A REVIEW OF THE
LOWER MISSISSIPPI RIVER POTAMOLOGY PROGRAM

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Abstract: The Mississippi River and Tributaries (MR&T) Project is a comprehensive water resources project for flood damage reduction and navigation improvement on the Mississippi River. MR&T elements include levees, floodways, diversion structures, tributary basin improvements, and channel improvements such as meander cutoffs, bank stabilization, dikes and dredging. Understanding how these elements, combined with natural factors, such as floods and droughts, impact the historical, current, and future river morphology is a complex challenge for those tasked with managing the Mississippi River for floods, navigation, environmental restoration, and coastal wetland loss.

Mississippi River potamology (the science of rivers) studies advance understanding of how natural and man-made factors combine to impact river morphology regarding present and future flood damage reduction, navigation, environmental restoration, and coastal wetland projects. The US Army Corps of Engineers (USACE) has conducted numerous potamology studies dating from the 1800s to modern times. Major studies were often the result of floods and follow-on beneficial projects. The epic 1927 flood fostered the first official USACE Potamology Investigations that resulted in more than 70 reports. The 1973 flood drove additional USACE potamology studies (T-1 and P-1 reports). However, funding, staffing, and interest in potamology studies waned, becoming almost nonexistent in recent times. Lessons learned and projects implemented from USACE’s 1940s–1980s potamology studies helped pass the record-setting 2011 flows. The 2011 Mississippi River flood renewed interest in potamology, resulting in the creation of the USACE Mississippi Valley Division’s (MVD) new Mississippi River Geomorphology and Potamology (MRG&P) Program. The first report of the MRG&P was a review of the Lower Mississippi River Potamology Program, including a comprehensive bibliography of potamology reports (Biedenharn et al., 2014). This paper provides a short review of USACE Mississippi River potamology studies.

INTRODUCTION

The Mississippi River and Tributaries (MR&T) Project is a complex, comprehensive water resources project, that provides flood control within the alluvial valley and navigation improvement of the Lower Mississippi River (LMR). The LMR extends from Cairo, IL, to the Gulf of Mexico, a distance of almost 1000 miles. The primary elements of the MR&T Project include levees, floodways and diversion structures, tributary basin improvements and channel improvement features such as meander cutoffs, bank stabilization, dikes, and dredging. The historical, present-day, and future morphology of the LMR reflects an integration of all these
features combined with natural factors such as floods and droughts, hurricanes, tectonic activity, geologic outcrops, climatic variability, and sea level rise. Understanding how these various factors affect the short- and long-term morphology of the LMR is a complex challenge for the river engineers and scientists responsible for managing this system for flood control, navigation, habitat restoration and reducing the loss of coastal marshes and wetlands in Louisiana. Much of the knowledge about the morphologic character of the LMR was gained through the U.S. Army Corps of Engineers (USACE) Potamology Program, which began in the early 1930s in recognition of the need to develop a better understanding of the underlying principles responsible for the behavior of the river.

HISTORICAL POTAMOLOGY PROGRAM

The word “potamology” has its root in the Greek word “potamas” and is defined as the scientific study of rivers or the science of rivers. Over the years, the focus of the program evolved as new demands and challenges arose. However, by the early to mid-1980s, the program basically ceased to exist. In this section, the history of the Potamology Program is described.

Pre-Potamology Studies. The Mississippi River is the third largest river system in the world; it is the largest navigable river system in the world; and it is an incredible economic engine and economic advantage for the United States. Industry and agriculture depend on its transportation infrastructure; it is a source of water and recreation for millions of citizens; it is a vital ecosystem and environmental treasure. And at times, it can show the brute force of nature through devastating floods. The Mississippi River was used throughout history by Native Americans for transportation. The first river structures were levees constructed by European settlers above New Orleans in the early 1700s.

The U.S. Army Corps of Topographic Engineers became involved early on in river operations - there are discharge records of the river dating back to 1817. Other information documents were produced through the 1800s, including the seminal “Physics and Hydraulics of the Mississippi River” report by Capt. A.A. Humphreys and Lt. H.L. Abbot, which is considered as the “beginning” of hydraulic engineering on the river (Humphreys and Abott, 1861). At the time, it was also widely considered as the “final” report on river engineering. Since then, the Mississippi River has shown that any potamology or river engineering studies should only be considered “interim” as the river is constantly changing, forcing USACE efforts to advance understanding and knowledge of river processes. A comprehensive discussion of the management and engineering philosophy during this early period is presented in Elliott (1932).

The beginning of official USACE potamology studies is directly tied to the decision by Mississippi River Commission (MRC) president Brig. Gen. Harley B. Ferguson in the early 1930s to implement a cutoff program on the Mississippi River. These initial efforts focused on the study of the alluvial processes and their application to the management of the river system. The first MRC studies were conducted at the U.S. Army Engineer Waterways Experiment Station (WES) during the period of 1932-1935. These studies focused on determining the most favorable alignment to stabilize the Mississippi River in connection with the initiation of the cutoff program.
Subsequent studies examined bed materials in the system, materials in transport, and meandering of alluvial channels. This work included model studies and field sampling and surveys. The efforts were conducted in the late 1930s to the mid-1940s.

**MRC Potamology Investigations.** The first official MRC “Potamology Investigations” were initiated in the fall of 1946. These were the most extensive and comprehensive such studies conducted at the time. The program examined meandering tendencies to develop modeling for future river projects, the causes of revetment failures to prevent future occurrences, means of channel stabilization other than revetment, and development and testing of comprehensive plans to improve specific troublesome river reaches.

The majority of the early investigations were conducted by WES (which was under MRC control until 1949) with field assistance by the USACE Memphis, Vicksburg, and New Orleans Districts. The work included extensive field observations at several points on the Mississippi River, large-scale laboratory projects, soils studies, and instrumentation development and evaluation.

The MRC Potamology Board was established in 1957 that consisted of representatives from the MRC; the Memphis, Vicksburg and New Orleans Districts; and WES. It was active until 1961 and helped foster completion of additional potamology investigations. The Board was re-established in 1963 and expanded to include the entire Lower Mississippi Valley Division; a representative from the St. Louis District was added to the Board. In 1963, the MRC also established a Potamology Research Branch in the Engineering Division to coordinate studies recommended by the Potamology Board. The Board and the Branch were instrumental in completing several investigations. Over the next two decades, the Board and Branch were active, but over time and reorganizations, they had ceased to be active functioning elements by the mid-to late-1970s. The USACE Committee on Channel Stabilization, established by the Chief of Engineers in 1962, was also instrumental in completing several studies impacting Mississippi River channel problems in the 1960s to early 1970s.

**Potamology Early Years.** Over the course of the mid-to-late-1900s, potamology studies and programs evolved to meet new demands and challenges. In the 1930s and 1940s the focus was on man-made cutoffs and their impact on the channel system. The spotlight moved to revetment failures and improved revetment construction and materials from the late 1940s to the early 1960s. From the 1960s to 1972, the focus shifted yet again as the MRC worked to develop the best ways to manage troublesome reaches of the river. Research and investigative studies were spawned by these activities, providing much needed information that advanced the understanding of the complex processes that nature and man-made structures combined to shape the river and how the river adjusted over time.

Crisis situations focus attention on problems. On the Mississippi River, the 1927 flood was such an event. The 1927 flood not only was the catalyst for the MR&T, it also drove efforts such as cutoffs and channel stabilization. Funding was made available to advance potamology knowledge as a result. The potamology studies of the 1930s through the late 1960s were accomplished due to this investment and the efforts of dedicated staff.

As with any crisis situation, knowledge and training prior to the event help provide the best response. Such was the case in 1927 when decades of preliminary work and research led to the
MR&T – the policy, direction, and framework in this landmark legislation were not developed overnight. The same can be said for potamology studies over the years. These studies provided USACE knowledge and also a generation of expert staff with the engineering expertise needed to help manage the river.

As is human nature, once we experienced a “comfortable” period in river conditions (fewer major floods and somewhat stable average flows), many leaders believed that our understanding of river behavior was sufficient for the current state. As such, interest, and more importantly, funding in potamology related studies waned.

**1973 Flood & T-1/P-1.** The 1973 Mississippi River flood was a “wake up” call for river science and engineering. The spring flood produced river stages that were higher (up to approximately 5 feet higher in some locations) than expected. These higher stages made it apparent that the stage-discharge relationships were several feet higher than the previous stage-discharge relationships used to establish levee grades and other flood control features. Therefore, the potential existed for a significant reduction in the flood capacity over a major portion of the LMR. To help address this critical issue, the President of the MRC - Division Engineer, LMVD implemented two new potamology study programs.

The “LMVD Potamology Study (T-1)” was initiated on August 7, 1974. This study was basically a data assembly effort that provided a current “snapshot” of conditions and information that focused on the nine major factors that impact river behavior. Each factor was covered by a separate T-1 Work Package:

- Work Package 1 – Review of the Cutoff Program
- Work Package 2 – Inventory of Revetment and Dike Systems
- Work Package 3 – Geological Inventory
- Work Package 4 – Hydrology Factors
- Work Package 5 – Hydraulic Factors
- Work Package 6 – Inventory of Physical Characteristics
- Work Package 7 - Inventory of Levees
- Work Package 8 - Inventory of Dredging Activities
- Work Package 9 - Inventory of Sediment Data

Work packages 1 and 5 were conducted by the USACE Vicksburg District; 2, 3, 4, 6, and 7 were done by the University of Missouri at Rolla for the USACE St. Louis District; 8 was compiled by the USACE Memphis District; and 9 was completed by WES for the USACE New Orleans District. This effort assembled a large mass of data to feed follow-on studies to determine primary cause and effect relationships related to the Mississippi River.

Building off the T-1 work packages, the LMVD Potamology Program (P-1) was developed. The P-1 Program focused on defining the cause-and-effect relationships that resulted in short- and
long-term changes in the stage-discharge relationships in the LMR and developing improved design concepts and construction criteria for channel stabilization. The program continued the advancement of the level of knowledge and understanding of the Mississippi River behavior, allowing USACE to develop the most efficient and cost effective flood risk reduction and navigation channel possible.

This program also expanded the USACE view of potamology with investigations of four major parameters: hydrology (highly variable stages), sedimentation (sediments on or near the channel bed scoured from one location and deposited downstream), channel geometry (variable alignment impacting flow and sediment transport), and man-made modifications (levees, cutoffs, revetments, and dikes).

In the mid-1990s, the USACE Mississippi Division (MVD) formed the River Engineering Study Team (REST) in an effort to revitalize potamology studies. The REST consisted of river engineers and scientists from the division and district offices. The first meetings of the REST occurred on board the MV Mississippi during the May 1995 Channel Improvement trip. The purpose of the REST was to recommend, set priorities, plan, direct, and publish results from river engineering investigations on the LMR, with an aim towards developing an understanding of the short- and long term cause and effect relationships between the observed channel morphology and the channel improvement features. The REST proposed four broad study areas: (1) analysis of hydraulic slope and vertical adjustments; (2) channel geometry studies; (3) sediment studies; and (4) short- and long term numerical modeling of channel morphology. Each of these study areas would consist of a number of individual sub-areas. Unfortunately, only a few REST studies were initiated, and within a few years, the REST team disbanded.

Although the REST no longer existed, the USACE districts did continue to conduct river engineering studies, generally aimed at specific troublesome reaches of the river. In 1995, the St Louis District Hydraulics Branch established the Applied River Engineering Center (AREC) with the aim to conduct applied river engineering studies on the Mississippi River in an office/laboratory environment. A key component of the AREC is the Hydraulic Sediment Response (HSR) model, which is a small-scale, physical sediment transport model used to replicate the mechanics of an actual river on an area the size of a normal table top. Since its conception, numerous river engineering studies have been conducted on the Mississippi.

**Historical Potamology Data and Unpublished Reports.** As discussed above, the publication of technical reports was a major accomplishment of the Potamology Program. However, perhaps equally important is the vast amount of historical data and unpublished studies that were conducted as part of the program. Typical types of data that were collected included detailed hydrographic surveys, sediment sampling (both suspended and bed material), velocity and current direction measurements, boring data, divided flow data, bed form data, geologic information, water surface slopes, and geomorphic assessments. Unfortunately, some of this information has already been lost, and most of the data and studies exist only in hard copy form in somewhat obscure locations in various offices and archive areas at the USACE district and division offices. This is a massive set of data that represents an extremely valuable resource, which not only provides an historical perspective of the river, but more importantly, could be used to inform present-day efforts to understand the river system. One goal of the MRG&P is to gather and organize this historical data so that it will be of use for future studies.
FUTURE CONSIDERATIONS

The record setting 2011 Mississippi River flood again stirred interest in potamology related studies. This time interest was not driven by problems or failures; it was how successful the system safely passed the record flows of this epic event. Just as the 1973 flood was a wakeup call, the 2011 flood should be an equally important benchmark for us to understand the reasons for the difference in river response to the two floods. The lessons learned from the potamology studies of the late 1940s to the 1980s, and implemented in the river since the 1973 flood, worked fantastically when put to the ultimate test. But USACE realized it had basically lost a generation of continued potamology advancement along with the experienced staff with that important knowledge.

While Mississippi River flood damage reduction and navigation issues continue to be a major emphasis of USACE activities, especially on the lower river, there are new demands, interests, and economic focus areas championed by the public, river users, and stakeholders in the vitality of this national asset. Environmental restoration, conservation, recreation, coastal land loss and erosion, water quality and supply (surface and aquifer) and other basin-wide and localized issues are requiring attention in today’s society.

Environmental factors, such as habitat development, fisheries enhancement, recreation, threatened and endangered species, invasive species, water quality, etc. are all now major considerations in USACE site specific projects and system-wide management strategies. Many new, and probably future, Mississippi River studies are being funded and driven based on environmental challenges.

In the last several decades, there has been an increased environmental activity concerning habitat development related to USACE dikes in the river. Notches have been installed on the bankside of dikes to increase habitat development that have provided additional recreational opportunities as well. During the MRC Low Water Inspection stop in Vicksburg, Miss., on August 21, 2013, the President of the MRC conducted a ceremonial signing of MVD/ERDC report “Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River,” with representatives of the U.S. Fish and Wildlife Service (USF&WS) and ERDC (Killgore et al., 2014). Besides featuring amazing interagency cooperation between USACE and USF&WS, the report featured a major potamology/geomorphology element.

The USACE has also lost a generation of experienced staff with potamology skills and expertise. This is due to various impacts including hiring reductions, funding constraints, and changes in mission focus. This staff expertise cannot be imported overnight, but must be fostered and grown by hiring and supporting capable engineers and scientists, providing training and mentoring, supporting intra- and interagency cooperation, and other innovative practices. There should always be a cadre of skilled professionals to pass corporate knowledge and ideas to those following, and also to those leading as well. A revitalized Potamology Program will keep USACE staff immersed, and interested, in understanding the morphologic processes that drive the important Mississippi River system.

This effort will have both short-term (less than 20 years) and long-term (20 to 200 years) implications and emphasis. Some river projects could use potamology knowledge
implementation today. On the other hand, the river is still responding to the cutoffs initiated 75+ years ago. Decisions made and implemented in the near future could have positive (or adverse) impacts for centuries. The re-establishment of a “Potamology” type program for the Mississippi River is needed to ensure incorporation of the best science and management practices from an engineering and environmental perspective for the complex and diverse demands of the 21st century and beyond.

REFERENCES


