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# Lower Mississippi River Bed Response to a High Flow Event

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## LOWER MISSISSIPPI RIVER BED RESPONSE TO A HIGH FLOW EVENT

Riverboat pilots and hydraulic engineers have long known that the bed of the Mississippi River may undergo pronounced elevation changes in response to differing flow conditions. These flow-related changes are cyclic and may be superimposed on long-term erosional or depositional trends caused both by natural processes and by the response of the river to navigation or flood control works. Knowledge of the effects of different flow conditions on river bed shoaling and scouring is important to vessel traffic, pipeline emplacement, structural design, and sediment transport considerations.

Measurements of bed elevation changes in the Mississippi River near St. Louis have been reported by Jordan (1965), Belt (1975), and Maher (1964). Jordan and Belt found inverse relationships between bed elevation and discharge, but their data was collected at bridges which laterally confine the river and these results may not apply to adjacent areas where the channel is broader. Maher, studying three reaches without bridges, observed that the river fills during and scours after a flood. The post-flood scouring generally took place over a period of a few months. This relationship was supported by Carey and Keller (1957) who noted that crossing bar elevations in the lower Mississippi rise and fall in concert with river stage.

This paper presents a set of cross-river depth profiles made in the Mississippi River during low flow conditions in September 1974 and repeated in May 1975 just after a period of unusually high flow. Twelve profiling lines were occupied south of New Orleans between river miles 59.0 and 61.5, a section which

includes a crossing of the main channel from the eastern to the western sides of the river. This part of the river can be considered estuarine in that a salt wedge is present and the water elevation varies tidally at lower flow stages. A comparison of the September 1974 and May 1975 profiles documents the response of the lower Mississippi River bed to a high flow event.

### DATA COLLECTION

Locations of the twelve profiling lines are shown on Figure 1. The lines, oriented normal to the river axis, are spaced at 0.3 to 0.4 km (0.2 to 0.25 mile) intervals and extend over a 4 km (2.5 mile) long section of the river. The river in this area is about 610 m (2000 ft) wide and is

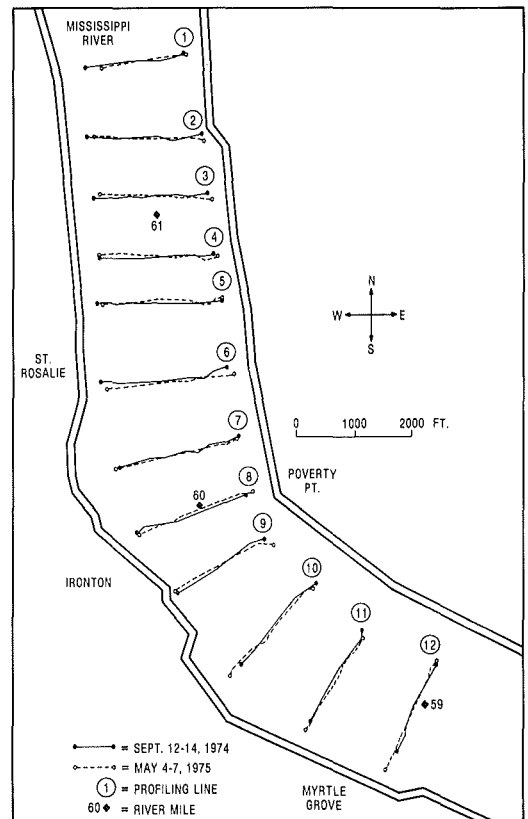


Figure 1. Location map.

bounded on each side by levees. The main channel is located on the eastern side of the river between lines 1 to 5, where its depth is about 30 m (100 ft) below sea level. The channel then crosses to the western side between lines 6 to 8. It remains on this side from lines 9 to 12 with depths ranging from 45 to 60 m (150 to 200 ft) below sea level. A protective revetment is located along the steep western bank in the vicinity of lines 9 and 10.

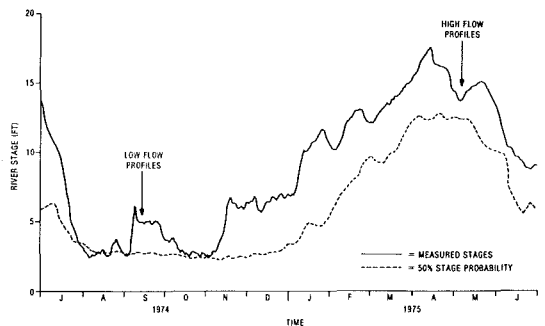
Water depths were measured along the lines with a Raytheon DE 719 fathometer®, which records depth as a function of time on a strip chart and has an accuracy of  $\pm 0.5$  percent of the indicated depth. On each day of use, the fathometer was calibrated for sound speed by bar checks and the transducer draft was checked. River stage was monitored during each survey with a Benthos recording tide gauge, and this data was translated to Mean Sea Level datum by extrapolating between daily river stage measurements from U.S. Army Corps of Engineers gauging stations at Chalmette (river mile 91.0) and West Point a La Hache (river mile 48.7). Positioning took place with a Motorola Mini-Ranger electronic navigation system including four transponders located at survey points on shore and an interrogator on the vessel. Positions determined with the system in this limited survey area are accurate to  $\pm 2.4$  m (8 ft) or better.

The lines were first occupied during September 12 to 14, 1974, and re-occupied from May 4 to 7, 1975. In the May survey, considerable effort was devoted to obtaining a close correspondence with the September positions and individual lines were re-run up to four times. In almost all instances, the final profile pairs were separated by less than 15 m (50 ft) and in many locations the cor-

respondence was better than 8 m (25 ft).

## RIVER CONDITIONS

River stages at the site were 0.9 to 1.2 m (3.0 to 3.8 ft) above Mean Sea Level during the September study and 2.5 to 2.6 m (8.1 to 8.4 ft) during the May study. In order to place these stages in the context of annual stage variations in the lower Mississippi River, it is convenient to refer to the U.S. Army Corps of Engineers gauging station at Carrollton (river mile 102.8) for which long-term data is available. Stages at the site are proportionally lower than those at Carrollton by a factor of about 35 percent. River stages measured at Carrollton from July 1974 through June 1975 are shown in Figure 2. Included in the figure is the stage exceeded 50 percent of the time on any given date based on 35 years of data at this station. It can be seen that river stages during the September 1974 survey were somewhat higher than normal for the month, which resulted from the passage of hurricane Carmen. The September stages were nevertheless low when compared to annual variations. The May 1975 survey was conducted when river stages were near their annual maximum related to spring runoff. This survey followed a period of unusually high stages, exceeding those historically



**Figure 2.** Mississippi River stages measured at Carrollton, Louisiana from July 1974 to June 1975 and the 50% stage probability based on historical data.

recorded on 90 percent of the days in question during the first 25 days of April 1975. Very high stages had most recently occurred in the spring of 1973, but no major floods had occurred in the 20 year period prior to that.

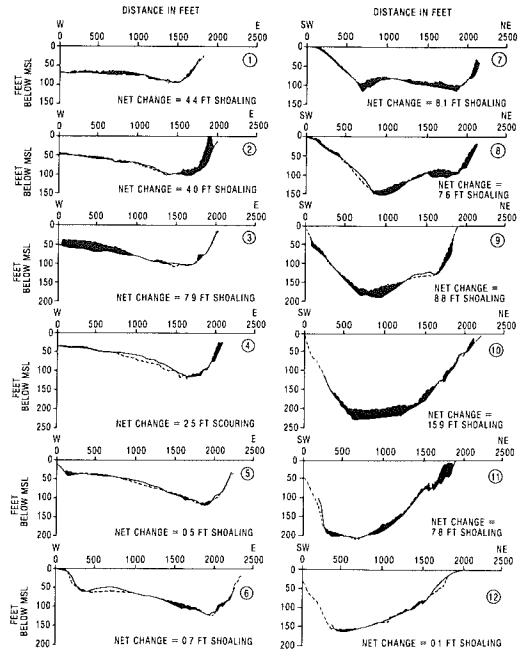
River discharge was not measured at the site. Extrapolating from U.S. Army Corps of Engineers discharge measurements at upriver stations, discharges were 9,912 to 11,328 m<sup>3</sup>/s (350,000 to 400,000 cfs) during the September 1974 study and 25,488 to 29,736 m<sup>3</sup>/s (900,000 to 1,050,000 cfs) during the May 1975 study.

## RESULTS

Results of the September 1974 and May 1975 surveys are compared in Figure 3 where the paired profiles for each line are superimposed. The bottom shoaling and scouring displayed represent changes associated with high flow conditions with references to the previous low flow elevations.

The overall impression of the river bottom response to high flow is one of dominant shoaling. Net shoaling occurred on 11 of the 12 profiling lines, with the average deposition on profiles ranging from 0.03 to 4.8 m (0.1 to 15.9 ft). Only line 4 showed net scour which averaged 0.8 m (2.5 ft). The composite response for all 12 lines was 1.6 m (5.3 ft) of shoaling implying the accumulation of  $3.75 \times 10^6$  m<sup>3</sup> (3000 acre ft) of sediment in the 4 km (2.5 mile) segment of the river studied.

The most consistent shoaling took place at lines 7 to 11, corresponding with the lower part of the channel crossing and the area immediately down-river. Deposition was concentrated in the deep channel and along the eastern side of the river. At lines 9 and 10, the channel underwent 7.6 to 9.1 m (25 to 30 ft) of



**Figure 3.** River bottom elevations along the profiling lines in September 1974 (solid lines) and May 1975 (dashed lines). Net shoaling between September and May is shown in black whereas net scouring is shown in gray.

shoaling. Significant deposition also occurred on the eastern side of line 2 and the western side of line 3.

Scouring was most common on the convex-upwards portions of the river bed adjacent to the channel as exemplified by lines 2, 4, 5, 6, 8 and 9. Elevation decreases were generally less than 3.0 m (10 ft) with a maximum scouring of 4.6 m (15 ft) observed at line 4. Some cutting occurred on the steep sides of the river bed at lines 11 and 12.

The cumulative effect of shoaling and scouring associated with high river flow was a large scale smoothing of the river cross-section. As a result, the channel crossing bar became quite subdued in bathymetric expression in comparison with its low flow configuration. In contrast with the observations of Carey and Keller (1957) that crossing bars rise and fall in concert with river stage, this bar remained at the same elevation or, at

lines 6 and 9, was scoured during the high flow period.

## DISCUSSION

When comparing the low and high flow profiles, consideration must be given to a very short term bottom changes associated with migrating sand waves. Carey and Keller, who conducted depth profiling along the Mississippi River axis between New Orleans and Baton Rouge, recorded asymmetric sand waves having amplitudes of 0.6 to 9 m (2 to 30 ft) and lengths of less than 15 to almost 183 m (50 to 600 ft). Downriver migration of such waves could presumably cause short term variations in cross-river profiles which could complicate the low flow-high flow comparison addressed in this paper. Indeed, asymmetric bottom traces in the channel at line 6 and on the eastern side of lines 11 and 12 suggest the presence of sand waves up to a couple of meters high in the study area. These features were present at the same locations during both the September 1974 and May 1975 surveys. Confinement of these asymmetric irregularities to these profiling lines coupled with consistency of shoaling and scouring trends among most adjacent profiles suggests that the observed bottom changes are dominated by a response to flow conditions and are not random variations resulting from sand wave migration.

In the absence of a survey subsequent to May 1975, the permanency of the high flow bottom response cannot be determined. Monitoring of the Mississippi River bed by Jordan (1965), Belt (1975), and Maher (1964) indicates that bed changes of the magnitude revealed by this study are cyclic and correlated with changes in flow conditions. Semi-permanent shoaling or erosion in the

river tends to occur slowly over extended periods with the exception of local responses to new navigation or flood control works. Aside from the construction of levees and limited placement of revetments, the Mississippi River has not been otherwise modified in the study area. Thus, it seems probable that the observed bottom changes are temporary and the results support Maher's contention that the river fills during and scours after a flood. Based on Maher's data, the return of the bottom to the low flow configuration would take a few months.

The net shoaling of the Mississippi River bed during periods of high flow indicates that sediments are delivered from the watershed faster than the river can transport them to the Gulf of Mexico. Maher's data suggests that the transport of this spring runoff sediment to the Gulf continues for a few months after the high flow event itself while the bed is lowered to its previous elevation. The degree of shoaling observed to coincide with high flow in the present study would, if representative of the lower Mississippi River, imply that substantial quantities of sediment are delivered to the Gulf during this few month lag period.

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