RED RIVER WATERWAY: DEVELOPMENT FOR COMMERCIAL NAVIGATION

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INTRODUCTION

The Red River, after rising in eastern New Mexico, follows an easterly path across the panhandle of Texas, forms the boundary between Texas and Oklahoma, and extends into southwestern Arkansas. Once in Arkansas, the Red River makes a southeasterly turn through central Louisiana to its mouth at the Atchafalaya River just west of the Mississippi River. Along its path, the Red River cuts through soils rich in iron oxide. This iron oxide gives the Red River its rusty color, and hence its name. The Red River is an incised channel with the 50-year frequency flood basically contained within top bank. During the late 1800s, the great Red River raft was removed. This raft consisted of a large log jam that extended some 150 miles upstream from near Natchitoches, Louisiana, to the Arkansas-Louisiana state line. The raft created a backwater effect that induced sediment deposition. The removal of the raft resulted in significant bed degradation. Approximately 15 feet of degradation occurred at Shreveport. Also, channel improvement on the Atchafalaya River potentially has contributed to the bed degradation on the lower Red River. In its natural state, the Red River is a high energy system characterized by high velocities, actively caving banks, and shifting sand bars. This bank caving serves as the primary source for the large suspended sediment load carried by the Red River.

PROJECT HISTORY AND STATUS

The Red River Waterway Project was authorized in 1968 with the primary purpose of providing a 9-foot deep by 200-foot wide navigation channel from the Mississippi River to Shreveport, Louisiana. A waterway project location map is provided as Figure 1. The construction of a system of five locks and dams in conjunction with a program of channel realignment and bank stabilization is required to provide and maintain the authorized project channel. At present, Locks and Dams No. 1, 2, and 3 are complete and in operation. Lock and Dam No. 1 (Lindy C. Boggs Lock and Dam) was put into operation during the fall of 1984. Lock and Dam No. 2 (John H. Overton Lock and Dam) became operational during the fall of 1987. Lock and Dam No. 3 has been in operation since December 1992. This lock and dam is currently holding an interim pool level. The pool will be raised to its permanent minimum level once remaining project work within the pool that would be impacted by the higher water level is completed. Locks and Dams No. 4 and 5 are under construction and scheduled for completion during January 1995. The channel realignment and bank stabilization program has progressed with practically all work complete and developing through Pool 3. Capout of revetments continues in Pool 4 while revetment and capout construction continues in Pool 5.

RED RIVER WATERWAY PROJECT FEATURES

Locks and Dams

On the Red River, five locks and dams are required to provide adequate channel depths to accommodate commercial navigation. Each of these locks and dams includes a lock chamber that is 84 feet wide with a useable length of 685 feet. This size chamber will allow for the lockage of six standard barges and a tow boat in a single lift. Each standard barge measures 35 feet wide by 195 feet long. The total lift provided by the five locks is 141 feet. Lock and Dam No. 1, located near Marksville, Louisiana, provides the greatest lift since stages downstream of this structure are dependent upon backwater from the Mississippi River. The maximum lift at Lock and Dam No. 1 is 36 feet. The maximum lift for Lock and Dam No. 2 is 24 feet, Lock and Dam No. 3 is 31 feet, and Locks and Dams No. 4 and 5 each have a maximum lift of 25 feet. For flows that exceed the 10-year frequency flood, channel velocities become sufficiently high to restrict commercial navigation. Therefore, the lock walls are designed so that the lock is operational only up to the 10-year frequency flood event. Each lock and dam also includes a gated dam that maintains the minimum pool during low water periods and passes flood flows. Lock and Dam No. 1 was designed to pass the project design flood (100-year frequency post project flood) with only one foot of swellhead. A gated dam with eleven tainter gates was required to meet this criteria. For the other four locks and dams, gate optimization studies were conducted. These studies compare the cost of each additional tainter gate to the cost associated with inundating additional upstream lands. These studies resulted in the upstream four locks and dams having fewer tainter gates and some type of overflow section. The lock and dam features for Lock and Dam No. 2 are shown in the photograph enclosed as Figure 2. In selecting the sites for the locks and dams and in selecting minimum pool levels, consideration is given to impacts associated with increased water levels. These impacts include inundating lands not normally flooded under pre-project conditions and groundwater impacts associated with holding a minimum pool that is higher than normal pre-project water surface elevations.

Channel Realignment

Many bends on the Red River are too tight to accommodate navigation by the Red River Waterway channel design tow (3 standard barges in tandem). Therefore, these bends are realigned via a channel cutoff across the neck of the old bendway. A photograph of a typical channel realignment constructed on the Red River is included as Figure 3. On the Red River, the pilot channel concept for channel realignment is utilized. This technique includes excavating a pilot channel that is smaller than the desired channel section. Since the Red River is a high energy system that primarily traverses easily erodible soils, the natural erosive action of the river develops the pilot channels to their ultimate section. On the Red River, pilot channels as small as 50 feet wide have been excavated that quickly eroded to the typical channel width of 400 to 600 feet. A non-overtopping earth closure dam is provided across the upstream end of the old bendways that are at least a mile in length. This closure dam prevents sediment laden river flow from entering the longer old bendways and thus helps preserve these bendways for environmental and recreational purposes. A non-overtopping closure dam also helps facilitate the development of the pilot channel by forcing all of the channel developing flow through the pilot channel. On the shorter bendways that are not being preserved, only a low stone closure is provided across the upstream end of the old bendway. This low closure helps facilitate development of the pilot channel during periods of low flow. During periods of higher flow, the stone closure is overtopped and divided flow occurs. This condition results in sediment deposition in the old bendway.

The channel realignment program on the Red River results in an approximately 50 mile reduction in length within the 280 miles of river downstream of Shreveport. This 18 percent reduction in channel length provides a more efficient channel. The added benefit of a shorter channel is a reduction in flood stages. For example, during May 1990 a major flood event occurred on the Red River. During this flood which exceeded the 100-year frequency event at Shreveport, the peak stage was approximately one to two feet lower than it would have been prior to construction of the realignments.

Bank Stabilization

On the Red River, revetments are used to stabilize the banks, thus locking the navigation channel into place. During the 1950s, 1960s, and early 1970s some board mattress revetments were constructed. Since these revetments are expensive due to construction being labor intensive, they are no longer used. Along the lower Red River downstream of the mouth of the Black River, articulated concrete mat (ACM) like that placed on the Mississippi River has been used. However, the placement of ACM requires a large physical plant that due to its size is restricted from operating on smaller rivers.

The type revetments currently used on the Red River are trenchfill revetments, stonefill revetments, and timber pile revetments. At those sites at which the desired bankline is located landward of the existing bankline, trenchfill revetment is used. This type revetment includes the excavation of a trench along the desired channel alignment and filling the trench with stone. As the bankline continues to erode, the trench is undermined and the stone in the trench launches down the face of the bank. This process stabilizes the bank, thus locking the channel into place. Trenchfill revetments have proved very effective on rivers like the Red River which have a very active meandering channel. A photograph of a typical trenchfill revetment as constructed on the Red River is provided as Figure 4.

At those sites at which the desired bankline is located riverward of the existing bankline, stonefill revetment or timber pile revetment is used. These type revetments protect the bank by inducing sediment deposition behind the revetment and thus building the bankline out toward the revetment. If the river is shallow along the desired alignment, stonefill revetment is used. This revetment includes placing stone in a peak section or a section with a flat crown along the desired alignment. In the deeper river locations, timber pile revetment is used. Timber pile revetment includes driving timber piles along the desired alignment and placing stone around the toe of the piling. These revetments are used in the deeper sections of river because they are cheaper to construct than are stonefill revetments. Once sediment deposition has occurred behind the stonefill or the timber pile revetment, the revetment is raised or "capped-out" by placing additional stone on top of the deposited material. This method of construction utilizes the sediment deposition behind the revetment to reduce the stone required to raise the revetment to its desired level. This method of construction is less expensive than initially constructing the revetment to its ultimate elevation. Due to the heavy suspended sediment load carried by the Red River, sufficient deposition usually occurs behind the revetments to allow the capout to be constructed after one or two highwater seasons. A photograph of a typical timber pile revetment constructed on the Red River is included as Figure 5. This photograph was taken after sediment deposition had occurred on the landside of the revetment, thus building the bankline out to the revetment.

On the downstream end of revetments, especially those in the upper reach of each pool where channel depth is most critical, kicker dikes are provided. This type dike is an extension of the revetment and forces the channel crossing from the revetment to the opposite bank. Providing these structures helps maintain navigable depths within the channel crossing, thus reducing maintenance dredging. In the very upstream most reach of the pools, additional contraction structures (ACS) are provided. ACS are stone dikes that extend from the convex bank to develop and maintain the channel against a revetment on the opposite bank. By constricting the channel, the narrower channel results in the scour of the bed thus deepening the channel to accommodate navigation. A photograph of a typical ACS constructed on the Red River is enclosed as Figure 6. These ACS are located in the very upstream most reach of Pool 1, immediately downstream of Lock and Dam No. 2.

Environmental / Recreational Features

Even though the primary purpose for the Red River Waterway Project is navigation, recreation is also an important feature of the project design. During the past decade, environmental consciousness has dictated that preservation and even enhancement of the environment be included in project design. The Vicksburg District and the project sponsor (Red River Waterway Commission) are planning, designing, and constructing recreational facilities such as picnic areas, boat ramps, camping areas, overlooks, nature trails, etc. Since Locks and Dams No. 1 and 2 have been put into operation and since river access in the form of boat ramps has been provided within these pools, recreational use of the river that was previously very limited has begun to flourish. Water sports such as fishing and water skiing and camping on sand bars are becoming common activities.

As previously discussed, the old bendways that are at least a mile long that are being severed by channel realignment are to be preserved for recreational and environmental purposes. Within the project reach, there are 29 such old bendways. Due to the sediment conditions on the Red River, bothersome deposition has occurred in the downstream end of the old bendways. Typically a shallow, narrow low water channel is naturally maintained through the sediment deposition. However, at one realignment, deposition has totally closed the old bendway off from the river. Due to the potential loss of these bendways to sediment deposition, the Vicksburg District has recently initiated a study to look at alternative methods of reducing this deposition. These measures include periodic dredging and/or structural measures such as dikes. Once these studies are completed during early FY 1996, the District will make a recommendation as to the preferred course of action.

SUMMARY

In its natural state, the Red River is wide and shallow with numerous shifting sand bars. In this condition, the Red River does not accommodate any level of commercial navigation except during undependable highwater periods. However, through the construction of a system of locks and dams, bank stabilization, and channel realignment, the Red River is being developed to provide for navigation from the Mississippi River to Shreveport. Through the use of sound engineering design that includes environmental considerations, reliable navigation can be provided for decades to come.

Figure 1. Red River Waterway Project Location Map

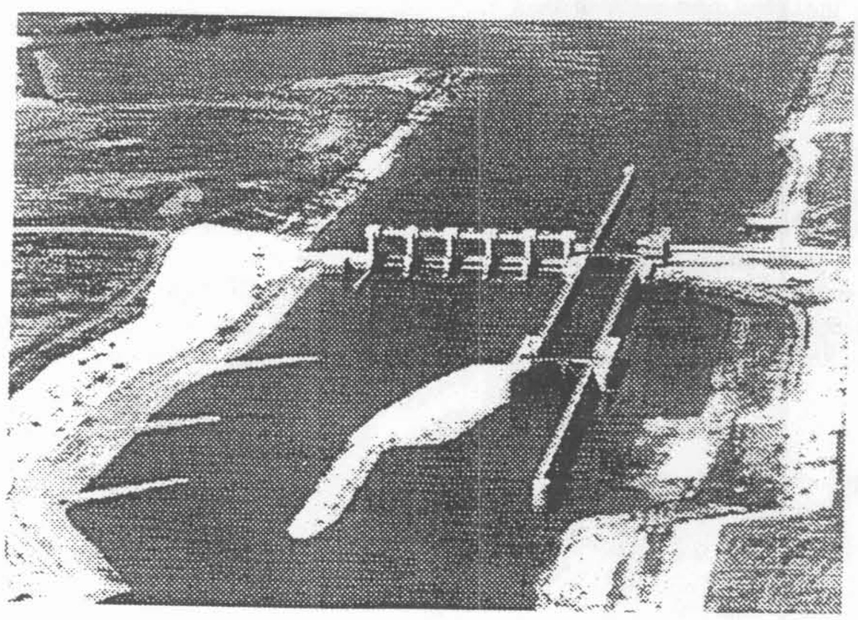

Figure 2. Lock and Dam No. 2

Figure 3. Grand Bend Realignment

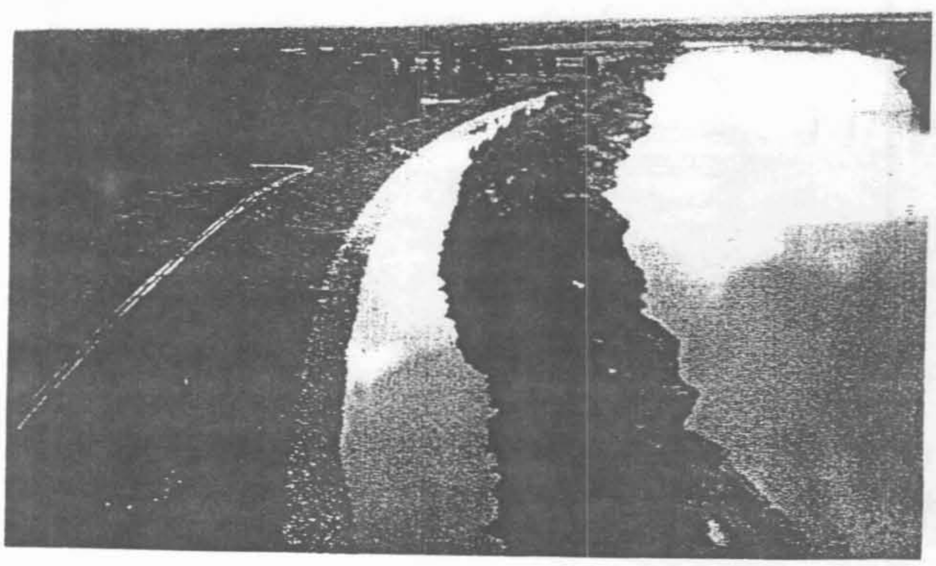

Figure 4. Hog Lake Trenchfill Revetment

Figure 5. Timber Pile Revetment

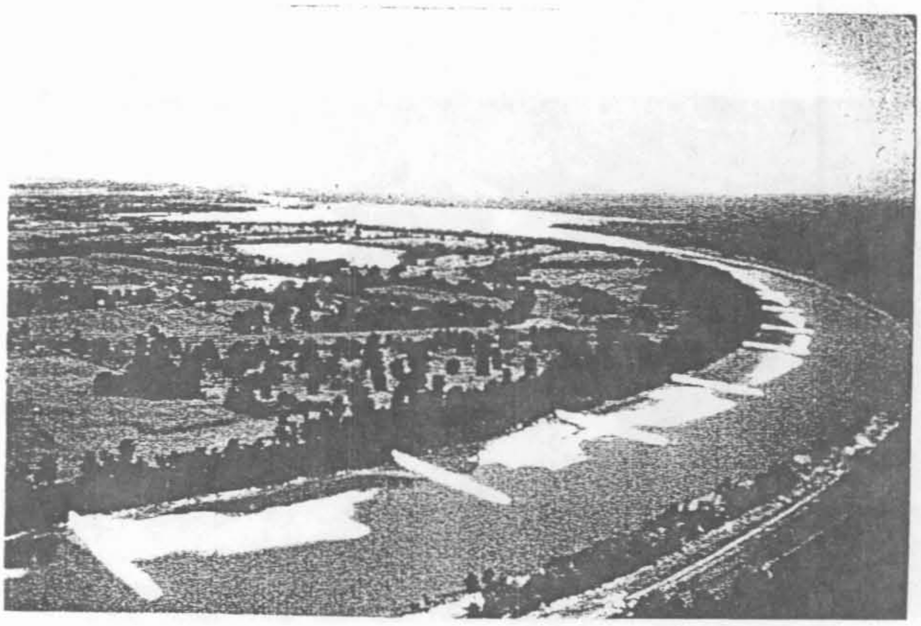

Figure 6. Hog Lake Additional Contraction Structures