Geomorphic Trends of the Mississippi River Revealed by Specific Gage Records and Channel Geometry Changes

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Extended Abstract

The Mississippi River between Cairo, IL and the Old River Control Complex, LA is a vital conduit for both commercial navigation and waters draining from much of the United States. Any changes to the hydraulic conveyance of this system are, therefore, of national importance. In this study, we describe our recent efforts to identify patterns and trends in the conveyance of the system. We developed specific gage records for a range of flows at 19 stations along the Mississippi River. The specific gage trends differed both between gages and, at some locations, between flows at the same gage. We also compared the regional trends from the specific gage records with trends in channel geometry, including cross-sectional and volumetric change, to help determine the source of the stage trends.

The development of the Mississippi River and its floodplain for navigation and flood control has been ongoing since the eighteenth century, with the most concerted efforts occurring as a result of the Flood Control Act (FCA) of 1928 (U.S. Congress 1928) following the Great Flood of 1927. With the complex requirements in navigation, flood risk reduction, and environmental restoration, all with multiple stakeholders, future Mississippi River management will require the most advanced knowledge available. The Mississippi River Geomorphology & Potamology (MRG&P) Program was developed in recognition of this challenge. The MRG&P Program is a joint effort of the U.S. Army Corps of Engineers (USACE), St. Louis, Memphis, Vicksburg, and New Orleans Districts and is conducted with the oversight of the Mississippi Valley Division (MVD) and benefits from technical contributions from the U.S. Army Engineer Research and Development Center. The study reported herein is just one of many components of the MRG&P Program (Lewis et al. 2019).

The objectives of this study were to examine the morphologic trends from the mid-1970s to present along the Lower Mississippi River (LMR) between Cairo, IL, (RM 954) and the Old River Control Complex, LA (RM320). The study area is illustrated in Figure 1. This was accomplished by means of analysis of specific gage trends and comparison of channel geometry. This study reflects an integration of two recently completed MRG&P reports by Biedenharn et al. (2017), and Little et al., (2017).

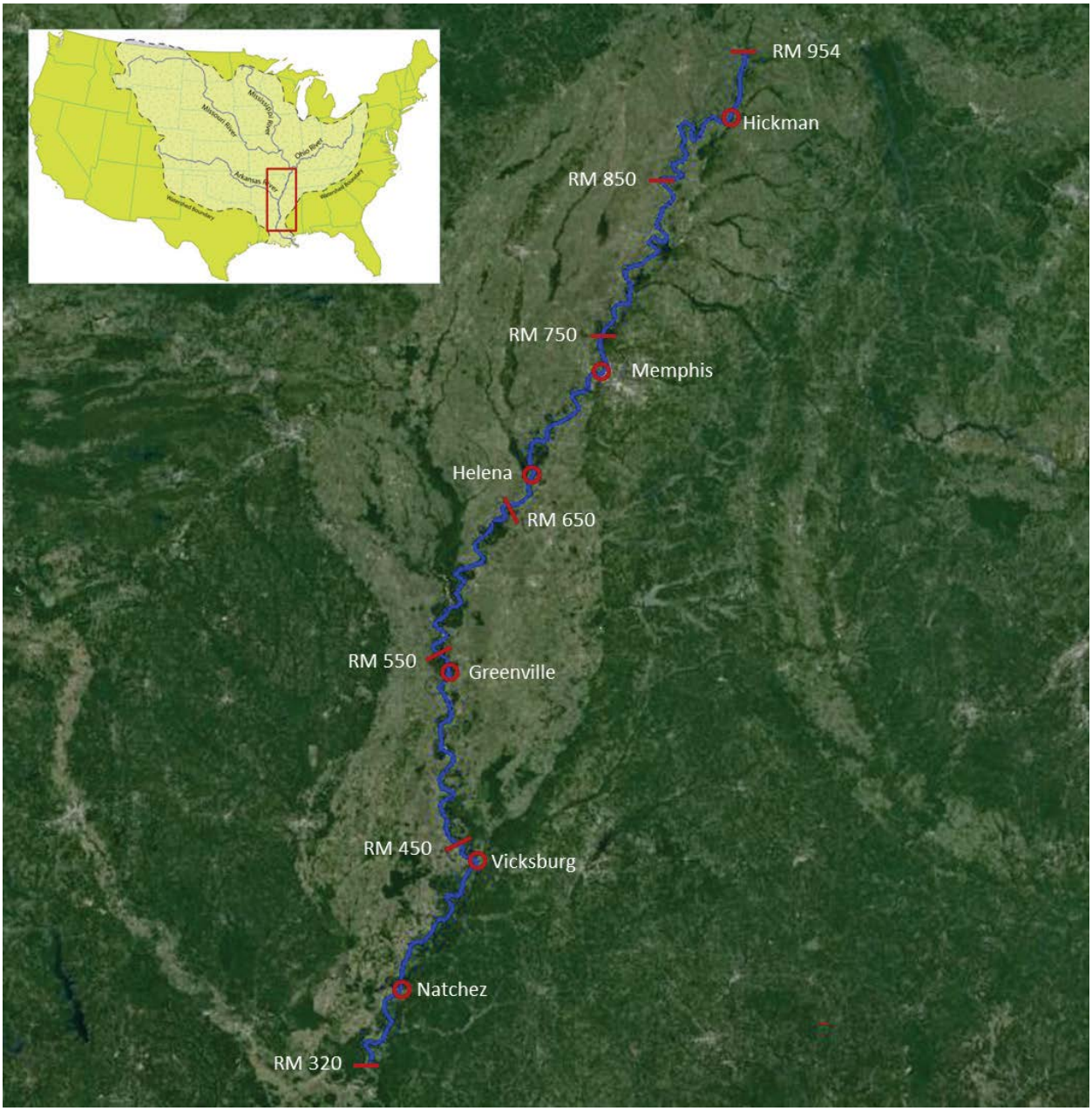

Figure 1. Map of the study area along the LMR from Cairo, IL (RM 954) at the upstream end to the Old River Control Complex, LA (RM 320) at the downstream end.

A geometric data analysis was conducted for the study reach to document long-term trends in the dimension, pattern, and profile of the LMR channel within the study reach. Hydrographic survey data for the years 1975, 1989, 1996, 2002, 2004, and 2013 were used to determine spatial and temporal variations in channel geometry and volume. Trends of geometric change (area, depth, width, conveyance, and channel volume) were identified along defined geomorphic reaches of the river (Little et al., 2017). Although there was considerable local variability in the survey comparisons, broad-scale trends were clearly evident. For the period 1975 to 2013 there was a consistent loss of cross sectional area and channel volume (aggradation) for the most downstream reach extending from about RM 320 (near ORCC) to about RM 435 (near Vicksburg, MS). For

the majority of the reach between RM 435 and RM 592 near Rosedale, MS, the geometry comparisons fluctuated but remained relatively constant, indicating no significant net erosion or deposition (dynamic equilibrium). However, there was a short reach extending from the vicinity of Greenville, MS (RM 530) to near Arkansas City, AR (RM 560), that revealed a slight erosional trend. The channel geometry comparisons indicated that the entire reach from about RM 592 to near Cairo, IL (RM 954) was gaining in cross sectional area and volume, indicating an erosional regime.

Morphologic trends along the LMR were also examined using specific gage records. Specific gage records were developed at the following 19 gaging stations along the LMR: Columbus, KY; Hickman, KY; Tiptonville, TN; Caruthersville, TN; Osceola, TN; Fulton, TN; Memphis, TN; Star Landing, MS; Mhoon Landing, MS; Helena, AR; Fair Landing, AR; Rosedale, MS; Arkansas City, AR; Greenville, MS; Lake Providence, LA; Vicksburg, MS; St. Joseph, LA; Natchez, MS; and Red River landing, LA (Biedenharn et al., 2017). Analyses of the historical specific gage records extending back into the mid-1800s, have shown that the meander cutoffs (which were mostly performed during the 1930s and early-1940s) resulted in larger and more abrupt stage reductions than those associated with any other event that has impacted the Mississippi River during at least the last 100 years. In some reaches, stage decreases of 15 feet were observed immediately following the cutoffs. During the post-cutoff period, the river has continued to adjust to the cutoffs, though stage changes have been much less abrupt than those during the cutoff period. However, this relatively simple pattern of response is complicated because the river is also adjusting to the impacts of other factors such as the dikes, revetments, levees, diversions, upstream reservoirs, maintenance dredging, tributary improvements, sediment yield reductions in the basin, and hydrologic extremes, all of which act to modify these broad-scale trends driven by the cutoffs.

For this study, we compared the trends generated by specific gage records and channel geometry analysis. Comparing these trends required that comparable flow regimes be considered. Examination of the specific gage records reveals there is often a contrast between high (overbank) flows and low to mid-range (in-bank) flows, with low to mid-range flow trends being indicative of channel scour and fill while high flow trends reflect the additional influences of overbank and floodplain processes. The channel geometry trends reported herein did not consider the overbank areas, and therefore, reflect conditions below top bank. Therefore, the specific gage records for the low to mid-range flows were selected for comparison with the channel geometry analyses. Both specific gage and channel geometry analyses indicate that the river is continuing to respond to the cutoffs through degradation that is migrating upstream, while aggradation is persisting in the reaches further downstream. These broad-scale trends, as indicated by both specific gage records and channel geometry analyses, are shown in Table 1. The specific gage trends are generally consistent with the trends indicated by the channel geometry comparisons.

Understanding historical and present-day fluvial processes and morphological responses in the LMR is essential to designing and delivering long-term management of the system for flood control, navigation, and ecology that is cost-effective, adaptable, and sustainable. Specific gage records and channel geometry analysis are important components of river engineering and geomorphic assessments aimed at developing a better understanding of the complex fluvial processes that drive the morphology of large rivers.

Table 1. Observed in-bank morphologic trends as determined by channel geometry comparisons and specific gage records for the mid-1970s to present time period.

Approximate Reach Limits	Observed Morphologic Trends	
	Channel Geometry	Specific Gage Records
RM 325 AHP to RM 435 AHP	Aggradation	Aggradation
RM 435 AHP to RM 600 AHP	Dynamic Equilibrium to Slight Degradation	Dynamic Equilibrium
RM 600 AHP to RM 954 AHP	Degradation	Degradation

References

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