change than mean depth, thalweg elevation is a better measure of channel change than maximum depth because the scatter associated with stage levels is subtracted out of this variable, characterizing form more directly. The variables complement one another since thalweg elevation is not stage-dependent but provides information only at a specific point, whereas the mean bed elevation provides information for the entire cross-section but is stage-dependent. Although trends of mean depth and maximum depth provide important complementary information, these are included in a more comprehensive report (Mossa, 2003) and not in this paper due to space considerations.

Width is a very different measure of channel change, and is the distance between the right and left edge of the water if there is only one channel is present. The width-depth ratio is considered to be an important measure of channel form, derived by dividing width by the mean depth. Increasing width-depth ratios are characteristic of channels with abundant bank erosion, sedimentation or both. Decreasing width-depth ratios are less common, but they would be indicative of scour or deepening, and possibly narrowing. More direct measures of deepening or filling can be discerned through examining trends in mean depth and maximum depth.

Long-term channel changes such as aggradation and degradation have been interpreted from discharge measurements by plotting specific variables over time, and by examining stage-discharge relationships and specific stage-discharge trends, and stage-discharge rating curves (e.g. Furness et al., 1967; Walters, 1975, 1976; Watson, 1982; Lagasse et al., 1991). The use of specific stage trends, where the stage associated with a particular discharge level is examined over time, is the least subjective and statistically simplest approach (Fig. 1-13). Numerous studies have assessed changes in channel morphology, especially aggradation and degradation using specific discharge-stage trends over time (Furness et al., 1967; Blench 1969; Bull and Scott, 1974, James, 1997). It has some advantages over assessing stage-discharge relationships in that the time periods are not arbitrarily divided. If the water level for a given discharge is dropping over time that suggests that the channel is either deepening or widening to accommodate the same flow volume. If the water level for a given discharge is rising over time that suggests that the channel is either narrowing or filling to have caused a rise for the same flow volume However, various sources of scatter in stage-discharge relationships, can complicate such relationships. If the cross section is altering in a complex manner (bar deposition in the bottom and widening at the banks) evaluating trends at various levels provides additional information. Stage-discharge trends were evaluated by sorting the data by discharge in ascending order, ranking the field measurements into percentiles. Then, the associated stage values were plotted for discharges ranked ± 5% of the 25th, 50th, and 75th percentiles to evaluate whether the stage or water level showed increases, decreases or stability at the various discharge levels.

ISSUES OF DATA QUALITY

There are numerous sources of scatter in the data due to collection procedures, measurement error, and natural variations. Where there are multiple channels, one reason for scatter is the problem of distinguishing the main channel from the channel complex. The geometric measures usually characterize a single channel at lower flows, and a channel and floodplain or a channel complex with several interconnected channels at higher flows. A second source of potential scatter is the transect location, which included the upstream side of bridge, downstream side of bridge, wading and boat measurements at various approximate locations (e.g. 300' upstream of gage), or not recorded. Bridges may be rebuilt at or nearby old bridges during the study period, which may cause apparent shifts in the data. Construction of bridges and alteration of the channel near the gage station can greatly affect the channel geometry and the subsequent interpretations of channel change. Bridge construction often alters the channel and floodplain form to improve flood conveyance and minimize potential scour effects. Discrepancies increase where bridge data are intermixed with non-bridge data, and where new bridges are built some distance away with different local modifications. Thus, ideally, it is helpful to learn as much as possible about the history of bridge reconstruction at a site when interpreting data. Measurement error is also another source of scatter in the data, and data vary in quality accordingly to research team constraints (number on team, hours expended) and the conditions of the system at that time. In some cases, discriminating based on quality (plotting only good and excellent measurements, and omitting fair and poor measurements) may improve the graphs, but in other cases it would just leave many omissions. Additionally, scatter occurs due to variability associated with the natural system, including differences in hydraulic behavior on rising and falling stages, migration of bedforms, and channel instability such as erosion and deposition. Yet, despite all of these sources of variation, these data often show pronounced trends in channel form and/or position that are clearly indicative of channel changes of different types.



9—207
(Sept. 1952)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

File No. Washington 2-4785.1 Field

Discharge measurements of Chickasawhay River at Leakesville, Miss, during the year ending Sept. 30, 19

No.	Date	Made by—	Width	Area	Mean velocity	Gage height	Discharge	Rating No. 4 Shift adj.	Percent diff.	Method	Number meas. sections	Gage height change	Time	Meas. rated	REMARKS
	1961		Feet	Sq ft	Fps	Feet	Cfs	Feet				Feet	Hr		
265	July 11	Neely	187	2540	1.20	13.84	3040		+2.7	2&8	27	-.01	1.67	G	d.s. side bridge
266	Aug. 22	do	181	1960	.81	11.35	1580		+5.3	.5, .6 2&8	27	-.02	1.08	G	do
267	Sept. 25	do	163	1620	.52	9.70	842		+4.2	.6 2&8	21	0	1.42	G/F	do
	1961														
268	Oct 23	do	192	470	1.06	8.84	499		-4.4	do	25	0	.75	G	wading
269	Dec 5	do	180	1880	.96	11.44	1800	+.52		do	24	0	[illegible]	G	d.s. side bridge
270	1962 Jan. 4	do	200	3400	2.12	18.95	7190		-0.3	do	30	-.01	.92	G	do
271	Feb. 14	Senseman	187	2740	1.31	14.80	3580		-1.1	2&8	25	-.01	1.17	G	u.s. side bridge
								RT. No. 5							
272	Mar. 28	do	185	2580	1.41	14.31	3630		-0.5	do	25	-.02	1.25	G	do
273	May 8	do	202	2570	1.24	13.72	3180		0	.6 2&8	25	-.03	1.17	G	do
274	May 30	Neely	165	1570	.55	9.81	860	-.25		do	25	-.01	.83	G	d.s. side bridge
275	July 9	do	164	1440	.46	9.03	663		-1.0	do	24	0	.75	G	do
276	Aug. 14	Senseman	163	1320	.35	8.32	463		+0.9	do	25	0	1.33	G-F	do
277	Sept. 5	Trotter	134	366	1.14	7.98	418	+.18		.5 & .6 2&8	28	+.01	1.00	G	wading
278	Oct. 10	Senseman	162	1270	0.40	0.16	514	+.36		.6 2&8	25	+.03	1.42	G	d.s. side br. [illegible] gage

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Figure 1-12. A summary of several discharge measurements provides an important data source with which to analyze channel cross-sectional changes over time. This sheet includes several measurements made during water year 1962 on the Chickasawhay River at Leakesville.

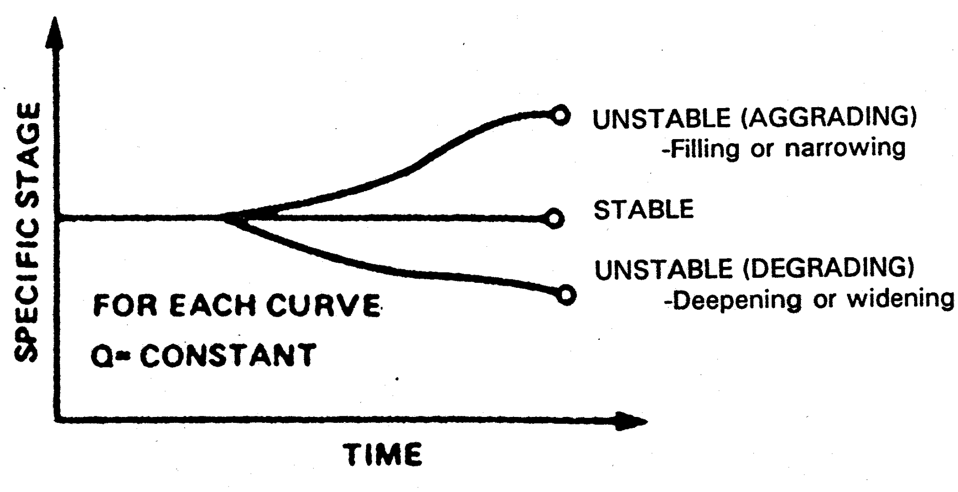

Figure 1-13. Specific stage trends show how the stage associated with a particular discharge level changes over time. A rising trend is caused by with aggradation, whereas a falling trend is caused by degradation.

RESULTS

Several geomorphic variables were plotted in the spreadsheets, some of which are included as figures for each location (Fig. 2-1 to 2-5, 3-1 to 3-5, 4-1 to 4-5, 5-1 to 5-5). Some of the most pertinent variables and key observations are described below and are summarized in Tables 1 and 2. As discussed earlier, further data gathering from future USGS visits, continuing data quality control, compilation of bridge data, GIS analyses of planform data, and other types of information collected may result in somewhat differing interpretations later in this study.

DISCHARGE SUMMARY DATA

Perhaps the most definitive findings are from the discharge summary data, which contain several hundred measurements of the stream cross-section characteristics plotted versus time. Of the four continuous locations on the Leaf River, the two upstream sites show some (Collins) to pronounced (Hattiesburg) decreases of about 1 and 2m in mean bed elevation and 0.5 and 4m in thalweg elevation (Table 1; Figs 2-1 to 2-4 and 2-1 to 3-4). Although not plotted in this paper, Hattiesburg also shows an increase in maximum depth of about 1.5m, changing most rapidly during the 1970s, and stabilizing since then, possibly due to in-channel mining in the nearby tributary. The specific stage-discharge trends also shows degradation, dropping approximately 0.5 m at Collins and more than 1m at Hattiesburg (Figs. 2-5 and 3-5). Other types of geomorphic changes are not pronounced and inconsistent.

The two downstream sites (New Augusta, McLain) show increases in mean bed elevation of 1m and thalweg elevation to 2m, some increases in width and larger increases width-depth ratio (Table 1; Figs 4-1 to 4-4 and 5-1 to 5-4). There were also decreases in mean and maximum depth, not included as plots in this paper. The stage-discharge data corroborate aggradation at New Augusta, even with the short period of record. However, at McLain there are no discernable trends in stage for a given discharge, suggesting that the channel is widening at the same time as it is experiencing aggradation, and therefore can hold a similar flow level.

HISTORIC CROSS SECTIONAL CHANGES OVER DECADAL TIMESCALES

Several cross-sectional measurements, showing changes every decade are shown as the last figure on each site (Figs. 2-6, 3-6, 4-6 and 5-6) and for stations with only sporadic measurements (Figure 6-1 and 7-1). Results presented in this report consist dominantly of visual illustrations of the decadal changes at various transects. Depending on data availability and other factors, sites may have as few as three time periods and other as many as eight time periods plotted.

Table 2 identifies periods of possible lateral migration and apparent rises or falls in bed elevation through plotting of sequential graphs. Channel bottoms can fluctuate markedly in short periods of time, however, so the measurement of depth at that time is less reliable than the more comprehensive statistical summary shown as each of the first five figures at the four continuous sites. Both the plots here (e.g. Fig. 3-4) and Wilson (1995), show nearly 10 m (>30 ft) of fluctuation in minimum bed elevation, much of which can occur in a single year. The historic cross sections represent two days of many in that sequence and may not, and often do not, show quite the same range as more comprehensive long-term data.

In most cases, the input of distance and depth points was straightforward and resulted in plots that reflected what appear to be accurate comparisons of channel positions at different times. In some cases, however, it was unclear or uncertain whether the channel did undergo such shifts as appear on the plots or whether this represents some type of difference in bridge markings or distance measurements associated with different transects, including the construction of new bridges, which would case apparent shifts in stream position. It is clear that there are issues here with data recording and plotting because the channel appears to shift back and forth one or more times during the period of record. Extensive efforts were made to apply appropriate corrections when it was relatively clear what the necessary adjustments should be to represent the stream channel accurately in terms of comparing one channel to the other. Most of the sites examined on the Leaf River appear realistic, but in the case of the Leaf River at Collins and possibly others, one or more of the so-called periods of “possible lateral migration” might be attributed to other factors or errors. In such cases, the interpretations derived from this data source currently require further investigation and data collection for validation. Based on some initial planform comparisions, it does appear that at least some of the lateral shifts in channel position at Hattiesburg did occur. Continuing work and analysis will help to establish which of these occurred and assist in assessing the timing and magnitude of these possible migrations.

DISCUSSION AND CONCLUSIONS

The changes documented here are mostly consistent with prior studies, although more locations and more variables were examined overall in this study. The trend towards river widening on the Lower Leaf concurs with that findings of Turnipseed (1993) who documented recent widening on the Leaf River near McLain. As this study, the cross sections plotted by Turnipseed (different ones than plotted in this study) show increases in bed elevation on the Leaf River near McLain, as shown on cross sections plotted here and on the more temporally comprehensive summary data. Similar to Brown and Mitchell (1995) and Wilson (1995), this study confirms degradation of about 0.3m (1 ft) per decade on the Leaf River at Hattiesburg, but documents such rates for a longer period overall.

The trends in mean bed elevation and thalweg elevation show varied changes as do the trends in stage-discharge relationships. In some cases, there are nonlinear trends, including sharp rises or falls at particular times and possible cycles of rises and falls over the period of record. There could be more follow-up, involving use of more sophisticated statistical tests in some cases, such as those described in Helsel and Hirsch (1991) to evaluate whether trends are significant, etc., and other inferences that can be made from the data.

Also of some concern interest is whether there is lateral erosion, or channel change in the x-y dimension. This is relevant for a number of reasons, related to the fact that changes in the x,y, and z dimensions are linked. If the stream is unstable as viewed from planform dimensions, this is important as subsequent stream movement in relation to the crossing influences the potential for scour (Richardson et al., 1991). It is expected that the examination of changes in channel planform will yield important information. Some preliminary work at various Leaf River sites suggests that the recent planform changes, from the early 1980s to mid-1990s, correspond well with areas sand bars during the most recent maps. Further work will assess this possibility, and will provide far more extensive spatial information regarding areas of channel change in a planform dimension.

It is unknown if there is a causative relationship between land use changes and bed elevation changes spatially or temporally. Tables 1 and 2 also provide some indication of the timing of these changes. Further study may help connect these changes with causative factors, at least in some instances. Continuing effort is ongoing regarding collecting various forms of historical temporal and spatial information about land use, agriculture, forests and mining. Cycles of aggradation and degradation are likely influenced by the emplacement of structures in river corridors, dredging for navigation, snag removal, and land use changes in the basin such as deforestation, agricultural activities, mining and urbanization. In all likelihood, the pronounced changes observed on the Leaf River at Hattiesburg in this study and others, is likely caused by the extensive in-channel sand and gravel mining on the Bowie River. Ideally, it would be helpful to obtain more data in this area, and thus the Bowie River and Leaf River at Hattiesburg are potential sites for field data collection. There certainly should be more work to understand the role of both natural factors (geology, soils, slopes) and human factors (land use changes, snag removals and dredging) on channel cross-sectional and channel bottom stability. Still, the data plotted herein suggest degradation on the Upper Leaf and aggradation on the Lower Leaf, helping to document spatial variations in channel change in the basin. Knowledge of the changes observed may be of benefit to planners, managers, and engineers. These data are not predictive but rather historic evidence of what has happened at bridges in southeastern Mississippi in the past century.

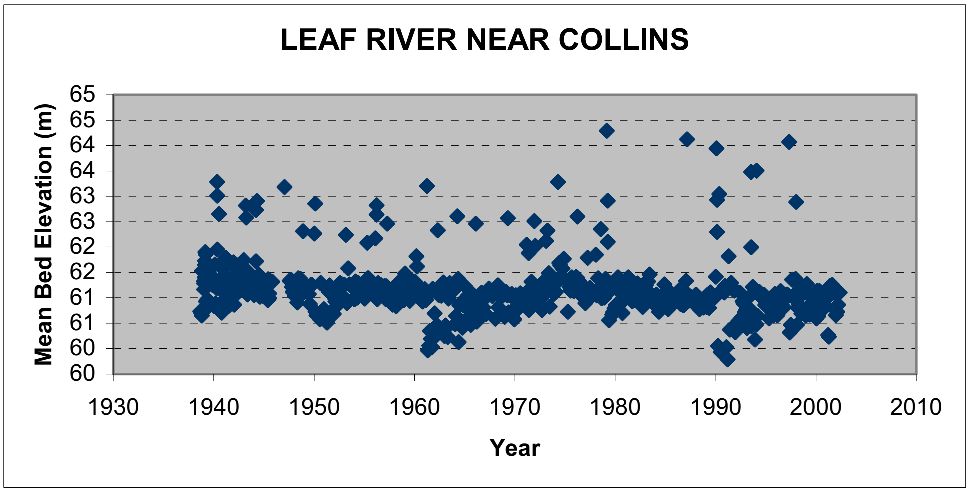

Figure 2-1 Mean Bed Elevation at Leaf River Near Collins/U.S. Hwy 84

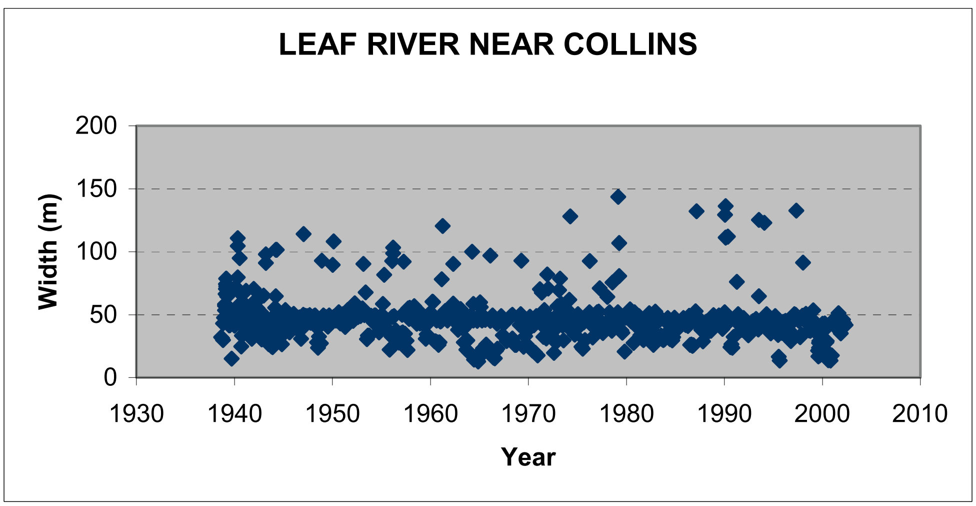

Figure 2-2 Width at Leaf River Near Collins/U.S. Hwy 84

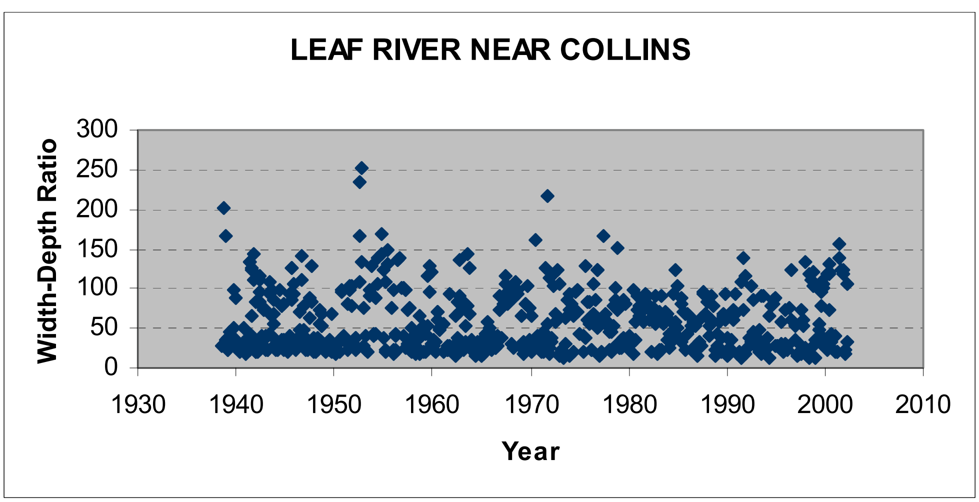

Figure 2-3 Width-Depth Ratio for Leaf River Near Collins/U.S. Hwy 84

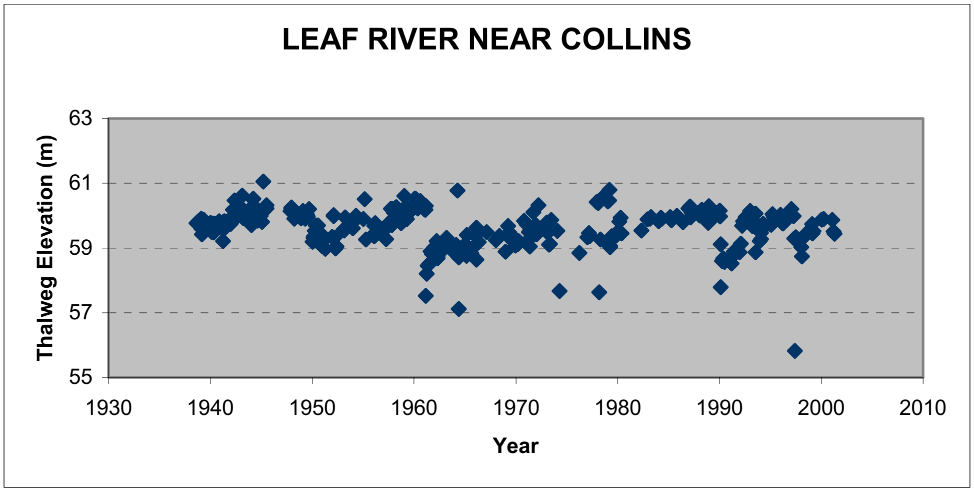

Figure 2-4 Thalweg Elevation (m) Leaf River Near Collins/U.S. Hwy 84

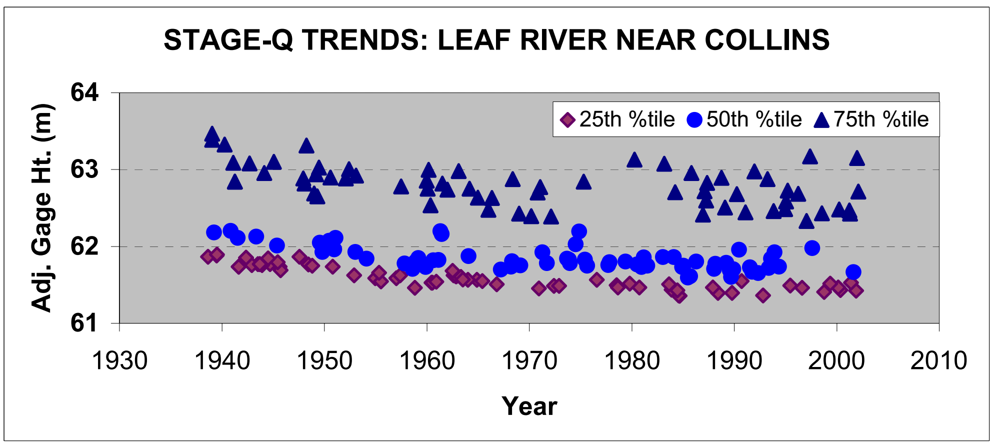

Figure 2-5 Stage-Q Trends: Leaf River Near Collins/U.S. Hwy 84

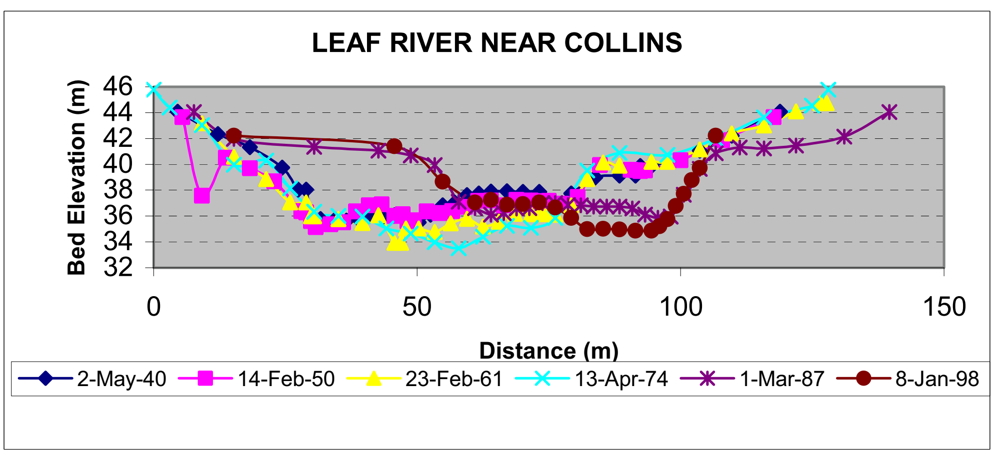

Figure 2-6 Bed Elevations: Leaf River Near Collins/U.S. Hwy84

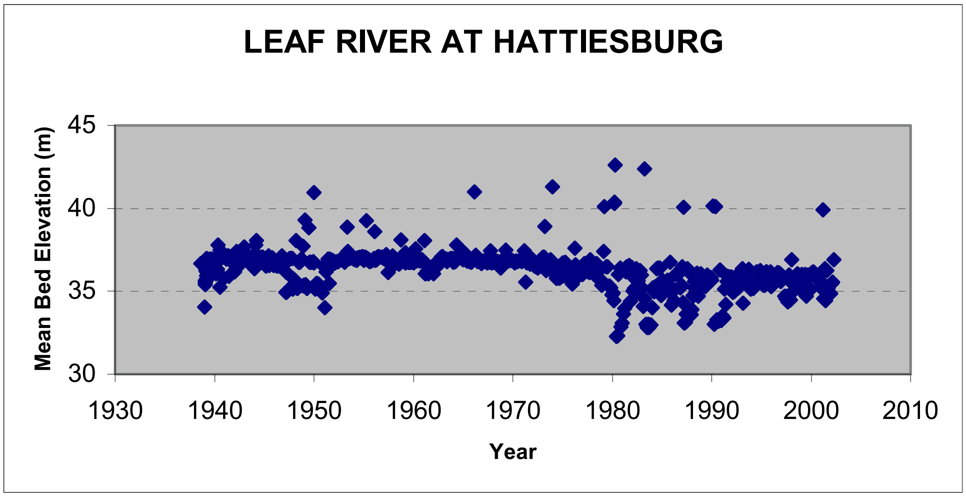

Figure 3-1 Mean Bed Elevation for Leaf River At Hattiesburg/U.S. Hwy 11

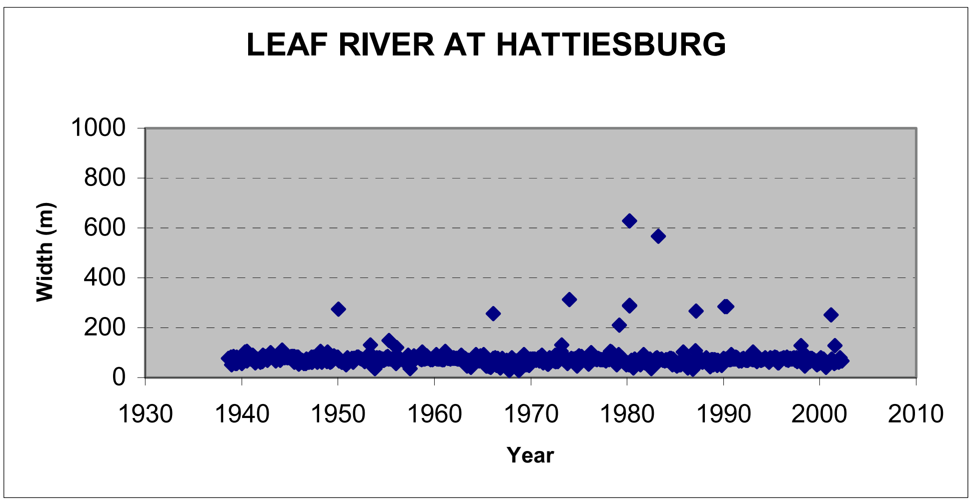

Figure 3-2 Width (m) for Leaf River At Hattiesburg/U.S. Hwy 11

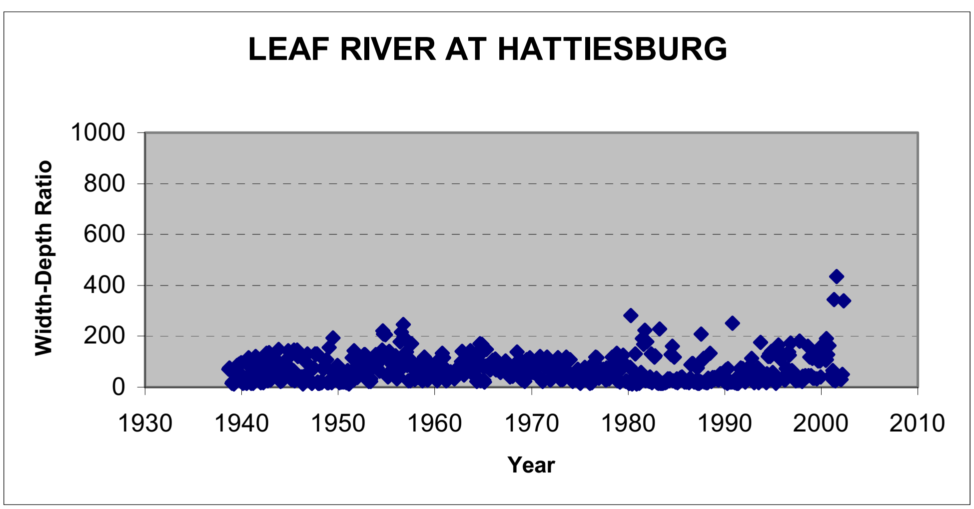

Figure 3-3 Width-Depth Ratio for Leaf River At Hattiesburg/U.S. Hwy 11

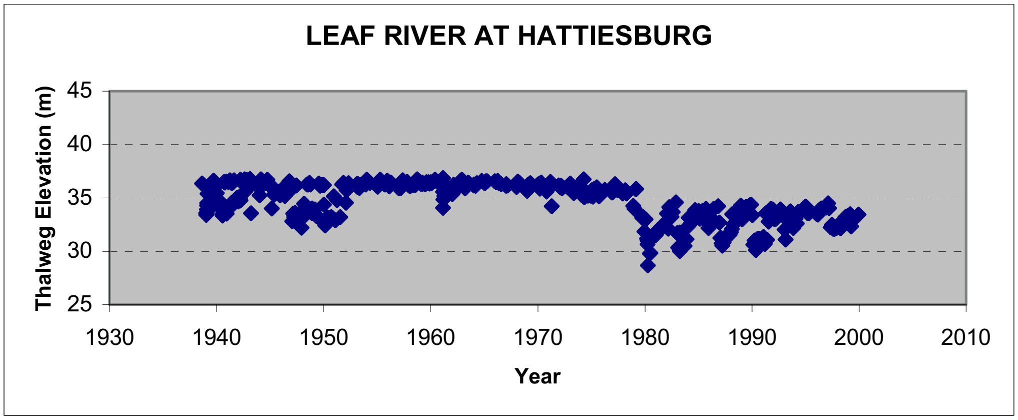

Figure 3-4 Thalweg Elevation (m) Leaf River At Hattiesburg/U.S. Hwy 11

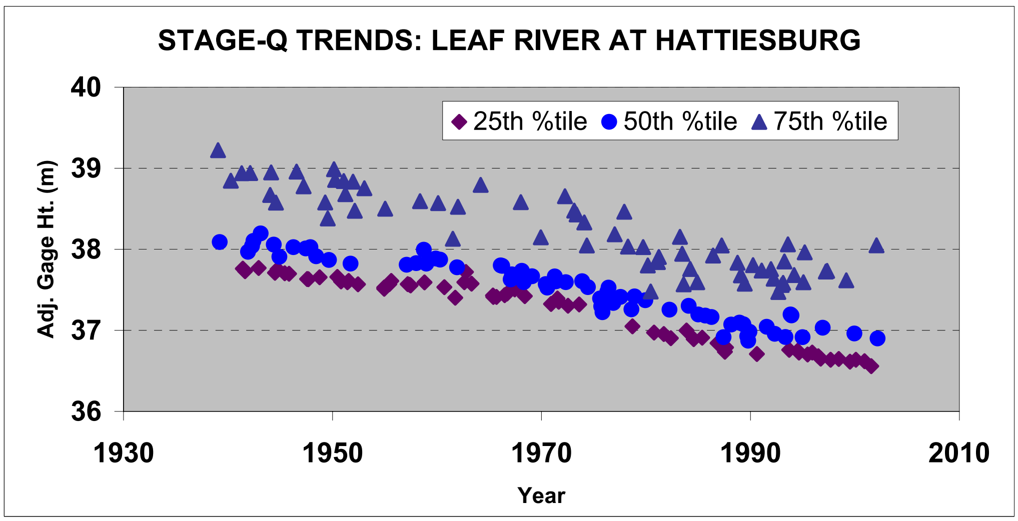

Figure 3-5 Stage-Q Trends: Leaf River At Hattiesburg/U.S. Hwy 11

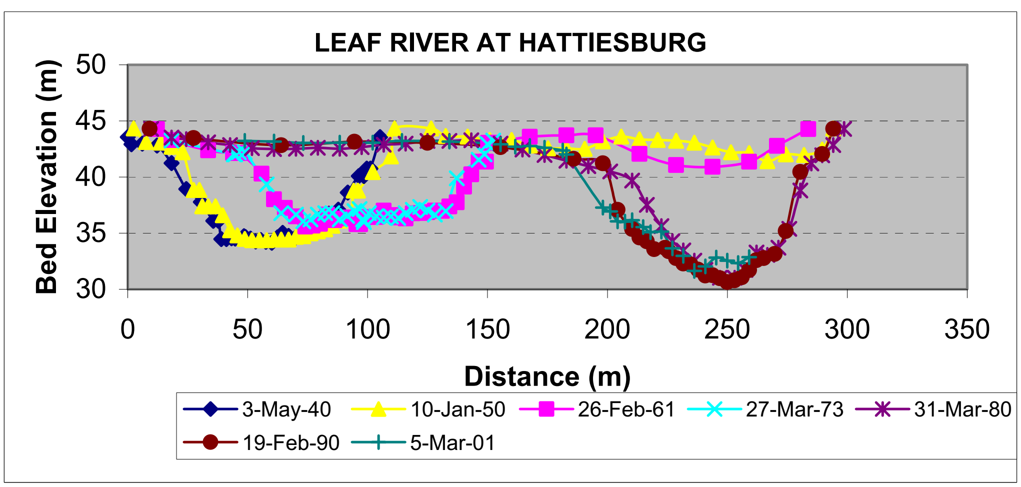

Figure 3-6 Bed Elevations for Leaf River at Hattiesburg

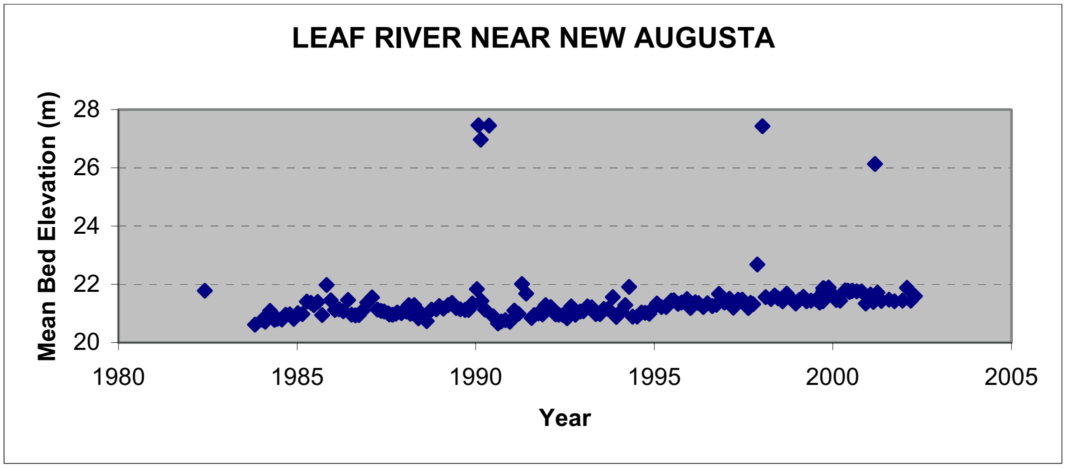

Figure 4-1 Mean Bed Elevation (m) Leaf River Near New Augusta/State Hwy 29

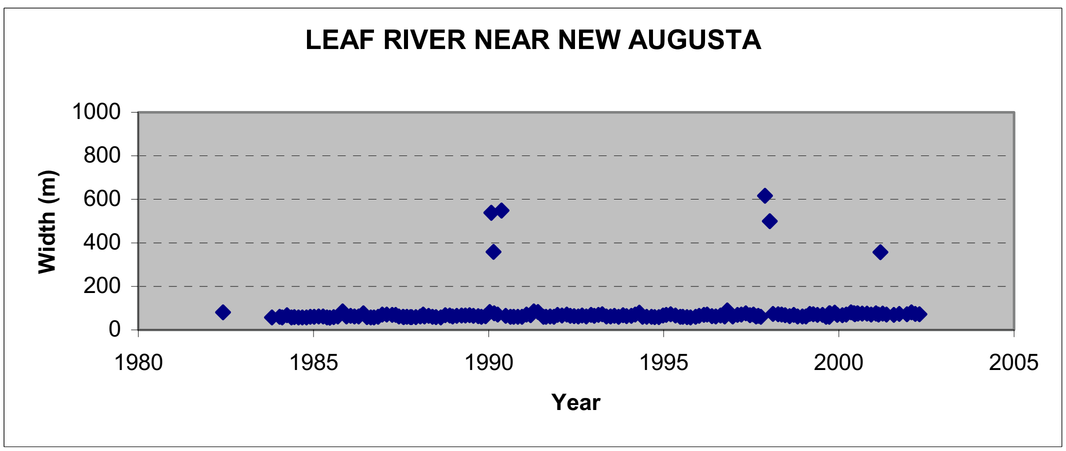

Figure 4-2 Width (m) for Leaf River Near New Augusta/State Hwy 29

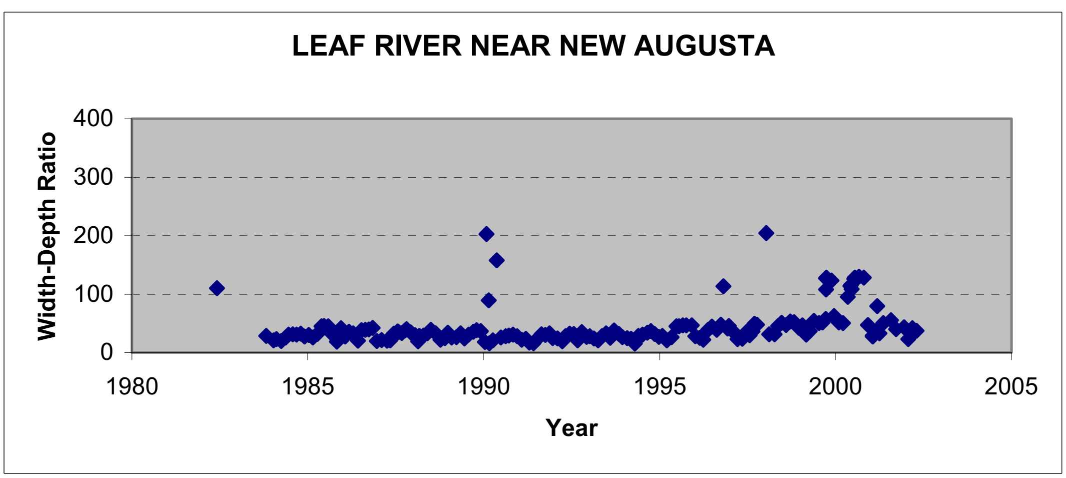

Figure 4-3 Width-Depth Ratio for Leaf River Near New Augusta/State Hwy 29

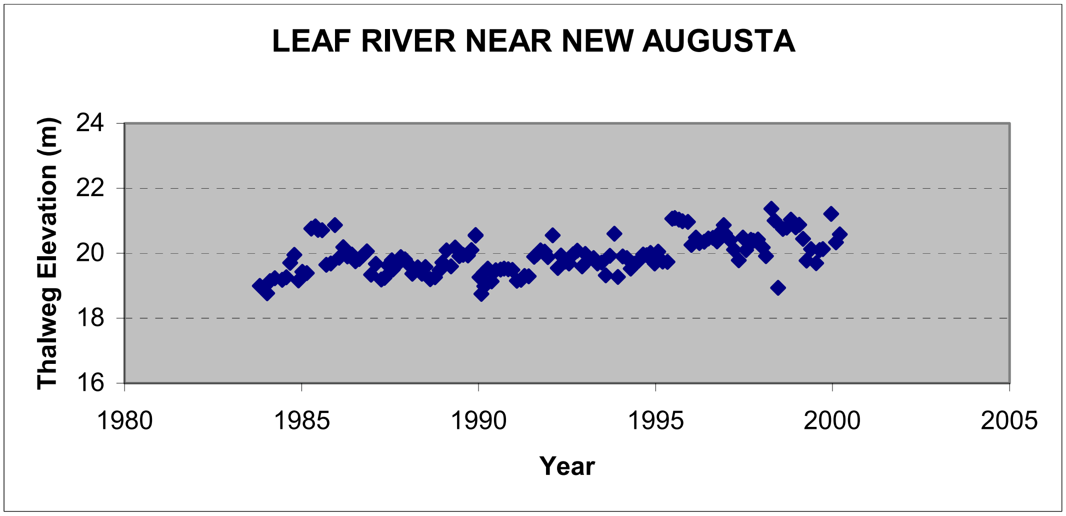

Figure 4-4 Thalweg Elevation (m) for Leaf River Near New Augusta/State Hwy 29

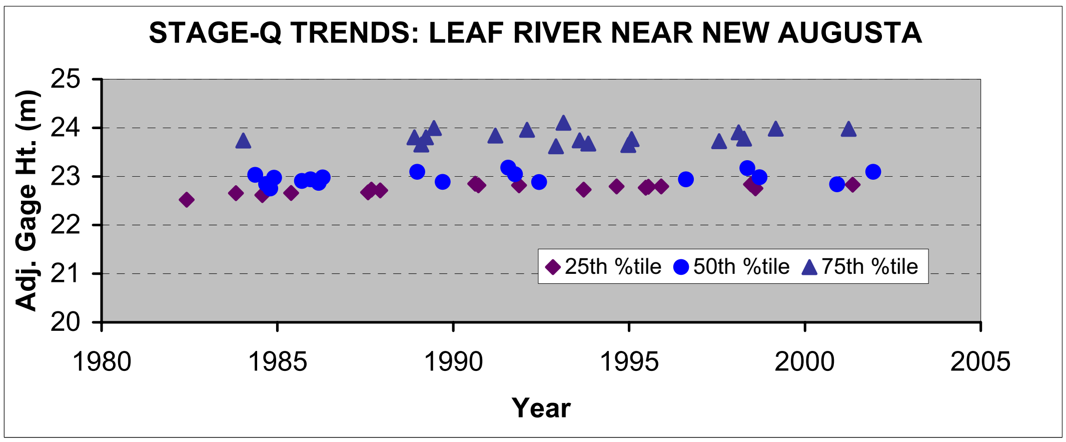

Figure 4-5 Stage-Q Trends: Leaf River Near New Augusta/U.S. Hwy 29

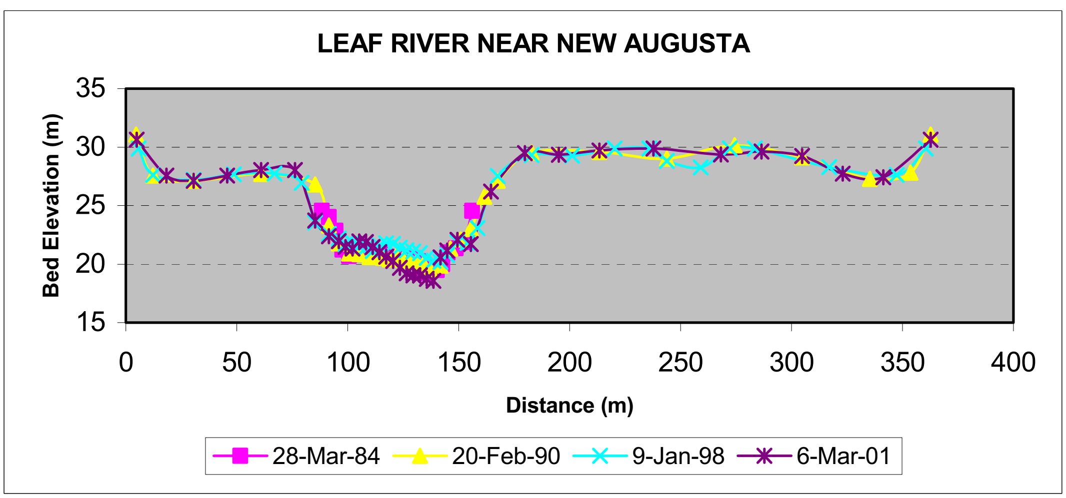

Figure 4-6 Bed Elevation for Leaf River at New Augusta

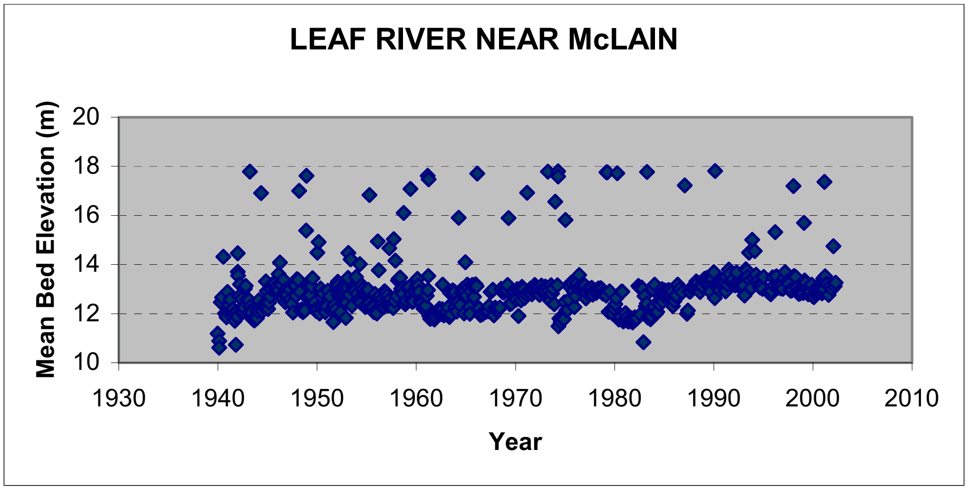

Figure 5-1 Mean Bed Elevation (m) for Leaf River Near McLain/U.S. Hwy 98

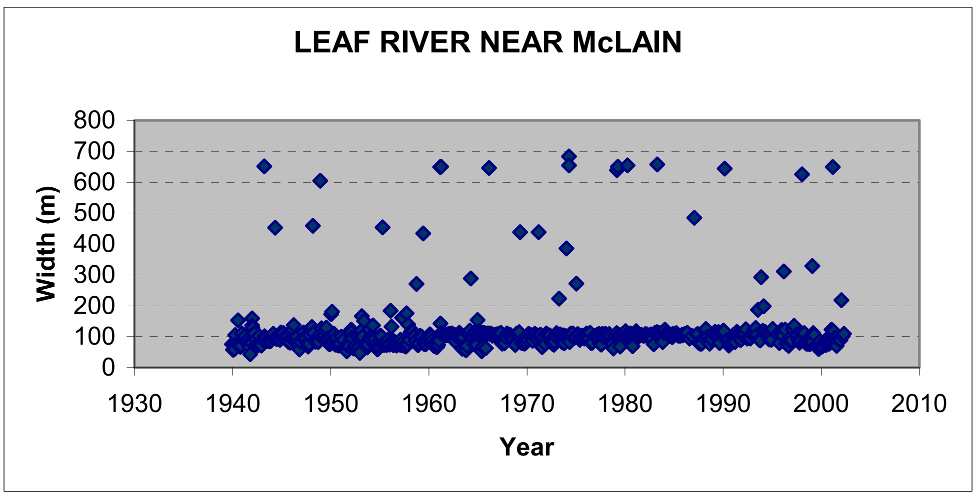

Figure 5-2 Width (m) for Leaf River Near McLain/U.S. Hwy 98

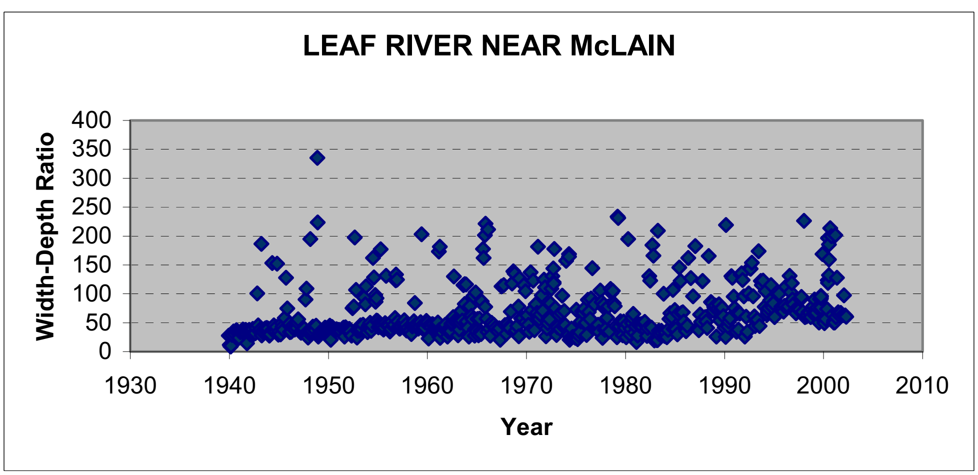

Figure 5-3 Width-Depth Ratio for Leaf River Near McLain/U.S. Hwy 98

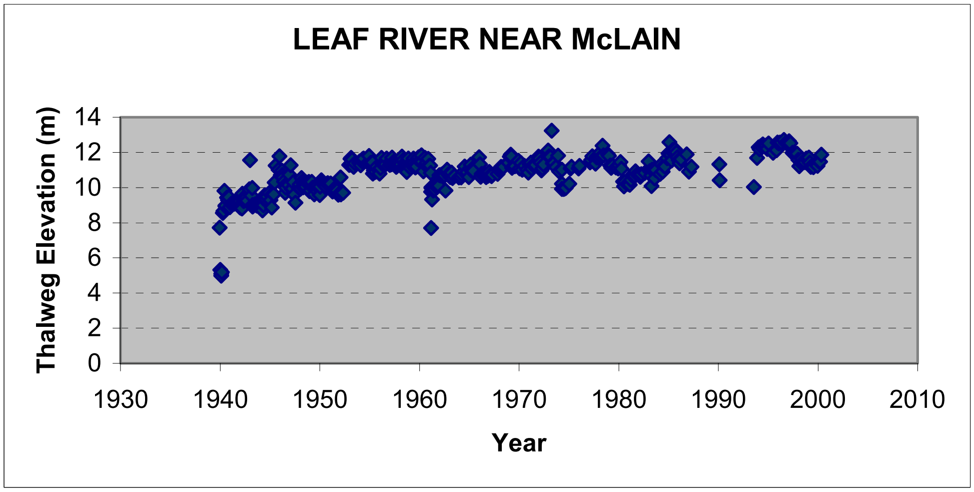

Figure 5-4 Thalweg Elevation (m) for Leaf River Near McLain/U.S. Hwy 98

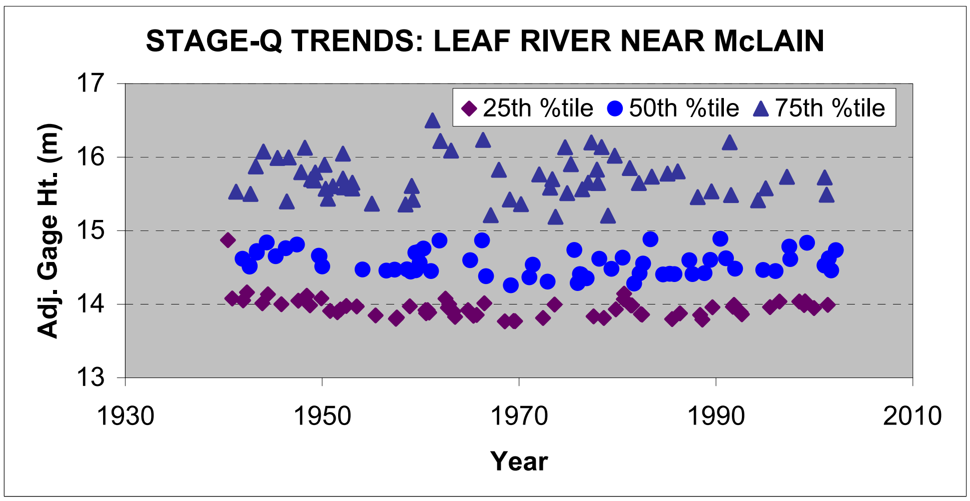

Figure 5-5 Stage-Q Trends for Leaf River Near McLain/U.S. Hwy 98

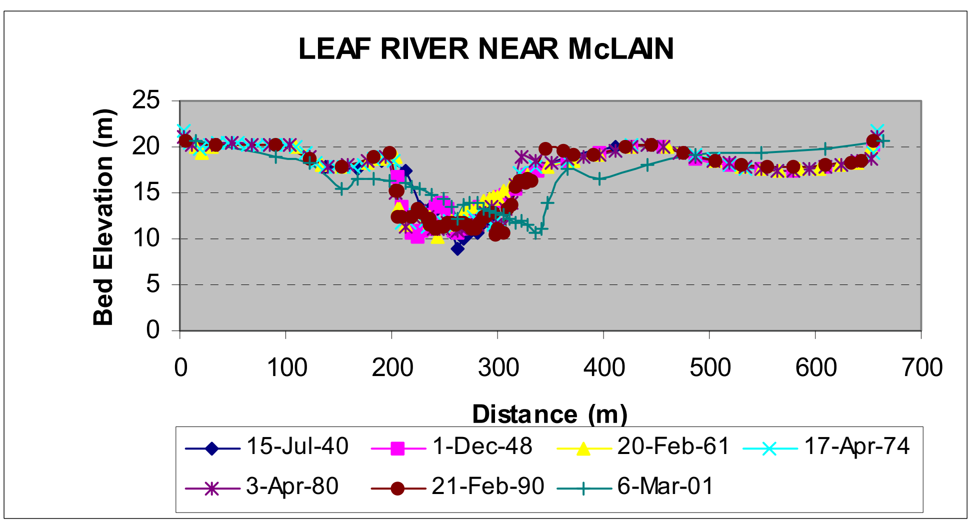

Figure 5-6 Bed Elevation for Leaf River near McLain

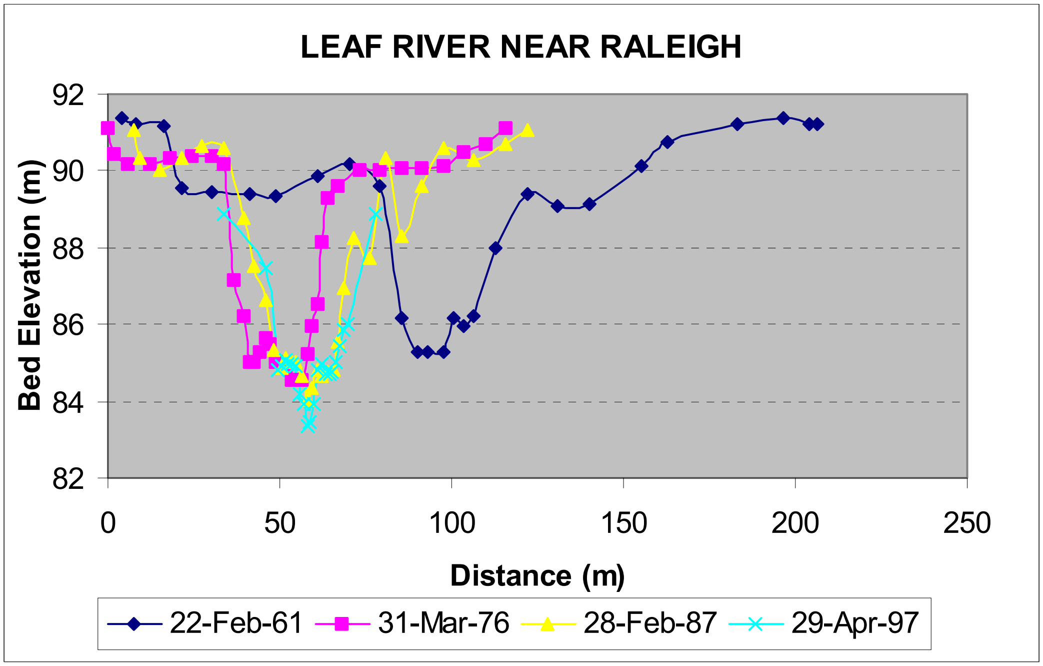

Figure 6-1 Bed Elev. (m) for Leaf River Near Raleigh/State Hwy 18

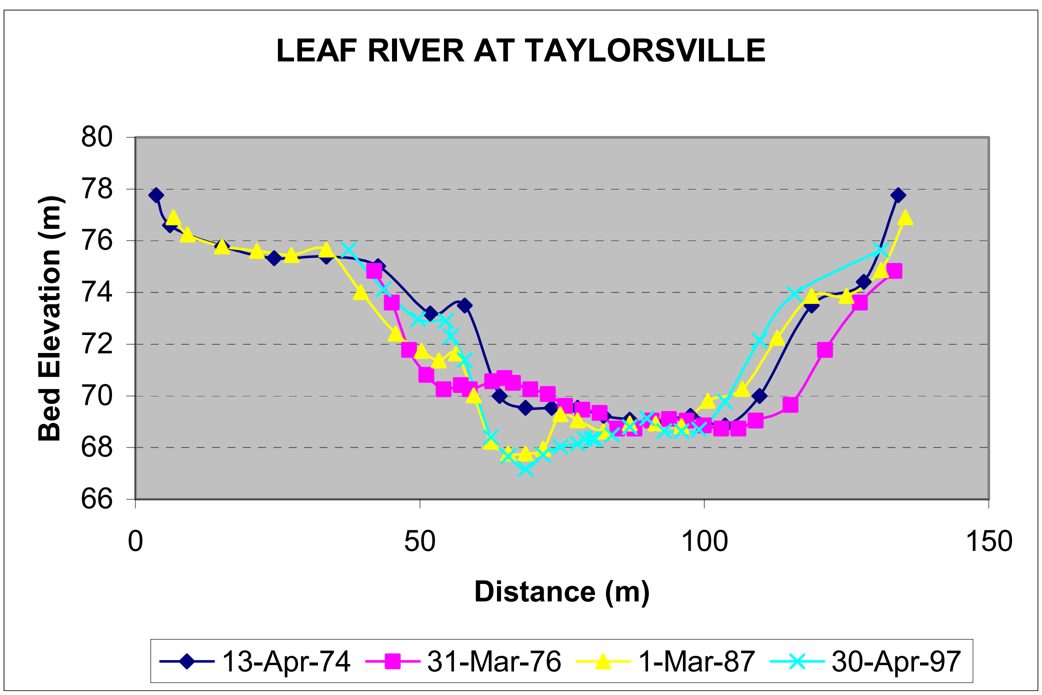

Figure 7-1 Bed Elev. (m) for Leaf River At Taylorsville/State Hwy 28

Table 1. Trends Interpreted from Discharge Cross Sectional Summary Data

	Area (mi2)	MBE (m)			Thalweg (m)			Stage-Q(m)			Width (m)			W/D Ratio		
LEAF RIVER		Trend	Amount	Timing	Trend	Amount	Timing	Trend	Amount	Timing	Trend	Amount	Timing	Trend	Amount	Timing
Collins	**743**	D	1	Throughout	D	0.5	40s	D	0.5	Throughout	S			S		
Hattiesburg	**1742**	D	2	Throughout	D	4	40s, 50s	D	1.2	Throughout	S			S		
New Augusta	**2542**	U	1.2	Throughout	U	2	00s	U	0.2	Throughout	U	10	Throughout	U	20	90s, 00s
McLain	**3495**	U	1	40s, 50s	U	3	90s	S			U	20	Throughout	U	30	70s, 90s

U=UPWARDS D=DOWNWARDS S=STABLE

Table 2. Historic Cross Sections and Timing of Notable Changes including Possible Lateral Migrations

LOCATION	Years Evaluated	Interval of 1st Possible Mig.	Interval of 2nd Possible Mig.	Interval of 3rd Possible Mig.	Lat Mig.(m)	Bed Elev Change (m)	Comments
near Raleigh	**61,76,87,97**	1961-1976	1976-1987		35	2 fall	data recording issues?
at Taylorsville	**74,76,87,97**				20	2 fall	minimal shifting
near Collins	**40,50,61,74,87,98**	1974-1987			40	1 fall	extensive mig. throughout
at Hattiesburg	**40,50,61,73,80,90,01**	1950-1961	1973-1980		190	2 fall	extensive shifts in elev.
near New Augusta	**84,90,98,01**					0	negligible mig. throughout
Near McLain	**40,48,61,74,80,90,01**	1940-1948	1990-2001		80	2 rise	lat. shifts throughout

ACKNOWLEDGEMENTS

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