VII. INVENTORY OF DIKES, REVETMENTS AND LEVEES

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A. Introduction

The development and control of a river system is a large and complex engineering problem requiring resources not available to private or local groups. Responding to the need for large-scale efforts in connection with the Mississippi River system, the United States Government created the Mississippi River Commission in 1879. The River and Harbor Act of 1890 charged the U.S. Army Corps of Engineers with maintaining navigable streams. This charge was extended to flood control by the Flood Control Act of 1928. The response to these charges by the U.S. Corps of Engineers and Mississippi River Commission on the Mississippi River has been a significant engineering achievement.

In order to assess the effect of human activities on this major inland waterway, an accurate record of what has been done is needed. To provide this record of engineering activities on the Mississippi River, an inventory of dikes, revetment, and levee construction based on available data was tabulated. Data were collected to show their location, apparent characteristics, and current status. These data were collected considering their possible use in hydraulic calculations. A shortage of records in some areas hampered completion of the inventory.

B. Channel Regulation Structures

1. Dikes: A dike may be defined as a structure used for channel

regulation or bank protection purposes. Dikes may be classified as either permeable or impermeable. Permeable dikes are built of materials which readily allow passage of flow. Their success depends on reduction of velocity to facilitate deposition of sediment. Impermeable dikes are built of material, such as sand and rock, which will not readily allow passage of flow. Some basic functions performed by dikes as training works are:

a. providing protection against bank erosion
b. guiding or deflecting flow
c. controlling channel widths at low stages
d. promoting sediment deposition or scour
e. creating storage areas for dredged material
f. promoting chute closures

Dike construction began before federal involvement on the river; for example, private dikes were used in the St. Louis area beginning in the 1830's. These dikes were built basically of stone.

After formation of the Mississippi River Commission in 1879, federal dike construction began to appear along the river. The early federal dikes were permeable types. However, by 1962 in the St. Louis District and by 1964 in the Memphis District, impermeable or stone-filled dikes had gained favor.

2. Revetments: A revetment is a bank protection structure which serves as a shield against erosion and as a training structure to maintain channel alignment. Materials used in revetments include rock, woven-willow mats, asphalt mats, and articulated concrete mats. Other materials such as concrete tetrahedrons, lap slabs, and reinforced asphalt have also been used, but on a much smaller scale. At present

the most popular material in the St. Louis District is rock while downstream articulated concrete mats are preferred.

Major federal activities in revetment construction had initial emphasis in the early 1880's as part of the program of the Mississippi River Commission. Another period of emphasis began in 1928 as a consequence of the Flood Control Act.

C. Levees

An inventory of levee construction would be incomplete without commentary relative to the natural levee system which exists solely by virtue of processes in nature. The early non-federal levee construction accompanying agrarian settlement along the river must also be recognized. Existence of these early levees, in many respects, affected subsequent levee construction activities. Section F of this chapter is a synopsis of the history and development of the program of river control.

D. Levee Crevasses

There are annual failures of small farm levees for which documentation is unavailable. Therefore, this study has been restricted to tabulation of significant crevasses of federally-owned levees within the Lower Mississippi Valley Division. This tabulation includes date of breach, location, type of breach, flood stage, size and type of area flooded, estimated damage and physical features of levee and breach. Much of the historical information is not documented. Recent breaches are well documented but their occurrences are rare. The most recent breach in the study limits was at Kaskaskia Island in the St. Louis District (1973). This failure was due to overtopping because the levee was not constructed to the authorized grade. In the St. Louis district between 1940 and 1950, several failures which occurred by overtopping during construction were not listed as crevasses. In general, most crevasses occur as a result of overtopping and subsequent erosion rather than as a direct structural failure.

E. Data Procurement and Compilation

1. Procurement: The procurement of inventory data was in accordance with specifications of the study contract. Special data forms were developed to facilitate the orderly compilation of the available data. The information on these forms which pertains to structures included physical location, date of construction or modification, materials used, elevations and profiles referenced to a low-water reference plane, and a summary of the current operational status of the structure. Information on forms pertaining to crevasses included date of breach, identification number and name, location, type of breach, and other information relating to the size of the breach. The prime sources for data were:

   a. Original plans
   b. OCE reports
   c. Congressional documents
   d. U.S. Corps of Engineers special reports
   e. U.S. Corps District channel improvement reports
   f. Project maps

2. Dike, revetment, levee, and crevasse data were placed in individual files by river-mile location and each file was partitioned according to Corps District. These were then coded, keypunched, and stored on the computer. Computer programs were written to sort each file and to produce the inventories of dikes, revetments, levees, and

crevasses presented in Appendices 7.1, 7.2, 7.4, and 7.5, respectively. Map locations of federal levees in the St. Louis District and dikes and revetments for the entire study area are shown in Appendix H as an incidental consequence of surficial soils mapping.

F. History of River Control - John B. Heagler, Jr.

The natural condition of the Lower Mississippi River is that of a meandering sedimentary stream which deposits its alluvium over the floodplain during high water. The pattern of alluvium distribution has determined the development of the river and has had important consequences for later levee construction. The geological history of the river is well treated by Fisk in his various reports. In discussing alluvial deposits (1947), he states:

> "Under natural conditions the river channel was unable to accommodate all of its high-stage flow and overtopped its banks periodically. Great quantities of silty and clayey sediments were laid down by these floodwaters, forming natural levees along the banks of the stream. The natural levee is typically best developed on the outside of river bends as a low sloping wedgelike ridge of sediments, over a mile in average width, tapering into the adjacent lowlands. These levees are being constructed above the general level of the floodplain basins and are the topographic forms which cause the meander belt to stand up as an alluvial ridge...Because of the fertility of the soil and the comparative ease with which it drains, the natural levee is the site of most of the agricultural land in the lower Mississippi Alluvial Valley."

Fisk also reports that these natural levees, while lower than 15 feet in the northern part of the Valley, are generally greater than 25 feet above the surrounding floodplain in the southern section. Humphreys and Abbot, in a study published almost a hundred years earlier, also noted the height of the natural levees near the river and included the following table of slopes in their report.

TABLE 7.1

Slope of the natural banks of the Mississippi.

Locality.	Bank.	Fall in first mile from river.	Authority.
		Feet.	
Near Cairo	Right.	4	Cairo and Fulton railroad company.
Near Memphis (measured from bank of Mill-seat lake)	Right.	6	Military road—Memphis to Little Rock.
Near Prentiss	Left.	7	Delta Survey (party of Mr. Pattison).
Near Gaines' landing	Right.	5	Gaines' landing and Fulton railroad company.
Northern boundary of Louisiana	Right.	8	Professor C. G. Forshey.
Near Lake Providence	Right.	8	Providence and Fulton railroad company.
Near Natchez; measured from bank of lake Concordia	Right.	8	Delta Survey (party of Mr. Pattison).
6.6 miles above Williamsport	Right.	7	Delta Survey (party of Mr. Ford).
1.3 miles above Williamsport	Right.	5	Delta Survey (party of Mr. Ford).
Below Williamsport, near Morgan's	Right.	9	Delta Survey (party of Mr. Ford).
New Texas road	Right.	10	Swamp-land commissioner's office, La.
11 miles above Point Coupée church	Right.	3	Delta Survey (party of Mr. Ford).
3 miles above Waterloo	Right.	12	Delta Survey (party of Mr. Ford).
4 miles below Port Hudson	Right.	9	Delta Survey (party of Mr. Ford).
7 miles below Lobdell's store	Right.	5	Delta Survey (party of Mr. Ford).
5 miles above Baton Rouge	Right.	3	Delta Survey (party of Mr. Ford).
Grosse Tête railroad	Right.	10	Dr. William Sidney Smith.
6 miles below Baton Rouge	Right.	13	Delta Survey (party of Mr. Ford).
7.5 miles below Baton Rouge	Right.	12	Delta Survey (party of Mr. Ford).
1.5 miles above bayou Manchac	Left.	6	Delta Survey (party of Mr. Ford).
Opposite bayou Manchac	Right.	11	Delta Survey (party of Mr. Ford).
4 miles above Bayou Goula	Right.	10	Delta Survey (party of Mr. Ford).
1.5 miles above Bayou Goula	Right.	6	Delta Survey (party of Mr. Ford).
8 miles below Bayou Goula	Right.	5	Delta Survey (party of Mr. Ford).
1 mile below Domenique's landing	Right.	6	Delta Survey (party of Mr. Ford).
3.5 miles above Donaldsonville	Right.	3	Delta Survey (party of Mr. Ford).
5 miles below Donaldsonville	Left.	5	Delta Survey (party of Mr. Ford).
10 miles below Donaldsonville	Left.	9	Delta Survey (party of Mr. Ford).
10 miles below Donaldsonville	Right.	6	Delta Survey (party of Mr. Ford).
20 miles below Donaldsonville	Left.	8	Delta Survey (party of Mr. Ford).
4 miles above Bonnet Carré church	Right.	7	Delta Survey (party of Mr. Ford).
Upper end Bonnet Carré crevasse	Left.	10	Delta Survey (party of Lieutenant Warren).
Lower end Bonnet Carré crevasse	Left.	3	Delta Survey (party of Lieutenant Warren).
Barataria canal	Right.	7	Surveys of canal company.
1 mile below Barataria canal	Right.	4	Delta Survey (party of Mr. Ford).
Near New Orleans	Right.	10	New Orleans and Opelousas railroad company.
Near New Orleans	Left.	10	Mr. G. W. R. Bailey.
11 miles below New Orleans	Left.	8	Delta Survey (party of Mr. G. C. Smith).

The general composition of these natural levees, as reported by Fisk is given in the following figure.

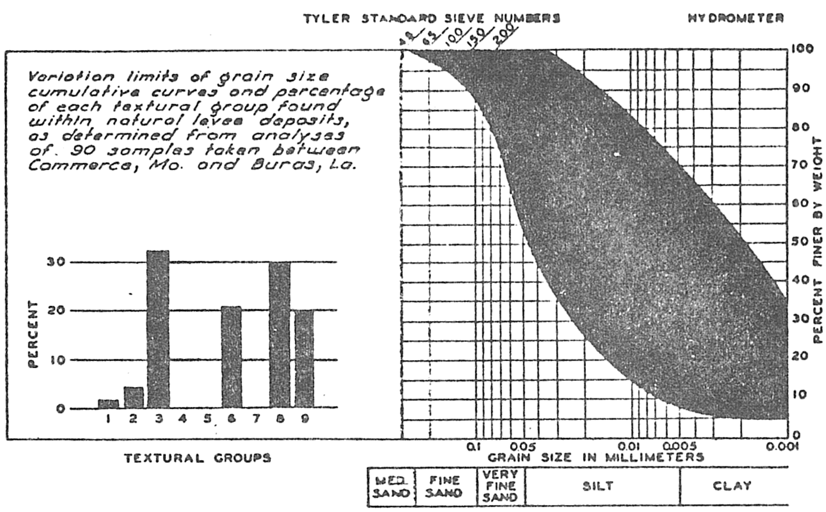

Figure 7.1 NATURAL LEVEE DEPOSITS

TEXTURAL GROUPS: COMPOSITION VARIES FROM SAND TO CLAY. CHARACTERISTIC TEXTURAL GROUPS ARE SANDY SILT, CLAY SILT, SILTY CLAY AND CLAY. THERE IS A GRADUAL DECREASE IN GRAIN SIZE SOUTHWARD FROM CAIRO, ILL. THE PERCENTAGE OF SANDY AND SILTY MATERIALS ALSO DECREASES AWAY FROM THE CREST OF THE NATURAL LEVEES.

SORTING: SANDY AND SILTY SEDIMENTS OF THE COARSER TEXTURAL GROUPS ARE USUALLY WELL SORTED; THE CLAYS ARE REPRESENTED BY THE COARSER HALF OF THEIR GROUP AND ARE GENERALLY POORLY SORTED.

WATER CONTENT: GENERALLY VERY LOW. LENSES OF CLAYEY SEDIMENTS OCCASIONALLY HAVE HIGH WATER CONTENT.

ORGANIC CONTENT: EXTREMELY LOW. SMALL LAYERS OCCUR LOCALLY.

COLOR: USUALLY LIGHT IN COLOR, VARYING FROM TAN, BROWNISH GRAY TO LIGHT GRAY. COLOR IS INFLUENCED BY SOURCE OF SEDIMENTS; RED AND ARKANSAS RIVERS CONTRIBUTE BROWN AND RED SEDIMENTS.

THICKNESS AND DISTRIBUTION: OCCURRENCE LIMITED TO NARROW ZONES ALONG PRESENT AND ABANDONED RIVER COURSES. THICKNESS OF THESE DEPOSITS VARIES WITH LATITUDE AND POSITION ALONG STREAM. DEPOSITS ATTAIN THEIR MAXIMUM THICKNESS AND DISTRIBUTION ON THE OUTSIDE OF BENDS. DEPOSITS ARE SELDOM OVER 15 FEET THICK IN THE NORTHERN PART OF THE VALLEY AND INCREASE TO A MAXIMUM OF ABOUT 25 FEET IN THE DELTAIC PLAIN REGION.

STRATIFICATION: GENERALLY MASSIVE, WELL-BEDDED EXTENSIVE LAYERS.

The natural levees form the highest aggradational floodplain feature and, as such, exhibit a significant influence on the river and the development of the floodplain. The surface drainage away from the river has turned the adjacent lowlands into backswamps into which the finest clays and silts carried by floodwaters, are deposited. Also, since the natural levees are higher than the surrounding floodplain they tend to block drainage from the floodplain back into the main channel and force it into secondary tributaries that ultimately enter the main channel at a lower elevation. Because of this, the backswamp areas are rather poorly drained. "When the natural levee deposits become too high, the river confined by them often breaks away during flood times and forms a new channel through the interstream depression." The natural levee is also subject to destruction by bank caving which may occur during low water. As the river's current impinges on the banks, strata underlying the natural levee may be eroded until the overburden load collapses into the stream and is carried away as sediment. Natural levees formed by river deposition have obviously beem important agents in determining the course of the river and the morphology of the river's floodplain. The natural levees also had and still have an important influence on the settlement patterns and land use of the floodplain. It is obvious that the landforms established by deposition during flood stages are susceptible to inundation from later high water. If the natural levees are submerged, the lowlands behind them are covered even more deeply. In discussing this fact J.A. Ockerson (1903) states that while people saw flood depths of three or four feet over the natural levees, "They did not appreciate the fact that perhaps five miles farther back the water was 10 ft., or more, in depth." The first Mississippi flood on record occurred in 1543 (Elliott, 1932). It began in early March and was not back within the banks until the end of May, about eighty days after it had begun. Although water was again confined by the natural levees, the lower lands behind them must have taken longer to clear because of the poor drainage of the backswamps. With floods of such depth and duration, it is apparent that no permanent settlement or cultivation could be established along the river without making provisions for floods. The use of artificial levees for the protection of man, his properties, and his endeavors began with the very first settlement of white men on the Mississippi floodplain. When Bienville chose a site in 1717 for the City of New Orleans, his engineer, de Latour, objected on the basis that it would be easily inundated by high water. Upon being overruled, de Latour constructed an earthen embankment, modeled after the European levees, to protect the city. It was only four feet high, 5400 feet long, and 18 feet wide, but it proved to be sufficient for protection. As settlement progressed along the river, the levee line was extended by individual landowners at their own expense both above and below the city to prevent flooding of the farmlands. To allow the greatest area for cultivation, to utilize the best agricultural soil, and to keep construction expenses low, these levees were set close to the river along the top of the natural levees. This meant that the levees often failed due to caving banks. Apparently this did not discourage construction, for by 1735 the levee line extended about thirty miles above New Orleans on both sides of the river. No specifications for levee grade and section for this period are known, but some minimum criteria must have existed, since levee construction did become the official policy of the French government. Riparian landowners were required to complete their levees by January 1, 1744, or forfeit their lands to the Crown. The required levees were small by today's standards and crevassed often, but they provided enough protection to be put into general use. What effect the leveeing of this portion of the river had on the Mississippi itself cannot be assessed. The river was still free to flood above this section and outlets such as the Atchafalaya were still unobstructed. Furthermore, according to Fisk, the alluvial deposits below Baton Rouge are mainly clays, as opposed to sandier alluvia above this point. Clay deposits resist erosion much better than sand, so any change in the channel due to levees would be slow and, in the absence of precise observations at the time, impossible to determine. The use of levees by individuals for flood protection continued even after the transfer of Louisiana to the United States and by 1812, the east bank had levees up to Baton Rouge and the west bank forty miles beyond that. By 1844, the west bank levee line was almost continuous up to the Arkansas River, while only a few levees protected the Yazoo Basin on the east side. During most of this period, it appears that there was very little planning done as to the location, dimensions, etc., of the levee system. Some of the largest levees were indeed built with engineering considerations, but this was generally not the case. The levees from the French period and after were constructed by the riparian landowners and supervised by local authorities to ensure adequate strength. What constituted adequate strength seems to have been based on experience rather than on any engineering criteria. As settlement continued, the task of flood control increased and slowly the engineering of levee construction became more important. For example, in 1833 Louisiana created a post for a civil engineer to be a supervisor of public works, including levees, and in 1835 legislatively specified the dimensions of the Concordia Levee. Larger engineering questions of flood control were also discussed. According to Harrison,

> "The long debate on the best plan for protection of the Alluvial Valley bagan in the 1840's. The need for outlets for Mississippi River floodwaters was discussed with attention to their possible location. Reservoirs were mentioned

> occasionally as a possible protection, but immediate efforts were directed towards levees as the only practical means of flood control."

Such attention to levees was given that by 1858 William Hewson was able to publish a detailed study of the various engineering aspects of levee construction and could recommend specifications for dimensions, materials, etc. With the gradual accumulation of knowledge about levees by landowners, engineers, and the States, over six hundred miles were erected before the Federal government became involved, to any major degree, in levee construction in 1850. Previous Federal involvement consisted simply of granting land for particular levees when these levees were being built. Under the prompting of Louisiana and several other states, Congress eventually passed a series of bills, the Swamp Acts, in 1849 and 1850. These granted all swamps and overflowed lands to the States, provided that the States would construct levees to protect the areas and open the swamps to cultivation by draining them. These laws are loosely worded and the actual intent of the Congress is unclear. Elliott feels that they were intended to be flood control legislation, while other writers, citing grants to States outside the frequently inundated Mississippi Valley such as Oregon, Michigan, and Florida, stress that the reclamation of wetlands was the basic intent. In much of the literature on the Lower Mississippi Valley "reclamation" and "flood control" appear to be almost synonymous. Thus, it cannot be claimed that the Swamp Acts are a clear statement of a Federal desire for flood control by an extensive levee system. It must also be stressed that the Federal government merely granted the lands for reclamation but expended no funds to aid this project. For example, even the surveys to determine what swamplands actually existed were done at the States' expense.

The major effect of the Swamp Acts in the Mississippi Valley was to organize levee construction much more than it had been. Responsibility for the levees had been slowly passing from the landowners to the States, but now the States assumed an even greater role as they began to specify grades and sections, and set up administrative systems for construction and maintenance. The expense of the levees were now assumed, through bonds and taxes on reclaimed land, by people other than the riverside landowners. Unfortunately, the levees built under this system were not large enough, poorly located and poorly constructed, while the administrative systems were defectively organized, and coordination between states was difficult. In spite of these failings, much practical experience with levee construction was gained by engineers and the levee system built was the best yet achieved. One contemporary evaluation of the system, while admitting its deficiencies, states:

> "Great practical good, however, has resulted even from the imperfect application of the system; for without it the greater part of the alluvial region below the mouth of the Ohio would be an uninhabitable swamp in the high-water months of the year."

In 1850, Congress also authorized a detailed survey of the river with a view to determining "the most practical plan for securing it from inundation." Captain A.A. Humphreys and Lieutenant H.L. Abbot made detailed observations of the river in 1851 and 1858 and considered a variety of proposed methods for flood control. The importance of the Delta Survey's report cannot be underestimated, for its conclusion that levees alone could control the river was accepted by later studies and eventually became the basis of flood control on the river, despite many other proposals. Until this point, levees had been built as necessities and little consideration was made of their potential effect on the river. Humphreys and Abbot, on the other hand, were required to make such an evaluation and much of their work included obtaining the precise data needed for such a task. Some interested people had kept stage records for a few cities, but a general collection of data did not exist. Thus, a major effort of the Delta Survey was the establishment of gages at various points along the river, and making a detailed study of the topography and characteristics of the Mississippi and its tributaries' basins. Utilizing these data, Humphreys and Abbot considered a series of flood control measures. The proposals generally followed one of two philosophies, later characterized by Corthell (1882) as a "Dispersion Theory" and a "Concentration Theory". The first is based on the principle that if one could get the water to the Gulf more quickly, either by shortening the river or by providing more outlets, floods would be lowered. The second functions on the basis that confining the water to the main channel would force the river to conduct all of its floodwater to the Gulf without spreading over the floodplain. Artificial cutoffs, designed to shorten the river, were decided to be impractical if they must be constructed from the mouth to the point where flood reduction is needed, as proponents desired. A cutoff of a single bend, while it would certainly depress flood stages above it, would merely raise stages below because the river could not handle the increased amount of water. Cutoffs, whether natural or artificial, were thus to be prevented. Artificial outlets, designed to remove the extra amount of water needed to create a flood, were considered in great detail. These were to be constructed either by creating new outlets or by enlarging already existing bayous which run parallel to the Mississippi. It was concluded that crevasses, and therefore outlets, do not induce sediment deposition immediately below their openings, a conclusion still contested years later, but the disposal of water after intake was the proposal's main defect. Some bayous were too long to be enlarged practically, while other might enlarge too much and divert too much of the river. In the case of a Bonnet Carre or Lake Borgne outlet, sediment deposition at the mouth would cause many problems. In general, outlets were seen as impractical, but it must be remembered that Humphreys and Abbot were considering all-season outlets, not spillways. Diversion of tributaries such as the Missouri, Arkansas, and Red Rivers, to reduce the total amount of water needed to be conducted by the Mississippi, was rejected. Humphreys and Abbot did not have all the data they felt they needed to make an absolute conclusion, but from what they had it appeared either that the diversions would create more injury once they were made or that they would have little effect on the Lower River. The final alternative to levees considered was the use of reservoirs. Humphreys and Abbot admitted that retention of water during floods and subsequent release during low water would have a neglible effect on the Lower River, because much of the rainfall causing floods falls directly over the Valley. On the other hand, reservoirs in the Lower Valley would be impossible because there are no suitable locations for them on the floodplain. After the discussion of the alternatives, the Delta Survey report contains a long analysis of levees and their effects. The main objection to levees with which Humphreys and Abbot dealt was that levees cause an elevation of river beds. Based on the European experience with the Po, it was argued that the sediment ordinarily spread over the floodplain would now be dumped on the river bed, raising the river