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Analysis and Comparison of Documented Seepage and Sand Boil Events on the Lower Mississippi River from 1937 to 2011

Volume 1: Main text

Joseph B. Dunbar, Amber L. Ensign, Nalini Torres,
and Maureen K. Corcoran

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Analysis and Comparison of Documented Seepage and Sand Boil Events on the Lower Mississippi River from 1937 to 2011

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Abstract

The following study examines the occurrence of seepage incidents and sand boils observed and documented during the 2011 Mississippi River Flood in the Lower Mississippi River Valley (LMV) within the boundaries of the U.S. Army Corps of Engineers (USACE), Mississippi Valley Division (MVD), Vicksburg District. This study examines the occurrence of sand boils in relationship to the underlying floodplain geology and identifies locations where large sand boils occurred. Large sand boil areas will be the focus for additional detailed study to better understand the mechanics of underseepage and internal erosion in USACE flood-control levees. Seepage and sand boil incidents documented during the 2011 Flood are presented in this report on geologic base maps and pre-flood imagery to compile a record of their occurrence and identify geologic relationships, as well as spatial patterns associated with the underlying fluvial landforms. A review of levee evolution within the LMV is summarized here along with past research studies of seepage involving major historic floods and their control.

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Preface

This study of the 2011 Mississippi River flood was conducted under the Infrastructure Technology Program, Flood and Coastal Storm Damage Reduction Program (FCSDR), in the research focus area for Improving Flood Risk Management and Water Control Infrastructure Resiliency and Reliability (WCIRR). Dr. Julie D. Rosati, U.S. Army Engineer Research and Development Center (ERDC), Technical Director, Coastal and Hydraulics Laboratory (CHL) was the Program Manager for FCSDR.

This study was conducted by personnel of the Geotechnical and Structures Laboratory (GSL). Dr. Michael Sharp, Technical Director, and Dr. Maureen K. Corcoran, Associate Technical Director, provided general supervision for this study. Dr. Joseph B. Dunbar, Geotechnical Engineering and Geosciences Branch (GEGB) of the Geosciences and Structures Division (GSD), was the principal investigator for this study of levee seepage and sand boil occurrence in the Vicksburg Engineer District during the 2011 flood. At the time of publication, Mr. Chris Price was Acting Chief, GEGB; Mr. James L. Davis was Chief, GSD. The Deputy Director of ERDC-GSL was Dr. William P. Grogan and the Director was Mr. Bart P. Durst.

COL Ivan P. Beckman was the Commander of ERDC, and Dr. David W. Pittman was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic feet (ft ³)	0.02831685	cubic meters
cubic inches (in. ³)	1.6387064 E-05	cubic meters
cubic yards (cu yd)	0.7645549	cubic meters
degrees Fahrenheit (°F) or (deg F)	(F-32)/1.8	degrees Celsius
feet (ft)	0.3048	meters
gallons (US liquid) (gal)	3.785412 E-03	cubic meters
inches (in.)	0.0254	meters
miles (nautical)	1,852	meters
miles (US statute)	1,609.347	meters
pounds (mass) (lb)	0.45359237	kilograms
pounds (mass) per square yard (lb/yd ²)	0.542492	kilograms per square meter
square feet (ft ²)	0.09290304	square meters
square miles	2.589998 E+06	square meters
square yards (yd ²)	0.8361274	square meters
tons (2,000 pounds, mass)	907.1847	kilograms
yards (yd)	0.9144	meters

1 Introduction

1.1 Purpose

The Flood of 2011 ranks as one of the major Mississippi River floods of record (Camillo 2012). For the first time in the history of the Mississippi River and Tributary Project (MR&T), three diversion structures were active simultaneously: Birds Point–New Madrid Floodway in Missouri, Morganza Floodway near Baton Rouge, LA, and the Bonne Carrie Spillway upstream of New Orleans, LA. However, water levels were well below the design flood elevations which the levees were built to withstand. Levees are the backbone of the MR&T project and protect the vast expanse of the developed alluvial valley from periodic overflows of the Mississippi River (Camillo 2012). Seepage and sand boil data from this historic flood provide an important source of information to evaluate levee performance, validate engineering design, and identify important geologic and engineering parameters leading to the development of sand boils.

This study involves review and analysis of the seepage and sand boils observed and documented during the Mississippi River Flood of 2011 in the Lower Mississippi River Valley (LMV) within the boundaries of the U.S. Army Corps of Engineers (USACE), Mississippi Valley Division (MVD), Vicksburg District. This study examines the occurrence of sand boils in relationship to the underlying floodplain geology and identifies locations where large sand boils occurred. Areas where large boils occurred will be the focus for additional detailed study and will be documented in a separate report of investigations. Seepage and sand boil incidents recorded during the 2011 flood are presented on geologic base maps and pre-flood imagery. The purpose was to compile a map based record of their occurrence and to identify geologic relationships and spatial patterns. Seepage and sand boils presented on base maps, herein, were recorded, described, and flood fought during the 2011 flood in order to protect the levee system from underseepage and internal erosion type failures.

1.2 Scope of study

This study presents seepage and sand boil incidents recorded by the Vicksburg District on U.S. Geological Survey (USGS) 15-min (scale 1:62500) quadrangle maps. An index to the 15-min maps containing the mainline Mississippi River levees within the Vicksburg District is presented in Figure 1.

Figure 1. Index map to 15-min quadrangles.

Data are presented on both geologic (Volume II) and photographic (Volume III) base maps for better understanding of the spatial patterns and geological distribution of these incidents. The design of the current day flood protection system in the LMV is a legacy of historic levee performance, involving large magnitude floods and the development of

engineering counter measures to protect the integrity of the levee system from these floods.

Major geologic and engineering studies performed during the past 75 years are described here for background information and for better understanding of the history and evolution of design of the current day flood protection system. These studies defined the geologic setting within the alluvial valley and helped in the development of an effective seepage control policy to protect the levees from underseepage and internal erosion failures. The levee design and construction, the alluvial geologic setting, and the types and pattern of seepage incidents observed during the 2011 flood are directly interconnected. Thus, a map-based presentation of the Flood of 2011 data using geologic base maps and pre-flood imagery was intended to permit visual comparison of these data.

Presentation of the 2011 flood incidents on pre-flood photographic base maps was intended to facilitate the identification of past flood protection measures that have been constructed for underseepage control.

Construction of both riverside and landside seepage berms in the LMV has been an ongoing response to seepage incidents identified during major flood events since the Flood of 1937 (U.S. Army Engineer Waterways Experiment Station (WES) 1948; Mansur et al. 1956; USACE 1973a). Presentation of the 2011 incident data on pre-flood photographic base maps permits visual examination of sand boil locations in terms of the levee right-of-way, and comparison to the presence of any seepage berms that may have been constructed in the past.

Relief well locations are not shown on the enclosed maps in Volumes II and III. This coverage would be an easy addition because these data are typically located using geospatial coordinates and can be easily displayed in a geographic information system (GIS) on a map coverage. Relief wells were first used in the Vicksburg District beginning in the mid-1990s and have become an important component for remediation against severe underseepage (Mendrop 2014)*.

* Mendrop, C. 2014. Personal communication. Geotechnical Branch Chief, U.S. Army Engineer, Vicksburg District.

1.3 Vicksburg District study area

Mississippi River levees within the boundaries of the Vicksburg District are located on twenty-one, 15-min USGS topographic base map quadrangles in Arkansas, Louisiana, and Mississippi (Figure 1). The District's area of responsibility extends from river mile 306 above the head of passes (AHP), near the vicinity of Angola, LA to river mile 632 AHP, near Clarksdale, MS. Beginning at the upstream limit and moving downstream, levees flank both sides of the Mississippi River to the vicinity of Vicksburg, MS. South of Vicksburg, the flood protection levee exists only on the west bank (Louisiana side) of the Mississippi River, where it prevents flood waters from spilling onto its former floodplain. The reach of the Mississippi River between Vicksburg, MS, and Angola, LA, is bounded on its eastern side by steep upland bluffs which expose Tertiary (65 to 2 million years) marine sediments and Pleistocene (2 million to 10,000 years) terrace deposits (Saucier 1994). Terrace deposits are sediments deposited on past floodplains of the Mississippi River, its tributaries, and coastal plain deposits that are elevated with respect to the present day floodplain and Gulf of Mexico shoreline. The levee system within the Vicksburg District was built on Holocene (<10,000 years old) alluvial sediments.

1.3.1 Previous seepage and sand boil studies

The map scale and format adopted for this study follows previously documented seepage and sand boil incidents from historic floods (USACE 1973a; WES 1948). WES (1948) shows seepage and sand boil locations on topographic base maps at the 15-min scale (1:62,500) from the Mississippi River Flood of 1937, the Mississippi River Flood of 1944, and other incidents (past crevasses and levee breaks) from historic (1927 and earlier) floods in the lower valley. Dunbar et al. (2015) provides general background information on the history of this map folio.

USACE (1973a) is a 15-min geologic base map of seepage and sand boil incidents from the Mississippi River Flood of 1973 in the Vicksburg District. The history of this publication in terms of the authors involved and the specific purposes for production of this map folio is unknown. This map product was likely intended for planning and addition of new seepage berms in the Vicksburg District because of the seepage performance data observed during the 1973 flood.

Both of the map folios described here have been digitally reproduced as part of this work effort and added to the library holdings at the U.S. Army Engineer Research and Development Center (ERDC) (WES 1948; USACE 1973a) to permit wider dissemination of historic information and for research purposes into underseepage and internal erosion. Neither of these publications ever received widespread circulation and were likely limited to only a few internal (USACE) copies. The sole surviving copy of (WES 1948) was part of the personal library holdings of C. I. Mansur. This folio was discovered while the author was scanning the historic map collection belonging to the Mississippi River Commission (MRC), MVD (USACE 1975). Mansur was the lead author on WES Technical Memorandum No. 3-424 (Mansur et al. 1956). This study along with other research conducted in the LMV for the President, MRC, is further described in this report for background purposes for understanding of levee engineering in the MR&T project. The lessons that were learned from MRC-funded research in the LMV would later be incorporated into the USACE engineering manual for levee design and construction (USACE 2000).

1.3.2 Seepage and sand boil incident data - A historic perspective

High-water surveillance and inspection of the levee system is an important part of levee safety for effectively controlling major floods in the LMV. Map-based portrayal of historic seepage and sand boil data permits effective early surveillance during flood events as well as long-term examination and identification of levee reaches where chronic seepage and sand boil issues exist. Cyclic flood events can have a cumulative impact on the levee system and a historical perspective is an important component to identify these impacts. Furthermore, display of incident data on base maps documents the locations where close monitoring is needed for future generations, especially for those infrequent events involving large magnitude floods. Thus, historic performance maps are an especially important tool for surveillance and flood-fight personnel, especially for large magnitude floods with recurrence intervals greater than 25 to 30 years.

A map-based presentation showing large historic flood events permits an easy way to compare and evaluate the current levee performance as compared to historic performance across multiple flood events. Figures 2 through 4 serve as an example of this type of critical review. This series of illustrations is from the Greenville and Winterville, MS, levee fronts and show historic seepage and sand boil data from the 2011, 1973, and 1937 floods, respectively. These illustrations identify historic changes that have

occurred in this area, including shortening the course of the river in the Greenville area by the cutoff program during the 1930s, levee setbacks to the levee right-of-way, and the presence of persistent seepage and sand boil activity in the reach north of Greenville during three major flood events. This reach is adjacent to the old course of the Mississippi River labeled as Batchelor Bend. This bend was cut from the active river in 1935 as part of the cutoff program following the Mississippi River Flood of 1927 to reduce flood stages by shortening the course of the river. During the Mississippi River Flood of 2011, a large boil was present at the edge of the seepage berm and required remediation of the boil and seepage berm extent. This set of illustrations indicates large sand boils have been problematic for this area according to the historic performance data presented.

The purpose for presenting the Greenville area example in Figures 2 through 4 was to highlight the nature of historic performance data presented in Volumes II and III. These data are not isolated incidents, but rather a culmination of incidents and changes to the levee system over multiple floods. Incidents are normally associated with multiple flood events and can be chronic in nature. Oftentimes they are caused by both natural and man-made imperfections in the blanket or other geologic factors. This study is intended to identify locations of the major sand boil areas during the 2011 flood and define geologic trends in their occurrence. Selected large sand boil areas will be the focus of site specific investigations that are documented in separate reports. Those investigations will involve the examination of detailed geologic and engineering data to better understand underseepage and internal erosion parameters in levees.

Figure 2. Greenville levee front showing 2011 seepage and sand boil incidents. Levee stationing is according to National Levee Database (NLD) designation.

Figure 3. Greenville and Winterville front levee showing seepage and sand boil occurrence during the 1973 flood (USACE 1973a). WES geologic map base underlies the 1973 flood incidents.

Figure 4. Greenville front levee showing performance data from the 1937 flood and underseepage control measures in 1948 (WES 1948). Solid blue line corresponds to presence of a berm or drainage wells. Sand boil and seepage information are noted where solid red line is heavy underseepage area and dashed red line is light to moderate underseepage area.

2 Map Data Format

2.1 Seepage and sand boil data

The source of seepage and sand boil data used in this report is from the 2011 high-water levee inspection by the Vicksburg District (USACE 2011). Three separate inspection teams were formed from the Geotechnical and the Levee and Drainage branches in the Vicksburg District. The main-line Mississippi River Levee (MRL) was subdivided into reaches and inspections were made by the respective teams walking or riding all-terrain vehicles (ATVs) along the toe of the levee in the different reaches during the course of the 2011 flood (USACE 2011). The inspection teams prepared notes regarding scour, current, seepage, sand boils, slides, and other noteworthy observations. Additionally, Android smartphones were used by the inspection teams to collect data and send these data to the Vicksburg District Freeboard website for assessment by emergency operations personnel. The Android smartphone application used to collect these data in real-time was the Mobile Information Collection Application (MICA), which uses global position system (GPS) technology.

The MICA application was developed by ERDC's Information Technology Laboratory (ITL) to capture levee distress in real-time and transmit this information to command and control centers for priority ranking used in flood fighting. Records of levee distress include GPS location, observed performance information, and photographs from each incident. The unfiltered MICA data often contain multiple reporting of the same sand boil by different observers. Multiple sand boil and seepage incidents for each location were evaluated, prioritized, and filtered for the final data presentation by USACE flood-fight officials to eliminate multiple listings in the Mississippi River Flood of 2011 Report. Consequently, seepage and sand boil incidents presented here were derived from the USACE (2011) high-water inspection report, rather than directly from the MICA database because of the multiple listings of incidents in the unfiltered MICA database.

The USACE (2011) incident report was used in this study for the display of seepage and sand boil incidents on the base maps presented here. The 2011 flood report is directly comparable to past seepage reports from the 1937 and 1973 floods as previously described. These earlier reports are the official record of incidents that were observed during these major flood

events (WES 1948; USACE 1973a, 1974). Seepage and sand boil incidents presented in this report generally follow the same basic map presentation format that was used to display the 1937 and 1973 incidents (WES 1948; USACE 1973a). The Greenville area in Figures 2 through 4 are examples of the three reporting formats used.

2.2 Map presentation methods and format

The MRL was subdivided into river reaches based on levee stationing identified by USACE (2011). Tabular inspection data from each river reach in this comprehensive report (Appendix A) were converted to a digital format by importing the data contained in the paper tables into a Microsoft Excel spreadsheet. These data were then manually edited in Microsoft Excel during this study to format the data for visual display using GIS software. These edited records were then imported into Environmental Systems Research Institute (ESRI)'s ArcGIS software using the geographic coordinates reported for each incident.

This list of records was next screened to extract only the seepage and sand boil incidents. Records involving current and scour were not imported because these records are generally not applicable to this study. Records of levee slides were included where seepage conditions were noted to have occurred. Seepage and sand boil records were imported into the ArcGIS software as either points or lines, depending on the nature of the coordinates used in the record and the geographic coordinates that were reported. For presentation purposes, the line data used to identify landside seepage were edited to conform to the levee footprint using the beginning and end (From and To) coordinates in the reported record. Seepage lines were next edited and shaped to conform to the levee right-of-way for display purposes in order to match the "From and To" extent observed by the inspection teams for each seepage record that was recorded. This type of editing was necessary to prevent seepage lines from crossing the levee where abrupt changes in the levee alignment occurred, and to be consistent with previous reporting of this data onto maps (WES 1948; USACE 1973a).

Depiction of sand boil data on the accompanying maps is presented as both point and line (arcs) feature types, because the incident data were reported as being in both types of incident format. A single large boil (point feature) and multiple boils along a specific levee reach (line feature) may be shown concurrently, because the incident data may present both types of feature classes for the conditions that were observed and reported

during the 2011 flood (USACE 2011). Consequently, the two types of feature classes may contain incidents in common with the larger boils being identified as a separate point feature class.

Seepage and sand boil data from the 2011 flood are presented on 15-min (1:62,500 scale) geologic base maps (Volume II) and photographic base maps (Volume III). Photographic coverage was provided by Bing's online digital service to ArcView. Geologic data used for the base maps were derived from the legacy LMV Engineering Geology Mapping data set (see lmvmapping@erdc.usace.army.mil). Geologic mapping was conducted at the 15-min scale on topographic base maps by WES geologists for the MRC between 1957 and mid-1990s for USACE districts within the LMV (examples are Kolb 1949, 1975; Kolb et al. 1968; Kolb and Van Lopik 1958; May et al. 1984; Saucier et al. 1964, 1967, 1969; 1994; Smith et al. 1986, Smith and Russ 1974; Smith and Saucier 1971). This body of geological work in the LMV will be described herein as the WES geological mapping program.

Incidents shown on the geology and photographic base maps in Volumes II and III are labeled with their National Levee Database (NLD) stationing to permit comparison to the incident tables. The NLD stationing was used for labeling purposes and permits referencing of the incident displayed on the maps to their original source data. An example subset map from the Greenville, MS, levee front was presented in Figure 2, showing the 2011 seepage and sand boil data reported for this area. Presented in Figure 2 are point data containing sand boils and point observations of seepage condition, as well as linear (vector or polyline data) where seepage conditions extend along a continuous levee reach. Thus, both point and vector data were used to denote incidents during the 2011 flood.

2.3 Classification of seepage and severity of sand boils

An underlying goal for presentation of the incident data was to accurately convey the severity of the seepage and sand boils identified from the data tables. In some instances, it was necessary to interpret the reported data for classification purposes. Background data are presented here on the classification scheme that was used for interpretation of records that were not clearly classified. The severity of seepage is normally classified as being light, moderate, and heavy; while sand boils are typically considered as being small, moderate, or large in their aerial extent. This basic classification scheme is analogous to a traffic light, involving green, amber, and red, corresponding to small or light, moderate, and heavy or large,

respectively. Sand boils are typically classified according to their size and by the volume of water that is flowing (Cunny 1987).

Areas experiencing heavy seepage will generally display numerous pin boils (small pipe openings without sand cones) and/or small sand boils with sand cones behind the levee (Cunny 1987). Moderate seepage involves running water at and beyond the levee toe, while light seepage corresponds to wet areas at and beyond the levee toe. Mansur et al. (1956) classified heavy seepage as more than 10 gal per min (gpm) per 100 ft of levee, medium seepage as between 5 and 10 gpm per 100 ft of levee, and light as less than 5 gpm (Kolb 1975).

Classification of seepage quantity and sand boils by size can be a subjective interpretation and may vary between different observers. Large sand boils are ordinarily classified as being large when the throat is greater than 12 in. in diameter, medium boils when the throat diameter is between 6 to 12 in. in diameter, and small when the boils are less than 6 in. in diameter. The occurrence of multiple sand boils can lead to areas with heavy seepage. Thus, every effort was made in this study to present the data with this general framework in mind.

3 History of Seepage and Levee Engineering in the Alluvial Valley

3.1 Geology of underseepage

Seepage and sand boils occur at the landside levee toe because of the high artesian pressure produced in the alluvial aquifer by confining flood waters between artificial levees (Figures 5 and 6). A meandering river system, such as the lower Mississippi River, by its inherent nature of channel migration and overbank flooding, is composed of a fine-grained top stratum, or blanket, and an underlying coarse-grained substratum (Figures 5 and 6). Because of channel migration and lateral accretion of coarse sediment in the channel as point bars, the substratum is formed and is composed of sand and fine gravel. A composite geologic map of the Yazoo Basin is presented as Plate 1 and shows the large number of abandoned channels that have formed within the past 10,000 years as the Mississippi River has migrated across its floodplain to its present day position. The Mississippi River has created distinct river courses forming meander belts that are composed of point bar deposits.

During high-water flooding, increased hydraulic pressure in the alluvial aquifer can fracture and heave the top stratum or blanket at the levee toe because of the artesian pressure acting at the base of the blanket, and produce seepage and sand boil conditions through cracks and other natural defects in the blanket. Entry points for aquifer recharge occur in the river channel, abandoned channels, and in riverside borrow pits that extend through the top stratum near the levee toe during flooding (Figures 5 and 6). Contributing factors that have been identified for seepage and sand boil formation are the underlying geology, namely the depositional environment (primarily point bar but can include natural levee, abandoned channel, or abandoned courses (multiple linked abandoned channels) see Volume II for examples), blanket thickness, blocked seepage exits, or any type of natural and man-made defect in the blanket (Figure 6).

Figure 5. Generalized cross section showing point bar geology beneath a levee in the LMV and seepage flow in the underlying alluvial aquifer (Mansur et al. 1956). The concept of exit gradient i_e behind the levee is expressed as the ratio of h_o/z , where h_o is the excessive pressure or head under the blanket, and z is the blanket thickness. The concept of exit gradient is central to blanket theory and forms the basis for seepage control measures involving berms and relief wells behind levees. A complete description presentation of blanket theory is presented in Mansur et al. (1956) and Appendix B in USACE (2000).

Figure 6. Abrupt changes in the top stratum from change in the depositional environment can concentrate underseepage in the aquifer and promote formation of sand boils. The figure shows concentration of seepage and development of sand boils adjacent to fine-grained point bar swales (Mansur et al. 1956). Open borrow pits into the aquifer shorten the seepage path and increase hydraulic gradients across the levee.

Blocked seepage exits typically involve an abrupt change in the floodplain geology (i.e., change in depositional environment) and associated change (reduction) in hydraulic conductivity of the soils within the depositional environment or due to levee orientation (Fisk 1944, 1946; Mansur et al. 1956). Recognized defects in the blanket include thin zones, point bar ridges, desiccation cracks, tree roots, man-made features, such as a utility or fence poles, boreholes, seismic shot points, activities of burrowing animals, or any combination of these different factors either individually or in combination.

Geologic investigations into underseepage problems involved case history studies by the Vicksburg District (USACE 1939 and 1941) and the MRC between 1941 and 1946 by Dr. H.N. Fisk, professor of geology at Louisiana State University (LSU), and his staff of graduate student geologists. This research was conducted because of severe seepage and sand boil incidents observed during the Mississippi River Flood of 1937 within the LMV levee system. Results of these different geologic case history studies would later be incorporated into the work by Mansur et al. (1956). A description of the underseepage mechanism in the lower Mississippi River alluvial valley and

problems involving levee engineering is presented in Appendix B (Fisk 1946). Presentation of the underseepage mechanism in Appendix B is from a lecture series given by Dr. Fisk to engineers from the Lower Mississippi River Valley Division Headquarters, WES, U.S. Army Engineer Districts Memphis, Vicksburg, and New Orleans. The clarity and brevity of this presentation concerning the underseepage mechanism bears inclusion here for further reading and to facilitate wider dissemination of basic geologic concepts that were identified nearly 75 years ago.

Figure 6 from Mansur et al. (1956) is often referenced to show seepage and sand boil relationships involving foundation geology and levee orientation and was derived from illustrations presented in Appendix B from the various case history studies by the geologic staff supporting Dr. Fisk. The series of illustrations in Appendix B identify locations used for study of the geology in relationship to known seepage problem sites in WES (1941b) and Mansur et al. (1956). This brief summary of underseepage principals, along with the information presented in Appendix B, will facilitate better understanding of the underseepage mechanism, causes of sand boil formation, and the incidents observed during the 2011 flood (see Volumes II and III).

3.2 Standard levee section

MRC (1947) has been the basis for current day levee design and construction in the LMV for the MR&T project (Appendix C). Lessons learned from geologic study of levee underseepage during the 1940s by Dr. Fisk and his team were incorporated by the MRC into the 1947 Levee Code (MRC 1947). The basic geometry of the standard levee section in the code specifies crest width, riverside, and landside slopes to control levee through seepage from long duration floods that were common on the lower Mississippi River (see Figure 7 and slope data in Tables 1 and 2). The design of the standard levee section in the 1947 Levee Code has been an evolutionary process. This evolution was due in part to closure of natural outlets within the Mississippi River's floodplain, the corresponding increase in river stage by reducing overflow areas (Camillo 2012), and because of poor performance in terms of seepage and sand boil incidents following major historic flood events on the lower Mississippi River. A copy of the 1947 Levee Code and associated amendments are presented in Appendix C for reference purposes and to provide wider distribution of legacy documents involving the MR&T levee system.

Figure 7. Evolution of the standard levee section in the LMV (Moore 1972).

Following the Great Mississippi River Flood of 1927, levees in the LMV were rebuilt to the 1928 standard levee section. Specific details of the 1928 profile in the Vicksburg District and construction details are described in Appendix D. The 1928 profile was completed in the Vicksburg District by the time of the Mississippi River Flood of 1937 (USACE 1941a and 1941b). The 1928 section was originally based on material type (Figure 8 and Table 1), which was later revised to a compaction specification by the 1947 Levee Code (Figure 7 and Table 2).

Table 1. 1928 standard levee profile (Moore 1972; USACE 1929).

Section	Crown Width, ft	Riverside Slope	Landside Slope to Contain Seepage Line of: ¹	Predominating Material
A	10	1 on 3	1 on 6	75 percent or more buckshot (clay)
B	10	1 on 3-1/2	1 on 6-1/2	Loam
C	12	1 on 5	1 on 8	75 percent or more sand

¹ Seepage line was assumed to spring from riverside slope, 1 ft below crown of levee.

Table 2. 1947 standard levee profile (Moore 1972; MRC 1947).

Section Type	Riverside Slope	Crown Width, ft	Landside Slope
1	1 on 3-1/2	10	1 on 4-1/2
2 ¹	1 on 4	10	1 on 5-1/2
2 ²	1 on 4	10	1 on 6
3	1 on 4-1/2	10	1 on 6-1/2

¹ Less than 25 ft in height

² Twenty-five feet or more in height.

Figure 8. 1928 levee section in the Vicksburg Engineer District. Note the slope on the landside levee toe to control the seepage during prolonged flooding. Class of levee based on type of soils in the embankment. See Appendix D for specifications and complete details of the 1928 standard levee profile.

The 1947 Levee Code also described the need for geologic studies to support levee engineering design. Levee design in the Vicksburg District was modified again following the Mississippi River Flood of 1973 because of flow line issues and channel aggradation in some reaches within the Vicksburg District limits. Consequently, the levees are being raised an additional 3 to 5 ft and widened accordingly due to freeboard considerations caused by channel sedimentation issues. Raising the crest elevation of the levee system in the Vicksburg District to meet the 1973 flow line standards is an ongoing process and continues today.

3.3 Construction of seepage berms

Historic levee construction in the LMV should be considered when examining the 2011 incident data. The basic levee prism that was specified by the MRC for the lower Mississippi River was built to accommodate a design flood event. It has subsequently been modified from the 1928 and 1947 profiles by seepage-related issues due to large historic flood events.

Seepage modifications typically have involved the addition of landside seepage berms between 150 and 300 ft in width, and, more recently (post-1990), use of relief wells in the Vicksburg District.

Additionally, riverside berms were built as well to fill deep borrow pits that extended into the substratum deposits (Figure 6), construction of riverside buttress berms for areas experiencing frequent shallow slough slides due to high plasticity clays, and where historic oxbows intersect the levee alignment. As an example of seepage berm modifications, Figure 9 shows a section of the MR&T levee alignment downstream of the Eagle Lake area where the main-line levee ties into the Yazoo backwater levee leading to Steele Bayou. This section of levee has experienced several seepage-related issues in the recent past and subsequent modifications. These modifications are further described in the following paragraphs to help facilitate understanding of performance-related seepage control measures.

Figure 9. Example of seepage berm construction. Photograph of the east bank of the main-line MR&T levee, between river mile 451 to 447, near Vicksburg, MS, showing the levee right-of-way and past remediation efforts for underseepage. This section of the levee was built between 1922 and 1926 to the 1914 profile, upgraded to the 1928 profile after the 1927 flood, and subsequently modified because of seepage-related issues with 150-ft and 300-ft-wide berms following the 1973 flood (USACE 1973a).

The Eagle Lake levee was built between 1922 and 1926 to the 1914 standard levee profile (Figure 7) as the New Brunswick levee extension, upgraded to the 1928 standard profile following the 1927 flood (USACE 1929, 1941a, 1941b) and subsequently modified again because of seepage-related issues following the 1973 flood. The intent for this particular example in Figure 8 is to draw attention to various changes that have occurred with the original levee design profile and geometry when examining 2011 seepage incidents along the levee right-of-way (Figure 9). Multiple levee modifications have occurred within this reach because of past performance incidents. The example shown in Figure 9 identifies one “moderately high-energy boil with a 12-in. throat, flowing approximately 75 to 100 gpm” at the toe of the 300-ft seepage berm at the location shown (see description in Appendix A, page 146, sta 9180+00 NLD). The large boil at this location was likely not an isolated incident because of the presence of several different widths and lengths of seepage berms that were constructed following the 1973 flood. The absence of a berm in the Figure 9 example is oftentimes based on the presence of a thick blanket at the levee toe due to a clay-filled swale, clay-filled abandoned channel, or presence of backswamp deposits.

The basis for seepage berm construction is centered on the concept of exit gradient (i_o) at the landside levee toe, where exit gradient is the ratio between the excessive head beneath the blanket (h_o) and the blanket thickness (z), where $i_o = h_o/z$ (see Figure 5). This excessive head can be viewed as the water level that would naturally occur in a piezometer installed at the landside toe of the levee during a flood event. A 300-ft-wide seepage berm is built where the exit gradient at the levee toe is >0.75 , while a 150-ft-wide berm is built where the gradient is between 0.5 and 0.75. Less than 0.5, a berm is not required. Criteria for berm design are presented in USACE (2000).

Another component has direct bearing on the development of sand boil incidents at sta 9180+00 NLD, which involves land use changes: the post-1973 construction of a water-control structure at Muddy Bayou and the construction of the Yazoo Basin backwater levee protection system. The latter includes the control structure at Steele Bayou and levees to protect the lower delta region from backwater flooding from the Mississippi River. Further explanation is warranted to fully understand the contribution of man-made activities to the development of sand boil and seepage issues at this location.

The Muddy Bayou control structure currently regulates backwater seepage flow into Eagle Lake (see Plate 21, Volume III). Muddy Bayou was a natural outlet channel for interior drainage into Eagle Lake that is derived from the Yazoo Basin (drainage basin along the east bank of the MR&T levees between Memphis and Vicksburg, see Plate 1). This bayou was formed when Eagle Lake was an active bend of the Mississippi River prior to 1867. Presently, the Muddy Bayou water-control structure serves to regulate the flow of backwater drainage (seepage and rainfall) into Eagle Lake, MS. The control structure was built in part to prevent agricultural drainage affecting water quality in Eagle Lake.

A short distance downstream and east of the Muddy Bayou control structure is the Steele Bayou control structure. Gates at the Steele Bayou control structure are normally closed when the Mississippi River is in flood stage to prevent rising flood water from entering into the lower parts of the Yazoo Basin and flooding the lower delta region. However, closing the gates at Steele Bayou traps rainwater and seepage flow during flooding, which collects behind the levee system until the flood stages on the Mississippi River are low enough to open the gates and permit this trapped water to drain into the Mississippi River.

Prior to construction of the Muddy Bayou and Steel Bayou control structures, and the Yazoo Basin backwater levee protection system, a tailwater would collect in the lower parts of the Yazoo Basin as the Yazoo River would back up when the Mississippi River was in flood stage, and would flood low-lying areas in the vicinity of Eagle Lake, especially during moderate to large flood events. This overflow would form a tailwater in the low-lying areas, and effectively reduce the hydraulic gradients that now form behind the levee in this area. Incident data from both the 1937 and 1973 floods do not show any sand boil activity in this area, which is attributed to the natural backwater flooding into this area prior to the control structures and Yazoo Basin backwater protection levees being built. Standing water behind the levee in this area would have masked this condition and/or prevented it from occurring because of the tailwater that reduced the hydraulic gradients (WES 1948; USACE 1973a). In summary, the Eagle Lake example illustrates how historic levee construction and land use modifications can have a direct bearing on current day seepage and sand boil performance.

3.4 Levee through seepage and underseepage

The Eagle Lake area identified two incidents as being through seepage in nature instead of underseepage. The 2011 seepage data contain a limited number of through seepage incidents (Figure 10). An important distinction is made on the map presentation of the 2011 incidents in terms of levee through seepage and underseepage incidents. The first being seepage through the levee embankment, while the latter being the movement of water horizontally in the substratum deposits or alluvial aquifer. A separate symbol was used to identify each type of event.

Figure 10. Through seepage (green triangle) and sand boil (red asterisk) incidents between river miles 447 to 451 (see Appendix A, page 146 for description).

Additional context is briefly presented on MRC history involving through seepage events on the lower Mississippi River and its relevance to presentation of incidents observed during the 2011 flood. The MRC sponsored extensive research between 1929 and 1941 into levee through seepage on the lower Mississippi River. Some of the early research involved evaluation of the banquet section that was the design standard for the 1914 profile (Figure 7) against the benefits of the 1928 trapezoidal section that was ultimately adopted by the MRC as being the final form of the standard section (Long 1930). Results of these different studies ultimately determined that the fundamental problems that were observed with levee performance and seepage on the lower Mississippi River were primarily due to underseepage in the deep alluvial aquifer instead of levee through seepage (USACE 1941a, 1941b; WES 1931a, 1931b, 1936, 1938, 1939, 1941a, 1941b, 1945). Directly related to this early research effort was the underlying design of the standard levee section previously described (Figures 7 and 8). The poor performance of the 1928 levee section on the lower Mississippi River during the 1937 flood in terms of seepage and sand boils would lead the MRC to sponsor numerous long-term studies to better understand and effectively control the effects of underseepage (Mansur et al. 1956; Moore 1972; USACE 1939; 1941a, 1941b; WES 1938, 1939, 1941a, 1941b, 1945). The needs for underseepage research by USACE following the 1937 flood are further described in United States (1939) and WES (1945).

The 1928 levee section was designed for long-duration floods that were common in the LMV, and the underlying design slopes were intended to control through seepage conditions. The 1V:5.5 to 6H back slopes were gained from long practical experience with Mississippi River floods in controlling levee through seepage (Figure 8). As previously described, the 1928 profile would later be modified in terminology by the 1947 Levee Code. Thus, the basic levee design in both the 1928 and 1947 sections specified a wide levee embankment section to effectively control through seepage conditions due to long duration floods (Figures 7 and 8). Nearly 90 percent of the all the levees built in the Vicksburg District were classified as clay levees (B levees in the 1928 profile, or Type II levees in the 1947 Code), which were typically not prone to through seepage issues (Moore 1972). The material spec identified by the 1928 profile was changed to a compaction spec by the 1947 Code with Type II levees corresponding to a moderate degree of compaction at the soils natural moisture content.

In terms of the presentation of the 2011 flood incidents, any observations where through seepage conditions were observed (and identified) were classified separately from underseepage-related incidents on the maps in Volumes II and III to identify areas where through seepage conditions were reported. Generally, most 2011 through seepage reports involve minor incidents associated with berms. However, one through-underseepage incident stands out involving a levee slide, which will be discussed in more detail in the next section of this report.

4 2011 Vicksburg District Seepage and Sand Boil Incidents

4.1 Seepage and sand boil incident data

The portion of the Mississippi River in the Vicksburg District is flanked by levees divided into 12 reaches, with 6 reaches each along the left descending (east) and right descending (west) banks. The 2011 flood data contains 518 incident descriptions of seepage and sand boils that were subdivided for display purposes into points (total of 192 incidents) and polylines (total of 326). In terms of their map presentation and organization for this study, moderate-to large-sized sand cones/boils were generally reported individually as point features, while seepage extent behind the levee and/or locations with smaller sand boils and pin boils along a levee reach were presented as polyline (arc) features.

Incidents involving surface scour, current flow, relief well descriptions, the presence of sloughs, low spots, or other observations not directly involving seepage and sand boils incidents were not included for display. Slides involving the levee were also presented on the seepage maps as this type of incident often involves a seepage component. Incidents that did not have a latitude and longitude coordinate associated with the recorded observation were not included on the enclosed maps.

Polyline (arc) seepage data contains 326 recorded incidents and these were classified as sand boils (30 incidents), through seepage (9 incidents), underseepage (286 incidents), and a single incident involving a combination of a sand boil, through seepage, and slide (i.e., Albemarle slide at sta 8218 NLD, 8170 field). Seepage incidents, as previously described, were displayed using the traffic light analogy, classified as light (green), medium or moderate (orange) and heavy (red). Presentation of polyline sand boil-related incidents may overlap with individual point reporting of larger sand boils. This condition is unavoidable due to the reporting nature of the incidents where this dual reporting convention was observed.

Some incident descriptions were classified by the observers as being in a range from light to moderate or moderate to heavy. Incidents characterized by a classification range were included in the higher classification bracket for display purposes. Thus, light to moderate and moderate to heavy were mapped as being moderate and heavy, respectively. The distribution of the

remaining 286 polyline underseepage incidents described in the 2011 flood report are as follows: heavy (14 incidents), moderate to heavy (13 incidents), moderate (25 incidents), light to moderate (36 incidents), and light (198 incidents). The vast majority of seepage data described in USACE (2011) are in the low to moderate category. The main focus of this study are those incidents reported as being in the large and heavy (red) category.

Point data were similarly classified, and involved 192 incidents composed of sand boils (74 incidents), slides (4 incidents), through seepage (11 incidents), and underseepage (88 incidents), underseepage with pin boils (15 incidents). Only 15 point type sand boils were classified as being heavy, large, or high-energy in nature, and 12 polyline areas were similarly classified. Thus, the combined 27 incidents of sand boils were reviewed for their description of condition, determination of overall severity, and for duplication of point and polyline features. A final list of 25 incidents was compiled from this data set, and these incidents are presented in Table 3 according to their NLD stationing. The summary table presents local name, incident description, associated quadrangle map where the incident occurs (for reference to Volumes II and III), and depositional environment associated with each incident. Information on the depositional environment was derived from the WES geological maps (Volume III).

4.2 Relationship between sand boils and depositional environment

Attention first focuses on all the 191 incidents of sand boil occurrence in the Vicksburg District during the 2011 flood involving small to large boils. As shown by Figure 11, this distribution is consistent with the earlier reporting by Mansur et al. (1956) and WES (1941b), which examined only a limited distribution of sites. Relationships between seepage occurrence and landform (depositional environment) was based on detailed site investigations of problem sites in these earlier studies and was concluded without the benefit of the comprehensive geologic mapping program by WES within the alluvial valley.

The majority of sand boil incidents identified in the Vicksburg District in Figure 11 correspond to the point bar environment (68.25 percent). The remaining number of incidents are associated with abandoned channels (23.5 percent), backswamp (6.25 percent), and outwash plain (2 percent) deposits. Included in Figure 11 is the distribution of point bar incidents in relationship to meander belt designation. Not surprising, the overwhelming majority of point bar incidents (121 incidents) are associated with the more

recent meander belt 1 deposits, which are less than 3,000 years old (Saucier 1994). Incidents involving meander belt 2 (2,700 to 4,800 years old) comprise eight incidents, and one incident was associated with a tributary stream.

Rather surprising, however, are the large number of incidents (45 incidents, 23.5 percent) that are associated with abandoned channel settings. Previous reports of sand boil occurrence and relationship to depositional environment identified the point bar deposits as being the primary landform (Kolb 1975; Mansur et al. 1956). The high frequency of abandoned channel incidents relates to the types of pervious sediments contained within this environment, their often lower surface elevation, the nature of the channel filling-avulsion process, and the underlying principles behind artesian pressure distribution in the alluvial aquifer. An example is described in a subsequent section using the Lake Chicot, AR, area as an illustration of fundamental principals involved. However, before examining the abandoned channel setting in more detail, further discussion of the major sand boil incidents involved during the Mississippi River Flood of 2011 are described.

Table 3. Moderate to large sand boils. (Note: These sand boils are highlighted in yellow in Appendix A.)

Name 1	Name 2	NLD Station	Field Station	Type	Condition	Remarks	Latitude	Longitude	Quad	Page No. Append A	Photos	Environment
Francis	Lower Francis (TM 3-424)	151	151+00	Sand Boil	High	A large, high-energy sand boil (photo 4, Appendix A) was identified moving significant quantities of silt and fine sand material at the toe of a 200-ft seepage berm. The boil was bagged by the Levee Board with prison labor for initial containment and subsequently sandbag ring was encircled by a larger earthen berm. A filter of sand and stone was constructed over the boil throat to filter fines and dissipate energy. Stabilization took 4 days of 24-hr/day effort (photos 5 to 7). Flow from boil was estimated at 300 gal/min. Boil had potential to cause backward erosion and piping and lead to loss of berm and foundation material. Two more sand boils were found 100 to 150 ft from berm toe (photos 8 to 10). These boils were moderate energy and move approximately 5 to 7 cu yd of material. Boils were bagged by local prisoners. Heavy seepage and numerous pin boils were noted and monitored 2,000 ft either side.	34.0862604	-90.8652468	Mellwood	A3	4-10	PB
Winterville	Greenville Front Levee	3744 to 3750	3710 to 3720	Sand Boil	Heavy	Winterville sand boil site - A large, high-energy sand boil approximately 30 ft from the toe of 200-ft seepage berm near levee Sta. 3720. The boil was estimated to be flowing approximately 300 to 350 gpm and was moving significant quantities of silt and fine sand (approximately 100 cu yd). Boil was bagged by levee board with prison labor and a small earthen levee was constructed by local contractor. A filter sand and stone was constructed over the boil throat to filter fines and dissipate energy. Four additional medium sized boils were identified within 250 ft of the berm toe that required either a small sandbag ring or a 30-gal drum for stabilization. Boils are located between levee sta 3710 and 7320.	33.4552370	-91.0497397	Refuge	A47	31-42	PB
Lake Ferguson	Greenville Front Levee	4065 to 4072	4031 to 4030	Sand Boil	Heavy	Multiple moderate to high-energy sand boils were identified moving large quantities of fine sand in two separate areas on the east side of the railroad tracks approximately 400 ft from the levee toe. There is no seepage berm in this area. Heavy seepage, numerous pin boils and saturated, soft ground was identified in and around the boil areas. One area is on the power line right-of-way and the other is in the woods approximately 30 yd to the southeast. During the initial site visit, there were numerous small boils identified in the wooded area. The throats on these boils ranged from 3 to 6 in. in diameter and several yards (5 to 8 cu yd) of material had been transported over a 1,000-sq ft area; however, most of these boils were producing clear water. Some of the larger boils were later stabilized with 30-gal drums placed over the throats of the boils. There were approximately three high flowing sand boils identified in a low spot along the power line. These boils were flowing approximately 100-200 gpm each, and were transporting a significant quantity of fine sand and clay/silt balls. More than 15 to 20 yd of material had already been transported from the boils and material was still being moved. Throat diameter of the boils ranged from 12 to 18 in. Levee board work crews and inmates addressed these boils by building a sandbag containment ring which had to be raised at a later date to increase the head over the boils.	33.3781530	-91.0742310	Refuge	A47	65-73	PB
Lake Ferguson	Greenville Front Levee	3886	3852+00	Sand Boil	Moderate/ High	Active sand boil identified on the edge of seepage berm approximately 75 yd from the railroad tracks near levee sta 3952. Area is under 6 to 10 in. of seepage water. Sand boil has a 12-in. throat and has formed a cone that is approximately 12 in. high. Boil is flowing approximately 50 gpm and continues to transport moderate quantities of silt/fine sand.	33.3994421	-91.0701666	Refuge	A48	61-62	AC
Leland Chute	Leland Chute	2139+95	2135+35	Sand Boil	Heavy	Bagged boil in ditch	33.3601000	-91.1632000	Refuge	A180	33-37	PB

Name 1	Name 2	NLD Station	Field Station	Type	Condition	Remarks	Latitude	Longitude	Quad	Page No. Append A	Photos	Environment
Leland Chute	Leland Chute	2142+80	2138+20	Sand Boil	Heavy	Bagged boil in ditch	33.3594000	-91.1637000	Refuge	A180	38-43	PB
Lake Chicot	Lake Chicot	2309+50 to 2544+90	2305+60 to 2541+20	Sand Boil	Heavy/ Large	Lake Chicot - The site is historically an area with large boils. A large, high-energy sand boil was located on the edge of a dredged channel at the south end of Lake Chicot. There were multiple sandbag rings placed around the boil. The throat would move and bypass the sandbag rings. A dike was eventually constructed across the channel. Moderate seepage was exiting the lake bank 30 ft above the water surface. Several other medium to large, moderate energy boils were located along the lake bank. These boils were also ringed with sandbags. The boil closest to the levee was approximately 400 ft from the toe of a 300-ft seepage berm. This boil has repeatedly moved significant quantities of material during previous high-water events and exhibits some potential to develop pipes that may migrate towards the berm/levee. Boils were identified up to 2,000 ft from the levee toe.	33.2905000	-91.10037	Refuge	A180		AC-PB
Fish Bayou	Lake Chicot	2544+20	2540+90	Sand Boil	Heavy	Area known as Fish Bayou located approximately 500 ft from berm toe at the downstream end of Lake Chicot.	33.2881300	-91.1713600	Refuge	A180	80-88	PB
Lake Washington Area	Washington/ Issaquena Counties	6048	6025+00	Sand Boil	Moderate to Heavy	Five or six small, active sand boils with 4- to 5-in. throats were identified along the toe of the seepage berm near levee sta 6020. Boils were flowing approximately 20 to 30 gpm and transporting fine sand producing cones 2 to 3 ft in diameter. Area being monitored by levee board. Some of the boils ringed by plastic drums.	33.0143355	-91.1355288	Readland	A76	16-17	PB
Longwood	River Mile 520	5400	5368+00	Sand Boil	Moderate- Large	On July 7, 2011, landowner called and reported a "hole" out in his field. Levee board took photos and measured hole to be 2 ft deep with 4-ft diam. There was evidence of very fine sand material in the buckshot bean field. The boil was located 780 ft from levee center line.	33.1438800	-91.0719000	Readland	A76	63-64	PB
Lake Washington Area	River Mile 516	5640+00 to 5651+00	5608+00 to 5619+00	Sand Boil	Heavy/ Large	Multiple large sand boils in this area. There are multiple boils in drainage ditch just off toe of berm. Also, there are multiple boils on both sides of the drainage ditch. Three of the boils occur right at the toe of the berm. Most of these were bagged and were no longer moving material. Throat sizes range from a couple inches to greater than 6 in. Sandbag ring constructed around a 30-ft x 10-ft sinkhole that formed in field. Plywood wall constructed around boil also. Seepage is also exiting in the berm crown	33.1054852	-91.1294727	Readland	A78	78-87	PB
Lake Washington Area	Washington/ Issaquena Counties	6051 to 6057	6030 to 6035	Sand Boil	Moderate to Heavy	Three to five sand boils and large area of widespread moderate seepage along the toe of the seepage berm near levee sta 6030. Seepage extends approximately 1/4-mile out into field. Two sand boils were ringed with 30-gal plastic drums. Two or three boils were identified near the drums. Boils were transporting fine sand and clay/silt balls. Numerous pin boils and moderate seepage in bean field near sta 6035. Most boils are transporting a small quantity of material and are under 2 or 3 in. of water.	33.0121588	-91.1374451	Readland	A107	18-22	PB
Lake Washington Area	Clarence Hall Road Site	6074 to 6050	6051 to 6070	Sand Boil	Heavy	Numerous, medium to large sand boils (25+) approximately 10 to 30 ft from the toe of the seepage berm between levee sta 6050 and 6070. Levee board was onsite placing drums, galvanized culverts, and sandbags over and around boils. Entire area is under 1 to 3 ft of seepage water from boils. Several boils are high-energy producing 50 to 100 gpm.	33.0121588	-91.1374451	Readland	A107	23-30	PB
Moon Chute	Moon Chute	2544+90	3273+00	Sand Boil	Heavy	Sand boil in ditch 200 ft from berm toe with 6-in. pipe. Moved about 2 yd of material. Additional pin boils in ditch with clear flow	33.1582000	-91.1795000	Readland	A292	104	PB

Name 1	Name 2	NLD Station	Field Station	Type	Condition	Remarks	Latitude	Longitude	Quad	Page No. Append A	Photos	Environment
Lake Washington Area	Near St Paul Church	6285	6265+00	Sand Boil	Heavy	Several (4 to 6) large, high-energy sand boils under 3 to 4 ft of water in a drainage ditch in the bean field approximately 200 ft north of Elwood Road near levee sta 6265. Two other boils have caused the banks of the ditch to cave. Boils are transporting small quantities of silt/fine sand. Area was flagged during inspection.	32.9994266	-91.1072870	Mayersville - Lake Providence	A108	51-52	PB
Ben Lomand Road	Carlisle Lake	7067	7100+00	Sand Boil	Heavy	Multiple, high-energy, sand boils approximately 10 to 50 ft from the seepage berm toe near levee sta 7100. Boils were flowing 20 to 50 gpm and transporting moderate quantities of fine sand (2 to 5 cu yd each). Throat diameters for the boils generally ranged from 2 to 10 in. Some of the boils were ringed with culverts.	32.8317126	-91.1031782	Mayersville - Lake Providence	A109	95-99	PB
Ben Lomand Road	Lake Washington Area	7195 to 7210	7120+00	Sand Boil	Heavy	Ben Lomand road site - Several medium to large sand boils were identified moving moderate quantities of fine sand and silt in a drainage ditch along the toe of the seepage berm and in an open area east of the ditch. All of the sand boils were within 10 to 20 ft of the seepage berm toe. Water berm was created over most of the sand boils in the ditch by the levee board by constructing dikes on the upstream and downstream sides of the sand boils. Also, at least three of the sand boils in the ditch were ringed with galvanized culverts. As a result of the dikes and culverts, most of the boils in the ditch were covered with at least 3 to 4 ft of water. Also, there were several medium boils identified in the edge of a field on the east side of the ditch that were ringed with culverts by the levee board and eventually two sandbag rings were constructed around the area to increase the head and slow the movement of material. Most of the boils were flowing approximately 50 to 100 gal/min each, and continued to by remedial action by the levee board transport a significant quantity of material until the area was stabilized.	32.8013736	-91.1219469	Mayersville - Lake Providence	A110	100-118	PB
Buck Chute	Eagle Lake	8749 to 8764	110+00 to 131+00	Sand Boil	Heavy	Buck Chute - Stabilization berm constructed at Buck Chute. Water Control Plan for Eagle Lake, A significant boil developed about 5 ft west of relief well BC-2-98. Stabilization berm constructed and was completed in early May 2011 to control seepage and sand boils. A deviation in the water control plan for Eagle Lake was enacted to minimize seepage pressures through the levee. Water level in Eagle Lake was raised to 89.8 ft.	32.5348209	-91.0780773	Alsatia	A146	74-91	AC
Tara Hunting Camp	Eagle Lake	8847 to 8964	210+00 to 327+00	Sand Boil	Heavy/ Large	Moderate to heavy underseepage, numerous active, medium sized sand boils and pin boils were observed within 50 ft of the levee toe between Brunswick Extension Levee (BEL) sta 210+00 and 327+00 near and around Tara Hunting Camp. Two to three, large, high-energy sand boils with 12- to 16-in. throats were identified between Sta. 210 and 220 that flowed 100+ gal/min and transported 5+ cu yd of fine sand/silt before and during remedial action. These boils were located between 10 and 20 ft from the toe of the levee. One boil, located near sta 212+00 BEL was ringed with sandbags by the levee board. The other boils were eventually stabilized with drums placed over the throats of the boils. A large water berm, several feet in depth, was created by the underseepage in this area and the bermed area was investigated by boat on 5/23/11. During this investigation, over 30 sand boils were identified under the surface of the water berm in the general area of levee sta 260.	32.4986254	-91.0754191	Alsatia	A147	95-109	PB

Name 1	Name 2	NLD Station	Field Station	Type	Condition	Remarks	Latitude	Longitude	Quad	Page No. Append A	Photos	Environment
Albemarle	Albermarle Slide/Boil	8218	8170	Sand Boil-Slide	Heavy	Five medium-sized, high-energy sand boils along the toe of the levee near 16-37 levee sta 8170 (no berm). A large, landside, slide developed immediately downstream from the boils. A stone ring was placed around the sand boils and a filter of sand was placed over the throats of the boils. The levee board worked throughout the night to stabilize the boil. The stabilization of the slide began the following day with Corps hired labor forces. An additional slide developed during the second night immediately upstream from the sand boils. Both slides were accompanied with and possibly the result of heavy seepage exiting at the slide face and on the slope below. Hired labor continued daytime stabilization of the slide by placing crushed limestone at the toe and sand on the lower end of the slide to provide additional weight and drainage. The slides were present in the lower 1/3 of the levee embankment and were relatively shallow in depth. A small slide near the levee toe formed immediately above the sand boils on the third day that connected the two larger slides. The hired labor forces maintained daytime activities on the site for approximately 14 days to stabilize both the slides and the boils. There were approximately 6,000 tons of limestone (#57 stone) and 11,000 tons of sands placed on the site to stabilize the slope. The boils at the levee toe and the embankment instability could have progressed to loss of levee foundation material and/or significant loss of the net levee section.	32.6282974	-90.9990409	Onward	A145	16-37	AC-PB
Tara Hunting Camp	Eagle Lake	9180	542+00	Sand Boil	Heavy	Moderately high-energy sand boil with a 12-in. throat along the toe of the seepage berm near levee sta 542 (BEL). Boil has transported about 3 cu yd of silt/fine sand and is flowing approximately 75 to 100 gpm. Boil was flagged for the levee board.	32.4628870	-90.9924057	Vicksburg	A147	117	PB
Oakwood	Near Villa Clara Church	6178	6183	Sand Boil	Large	Inspected May 28, 2011. Reported by night crew approximately 4 miles south of St Joe, LA. Boil is located 950 ft landside for top of levee at sta 6185+75 downstream of culvert in ditch. This large, high-energy boil has produced possibly over 100 yd of material. Ditch at this location is about 10 ft deep and there is material above water level. Within a 2-hr period the boil increased from 4- to 6-ft- diam with a 13-ft-diam sand cone. Outside perimeter of the sand cone is approximately 60 ft in diameter with some material flowing downstream. This area has a 100-ft-diam sunken cracked area along the upstream and east-west side of ditch. The boil throat is at least 18 ft in depth. Majority of material appears to be a silty sand with some clay particles inside hole. Clay does not appear to be foundation material. On May 29, the levee board placed two sandbag dams across the ditch one on each side. There was about 4 ft of water over the boil.	31.8831611	-91.2736138	Locust Ridge	A287	22-24	PB
Oakwood	Near Villa Clara Church	6178+50	6183+50	Sand Boil	Heavy	Large high-energy boil inspected on June 1, 2011. Seventy-five feet NNW of above boil.	31.8833440	-91.2737270	Locust Ridge	A287		PB
Lake Bruin	Lake Bruin/ Melancon Camp	5659	5663+00	Sand Boil	Heavy	Large boils at Melancon Camp. - They have moved material from behind seawall. Most are located in the lake and cannot be measured. Some small ones along the bank. Seven boils in Lake Bruin, which have produced 10 yd of silty sand, range in size from 2 to 5-ft diam.	31.9880299	-91.1863609	St Joseph	A285	1-6	PB
Lake Bruin	Lake Bruin/ Melancon Camp	5706	5710+00	Sand Boil	Large	Large boils in Botany Bay Ditch. - Boils have been sandbagged and ditch has been bagged to allow higher head over boils. Both have moved large amount of material. Approximately 450 ft from the levee toe.	31.9762521	-91.1891261	St Joseph	A285	7-10	PB

Figure 11. 2011 Sand boil distribution by depositional environment.

4.3 Occurrence of high priority and large sand boils

High priority and/or large sand boil incidents during the 2011 flood in the Vicksburg District are identified in Table 3. These incidents number 25 in total. The vast majority of these incidents are associated with point bar (PB) deposits, followed by two incidents associated with abandoned channels (AC), and two incidents occurring at the boundary between the point bar and the abandoned channel environment. Incidents involving abandoned channel settings are expected to occur because of their lower ground elevation (contributing to higher gradients), presence of aquifer sands near surface, and/or oftentimes a thin top stratum (blanket) present, especially involving historic abandoned oxbows.

4.4 Blocked exits

Incidents occurring at the boundary between two environments are considered to be representative of a blocked exit type setting (Figure 6). An abrupt change in the hydraulic conductivity of the seepage pathway occurs at these locations within the alluvial aquifer. The seepage model shown by Figure 6 from Mansur et al. (1956) is representative of a blocked exit because of the presence of fine-grained swale deposits. A swale corresponds to fine-grained filling of slough deposits that separate the

sand ridges (lateral bars) in the point bar environment. Presentation of the blocked exit condition is also shown in Appendix B, see Figure B2 (Fisk 1945). Illustrations in Appendix B identify other conditions favorable for seepage and sand boil formation behind levees involving blocked exit conditions. Ridge and swale or meander scroll topography are diagnostic features of the point bar environment and are believed to be a major contributor to a blocked exit condition (Fisk 1946; Mansur et al. 1956). At the local landform scale, the blocked exit condition is more representative of sand boil incidents involving point bar deposits, because of the abrupt change in horizontal conductivity in the aquifer and the higher pressure concentrations at these locations.

4.5 Abandoned channels

The large number of incidents of sand boils associated with abandoned channel settings is likely a function of their lower surface elevation and the shallow daylighting of aquifer sands in these settings. This condition is especially apt to occur where oxbow lakes are relatively young in terms of their separation from the main river. Another contributing factor to the high number of incidents is the thickness of the blanket (top stratum) in the oxbow channel. The blanket is more apt to be thin or absent near the arms of the avulsion point, especially in abandoned channels that are less than 100 years old. Depth to the underlying aquifer sands varies with the distance from the neck cutoff (avulsion) location. Typically, both the upper and lower arms of abandoned channels contain pervious sand deposits, which are deposited fairly shortly after separation from the main channel. Following separation, the oxbow then receives only fine-grained sediment from overbank deposition during the annual flooding cycle as a direct connection to the oxbow is blocked by coarse channel fill at the separation point. The lake-filling process can vary from as little as 100 years to as much as 1,500 years, depending on sediment supply (Gagliano and Howard 1984).

Oxbow lakes that have been separated from the main channel less than 200 to 300 years ago are apt to have a relatively thin blanket near their upper and lower ends, and contain shallow aquifer sands in the subsurface. This combination of blanket thickness and shallow depth to aquifer sands, combined with their much lower surface elevation, makes these locations favorable for sand boil occurrence behind levees. Incidents associated with this landform were fairly common during the 2011 flood at Lake Chicot, AR, Lake Providence, LA, and Eagle Lake, MS, (Table 3).

4.6 Lake Chicot example

Sand boil incidents during the 2011 flood at Lake Chicot are described here in more detail to highlight basic relationships described and identified by the incident distribution in terms of depositional setting, topography, floodplain soils, lower surface elevation, and general proximity to the river. The character and extent of sediment filling within an abandoned channel loop at different points along its length are shown by Plate 2. This example was originally presented by Fisk (1947) as part of a study on the effects of fine-grained deposits on river migration. The series of channel cross sections in Plate 2 show the nature and thickness of channel-fill deposits along various points in the old river channel as well as the changes in channel bathymetry (elevation in feet mean sea level) that was present in 1947. Because of the levee system blocking introduction of new sediment into the lake, it is unlikely that the 1947 bathymetry has significantly changed over the past 68 years.

The series of cross sections through the Lake Chicot channel show the coarse nature of the channel-fill deposits in the vicinity of the neck cutoff, which become progressively finer grained in texture in the interior parts of the abandoned channel. However, the presence of backwater drainage into the oxbow lake can locally affect the texture of the channel fill deposits as shown by the occurrence of shallow sands in cross section D-D' in Plate 2. At this location, a tributary stream intersects the old channel and is introducing sand into the channel.

The 1947 surface topography has been overlain on a current photograph of the Lake Chicot area in Plate 3. This example clearly shows the extent of active river channel migration that has occurred in this reach since 1947, prior to hardening the present course of the river with revetment and control dikes. Separation of Lake Chicot from the main channel occurred prior to the 1700s and is in the lacustrine stage of the filling cycle (Gagliano and Howard 1984). Overlain on Plate 3 are the locations of the recorded sand boil and seepage incidents from the 2011 flood (see also Table 3 and Appendix A). The association of sand boil incidents at the upper and lower arms of the old oxbow is clearly evident from this example. Aquifer sands are fairly shallow as shown by the boring data in Plate 2.

The relationship between landform topography and sand boil occurrence is shown in Plate 4 with the addition of the 2006 Light Detection and Ranging (LiDAR) data along the levee corridor from the Lake Chicot area. The

importance of local topographic features involving depositional environments is further highlighted by the 2006 LiDAR data. The relationship between the ridge and swale topography that is characteristic of the point bar landform and the occurrence of sand boils is identified by Plate 4.

Local topography has been accented by using hill-shading techniques in Plate 4 to show the relief that is present. Large to moderate sized sand boils were located at the edge of the old channel or at the nearby point bar ridges, where aquifer sands daylight at the surface. The intervening swales are typically fine-grained and promote a blocked exit condition locally. The presence of a drainage ditch at the landside toe of the levee between stations 2124 to 2161 (north eastern reach of Plate 4) probably intersected point bar sand ridges, where the shallow aquifer sands daylight in the bottom of the drainage ditch and help create a seepage pathway for these boils to develop.

In summary, incidents associated with abandoned channel settings and point bar deposits were not isolated cases during the 2011 flood. These incidents are fairly representative of a class of alluvial depositional environment where local topography, soil type, blanket thickness, depth to aquifer sands, surface elevation, presence of blocked exits, and other kinds of local defects unique to each location occur. A major goal of the WES geologic mapping program in the LMV was to characterize the soils composing the various depositional environments and their distribution across the floodplain (Kolb et al. 1968; Saucier 1994, 1967, 1964). This characterization identified basic relationships that exist between depositional environment and sediment texture based on energy flow within these environments.

4.7 Performance history during past floods

Major floods as previously described occurred in 1937, 1973, and 2011 in the LMV. Incidents of sand boil occurrence during the 2011 flood have been described in the preceding sections and their relationship to the underlying geology in terms of environments of deposition have been explored. Sand boil incidents from the 1937 and 1973 floods are similarly evaluated and summarized in this section and are compared to the 2011 data, especially as it relates to reaches that have experienced chronic sand boil and seepage issues. Table 4 presents a general summary of historic sand boil point data, size/severity distribution of known incidents for the three largest floods of record in the Vicksburg District, using the historic

maps of sand boil and seepage incidents from these floods (WES 1948; USACE 1973a and 1973b).

The vast majority of sand boil incidents are typically small to moderate in size and severity. Large and/or severe sand boils correspond to about one quarter of all the incidents observed.

Table 4. Comparison of point sand boil data based on size-severity across major floods in the Vicksburg District.

Flood Event	Small No. and (%)	Moderate No. and (%)	Large No. and (%)	Total Incidents
1937	96 (65)	27 (18)	24 (16)	147
1973	52 (55)	9 (10)	33 (35)	94
2011	37 (50)	22 (29)	15 (20)	74
General Average	56.7 %	19.3 %	24 %	-

Figures 12 and 13 present the distribution of sand boil incidents for the 1973 and 1937 floods, respectively, according to the underlying depositional environment. Point bar deposits in Figures 12 and 13 for the 1973 and 1937 floods are shown both cumulatively and classified according to their meander belt age using Saucier's (1994) chronology. General trends in terms of landform distribution are similar across the three major floods as one would expect. Point bar deposits account for nearly 75 percent of the total incidents, abandoned channels represent about 20 percent, and the remaining 5 percent are a combination of other environments, abandoned course, outwash plain and backswamp.

These other environments were associated primarily with the 1937 flood data and involved a channel that was subsequently modified by cutoffs to shorten the course of the river (Figure 14). Approximately 151.9 miles of the Mississippi River in the central part of the alluvial valley were removed through a series of 16 cutoffs across major meander loops in the river between 1929 and 1943 (Winkley 1977, Figure 14). The purpose for the cutoffs was to quickly route flood flow through the central alluvial valley, thereby lowering flood stages. Twelve of the 16 cutoffs occurred within the Vicksburg District area. The success of the cutoff program in reducing flood stage eliminated the need for a planned Boeuf-Tensas floodway across Louisiana (Camillo 2012). The distribution of incidents involving depositional environments in Table 4 likely includes a modified channel and levee right-of-way after 1942 when the last of the cutoffs were completed.

Figure 12. Distribution of 1973 sand boils based on depositional environment.

Figure 13. Distribution of 1937 sand boils based on depositional environment. Point bar incidents are separated into their respective meander belt ages (Hpm1 to 3) on right side of graph.

Figure 14. Channel cutoffs between Memphis, TN, and Angola, LA, between 1929 and 1942 (Winkley 1977). Thirteen cutoffs occurred in the Vicksburg District.

4.8 Chronic seepage and sand boil areas

A list of the significant seepage and sand boil areas during the 2011 flood was presented in Table 3. This listing was compared to the seepage and sand boil maps from the 1937 and 1973 floods to determine whether any of these locations have experienced chronic performance issues. This comparison of historic locations is presented as Table 5 and identifies four principal areas, Francis, Leland Chute-Lake Chicot, Greenville, and a reach of the Lake Washington area that has experienced performance issues across each of the three major flood events. These four locations are examined in more detail in this section.

Francis, MS. Seepage and sand boils for Francis, MS, are shown in Figures 15a through 15c for the 1937, 1973 and 2011 floods, respectively. A levee setback occurred at this location as shown by Figure 15a (WES 1948, Plate 17). The exact date of the setback is unknown. Although the lower Francis new levee section had no observed performance issues in 1937, it is included here because of later chronic seepage and sand boil issues occurring during the 1973 and 2011 floods as shown by the respective maps in Figures 15b and 15c. Additionally, this reach is included here because it was one of the initial study sites for underseepage examined in WES (1941b) and Mansur et al. (1956). The area shown in Figure 15a was designated as the lower Francis by Mansur et al. (1956). This same designation will be continued here for discussion purposes. As shown in Figure 15a, a sublevee was fronting the current day levee when the 1939 topographic base map was produced.

Large boils were present at lower Francis during both the 1973 and 2011 floods. A large boil occurred at lower Francis at sta 151+00, at the edge of the seepage berm (see Tables 3 and 5 for index to photographs in Appendix A for this large boil). As shown by the geology map (Figure 15b, also see Mellwood Quadrangles in Volumes II and III), the boil area is located near the boundary between the point bar and abandoned channel deposits. This continued seepage and sand boil occurrence is likely due to a blocked exit condition caused by the presence of the abandoned channel. The abrupt change in hydraulic conductivity within the aquifer sands by the presence of the fine-grained abandoned channel deposits has likely resulted in excessive seepage at point bar ridges and/or hydraulic fracturing of the thin blanket from buildup of pore pressures in the underlying aquifer beneath the blanket.

Table 5. Chronic seepage areas.

Name1	Name2	1937_Flood	1973_Flood	NLD_Stat	Field_Sta	Type	Condition	Remarks	Lat	Long	Quad	Page	Photos	Environment
Francis	Lower Francis (TM 3-424)	no	yes	151	151+00	Sand Boil	High	A large, high-energy sand boil (photo 4) was identified moving significant quantities of silt and fine sand material at the toe of a 200-ft seepage berm. The boil was bagged by the Levee Board with prison labor for initial containment and subsequently sandbag ring was encircled by a larger earthen berm. A filter of sand and stone was constructed over the boil throat to filter fines and dissipate energy. Stabilization took 4 days of 24-hr/day effort (photos 5 to 7). Flow from boil was estimated at 300 gal/min. Boil had potential to cause backward erosion and piping and lead to loss of berm and foundation material. Two more sand boils were found 100 to 150 ft from berm toe (photos 8 to 10). These boils were moderate energy and move approximately 5 to 7 cu yd of material. Boils were bagged by local prisoners. Heavy seepage and numerous pin boils were noted and monitored 2,000 ft either side.	34.08626	-90.865247	Mellwood	A3	4-10	PB
Winterville	Greenville Front Levee	yes	yes	3744 to 3750	3710 to 3720	Sand Boil	Heavy	Winterville sand boil site - A large, high-energy sand boil approximately 30 ft from the toe of 200-ft seepage berm near levee sta 3720. The boil was estimated to be flowing approximately 300 to 350 gpm and was moving significant quantities of silt and fine sand (approximately 100 cu yd). Boil was bagged by levee board with prison labor and a small earthen levee was constructed by local contractor. A filter sand and stone was constructed over the boil throat to filter fines and dissipate energy. Four additional medium-sized boils were identified within 250 ft of the berm toe that required either a small sandbag ring or a 30-gal drum for stabilization. Boils are located between levee sta 3710 and 7320.	33.455237	-91.04974	Refuge	A48	31-42	PB
Lake Ferguson	Greenville Front Levee	yes	no	3886	3852+00	Sand Boil	Moderate/ High	Active sand boil identified on the edge of seepage berm approximately 75 yd from the railroad tracks near levee sta 3952. Area is under 6 to 10 in. of seepage water. Sand boil has a 12-in. throat and has formed a cone that is approximately 12 in. high. Boil is flowing approximately 50 gpm and continues to transport moderate quantities of silt/fine sand.	33.399442	-91.070167	Refuge	A48	61-62	AC
Lake Ferguson	Greenville Front Levee	no	no	4065 to 4072	4031 to 4030	Sand Boil	Heavy	Multiple moderate to high-energy sand boils were identified moving large quantities of fine sand in two separate areas on the east side of the railroad tracks approximately 400 ft from the levee toe. There is no seepage berm in this area. Heavy seepage, numerous pin boils and saturated, soft ground was identified in and around the boil areas. One area is on the power line right-of-way and the other is in the woods approximately 30 yd to the southeast. During the initial site visit, there were numerous small boils identified in the wooded area. The throats on these boils ranged from 3 to 6 in. in diameter and several yards (5 to 8 cu yd) of material had been transported over a 1,000 sq ft area; however, most of these boils were producing clear water. Some of the larger boils were later stabilized with 30-gal drums placed over the throats of the boils. There were approximately three high-flowing sand boils identified in a low spot along the power line. These boils were flowing approximately 100 to 200 gpm each, and were transporting a significant quantity of fine sand and clay/silt balls. Over 15 to 20 yd of material had already been transported from the boils and material was still being moved. Throat diameter of the boils ranged from 12 to 18 in. Levee board work crews and inmates addressed these boils by building a sandbag containment ring which had to be raised at a later date to increase the head over the boils.	33.378153	-91.074231	Refuge	A48	65-73	PB

Name1	Name2	1937_Flood	1973_Flood	NLD_Stat	Field_Sta	Type	Condition	Remarks	Lat	Long	Quad	Page	Photos	Environment
Leland Chute	Leland Chute	yes	yes	2139+95	2135+35	Sand Boil	Heavy	Bagged boil in ditch	33.3601	-91.1632	Refuge	A180	33-37	PB
Leland Chute	Leland Chute	yes	yes	2142+80	2138+20	Sand Boil	Heavy	Bagged boil in ditch	33.3594	-91.1637	Refuge	A180	38-43	PB
Lake Chicot	Lake Chicot	yes	yes	2309+50 to 2544+90	2305+60 to 2541+20	Sand Boil	Heavy/ Large	Lake Chicot - The site is historically an area with large boils. A large, high-energy sand boil was located on the edge of a dredged channel at the south end of Lake Chicot. There were multiple sandbag rings placed around the boil. The throat would move and bypass the sandbag rings. A dike was eventually constructed across the channel. Moderate seepage was exiting the lake bank 30 ft above the water surface. Several other medium to large, moderate energy boils were located along the lake bank. These boils were also ringed with sandbags. The boil closest to the levee was approximately 400 ft from the toe of a 300-ft seepage berm. This boil has repeatedly moved significant quantities of material during previous high-water events and exhibits some potential to develop pipes that may migrate towards the berm/levee. Boils were identified up to 2,000 ft from the levee toe.	33.2879	-91.1691	Refuge	A180		AC-PB
Fish Bayou	Lake Chicot	yes	yes	2544+20	2540+90	Sand Boil	Heavy	Area known as Fish Bayou located approximately 500 ft from berm toe at the downstream end of Lake Chicot.	33.28813	-91.17136	Refuge	A180	80-88	PB
Lake Washington Area	Washington/ Issaquena Counties	no	no	6048	6025+00	Sand Boil	Moderate to Heavy	Five or six small, active sand boils with 4- to 5-in. throats were identified along the toe of the seepage berm near levee sta 6020. Boils were flowing approximately 20 to 30 gpm and transporting fine sand producing cones 2 to 3 ft in diameter. Area being monitored by levee board. Some of the boils ringed by plastic drums.	33.014336	-91.135529	Readland	A76	16-17	PB
Longwood	River Mile 520	yes	no	5400	5368+00	Sand Boil	Moderate- Large	On July 7, 2011, landowner called and reported a "hole" out in his field. Levee board took photos and measured hole to be 2 ft deep with 4 ft diameter. There was evidence of very fine sand material in the buckshot bean field. The boil was located 780 ft from levee center line.	33.14388	-91.0719	Readland	A76	63-64	PB
Lake Washington Area	River Mile 516	yes	yes	5640+00 to 5651+00	5608+00 to 5619+00	Sand Boil	Heavy/ Large	Multiple large sand boils in this area. There are multiple boils in drainage ditch just off toe of berm. Also, there are multiple boils on both sides of the drainage ditch. Three of the boils occur right at the toe of the berm. Most of these were bagged and were no longer moving material. Throat sizes range from a couple inches to greater than 6 in. Sandbag ring constructed around a 30-ft x 10-ft sinkhole that formed in field. Plywood wall constructed around boil also. Seepage is also exiting in the berm crown.	33.105485	-91.129473	Readland	A78	78-87	PB
Lake Washington Area	Washington/ Issaquena Counties	no	no	6051 to 6057	6030 to 6035	Sand Boil	Moderate to Heavy	Three to five sand boils and large area of widespread moderate seepage along the toe of the seepage berm near levee sta 6030. Seepage extends approximately 1/4 mile out into field. Two sand boils were ringed with 30-gal plastic drums. Two or three boils were identified near the drums. Boils were transporting fine sand and clay/silt balls. Numerous pin boils and moderate seepage in bean field near sta 6035. Most boils are transporting a small quantity of material and are under 2 or 3 in. of water.	33.012159	-91.137445	Readland	A107	18-22	PB
Lake Washington Area	Clarence Hall Road Site	no	no	6074 to 6050	6051 to 6070	Sand Boil	Heavy	Numerous, medium to large sand boils (25+) approximately 10 to 30 ft from the toe of the seepage berm between levee sta 6050 and 6070. Levee board was onsite placing drums, galvanized culverts, and sandbags over and around boils. Entire area is under 1 to 3 ft of seepage water from boils. Several boils are high-energy producing 50 to 100 gpm.	33.012159	-91.137445	Readland	A107	23-30	PB

Name1	Name2	1937_Flood	1973_Flood	NLD_Stat	Field_Sta	Type	Condition	Remarks	Lat	Long	Quad	Page	Photos	Environment
Moon Chute	Moon Chute	no	yes	2544+90	3273+00	Sand Boil	Heavy	Sand boil in ditch 200 ft from berm toe with 6-in. pipe. Moved about 2 yd of material. Additional pin boils in ditch with clear flow.	33.1582	-91.1795	Readland	A292	104	PB
Lake Washington Area	Near St Paul Church	no	no	6285	6265+00	Sand Boil	Heavy	Several (4 to 6) large, high-energy sand boils under 3 to 4 ft of water in a drainage ditch in the bean field approximately 200 ft north of Elwood Road near levee Sta. 6265. Two other boils have caused the banks of the ditch to cave. Boils are transporting small quantities of silt/fine sand. Area was flagged during inspection.	32.999427	-91.107287	Mayersville - Lake Providence	A108	51-52	PB
Ben Lomand Road	Carlisle Lake	no	no	7067	7100+00	Sand Boil	Heavy	Multiple, high-energy, sand boils approximately 10 to 50 ft from the seepage berm toe near levee sta 7100. Boils were flowing 20 to 50 gpm and transporting moderate quantities of fine sand (2 to 5 cu yd each). Throat diameters for the boils generally ranged from 2 to 10 in. Some of the boils were ringed with culverts.	32.831713	-91.103178	Mayersville - Lake Providence	A109	95-99	PB
Albemar	Albermarle Slide/Boil	no	no	8218	8170	Sand Boil-Slide	Heavy	Five medium-sized, high-energy sand boils along the toe of the levee near 16-37 levee sta 8170 (no berm). A large, landside, slide developed immediately downstream from the boils. A stone ring was placed around the sand boils and a filter of sand was placed over the throats of the boils. The levee board worked throughout the night to stabilize the boil. The stabilization of the slide began the following day with Corps-hired labor forces. An additional slide developed during the second night immediately upstream from the sand boils. Both slides were accompanied with and possibly the result of heavy seepage exiting at the slide face and on the slope below. Hired labor continued daytime stabilization of the slide by placing crushed limestone at the toe and sand on the lower end of the slide to provide additional weight and drainage. The slides were present in the lower 1/3 of the levee embankment and were relatively shallow in depth. A small slide near the levee toe formed immediately above the sand boils on the third day that connected the two larger slides. The hired labor forces maintained daytime activities on the site for approximately 14 days to stabilize both the slides and the boils. There were approximately 6,000 tons of limestone (#57 stone) and 11,000 tons of sands placed on the site to stabilize the slope. The boils at the levee toe and the embankment instability could have progressed to loss of levee foundation material and/or significant loss of the net levee section.	32.628297	-90.999041	Onward	A145	16-37	AC-PB
Ben Lomand Road	Lake Washington Area	yes	yes	7195 to 7210	7120+00	Sand Boil	Heavy	Ben Lomand road site - Several medium to large sand boils were identified moving moderate quantities of fine sand and silt in a drainage ditch along the toe of the seepage berm and in an open area east of the ditch. All of the sand boils were within 10 to 20 ft of the seepage berm toe. Water berm was created over most of the sand boils in the ditch by the levee board by constructing dikes on the upstream and downstream sides of the sand boils. Also, at least three of the sand boils in the ditch were ringed with galvanized culverts. As a result of the dikes and culverts, most of the boils in the ditch were covered with at least 3 to 4 ft of water. Also, there were several medium boils identified in the edge of a field on the east side of the ditch that were ringed with culverts by the levee board and eventually two sandbag rings were constructed around the area to increase the head and slow the movement of material. Most of the boils were flowing approximately 50 to 100 gal/min each, and continued to by remedial action by the levee board transport a significant quantity of material until the area was stabilized.	32.801374	-91.121947	Mayersville - Lake Providence	A110	100-118	PB

Name1	Name2	1937_Flood	1973_Flood	NLD_Stat	Field_Sta	Type	Condition	Remarks	Lat	Long	Quad	Page	Photos	Environment
Buck Chute	Eagle Lake	no	no	8749 to 8764	110+00 to 131+00	Sand Boil	Heavy	Buck Chute - Stabilization berm constructed at Buck Chute. Water Control Plan for Eagle Lake, A significant boil developed about 5 ft west of relief well BC-2-98. Stabilization berm constructed and was completed in early May 2011 to control seepage and sand boils. A deviation in the water control plan for Eagle Lake was enacted to minimize seepage pressures through the levee. Water level in Eagle Lake was raised to 89.8 ft.	32.534821	-91.078077	Alsatia	A147	74-91	AC
Tara Hunting Camp	Eagle Lake	no	no	8847 to8964	210+00 to 327+00	Sand Boil	Heavy/ Large	Moderate to heavy underseepage, numerous active, medium sized sand boils and pin boils were observed within 50 ft of the levee toe between Brunswick Extension Levee (BEL) sta 210+00 and 327+00 near and around Tara Hunting Camp. Two to three, large, high-energy sand boils with 12- to 16-in. throats were identified between sta 210 and 220 that flowed 100+ gal/min and transported 5+ cu yd of fine sand/silt before and during remedial action. These boils were located between 10 and 20 ft from the toe of the levee. One boil, located near sta 212+00 BEL was ringed with sandbags by the levee board. The other boils were eventually stabilized with drums placed over the throats of the boils. A large water berm, several feet in depth, was created by the underseepage in this area and the bermed area was investigated by boat on 5/23/11. During this investigation, more than 30 sand boils were identified under the surface of the water berm in the general area of levee sta 260.	32.498625	-91.075419	Alsatia	A147	95-109	PB
Tara Hunting Camp	Eagle Lake	no	no	9180	542+00	Sand Boil	Heavy	Moderately high-energy sand boil with a 12-in. throat along the toe of the seepage berm near levee sta 542 (BEL). Boil has transported about 3 cu yd of silt/fine sand and is flowing approximately 75 to 100 gpm. Boil was flagged for the levee board.	32.462887	-90.992406	Vicksburg	A147	117	PB
Oakwoo	Near Villa Clara Church	no	no	6178	6183	Sand Boil	Large	Inspected May 28, 2011. Reported by night crew approximately 4 miles south of St Joe, LA. Boil is located 950 ft landside for top of levee at sta 6185+75 downstream of culvert in ditch. This large, high-energy boil has produced possibly more than 100 yd of material. Ditch at this location is about 10 ft deep and there is material above water level. Within 2-hr period the boil increased from 4 ft to 6 ft in diameter with a 13-ft-diam sand cone. Outside perimeter of the sand cone is approximately 60 ft in diameter with some material flowing downstream. This area has a 100-ft-diam sunken cracked area along the upstream and east-west side of ditch. The boil throat is at least 18 ft in depth. Majority of material appears to be a silty sand with some clay particles inside hole. Clay does not appear to be foundation material. On May 29, the levee board placed two sandbag dams across the ditch one on each side. There were about 4 ft of water over the boil.	31.883161	-91.273614	Locus Ridge	A287	22-24	PB
Oakwood	Near Villa Clara Church	no	no	6178+50	6183+50	Sand Boil	Heavy	Large high-energy boil inspected on June 1, 2011. Seventy-five feet NNW of above boil.	31.883344	-91.273727	Locust Ridge	A287		PB
Lake Bruin	Lake Bruin/ Melancon Camp	no	no	5659	5663+00	Sand Boil	Heavy	Large boils at Melancon Camp - They have moved material from behind seawall. Most are located in the lake and cannot be measured. Some small ones along the bank. Seven boils in Lake Bruin which have produced 10 yd of silty sand range in size from 2 to 5 ft diam.	31.98803	-91.186361	St Joseph	A286	1-6	PB
Lake Bruin	Lake Bruin/ Melancon Camp	no	yes	5706	5710+00	Sand Boil	Large	Large boils in Botany Bay Ditch - Boils have been sandbagged and ditch has been bagged to allow higher head over boils. Both have moved large amount of material. Approximately 450 ft from the levee toe.	31.976252	-91.189126	St Joseph	A286	7-10	PB

Figure 15b. Francis 1973.

15c. Francis 2011.

4.9 Leland Chute-Lake Chicot

Seepage and sand boil occurrences for the Leland Chute-Lake Chicot area are shown in Figures 16a through 16c for the 1937, 1973 and 2011 floods, respectively. The geology and stratigraphy of the Lake Chicot abandoned channel area was previously described (Plates 2 through 4) using boring data from Fisk (1947) to characterize the nature of abandoned channel deposits. As shown by the series of flood maps in Figures 16a to 16c, low lying areas within and adjacent to the arms of the Lake Chicot abandoned channel are prone to sand boil activity. Using boring information previously described from the Lake Chicot area (see section C-C', Plate 2), aquifer sands are identified as being relatively shallow adjacent to the channel margins. This condition is likely enhanced by smaller drainage channels that occupied the oxbow before a levee was built across the old channel during historic times, which has prevented high water from flowing into the old lake during the annual flooding cycle. The photograph from the 1922 flood at Vancluse, AR (bottom of Figure 16a), looking at the large sand boil behind the levee and the view upstream at the steamboat in the background, shows the general conditions and relief present in the old channel where the levee crosses the upstream arm at this location.

During the 1973 and 2011 floods, moderate to large sand boil activity occurred within both the upper and lower arms of Lake Chicot as shown by Figures 16b and 16c (boil photographs in Appendix A, see page A179 for index to photographs of the boils). Further upstream in the Leland Chute area, persistent sand boil activity has occurred. This occurrence is associated with the point bar ridge and swale topography and the presence of a landside drainage ditch, which has exposed these sands as previously described. The front cover of this report shows an aerial photography taken during the 2011 flood of the Leland Chute area with the upper arm of Lake Chicot in the background. The "V"-shape of the levee immediately upstream of the upper arm of Lake Chicot suggests a past crevasse at this location. The USACE hydrographic survey of 1879-1880 identifies the presence of a local levee with this same orientation, and there is no record of a historic crevasse at Vancluse between during the period 1770 and 1930 (U.S. Congress 1931).

Figure 16a. Leland Chute-Lake Chicot area, cumulative 1922 to 1945 flood performance data. Lower photograph of large bagged sand boil during the 1922 flood is located in the upper loop of the Lake Chicot abandoned channel, along the south side of the old channel. The sharp bend in the levee just upstream of the upper arm of Lake Chicot predates the 1879-1880 hydrographic survey of Mississippi River and corresponds to the local levee right-of-way at this time (chart 40, 1879-1880 survey of the Mississippi River). Solid blue line corresponds to presence of a berm or drainage wells. Sand boil and seepage information are noted where solid red line is heavy underseepage area and dashed red line is light to moderate underseepage area.

Figure 16b. Leland Chute-Lake Chicot area during 1973 flood. Boils and seepage use the traffic light analogy with red (large/high), orange (moderate), and green (low/small). Blue line corresponds to seepage berms present during the 1973 flood.

Figure 16c. Leland Chute-Lake Chicot area during the 2011 floods.

Greenville-Winterville. Seepage and sand boil occurrences for the Greenville-Winterville area were previously shown in Figures 2 through 4 for the 2011, 1973, and 1937 floods, respectively (note chronology is reversed from the above two areas). This reach was previously used to serve as an example for the importance of conducting a historic comparison of past performance data across major flood events. No detailed discussion was performed during this earlier presentation. This area will be examined in more detail in this section. For consistency of presentation and discussion of flood order, the Greenville-Winterville area is presented as Figures 17a through 17c.

For purposes of this discussion, the Winterville levee reach occurs north of Greenville and the Greenville levee front area extends downstream from Greenville in the areas shown by Figures 17a through 17c. Chronic sand boil activity has occurred during each major flood event in this area as shown by Figures 17a through 17c. During the 2011 flood, a major sand boil occurred at the edge of the seepage berm in the Winterville reach. This boil required emergency repairs to control loss of foundation soils (Figure 17c). This entire area has had a seepage berm in place since the 1937 flood as shown by the blue line in Figure 17a. Small to moderate sand boil activity occurred during the 1973 flood and heavy seepage was present, especially adjacent to abandoned channels as shown by Figure 17b. Similarly, moderate to large sand boil activity was present during the 2011 flood as shown by Figure 17c.

An investigation of the Winterville sand boil was performed by Stephens (2014). The investigation involved a backhoe excavation into the boil to expose features of the boil and characterize the underlying stratigraphy and cone-penetrometer tests (CPT) to determine blanket properties. This investigation identified localized defects (i.e., surface depression, tree roots), forming a roof, and thin spots in the blanket (i.e., due to ridge and swale topography from CPT data). Excavation of the boil area identified small clay balls in the boil throat and evidence of turbulence from the character of the clay balls and orientation of mixed sands in the excavation.

Figure 17a. Greenville area 1937 flood (WES 1948).

Figure 17b. Greenville area 1973 flood (USACE 1973a).

Figure 17c. Greenville area 2011 flood.

An interesting historic account of seepage and piping during the 1929 flood occurs in the vicinity of the La Grange crevasse, which is located south of Greenville (Figure 17d), near levee sta 4100+00. The crevasse occurred on 27 March 1903 and was 3,875 ft long (U.S. Congress 1931). The exact cause of the crevasse was unknown (U.S. Congress 1931), but was assumed to be from underseepage (WES 1948). The description of the large sand boil during the 1929 flood at this area in Figure 17d points to a case for hydraulic fracturing of the thin blanket due to excessive hydrostatic pressure in the aquifer sands, leading to piping of foundation sands, formation of a large cavity beneath the levee, and eventual collapse of the levee foundation into the void. The levee collapse into the void prevented complete breaching and another catastrophic failure at this location. Noteworthy details of this incident are contained in the description in Figure 17d.

This 1929 case serves to highlight the susceptibility and hazards of abandoned channel settings for presence of sand boil activity. Interestingly, the new levee that was constructed during the 1930s as a setback contains a seepage berm as shown by the presence of the blue line in Figure 17d. This levee setback and seepage berm would have been built to the 1928 levee profile standards that were adopted by the MRC following the Great Mississippi River Flood of 1927 (Figure 8). Characteristics of this levee profile were previously described in Chapter 3 of this report. What is interesting about this particular example is the heavy seepage that was present during the 1973 flood in the vicinity of the La Grange crevasse (Figure 17b) and moderate seepage that was present during the 2011 flood (Figure 17c). What is unknown about this example are the additional seepage control measures that may have been added because of performance-related issues at this location after each flood event. The geologic map in Figure 3 identifies the presence of an abandoned channel and major ridge and swale topography landside of the levee in the vicinity of the La Grange crevasse area where past issues have occurred. The previous discussion does not address any relief wells that may exist at this location.

Figure 17d. Location of the LaGrange crevasse in the lower Greenville levee reach (WES 1948). The crevasse occurred on 27 March 1903 and was 3,875 ft long (from House Document No. 798 on report to U.S. Congress 1931). The cause for the crevasse was assumed to be underseepage (WES 1948). Large sand boil occurred in 1929 flood (see last paragraph) and represents a case for hydraulic fracturing of the blanket, and levee underseepage causing piping and backward erosion leading to a large cavity under the levee, and eventual collapse of the levee foundation into the void. The collapse preventing breaching of the levee.

Greenville sand boil (1929). LaGrange crevasse occurred 3 miles south of Greenville. Cause of crevasse is listed as unknown but probably was caused by underseepage. Crevasse resulted in deposit of a thick stratum of coarse sand in a roughly semicircular area behind the levee. Crevasse closed by a setback loop protected by sublevees.

Upper end of loop relocated in 1913 across crevasse sand. Sand was excavated to original ground surface and put in a landside (L.S.) berm for new levee. Berm appears to have been of considerable effect in controlling underseepage. Near junction of 1903 and 1913 setbacks, levee for 300 ft was protected neither by berms nor sublevees. Foundation consists of 5 to 7 ft relatively impervious material underlain by sand.

In 1929 with the Greenville gage above 50 ft for 21 days, partial failure of the levee occurred. Hydrostatic head in the pervious substratum blew up the surface soil at the L.S. toe over an area 4 ft by 7 ft, followed by a settlement 30 ft wide entirely across the levee. This settlement of the levee, which consisted of sandy soil and which was unable to support itself above the flowing stream, cut off the foundation cavity, thereby stopping the flow of water and saving the levee.

Lake Washington area. Seepage and sand boil occurrences for the Lake Washington area are shown in Figures 18a through 18c for the 1937, 1973, and 2011 floods, respectively. The levee through this reach was set back and reconfigured when the Worthington Cutoff was dredged across Matthews Bend in 1933. The Lake Washington area levee right-of-way

would have been redesigned because of the cutoff through this area and would have been built to the new 1928 profile standards prior to the 1937 flood. The extent of seepage berm construction in this reach in 1937 is shown by Figures 17a. Identified on Figure 17c is a current image of this same area with seepage berm construction during the 2011 flood. Remnants of the 1928 profile are still in place, and these reaches correspond to where older, clay filled, abandoned channel deposits intersect the levee as shown by geology map in Figure 17b. For the most part, this area has a 300-ft-wide seepage berm in place.

Despite the additional seepage berm measures that were adopted following the 1973 flood (Figure 17b), two noteworthy boils were identified behind the levee during the 2011 flood in the Longwood area at sta 5400 and at sta 5651 at Worthington Point (Table 5). The addition of a continuous seepage berm in this area highlights the chronic nature of the underseepage problem through this reach. The presence of a thin blanket in younger point bar deposits and numerous older (clay filled) abandoned channels behind the levee through this reach are major contributing factors to performance issues. Additionally, another contributing factor to this chronic performance is the narrow flood corridor that was established when the point bar neck sands were dredged to create the Worthington point cutoff. The new channel would have scoured deeply into these aquifer sands as the oxbow diminished in channel capacity to carry the flow. As shown by Figure 17a, the presence of channel sands is shown at relatively shallow elevation (depths). Thus, the hydraulic gradient is relatively high across the levee profile through this reach because of the close proximity of the new channel to the levee.

Figure 18a. Seepage and sand boils from the 1937 flood (WES 1948). Note the amount of seepage berm present in 1948 (denoted by the solid blue line).

Figure 18b. Seepage and sand boil data from the 1973 flood (USACE 1973a). Note the amount of seepage berm present in 1973 (solid blue line).

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4.10 Other areas in Table 5

Other areas in Table 5 that have experienced performance issues in recent times are the Albemarle slide and the lower Eagle Lake area as previously described. The Albemarle area (sta 8170) is an interesting case because of the slide that occurred during the 2011 flood, where underseepage was attributed to the partial levee failure. However, this reach has been known for slough slides where the riverside slope has experienced minor slides because of high plasticity CH soils from the former river channel. A shallow riverside slide had occurred at this same location two years prior to the 2011 flood. Thus, it is uncertain as to whether levee through seepage had contributed to this slide. Emergency repairs to stabilize the levee and rebuild following the 2011 flood did not permit a forensic investigation of a through seepage mechanism as being a contributing factor.

As noted in Chapter 3, the Eagle Lake area prior to 1973 would collect backwater drainage behind the levee through Muddy Bayou and Steele Bayou. The Muddy Bayou and Steele Bayou control structures were built following the 1973 flood and were designed to prevent extensive backwater flooding into the Buck Chute area (southern arm of Eagle Lake) and the Tara Wildlife Hunting Camp areas. This reach of levee is known as the New Brunswick Extension with Eagle Lake, Forest Home, and Halpino Lake Enlargements (Figure 9). Sand boils started becoming a significant seepage issue in the early 1990s and were problematic during the 2008 and 2009 floods. Performance issues prior to the 1973 flood were not noted for this area. Thus, this reach during the past 20 years has been the focus of extensive seepage control measures following the 2011 flood. Detailed geologic and geophysical studies of the Buck Chute and Terra levee reaches are described by Martin et al. (2016) and Strange et al. (2016).

4.11 Seepage control measures

Seepage control measures mainly involve seepage berms, relief wells (not examined in this study), drainage ditches, and a combination of these methods. Identified on the WES (1948) and USACE (1973a) flood performance maps were seepage berm locations. These locations were digitized in ArcView to obtain the total length of berm construction for the two-time periods (1948 and 1973). Additionally, Bing photography was used to map the addition of new berms that have been constructed after 1973. The total extent of main-line Mississippi River levees in the Vicksburg District is approximately 524 miles for perspective purposes. In 1948, there

were 62 miles (12 percent of total length) of seepage berms that had been constructed in the Vicksburg District. In 1973, there was an additional 95 miles of seepage berms that had been built between 1948 and 1973, corresponding to 157 total miles (30 percent of total length). An additional 231 miles of berms were constructed following the 1973 flood, for a combined length of 387 miles (74 percent of total length). These values do not differentiate between berm type or width (150- or 300-ft-wide berms). The increasing extent of berms has generally reduced the severity of seepage based on the areas that had previously experienced heavy seepage.

5 Summary and Conclusions

5.1 Summary

The backbone of the MR&T flood protection system involves levees to prevent periodic overflow of the developed alluvial valley by the Mississippi River. Incidents of sand boil and seepage activity recorded during the Mississippi River Flood of 2011 by the Vicksburg District were overlain onto photographic and geologic base maps for this study to evaluate the distribution of incidents in terms of the underlying depositional environment and historic land use changes. The presentation of the 2011 flood incidents of seepage and sand boil incidents onto photographic and geologic base maps follows similar depictions of performance data from the 1937 and 1973 floods (WES 1948; USACE 1973b). This study reviews historic levee construction activities by the USACE following the Great Mississippi River Flood of 1927 and past studies to evaluate levee underseepage and their control. From the distribution of incidents involving three major floods of record in the Vicksburg District between 1937 and 2011, areas where chronic sand boil and seepage activity occur are identified and reviewed as to geologic controls and underlying changes in levee design to remediate these areas. Geologic data from the alluvial valley were obtained from the legacy WES geologic mapping program conducted for the MRC between the late-1940s and the mid-1990s (see lmvmapping.erdg.usace.army.mil).

Important to understanding the performance of the MR&T levee system during large flood events is the underlying design principals and changes that have occurred to the levee system since the modern day system was established with the completion of the 1928 levee profile by the time of the Mississippi River Flood of 1937. In addition, the reach of the Mississippi River in the Vicksburg District encompasses 15 of the 16 meander cutoffs that were constructed between 1929 and 1942, effectively shortening the course of the river by 135 miles and resulting in significant changes to the levee corridor. MRC legacy documents and noteworthy studies involving levee seepage issues are incorporated into this investigation where applicable. Included in this report are appendices containing the 1947 Levee Code and the 1928 Design and Construction standards used by the Vicksburg District to rebuild the levee system from the 1914 profile to the 1928 profile following the 1927 flood. The goal for including this information here was to consolidate this information into a single source

for those seeking additional information. These type of studies are the corporate history regarding the levee system which become less consolidated with the passage of time, personnel changes in the USACE organization, and transfer of responsibility to the next generation of engineers tasked with maintaining the flood protection system. The current levee system has evolved and will continue to evolve in the future because of the dynamic nature of the river, the demands imposed on the system during each major flood event, and future changes in land use.

Levee boards are responsible for the day to day operation and normal maintenance of the main-line levees and these boards were in operation prior to the passage of the Flood Control Act of 1928, which authorized the MR&T Project. Most of the levees that were in place in 1927 were typically private levees that were under the jurisdiction of the local levee boards. USACE presence in the lower valley prior to 1928 was primarily related to maintaining navigation, mapping the navigable waterways, and regulating levee construction along navigable waterways. Today, the levee system is a shared partnership between the USACE Districts and the local levee boards which are responsible for their maintenance and management.

5.2 Conclusions

Sixty-eight percent of the seepage and sand boil incidents identified during the 2011 flood are associated with recent point bar deposits, which are less than 3,000 years old. This distribution is consistent with earlier studies of sand boil and landform relationships (Mansur et al. 1956; Kolb 1975). Blocked exit conditions were the most favorable locations for sand boil occurrence, involving ridge (lateral bars) and swale (clay filling slough between lateral bars) topography and at the boundaries between point bar and abandoned channels. Levee orientation in relationship to depositional features has an important bearing on the concentration of seepage behind the levee, especially where the levee creates a closed basin condition with the underlying alluvial aquifer and less permeable depositional environments that intersect the levee.

The next highest concentration of sand boils occurs in the abandoned channel, with approximately 23.5 percent of all the observed incidents during the 2011 flood being in oxbow settings. Incidents involving abandoned channels are typically associated with meander loops that are relatively young in terms of their abandonment from the main channel and are in the early stages of their natural filling cycle. Most incidents

during the 2011 flood were located in close proximity to the cutoff, where the fine-grained blanket is relatively thin and the alluvial substratum or aquifer sands occur at shallow depths. Lake Chicot, Lake Providence, and Eagle Lake are examples where this condition was common during the 2011 flood.

Twenty-five significant boil areas were identified from the recorded 2011 flood incident data. Four areas of chronic sand boil occurrence were identified from this listing based on performance incidents occurring at these locations during the three major floods of record, 1937, 1973, and 2011 floods. These areas correspond to the Francis, Leland Chute-Lake Chicot, Winterville-Greenville Levee Front, and Lake Washington reaches. Seepage berms have been typically constructed following the major floods at these locations as evidenced by historic performance maps from the 1937, 1973 and 2011 floods (WES 1948; USACE 1973a). These maps identify the presence of seepage berms that have been developed in response to poor performance during flooding.

Approximately 15 percent of all the sand boil incidents recorded during the 2011 flood involved large/high-energy sand boils. Historically, large boils account for between 15 to 24 percent of the total incidents during large floods. The majority of seepage areas during the 2011 flood were in the low to moderate category. Areas of high seepage were generally less than the 1973 flood extent because of the addition of new seepage berms and the increasing use of relief wells in seepage prone areas since the mid-1990s. The efficacy of relief wells and their impact to the overall levee system in terms of controlling seepage were not considered by this study.

Approximately 387 miles of seepage berms have been added to the main-line levee system in the Vicksburg District since the 1928 profile was adopted as the standard profile following the 1927 flood.

5.3 Recommendations

The following recommendations are made for conducting research of problem levee reaches.

1. Continue long-term historic assessment study of the Memphis and New Orleans Districts.
2. Conduct focused studies of chronic problem sites to determine specific properties about each site. These studies should involve a detailed geological site characterization, evaluation of existing boring data,

- topography, and other physical parameters to fully understand the specific engineering and hydraulic factors at play.
3. Major sand boils should be excavated to obtain detailed information on boil characteristics and properties (namely the blanket and ejecta soils, seepage pathways, their size and extent, type of aquifer soils).
 4. Sand boil ejecta should be routinely collected and grain-size data obtained to determine the depth and the stratigraphic horizon from which the foundation material is being removed.
 5. A detailed checklist of sand boil properties should be collected from all large boils in future flood events.
 6. Geophysical methods should be incorporated into a study of chronic problem sites to image between the available boring data to help resolve blanket characteristics and properties.
 7. Finally, conduct a study of long-term impacts from multiple flood events and levee performance. Do chronic seepage problems cause subsurface erosion and degradation that leads to more severe problems with time? Selected study sites should be targets for this chronic condition and assessment of levee performance data conducted in relation to seepage control measures.

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Plate 1. Alluvial geology map of the Yazoo Basin (Saucier and Kolb 1967). Generalized geologic profile extends from Memphis to vicinity of Vicksburg and shows the top stratum and substratum deposits in relationship to the longitudinal profile.

Plate 2. Character of abandoned channel filling at various locations along the Lake Chicot oxbow (Fisk 1947). This area was the site of numerous sand boil incidents during the 2011 flood.

Plate 3. Lake Chicot, AR.

Plate 4. Lake Chicot, AR, 2006 LiDAR data.

Appendix A: 2011 Report with Photos

Appendix A: 2011 Flood Report - Incident Data

US Army Corps of Engineers, Vicksburg District

August 2011

EAST BANK MISSISSIPPI RIVER LEVEE
STATION 0+00 TO 1500+00

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: District Line to Rosedale

DATE: May 16-18, 2011

TEAM MEMBERS: Heather Sibley, Lance Gullett and Justin Jones

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
--	--	--	--	0+00 to 5+00	0+00 to 5+00	Current	Moderate	Moderate Current just out from the toe of the levee.	
34.1188619	90.87694957	34.11147204	90.87997861	2+00 to 36+00	2+00 to 36+00	Under Seepage	Moderate	Moderate seepage. No pin boils noted. Extends from the levee toe out 100ft.	1
34.11147204	90.87997861	34.10548407	90.88043276	36+00 to 58+00	36+00 to 58+00	Under Seepage	Light	Seepage transitions to light seepage. Not flowing and no boils found. Extends from the levee toe out 200 ft.	
34.10291772	90.88032166	34.09872932	90.87199129	68+00 to 102+00	68+00 to 102+00	Under Seepage	Light	Light seepage. Begins at the toe and extends out. Cannot determine full limits of seepage.	
34.09800244	90.8711749	34.08962979	90.86691213	105+00 to 159+00	105+00 to 159+00	Under Seepage/Pin Boils	Heavy	Heavy Seepage. Numerous pin boils in field. Two areas with very light seepage exiting just up the slope from the toe of the berm. Extends from the toe out 1000 ft.	2
34.08962979	90.86691213	--	--	137+00	137+00	Sand Boil		Small Boil throat less than 3 inches. Has been bagged. Moving very small amount of material. Located approximately 25 ft from the toe.	3
34.08578056	90.86633889	--	-	151+00	151+00	Sand Boil		A large, high energy sand boil (photo 4) was identified moving significant quantities of silt and fine sand material at the toe of a 200 foot seepage berm. The boil was bagged by the Levee Board with prison labor for initial containment and subsequently the sandbag ring was encircled by a larger earthen berm constructed by Corps hired labor forces. A filter of sand and stone was constructed over the boil throat to filter fines and dissipate energy. The stabilization of the boil took 4 days of 24 hr/day effort (photos 5-7). Flow from the boil was estimated at approximately 300 gals/min. This boil appeared to have the potential to result in backward erosion and piping that could eventually lead to loss of berm and levee foundation material. Two additional sand boils were identified approximately 100 – 150 feet from the berm toe (photos 8-10). These boils were classified as moderate energy levels and moved approximately 5-7 cubic yards of material. These boils were also bagged by the local prisoners. Heavy seepage and numerous pin boils were noted and monitored along the slope and toe of the berm upstream and downstream of these boils for a reach of approximately 2,000 feet. Area known as Francis.	4-10
34.08413458	90.8641464	34.08248059	90.86361787	158+00 to 166+00	158+00 to 166+00	Under Seepage	Light	Seepage is light and ends just before the end of the seepage berm. From the end of the berm on the North to the start of the berm on the South, there is a small amount of seepage where berm ends.	
34.07896114	90.86270461	34.07062451	90.86762874	177+00 to 211+00	177+00 to 187+00	Under Seepage	Light	Begins at the toe. Seepage starts at the start of the seepage berm and doesn't appear to go out more than 100ft from the toe of the berm. At 34.07152649 90.86644311 is a swampy wet area just past the toe so cannot get full extent of seepage in that area. From Levee Marker Sta. 177+00 to 181+00 there is seepage exiting just up the slope of the berm and does not extend any higher than 5ft from the toe.	
34.068335	90.86654317	34.06554717	90.86485715	226+00 to 237+00	202+00 to 213+00	Under Seepage	Light	Light to very light seepage beyond berm toe.	

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
34.06404489	90.86378762	34.0628319	90.86304608	244+00 to 249+00	220+00 to 225+00			Slough located 20ft from the berm toe.	
34.05133852	90.86120164	34.04965761	90.86123141	291+00 to 297+00	266+00 to 272+00	Under Seepage	Light	Very light seepage located 20 to 150 ft from the toe of the levee.	
34.0455402	90.86087225	34.04202794	90.86113954	310+00 to 326+00	286+00 to 302+00	Under Seepage/Pin Boils	Moderate to Heavy	Starts at toe of levee and stops 100ft from toe. Starts light and increases in downstream direction. Seepage begins 3 to 5 ft up levee slope in some areas. A few pin boils were noted. Seepage extends until beginning of berm at Station 300+00.	11
34.03724655	90.86055956	34.0363876	90.86060522	344+00 to 348+00	319+50 to 323+50	Under Seepage	Light	Light seepage in slough. Starts near toe and extends into slough.	
				352+00	327+00	Current	Light	Light current along the levee. Then at approx. Sta 327+00 levee turns and there is almost no current downstream of the PI.	
34.03236969	90.86214242	34.01696521	90.88741378	360+00 to 450+00	336+00 to 426+00	Under Seepage	Light	Light seepage along berm toe and drainage ditch. Extends to slough/pond continues on into soybean field where seepage extends 1200ft. Where the berm ends, seepage begins 150ft from the levee toe and extends into wheat field.	12-15
34.01696521	90.88741378	34.01700607	90.89170857	450+00 to 464+00	426+00 to 439+00	Under Seepage/Pin Boils	Moderate to Heavy	Moderate to heavy seepage with few pin boils located in soybean field. Begins near the toe and extends into the soybean field. Numerous pin boils downstream further from the toe.	16-17
34.01700607	90.89170857	34.01549985	90.89946151	464+00 to 492+00	439+00 to 467+00	Under Seepage	Light to Moderate	Light to moderate seepage 500ft from levee toe and into soy bean field. Possibly some old pin boils, no longer moving any water or material. Downstream the seepage exists near the toe.	18
34.01696521	90.88741378	34.01756168	90.89521981	450+00 to 479+00	426+00 to 455+00	Under Seepage	Light	It is hard to tell in this area if there is a berm. There is no apparent toe, but there is a flat open area that extends past levee toe to a wood line/field. If this is indeed a berm, there is light seepage exiting in the slope. Since the toe is not apparent, not sure how far from toe, but doesn't appear to be significant and more than 100ft from toe of levee.	
34.0151551	90.9003773	34.01311068	90.9044229	495+00 to 508+00	469+50 to 483+50	Under Seepage	Light	Light. Area of water with no apparent seepage entry. Not sure if this is a low spot that most always stays wet or if it is a seepage issue. No seepage for about 150ft past the wet spot, but picks back up on the other side.	19
34.01267357	90.90515059	34.01535685	90.92094801	510+00 to 566+00	484+50 to 530+00	Under Seepage	Light	Light seepage 65 ft from toe of berm. Mostly in the ruts in the field. Dry near the toe of the berm. Slough is located 250ft from the toe at the start and at 34.01195105 90.90905925 the slough gets within 5ft of the berm toe. At 34.01367541 90.91171468 the slough goes away from the toe. There is seepage on the upstream and downstream of the slough.	20-21
34.01535685	90.92094801	--	--	566+00 to 570+00	530+00 to 534+00	Under Seepage/Pin Boils	Heavy	Heavy seepage in corn field approximately 100ft from toe of berm. Cannot get full extents, but appears to extend at least a couple hundred feet. Fairly localized area that only extends about 150 ft parallel to the levee. Numerous small pin boils were noted moving very small amounts of sand. Transitions to light seepage which ends 250ft further downstream.	22-24
34.01538202	90.92956926	34.00907854	90.93723951	591+00 to 631+00	555+00 to 595+00	Under Seepage	Moderate	Begins at toe of seepage berm. Moderate with flow coming out at the toe and draining. Extends about 100 ft parallel to levee and then transitions to light seepage. Heavily wooded area so not sure how far it extends perpendicular to the levee. Just before end of seepage, there is a slough just outside the electric fence 300ft from levee toe has green grass under water so this area is not always wet.	25

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
34.01491179	90.93036725	--	--	600+00 to 603+00	564+00 to 567+00	Under Seepage	Light	Hard to tell if this is a berm as there is no apparent toe, but again has large flat area starting at levee toe extending until electric fence approximately 300ft wide. An area just upstream of here was thicker along the berm crown, so either berm ended or just thinned. However, if this is a berm, there is seepage exiting on the crown for approximately 300ft parallel to levee.	26-27
34.0029597	90.9436325	33.99793411	90.94608602	663+00 to 686+00	627+50 to 650+00	Under Seepage	Light to Moderate	Standing water from levee toe to what appears to be a pre-existing pond. Water appears to be out of the banks of the pond, possibly from seepage.	28-30
33.9917666	90.94749812	33.99086346	90.94756096	708+00 to 712+00	672+50 to 676+50	Under Seepage	Light	Light seepage gathering in ditch starting at the toe of the seepage berm.	
33.98398877	90.94856822	33.98207131	90.94930261	737+00 to 745+00	701+50 to 709+50	Under Seepage	Light	Light seepage gathering in ditch 400ft from the levee toe. Extends out up to 1000ft into a soybean field.	31
				761+00	726+00	Current	Moderate	Moderate Current just out from the toe of the levee.	
33.93040839	90.99080277	33.93012491	90.99133327	1055+00 to 1060+00	1020+00 to 1025+00	Under Seepage	Light	Starts at toe and extends 200ft out.	32-33
33.92998222	90.99365736	33.92752642	90.99756913	1064+00 to 1085+00	1029+00 to 1050+00	Under Seepage	Light	Light seepage on road near toe of berm and in corn field fed by drainage ditch with culverts.	34
33.92171194	91.00241327	--	--	1112+00 to 1115+00	1077+00 to 1080+00	Under Seepage	Light	Light seepage extending into bean field. Mostly just standing water that could be from the flowing well. Only extends couple hundred feet.	35
33.92075934	91.00278704	--	--	1115+00	1080+00			Farmer's well flowing 30-40gpm due to high river stages located approximately 350 ft from the levee.	36
33.89880675	91.02105371	--	--	1212+00	1177+00			Low spot 80ft from toe extends 100ft in either direction parallel to levee did not appear to be seepage.	37
33.89834111	91.02241928	--	--	1217+00	1182+00			Wet spot 100ft downstream. Did not appear to be seepage because the water was receding.	38
33.88987274	91.03198145	33.88939459	91.03265238	1260+00 to 1264+00	1225+00 to 1229+00	Under Seepage	Light	Hog damage with light seepage. Starts near toe and extends 40ft perpendicular to levee.	39-40
33.847438	91.029646	33.84327107	91.03127442	1435+00 to 1450+00	1400+00 to 1415+00			Some water in concrete drainage ditch no seepage in area around the outside of the drainage ditch. As you get further south, the ditch becomes overfull and there is a small amount of water outside the limits of the ditch so there may be some small amount of seepage here. At the ending coordinates, either the ditch ends, or it is just further away from levee in an overgrown area where it cannot be seen anymore.	41
33.84024589	91.03405299	--	--	1465+00	1430+00	Current	Heavy	Heavy current near water's edge.	
33.83901745	91.03068643	33.83595525	91.02794067	1475+00 to 1491+00	1440+00 to 1456+00	Under Seepage	Light	Berm gets smaller or ends and water is located at toe of the berm. The seepage is light and not moving.	42

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STATION 1500+00 TO 3000+00

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEEVE SECTOR: Rosedale to Lake Bolivar

DATE: May 18, 2011

TEAM MEMBERS: James Sims, Dustin Herr, Ryan Reeves, Jim Hearn

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.81886831	91.00144065	33.81886831	91.00144065	1594+00	1559+00	Under Seepage	Light	Light under seepage approximately 75 to 100 feet from the toe of the levee. No pin boils were observed. Seepage area is approximately 50 feet wide and 75 feet long. Surrounding area is saturated.	1
33.81764188	90.99924689	33.81338905	90.99537994	1618+00	1565+00 to 1581+00	Under Seepage	Light	Widespread light under seepage starting at the toe of the seepage berm and extending approximately 250 to 300 feet into the woods (photo 2). Light seepage and standing water was observed within a ring levee off the toe of the berm.	2-3
33.81338905	90.99537994	33.81228052	90.99295616	1633+00	1581+00 to 1599+00	Under Seepage	Light	Light seepage and standing water within an old ring levee approximately 100 feet from the toe of the berm. Area is approximately 100 feet wide and 500 feet long.	4-5
33.80178504	90.98387623	33.79962	90.98482	1682+00 to 1690+00	1648+00 to 1655+00	Under Seepage	Light	Light seepage between the toe of the berm and a small toe levee near the woods approximately 50 feet wide and 500 feet long. Seepage also identified in the woods behind the toe levee which extends approximately 200 feet through the woods and into an adjacent corn field.	6-8
33.80178504	90.98387623	33.79962	90.98482	1682+00 to 1690+00	1648+00 to 1655+00	Under Seepage	Light	Light seepage between the toe of the berm and a small toe levee near the woods approximately 75 feet wide and 500 - 600 feet long. Seepage also identified in the woods behind the toe levee which extends approximately 200 feet through the woods and into an adjacent corn field.	9
33.79824034	90.98367397	33.79548	90.98508	1693+00 to 1705+00	1659+00 to 1670+00	Under Seepage	Light	Light seepage between the toe of the berm and a small toe levee near the woods approximately 75 feet wide and 300 feet long. (Site is between Levee Sta. 1659 and 1670).	10
33.75839541	91.02122709	33.75839541	91.02122709	1905+00	1870+00	Under Seepage	Very Light	Very light seepage approximately 30 to 40 feet from the toe of the seepage berm. Damp area with some standing water approximately 50 feet wide and 75 feet long.	11
33.75672498	91.02373737	33.75672498	91.02373737	1918+00	1882+00	Under Seepage	Very Light	Very light seepage in edge of corn field approximately 75 yds. from levee toe. Area is approximately 20 feet wide and 50 feet in length. Seepage berm cannot be identified.	12
33.75288298	91.02396933	33.74701487	91.02315479	1934+00 to 1955+00	1900+00 to 1920+00	Under Seepage	Light	Light seepage from the toe of the berm extending out 150 feet between Levee Sta. 1900 and 1920. Seepage extends though the field and into the woods and inot an old slough starting near Levee Sta. 1910.	13-15
33.74517483	91.02399651	33.74517483	91.02399651	1962+00	1935+00	Under Seepage	Light	Widespread light seepage in the woods approximately 30 feet from the toe of the berm, possibly into an old slough or lake.	
33.74298177	91.02399655	33.72534	91.02121	1969+00 to 2035+00	1940+00 to 2000+00	Under Seepage	Light	Light seepage along a ditch approximately 50 feet from the toe of the berm.	16-17
33.72328212	91.02148339	33.72328212	91.02148339	2043+00	2008+00	Under Seepage	Light	Light seepage in along ditch draining into a small pond or crevasse approximately 150 yards from levee toe near Levee Sta. 2008.	18

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.69927545	91.0286645	33.69927545	91.0286645	2142+00	2110+00	Under Seepage	Light	Light seepage from the toe of the berm extending out in a corn field approximately 300 feet near Levee Sta. 2110. Seepage area is 300 to 400 feet in length.	19-21
33.69574044	91.02625476	33.69574044	91.02625476	2158+00	2123+00	Under Seepage	Light	Possible light seepage or wet area identified in the woods approximately 500 feet from the toe of the levee at Levee Sta. 2123. Surrounding area is dry.	22
33.69351302	91.02504064	33.69253	91.0246	2166+00 to 2168+00	2131+00 to 2134+00	Under Seepage	Light	Light seepage in the woods approximately 400 feet from the levee toe.	23
33.68879273	91.02409858	33.68879273	91.02409858	2182+00	2148+00	Under Seepage	Light	Light seepage in a low spot inside a ring levee off the toe of the berm near Levee Sta. 2148 approximately 600 feet from the toe of the levee.	24
33.68673	91.02417	33.68675929	91.02417334	2189+00 to 2191+00	2152+00 to 2158+00	Under Seepage	Light	Light seepage in a low spot inside a ring levee off the toe of the seepage berm approximately 500 feet from the levee toe. Extends from Levee Sta. 2152 to near Levee Sta. 2158.	25-26
33.67567552	91.0258355	33.67567552	91.0258355	2229+00	2194+00	Under Seepage	Light	Light seepage approximately 300 feet from levee toe at Levee Sta. 2194. Extends out approximately 100 feet and widens to 300 feet near near Ingersol Road.	27-28
33.67325	91.02718	33.67325	91.02718	2238+00	2203+00	Sand Boil	Moderate	Medium seepage/pin boils in a pasture and along Ingersol Road near Levee Sta. 2203. Approximately 200 feet from the toe of the levee.	29-30
33.67325	91.02718	33.6665	91.03417	2238+00 to 2277+00	2203+00 to 2240+00	Through Seepage	Light	Light seepage on top of the seepage berm approximately 50 to 100 feet from the woods between Levee Sta. 2203 and 2240. Seepage is approximately 50 to 75 feet wide. Cannot distinguish berm at Sta. 2222; however, seepage can be seen in ditch in the woods.	31
33.66667408	91.03375951	33.66667408	91.03375951	2267+00	2231+00	Sand Boil	Moderate	Sand boil under 1.5 to 2.0 feet of water in wooded area approximately 350 to 400 feet from the toe of the levee near Sta. 2231. Boil has made approximately 1-2 cubic yards of fine sand and has a 12- 18 inch throat. Numerous (10-15) pin boils in the same area. Seepage water was also observed on top of the seepage berm approximately 200 feet from the berm toe.	
33.66493961	9103856805	33.66296	91.04516	2285+00 to 2304+00	2250+00 to 2270+00	Under Seepage	Light	Light seepage on top of the seepage berm near Sta. 2250. Area is 50 to 75 feet long and 75 feet wide and approximately 300 feet from the levee toe. Seepage extends off the berm toe and into the woods between Sta. 2250 and 2270.	32-33
33.66228704	91.05173309	33.66228704	91.05173309	2325+00	2290+00	Under Seepage	Light	Light seepage in wooded area just off the toe of the berm at Sta. 2290. Standing water is clear.	34
33.66183394	91.0527781	33.66184	91.05306	2328+00 to 2330+00	2293+00 to 2295+00	Under Seepage	Light to Moderate	Light to moderate seepage along access road and in surrounding area between Sta. 2293 and 2295 (Little Man's Landing Entrance). Seepage area is approximately 500 feet from the levee toe. Two to five small pin boils observed near abandoned house. Seepage water is clear.	35-39
33.661561	91.052689	33.661561	91.052689	2330+00	2295+00	Sand Boil	Moderate	Small sand boil located in driveway in front of a house on Little Man's Landing Road at Levee Sta. 2295. Sand boil has a 4-5 inch troat and is not transporting material.	
33.65844141	91.06250651	33.65844141	91.06250651	2363+00	2330+00	Under Seepage	Light	Light seepage in a field approximately 400 feet from levee toe near Sta. 500 feet long and 150 to 200 feet wide.	40

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.65627142	91.07000784	33.6530074	91.07840416	2388+00 to 2417+00	2355+00 to 2382+00	Under Seepage	Light	Light seepage in corn field between Levee Sta. 2355 and 2382 on south side of Bolivar Road. Seepage seepage extends out in field 200 to 400+ feet. Seepage confined to ditch near Sta. 2370.	41-44
33.65214	91.08445	33.65214	91.08445	2438+00	2409+00	Through Seepage	Light	Light through seepage on top of the seepage berm near Levee Sta. 2409. Seepage area is approximately 30 yards long and 30 yards wide and is located approximately 20 yards from the seepage berm toe.	45
33.65252397	91.0886489	33.65339	91.09421	2444+00 to 2461+00	2410+00 to 2428+00	Through Seepage	Moderate	Numerous pin boils (20 to 30) and moderate seepage in corn field near levee Sta. 2410. Very little material transported by pin boils extending 50 to 75 yards into corn field. Light seepage extends out into the corn field between Levee Sta. 2410 and 2428.	46-48
33.66258614	91.12074863	33.66258614	91.12074863	2554+00 to 2560+00	2520+00 to 2530+00	Under Seepage	Light	Light seepage in ditch and in field approximately 300 feet from the toe of the levee. Area extends from 100 to 500 feet out from the toe of the levee. Possible source of some of this seepage may be a flowing irrigation well observed near Levee Sta. 2530.	49-53
33.66257434	91.13414106	33.66600	91.14644	2585+00 to 2634+00	2551+00 to 2600+00	Under Seepage	Light	Light seepage observed approximately 200 feet from the toe of the levee extending out for a distance of 1000 feet + near Levee Sta. 2551. Seepage berm starts near Levee Sta. 2551+40. Light seepage 20 feet off the toe of the seepage berm extending down stream for approximately 2000 feet. Moderate seepage with several sand boils in a corn field located near Levee Sta. 2600.	54-60
33.6687078	91.15117997	33.66412	91.15781	2650+00 to 2690+00	2618+00 to 2660+00	Under Seepage	Light	Light seepage in a low spot 20-30 feet from the toe of the seepage berm near Levee Sta. 2618. Ring levee holding water at toe of the berm begins near Sta. 2620 and ends near Sta. 2650. Clear, standing, water.	61-65
33.66173826	91.15997205	33.66173826	91.15997205	2695+00	2661+00	Under Seepage	Very Light	Very light seepage in low area approximately 150 yards from the toe of the levee. Seepage berm existance cannot be determined.	66
33.66072878	91.16072878	33.66072878	91.16072878	2700+00	2668+00	Under Seepage	Very Light	Very light seepage along fence approximately 20 feet from the toe of the seepage berm. Seepage is approximately 150 feet yards wide and 100 feet long near Levee Sta. 2668.	67
33.65864364	91.16244547	33.65864364	91.16244547	2708+00	2675+00	Under Seepage	Very Light	Very light seepage in a low spot and ditch approximately 20 feet from the toe of the seepage berm near Levee Sta. 2675.	68-70
33.65436177	91.16517513	33.65137	91.15979	2726+00 to 2753+00	2690+00 to 2720+00	Under Seepage	Light	Light seepage along the toe of the seepage berm that extends out approximately 150 feet between Levee Sta. 2680 and 2720.	71-73
33.65093776	91.15853697	33.65093776	91.15853697	2758+00	2722+00	Under Seepage	Light	Light seepage in low spot approximately 150 feet from the toe of the levee near Sta. 2722. No seepage berm identified. Seepage water is clear.	74-75
33.64847838	91.15403412	33.64783	91.15335	2773+00 to 2775+00	2740+00 to 2743+00	Under Seepage	Very Light	Light seepage approximately 200 feet from the levee toe near Levee Sta. 2740 extending out into field. Seepage extends approximately 250 to 500 feet out. Light wet spots in field approximately 100 feet from the levee toe between Levee Sta. 2741 and 2742. Another larger spot was observed near Sta. 2743. Spots are 150 to 200 feet wide and approximately 300 feet long.	76-77
33.64302513	91.14801013	33.64278	91.14376	2802+00 to 2816+00	2765+00 to 2785+00	Under Seepage	Light	Light clear seepage inside several ring levees at the berm toe between Levee Sta. 2765 and 2785. Light seepage also in the field behind the ring levees approximately 100 feet from the ring levees extending out 300 to 400 feet.	78-81

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.64400224	91.14030568	33.6238	91.12202	2828+00 to 2929+00	2792+00 to 2895+00	Under Seepage	Light	Light seepage in a ditch at the toe of the seepage berm between Levee Sta. 2790 and 2895. Water in the ditch is clear and is flowing down stream.	82-84
33.62187814	91.12089806	33.62057	91.11994	2737+00 to 2944+00	2902+00 to 2908+00	Under Seepage	Light	Light seepage in the woods approximately 30 feet from the toe of the seepage berm between Levee Sta. 2910 and 2920. Seepage extends approximately 150 feet into the woods.	85-86
33.61980862	91.11899542	33.61255	91.12078	2945+00 to 2973+00	2910+00 to 2940+00	Under Seepage	Light	Light seepage and standing water off the toe of the seepage berm and in the woods between Levee Sta. 2910 and 2940.	87-89
33.60616748	91.1226321	33.6034	91.12206	2999+00 to 3008+00	2965+00 to 2975+00	Under Seepage	Light	Small areas of light seepage approximately 300 feet from the toe of the levee between Levee Sta. 2965 and 2975. Seepage is generally clear.	90
33.60806	91.12198	33.60806	91.12198	2992+00	2955+00	Under Seepage	Light	Access road leading to levee ramp (27 Break Road) before chain crossing has light seepage with pumping gravel near Levee Sta. 2955.	91-93

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STATION 3000+00 TO 4500+00

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: Lake Bolivar to Highway 82

DATE: May 16, 2011

TEAM MEMBERS: James Sims, Dustin Herr, Ryan Reeves, Jim Hearn

START		END		STATION NLD	STATION FIELD MARKER	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude						
33.58603026	91.12101992	33.58603026	91.12101992	3072+00	3040+00	Slide	Light	Possible slide or levee damaged by cattle approximately 10 feet up from the toe of the levee near Sta. 3040.	1
33.57750377	91.12755206	33.57750377	91.12755206	3108+00	3075+00	Under Seepage	Light	Light seepage in low area 150 yards from the levee toe near Sta. 3075. Area is approximately 10 yards wide.	2
33.57288961	91.13396492	33.57195	91.13556	3133+00 to 3136+00	3100+00 to 3108+00	Under Seepage	Light	Light seepage in field approximately 150 yards from the toe of the levee between Sta. 3100 and 3108. Area is approximately 100 yards wide and 200 yards long.	3-4
33.56972699	91.13833917	33.56972699	91.13833917	3157+00	3125+00	Under Seepage	Light	Widespread light seepage approximately 100 yards from the toe of the levee extending into the woods and field for approximately 100 to 200 yards. Clear water noted seeping from around a piezometer near the wood line near Sta. 3125.	5
33.56273076	91.14501628	33.56539038	91.14271368	3172+00 to 3192+00	3140+00 to 3160+00	Through Seepage	Light	Widespread seepage on top of the seepage berm from approximately levee sta. 3140 to 3160. Seepage is approximately 100 feet wide and extends up from the toe of the berm.	6
33.56071579	91.14773982	33.56071579	91.14773982	3196+00	3162+00	Under Seepage	Light	Widespread seepage and standing water within an earthen ring levee near levee Sta. 3162. Seepage begins approximately 35 yards from the levee toe and extends approximately 100 yards into wooded area. Ring levee is overtopped on the northeast corner. A sand boil with a 6-inch throat was identified in the ponded area. Boil was stable.	7-10
33.5604	91.14803	33.55987	91.14882	3197+00 to 3201+00	3163+00 to 3170+00	Through Seepage	Light	Light seepage on top of the seepage berm from near levee Sta. 3163 to Sta. 3170.	
33.54508094	91.1511177	33.54508094	91.1511177	3278+00	3245+00	Under Seepage	Light	Light seepage from the berm toe extending out approximately 50 yards near levee Sta. 3245. Seepage extends downstream from approximately 100 yards.	11
33.53888418	91.15161226	33.53888418	91.15161226	3285+00	3251+00	Under Seepage	Light	Light seepage in a low area approximately 150 yards from the toe of the levee near Sta. 3251. Seepage berm cannot be identified.	12
33.5371533	91.15131648	33.52690206	91.14132887	3291+00 to 3348+00	3260+00 to 3312+00	Under Seepage	Light	Light seepage in drainage ditch along the toe of the seepage berm extending from levee sta. 3260 to 3312.	13
33.52151822	91.13672269	33.52151822	91.13672269	3371+00	3339+00	Under Seepage	Light	Light seepage along a cattle path off the seepage berm toe near levee Sta. 3339. Seepage extends upstream approximately 150 yards.	14-17
33.49741	91.11043	33.4969265	91.11014706	3493+00 to 3496+00	3460+00 to 3463+00	Under Seepage	Light	Light seepage approximately 50 yards from the levee toe between levee Sta. 3460 and 3463. Seepage is approximately 50 to 100 feet wide.	18
33.48164	91.10782	33.48083803	91.10758151	3551+00 to 3554+00	3519+00 to 3521+00	Under Seepage	Light	Light seepage approximately 20 yards from the toe of the seepage berm between levee Sta. 3519 and 3521. Seepage is approximately 150 yards wide.	19
33.47434	91.09022	33.47434	91.09022	3618+00	3585+00	Under Seepage	Light	Light seepage approximately 25 yards from the toe of the seepage berm in a wheat field near levee station 3585. Seepage area is approximately 50 yards long and 25 yards wide.	20-21
33.47376433	91.08870023	33.47376433	91.08870023	3622+00	3590+00	Sand Boil	moderate	Small sand boil with 2 to 3 inch throat under water in the edge of an old slough approximately 50 yards from the seepage berm toe near levee Sta. 3590. Sand boil has been flagged and is flowing clear water at a rate of less than 20 gpm.	22
33.46619	91.06873	33.46612896	91.06861329	3688+00	3655+00	Under Seepage	Light	Light seepage along the toe of the seepage berm near levee Sta. 3655. Seepage extends approximately 75 yards upstream and is approximately 20 to 30 feet wide.	23

START		END		STATION NLD	STATION FIELD MARKER	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude						
33.46929403	91.06947247	33.46929403	91.06947247	3670+00 to 3680+00	3640+00 to 3660+00	Sand Boil	Moderate	Multiple sand boils within canal at Black Bayou. Sand boils have been stabilized by the levee board with the installation of an earthen dam and galvanized culvert in the canal. Flow through the culvert was estimated to be 200 to 300 gpm. Sand boils in the canal are approximately 1200 feet from the toe of the levee. (Site is located off North Lake Ferguson Road between Levee Sta. 3640 and 3660).	24-28
33.46317	91.06138	33.46217026	91.05817124	3712+00 to 3725+00	3680+00 to 3691+00	Through Seepage	Light	Light through seepage on top of seepage berm from levee Sta. 3680 to 3691. Seepage is approximately 50 to 100 yards wide on the berm.	29-30
33.45778773	91.05204931	33.4569	91.05114	3744+00 to 3750+00	3710+00 to 3720+00	Sand Boil	Heavy	Winterville Sand Boil Site - A large, high energy sand boil approximately thirty feet from the toe of 200 foot seepage berm near levee Sta. 3720. The boil was estimated to be flowing approximately 300-350 gpm. and was moving significant quantities of silt and fine sand (approximately 100 cubic yards). The boil was bagged by the Levee Board with prison labor and a small earthen levee was constructed by a local contractor. A filter of sand and stone was constructed over the boil throat to filter fines and dissipate energy. Four additional medium sized boils were identified within 250 feet of the berm toe that required either a small sand bag ring or a 30-gallon drum for stabilization. Boils are located between Levee Sta. 3710 and 3720).	31-42
33.45523702	91.04973971	33.45523702	91.04973971	3758+00	3725+00	Sand Boil	Moderate-Heavy	Light seepage and two small sand boils that were ringed with 30-gallon drums by the levee board near levee Sta. 3725. The sand boils were stable and flowing approximately 30-50 gpm of clear water. The boils and seepage area extends from the toe of the seepage berm and is approximately 200 yards wide.	43-45
33.45183974	91.04785526	33.45183974	91.04785526	3770+00	3738+00	Under Seepage/Pin Boils	Moderate	Moderate seepage with five pin boils with 1 to 2 inch throats near levee Sta. 3740. Area is within 25 feet of the toe of the seepage berm.	46-47
33.45177212	91.04406652	33.45177212	91.04406652	3776+00	3741+00	Under Seepage	Light	Light seepage in ditches and in residential area along Highway 1 near Lake Fergusson. Seepage is located near Levee Sta. 3741 and is approximately 800 feet from the toe of the levee.	48-51
33.44615703	91.04725582	33.44615703	91.04725582	3791+00	3759+00	Under Seepage	Light	Light seepage in a field along along the toe of the seepage berm near levee Sta. 3759. Water in the field is approximately 8 inches deep.	52-53
33.44273663	91.0495045	33.44273663	91.0495045	3800+00	3765+00	Sand Boil	Moderate	Sand boil and light to moderate seepage at the intersection of Abbot Road and Barnes Landing near levee Sta. 3765. Sand boil is ringed with a 30-gallon plastic drum and is flowing approximately 30 gpm. Light to moderate seepage was observed along ditch and in residential area. Light through seepage on top of the seepage berm near levee Sta. 3770 extending from the toe of the levee to the toe of the berm and approx. 200 yards upstream.	54-56
33.43817539	91.04912592	33.43039867	91.04962619	3820+00 to 3849+00	3788+00 to 3816+00	Under Seepage/Pin Boils	Light to Moderate	Light to moderate seepage from the toe of the seepage berm extending out approximately 40 to 60 yards between levee Sta. 3788 and 3816. Several small pin boils under 3 to 6 inches of water along stretch that are moving small quantities of silt and very fine sand.	57-59
33.42750527	91.05013354	33.42750527	91.05013354	3852+00 to 3860+00	3820+00 to 3829+00	Under Seepage	Light	Light seepage along the toe of the seepage berm between levee Sta. 3820 and 3829. Seepage is approximately 100 yards long and 20 yards wide and is held in by a ring levee off the toe of the berm.	60
33.39944213	91.0701666	33.39944213	91.0701666	3886+00	3852+00	Sand Boil	Moderate/Heavy	Active sand boil identified on the edge of seepage berm approximately 75 yards from the railroad tracks near levee Sta. 3952. Area is under 6 to 10 inches of seepage water. Sand boil has a 12-inch throat and have formed a cone that is approximately 12-inches high. Boil is flowing approximately 50 gpm and continues to transport moderate quantities of silt/fine sand.	61-62

START		END		STATION NLD	STATION FIELD MARKER	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude						
33.419069	91.058111	33.419069	91.058111	3896+00	3863+00	Under Seepage/Pin Boils	Moderate	Three or four pin boils and moderate seepage at the intersection of Hunt and Court Streets in Greenville. Site is near Levee Sta. 3863.	
33.38902229	91.07378533	33.38089	91.07314	4028+00	3995+00	Under Seepage	Light	Light seepage along power line on both sides of the railroad tracks near levee Sta. 3995. Seepage is approximately 50 feet wide and extends downstream approximately 300-500 yards.	63-64
33.37860781	91.07400535	33.37758257	91.074514	4065+00 to 4072+00	4031+00 to 4040+00	Sand Boil	Heavy	Multiple moderate to high energy sand boils were identified moving large quantities of fine sand in two separate areas on the east side of the railroad tracks approximately 400 feet from the levee toe. There is no seepage berm in this area. Heavy seepage, numerous pin boils and saturated, soft ground was identified in and around the boil areas. One area is on the power line right-of-way and the other is in the woods approximately 30 yards to the southeast. During the initial site visit, there were numerous small boils identified in the wooded area. The throats on these boils ranged from 3 to 6 inches in diameter and several yards (5 to 8 cyds.) of material had been transported over a 1000 1000 square foot area; however, most of these boils were producing clear water. Some of the larger boils were later stabilized with 30-gallon drums drums placed over the throats of the boils. There were approximately approximately three high flowing sand boils identified in a low spot along the power line. These boils were flowing approximately 100-200 gpm each, and were transporting a significant quantity of fine sand and clay/silt balls. Over 15 to 20 yards of material had already been transported from the boils and material was still being moved. Throat diameter of the boils ranged from 12 to 18 inches. Levee board work crews and inmates addressed these boils by building a sand bag containment ring which had to be raised at a later date to increase the head over the boils.	65-73
33.375919	91.074039	33.375919	91.074039	4077+00	4045+00	Under Seepage	Light	Light, clear seepage behind Buckshot Marine near levee Sta. 4045.	
33.374711	91.075681	33.374711	91.075681	4082+00	4049+00	Under Seepage	Moderate	Moderate seepage around an apartment complex near levee Sta. 4049.	
33.372481	91.075511	33.372481	91.075511	4089+00	4055+00	Under Seepage	Light	Light to moderate seepage at Delta Steel Sales Lot near levee Sta. 4055.	
33.37025	91.07851	33.37025	91.07851	4099+00	4066+00	Under Seepage/Pin Boils	Moderate	Moderate seepage/saturated soil on top of seepage berm with 5 to 10, pin boils near levee Sta. 4066. Pin boils have transported small quantities of silt, but currently are producing clear water. Area is approximately 30 yards wide and 50 yards long.	
33.37025	91.07851	33.36764216	91.0807224	4099+00 to 4110+00	4066+00 to 4078+00	Under Seepage	Light	Light seepage around businesses and along Harbor Front Road between levee Sta. 4066 and 4078. Seepage begins approximately 15 yards from the toe of the seepage berm and extends out approximate 50 to 100 yards.	74-79
33.35850925	91.08910007	33.35850925	91.08910007	4151+00	4119+00	Under Seepage	Light	Very light seepage in wooded area approximately 20 yards from the railroad tracks off the toe of the seepage berm near levee Sta. 4119. Seepage drains into an old slough approximately 30 yards from the toe of the seepage berm.	80
33.35610669	91.09436779	33.35610669	91.09436779	4168+00	4135+00	Under Seepage/Pin Boils	Moderate	Moderate seepage with numerous small pin boils near levee Sta. 4135. Area is approx. 75 yards wide and extends downstream approximately 100 yards. Pin boils are flowing clear water.	81-84
33.35333521	91.10247586	33.35333521	91.10247586	4194+00	4161+00	Under Seepage	Light	Four areas of light seepage approximately 20 yards from the railroad tracks in the edge of a pasture near levee Sta. 4161. Each area is approximately 25 feet wide and 50 feet long and is inactive.	85-87
33.334781	91.140339	33.334781	91.140339	4333+00	4300+00	Heavy Current/Scour	Moderate	High current observed along riverside berm near levee Sta. 4300.	

START		END		STATION NLD	STATION FIELD MARKER	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude						
33.33068647	91.1412728	33.33068647	91.1412728	4348+00	4315+00	Under Seepage	Light	Light seepage from under the seepage berm near levee Sta. 4315. Area is approximately 25 feet long and 50 feet wide.	88
33.319239	91.137919	33.319239	91.137919	4391+00	4359+00	Sand Boil	Moderate	Multiple sand boils with 2 to 4-inch throats located in a slough area under approximately 3 to 4-feet of water near levee Sta. 4359. Flow from boils is light and moving small quantities of silt/fine sand.

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STATION 4500+00 TO 5930+00

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: Highway 82 to Lake Washington

DATE: May 18-20, 2011

TEAM MEMBERS: Heather Sibley, Lance Gullett and Justin Jones

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.29276142	91.1276563	33.28505496	91.11360415	4508+00 to 4559+00	4475+00 to 4526+00	Under Seepage	Light	Begins at toe and extends 200ft into corn field. Foamy water, but no pin boils were seen and the water was standing still.	1-4
33.28505496	91.11360415	33.28272458	91.11273423	4559+00 to 4568+00	4526+00 to 4535+00	Under Seepage	Light	No longer near the toe of the berm. From the crown of the levee it appears to begin approximately 150ft from the toe of the berm in corn field.	
33.28358996	91.11158287	33.28017218	91.09954723	4568+00 to 4621+00	4535+00 to 4588+00	Under Seepage	Light to Moderate	Light to moderate seepage in corn field. Starts near the toe. Extends a couple hundred feet into corn field.	5-9
33.28202177	91.11044344	33.28125563	91.1101363	4574+00 to 4576+00	4541+00 to 4543+00	Under Seepage	Light	Light seepage exiting on berm crown. Extends up 50ft from the toe of the berm.	10-11
				4576+00 to 4608+00	4543+00 to 4575+50	Under Seepage	Light	Note: if berm there is seepage coming through up to 30ft away from the toe of the levee.	12
33.28627115	91.09395386	33.29472924	91.07019393	4650+00 to 4727+00	4617+50 to 4694+50	Under Seepage	Light to Moderate	Full drainage ditch seems to be above normal with clear water. Drains to a pond (at 33.28892746 91.08988867.) that is also above normal. No seepage along the banks of the pond, off the berm toe, or 500ft off the levee. At ending coordinates, the ditch turns away from the levee.	13-14
33.29470325	91.06877801	--	--	4734+00 to 4734+30	4701+50 to 4701+80	Under Seepage	Light	Light seepage in small ditch into soybean field. 100ft from levee toe. The ditch is only 30ft long.	15
33.29409653	91.06231384	33.29401037	91.06163276	4751+00 to 4756+00	4718+50 to 4723+50	Under Seepage	Light	Near toe in what appears to be a small drainage ditch. 60ft from the toe it extends out about 45ft.	16
33.29107669	91.0503393	33.28948491	91.04665348	4790+00 to 4801+00	4757+50 to 4768+50	Under Seepage	Light	Light seepage in low area could be more due to drainage than seepage. The corn field behind is dry. The low area is 85ft from toe and extends 15 to 20 ft. At 33.29011014 91.04770259 the ditch goes away from the levee and through corn field. For approximately 100ft along a high spot, it is not wet, but at 33.29006664 91.04757029 low area is back in same area and wet.	17-19
33.28937148	91.04665043	33.28796512	91.04533043	4801+00 to 4808+00	4768+50 to 4775+50			Ponding in low area. Not flowing. Located approximately 80ft from the toe and extends out 30ft.	
33.27911873	91.03890873	33.27704257	91.03826811	4843+00 to 4853+00	4811+00 to 4821+00	Under Seepage	Light to Moderate	Begins a little past the berm toe and extends into bean field. No boils were noted, but there is a lot of standing water in field that is slowly flowing through the bean rows.	20-22
33.27159041	91.03724613	33.27125879	91.0372749	4873+00 to 4876+50	4840+50 to 4844+00	Under Seepage	Light to Moderate	Starts at the levee toe and runs approximately 100ft away from the toe. Has very low flow in the cow trail. At the start water is seeping out 6ft up the levee slope but only for very small reach.	23
33.27034334	91.03711502	--	--	4878+00 to 4878+30	4845+50 to 4845+80	Under Seepage	Light	Light seepage starting at the levee toe. Is only 30ft long by 30ft wide.	24
33.25367821	91.03988996	33.2505236	91.04084686	4939+00 to 4950+00	4906+00 to 4917+00	Under Seepage	Light to Moderate	Starts light coming out about 6ft up slope for hundred feet or so. Goes to moderate seepage 150ft downstream.	25-27
33.2505236	91.04084686	33.24646064	91.04258922	4950+00 to 4965+01	4917+00 to 4932+51	Under Seepage/Pin Boils	Heavy	Heavy seepage exiting several feet up the levee slope and beyond as well as numerous small to medium sized boils at and beyond the toe of the levee were identified. There is no berm in this area. A dike was constructed across a ditch to impound water over a number of the boils. Other boils were stabilized by sinking 30-gallon drums over the throat of the boils. Each boil moved silt and fine sand; however none of the boils moved a significant quantity of material.	28-38

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.25295989	91.0402473	33.24646064	91.04258922	4942+00 to 4965+00	4909+00 to 4932+50	Through Seepage	Light	Seepage exiting through slope. At the maximum point it is only about 5ft up the slope from the toe.	
33.24646064	91.04258922	33.24331921	91.04375258	4965+00 to 4978+00	4935+50 to 4944+50	Under Seepage	Light	Light Seepage with ponding in ditch. Exiting near the toe of the levee. Full limits of seepage could not be determined.	39
33.24236184	91.04432022	33.24178033	91.0447349	4982+00 to 4987+00	4949+50 to 4954+50			Water in ditch approx. 25 ft from toe. There is a pipe running into ditch from trailers and the water appears to be coming from there. The ditch still exists <u>past the end coordinates, but it is dry.</u>	40
33.22313143	91.06964331	33.21884907	91.07615013	5085+00 to 5112+00	5053+00 to 5089+50	Under Seepage	Light	Starts 70ft from toe and goes into bean field. After 500ft, the seepage is exiting right at the toe.	41-42
33.21884907	91.07615013	33.21516422	91.07583872	5112+00 to 5126+00	5089+50 to 5095+50	Under Seepage	Moderate	Seepage with ponding 0 to 50ft from the toe with some seepage exiting 3 to 4 ft up the slope. Still have seepage in the bean field. There is a levee behind the ponded area, but it does not appear to always be full of water because of green grass in water. No pin boils were noted, but the water was foamy. At the end coordinates, the ponding ends.	45-47
33.21516422	91.0758387	33.21318728	91.07579788	5126+00 to 5135+00	5095+50 to 5103+50	Under Seepage	Light	Exiting at the toe of the levee. Cannot determine full limits of seepage, but at least a couple hundred feet out.	
33.21122432	91.07520112	33.20883504	91.07494531	5141+00 to 5150+00	5108+00 to 5117+00	Under Seepage	Light	Light seepage flowing into low areas. Starts near toe.	48-49
33.20761831	91.07476041	--	--	5153+00	5120+00	Under Seepage	Light	Seepage 20ft by 20ft area just off the toe of the berm.	
33.20663588	91.07462281	33.20560575	91.07473286	5158+00 to 5161+00	5125+50 to 5129+50	Under Seepage	Light	Light seepage in field extending out 700ft from the levee toe.	50-52
33.20650575	91.07473286	33.20464578	91.07458311	5161+00 to 5166+00	5129+50 to 5133+50	Under Seepage	Light	Seepage begins to pond 100ft from the levee toe. Extends out at least 700ft into field.	
33.20464578	91.07458311	33.20296065	91.07458299	5166+00 to 5173+00	5133+50 to 5140+50	Under Seepage	Light	Seepage begins in field between the levee and the ponding area. Starts 30ft from the toe and extends 700ft into field.	
33.20429691	91.07441071	33.1994886	91.07424225	5167+00 to 5184+00	5134+50 to 5151+50	Under Seepage	Light	Seepage begins coming out a few feet above the berm toe. The seepage is not continuous, there are gaps 100ft wide or so that have no seepage and then spots with seepage.	
33.20296065	91.07458299	33.1994886	91.07424225	5173+00 to 5184+00	5140+50 to 5151+50	Under Seepage	Light	Seepage recedes back into field 70ft from toe extending back 700ft except for the areas where there is light seepage exiting through slope.	53
33.18233184	91.06902614	33.18139146	91.06841432	5249+00 to 5252+00	5216+00 to 5219+00			Small ditch parallel to levee 300ft from the levee toe. There is not an apparent berm toe in this area.	54
33.18139146	91.06841432	33.17143232	91.06715748	5252+00 to 5289+00	5219+00 to 5256+00	Under Seepage	Light	Ponding area. Past ponding area the seepage spreads out away from the levee toe. Starts 45ft or more from levee toe. Due to ponding cannot get extents of seepage perpendicular to levee.	
33.17571801	91.06698705	33.17143232	91.06715748	5273+00 to 5289+00	5240+00 to 5256+00	Under Seepage	Light	There is not an apparent berm toe, but there is an open space similar to berm at the levee toe. If this is a berm, there is seepage exiting along its entire crown back to the levee toe. Near the end of the reach, there is very light seepage exiting 1 to 2 ft up the slope of the levee. At the end location, there is a definite rise and start of a larger seepage berm.	
33.17143232	91.06715748	--	--	5289+00	5256+00			Pond area starts which has less water than normal so not a seepage concern.	55-56

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.16806147	91.06444262	33.14979227	91.06871217	5305+00 to 5370+00	5272+50 to 5337+50	Under Seepage	Light to Moderate	Just downstream of pond area, there is a swampy wet area that may have seepage. Starts just off the toe of the berm and extends into wheat field approximately 95ft wide. Looks like it is always wet, but water is higher than usual. Transitions into a small ditch with flowing water then back to larger swampy area. No seepage outside of the low spot with standing water, but there is green grass underwater. Walked back into field approximately 500 ft and there was flowing water coming out of low area.	57-58
33.14979227	91.06871217	33.1341943	91.07510589	5370+00 to 5440+00	5337+50 to 5408+00	Under Seepage	Light	In this area, it does not appear there is normally water. Water is flowing out of culvert under a ramp off of the levee. Seep water is coming out of the ramp road. Water is about 200ft from the levee toe, there is no apparent berm.	59-62
33.14388	91.0719	--	--	5400+00	5368+00	Sand Boil		On July 7, 2011, landowner called and reported a "hole" out in his field. Levee board took photos and measured hole to be 2 ft deep with 4 ft diameter. There was evidence of very fine sand material in the buckshot bean field. The boil was located 780 ft from the centerline of the levee at Station 5368.	63-64
33.12156836	91.08633698	33.1196691	91.08823962	5493+00 to 5502+00	5461+00 to 5470+00	Under Seepage	Light	Starts approximately 85ft from the toe downstream the seepage is at the toe.	65-66
33.11757493	91.09103912	33.11564025	91.09427613	5513+00 to 5527+00	5481+00 to 5495+00	Under Seepage	Light	Starts with light seepage at the toe of the berm. Transitions to a full drainage ditch, but there is no seepage in the field behind ditch. The seepage berm ends just past the end of this reach.	
33.11750733	91.09135419	33.11637338	91.09342461	5514+00 to 5523+00	5482+00 to 5491+00	Under Seepage	Light	Extends from the toe of the berm to within 25ft of the levee toe. On average extends 100ft from the levee toe. Seep water is in puddles all along the berm crown.	67-68
33.1149811	91.09654962	33.11048589	91.10378433	5530+00 to 5559+00	5499+00 to 5527+00	Under Seepage	Light to Moderate	Light seepage starts at toe and extends approximately 150ft into ditch. Couple hundred feet south a wheat field is behind ditch with moderate seepage which extends 500ft from the berm toe. When walking in the wheat field bubbles come up, but there are no flowing pin boils.	69
33.11454654	91.09719702	--	--	5536+00 to 5537+00	5505+00 to 5506+00	Under Seepage	Light	Seepage exiting berm crown 25ft from end of berm. This berm is thinner than one near it, but still has an apparent toe cleared so is believed to be a seepage berm. Very localized area that only extends 100ft parallel to the levee.	70-71
33.10983286	91.10501551	33.10588712	91.1132699	5565+00 to 5593+00	5533+00 to 5561+00	Under Seepage	Light to Moderate	Seepage beginning at berm toe and extends at least 200ft into bean field. Water in drainage ditch is running from south to north. Downstream, the bean field gets drier. At 33.10767695 91.109823 seepage begins 300ft from the toe in bean field. At 33.10727926 91.11059336 seepage transitions to 50ft from the toe and extends out at least 300ft into bean field. at 33.10663556 91.11142917 seepage starts at the berm toe and extends over 300ft into bean field.	72-74
33.10866818	91.10778806	33.1082871	91.10862132	5574+00 to 5578+00	5542+00 to 5546+00	Under Seepage	Light	Seepage begins upstream 20ft from the toe of the berm and downstream transitions to 100ft from the toe of the berm.	
33.10475549	91.11450724	33.10520954	91.12214459	5596+00 to 5618+00	5564+00 to 5586+00			Ponding. Low swampy area. No evidence that water is seepage in immediate area. Appears to be fed by a drainage ditch that is fed by a corn field that is being irrigated.	75-76
33.10535625	91.1270479	33.1054538	91.12784906	5635+00 to 5637+00	5603+00 to 5605+00	Under Seepage	Light to Moderate	Starts at the toe and extends out 400ft.	
33.1054538	91.12784906	33.10507781	91.13136746	5637+00 to 5651+00	5605+00 to 5619+00	Under Seepage/Pin Boils	Heavy	Seepage transitions to heavy seepage with numerous pin boils. Begins at toe and extends into corn field.	77

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.10548515	91.12947266	33.10514556	91.13138678	5640+00 to 5651+00	5608+00 to 5619+00	Sand Boil		Multiple large sand boils in this area. There are multiple boils in drainage ditch just off toe of berm. Also, there are multiple boils on both sides of the drainage ditch. 3 of the boils occur right at the toe of the berm. Most of these were bagged and were no longer moving material. Throat sizes range from a couple inches to greater than 6 inches. Sandbag ring constructed around a 30' by 10' sinkhole that formed in field. Plywood wall constructed around boil also. Seepage is also exiting in the berm crown.	78-87
33.10507781	91.13136746	33.10431909	91.1322489	5651+00 to 5656+00	5619+00 to 5624+00	Under Seepage	Light	Seepage transitions back to light seepage at the toe and into corn field.	88
33.10292555	91.13399277	33.09600423	91.14040961	5662+00 to 5699+00	5630+00 to 5667+00	Under Seepage/Pin Boils	Moderate to Heavy	Starts at the toe and extends out over 500ft. Moderate to heavy seepage with a few pin boils. The number of pin boils increase downstream.	89-90
33.09410192	91.14123254	33.0884052	91.13749626	5705+00 to 5743+00	5673+00 to 5710+00	Under Seepage	Light	Seepwater is in drainage ditch and is exiting the toe.	91
33.09276903	91.14174425	--	--	5711+00	5688+00	Sand Boil		Sand boil which has been bagged. Is running clear water. Approximate Sta 5688. Other small boils developed after sand bags were placed for first boil. Throat sizes were less than 3 inches.	92-94
33.0884052	91.13749626	33.07116851	91.12504744	5743+00 to 5817+00	5710+00 to 5794+50	Under Seepage	Light	Light seepage continues in corn field. However, the corn is not discolored and the ground is only damp, no standing water. At 33.08078375 91.13263148 drop off of higher ground and seepage starts 60ft from the toe. In the areas where there was a berm, seepage was beginning at the berm toe.	95-97
33.06960906	91.12272822	33.05878805	91.11495691	5827+00 to 5870+00	5804+50 to 5848+00	Under Seepage	Light	Light seepage at toe. The corn field behind is wet, but could be more to do with irrigation because none of the corn is yellow.	98
33.05878805	91.11495691	33.0535489	91.11527146	5870+00 to 5889+00	5848+00 to 5867+00	Under Seepage	Heavy	Heavy seepage with pin boils throughout area extends out 1000ft. Pin boils start approximately 25ft from the toe of the berm.	99-106
33.05904653	91.11487726	33.05878805	91.11495691	5870+00 to 5871+00	5848+00 to 5849+00	Sand Boil		Multiple boils in ditch between toe of berm and logging road. Ditch and boils are not seen until get across fence from toe about 35ft from berm toe. Berm is couple hundred ft wide as well. The logging road pumps when walked on. Most of the boils are similar in size with throats of approximately 3 inches and have only moved small amounts of sand. Less than a yard each.	
33.05527	91.11521	--	--	5878+00 to 5882+00	5856+00 to 5860+00	Sand Boil		Multiple boils on the side of the ridge. Largest has a 2in throat. 100ft from the toe of the berm.	
33.0535489	91.11527146	33.04891662	91.11671124	5889+00 to 5907+00	5867+00 to 5886+50	Under Seepage	Moderate	Seepage changed to moderate. Begins near toe and extends out 1000 ft.	107
33.05253284	91.11561688	--	--	5893+00	5871+00	Sand Boil		Sand boil under an uprooted tree. Small with only a little sand moved.	108
33.04891662	91.11671124	33.04857062	91.11701405	5907+00 to 5909+00	5886+50 to 5888+50	Under Seepage	Light to Moderate	Seepage changes to light, but there is some flow into lake. There is no seepage past lake. The lake appears to be a little higher than usual and the water comes to the toe of the berm.	109
33.04328102	91.11854965	--	--	5927+00	5950+00	Under Seepage	Light	Very light seepage in a mostly dry field. There are some damp patches that are no larger than 40ft by 40ft. Ended at Station 5910+00.	110

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STATION 5930+00 TO 7500+00

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: Lake Washington to Tallula

DATE: May 20, 2011

TEAM MEMBERS: James Sims, Ryan Reeves, Dustin Herr, Jim Hearn

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.03621261	91.1202294	33.03621261	91.1202294	5953+00 to 5967+00	5930+00 to 5945+00	Under Seepage	Light	Light seepage from the edge of the seepage berm extending out into corn field approximately 500 feet between levee Sta. 5930 and 5945. Seepage ends in a drainage ditch through the corn field near Sta. 5945.	1-4
33.0229638	91.12422764	33.0229638	91.12422764	6004+00	5981+00	Under Seepage	Light	Light seepage in the woods approximately 400 feet from the toe of the seepage berm near levee Sta. 5981. Seepage is approximately 75 feet wide and extends downstream approximately 500 feet. Seepage water is generally clear and drains into old slough.	5-6
33.02128196	91.12472206	33.02128196	91.12472206	6009+00 to 6020+00	5989+00 to 6000+00	Under Seepage	Light	Light seepage in a small patch of trees approximately 20 feet from the seepage berm toe extending along ditch and through field between levee Sta. 5989 and 6000. Extends out into field at least 600+ feet near levee Sta. 5991.	7-9
33.018994	91.12765695	33.018994	91.12765695	6019+00	5999+00	Under Seepage/Pin Boils	Moderate	Moderate seepage with 5 or 6 small, active, pin boils approximately 15 feet from the toe of the seepage berm near levee Sta. 5999. Most of the pin boils have 1-inch throats and were flowing generally clear water.	10-12
								Widespread light seepage along the toe of the seepage berm extending out into field approximately 600 feet between levee Sta. 6005 and 6025.	13-15
33.01767218	91.12961412	33.01433551	91.1355288	6027+00 to 6048+00	6005+00 to 6025+00	Under Seepage/Pin Boils	Light	Seepage water in the field is clear and a few very small pin boils were identified in low spots under 3 to 6-inches of water.	
33.01433551	91.1355288	33.01433551	91.1355288	6048+00	6025+00	Sand Boil	Moderate to Heavy	Five or six small, active sand boils with 4 to 5-inch throats were identified along the toe of the seepage berm near levee Sta. 6020. Boils were flowing approximately 20 to 30 gpm and transporting fine sand producing cones 2 to 3-feet in diameter. Area being monitoring by levee board. Some of the boils are ringed with plastic drums.	16-17
33.01215884	91.13744505	33.01292241	91.13667771	6051+00 to 6057+00	6030+00 to 6035+00	Sand Boil	Moderate to Heavy	Three to five sand boils and large area of widespread moderate seepage along the toe of the seepage berm near levee Sta. 6030. Seepage extends approximately 1/4-mile out into field. Two sand boils were ringed with 30-gallon plastic drums. Two or three boils were identified near the drums. Boils were flowing approximately 10 to 20 gpm and transporting fine sand and clay/silt balls. Numerous small pin boils and moderate seepage in bean field near levee Sta. 6035. Most boils are transporting a small quantity of material and are under 2 or 3-inches of water.	18-22
33.01002171	91.14228265	32.00787	91.14659	6074+00 to 6050+00	6051+00 to 6070+00	Sand Boil	Heavy	Numerous, medium to large sand boils (25+) approximately 10 to 30 feet from the toe of the seepage berm between levee Sta. 6050 and 6070. Levee board was on-site placing drums, galvanized culverts, and sand bags over and around boils. Entire area is under 1 to 3 feet of seepage water from the boils. Several boils are high energy producing 50 to 100 gpm. (Clarence Hall Road Site)	23-30

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
33.00545728	91.14794463	33.00545728	91.14794463	6102+00	6080+00	Under Seepage	Light	Light seepage approximately 200 to 300 feet from the toe of the seepage berm extending out into field. Seepage is generally clear and no pin boils were identified.	31-32
33.00895	91.147	33.0042	91.14781	6088+00 to 6106+00	6070+00 to 6085+00	Heavy Current/Scour	Moderate	Strong, fast current along the riverside berm of the the levee between levee Sta. 6070 and 6085.	
32.99744364	91.14408161	32.99718	91.11069	6133+00 to 6272+00	6110+00 to 6250+00	Under Seepage	Light	Widespread light seepage in a drainage ditch along the toe of the seepage berm between levee Sta. 6110 and 6250. Seepage runs down-stream and extends out into a corn field for approximately 500 to 600 feet. A few small pin boils were observed in low areas in the field. Small sand boils may be present in the bottom of the ditch.	33-40
32.99445	91.11863	32.99445	91.11863	6144+00	6120+00		Light	Light to moderate through seepage on top of the seepage berm near levee Sta. 6120. Seepage is approximately 100 yards long and 25 yards wide.	41-42
32.996931	91.088311	32.996931	91.088311	6339+00	6320+00	Sand Boil	Moderate	Multiple sand boils in Valewood ditch just north of the Addie ramp. Throat diameter of boils range from 6 to 8-inches. Water in ditch is flowing clear.	43
32.9980872	91.10859187	32.9980872	91.10859187	6280+00	6260+00	Under Seepage	Moderate	Moderate seepage in ditch along Elwood Road and across the road into field. Several small pin boils and pumping gravel in the road (road closed). Numerous pin boils in bean field across the road under standing water. Area is approximately 250 to 300 feet from the toe of the seepage berm.	44-50
32.99942664	91.10728704	32.99942664	91.10728704	6285+00	6265+00	Sand Boil	Heavy	Several (4 to 6) large, high energy sand boils under 3 to 4 feet of water in a drainage ditch in the bean field approximately 200 feet north of Elwood Road near levee Sta. 6265. Two other boils have cause the banks of the ditch to cave. Boils are transporting small quantities of silt/fine sand material. Area was flagged during the inspection.	51-52
32.99768333	91.09044669	32.99387	91.08563	6333+00 to 6351+00	6310+00 to 6328+00	Under Seepage	Light	Light, widespread underseepage in field across Elwood and Ross-Winn Roads approximately 500 feet from the toe of the levee.	53-55
32.99768333	91.09044669	32.99768333	91.09044669	6335+00	6311+00		Light	Light to moderate through seepage on top of the seepage berm near levee Sta. 6311. Area is approximately 250 feet long and 100 feet wide.	56
32.98973	91.08112	32.98973	91.08112	6377+00	6356+00		Light	Light through seepage on top of the seepage berm approximately 20 from the toe of the berm near levee Sta. 6356. Seepage is approximately 25 yards wide and 50 yards long.	
32.98167	91.07198	32.9796684	91.07103525	6411+00 to 6418+00	6389+00 to 6395+00	Under Seepage/Pin Boils	Moderate	Moderate seepage with a numerous pin boils in levee entrance road and residence yard approximately 100 feet from the toe of the seepage berm near levee Sta. 6389. Moderate seepage extends down stream in the woods to near levee Sta. 6395.	57-61
32.9796684	91.07103525	32.9731	91.06842	6418+00 to 6443+00	6395+00 to 6420+00	Under Seepage	Light	Light seepage from the toe of the seepage berm extending out approximately 200 to 300 feet into a cleared timber area and continuing downstream to near levee Sta. 6420. Seepage is generally clear and no pin boils were identified.	62-68
32.97548	91.06928	32.96489	91.06773	6452+00 6492+00	6430+00 to 6470+00		Moderate	Moderately fast current flowing against riverside levee toe from near levee Sta. 6430 to 6470. Light to moderate seepage in field.	

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
32.93982762	91.05941308	32.93982762	91.05941308	6670+00	6650+00	Under Seepage/Pin Boils	Moderate	Moderate seepage begins along the toe of the seepage berm along levee access road to Mayersville Grain Bin near levee Sta. 6650 and continues downstream. At levee Sta. 6650, seepage extends out from the toe of the seepage berm approximately 300 to 500 feet. Two or three small pin boils were identified along the fence just north of the access road. Pin boils were low flow.	69-78
32.91025	91.05331	32.91025	91.05331	6692+00	6690+00		Light	Light seepage on top of the seepage berm approximately 10 to 15 feet from the toe of the berm just north of Mayersville near levee Sta. 6690. Seepage is approximately 100 feet wide and 300 feet long. Light seepage in field across paved road approximately 150 feet from the toe of the seepage berm.	
32.89250015	91.05297813	32.84606	91.07297	6760+00 to 6850+00	6710+00 to 6800+00	Under Seepage/Pin Boils	Moderate	Moderate underseepage with pin boils approximately 10 to 20 feet from the seepage berm toe extending out approximately 300 feet near levee Sta. 6710. Area extends downstream approximately 300 to 500 feet. Three to five, high energy sand boils in a ditch along the toe of the seepage berm in the woods near levee Sta. 6750. Boils have 3 to 5-inch throats and are flowing 20 to 30 gpm each. Boils are covered with approximately 6 inches of water and have transported approximately 3 to 5-cubic yards of silt/fine sand. Area was flagged during the inspection. Moderate seepage with a few pin boils along the fence approximately 250 feet from the toe of the levee (seepage berm not identified) near levee Sta. 6800.	79-83
32.87071578	91.0749221	32.86784	91.07434	6874+00 to 6888+00	6830+00 to 6860+00	Under Seepage/Pin Boils	Moderate	Light seepage near the toe of the seepage berm extending out into field approximately 300+ feet between levee Sta. 6830 and 6860. Moderate seepage and five or six small pin boils in a ditch approximately 10 feet from the toe of the seepage berm near levee Sta. 6860.	84-87
32.85256267	91.07582051	32.85256267	91.07582051	6946+00	7020+00	Under Seepage/Pin Boils	Moderate	Light to moderate underseepage along toe of the seepage berm and extending out and filling low area approximately 150 feet from berm toe. Area is very soft/spongy with a few small pin boils that were identified. Light seepage extended downstream to an old slough near levee Sta. 7020.	88-94
32.83171263	91.10317817	32.83171263	91.10317817	7067+00	7100+00	Sand Boil	Heavy	Multiple, high energy, sand boils approximately 10 to 50 feet from the seepage berm toe near levee Sta. 7100. Boils were flowing 20 to 50 gpm and transporting moderate quantities of fine sand (2 to 5 cubic yards each). Throat diameters for the boils generally ranged from 2 to 10-inches. Some of the boils were ringed with culverts.	95-99

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
32.80137359	91.12194688	32.80137359	91.12194688	7195+00 to 7210+00	7120+00	Sand Boil	Heavy	Ben Lomand Road Site - Several medium to large sand boils were identified moving moderate quantities of fine sand and silt in a drainage ditch along the toe of the seepage berm and in an open area east of the ditch. All of the sand boils were within 10 to 20 feet of the seepage seepage berm toe. A water berm was created over most of the sand boils in the ditch by the levee board by constructing dikes on the upstream and downstream sides of the sand boils. Also, at least three of the sand boils in the ditch were ringed with galvanized culverts. As a result of the dikes and culverts, most of the boils in the ditch were covered with at least three to four feet of water. Also, there were several medium boils identified in the edge of a field on the east side of the ditch that were ringed with culverts by the levee board and eventually two sand bag rings were constructed around the area to increase the head and slow the movement of material. Most of the boils were flowing approximately 50 to 100 gallons per minute each, and continued to transport a significant quantity of material until the area was stabilized by remedial action by the levee board.	100-118
32.78372228	91.12866498	32.7652499	91.11011642	7261+00 to 7368+00	7210+00 to 7220+00	Under Seepage	Light	Light to moderate seepage in a field approximately 50 feet from the seepage berm toe near levee Sta. 7210. Seepage extends out approximately 200 to 300 feet and extends downstream to near levee Sta. 7420 where new relief wells begin.	119-128
32.763281	91.092714	32.763281	91.092714	7415+00	7368+00	Sand Boil	Moderate	Sand boil identified approximately 900 feet from the toe of the seepage berm near levee Sta. 7368. Boils has a throat diameter of approximately 12-inches and is under water.

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STATION 7500+00 TO END

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEEVE SECTOR: Tallula to the end of the Mainline

DATE: May 22, 2012

TEAM MEMBERS: James Sims, Ryan Reeves, Dustin Herr, Jim Hearn

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
32.75107208	91.04533914	32.75107208	91.04533914	7592+00	7540+00	Under Seepage	Light	Light seepage in the woods off the toe of the seepage berm near levee Sta. 7540. Seepage is approximately 50 feet wide.	1-2
32.715981	91.04105	32.715981	91.04105	7728+00	7680+00	Sand Boil		Numerous sand boils identified in field/pond area near Fidler downgradient from relief well 107. Most boils were found in SE corner of an open pasture around an area of standing water. Some of the boils were under water. All of the boils are small and were transporting small quantities of silt/fine sand.	
37.70960136	91.0460203	37.70960136	91.0460203	7753+00	7705+00	Under Seepage/Pin Boil	Moderate	Light to moderate seepage along the pipeline near levee Sta. 7705 between relief wells 104 and 105. Seepage extends out 250 to 300 feet into and old slough. A possible sand boil was identified inside a fenced area that impounds the gas line. Boil is under water and was not accessible.	3-5
32.70103	91.05349	32.69494	91.05768	7791+00 to 7817+00	7740+00 to 7770+00	Heavy Current/Scour	Moderate	Light to moderate current against the riverside toe of the levee from near levee Sta. 7740 to 7770.	
32.69841061	91.0545223	32.69841061	91.0545223	7800+00	7751+00	Under Seepage	Light	Light seepage approximately 100 feet from the toe of the levee extending out into the woods between relief wells 89 and 90. Seepage is clear and is approximately 500 feet long.	
32.64874299	91.04435171	32.64874299	91.04435171	8030+00	7980+00	Under Seepage	Light	Light seepage approximately 100 feet from the toe of the levee near levee Sta. 7980. Seepage is clear and drains into an old slough.	6
32.64868269	91.04664869	32.64868269	91.04664869	8039+00	7990+00	Under Seepage	Light	Light seepage from a water well behind hunting camp house near levee Sta. 7990. Well is located approximately 100 yards from the toe of the levee.	7-8
32.65110227	91.02281972	32.65110227	91.02281972	8102+00	8055+00	Under Seepage	Light	Light seepage approximately 10 feet from the toe of the seepage berm and on top of the seepage berm between Relief Wells C-5 and C-6 near levee Sta. 8055. Relief wells C-5 through C-8 were not flowing. Seepage was identified around the concrete pads of wells C-5 and C-6. Water level in each well was less than 1 foot below top of riser. A possible sand boil was identified approximately 50 feet south of relief well C-9. Area was not accessible. Possible boils were under water and area appeared to be stable.	9-14
32.63357532	91.00052779	32.63357532	91.00052779	8098+00	8050+00	Under Seepage	Light	Light seepage in the woods approximately 100 feet from the toe of the levee near levee Sta. 8150. Area is south of the highway 465 levee access ramp. Seepage flows into a ditch/creek.	15

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
32.62829741	90.99904092	32.62795987	90.99906234	8218+00	8170+00	Sand Boil Through Seepage Slide	Heavy	Five medium-sized, high energy sand boils along the toe of the levee near levee Sta. 8170 (no berm). A large, landside, slide developed immediately downstream from the boils. A stone ring was placed around the sand boils and a filter of sand was placed over the throats of the boils. The levee board worked throughout the night to stabilize the boil. The stabilization of the slide began the following day with Corps hired labor forces. An additional slide developed during the second night immediately upstream from the sand boils. Both slides were accompanied with and possibly the result of heavy seepage exiting at the slide face and on the slope below. Hired labor continued daytime stabilization of the slide by placing crushed limestone at the toe and sand on the lower end of the slide to provide additional weight and drainage. The slides were present in the lower 1/3 of the levee embankment and were relatively shallow in depth. A small slide near the levee toe formed immediately above the sand boils on the third day that connected the two larger slides. The hired labor forces maintained daytime activities on the site for approximately 14 days to stabilize both the slides and the boils. There were approximately 6,000 tons of limestone (#57 stone) and 11,000 tons of sands placed on the site to stabilize the slope. The boils at the levee toe and the embankment instability could have progressed to loss of levee foundation material and/or significant loss of the net levee section. (Albemarle Slide Site).	16-37
32.62566294	90.99686835	32.62566294	90.99686835	8234+00	8185+00	Under Seepage	Light	Light seepage along the toe of the levee extending out into the woods approximately 300 feet near levee Sta. 8185. Seepage area is approximately 150 feet wide.	38-40
32.61603481	90.99292562	32.61603481	90.99292562	8269+00	8220+00	Under Seepage	Light	Light seepage from along the toe of the levee extending approximately 200 feet out into the woods near levee Sta. 8220.	41-42
32.60990058	90.99396942	32.5986	91.00508	8295+00	8249+00	Under Seepage	Moderate	Moderate seepage with numerous sand boils in a drainage ditch along a gravel road the parallels the toe of the seepage berm near levee Sta. 8249. Sand boils have 2-inch to 8-inch throats and were moving small quantities of silt/fine sand. Most of the boils were under water and were being monitored by the levee board.	43-46
32.604097	90.999414	32.604097	90.999414	8317+00	8270+00	Under Seepage	Moderate	Moderate seepage along the toe of the levee and over Collins road near levee Sta. 8270.	
32.60334381	91.00052154	32.59848	91.00639	8321+00 to 8347+00	8275+00 to 8300+00	Under Seepage	Moderate	Moderate seepage with numerous pin boils from the toe of the levee and extending through the wooded area and into a ditch along a gravel road that parallels the levee. Seepage area extends from levee Sta. 8275 to Sta. 8300.	47-50
32.60110424	91.00190834	32.60110424	91.00190834	8335+00	8288+00	Sand Boil	Moderate	Small sand boil with a 4-inch throat near drainage ditch along a gravel road that parallels the levee near levee Sta. 8285. Boil has been flagged and area is being monitored by levee board.	51
32.59448316	91.01077152	32.59448316	91.01077152	8368+00	8320+00	Under Seepage	Light	Light underseepage from the toe of the seepage berm extending out approximately 30 yards into the woods near levee Sta. 8320.	52-55
32.57712271	91.02844784	32.57712271	91.02844784	8455+00	8409+00	Under Seepage	Light	Light underseepage in wooded area approximately 100 feet from the toe of the seepage berm. Area is approximately 150 to 200 feet wide and is located approximately 350 feet north of the Warren County line.	56

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
32.56992867	91.03724233	32.56992867	91.03724233	8493+00	8445+00	Slide	Light	Small crack noted in seepage berm near levee Sta. 8445. Crack width varies from 0.5 to 1 inch and extends approximately 100 feet in length.	57
32.56723143	91.0416534	32.56465365	91.05326993	8509+00 to 8550+00	8460+00 to 8500+00	Under Seepage	Light	Light underseepage from the toe of the seepage berm extending into the woods and open field approximately 100 to 150 feet between levee Sta. 8465 and Sta. 8500. Seepage water is generally clear.	58-63
32.564031	91.054686	32.5589	91.06687	8553+00 to 8597+00	8510+00 to 8550+00	Under Seepage	Moderate	Moderate to heavy seepage along levee toe between levee Sta. 8510 and 8550.	
32.56127261	91.06164039	32.56127261	91.06164039	8577+00	8530+00	Sand Boil	Moderate	Moderate seepage and sand boils approximately 30 to 50 feet from the toe of the seepage berm near levee Sta. 8530. One large sand boil has been ringed by the levee board with a 30-gallon drum. Numerous pin boils were identified in a field approximately 300 feet downstream from the boil that was ringed with the drum. Some boils in the field were transporting small quantities of silt/fine sand and a few had 3 to 4-inch throats. Boils near the southern entrance of Highway 465.	64-69
32.55124403	91.06668772	32.55124403	91.06668772	8634+00	8586+00	Under Seepage	Light	Light underseepage approximately 30 feet from the toe of the seepage berm near levee Sta. 8590. Seepage is approximately 150 feet wide and extends approximately 100 feet out into the wooded area.	70
32.54863775	91.06814146	32.54863775	91.06814146	8645+00	8+00 (BEL)	Under Seepage	Light	Light underseepage from approximately 50 feet from the toe of the levee (no seepage berm) extending out approximately 300 feet and into a wooded area near levee Sta. 8+00 - Brunswick Extension Levee (BEL).	71-73
32.53482086	91.07807727	32.52138	91.07268	8749+00 8764+00	110+00 to 131+00 (BEL)	Sand Boil	Heavy	Buck Chute - A stabilization berm was constructed at Buck Chute, which was completed in early May, 2011, to control seepage and sand boils. Also, a deviation to the water control plan for Eagle Lake was enacted to minimize seepage pressures through the Levee. The water level in Eagle Lake was raised to 89.8 feet. There were no significant issues with seepage at buck chute during the flood. However, a significant sand boil developed approximately 5 feet west of relief well BC-2-98.	74-91
32.52820892	91.07615484	32.52820892	91.07615484	8735+00	90+00 (BEL)	Heavy Current/Scour	Light	Heavy current and small whirlpools noted along riverside of levee upstream from Buck Chute near levee Sta. BEL. 90.	
32.51769	91.07168	32.5154602	91.07181245	8777+00 to 8786+00	140+00 to 150+00 (BEL)	Under Seepage	Light	Light underseepage along the toe of the levee extending out approximately 200 feet from levee Sta. 140 to 150. Seepage is mostly clear water.	92-94

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
32.49862535	91.0754191	32.47617	91.06052	8847+00 to 8964+00	210+00 to 327+00 (BEL)	Sand Boil	Heavy	Moderate to heavy under seepage, numerous active, medium sized sand boils and pin boils were observed within 50 feet of the levee toe between Brunswick Extension Levee (BEL) Sta. 210+00 and 327+00 near and around Tara Hunting Camp. Two to three, large, high energy sand boils with 12 to 16 inch throats were identified between Sta. 210 and 220 that flowed 100+ gallons per minute and transported 5+ cubic yards of fine sand/silt before and during remedial action. These boils were located between 10 and 20 feet from the toe of the levee. One boil, located near Sta. 212+00 BEL was ringed with sand bags by the levee board. The other boils were eventually stabilized with drums placed over the throats of the boils. A large water berm, several feet in depth, was created by the under seepage in this area and the bermed area was investigated by boat on 5/23/11. During this investigation, over 30 sand boils were identified under the surface of the water berm in the general area of levee Sta.260 BEL.	95-109
32.47460845	91.05658291	32.46939	91.04095	8967+00 to 9027+00	330+00 to 390+00 (BEL)	Under Seepage/Pin Boil	Heavy	Moderate to heavy seepage and several small, low energy, sand boils along the levee toe between levee Sta. 330 (BEL) and Sta. 390 (BEL). Several boils were ringed with 30-gallon plastic drums by the levee board. Some of the boils were pin flagged and were being monitored. Numerous smaller boils are possible under water in this area.	
32.46707963	91.03314342	32.46648	91.02852	9052+00 to 9067+00	415+00 to 430+00 (BEL)	Under Seepage	Light to Moderate	Light to moderate seepage along and under the seepage berm extending approximately 150 feet out into the field between levee Sta. 415(BEL) and Sta. 430 (BEL). Seepage berm starts near Sta. 410 (BEL).	110-111
32.46749665	91.01755564	32.46749665	91.01755564	9113+00	475+00 (BEL)	Under Seepage	Light	Light seepage along the toe of the seepage berm extending approximately 300 feet out into a corn field near levee Sta. 475 (BEL). Seepage appears clear with low energy. Area is monitored by levee board.	112-113
32.46508251	90.99750392	32.46508251	90.99750392	9162+00	525+00 (BEL)	Through Seepage	Light	Minor, light, through seepage noted on top of the seepage berm approximately 100 feet from the berm toe near levee Sta. 520. Seepage also noted along the toe of the berm extending out approximately 250 feet.	114-116
32.46288702	90.99240566	32.46288702	90.99240566	9180+00	542+00 (BEL)	Sand Boil	Heavy	Moderately high energy sand boil with a 12-inch throat along the toe of the seepage berm near levee Sta. 542 (BEL). Boil has transported about three cubic yards of silt/fine sand and is flowing approximately 75-100 gpm. Boil was flagged for the levee board.	117
32.46196046	90.99095339	32.46196046	90.99095339	9186+00	550+00 (BEL)	Through Seepage	Light	Light seepage through the seepage berm near levee Sta. 550 (BEL). Seepage area is approximately 100 feet wide and approximately 300 feet long. Some minor seepage was observed approximately 50 feet from the berm toe in the same area.	118-120

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WEST BANK MISSISSIPPI RIVER LEVEE IN
ARKANSAS
STATION 0+00 TO 3990+77

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEEVE SECTOR: West Bank MRL - Station 0+00 - Station 3990+77 (Upper end near Rohwer to LA Line)

DATE: 5/16/2011 - 5/18/2011

TEAM MEMBERS: Andy Hardy, Lane Vargas, and Ben Emery

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude	NLD	LEEVE				
33.74760	-91.25460	33.74540	-91.25230	122+00-132+20	122+00-132+20	Under Seepage	Moderate	Seepage at toe of berm and 25' beyond toe of berm.	1-3
33.74630	-91.25350	--	--	127+50	127+50			Moderate flow visible near toe of berm and into adjacent field but no source found.	1-3
33.74540	-91.25230	33.74440	-91.25020	132+20-142+80	132+80-143+20	Under Seepage	Light	Standing water at berm toe and 25' into fields.	
33.74440	-91.25020	33.73290	-91.24200	142+80-192+00	143+20-192+70	Under Seepage	Light to Moderate	Standing water at berm toe and 1500' into field.	4-5
33.73180	-91.23940	33.72950	-91.23480	200+70-216+90	201+20-217+60	Under Seepage	Light	At levee toe and 300' into field	
33.72390	-91.22418	--	--	263+00	263+80	Sand Boil	Moderate	Sand boil with 6" diameter and 1' depth. Clear flow at trickle pace. Located 300' from toe of levee.	6
33.69941	-91.23174	33.69923	-91.23245	371+30-373+00	372+30-374+00	Under Seepage	Light	At berm toe and immediate area.	
33.68880	-91.24030	33.68240	-91.24040	422+90-445+90	424+00-447+00	Under Seepage	Light	At berm toe and immediate area.	
33.68120	-91.24050	33.67900	-91.24090	456+10-458+40	457+50-459+80	Under Seepage	Light	At berm toe and immediate area.	
33.64414	-91.21746	--	--	610+00	611+20	Under Seepage	Moderate	Leaking well head 20' from berm toe is the likely source of collected water.	7
				615+00	616+20	Under Seepage	Light	Seepage at fence near berm toe and around possible cattle pond near berm toe.	8
33.61906	-91.19824	33.61810	-91.19730	722+50-727+00	723+80-728+20	Under Seepage	Light to Moderate	In levee toe ditch and 150' into field.	
33.46592	-91.24902	33.46200	-91.25090	1390+00-1405+50	1391+20-1406+70	Under Seepage	Light	At levee toe and 300' into fields and around the edge of a small patch of woods at the toe of the levee near the upstream end of the reach.	
33.46200	-91.25090	33.45750	-91.26200	1405+50-1448+00	1406+70-1450+90	Under Seepage	Moderate	Seepage on berm, at berm toe, and 300' into fields.	9
33.46070	-91.25230	--	--	1410+30	1411+10	Under Seepage/Pin Boils	Moderate	Group of pin boils in corner of field adjacent to berm toe. Boils were numerous, but area was inundated with seep water, providing adequate head to prevent moving any material.	
33.45800	-91.26010	--	--	1442+20	1443+00	Under Seepage/Pin	Moderate	Group of pin boils in field near berm toe. Minimal material moved.	
33.45750	-91.26200	33.44530	-91.25980	1448+00-1493+80	1450+90-1497+00	Under Seepage	Light	Seepage on berm, at berm toe, and into adjacent fields and wooded area 400' from berm toe.	
33.44370	-91.25920	33.44240	-91.25900	1499+50-1501+70	1502+70-1504+90	Under Seepage/Pin Boils	Light to Moderate	Group of pin boils near toe of berm at the edge of the wood line, seepage on seepage berm, at the toe, and 50' into fields.	
--	--	33.44340	-91.25980	1500+50	1503+70	Sand Boil	Moderate	Boil at toe of seepage berm in edge of wood line with an 8" cone no longer moving material and low flow.	
33.44240	-91.25900	33.43830	-91.24330	1501+70-1556+50	1504+90-1561+20	Under Seepage	Light to Moderate	On seepage berm, at the toe, and into fields. Animal burrow approx. 1' diameter at toe of berm.	10
33.43830	-91.24330	33.43420	-91.24340	1556+50-1575+00	1561+20-1579+80	Under Seepage	Moderate to Heavy	In ditch at the toe of the berm and into fields. Three sand boils with a trickle flow and 10 pin holes within a 200' area located 300' from toe at Sta. 1575+00.	11-12
33.43198	-91.24282	--	--	1585+00	1590+20	Under Seepage	Moderate to Heavy	Sandbag weir structure constructed in ditch located near Lake Chicot Pumping Plant. Ditch extend upstream beyond Station 156+00 near berm toe. Eventually flowed 20 feet wide and clear.	13-15
33.41890	-91.21040	33.41300	-91.21380	1697+10-1723+00	1691+40-1717+50	Under Seepage	Light to Moderate	Seepage on berm, at berm toe and 300' into fields	16-18
33.41300	-91.21380	33.41160	-91.21140	1723+00-1728+10	1717+50-1734+60	Under Seepage	Light	On seepage berm	
33.37400	-91.14630	33.37150	-91.13990	2018+00-2056+30	2013+00-2051+80	Under Seepage	Light to Moderate	At berm toe and 500' into adjacent fields	20-25

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEEVE SECTOR: West Bank MRL - Station 0+00 - Station 3990+77 (Upper end near Rohwer to LA Line)

DATE: 5/16/2011 - 5/18/2011

TEAM MEMBERS: Andy Hardy, Lane Vargas, and Ben Emery

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude	NLD	LEEVE				
33.36870	-91.14570	33.36670	-91.14880	2077+80- 2089+70	2072+30- 2084+20	Under Seepage	Light	In adjacent fields near levee toe	26
33.36450	-91.15290	33.36370	-91.15460	2105+20- 2109+30	2100+50- 2105+60	Under Seepage	Light	In adjacent fields near levee toe	27
33.36150	-91.15810	33.35557	-91.16834	2124+60- 2161+00	2121+20- 2156+50	Under Seepage	Heavy	Leland Chute - Moderate seepage exiting at the toe of the levee and beyond as well as numerous small to medium sized boils located in a ditch located approximately 100 feet beyond the toe of the levee were identified in a approximately 1 mile long reach. There is no berm in this area. A series of dikes were constructed across the ditch to impound water over a number of the boils. Other boils were stabilized by sandbag rings. Each boil moved silt and fine sand; however none of the boils moved a significant quantity of material.	
33.36210	-91.15900	--	--	2126+40	2121+20	Under Seepage/Pin	Heavy	Pin boils in ditch 100' from levee toe, area sandbagged	28-32
33.36120	-91.16100	--	--	2132+10	2126+50	Under Seepage	Heavy	At levee toe and 80' beyond. Area is low and traps water between levee and ditch.	
33.36010	-91.16320	--	--	2139+95	2135+35	Sand Boil	Heavy	Bagged boil in ditch	33-37
33.35940	-91.16370	--	--	2142+80	2138+20	Sand Boil	Heavy	Bagged boil in ditch	38-43
33.35310	-91.17170	33.35310	-91.17390	2176+00- 2187+30	2171+50- 2182+80	Through Seepage	Light	Approximately 6' up levee and a few pin boils at toe. No material moved, and flow is a trickle at most.	
33.35571	-91.18293	--	--	2215+00	2210+50	Slide		Crack in the levee is on the riverside crown. The width of the crack varies from 1/4" to 1". The length of the crack is approx 100' long	
33.35573	-91.18975	33.34326	-91.18448	2239+00- 2294+00	2234+00- 2290+10	Sand Boil	Moderate	Numerous sand boils and pin boils on the upstream end of Lake Chicot. All boils were 500' to 1000' from levee toe and located on the edge of the lake water line or in adjacent slough area. Most sand boils moved fine material and looked 2" to 4" in diameter. Boils eventually stopped moving material and were never bagged.	49-72
33.35573	-91.18975	33.35017	-91.18617	2239+00- 2261+00	2234+00- 2257+00	Sand Boil	Moderate	Numerous boils in lake and slough area 500' from berm toe. Boils moved some material, but eventually moved only clear water.	49-65
33.34479	-91.18625			2274+00- 2294+00	2270+00- 2290+10	Sand Boil	Moderate	Numerous boils in slough area 500' from berm toe. Boils moved some material, but eventually moved only clear water.	66-71
33.34600	-91.18320	33.34470	-91.18360	2280+00- 2287+00	2276+10- 2283+10	Under Seepage	Light	At berm toe and 100' into adjacent field	72-79
33.34010	-91.18560	33.33890	-91.18620	2304+00- 2309+50	2300+10- 2305+60	Under Seepage	Light	On berm and at berm toe	
33.29050	-91.10037	33.28790	-91.16910	2309+50- 2544+90	2305+60- 2541+20	Under Seepage	Moderate to Heavy	Lake Chicot - The site is historically an area with large boils. A large, high energy sand boil was located on the edge of a dredged channel at the south end of Lake Chicot. There were multiple sandbag rings placed around the boil. The throat would move and bypass the sandbag rings. A dike was eventually constructed across the channel. Moderate seepage was exiting the lake bank 30 feet above the water surface. Several other medium to large, moderate energy boils were located along the lake bank. These boils were also ringed with sandbags. The boil closest to the levee was approximately 400 feet from the toe of a 300 ft seepage berm. This boil has repeatedly moved significant quantities of material during previous high water events and exhibits some potential to develop pipes that may migrate towards the berm/levee. Boils were identified up to 2,000 feet from the levee toe.	
33.28813	-91.17136	--	--	2544+20	2540+90	Sand Boil	Heavy	Area know as Fish Bayou located approx 500' from berm toe at the downstream end of Lake Chicot.	80-88
33.28838	-91.16947	--	--	2544+20	2540+90	Under Seepage	Moderate	In low, wooded area between berm toe and County Rd 71. Numerous pin boils moving clear water.	93

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: West Bank MRL - Station 0+00 - Station 3990+77 (Upper end near Rohwer to LA Line)

DATE: 5/16/2011 - 5/18/2011

TEAM MEMBERS: Andy Hardy, Lane Vargas, and Ben Emery

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude	NLD	LEVEE				
33.28397	-91.16861	--	--	2558+00	2254+30	Under Seepage	Light	Light seepage in low area.	
33.22350	-91.12260	33.22230	-91.12030	2833+90- 2841+10	2829+20- 2837+40	Under Seepage	Light	At levee toe and 600' into adjacent fields.	94-95
33.21390	-91.11790	33.20400	-91.10850	2873+70- 2920+00	2870+70- 2917+00	Under Seepage	Light to Moderate	On seepage berm and 1500' into fields and adjacent woods.	96-99
33.20571	-91.11270			2905+00	2902+00	Under Seepage/Pin	Light to Moderate	Small group of pin boils 50' from berm toe.	
33.20330	-91.10640	33.19990	-91.10680	2925+90- 2940+50	2923+90- 2937+50	Under Seepage	Light to Moderate	At levee toe and 1500' into adjacent fields.	
33.19720	-91.10540	33.19610	-91.10470	2951+00- 2956+30	2946+40- 2951+70	Under Seepage	Light	At berm toe and into the narrow wood line and adjacent fields for 100'.	
33.19330	-91.10320	33.19140	-91.10360	2968+10- 2975+60	2963+50- 2971+00	Under Seepage	Light	At levee toe and 300' into adjacent fields and woods.	
33.18590	-91.10520	33.18460	-91.10550	2996+00- 3001+50	2993+00- 2997+50	Under Seepage	Light	On seepage berm.	100
33.18460	-91.10550	33.18210	-91.10760	3001+50- 3013+20	2997+50- 3010+20	Under Seepage	Light	At berm toe and 300' into adjacent fields.	
33.17880	-91.11080	33.17270	-91.11450	3028+40- 3053+00	3025+40- 3051+50	Under Seepage	Light	At levee toe and 100' into adjacent fields	
--	--	33.16760	-91.12110	3081+50	3080+00	Under Seepage	Light	Small patch of seepage 150' from levee toe into field	
33.16500	-91.12410	33.16410	-91.12590	3094+50- 3101+10	3091+50- 3098+10	Under Seepage	Light	At toe of berm and 600' into adjacent fields	
33.16240	-91.12900	33.16210	-91.13070	3112+70- 3118+20	3109+70- 3115+20	Under Seepage	Light	At toe of levee and 150' into adjacent fields and woods	
--	--	33.15770	-91.14810	3175+20	3172+40	Under Seepage	Light	At toe of levee and 75' into fields	
33.16150	-91.15810	33.15960	-91.17170	3210+30- 3250+00	3207+60- 3247+60	Under Seepage	Light	At berm toe and 500' into adjacent fields	101
33.15960	-91.17170	33.15750	-91.17850	3250+00- 3272+20	3247+60- 3269+80	Under Seepage	Light to Moderate	At berm toe and 2000' into adjacent fields	102
33.15750	-91.17850	33.15650	-91.18150	3272+20- 3281+00	3269+80- 3278+60	Under Seepage	Moderate to Heavy	At berm toe and 600' into adjacent fields	103
33.15820	-91.17950	--	--	3276+40	3273+00	Sand Boil	Heavy	Sand boil in ditch 200' from berm toe with 6" pipe. Moved about 2 yards of material. Additional pin boils in ditch with clear flow	104
33.15390	-91.18030	--	--	3278+30	3274+90	Under Seepage/Pin Boils	Light to Moderate	Few pin boils in ditch at berm toe with trickle flow. Moving clear material.	
33.15650	-91.18150	33.14910	-91.19140	3281+00-	3278+60	Under Seepage	Light	On berm near toe and 1500' into adjacent fields.	105,107
33.15660	-91.18168	--	--	3282+00	3279+60	Sand Boil	Light	Two small sand boils in ditch at berm toe with clear flow.	
33.14950	-91.19292	--	--	3322+00	3319+00	Sand Boil	Light	Sand Boil located Behind a well house near a satellite dish. Three foot diameter ring levee approx. 1500' from levee toe.	106
33.14370	-91.19430	33.14090	-91.19660	3342+00-	3339+00	Under Seepage	Light	At berm toe and 1500' into adjacent fields	
33.14010	-91.19810	--	--	3360+50	3357+50	Under Seepage	Light	Extending 3' feet up berm toe and at the berm toe	
33.13410	-91.20330	33.13060	-91.20540	3387+00-	3384+00	Under Seepage	Light	At toe of berm and into adjacent fields	108
33.09580	-91.20760	33.09510	-91.20660	3533+30- 3537+20	3530+30- 3534+20	Under Seepage	Light	Light at levee toe and into adjacent fields about 150'. Short stretch about 300' in length where no seepage berm exists.	109-111

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: West Bank MRL - Station 0+00 - Station 3990+77 (Upper end near Rohwer to LA Line)

DATE: 5/16/2011 - 5/18/2011

TEAM MEMBERS: Andy Hardy, Lane Vargas, and Ben Emery

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	LEVEE				LINKS
33.09510	-91.20660	33.09020	-91.19980	3537+20-3564+00	3534+20-3561+00	Under Seepage/Pin Boils	Heavy	Grand Lake -Two medium sized, moderate energy boils were located approximately 50 feet beyond the 400 ft seepage berm toe. Sandbag rings were constructed around both boils but the rings did not stop the transport of silt and fine sand. Heavy seepage, numerous pin boils and large water blisters were also located in the immediate area. A large earthen berm was constructed around the area to increase the head over the boils. The berm impounded approximately 5.5 acres of water. This effort did minimize material transport.	112-119
33.09020	-91.19980	33.08850	-91.19770	3564+00-3573+80	3561+00-3570+80	Under Seepage	Moderate	At toe of berm and 600' into adjacent fields	120
33.08850	-91.19770	33.08620	-91.19420	3573+80-3587+10	3570+80-3584+00	Under Seepage/Pin Boils	Heavy	At toe of berm and pin boils with heavy flow. Several water bulges were bagged.	121-122
33.08956	-91.18778	--	--	3595+00	3591+90	Under Seepage/Pin	Light	Light seepage at toe of berm with several pin boils.	123-124
33.08190	-91.18740	33.07890	-91.18210	3613+10-3633+00	3610+00-3629+90	Under Seepage	Moderate	At toe of berm and 800' into adjacent fields	125
33.07770	-91.18060	33.07620	-91.17960	3640+00-3646+00	3636+90-3643+90	Under Seepage	Light	At toe of berm and 300' into adjacent woods	
33.07600	-91.17980	33.07420	-91.17820	3646+00-3654+50	3643+90-3653+10	Under Seepage	Light	At toe of berm	
33.07000	-91.17580	33.06940	-91.17520	3671+00-3673+60	3669+40-3672+20	Under Seepage	Light	At toe of berm and 150' into adjacent field	
33.06810	-91.17400	33.05080	-91.16940	3680+10-3749+60	3678+50-3746+70	Under Seepage	Light to Moderate	On last 25 feet of berm and 1200' into adjacent fields	126-129
33.05080	-91.16940	33.04170	-91.17190	3749+60-3785+00	3746+70-3782+10	Under Seepage/Pin Boils	Heavy	Willow Lake - The site is historically an area with numerous small to medium sized boils. There were numerous medium sized boils and one large boil identified. A sandbag ring was constructed around the large boil. The bagged boil was located approximately 100 feet beyond the toe of a 350-foot seepage berm. The bagging effort controlled the material transport from the boil. Heavy seepage and pin boils were prevalent throughout the area.	130-133
33.03188	-91.17647	33.02788	-91.17584	3820+00-3850+00	3815+50-3850+50	Under Seepage	Light	At berm toe and 200' into adjacent field	
33.00660	-91.21240	33.00490	-91.21350	3986+50-3993+00	3986+00-3992+50	Under Seepage	Light	At toe of seepage berm and edge of adjacent field.

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WEST BANK MISSISSIPPI RIVER LEVEE IN
LOUISIANA
STATION 0+00 TO 3450+00

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: LA State Line to I-20

DATE: May 22-25, 2011

TEAM MEMBERS: Heather Sibley, Lance Gullett and Justin Jones

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
32.9981806	91.21704682	32.99646549	91.21829574	28+00 to 35+00	28+00 to 35+00	Under Seepage	Light	Seepage begins 15ft from the toe and extends out and undetermined distance. There is a wet field with standing water around the edge, but could be due to rain that occurred May 21, 2011. When the berm ends, there is standing water inside fence near the toe for about 25ft then the ground is just damp. Starting at 32.99700887 91.21775042 the seepage starts at the toe and extends out 200ft. The field is wet with standing water at the toe and in the field.	1-3
32.99567626	91.2187172	32.99482473	91.21936404	39+00 to 43+00	39+00 to 43+00	Under Seepage	Light	Light seepage beginning at the toe and extends about 80ft into field. The rest of the field is only slightly damp.	4
32.9934623	91.22041536	32.99171252	91.22136013	49+00 to 55+00	49+00 to 55+00	Under Seepage	Light	Starts at the toe and extends 60ft. Standing water near the toe and edges of the field.	5
32.97252901	91.22496306	32.97187977	91.22499448	127+00 to 130+00	127+00 to 130+00	Under Seepage	Light	Very light starts at toe and extends out 100ft.	6-7
32.9663171	91.22242151	32.96430718	91.2213433	151+00 to 158+00	151+00 to 158+00	Under Seepage	Light	Very light near the toe out 15ft. Looks like it may have more to do with drainage than seepage because the area around is dry.	8-9
32.96306519	91.22106288	32.96058866	91.2200586	165+00 to 174+00	165+00 to 174+00	Under Seepage/Pin Boils	Heavy	Starts at the toe of berm and extends down bean rows 50ft. About 400ft downstream it transitions to moderate seepage extending a couple thousand feet into corn field. Multiple small boils. The slope of the berm is wet just up to the crown.	10-12
32.96060326	91.22003495	32.95796753	91.21855246	174+00 to 185+00	174+00 to 185+00	Under Seepage	Light	Wet spot at the toe of the berm which is about 100ft wide. Seepage is behind wet spot in corn field. When the seepage berm ends, there is seepage all the way up to the toe of the levee for about 200ft then transitions to 115ft from the toe.	13
32.95796753	91.21855246	32.95331457	91.21891404	185+00 to 202+00	185+00 to 202+00	Under Seepage/Pin Boils	Moderate to Heavy	At start coordinate, the wet spot ends, but there is still seepage. Some small pin boils are in the field.	14
32.95331457	91.21891404	32.95147644	91.21720647	202+00 to 211+00	202+00 to 211+00	Under Seepage	Light	Very light seepage in corn field.	15
32.95016613	91.21633334	32.94804805	91.21437165	217+00 to 224+00	217+00 to 224+00	Under Seepage	Light	Exiting near the berm toe and extending a few thousand feet into field.	16
32.94804805	91.21437165	32.91461011	91.21046248	224+00 to 362+00	224+00 to 362+00			*Note: there was a bean field that was consistently wet and appeared to be due to rain, not seepage. No standing water was noted, and entire field appeared to have the same dampness.	
32.91461011	91.21046248	--	--	362+00	362+00	Under Seepage	Light	Extends out 150ft from the toe. There was some standing water, but very localized area only 30ft parallel to levee so could be drainage problem more than seepage.	17
32.90358801	91.19321507	--	--	340+00	340+00			45ft from the toe there is an old pipe that is broken off at the ground which is flowing water. No material is being moved, but the area has been sandbagged. No seepage or boils located near here.	18-19
32.877689	91.1645389	--	-	591+00	591+00	Sand Boil		Boil approximately 1500ft from the berm toe in ditch that runs through field. Has moved small amount of material, but is now running clear. (WP0007)	

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				LINKS
32.87738249	91.15966032	32.87667818	91.15960239	595+00 to 597+00	595+00 to 597+00	Under Seepage	Light to Moderate	Seepage is exiting near the toe.	20
32.87734027	91.15957756	32.87667818	91.15960239	595+00 to 597+00	595+00 to 597+00	Under Seepage	Light	Berm begins and has seepage exiting the slope.	21
32.87667818	91.15960239	32.86290525	91.16136013	597+00 to 650+00	597+00 to 650+00	Under Seepage/Pin Boils	Heavy	Seepage exiting at toe and extending back more than 1000ft. Heavy seepage. Hundreds of pin boils, some larger boils that have been bagged. This is part of the Wilson Point area that had never had water on it until the old levee failed which caused the boils to develop. The end coordinates mark the beginning of the relief wells. There is still heavy seepage up until the start of the relief wells. Because of the wells, it is hard to determine the amount of seepage once the wells start since they are flowing. There are some boils located behind the wells so there is still some heavy seepage occurring past the end coordinates. See below for Sand boil information.	22-32
32.87389214	91.16186656	--	--	608+00	608+00	Sand Boil		There is a sand boil in ditch approximately 850ft from the berm toe that has moved some material, but is now running clear water. WP008	
32.87519453	91.15960391	--	--	603+00	603+00	Sand Boil		WP006 - Sand boil that at time of our inspection had been bagged and filled with rock. Was located at the levee toe and has moved several yds of material. Sit rep does not specify size of throat and could not estimate it due to rock and sand operation.	
32.87388065	91.15958888	--	--	609+00	609+00	Sand Boil		WP 005 - still moving some material. Sand cone was 1.5ft tall and 6ft wide a ruler can be stuck in throat 3 ft. Located at the levee toe. Sit rep notes several boils at the toe of the LS berm that have moved small amounts of material STA 609.	
32.87032312	91.16067773	--	--	622+50	622+50	Sand Boil		WP 003 - smaller boil located at the levee toe.	
32.87051104	91.16097032	--	--	622+00	622+00	Sand Boil		WP 001 - small boil 25ft from the levee toe. Ground is pumping and gurgling when walked on. Noted in sit rep May 14, between levee STA 600 to 650 at toe of LS berm, there are several boils running clear water and several bulges approximately 6in in height. These bulges are at the toe of the berm. On the date of the inspection for this report, the bulges were not noted, but there was pumping.	
32.87355	91.15968056	--	--	610+00	610+00	Sand Boil		WP 004 - several small boils located off toe of berm all have moved small amount of material Sta 610.	
32.87504237	91.15937619	32.87372235	91.15958414	604+00 to 609+50	604+00 to 609+50	Under Seepage	Light	Seepage is exiting the berm 25ft from the toe.	
32.86689	91.1706	--	--	637+50	637+50	Sand Boil		There are 9 boils at this location in ditch along highway 596. Boils are 2500ft to 3000ft from levee. All are moving material. Levee Board built sand bag dams in ditch and contained boils.	
32.86290525	91.16136013	32.81974277	91.16998203	650+00 to 824+00	650+00 to 824+00			Relief wells begin. The levee slope at the relief wells is damp 10ft up the slope. Wells 1-10, 20-22, 25-30, and 73-89 are all flowing above the water level in ditch. Wells 11-19, 23-24, and 31-72 are all flowing, but they are underwater. Note: starting at well number 31, the bean field behind the wells is wet and yellow 1000ft or more. At the end of the wells, there is a wet swampy area just past the toe that may have some seep water, but also has water from the wells running into it.	33-34
32.82191023	91.16968807	--	--	815+00	815+00	Sand Boil		Boil behind wells looks to be flowing clear water. Small boil located approximately 50ft from berm toe between wells #81 and #82.	35

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				LINKS
32.81974277	91.16998203	32.81665591	91.17106614	824+00 to 834+00	824+00 to 834+00	Under Seepage	Light	End of wells looks like there is some light seepage exiting right at the toe. Swampy area makes it hard to tell if it extends further back. At the end of the reach, the swampy area gets further from the toe.	36
32.811611	91.18001944	32.80764934	91.1758967	885+00	885+00	Sand Boil		Many sand boils. Most are small boils located near the edge of the water at Lake Providence. There are a few boils out in the water that are flowing and it is hard to determine their size. Most are only moving trace amounts of sand. Boils are numbered LP001 through LP025.	37-43
32.79987301	91.17034029	32.79513116	91.17081383	906+00 to 923+00	906+00 to 923+00	Under Seepage	Light	Seepage starts in ditch 200ft away from the toe of the levee and is light to very light. Fairly localized area and does not extend across road. There is only a small amount of water in the ditch and it is not flowing. There is a ditch on the other side of road as well that has a small amount of water in it, but also not flowing and a field starts downstream is dry.	
32.78106847	91.17863934	32.78067807	91.17860221	981+00 to 982+00	981+00 to 982+00	Sand Boil		Two small sand boils located across Highway 465 in drainage ditch. Numbered DD001 and DD002. Couple hundred feet from levee toe.	44-45
32.78793371	91.17420866	32.77578783	91.17786367	953+00 to 1001+00	953+00 to 1001+00			Relief wells start. Wells 17 and 36 are barely flowing and wells 24, 25, 34, and 35 are not flowing at all.	46
32.74790606	91.17856086	32.73934598	91.17483848	1101+00 to 1137+00	1101+00 to 1137+00			Relief wells start back with #37. The corn field is wet a couple hundred yards before the start of the wells, but looks to be from the well flow, not seepage. Wells 59-61 are underwater, but flowing.	47-49
32.74064739	91.17736177	32.74004344	91.17651382	1128+00 to 1132+00	1128+00 to 1132+00	Under Seepage	Light	Seepage is coming off of toe of levee above the wells. Less than 10ft up the slope.	50
32.73740961	91.17286527	32.73585151	91.16808811	1147+00 to 1159+00	1147+00 to 1159+00	Under Seepage	Light	Very light seepage on bank of full drainage ditch. Begins 20ft from the berm toe and extends 300ft out.	51
32.73585151	91.16808811	32.73048634	91.15934263	1159+00 to 1195+00	1159+00 to 1195+00	Under Seepage	Light	Light seepage now begins on the ditch bank 50ft from the berm toe and extends 400ft into field. The berm ends at 32.73311288 91.16449814, but the seepage continues. Once berm ends, seepage is at the levee toe and extends 700ft into field.	52
32.73048634	91.15934263	32.72883297	91.15934263	1195+00 to 1203+00	1195+00 to 1203+00	Under Seepage/Pin Boils	Heavy	Heavy seepage begins near the levee toe and extends out 1000ft. There are small, bagged sand boils in reach. This is the reach where earlier there were blisters that came up on the berm. When popped the blisters ran water out. There were no more blisters noted at the time of this inspection, but there were multiple clear boils in the reach.	53-55
32.72883297	91.15934263	32.72802037	91.1592073	1203+00 to 1207+50	1203+00 to 1207+50	Under Seepage	Light to Moderate	Light seepage 50ft from levee toe and extends out 400ft to ditch.	56
32.72654862	91.15903098	32.72467125	91.15847617	1213+00 to 1219+00	1213+00 to 1219+00	Under Seepage	Light	With the exception of the small area at beginning with seepage exiting 20ft on berm, light seepage begins at the berm toe and extends out over 2000ft.	57-58
32.72467125	91.15847617	32.72422624	91.15821942	1219+00 to 1222+00	1219+00 to 1222+00	Under Seepage	Light	Light seepage is exiting at the berm toe and in ditch 20ft away. However, there is no longer any seepage further out in the field. At the end coordinates, there is no longer any seepage at the toe, but there is still approximately 2ft of water in the drainage ditch.	
32.72055533	91.14955554	--	--	1246+00 to 1247+00	1246+00 to 1247+00	Under Seepage	Light	Some light seepage is visible 50ft from berm in field across from drainage ditch. Appears to be a small isolated low area that extends 100ft parallel to levee.	

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				LINKS
32.71957209	91.14760893	--	--	1250+00 to 1251+00	1250+00 to 1251+00	Under Seepage	Light to Moderate	Light to moderate seepage in field across ditch from berm. Starts 50ft from berm and extends 600ft into field. The water is flowing into the ditch near the berm. Isolated area that is approximately 100ft parallel to levee.	59
32.72218295	91.14633092	--	--	1256+00 to 1258+00	1256+00 to 1258+00	Under Seepage	Light	Isolated light seepage visible on the south edge of field 1000ft from berm toe. Less than 200ft wide.	
32.72179573	91.14397424	32.72178269	91.14339358	1261+00 to 1263+00	1261+00 to 1263+00	Under Seepage	Light	Light seepage begins 200ft from levee toe extends into ditch which is 120ft from start of seepage.	60
32.72070605	91.13818384	32.72119478	91.13318452	1284+00 to 1297+00	1284+00 to 1297+00	Under Seepage	Light	Light seepage out in field 200ft from levee toe. Extends 100ft at the beginning, but near the end area drains into ditch and extends 20ft behind ditch into plowed field.	61
32.72170783	91.13111299	32.72205458	91.12958076	1303+00 to 1312+00	1303+00 to 1312+00	Under Seepage	Light	Very light seepage 100ft from levee toe at drainage ditch and extends out 20ft perpendicular to ditch.	62
32.71991937	91.1266103	32.71863842	91.12637569	1324+00 to 1327+00	1324+00 to 1327+00	Under Seepage	Light to Moderate	Seepwater in ditch at levee toe. Seepage extends 500ft into woods and field.	63
32.71563056	91.12073056	--	--	1345+00	1345+00	Sand Boil		3 boils located at Homestead. HS002 located 15ft from toe of berm and has moved small amount of material (photo 64). HS003 at 32.7156 91.1208 15ft from berm toe in rowed up field with 2 to 3in throat and has moved approximately 1/2 yds materia (photo 65)l. HS001 at 32.715369 91.120769 was discovered from helicopter and is located 75 ft from toe of berm and has moved 1/2 yd material (photo 66).	64-66
32.71863842	91.12637569	32.71597724	91.11507855	1327+00 to 1360+00	1327+00 to 1360+00	Under Seepage	Moderate to Heavy	Berm begins and seepage at toe and extends 300ft into woods and field. Comes up to the pipeline area at Sta. 1350+00 where the berm is not constructed and there is standing water all in area where berm should be. No boils were noted. One the south side of the pipeline when berm starts back, the seepage is very light at the berm toe and ends about 100ft after start of berm.	67-69
				1340+00	1340+00	Current	Moderate to Heavy	Current is moderate to heavy 150ft from the water's edge. Light current right at the water's edge.	
32.71392742	91.11627539	32.70396211	91.11692627	1366+00 to 1415+00	1366+00 to 1415+00	Under Seepage	Light to Moderate	Light seepage exiting at the toe of the berm and extending out 300ft. Water slowly flowing in low areas of field. No pin boils were found. When berm ends the seepage is 100ft from the toe.	70
32.69767148	91.13454037	32.69947438	91.14493777	1474+00 to 1511+00	1474+00 to 1511+00	Under Seepage	Light to Moderate	Starts at the toe and extends out 500ft into corn field. Water is barely flowing in corn rows. No boils were seen. At 32.69818487 91.13849771 a berm begins and there is light seepage at the berm toe. Judging by the extents of the yellowed corn, the seepage only extends a couple hundred feet into corn field once berm begins.	71-72
32.6882109	91.17382925	32.66250311	91.17276506	1609+00 to 1715+00	1609+00 to 1715+00	Under Seepage/Pin Boils	Moderate to Heavy	Light seepage begins at start across road and in corn field just north of the Transylvania water tower. Begins approximately 150ft from the toe of levee and extends into corn field. If there is a berm in this area the seepage is exiting right at its toe. A bean field starts and judging by the yellow beans the seepage extends 300ft into beans. There are several small pin boils noted, but most were barely flowing and the water is nearly standing still. There is a farmers well flowing into field also few hundred feet from levee. Near well a corn field starts and small pin boils were noted in corn.	73-77
32.66551786	91.17585728	--	--	1699+00	1699+00	Sand Boil		Located 10ft from the toe of berm in corn field (berm is 200ft wide). Material moved is in a 5.5ft diameter circle 9in thick. Throat is approximately 5 inches. Had not been bagged and was moving small amount of material.	78-79

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
32.6563094	91.17416831	32.65136468	91.17574285	1740+00 to 1761+00	1740+00 to 1761+00	Under Seepage	Light	Starts at toe and extends out 75ft. Seepage is light exiting the toe. At 32.65552813 91.17473541 a seepage berm begins and the seepage starts at the berm toe and extends 200ft into field. At 32.6529984 91.17722243 seepage moves out 200ft from the toe and extends further back in field. There is a well located there, but it is too far away to see if it is flowing and the seepage appears to end on the downstream side of the well.	80-82
32.64196456	91.17330628	--	--	1796+00	1796+00	Under Seepage	Light	Light very localized area starting at the toe only wet on either side of ramp off levee about 100ft and extends out 80ft.	83
32.62288426	91.16251596	32.6015931	91.15698392	1875+00 to 1957+00	1875+00 to 1957+00	Under Seepage	Moderate to Heavy	Swampy area with water higher than usual. Starts at the berm toe with some seepage exiting along the slope of the berm just up from the toe. This area is referred to as "Ice Box Hole". No active boils seen at start. Multiple boils were located in area. Large boils are listed and discussed below, but there were additional small boils in the area.	84
32.61420741	91.15876504	32.611761	91.1589	1910+00 to 1919+00	1910+00 to 1919+00	Sand Boil		Multiple boils in area known as Ice Box Hole. Boils range in size from throats less than 1in to 6in throat. Most have not moved more than 1/2 yd of material. Located 100 to 200ft from the toe of the berm.	85-92
32.60263781	91.15710544	--	--	1952+00	1952+00	Sand Boil		New boil at approximate Sta. 1952 a the toe of the berm. Is about 1 mile south of Ice Box Hole. Has moved 1/2 yd material.	93
32.6015931	91.15698392	32.59292666	91.14931728	1957+00 to 1997+00	1957+00 to 1997+00	Under Seepage	Light to Moderate	Heavy seepage transitions to light to moderate seepage beginning at toe and extending into woods. At the ending coordinates, there is still some water in drainage ditch, but seepage seems to end.	94
32.59730922	91.15109972	32.59292666	91.14931728	1979+00 to 1997+00	1979+00 to 1997+00	Under Seepage	Light	Seepage on berm exiting up to 150ft from berm toe (50ft from levee toe).	
32.5824478	91.14047869	32.57116579	91.12812061	2044+00 to 2100+00	2044+00 to 2106+00	Under Seepage/Pin Boils	Moderate to Heavy	Begin ditch full of water with boils in ditch. This area is referred to as Henderson. The ditch is located 150ft from toe of levee (this is possibly a berm, but toe not apparent). Levee board had performed a good bit of dozer work in area and placed sand bag weirs to help raise the level of the water over some of the boils. Below are the coordinates and description of located boils.	95
32.57881394	91.13617654	32.572011	91.1295694	2062+00 to 2095+00	2068+00 to 2101+00	Sand Boil		Numerous boils in ditch near toe of berm. Most of which have moved less than 1yd of material. The maximum amount of material moved is 3 boils grouped together which have moved about 6 yds of material and correspond to HN001. Sand bag dams were built in the ditch to get water over all boils. Most of the boils were still moving small amounts of material May 24 when they were inspected for this report. Some of the dams were raised on May 28 to get more water over boils. These boils are referred to as Henderson and some are in and around the borrow area that was used to raise levee item 464-R. The boils are labeled HN001 to HN018.	96-103
32.57116579	91.12812061	32.56415977	91.125081	2100+00 to 2132+00	2106+00 to 2138+00	Under Seepage	Light to Moderate	Seepage transitions from heavy/moderate to moderate/light. At end coordinates, there is still water in ditch, but does not appear to be entering ditch so looks like it is backup from boils and seepage to north.	104-105

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
32.56876328	91.12542414	32.5657694	91.1252	2115+00 to 2126+00	2121+00 to 2132+00	Sand Boil		At the beginning coordinates, there is a large boil that has moved a few yards of material. There is a sand bag spillway constructed 300ft down the ditch from the boil that could be raised to get more head over boil. Numerous boils in ditch. Boils are located about 30ft from the berm toe. Most of these boils have moved less than 1yd of material. Sand bag dams have been constructed in ditch to get water over boils.	106-108
32.56236026	91.12448006	32.55991924	91.12628775	2139+00 to 2148+00	2145+00 to 2154+00	Under Seepage	Light	Starts about 200ft from toe and extends out a couple hundred feet into corn field. Seepage ends at the end of the corn field.	109-110
32.55047241	91.12917484	32.54785476	91.12970785	2183+00 to 2194+00	2189+00 to 2200+00	Under Seepage	Moderate	Moderate seepage at toe of berm and extends into field on opposite side of ditch. There is water flowing out of the field into the ditch. The end coordinates mark where the seepage ends on the levee side of the ditch, the opposite side of the ditch could not be gotten to due to thick brush and water.	111
32.54221734	91.13177965	32.54166911	91.13200435	2214+00 to 2217+00	2220+00 to 2223+00	Sand Boil		Multiple sand boils in this reach. Labeled 461-R-001 thru 461-R-004 and 461-R-015 all are fairly small with 1yd of material or less moved. At the time of the inspection for this report, the water level in the ditch had been increased by sand bag dams enough that all boils were flowing nearly clear water. Boils are in ditch at toe of landside berm.	112-115
32.54221734	91.13177965	32.52048873	91.13263084	2214+00 to 2296+00	2220+00 to 2304+00	Under Seepage/Pin Boils	Moderate to Heavy	From 461-R 004 boil the field across from the ditch is damp and has been for 200yds. Ditch has been bagged where the boils are. There are multiple boils in ditch and moderate to heavy seepage in field behind ditch as you go south. The seep water in field is draining into the ditch.	
32.53683056	91.1316	32.53204027	91.13121395	2233+50 to 2251+00	2239+00 to 2257+00	Sand Boil		Numerous sand boils in this area. Are referred to as 461-R boils. There is a gap between other 461-R boils and these. The boils here are located in ditch near landside toe 30 to 40ft from the toe of the berm. Most of them have moved less than 1yd of material.	116-121
32.5026427	91.12946686	32.50170596	91.12936597	2360+00 to 2364+00	2366+00 to 2370+00	Under Seepage	Light	Seepage begins at toe and extends out.	122
32.48153915	91.12422098	32.47523481	91.12069106	2440+00 to 2465+00	2445+00 to 2470+00	Under Seepage	Light	Light seepage confined to ditch at berm toe.	123
32.47523481	91.12069162	--	--	2465+00	2470+00	Sand Boil		457R-001 - small boil in ditch between toe and stone road that runs along end of field just below the Madison Port Road.	124
32.47523481	91.12069106	32.4654505	91.1131995	2465+00 to 2507+00	2470+00 to 2512+00	Under Seepage	Light to Moderate	Seepage starts at toe, 10ft goes into full ditch and light wet area in soybean field 100ft from the berm toe. Seepage is light to moderate with the exception of boil in ditch.	125
32.4654505	91.1131995	32.45725747	91.10619601	2507+00 to 2545+00	2512+00 to 2550+00	Under Seepage	Light to Moderate	Seepage is visible in plowed field 2000ft from toe. Seepage begins at toe.	126
32.45725747	91.10619601	32.45082803	91.1021291	2545+00 to 2570+00	2550+00 to 2575+00	Under Seepage/Pin Boils	Heavy	Multiple pin boils are located 20ft from the berm toe.	127
32.45082803	91.1021291	32.4386704	91.08098587	2570+00 to 2648+00	2575+00 to 2653+00	Under Seepage	Light to Moderate	Light to moderate seepage continues in field beginning at the toe of the berm. With the exception of the few large boils noted below, no pin boils are noted in this reach.	128
32.44968056	91.1035611	--	--	2570+00	2575+00	Sand Boil		TK001 site. 8 Boils have been found in ditch approximately 400ft from the landside berm toe. Each have moved 0.5 to 1yd of material. Sand bag dams were constructed to get water over the top of the boils. Sand cone diameters are 5ft or less.	129-132

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				LINKS
32.449189	91.099711	--	--	2579+00	2584+00	Sand Boil		TK002 Site. New boil was found May 25. Located approximately 50ft from toe of landside berm in bean field. 1.25yd of material has been moved. Boil has an approximate 5inch throat and the sand material is 20ft diameter but not deep.	133
32.4386704	91.08098587	32.43624216	91.07560167	2648+00 to 2673+00	2653+00 to 2678+00	Under Seepage	Light	Lake begins. Light seepage had continued extending far into field. Seepage was light to moderate. Light seepage continues along the lake.	
32.43460846	91.07472202	32.4241	91.03518056	2676+00 to 2810+00	2681+00 to 2815+00	Under Seepage	Moderate to Heavy	Light seepage beginning at berm toe and extending into woods at start. Transitions to moderate to heavy seepage with sand boils and ends just past the last boil.	134
32.4243611	91.0352389	32.4241	91.03518056	2807+00 to 2810+00	2812+00 to 2815+00	Sand Boil		Boils located at each coordinate. Labeled 450R-001 and 450R-002. These boils are in ditch that goes away from the levee. Closest one is 300+ ft from toe of levee. They have moved some small amount of clay but looks like they are mostly clear or just moving sand/silt now.	135-137
32.42970688	91.06092847	32.42585977	91.05025334	2723+00 to 2758+00	2728+00 to 2763+00	Under Seepage	Light	Seepage exiting berm crown all the way back to the levee tie-in. Standing water is present along most of the berm. Note: for the most part, there are many small areas 100ft long or less that has seepage exiting on the crown of an apparent berm.	138
32.42067479	91.0296141	32.41959217	91.02806991	2829+00 to 2836+00	2834+00 to 2841+00	Under Seepage	Light	If there is a berm here, there is seepage on the crown 75ft from the levee tie-in.	139
32.42067479	91.0296141	32.41641899	91.02300178	2829+00 to 2854+00	2834+00 to 2859+00	Under Seepage	Light to Moderate	Seepage is located across ditch from toe. Light to moderate amount. Ditch is just off of levee toe.	140-141
32.41309121	91.01989135	32.41123311	91.01945368	2872+50 to 2878+50	2877+00 to 2883+00	Under Seepage	Light	Light seepage in corn field off berm toe. Does not appear to extend into corn field very far as corn is not yellow only first couple of rows nearest toe are yellow. Also, the actual toe is very dry, could be irrigation.	142
32.40736478	91.01983327	--	--	2897+00 to 2900+00	2902+00 to 2905+00	Under Seepage	Light	Very localized area of seepage extends out approximately 100ft beginning at toe. Goes approximately 300ft parallel to levee.	143-144
32.40269424	91.02545613	--	--	2920+00	2924+00			There is some water in the ditch on either side of road, but the field and toe are both dry. After a couple hundred yards, both of the ditches are dry. Road is located just off of the toe.	145
32.39499856	91.030726	32.39303714	91.03140463	2953+00 to 2960+00	2957+00 to 2964+00	Under Seepage	Light	Starts in the ditch at the toe and there are a few sporadic wet spots in the bean field across the road.	146
32.39303714	91.03140463	32.38445859	91.03290175	2960+00 to 2992+00	2964+00 to 2996+00	Under Seepage	Light to Moderate	Transitions to light to moderate seepage. Seepage starts across the road in bean field 100ft from a small berm toe. About 600ft downstream the seepage begins entering right at the toe of the berm. The road veers away from the toe and there is a bean field on both sides of the road.	147
32.37798249	91.02962556	32.35362296	91.01399214	3016+00 to 3115+00	3020+00 to 3119+00	Under Seepage	Light	Begins at the toe and extends out 250ft. Standing water in field rows. There does not appear to be any seepage withing 300ft of the levee just past the boils at the Mound Airport.	148
32.35173056	91.018461	--	--	3110+00	3114+00	Sand Boil		Multiple boils located in ditch near bridge leading to airport. Boils are labeled AR001 - AR005. Boils are a couple hundred ft from toe and are all in canal/ditch near bridge. 1yd or less of material moved by each boil.	149-151
32.32868765	90.9535482	32.33022931	90.9269582	3328+00 to 3409+00	3332+00 to 3413+00	Under Seepage	Light to Moderate	Begins at the toe of the berm and extends into the corn field.

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STATION 3450+00 TO 5600+00

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: West Bank MRL - Station 3450+00 - Station 5600+00 (I-20 to Lake Bruin)

DATE: 5/19/2011 - 5/21/2011

TEAM MEMBERS: Andy Hardy, Lane Vargas, and Ben Emery

START		END		STATION NLD	STATION LEVEE	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude						
32.29780	-90.98280	32.29750	-90.98300	3653+50- 3655+50	3657+30- 3659+30	Under Seepage	Light	At levee toe	1
32.28183	-90.99055	--	--	3717+00	3713+60	Heavy Current/Scour	Light	Wash area on riverside of levee	2
32.26610	-90.98970	32.24910	-90.98860	3776+40- 3841+70	3773+90- 3837+00	Under Seepage	Light	20 yards from berm toe and 800' into adjacent field	3-4
32.25696	-90.98673	--	--	3810+00	3807+30	Under Seepage	Light	At berm toe and 100' into field.	
32.25354	-90.98905	32.25108	-90.98755	3825+00- 3835+00	3822+30- 3832+30	Under Seepage	Light	At berm toe and 300' feet into field. Water collected in low area of adjacent field.	5-7
32.24590	-90.99090	32.24510	-90.99200	3857+20- 3861+70	3854+50- 3858+00	Under Seepage	Light	20 yards from levee toe and 300' into adjacent field	8
32.24260	-90.99570	32.24090	-90.99820	3876+30- 3886+40	3873+60- 3883+70	Under Seepage	Light	20 yards from levee toe and 300' into adjacent field	9-10
32.24020	-91.00520	32.24060	-91.01160	3910+00- 3935+00	3906+50- 3931+50	Under Seepage	Light	At levee toe and 1500' into adjacent field	11-12
32.24273	-91.02016	--	--	3958+00	3961+00	Slide		Old slough slide on riverside of levee approx. 100' long and 10' from levee crown.	13-15
32.24520	-91.03380	--	--	4000+90	3997+40	Under Seepage	Light	At berm toe and 300' into adjacent field	
32.24570	-91.04210	32.24550	-91.04400	4025+60- 4032+10	4021+20- 4028+70	Under Seepage	Light	At berm toe and 600' into adjacent field	16-17
32.24560	-91.04690	32.24620	-91.05480	4041+00- 4065+50	4037+60- 4061+10	Under Seepage	Moderate	On berm and 1500' into adjacent field	18-19
32.24620	-91.05480	32.24620	-91.05710	4065+50- 4072+60	4068+20- 4079+10	Under Seepage	Light to Moderate	On berm and 1500' into adjacent field	
32.24620	-91.05710	32.24640	-91.06060	4072+60- 4083+50	4079+10- 4134+40	Under Seepage	Light	On berm and 1500' into adjacent field	
32.24640	-91.06060	32.24680	-91.07850	4083+50- 4138+80	4079+10- 4134+40	Under Seepage	Light	At toe of berm and 150' into adjacent woods	
32.24610	-91.08150	32.24610	-91.08590	4148+00- 4161+60	4152+90- 4165+50	Under Seepage	Light	At levee to and 150' into adjacent field	20
32.23625	-91.12508	--	--	4295+00	4299+80	Under Seepage	Light	On road at levee toe	21
32.22460	-91.12650	32.21730	-91.13610	4341+50- 4386+90	4346+30- 4391+70	Under Seepage	Light to Moderate	At levee toe and 300' into adjacent field	22-31
32.20624	-91.15794	--	--	4465+00	4470+80	Under Seepage	Light	At levee toe and 20' into adjacent field.	32
32.18840	-91.17210	32.18200	-91.17450	4546+40- 4570+50	4551+20- 4575+30	Under Seepage	Light	At levee toe and 40' into adjacent woods.	
32.17690	-91.17560	32.17500	-91.17610	4589+10- 4600+90	4591+20- 4602+00	Under Seepage	Light	At levee toe and 20' into adjacent woods.	
32.17280	-91.17710	32.15580	-91.17940	4605+00- 4668+00	4607+20- 4672+90	Under Seepage	Light	At levee toe and 40' into adjacent woods.	
32.15350	-91.17970	32.14920	-91.17840	4676+50- 4692+10	4681+40- 4697+10	Under Seepage	Light	At levee toe and 600' into adjacent field.	
32.14920	-91.17840	32.14190	-91.17610	4692+10- 4720+20	4697+10- 4725+20	Under Seepage	Light	At berm toe and 500' into adjacent field.	33-34

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: West Bank MRL - Station 3450+00 - Station 5600+00 (I-20 to Lake Bruin)

DATE: 5/19/2011 - 5/21/2011

TEAM MEMBERS: Andy Hardy, Lane Vargas, and Ben Emery

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude	NLD	LEVEE				
32.14190	-91.17610	32.13360	-91.17650	4720+20-4753+00	4725+20-4755+90	Under Seepage	Light	At toe of levee and 100' into adjacent field.	
32.13360	-91.17650	32.12930	-91.17580	4753+00-4767+90	4755+90-4770+80	Under Seepage	Light	In the fields 150' from levee toe and 600' into adjacent field.	
32.11540	-91.17270	32.11370	-91.17200	4828+00-4834+50	4833+80-4840+30	Under Seepage	Light	At levee toe and 300' into adjacent fields	
32.11370	-91.17200	32.11080	-91.17070	4834+50-4846+80	4840+30-4852+60	Under Seepage	Light	At levee toe and 800' into adjacent fields	
32.10850	-91.16980	32.10110	-91.16710	4854+00-4856+30	4859+80-4862+20	Under Seepage/Pin Boils	Light to Moderate	At toe of small berm and 300' into fields with a few pin boils scattered near berm toe and 30' feet into fields and moving only clear water from station 4854+00 to 4856+00.	35-36
32.10110	-91.16710	32.09964	-91.16945	4886+30-4895+00	4892+20-4960+20	Under Seepage/Pin Boils	Moderate	Few pin boils grouped together at Station 4887+00 at toe of levee in a stretch where there an 800' gap in the seepage berm. Seepage 300' into fields from levee toe	37-42
32.09964	-91.16945	32.08450	-91.17740	4886+30-4954+30	4892+20-4960+20	Under Seepage	Moderate	At berm toe and 200' into fields.	
32.09802	-91.17092	--	--	4901+00	4907+20	Sand Boil	Moderate	Boil located on landside of ditch at north end of corn field, 2" diameter hole with small amount of material. Seepage and pin boils increasing on landside and levee side of ditch.	
32.08396	-91.17785	--	--	4952+00	4957+90		Light	Four bulges found at north end of berm pumping a very small amount of cloudy water.	
32.08450	-91.17740	32.07700	-91.18150	4954+30-4991+90	4960+20-4997+90	Under Seepage/Pin Boils	Moderate to Heavy	Numerous pin boils in field adjacent to berm toe for 400' and seepage 600' into fields. Seep water flowed briskly from corn fields and into a ditch 400' from berm toe. Several small boils in ditch were controlled by constructing sandbag dams along ditch.	43
32.07700	-91.18150	32.06940	-91.18310	4991+90-5017+00	4997+90-5023+00	Under Seepage	Moderate	At berm toe and 600' into fields	
32.06940	-91.18310	32.06020	-91.18220	5017+00-5050+50	5023+00-5056+50	Under Seepage	Light	At berm toe and 300' into fields.	
32.06020	-91.18220	32.05620	-91.18130	5050+50-5066+00	5056+50-5072+00	Under Seepage	Light	At berm toe and 20' into adjacent field.	
32.05210	-91.17950	32.05150	-91.17930	5081+50-5084+00	5087+50-5090+01	Under Seepage	Light	At berm toe and 20' into adjacent field.	
32.05150	-91.17930	32.04350	-91.17760	5084+00-5113+10	5090+00-5119+10	Under Seepage	Light	Spotty seepage 1000' - 1200' into fields from berm toe.	
32.04080	-91.17550	32.03810	-91.17390	5125+00-5136+00	5131+00-5142+00	Under Seepage	Light	At berm toe and 40' into adjacent field.	
32.03410	-91.15810	32.03230	-91.15450	5193+50-5205+40	5199+50-5211+40	Under Seepage	Light	at seepage berm toe and 20 yards into fields	
32.02868	-91.14656			5215+00-5220+00	5221+00-5226+00	Under Seepage/Pin Boils	Moderate	Moderate seepage and pin boils at toe of berm and into field for 200'.	45-50
32.03370	-91.13930	--	--	5250+80-5275+00	5257+00-5281+20	Sand Boil	Heavy	Davis Landing - The site is historically an area with numerous small to medium sized boils with heavy seepage. There were several medium sized boils that were bagged. Some boils that had been previously bagged in the 2008 High Water event reappeared and did not require further sandbagging efforts. The majority of the boils were located in or near a slough that runs essentially parallel with the levee, and all boils were at least 500 ft from the levee toe.	51-63

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: West Bank MRL - Station 3450+00 - Station 5600+00 (I-20 to Lake Bruin)

DATE: 5/19/2011 - 5/21/2011

TEAM MEMBERS: Andy Hardy, Lane Vargas, and Ben Emery

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	LEVEE				LINKS
32.02860	-91.12280	32.01680	-91.13400	5338+50- 5393+40	5344+50- 5400+00	Under Seepage/Pin Boils	Moderate to Heavy	Winter Quarters - Seepage at toe of berm and light 500' into adjacent fields. Numerous pin boils in ditch near toe of small berm. Several sandbag dams were constructed along the ditch to create head on the boils and control movement of material.	64-71
32.00600	-91.16130	32.00410	-91.16890	5490+50- 5516+00	5511+00- 5527+50	Under Seepage	Light	At toe of levee and 150' into adjacent fields.	72

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STATION 5600+00 TO 7200+00

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: Lake Bruin to Lake St. John

DATE: May 26, 2011

TEAM MEMBERS: Heather Sibley, Lance Gullett and Justin Jones

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
				5600+00 5716+00	5604+00 to 5800+00			Note: From Station 5600+00 to 5716+00 there is no seepage near the toe of the levee, but there are multiple sand boils in the Botany Bay ditch and near the bank of the lake. See below for details on boils.	
31.98802986	91.18636091	--	--	5659+00	5663+00	Sand Boil		Large boils at Melancon Camp. They have moved material from behind seawall. Most are located in the lake and cannot be measured. Some small ones along the bank. 7 boils in Lake Bruin which have produced 10yds of silty sand range in size from 2ft to 5ft diameter. Erosion landside of walkway has increased and does not appear to have any material underneath.	1-6
31.97625211	91.18912606	31.97627105	91.18913094	5706+00	5710+00	Sand Boil		Large boils in Botany Bay Ditch. Boils have been sandbagged and ditch has been bagged to allow higher head over boils. Both have moved large amount of material. Approximately 450 ft from the levee toe.	7-10
31.97427198	91.19008269	31.95778666	91.19687706	5716+00 to 5782+00	5720+00 to 5786+00	Under Seepage	Light to Moderate	Seepage begins near the toe. There are a couple stretches about 100yds where there is no seepage near toe, but then it starts right back up. There is also one stretch about 200ft where the seepage is exiting 3ft up the slope from the toe. Full extents were unable to be seen, but there are seepage and boils at lake.	11
31.97440753	91.19457165	31.97423744	91.19439809	5724+00 to 5727+00	5730+00 to 5731+00	Sand Boil		Approximately 5 boils were found 10 to 15ft from Lake Bruin bank. Ranged from 1 to 4 inch throats. These boils are located over 500ft from the toe of the levee.	12-13
31.96721	91.1952305	--	--	5747+50	5755+00	Sand Boil		Sand boil moving small amounts of material approximately 300ft from landside toe of levee.	14
31.96157886	91.19995377	31.95764166	91.19981029	5769+00 to 5787+00	5781+00 to 5799+00	Sand Boil		Many boils in Lake Bruin State Park. At the time of this inspection most of the boils had been bagged and controlled. Only sand bags and pin flags could really be seen due to water.	15-19
31.93843421	91.20679698	31.93503209	91.21155905	5861+00 to 5880+00	5869+00 to 5888+00	Under Seepage	Light	At Sta. 5868 Seepage begins where the old front levee ends. Seepage is exiting at the toe and extending couple hundred feet into bean field. Further out in the field, no seepage can be seen from the top of the levee.	20
31.93001051	91.21990788	--	--	5912+00	5920+00	Sand Boil		Small boil - Panola (Lake Bruin) was noted by other geotech personnel on May 19. Was not seen at the time of the inspection for this report.	21

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
31.88316111	91.2736138	--	--	6178+00	6183+00	Sand Boil		Inspected May 28, 2011. Reported by night crew approximately 4 miles south of St Joe, LA. Boil is located 950 ft landside for top of levee at station 6185+75 downstream of culvert in ditch. This large, high energy boil has produced possibly over 100yds of material. The ditch in this location is about 10ft deep and there is material above water level. Within 2hr period the boil increased from 4ft - 6ft diameter throat with approximately 8ft diameter sand cone to a 10ft throat with a 13ft diameter sand cone. The outside perimeter of sand is approximately 60ft in diameter with some material flowing downstream. This area also has a 100ft diameter sunken (cracked) area along the upstream and east-west side of ditch. The boil throat is at least 18ft in depth. The majority of material appears to be a silty sand with some clay particles inside hole. The clay does not appear to be foundation material. On May 29, the levee board placed two sand bag dams across ditch one on each side. There was about 4ft of water over the boil.	22-24
31.883344	91.273727	--	--	6178+50	6183+50	Sand Boil		Large high energy boil inspected on June 1, 2011. 75ft NNW of above boil.	
31.8694779	91.34384408	31.86861268	91.34517923	6414+00 to 6419+00	6422+00 to 6427+00	Under Seepage	Light	Light seepage right at the toe of the levee. Appears to be only extending 20ft perpendicular to the levee.	25-26
31.86503046	91.35100959	--	--	6436+00	6444+00	Sand Boil		Kemp Bend #4 underwater. Noted on May 24 by other geotech personnel.	27
31.86438557	91.35068807	--	--	6437+00	6445+00	Sand Boil		Kemp Bend #3 Low energy boil 10+ yards of material moved. Noted on May 24 by other geotech personnel.	28
31.86476999	91.35032573	--	--	6436+00	6444+00	Sand Boil		Kemp Bend #2 Nearly dormant. Noted May 24 other geotech personnel.	29
31.86417696	91.34948948	--	--	6436+50	6444+50	Sand Boil		clear flow with low energy Kemp Bend #1 noted May 24 by others.	30
31.85712376	91.35006651	31.85043195	91.35204438	6462+00 to 6487+00	6470+00 to 6495+00	Under Seepage	Light	Seep water built up in low area 20ft from the toe of the berm. 500ft downstream begins seeping right at the toe. At the end coordinates, the relief wells begin. Between the two well sections, light seepage exists.	31
31.85241944	91.35528056	--	--	6482+00	6490+00	Sand Boil		Kemp Bend West Ditch (KBWD0001 thru 0007) Station 6500 to 6505 no significant change in slide or seepage at this location was reported May 27, 2011. 7 boils were found in ditch approximately 1500ft from the levee. Boils range from 2in to 6in diameter throats with 1cu.ft to 0.25 yd of sandy material. Several of the boils are flowing clear.	
31.82742728	91.35854571	31.82259167	91.35949946	6573+00 to 6591+00	6577+00 to 6595+00	Under Seepage	Light	Light seepage at the levee toe and into corn field. Once the wells and berm ends, the seepage stops.	32
31.81391133	91.36739689	31.81300268	91.368077	6632+50 to 6637+00	6640+50 to 6645+00	Under Seepage	Light	Light seepage in ditch at levee toe.	33
31.76129968	91.39675149	31.75451889	91.40127288	6897+00	6905+00	Seepage	Light	Light seepage exiting 30ft from the toe.	34
31.7550833	91.39995833			6893+70	6901+70	Slide		Slide located on riverside 20ft from crown and 22ft long. Slide was found on May 7 according to pin flag at location.	35-37
31.74867289	91.40374754	31.70970023	91.4125142	6919+00 to 7064+00	6927+00 to 7072+00	Under Seepage/Pin Boils	Heavy	There is seepage and ponding 15ft from the berm toe. The water in pond is higher than usual and there were several pin boils. Once the relief wells begin, there are pin boils and larger behind wells 80ft from toe. At the end, the ditch still has some water in it, but appears to be drainage because field is dry.	38-39

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
31.74516846	91.40857498	--	--	6932+00	6940+00	Sand Boil		St John #002 noted on May 24 by others. Moderate energy with clear flow. 12 inches of head. Also seen by group for this inspection and it was noted that there has been another boil that has popped up outside of the constructed sand bag ring that is moving a small amount of material and has approximately 5inch throat. These boils are located a few hundred yards or more from the levee. From sit rep, the boil outside of ring is a medium energy sand boil with a 4inch throat and 7ft fone which has moved 1yd of sand. Approximately 1050ft from the levee crown. The site is historically an area with numerous small to medium sized boils. There were six medium sized, moderate energy boils sand bagged during this event. Several of these were boils that reappeared in existing sandbag rings from the 2008 High Water event. The boils typically moved 1 – 2 cubic yards of silt and fine sand. The boils are located in an area of the levee with an existing 300-foot seepage berm. The boils are located in a large slough and vary from 1,000 to 1,500 feet from the toe of the levee.	40-42
31.74513957	91.40857582	--	--	6932+00	6940+00	Sand Boil		St John #001 noted by others on May 24. Moderate energy with clear flow and 18inches of head. Also noted by inspection group and by that time, the boil was under water and no longer moving material.	
31.7457388	91.40606944	31.7451611	91.4072388	6928+00 to 6933+00	6936+00 to 6941+00	Sand Boil		Multiple boils in area. Most have moved less than 1yd of material. All are located 800ft or more from toe of levee. These are in same area as St John 001 and 002, but are smaller.	
31.74364563	91.40531459	--	--	6937+50 to 6939+50	6945+50 to 6947+50	Through Seepage	Light	If a berm, there is seepage on the crown 60ft from the toe. Extends 200ft downstream parallel to levee.	43
31.73467747	91.40771417	31.7252404	91.40974569	6972+00 to 7007+00	6980+00 to 7015+00			Wells begin with #32. There are some small boils behind the wells. See below for details and coordinates. All of the wells were flowing. There was seepage all the way to start of wells and since there are boils there is still seepage behind wells.	
								Seepage and boils behind well pictures	44-48
31.7348166	91.4101	--	--	6973+00	6981+00	Sand Boil		Medium energy sand boil with a 3inch throat and 5ft sand cone that has moved 4cu. Ft. of sand. The boil is 1040ft from the levee crown.	
31.73366534	91.40860752	31.7334868	91.4088339	6976+00 to 6978+00	6980+00 to 6982+00	Sand Boil		2 sand boils were noted (one at each coordinate) in this location behind the relief wells. Both were similar in size with approximately a 6ft diameter 4inch thick sand/silt mix being moved. Neither are moving much material now and they both had a throat of 1.5 inches. Sit Rep note multiple small, low energy boils in the area. Most of which have moved less than 1yd of material. All except for the two with presented coordinates are 600ft or more from the levee.	
31.731522	91.410188	--	--	6985+00	6993+00	Sand Boil		6 small low energy sand boils. The largest has moved less than 2 cu. Ft. of sand with a 4ft cone.	
31.72605851	91.41052715	--	--	7004+00	7012+00	Sand Boil		More small boils were noted behind the relief wells. These were even smaller than the previous ones.	
31.72309507	91.41064458	--	--	7015+00	7023+00	Sand Boil		Several small pin boils and slightly larger boils were noted near the end of the relief wells. These started a couple hundred feet from the levee toe.	49

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
31.70662057	91.41252234	--	--	7075+00 to 7076+00	7083+00 to 7084+00	Under Seepage	Light	May be irrigation water and not seepage. Corn is not yellow. Extends 100ft south parallel to levee.	50
31.6829694	91.41136389	--	--	7165+00	7173+00			Cow depression on riverside levee slope. 20ft wide with 3ft face. Was originally noted as a slide.	51
31.69256691	91.41066884	31.68682868	91.41128218	7127+00 to 7148+00	7135+00 to 7156+00	Under Seepage	Light	Light seepage 200ft from the toe in bean field. Downstream the seepage gets closer to toe. Right near the end of the seepage, it is exiting 25ft away from the toe.	52
31.67896515	91.41565516	31.67634374	91.41371442	7188+00 to 7200+00	7191+00 to 7200+00	Under Seepage	Light	There is light seepage exiting in the corn field 25ft from the toe. This is not the end of the seepage, but the end of the reach. The seepage extends at least an additional 1500ft downstream of the end of the reach.	53

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STATION 7200+00 TO 8700+00

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: West Bank MRL - Station 7200+00 - Station 9050+00 (Lake St. John to below Vidalia)

DATE: 5/22/2011 - 5/23/2011

TEAM MEMBERS: Andy Hardy, Lane Vargas, and Ben Emery

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO LINKS
Latitude	Longitude	Latitude	Longitude	NLD	LEVEE				
31.67630	-91.41370	31.66420	-91.41500	7199+00- 7221+50	7200+00- 7222+50	Under Seepage	Light	At berm toe and 600' into adjacent fields	
31.65600	-91.42170	31.65380	-91.42670	7288+40- 7307+10	7296+00- 7315+20	Under Seepage	Light	80' from levee toe and 600' into adjacent fields	
31.65010	-91.43050	31.64900	-91.43300	7325+50- 7333+70	7333+70- 7341+90	Under Seepage	Light	At levee toe and 300' into adjacent fields	
31.64840	-91.43600	31.64810	-91.48300	7344+60- 7351+30	7353+10- 7359+80	Under Seepage	Light	At levee toe and 120' into adjacent fields.	
31.64740	-91.44290	--	--	7367+00	7375+50	Under Seepage	Light	100' off levee toe in the corner of the field and wooded area.	
31.64760	-91.44960	31.64540	-91.46060	7387+20- 7423+50	7395+30- 7430+50	Under Seepage	Light	120' off levee toe and 600' into adjacent field.	
31.65130	-91.47360	31.65190	-91.47410	7474+00- 7475+00	7481+50- 7482+50	Under Seepage	Light	150' off levee toe and extending into adjacent woods.	
31.65270	-91.47440	31.65470	-91.48820	7478+80- 7518+70	7485+30- 7524+60	Under Seepage	Light	At toe of berm and 300' into fields	
31.65470	-91.48820	31.65430	-91.49120	7518+70- 7529+00	7524+60- 7534+90	Under Seepage	Light	On berm and 600' into adjacent fields	
31.65430	-91.49120	31.65370	-91.49570	7529+00- 7542+80	7534+90- 7551+20	Under Seepage	Light	At berm toe and 600' into adjacent fields	
31.65240	-91.49860	31.64110	-91.51480	7550+30- 7615+00	7558+50- 7623+00	Under Seepage	Light	At berm toe and 600' into adjacent fields	
31.58090	-91.44450	31.58140	-91.43890	8017+00- 8034+50	8024+20- 8041+70	Under Seepage	Light	At berm toe and 800' into adjacent fields	
31.58420	-91.42920	31.58430	-91.42780	8068+60- 8072+60	8077+60- 8081+60	Under Seepage	Light	At levee toe and 300' into adjacent fields	
31.58430	-91.42780	31.58250	-91.41910	8072+60- 8103+50	8081+60- 8111+50	Under Seepage	Light	At berm toe and 150' into adjacent fields	
31.58170	-91.41810	31.57900	-91.41680	8107+90- 8121+00	8118+90- 8132+00	Under Seepage	Light	On berm.	
31.57900	-91.41680	31.57480	-91.41720	8121+00- 8137+00	8132+00- 8145+00	Under Seepage	Light	At berm toe and 150' into adjacent fields	
31.57480	-91.41720	31.56540	-91.42170	8137+00- 8176+00	8145+00- 8187+00	Under Seepage	Light to Moderate	At levee toe and 300' into residential area of north Vidalia. Low lying areas in yards had standing water, and water seeped though faults in driveways and roads. Only a minimal flow was observed in outlet ditches.	
31.57299	-91.42372	--	--	8160+00	8172+00	Sand Boil	Light to Moderate	Sand Boils in and around ditch 2000' from levee toe near baseball park on the north side of Vidalia.	1-5
31.56010	-91.42970	31.55890	-91.43180	8208+10- 8216+10	8185+00- 8193+00	Under Seepage	Light	At berm toe and 150' into residential area of Vidalia. Low lying areas in yards had standing water, and water seeped though faults in driveways and roads. Only a minimal flow was observed in outlet ditches.	
31.55660	-91.43610	31.55160	-91.44310	8231+50- 8260+00	8208+40- 8265+20	Under Seepage	Light	At berm toe and 100' into residential area on south Vidalia.	

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: West Bank MRL - Station 7200+00 - Station 9050+00 (Lake St. John to below Vidalia)

DATE: 5/22/2011 - 5/23/2011

TEAM MEMBERS: Andy Hardy, Lane Vargas, and Ben Emery

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	LEVEE				LINKS
31.55660	-91.43610	--	--	8321+50	8330+20	Sand Boil	Light	In ditch along the old railway line 2000' from levee toe	6-7
31.54400	-91.46690	--	--	8340+00	8348+70			Relief Wells flowing	
31.54400	-91.46690	31.54260	-91.47050	8340+00- 8352+10	8348+70- 8360+80	Under Seepage	Light	Between berm toe and adjacent lake (borrow pit)	
31.54260	-91.47050	31.54140	-91.47980	8352+10- 8384+50	8360+80- 8394+40	Under Seepage	Light	At berm toe and 300' into adjacent fields.	
31.53900	-91.49110	31.53970	-91.50360	8421+00- 8461+50	8432+30- 8473+20	Under Seepage	Light	In ditch at berm toe.	
31.50390	-91.52560	31.49920	-91.52580	8631+00- 8648+40	8639+30- 8657+10	Under Seepage	Light	At levee toe and 150' into adjacent field.	
31.49920	-91.52580	31.48460	-91.52740	8648+40- 8703+90	8657+10- 8711+90	Under Seepage	Light	At berm toe and 150' into adjacent fields

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STATION 8700+00 TO 10487+58

2011 MISSISSIPPI RIVER HIGH WATER REPORT

LEVEE SECTOR: Deer Park to the end of the Vicksburg District Line

DATE: May 25, 2012

TEAM MEMBERS: James Sims, Ryan Reeves, Dustin Herr, Jim Hearn

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
31.36252121	91.57804882	31.36252121	91.57804882	9231+00	9245+00	Under Seepage	Light	Light seepage flowing into a possible natural slough approximately 200 feet from the toe of the seepage berm between levee Sta. 9240 and 9250. Light, clear, seepage observed between berm toe and slough area.	1-2
31.35345131	91.57491101	31.35345131	91.57491101	9256+00	9270+00	Under Seepage	Light	More light seepage flowing into a pond/lake area approximately 75 feet from the toe of the seepage berm near levee Sta. 9270. Light, clear seepage flows into north end of lake/slough.	3-5
31.33965	91.5568	31.33965	91.5568	9326+00	9338+00	Through Seepage	Light	Seepage coming through the levee approximately 2 feet above the toe near levee Sta. 9338.	
31.33314389	91.55507518	31.33314389	91.55507518	9361+00	9369+00	Under Seepage	Light	Light seepage in drainage ditch approximately 200 feet from toe of the seepage berm. Clear water noted flowing in the ditch. Area has been flagged and monitored.	6-7
31.3318758	91.54745181	31.3318758	91.54745181	9385+00	9400+00	Under Seepage	Light	Light seepage along the toe of the berm extending out approximately 100 feet between levee Sta. 9400 and 9410.	8-10
31.32611	91.53251	31.32611	91.53251	9442+00	9450+00	Through Seepage	Light	Light seepage noted on top of the seepage berm near levee Sta. 9450. Seepage is located approximately 20 feet from the toe of the seepage berm and is approximately 20 feet wide and extends downstream approximately 100 feet.	11-12
31.32321	91.52894	31.32321	91.52894	9460+00	9470+00	Under Seepage	Light	Flowing irrigation well approximately 200 feet from the toe of the seepage berm near levee Sta. 9470. Well was flowing less than 20 gpm.	13
31.31894274	91.52878847	31.31894274	91.52878847	9475+00	9480+00	Through Seepage	Light	Light seepage on top of the seepage berm near levee Sta. 9480. Seepage is approximately 15 feet from the toe of the seepage berm. Seepage also observed along the toe of the berm extending out approximately 100 feet.	14
31.31485	91.52886	31.31485	91.52886	9490+00	9500+00	Sand Boil	Moderate	Several small sand boils observed in a drainage ditch along toe of seepage berm near levee Sta. 9500. Each boil has transported less than one cubic yard of silt/very fine sand and are flowing approximately 3 to 5 gpm. Most of the throats of the boils are 3-inches in diameter or less. More sand boils were identified approximately 1000 feet from the levee toe. These are small, low energy boils.	15-18
31.32489	91.52936	31.0058	91.53234	9453+00 to 9545+00	9450+00 to 9550+00	Heavy Current/Scour	Moderate	Rapid current noted along riverside of the levee between levee Sta. 9450 and 9550.	
31.31192	91.52959	31.31192	91.52959	9508+00	9520+00	Sand Boil	Light to Moderate	Numerous pin boils observed approximately 100 feet from the toe of the seepage berm extending out approximately 300 feet or more in a field on the north end of Sharps relief well.	19-20
31.30913134	91.52956731	31.30913134	91.52956731	9515+00	9550+00	Through Seepage	Light	Light seepage on top of the seepage berm approximately 75 feet from the berm toe above relief wells near levee Sta. 9540. Seepage is approximately 30 feet wide and 200 to 250 feet long.	21-23
31.286356	91.571678	31.286356	91.571678	9713+00	9720+00	Sand Boil	Light	Small sand boil under approximately 10-inches of water approximately 2000 feet from the landside toe of the levee.	

START		END		STATION	STATION	TYPE	EXTENT	REMARKS	PHOTO
Latitude	Longitude	Latitude	Longitude	NLD	FIELD MARKER				
31.27998407	91.55512001	31.27998407	91.55512001	9718+00	9722+00	Under Seepage/Pin Boi	Moderate	Moderate seepage and numerous pin boils in a field just south of the Sharps relief wells. Seepage extends out 300+ feet from the toe of the seepage berm and ends in the field near levee Sta. 9722.	24-25
31.28216928	91.57592711	31.28216928	91.57592711	9725+00	9730+00	Under Seepage	Light	Light seepage in a drainage ditch along the toe of the seepage berm near levee Sta. 9700. Ditch is connected to a pond.	26-27
31.2830422	91.59769039	31.2830422	91.59769039	9796+00	9800+00	Under Seepage	Light	Light seepage around farm buildings on north side of Slocum Levee Road off the toe of the levee near levee Sta. 9830. Seepage area is approximately 300 feet long and 200 feet wide. Possible flowing residential well inside small shed.	28-29
31.20524799	91.62972272	31.20524799	91.62972272	10285+00	10300+00	Under Seepage	Light	Light seepage approximately 100 feet from the toe of the levee in a field near levee Sta. 10300. Seepage area is approximately 10 feet wide and 30 feet long.	30

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Appendix B: Lecture IV: Underseepage (Fisk 1946)

(Note accompanying illustrations by R. J. LeBlanc, Assistant Geologist to H. N. Fisk)

LECTURE IV

Historic Background

The following lecture on underseepage is reproduced here in its entirety from Fisk (1946). This lecture series was presented at the request of the MRC to engineers at the MRC, WES, and LMV districts between 1944 and 1946 for purposes of training basic geologic principals in relationship to levee underseepage. The basic concepts contained in this short narrative and accompanying illustrations forms the fundamental geologic concepts that will be described by Mansur et al. (1956) ten years later. The geologic site characterization described by Mansur et al. (1956) was primarily performed by Fisk and his team of geologists at LSU. Members of this team would later be transferred to Vicksburg in 1947 at the request of the MRC, and this team was established as the Geology Branch, in the Soils Laboratory, USAE Waterways Experiment Station. Dr. R. J. Leblanc would serve as the first Chief of the newly formed Geology Branch in Vicksburg, before accepting a position at Shell Oil in Houston, TX, in 1948. The last co-author in Mansur et al. (1956), Dr. J. R. Schultz, was the second Chief of the Geology Branch at WES during the conduct of this study. It is serendipity from a historical perspective that the following report on the 2011 Mississippi River Flood would occur by a member of the legacy Geology Branch that was formed at WES nearly 75 years earlier. The senior author of this report has great admiration of the 20-year-long research program that was sponsored by the MRC to effectively control underseepage in the LMV, and the successful performance of this amazing engineering accomplishment.

Introduction

This lecture is intended to give a brief summary of the main factors which control underseepage and to discuss the secondary factors under which general and localized seepage has occurred at several sites.

UNDERSEEPAGE

The term underseepage, or underseepage process, is commonly used to denote water transmitted landward from the river under a levee rather than through a levee (through seepage). Seepage which results from such subterranean flow may be general, i.e., occurs along the levee and for considerable distance landside, or it may be localized to areas close to the landside toe of the levee. A sand boil is a special type of localized seepage, where the flow of water is concentrated at a point.

Underseepage is a high-water phenomenon which is controlled by two principal factors; the layering of the alluvial deposits in a relatively impermeable top stratum underlain by a permeable substratum, and excessive substratum pressures developed when the column of river water rises high above the natural ground surface between artificial levees.

Inasmuch as the principal factors controlling underseepage are everywhere present along the levee during high-water stages, the occurrence of seepage at a given locality must of necessity result from conditions peculiar to that seepage site. These local conditions, secondary factors, result from top stratum weakness, and from irregularities in distribution of the alluvial deposits. Most local weaknesses in the top stratum deposits have been formed artificially although some are the result of natural processes or are related to properties of the deposits.

Relation of underseepage to the distribution of alluvial deposits

Studies were made of a large number of sites where underseepage occurred in 1937. Almost without exception, seepage occurred in those areas where the previous substratum approached the surface. Most of the high substratum areas were the narrow ridges which alternate with swales in point bars. Underseepage does not occur in the swales nor has it been recorded in areas where the top stratum is abnormally thick. The distribution of alluvial deposits in areas where underseepage has not been

recorded are shown on the cross sections of Figure 1. The general nature of the distribution of deposits in areas where seepage was widespread is shown on Figure 2, and the distribution in areas where seepage was confined to the toe of the levee is shown on Figures 3 and 4. An example of possible seepage through the levee is shown on Figure 5.

Movement of subsurface water during change in river stage

In a geological examination made of an underseepage site in the vicinity of Louisiana State University at Baton Rouge, seepage was found to be localized to ridges of a typical “Ridge and Swale” topography of an old point bar. Piezometer wells are installed, some wells being approximately a mile from the landside toe of the levee. Daily readings were made of water level in the wells and correlations were made with river stages. It was found that there was only a short lag between the rise of river stage and the rise of water level in the wells. Plotting of the pressure readings showed conclusively that pressures were translated more rapidly in the substratum underlying the ridges than in the substratum underlying the swales. This was true not only during rising stages but in falling stages when the pressure transfer was riverward. Irregularities in pressure transfer, however, were more pronounced at a distance from the river during rising stages and more pronounced near the river during falling stages. No satisfactory explanation can be presented for this condition except for a possibly higher permeability of the substratum ridge sediments.

The pressures were transferred landward with an irregular steep front. This steep frontal zone was first developed close to the artificial levee and was gradually forced landward by the rise in pressure associated with the rise in river level. Riverward transfer of pressure lagged behind the drop in river stage so that the steep “frontal” area remained as a low pressure ridge during falling stages.

Figure 1.

Figure 2. (Note the cover photo of this report).

Figure 3.

Figure 4.

Figure 5.

Appendix C: 47 Levee Code

WAR DEPARTMENT

CORPS OF ENGINEERS

MISSISSIPPI RIVER COMMISSION

CODE FOR UTILIZATION
OF
SOILS DATA FOR LEVEES

MISSISSIPPI RIVER COMMISSION

VICKSBURG, MISSISSIPPI

APRIL 1947

O. L. KATOLICH
DESIGN BRANCH
J. H. WHITLEY, JR.
DESIGN BR.

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LMVVY

CORPS OF ENGINEERS, U. S. ARMY
Office of the President
MISSISSIPPI RIVER COMMISSION
Vicksburg, Mississippi

15 MAY 1956

SUBJECT: Design Section for Levees

TO: District Engineer, Memphis District, CE, Memphis, Tenn.
District Engineer, Vicksburg District, CE, Vicksburg, Miss.
District Engineer, New Orleans District, CE, New Orleans, La.
(COPY TO EACH)

1. Reference: War Department Pamphlet, Corps of Engineers, Mississippi River Commission, entitled: "Code for Utilization of Soils Data for Levees," dated April 1947.

2. In order to establish a more uniform procedure for the planning and construction of levees, the following criteria will be applied to all main stem levee construction on the Mississippi River between Cape Girardeau and Baton Rouge:

a. All new levees, plus those not yet constructed to authorized grade, will be designed to fit the 1947 Code Section.

b. Existing levees which are up to authorized grade, but deficient in "B" Section, will be designed to fit the 1947 Code Section.

c. Existing levees which are up to authorized grade and contain the "B" Section, but require berms and/or impervious blankets to correct a serious seepage condition, will be designed to fit the 1947 Code Section.

d. Existing levees which are up to authorized grade, contain the "B" Section and have no seepage or foundation problem, but require a wider roadway, will be altered only to the extent necessary to widen the roadway in accordance with the standard levee specifications.

e. For existing levees which are up to authorized grade, contain the "B" Section, but whose slopes are less than 1 on 3-1/2 to a degree that seriously hampers performance of satisfactory maintenance, consideration will be given to effecting slope adjustments to conform to the 1947 Code Section.

f. In all cases of requests for levee enlargement due to serious seepage and/or foundation conditions, field data on soil classification

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SUBJECT: Design Section for Levees

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SUBJECT: Design Section for Levees

and general conditions will be submitted in sufficient detail to permit a reasonable appraisal of conditions to support the request.

3. Levee cross sections will be applied to the project flow line as base of reference when checking existing levee embankments for adequacy to meet the "B" Section or 1947 Code Section as referred to herein.

4. The "1947 Code" Section and the "B" Section as mentioned herein are defined as follows:

The average line springs from the riverside slope at the elevation a. 1947 Code Section. flow line. The landside slope shall extend in a straight line from the landside edge of the crown to the point where the average line intersects the ground surface.

Designation	Type of Construction	Cross Section
1.	New levee; compacted to maximum density at optimum moisture content. Comparable to earth dam construction.	Riverside slope, 1 on 3-1/2. Crown, horizontal, 10 ft. wide. Landside slope, 1 on 4-1/2.
2.	New levee; moderate degree of compaction at natural moisture content; uncompacted fills of materials which are too wet for compaction.	<u>Levees less than 25 ft. in Height</u> Riverside slope, 1 on 4. Crown, horizontal, 10 ft. wide. Landside slope, 1 on 5-1/2. <u>Levees, 25 ft. or higher</u> Riverside slope, 1 on 4. Crown, horizontal, 10 ft. wide. Landside slope, 1 on 6.
3.	New levee; uncompacted emergency construction, material sufficiently dry for a moderate degree of compaction	Riverside slope, 1 on 4-1/2. Crown, horizontal, 10 ft. wide. Landside slope, 1 on 6-1/2.
4.	Enlargement	For enlargement work the existing levee shall be considered as a semi-compacted fill. Crown width and slopes shall be as prescribed above for the type of construction involved.

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SUBJECT: Design Section for Levees

1953

b. 1928 "B" Cross Section - net dimensions.

Crown width 10.0 ft.

Riverside slope 1 on 3-1/2

Landside slope to contain seepage line on 1 on 6-1/2.

The seepage line springs from the riverside slope at the elevation of the assumed maximum flow line. The landside slope shall extend in a straight line from the landside edge of the crown to the point where the seepage line intersects the ground surface.

/s/ John R. Hardin

JOHN R. HARDIN

Major General, USA

President, Mississippi River Commission

WAR DEPARTMENT
CORPS OF ENGINEERS
Office of the President
MISSISSIPPI RIVER COMMISSION
Vicksburg, Mississippi

LMVKE

6 DEC 1955

SUBJECT: Code for Utilization of Soils Data for Levees

TO: District Engineer, Memphis District, CE, Memphis, Tenn.
District Engineer, Vicksburg District, CE, Vicksburg, Miss.
District Engineer, New Orleans District, CE, New Orleans, La.
(COPY TO EACH)

1. Reference is made to letters of this office, subject "Review of Code for Design and Construction of Levees" dated 7 and 30 June 1955 convening a committee meeting on 7 July 1955 to discuss the need for revising the foundation settlement and shrinkage provisions of the subject code.

2. The code provisions for levee enlargements, as published, are subject to variable interpretations. The code committee, therefore, suggested certain modifications which, I believe, establish a sound basis for design and will lead to a more uniform treatment throughout the division. Accordingly, the following modifications are approved and should be made effective in all future design and construction of levee work:

a. Par 41, Special Sections, Page 11, add the following sentence at the end of the paragraph, "Minor topping and correction of slope deficiencies will be guided by practical considerations with the general objective of restoring the original design".

b. Par 46, Page 12, delete this paragraph in its entirety and substitute the following:

"The need for foundation settlement allowances for levee enlargements shall be determined on the basis of best methods, data, and information available, and shrinkage allowances shall be the same as those shown in paragraph 45. The construction gross grade shall not exceed the theoretical gross grade, based upon settlement and shrinkage calculations, by more than 0.5 ft".

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SUBJECT: Code Utilization of Soils Data for Levees

c. Par 72, Freeboard, Page 19, add the following sentence between the 2nd and 3rd sentences, "The remainder of this paragraph indicates the expressed desires of the Code Committee; however, their statements cannot be held to violate officially prescribed freeboards".

3. In addition to the above modifications, the Waterways Experiment Station has made up a table on soils classification to replace figures 1 and 2. This table contains essential data shown in table 1 of TM No. 3-357 (Unified Soil Classification System) and table A-1 of Appendix A thereto. Copies of this table are available and will be furnished for the copies in your district. This office should be advised as to the number of copies required.

4. The code is in need of other minor modifications to bring the text up to date, however, it is not proposed to make these additional changes until a new issue of the code is warranted.

/s/ John R. Hardin

1 Incl:
Table 1

JOHN R. HARDIN
Brigadier General, USA
President, Mississippi River
Commission

THEATER OF OPERATIONS AIRFIELD SPECIFICATIONS

Features	Categories		
	1	2	3
RUNWAY GRADES:			
Longitudinal max	1.5%	1.5%	1.0%
Transverse required	1.5%	1.5%	1.5%
SHOULDER GRADES:			
Minimum	2.0%	2.0%	2.0%
Maximum	3.0%	3.0%	3.0%
TAXIWAY GRADES:			
Longitudinal max ¹	3.0%	3.0%	3.0%
Transverse required	1.5%	1.5%	1.5%
RUNWAY:			
Length ²	4,500'	6,000'	8,000' ³
Width	120'	150'	200'-300'
Shoulder	50'	50'	50'
CLEARANCE:			
Center line runway to obstacle	210'	275'	350'-500'
Center line runway to center line taxiway	485'	512.5'	637.5'-700'
Center to center of parallel runways	500'	750'	1,000'
10' elevation sight distance	3,500'	5,000'	6,000'
CLEAR ZONE:			
Length	500'	1,000'	1,000'
Width	420'	550'	700'-1000'
OVERRUN:			
Length	500'	1,000'	1,000'
Width	220'	250'	300'-400'
TAXIWAY:			
Width	50'	75'	75'-100'
Shoulders	12.5'	12.5'	12.5'
Clearance from center line of taxiway	85'	97.5'	137.5'-200'
APPROACH ZONE:			
Glide angle	1:40	1:50	1:50
Length	2 mi	2 mi	5 mi - 10 mi
Width at opening	3,000'	4,000'	4,000'
HARDSTANDS:			
Diameter	70'-100'	100'	120'-160'
Center to center spacing	300'	400'	400'-500'
Clearance from taxiway center line	85'-125'	137.5'	137.5'-250'
Clearance from runway center line	210'	275'	400'-450'
DESIGN WHEEL LOADING:			
Runway	16,000#	40,000#	70,000#-150,000#
Taxiway	20,000#	50,000#	87,500#-187,500#
Hardstand	20,000#	50,000#	87,500#-187,500#
Apron	20,000#	50,000#	87,500#-187,500#

NOTES:

- ¹ — May be increased to 5% for a length not in excess of 400'.
² — 5% increase for each 1000' above sea level.
³ — Capable of development to 10,000' where possible.

AIRFIELD CATEGORIES:

- 1 — Light transport and interceptor fighters.
2 — Medium transports, jet fighters, long range fighters and light bombers.
3 — Heavy transports and heavy bombers.

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Major divisions	Soil groups and typical names	Suggested group symbols	General identification		Observation and tests relating to material in place	Principal classification tests (on disturbed samples)	Value as foundation when not subject to frost action	Value as base directly under wearing surface	Potential frost action	Shrinkage, expansion, elasticity	Drainage characteristics	Compaction characteristics and equipment	Solids at opt. compaction lb. per cu. ft. and void ratio, e	California bearing ratio for compacted and soaked specimen	Comparable groups in public roads classification
			Dry strength	Other pertinent examination											
Coarse grained soils	Gravel	GW	None	Gradation, grain shape	Dry unit weight or void ratio,	Mechanical analysis	Excellent	Good to excellent	None to very slight	Almost none	Excellent	Excellent, tractor	>125 e<0.35	>50	A-3
	and	GC	Medium to high	Gradation, grain shape binder exam. wet and dry	Degree of compaction,	Mechanical analysis, liquid and plastic limits on binder	Excellent	Fair to excellent	Medium	Very slight	Practically impervious	Excellent tamping roller	>130 e<0.30	>40	A-1
	gravelly	GP	None	Gradation, grain shape	Cementation, durability of grains,	Mechanical analysis	Good to excellent	Poor to good	None to very slight	Almost none	Excellent	Good tractor	>115 e<0.45	25-60	A-3
	soils	GF	Very slight to high	Gradation, grain shape binder exam. wet and dry	Stratification and drainage characteristics,	Mechanical analysis, liquid and plastic limits on binder if applicable	Good to excellent	Poor to good	Slight to medium	Almost none to slight	Fair to practically impervious	Good, close control essential, rubber tired roller, tractor	>120 e<0.40	>20	A-2
	Sands	SW	None	Gradation, grain shape	Ground water conditions,	Mechanical analysis	Good to excellent	Poor to good	None to very slight	Almost none	Excellent	Excellent, tractor	>120 e<0.40	20-60	A-3
	and	SC	Medium to high	Gradation, grain shape binder exam. wet and dry	Traffic tests,	Mechanical analysis, liquid and plastic limits on binder	Good to excellent	Poor to good	Medium	Very slight	Practically impervious	Excellent, tamping roller	>125 e<0.35	20-60	A-1
	sandy	SP	None	Gradation, grain shape	Large scale load tests or	Mechanical analysis	Fair to good	Not suitable	None to very slight	Almost none	Excellent	Good, tractor	>100 e<0.70	10-30	A-3
	soils	SF	Very slight to high	Gradation, binder exam. wet and dry	California Bearing tests	Mechanical analysis, liquid and plastic limits on binder if applicable	Fair to good	Not suitable	Slight to high	Almost none to medium	Fair to practically impervious	Good, close control essential, rubber tired roller	>105 e<0.60	8-30	A-2
	Fine grained soils having	ML	Very slight to medium	Examination wet (shaking test and plasticity)	Dry unit weight, water content and void ratio,	Mechanical analysis, liquid and plastic limits if applicable	Fair to poor	Not suitable	Medium to very high	Slight to medium	Fair to poor	Good to poor, close control essential, rubber tired roller	>100 e<0.70	6-25	A-4 A-6 A-7
	low to medium compressibility	CL	Medium to high	Examination in plastic range	Consistency—undisturbed and remolded,	Liquid and plastic limits	Fair to poor	Not suitable	Medium to high	Medium	Practically impervious	Fair to good, tamping roller	>100 e<0.70	4-15	A-4 A-6 A-7
	High compressibility	OL	Slight to medium	Examination in plastic range, odor	Stratification, root holes, fissures, etc.	Liquid and plastic limits from natural condition and after oven drying	Poor	Not suitable	Medium to high	Medium to high	Poor	Fair to poor, tamping roller	>90 e<0.90	3-8	A-4 A-7
	Fine grained soils having high compressibility	MH	Very slight to medium	Examination wet (shaking test and plasticity)	Drainage and ground water conditions,	Mechanical analysis, liquid and plastic limits if applicable	Poor	Not suitable	Medium to very high	High	Fair to poor	Poor to very poor	<100 e>0.70	<7	A-5
Fine grained soils containing little or no coarse grained material	high compressibility	CH	High	Examination in plastic range	Traffic tests, Large scale load tests,	Liquid and plastic limits	Poor to very poor	Not suitable	Medium	High	Practically impervious	Fair to poor tamping roller	>90 e<0.90	<6	A-6 A-7
	high compressibility	OH	High	Examination in plastic range, odor	California bearing tests or	Liquid and plastic limits from natural condition and after oven drying	Very poor	Not suitable	Medium	High	Practically impervious	Poor to very poor	>100 e<0.70	<4	A-7 A-8
	Fibrous organic soils with very high compressibility	Pt	Readily identified		Consistency, texture and natural water content		Extremely poor	Not suitable	Slight	Very high	Fair to poor	Compaction not practical			A-8

LEGEND FOR GROUP SYMBOLS

NOTE: In Column 7, values are for subgrade and base courses, except for base courses directly under wearing surface.

NOTE: Values in Columns 7 and 8 are for guidance only. Design should be based on test results in accordance with text.

NOTE: Unit weights in Column 13 apply only to soils with specific gravities ranging between 2.65 and 2.75.

G — GRAVEL
S — SAND
M — MO. VERY FINE SAND, SILT, ROCK FLOUR
C — CLAY
Pt — PEAT

F — FINES, MATERIAL <0.1MM
O — ORGANIC
W — WELL GRADED
P — POORLY GRADED
L — LOW TO MEDIUM COMPRESSIBILITY
H — HIGH COMPRESSIBILITY

C
O
P
Y

WAR DEPARTMENT
CORPS OF ENGINEERS
Office of the President
Mississippi River Commission
Vicksburg, Mississippi

LMVKL

JAN 13 1948

SUBJECT: Modification of Levee Specifications

TO: The District Engineer, Memphis District, CE, Memphis, Tenn.;
Vicksburg District, CE, Vicksburg, Miss.; and New Orleans
District, CE, New Orleans, La. (COPY TO EACH)

1. The Mississippi Valley Flood Control Branch of the Associated General Contractors requested a conference for the purpose of discussing certain provisions of the currently standard specification for levee construction. The conference was held on 15 December 1947 and it was tentatively agreed to try out the following changes for the period of one year in the interest of reducing bid prices by removing penalties and what appear to be unnecessary restrictions:

Par. 7. As now written this paragraph permits payment of only 67½% of the value of the yardage in a station of levee fully completed except for dressing and sodding. The contractors aver that they sometimes are delayed in sodding by labor shortages due to cotton picking, and other causes not their fault, and feel that inasmuch as the 10% retained percentage withheld until final acceptance is more than ample to cover the cost of sodding, the restriction of payment to 67½% (75% less 10%) instead of to 90% for levee fully completed otherwise often imposes unreasonable financing difficulties.

Par. 14. As now written paragraph 14 requires the contractor to furnish inspection forces with lodging at fifty cents a night and meals at thirty cents each. Since the services obviously can not be furnished for such prices it is proposed to raise the rates to those now applicable to transients on Government boats and quarterboats, namely \$1.00 for lodging, seventy-five cents for each meal. The contractor never knows just how much he will lose on the present rates since he does not know how many men will be quartered on him, so he probably puts a liberal contingency allowance in his bid.

Par. 18. The present wording of paragraph 18 requires the contractor to clear and grub the levee foundation but makes no allowance for paying for refill of stump holes. Former issues of specifications did provide for payment of refill yardage at contract unit price. The omission in the current issue was based upon the widespread use of bull-

LMVKL

SUBJECT: Modification of Levee Specifications

dozers for clearing and grubbing and the difficulty under such conditions, of accurately measuring the holes.

The contractors allege that a great deal of their clearing and grubbing still requires hand operation, and that where bulldozer grubbing is used, an arbitrary yardage allowance based upon diameter of tree will be satisfactory.

This they apparently feel will largely remove the uncertainty as to how much to increase the unit price bid for embankment yardage in order to make themselves whole in the matter of foundation preparation.

Par. 20. The contractors ask that when the compaction methods called for by Par. 20(b) are prescribed, separate payment be made for adding water to the material preparatory to rolling when such addition is required by the contracting officer. Paragraph 20(b) relates to rolled fill construction comparable to that of a rolled fill dam. It is applicable only to soils whose moisture content approaches optimum and because of the high moisture contents of the natural soils in the lower valley we have not yet prescribed such construction and are not likely to prescribe it very often. Thus the change desired by the contractors may be somewhat academic in nature but no objection is seen to incorporating it in the interest of avoiding uncertainty in bids. It seems preferable to state a price in paragraph 34 rather than to have the bidder name a price for the addition of water. The amount to be added is altogether indeterminate and is quite likely to be nil, and the making of award should not be further complicated by having to consider it.

Par. 35. Paragraph 35 forbids any reduction in the capacity of the plant employed on the work except by written permission of the contracting officer. This paragraph has become a source of irritation and expense to the contractors, and in some respects apparently militates against the Federal interest. The contractors hesitate to throw in added equipment which becomes available for a period between other commitments, because once they get it on the job they have no assurance whatever that they will ever be able to remove it until the job is completed. They had even been refused permission upon occasion to return special plant borrowed from the county for a specific term and function. On the basis of the representations made I agreed to see how we got along without the provision for one year.

2. The attached copy of specifications has been modified in red to incorporate the changes discussed above. These modifications have been approved by the Chief of Engineers, and it is requested that these modifications be incorporated in all future levee specifications. Until such

LMVKL

SUBJECT: Modification of Levee Specifications

time as these paragraphs can be modified and new pages reprinted, these modifications may be covered in paragraph 34. On work that has been advertised, modification of the specifications should be accomplished by the issuance of an addendum.

3. It is further requested that your forces check and report upon the effects of these modifications during the period agreed upon for their trial, at the end of which time the situation will be resurveyed and such action recommended as study indicates to be desirable.

4. This office should be notified immediately of the quantity of modified pages needed to supersede copies now on hand.

R. W. CRAWFORD
Major General, U. S. Army
President, Mississippi River Commission

1 Incl:

Cy Specs as modified

WAR DEPARTMENT
CORPS OF ENGINEERS
MISSISSIPPI RIVER COMMISSION

CODE FOR UTILIZATION
OF
SOILS DATA FOR LEVEES

MISSISSIPPI RIVER COMMISSION
VICKSBURG, MISSISSIPPI

APRIL 1947

CODE FOR UTILIZATION OF SOILS DATA FOR LEVEES

Introduction

1. The Board for Utilization of Soils Data for Levees was established by Special Orders No. 79-1/2, dated 26 September 1945, issued by M. C. Tyler, Brigadier General, Corps of Engineers, President, Mississippi River Commission. The mission of this Board was to make a complete review of current practices and technique in order to bring up to date the Mississippi River Commission soils mechanics and levee code which was developed by a similar Board in October 1941. The Board convened on 8 November 1945 and three subcommittees, namely, Planning, Design and Construction, and Exploration and Testing, were appointed to make a study of practices from 1941 to the present, in order that the 1941 code could be brought up to date. The three committees have convened in numerous meetings since 8 November 1945 and after consideration of the numerous problems involved since adoption of the 1941 code recommend certain general policies with respect to planning, exploration, testing, design, and construction of main line Mississippi River levees, and the application of the same general principles to other levees, insofar as may appear practicable and necessary.

Purpose

2. The primary purpose and objective of this Board was to revise the 1941 Levee and Soils Code to take advantage of the following specifically listed items in the planning, investigation, testing, design, and construction of levees.

a. Utilize all the geological data which have been obtained to date in the development of more intelligent and economical plans, specifications, and design for levees. The geological data will assist materially in the delineation of areas which are obviously safe for levee construction from those areas which are definitely critical as far as safety is concerned. In the safe areas a minimum of field investigation coupled with a standard levee design for simplification and economy will be the goal of the new code. In the critical areas, more detailed investigations and special design procedures than those now followed will prove to be desirable.

b. Eliminate obsolete methods and procedures in design and construction and take advantage of new and improve methods and procedures.

c. By means of a. & b. above, develop a new code for planning, investigation, design, and construction, which is practicable in application, yet furnishes the necessary safety and economy for levees.

Planning

Location Planning

3. General. Planning for levee improvements must of necessity treat with many and varied problems. The type of levee improvements as between enlargement and new levee is determined primarily by an estimation of the anticipated life of the existing levee. There are several controlling factors which are taken into consideration in planning levee improvements. Availability of funds is the first factor which determines the amount of work which can be performed. The nature and location of the improvement must recognize the following additional factors: urgency; availability of rights-of-way; land and crop values; effect of current scour; foundation conditions and availability of suitable borrow materials; changes in alignment of rivers as affected by existing and natural causes, or as influenced by revetments, dikes, channel dredging, improvement dredging, cutoffs; and by improvements, such as highway and railroad bridges, pipe lines, and population centers.

4. Recognition must also be given to the possibility of affording economical protection by revetments, dikes, or channel improvements in lieu of setting a levee back from a caving bank. Future planning should also be coordinated with the Channel Stabilization Program now authorized; a program which is planned to eliminate to a large extent the necessity for future levee relocation.

5. Levee planning should be separated into two major parts; the Annual and Long Range Programs. The Annual Program should deal with levee improvements of immediate need. The Long Range Program should procure all pertinent geological data needed in preparation of the Annual Program and should be closely coordinated with the Bank Stabilization Program (which may indicate the need for future levee relocation).

6. Geological studies recently completed by the Mississippi River Commission have demonstrated that geological data can be utilized profitably in both the Annual and Long Range Programs. The Commission staff should include a sufficient number of competent alluvial geologists. As an aid in arriving at better solutions to the problems concerned with the location and construction of levees, geological studies should be used as follows.

7. Annual program. In areas where levee improvements are to be undertaken by the District Engineer, a geological examination should constitute the preliminary step in the Engineering Studies.

8. The function of the geologist is to advise the engineers in charge of investigation, design, construction, and maintenance of levees as to the general nature and distribution of alluvial deposits and faults in the vicinity of proposed levee works. These initial studies should permit the isolation of critical areas in which foundation weaknesses

and/or seepage problems would be likely to occur. The soil mechanics engineer should review the geological data and advise the design engineer where critical areas are located and what additional exploration or studies are required.

9. Preliminary geological studies would also present information as to the source areas for construction materials.

10. Long range program. Competent alluvial geologists should integrate the several types of data pertinent to levee planning, construction and maintenance, together with data for dredging and channel stabilization. Interpretations should be made of aerial photographs, mapped alluvial valley deposits and all subsurface data, such as logs of borings and seismic records. The geologists should coordinate these basic data for the engineers in charge of the various phases of river control.

11. Predictions of river behavior based upon the systematic geological studies should permit judicious opinions concerning; (a) maximum extent of local channel migration; (b) rate or rates of migration, and (c) areas which will be destroyed by channel migration. The engineer should utilize the above-mentioned data in determining the necessity of and the most advantageous method for treatment.

12. Accumulated geological data should be utilized by the engineer in hydraulic model studies, which should supplement engineering studies and form a new guide for predicting the pattern of future river changes.

13. Upon completion of each geological study, data should be forwarded to the district concerned in the form of a detailed report containing all pertinent information.

Construction planning

14. General. The technique of levee construction has progressed tremendously since its inception. Development of new methods and equipment has resulted in an enormous increase in ability to do work, in greatly reduced costs, and in construction of better levees. Tower excavators, large draglines, and efficient hauling units are examples of developments in equipment. The increase in soil mechanics knowledge has resulted in construction of better levees. Plans for work should be so drawn as to encourage the development of improved methods and equipment which would produce better and more economical levees.

15. Time for construction. In cases where it is neither necessary nor advantageous to complete the work in one season, the specifications should provide for construction in two or more working seasons. Every effort should be made to plan the investigation, design and advertisement of the work that full advantage is taken of the favorable construction season.

16. Drainage. In heavily wooded areas, or where the existing drainage is poor, consideration should be given to clearing and draining the site of the work well in advance of construction. The drainage of borrow pits is not essential, except where located near population centers and adjacent to caving or revetted banks. All borrow pits within approximately 1,000 feet of caving or revetted banks should be drained to avoid increasing the water pressure behind these banks when the water in the river recedes, and to reduce sloughing. Borrow pits in the vicinity of population centers should be drained for mosquito control. Any necessary drainage of borrow pits, should, if feasible, be included in the plans for levee construction. (Local interests should be urged to provide landside drainage ditches for the purpose of removing excess water from the levee toe. These ditches should be excavated only to depths sufficient to provide adequate drainage.)

17. Access roads, roadways, etc. For purposes of inspection and flood fighting, access roads should be provided in cooperation with state and local authorities so that all levees can be reached at reasonably close intervals by all-weather roads. A levee roadway 15 feet in width should be added to all main Mississippi River levees, except in urban areas. On tributary and backwater levees, a total crown width of at least 14 feet should be provided. As time and funds permit, the crowns of the more inaccessible levees should be surfaced for all-weather traffic. Road crossings of suitable dimensions should be provided at convenient locations and intervals. Except when set up for use on future enlargement work, the exact location for traverses or road crossings should not be specified, but should be left to the judgment and decision of the contracting officer's field representative, as he is more familiar with the local conditions and can shift them where they would be better located, thus obtaining closer harmony with the local interests. In general, no large amount of road surfacing should be undertaken until the more essential job of strengthening the levees is completed.

18. Wave wash protection. All levees that are exposed to excessive wave action during high-water periods should be protected. The protective structures should be sufficiently strong to resist not only wave action but also the pounding of drift and floating debris. Concrete and asphalt pavements of good quality on a well-prepared foundation are considered to be the preferable forms of protection for reasonably permanent levees.

Exploration and Testing

General

19. A field exploration manual should be prepared by the Mississippi River Commission to properly coordinate and standardize the

exploration work of the three Districts.

Location, number and
depth of borings

20. Preliminary borings for the delineation of pertinent geological features should be located by a competent geologist in cooperation with the soil mechanics engineer. The borings should be so located that the nature of the materials will be determined in sufficient detail to fully verify the geological picture of the foundation conditions. Additional borings for determining the general suitability of the levee foundations with respect to soil mechanics should be located. After a thorough review of all borings by the soil mechanics engineer, it may be desirable to further explore certain critical areas. In accretion areas, foundation borings should be sufficiently deep to assure penetration into clean sand. In thick backswamp deposits where unstable foundation materials are encountered, such materials should, in general, be completely penetrated by the borings, but the latter need not necessarily be carried to clean sand. In both cases the minimum depth of the borings should not be less than the height of the levee. At intervals of about one mile borings should be extended completely through the pervious sands and gravels into the tertiary materials to furnish data on the general underseepage problem. For new levees, foundation borings should be located along the proposed center line, and for enlargements along the riverside toe of the existing levee. Full use should be made of all existing reliable data.

21. Borrow pit borings should be located on the recommendations of a qualified geologist in cooperation with the soil mechanics engineer at locations such that the occurrence of the different types of deposits representative of the borrow pits will be developed. As drilling operations progress, additional borings required for the determination of the extent of occurrence of materials with excessive water content, or for other considerations of an engineering nature, should be located by the soil mechanics engineer. The depth of exploration should be limited to the estimated practical depth of excavation, or as other controlling factors may dictate.

Methods of subsurface exploration

22. Boring equipment used should be capable of making borings suitable for obtaining the desired information. Wash borings, or borings which do not yield a complete log from top to bottom of hole should be avoided, except for special studies for which they may be suitable. Disturbed samples should be placed in suitable airtight containers, which should be filled as nearly as practicable with the material being sampled and carefully sealed to prevent loss of moisture from the sample during shipment to the laboratory. Undisturbed samples for shear or consolidation tests should be approximately 5 inches in diameter and should be taken in sufficient number to properly evaluate the shear strength of the foundation being studied. Undisturbed samples

should rarely, if ever, be taken from borrow pit borings, unless other drilling methods will not yield accurate water contents. In all cases, care should be exercised to obtain samples with water contents as nearly as possible equal to those in the natural materials, by removing excess water from the surface of clay cuttings, or by any other method required. Great care should be exercised in taking disturbed samples of sands and gravels to insure that true representation as to gradation is obtained. Such samples are necessary to gain information on the permeability characteristics of the materials and probable severity of underseepage. In locations where underseepage is definitely known to be a very critical problem, it may be necessary to take undisturbed samples of the granular material by the freezing method for a more accurate determination of the permeability characteristics. (Test pits, trenches, probings, and geophysical methods should, in general, not be used for subsurface explorations on routine levee investigations.)

Record keeping

23. Detailed field and laboratory log files and location maps of all borings taken should be maintained, and a copy of all field or laboratory logs with location maps should be furnished the geologist and soil mechanics engineer for their use.

Standard laboratory methods of testing

24. A laboratory testing manual should be prepared by the Mississippi River Commission to properly coordinate the testing procedures of the three districts.

Extent of laboratory testing required

25. The absolute minimum of laboratory testing required for routine levee design should consist of the following: (1) visual classification of all samples; (2) sufficient mechanical analyses to check and assure accurate visual classification; (3) water content determinations on cohesive materials as indicated from the visual classification, (4) Atterberg limits of a representative number of all materials with high water contents, and (5) effective size of pervious material to appraise underseepage potentiality. If, at this point in the laboratory investigation, it is seen that nowhere on the levees under consideration, either embankment or foundation, are there any materials with water contents which appear too high for safety for the materials as visually classified, it is not absolutely essential that further tests or a special design be made. Such conditions normally exist over the major portions of the levee, but over some portions of most items of work it is usually indicated that further tests are needed, to assure safety and to design special berms to protect the standard cross sections. The indications of where a special design for stability is required should be based on comparisons of Atterberg limits with natural water content and soil type. Usually, if the

plasticity index of a soil is more than 25, and if its natural water content minus the plastic limit is less than 25 per cent of the plasticity index, no difficulties with weak foundation material or wet borrow material are indicated. However, when slightly plastic borrow materials with plasticity indices less than 6 and water contents greater than the plastic limit are encountered, handling difficulties may be experienced, but probably no foundation trouble will be encountered. Decision as to further testing for stability should be made by the soil mechanics engineer from the data obtained from visual classification, water content and Atterberg limit determinations, as explained above, but should also be based on experience with the shear characteristics of the material in the vicinity. If there is indication of water contents in excess of those outlined above for the materials encountered in the foundation, undisturbed samples should be taken for shear testing. For information on the probable severity of underseepage the uniformity coefficient should be determined from the mechanical analysis of the granular materials.

26. Tests other than those given above may be required for special cases where the stability on underseepage problems are critical, but should be held to a minimum. These tests may consist of one or more of the following; compaction, consolidation, solubility, specific gravity (other than those made in connection with shear or compaction data), and permeability. As a general rule, shear data on actual undisturbed foundation materials should be used for design.

Field testing

27. Field testing should generally be limited to visual classification and, in some cases, water content and density determinations. Simple field in-place permeability tests may be run in bore holes where the underseepage problem appears to be critical. Data from this test may be used to assist in designing the most economical and effective treatment for underseepage. Field tests of large scope are considered to be special items and are, therefore, not covered by the provisions of this Code.

Soil classification and legend

28. Soils should be classified in accordance with the LMVD classification on the basis of mechanical analysis. A classification triangle for this classification is shown on figure 1. The legend shown on figure 2 should be used in plotting borings for use on contract drawings. (See Geological Section about color legend.)

Definition of impervious soil

29. The present limitation on permeability of 1×10^{-5} cm/sec. is too restrictive and often results in unduly expensive work, consequently this factor should be increased to 1×10^{-4} cm/sec.

Record keeping

30. Records of tests made should be kept in laboratory files in permanent form. Files should consist of summarized data in graphical or tabular form, and not necessarily of laboratory data sheets. A shear-test record, similar to that shown on figure 3 and containing stress-strain curves and shear diagram is a satisfactory type of sheet for record purposes. Similar sheets should be devised for other tests to show the data.

Design

General

31. During the past few years two standard levee sections have been used; i.e., "Compacted" and "Uncompacted." Interviews with the Districts and data obtained from investigations during construction make it appear both desirable and practicable to use three standard cross sections rather than two. The three types of cross sections recommended are as follows:

a. Type 1. Slightly smaller than the present compacted cross section. Compacted to maximum density at optimum moisture content. Comparable to earth dam construction.

b. Type 2. Intermediate in size between compacted and uncompacted fill. Embankments having a moderate degree of compaction at natural moisture content. Uncompacted fills of material which is too wet for compaction.

c. Type 3. Moderately larger than the present uncompacted cross section. Uncompacted emergency construction of relative dry material, that is, material sufficiently dry for a moderate degree of compaction. The reasons for adopting the three cross sections as standards and more detailed description of their characteristics are given in the following paragraphs.

32. The advantages of levees constructed of compacted material are fully recognized. However, one of the fundamental factors which controls compaction is the moisture content of the soil. Moisture control in levee construction has been and will be impractical. This view is generally entertained by all offices interested in levee construction in the Lower Mississippi Valley. There are many jobs on which the water content of the soil is too high to permit 100 per cent standard Proctor compaction being obtained, but yet the soil can be compacted to a worthwhile degree. One of the primary reasons for type 2 construction is to obtain, at a minimum cost, the maximum practicable compaction on soils containing excess moisture. On such work, the compaction obtained under the present "compaction" specifications has been, in general, no more than can be

obtained under the specifications for type 2 fill, proposed in this Code. This statement is verified by the graph of figure 4, which shows the relationship between per cent compaction and moisture content for both the present compacted and uncompacted fill specifications using hauling equipment. Insertion of the type 2 section will allow more flexibility in construction procedures, and should lead to improved procedures and equipment which will result in greater speed and economy of construction.

33. The rainfall throughout the Lower Mississippi Valley is heavy and fairly well distributed throughout the year. The ground-water table is ordinarily near the surface, so that ground water is usually encountered in borrow pits of any appreciable depth. Prolonged bankfull stages or higher stages of the Mississippi River saturate the surrounding country. These conditions stop levee construction entirely for a considerable portion of the year and reduce the efficiency of construction operations during much of the remaining portion. All types of construction equipment are affected, but hauling equipment is more severely handicapped than long-boom draglines or tower machines. Figure 5 attached shows the relationship between hauled and cast-in-place fills (data averaged for the Vicksburg and New Orleans districts) with respect to lost time due to weather. This figure shows that draglines are considerably better adapted to perform work in the winter and spring months, while there appears to be only a slight advantage to the dragline during the summer and fall months. Because of its dependency upon favorable weather and working conditions, hauling equipment cannot be relied upon for emergency work (setback levees). In order to be able to meet emergencies, when the soil is too wet for compaction, it is highly desirable to have available the equipment best suited to cope with adverse conditions; namely, draglines and tower machines. Such equipment will not be available if contractors cannot be assured of a reasonable and continual volume of work. A method of construction utilizing draglines, supplemented by some other type of equipment, such as bulldozers, should be developed for type 2 construction so as to provide work for large draglines in sufficient volume to insure their remaining available.

34. Past experience has proven that satisfactory levees can be constructed of uncompacted material. However, in some instances compacted impervious facings should be added, and a larger cross section provided to achieve parity in strength with compacted levees. Therefore, the uncompacted section is retained for use where any form of compaction is obviously impracticable, or as an emergency measure, when the soil is too wet for compaction.

Cross section

35. General. The Board has arbitrarily assumed that the unit shearing strength of the type 1 section is 100 per cent; of the type 2 section, 90 per cent, and of the type 3 section, 80 per cent. These strength figures were used in arriving at approximately uniform stability for the types 1, 2 and 3 levee sections. An exception to this assumption is the inclusion of the wet loose fill construction in the type 2 section. The

justification for this is, first, from a practical viewpoint the change from a semi-compacted method of construction to a loose fill method can be made more feasible as far as contractual and rights-of-way matters are concerned, second, the most severe field problem is encountering wet weather after a job has started, and third, the type 2 section has been proven to have sufficient stability if it is possible to construct the section. In arriving at the size of the section, the material type was given less significance than degree of compaction.

36. The three types of levee sections have been predicated on a stable foundation. In cases where unstable foundations exist, or detrimental underseepage conditions prevail, adequate corrective measures will be designed as a secondary consideration, to take care of the special critical conditions which exist.

37. New levees. The recommended net dimensions of the three types of sections for main line levees are as follows:

<u>Type</u>	<u>Riverside Slope</u>	<u>Crown Width</u>	<u>Landside Slope</u>
<i>Designation</i> 1	1:3.5	10 ft	1:4.5 (1)
2 less than 25' in height	1:4.0	10 ft	1:5.5 (2)
2 25' and higher	1:4.0	10 ft	1:6.0 (3)
3	1:4.5	10 ft	1:6.5 (4)

For tributary levees above the head of Mississippi backwater, the following net cross sections will control:

<u>Height</u>	<u>Riverside Slope</u>	<u>Crown Width</u>	<u>Landside Slope</u>
15 feet or less	1:3.0	10 ft*	1:4.0 (min) (5)
(Note: Over 15 feet in height: Same as provided for main line levees)			

*Note: Where deemed necessary for roadway purposes, the crown width may be increased to 14 feet.

38. When specifications are submitted to the Commission for review they will be accompanied by a report setting forth the reasons for selection of the type of construction proposed. Except where special conditions require otherwise, the selection of the section to be used should be governed by the following conditions.

a. Type 1. (1) For plastic soils, when the water content as estimated for the time of construction is equal to or less than the plastic

limit plus 20 per cent of the plasticity index.

(2) For all non-plastic soils except silts, regardless of the water content.

(3) For silty materials of low plasticity when the water content as estimated for the time of construction is equal to or less than the plastic limit.

b. Type 2. When the moisture content of the soil is greater than specified above, except as noted under type 3.

c. Type 3. On uncompacted emergency construction of relative dry material, that is, material sufficiently dry for a moderate degree of compaction, and also uncompacted very stiff wet clays.

39. Enlargements. For enlargements, the existing levee should in all cases be considered as semi-compacted fill. Where the existing landside slope of the levee is flatter than 1:5.5 for levees less than 25' in height and 1:6 for levees greater than 25', the landside slope of a riverside enlargement should commence at the landside edge of the crown of the existing levee. Where the existing landside slope of the levee is steeper than 1:5.5 for levees less than 25' in height and 1:6.0 for levees greater than 25', the landside slope of the enlargement should commence at a point where a 1:5.5 or 1:6.0 slope (whichever is applicable) commencing at the landside toe intersects the surface of the levee. From either of these commencement points the net landside slope of the enlargement should be that applicable to the type of construction; i.e., 1:4.5 for type 1; 1:5.5 or 1:6.0, (whichever is applicable) for type 2, and 1:6.5 for type 3. Crown widths and riverside slopes should be the same as for new levees. Where control of through seepage is required, the minimum thickness of enlargement should be 5 feet, measured normal to the riverside slope of the existing levees.

40. Every effort should be made to obtain the best compaction possible. Often this can be done by requiring the contractor to excavate a vertical or sloping pit face to full depth rather than excavating in thin horizontal layers.

41. Special sections. Variations from the proposed standard levee sections will be necessary at certain locations to fit conditions peculiar thereto. The design for a hydraulic fill section should be special for the location and conditions under consideration. *IN 50127*

Gradation of material in cross section

42. Material should be placed in the levee section so that a gradation more permeable to the landward exists. Experience and data have shown that very few cases of through seepage have been recorded on levees constructed to the 1928 section. Most cases of wet and sloughing landside

limit plus 20 per cent of the plasticity index.

(2) For all non-plastic soils except silts, regardless of the water content.

(3) For silty materials of low plasticity when the water content as estimated for the time of construction is equal to or less than the plastic limit.

b. Type 2. When the moisture content of the soil is greater than specified above, except as noted under type 3.

c. Type 3. On uncompacted emergency construction of relative dry material, that is, material sufficiently dry for a moderate degree of compaction, and also uncompacted very stiff wet clays.

39. Enlargements. For enlargements, the existing levee should in all cases be considered as semi-compacted fill. Where the existing landside slope of the levee is flatter than 1:5.5 for levees less than 25' in height and 1:6 for levees greater than 25', the landside slope of a riverside enlargement should commence at the landside edge of the crown of the existing levee. Where the existing landside slope of the levee is steeper than 1:5.5 for levees less than 25' in height and 1:6.0 for levees greater than 25', the landside slope of the enlargement should commence at a point where a 1:5.5 or 1:6.0 slope (whichever is applicable) commencing at the landside toe intersects the surface of the levee. From either of these commencement points, the net landside slope of the enlargement should be that applicable to the type of construction; i.e., 1:4.5 for type 1; 1:5.5 or 1:6.0, (whichever is applicable) for type 2, and 1:6.5 for type 3. Crown widths and riverside slopes should be the same as for new levees. Where control of through seepage is required, the minimum thickness of enlargement should be 5 feet, measured normal to the riverside slope of the existing levees.

40. Every effort should be made to obtain the best compaction possible. Often this can be done by requiring the contractor to excavate a vertical or sloping pit face to full depth rather than excavating in thin horizontal layers.

41. Special sections. Variations from the proposed standard levee sections will be necessary at certain locations to fit conditions peculiar thereto. The design for a hydraulic fill section should be special for the location and conditions under consideration. IN 50127

Minor topping and correction of slope deficiencies will be guided by practical considerations with the general objective of restoring the original design.

tion more permeable to the landward exists. Experience and data have shown that very few cases of through seepage have been recorded on levees constructed to the 1928 section. Most cases of wet and sloughing landside

toes are due to underseepage.

43. All levee sections, except riverside enlargements, may allow placement of sand on the landside, keeping in mind that the levee section must grade more permeable to the landward. The amount of sand should not exceed approximately two-thirds of the cross-sectional area of the levee. Levees constructed entirely of sand must have a watertight riverside blanket facing or an impervious central core.

44. From the viewpoint of ultimate stability, it is satisfactory to use all available borrow materials in new levee construction, with the exception of highly organic materials. Highly plastic clays and very wet materials should not be used, if possible to avoid them. Every effort should be expended during the borrow excavation and placement procedures to secure adequate segregation of materials in the fill, especially when the least permeable material is readily penetrated by water in a short period of time.

Shrinkage and foundation settlement

45. The foundation settlement in each specific case should be estimated and the same allowance made, regardless of levee type. The shrinkage factors to be allowed for consolidation within the levee section itself are as follows:

Dry fill construction, Type 1,	5%
Dry fill construction, Type 2,	10%
Dry fill construction, Type 3,	15%
Hydraulic fill construction,	10%

~~46. On enlargements, the total allowances for shrinkage and foundation settlement should be made as above except that they should be not less than 1 foot for type 1 and 2 feet for types 2 and 3.~~

Compaction

47. Type 1. The specification on compacted fill should be modified to include the mandatory use of the sheepsfoot roller. Although adequate compaction can be secured by the controlled use of hauling equipment, controlling such movement so as to insure satisfactory coverage of the entire area of the fill is generally impracticable, and consequently compaction should be secured by the use of a sheepsfoot roller of adequate weight operated continuously over the entire area of the fill during construction. The amount of rolling equipment should be balanced with the number and size of hauling units. No change should be made in the requirements as to lifts or moisture control.

48. Type 2. One of the primary reasons for the type 2 section is to provide a means of obtaining the maximum practicable compaction of wet soils with the least cost and reduction in output. Alternate methods will be specified for achieving compaction, as outlined below.

toes are due to underseepage.

43. All levee sections, except riverside enlargements, may allow placement of sand on the landside, keeping in mind that the levee section must grade more permeable to the landward. The amount of sand should not exceed approximately two-thirds of the cross-sectional area of the levee. Levees constructed entirely of sand must have a watertight riverside blanket facing or an impervious central core.

44. From the viewpoint of ultimate stability, it is satisfactory to use all available borrow materials in new levee construction, with the exception of highly organic materials. Highly plastic clays and very wet materials should not be used, if possible to avoid them. Every effort should be expended during the borrow excavation and placement procedures to secure adequate segregation of materials in the fill, especially when the least permeable material is readily penetrated by water in a short period of time.

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Dry fill construction, Type 1,	5%
Dry fill construction, Type 2,	10%
Dry fill construction, Type 3,	15%
Hydraulic fill construction,	10%

46. The need for foundation settlement allowances for levee enlargements shall be determined on the basis of best methods, data, and information available, and shrinkage allowances shall be the same as those shown in paragraph 45. The construction gross grade shall not exceed the theoretical gross grade, based upon settlement and shrinkage calculations, by more than 0.5 ft.

area of the fill is generally impracticable, and consequently compaction should be secured by the use of a sheepsfoot roller of adequate weight operated continuously over the entire area of the fill during construction. The amount of rolling equipment should be balanced with the number and size of hauling units. No change should be made in the requirements as to lifts or moisture control.

48. Type 2. One of the primary reasons for the type 2 section is to provide a means of obtaining the maximum practicable compaction of wet soils with the least cost and reduction in output. Alternate methods will be specified for achieving compaction, as outlined below.

a. Each load shall be spread by bulldozer as it is placed in the section or, as an alternate, material may be spotted so as to be spread into layers and compacted by three passes of a tractor or similar equipment weighing at least ten tons and exerting a unit pressure of not less than 6 lbs. per square inch. The thickness of layers will be 12 inches for clay soils and 18 inches for silty or sandy soils. Where casting equipment is used, the material placed in the lower two-thirds of the embankment should be dropped a minimum distance of 10 feet. The bulldozer should continue to operate on the upper one-third of the levee, but dropping of the material 10 feet need not be required.

b. The specifications should be written so as to require the contractor to construct by the above method when the material is dry enough for such construction and allow uncompacted fill when the material is too wet for this type of construction. If, after the contract has been entered into, the material is found to be too wet for construction by the method described in paragraph a. above, the contractor will be permitted to construct an uncompacted fill to the type 2 cross section and to a gross grade determined by increasing the shrinkage allowance to 15%. In this event the contract unit price will be reduced by 10%. The requirements of this paragraph will not be incorporated in the Standard Levee Specifications, but will be included in the special provisions and will be optional with the contractor on jobs where completion is not urgent.

In all instances, the completed levee shall be finished by rolling the entire surface with three passes of a bulldozer or similar equipment.

49. Type 3. For the uncompacted section and where the moisture content will permit, a worthwhile amount of compaction can be obtained by requiring that on dragline construction the material placed in the lower two-thirds of the height of the levee be dropped a minimum of 10 feet. The dropping of the soil through 10 feet should not be required on tower machine construction. An attempt should be made to improve the tower machine construction procedures.

Seepage

50. General. In the location and design of levees, seepage conditions are considered to be one of the paramount features of design. Seepage correction at critical points on presently built levees is now of primary importance in the work of the three Districts.

51. Through seepage. Through seepage in the present main line levee system seldom offers a serious problem. For those cases where it is a problem, an impervious core placed through the center of the levee section should be more effective against through seepage than a thin riverside blanket of impervious material. The experiment with the trenching machine now being conducted in the Memphis District should be continued with the hope of perfecting a machine capable of excavating a trench through the center of the levee. It may be entirely feasible to build an impervious core in stages of from 5 to 10 feet as the levee is constructed. Such a procedure would involve the general leveling of the

levee section at the given stage heights and the placement of an impervious core in a trench excavated by dragline or trenching machine. Consideration should be given to the placement of the impervious central core by either means mentioned above, on future construction of new levees where the material is of such a pervious nature as to require protection against through seepage. As soon as the deep trenching machine is perfected, consideration should be given to placing a central impervious core rather than the riverside impervious blanket. The present blanketing practice is unnecessary from the standpoint of through seepage in a large percentage of cases. In many places where impervious blankets have been constructed, the landside toes and the lower portion of the landside slopes become wet when subjected to high river stages. Such a condition probably results from underseepage and not from through seepage.

52. Unquestionably, failures which take place as a result of through seepage develop ^{from} ~~into~~ either a condition of piping before failure, or a general softening of the fill due to saturation, with resultant loss of shear strength and the inducement of liquid (pore pressure) flow slides. Piping may occur along a line or plane of loose material which is bridged across by a relatively stable layer of material. Holes made by burrowing animals are often the source of piping in small levees. Compacting and flattening of the slopes are the best preventive against liquid flow slides and close maintenance and inspection are the best preventives against burrowing animals.

Underseepage

53. Where a relatively thin (with respect to levee height) impervious top stratum exists above a highly pervious substratum of sand, conditions favorable to dangerous underseepage are present. Where river stages result in a hydraulic gradient or ratio of head to thickness of top stratum approaching unit, dangerous boils are likely to be encountered. A hydraulic gradient as low as 0.7 approaches the critical gradient for silts and fine sands. Moreover, seep water in the fields is detrimental to farming. Therefore, it is desirable to design corrective measures for underseepage. To do this, certain data are necessary. Principal among these data are: (1) Information on the permeability and thickness of impervious top stratum; (2) Information on accessibility of water to the pervious stratum on the riverside; (3) Information on the thickness and perviousness of the sand strata; and (4) Information on the actual pressures which may be experienced under record river stages. The first three items can be fairly reasonably estimated from field studies and investigations; however, very little is known about the last item. In order to gain information on pressures, which is considered absolutely necessary for the intelligent design of any corrective measures for underseepage and for adequate and proper future planning, a sufficient number of piezometer systems should be installed at strategic locations along the levees. A standing committee should be appointed to determine the proper location and an adequate number of piezometer systems. A study of geological information will materially assist in the selection of these locations. The areas to be studied for piezometer installations should not be restricted to those where free seepage or sand boils have

been prevalent, but should include areas which have evidenced little or no trouble. Duplicate sites in each District should be selected where the top impervious stratum is 5, 10, and 15 feet in thickness, and sufficient piezometers should be installed to establish adequate piezometric profiles. Any areas which may be suspected as possible locations of serious trouble in case of a record flood should be checked with piezometer systems. Readings on these piezometers should be made at various stage heights of water. Curves should be drawn and extrapolations made to estimate the probable pressures which would exist under the impervious top stratum at the landside toe of the levee under record river stages.

54. There are numerous corrective measures against underseepage. Principal among these are: (1) landside berms, (2) riverside berms and borrow pit refill, (3) borrow pit restrictions, (4) impervious cutoffs in foundation, (5) landside drainage, which may be obtained by means of drainage wells or drainage trenches, (6) sublevees, and (7) taking advantage of geological features. These items are briefly discussed in the order named.

55. Landside berms are in most cases a partial safeguard in reducing hydrostatic pressures beneath the top stratum immediately landward of the levee structure by increasing the path of flow. Random fill material may be used, but, wherever possible, pervious sand should be used in berm construction. The design of berms to date has been a cut-and-try problem, based on previous observations and experience. The quantitative effect of landside berms in reducing pressures is generally unknown, in that piezometric information on actual berm installations is lacking. Landside berms have the following advantages: (1) they move boils and seepage farther from the levee proper, and (2) they provide additional working area and facilitate flood fighting.

56. Riverside berms may be utilized when riverside borrow pits have been excavated through an impervious top stratum exposing the pervious sand. The refilling of these pits with impervious material aids in sealing off close entry of seepage on the riverside, and the resultant longer path of flow from the river to the levee will cause a reduction of head.

57. Whenever underseepage conditions are likely to exist, if possible and feasible, riverside borrow pit depth should be restricted so as not to expose the pervious material. Where an impervious top stratum exists to a considerable distance riverward of the levee, the use of landside pits located at a sufficient distance from the levee in lieu of riverside pits will decrease the danger from underseepage and facilitate the control of interior drainage.

58. Development of a trenching machine indicates the practicability of excavating cutoff trenches in natural ground below the water table. Serious study should be given to the possibilities of constructing impervious cutoff walls, extending to depths which will materially decrease underseepage pressures.

59. Landside drainage by use of drainage wells or trenches may at certain locations be made quite effective in reducing dangerous substratum pressures, by proper and adequate design. In certain specific locations, the use of drainage trenches or wells might be feasible, from the standpoint of both economy and adequate protection to the levee, especially in urban or highly developed areas, where it would be impracticable to use other structures for the control of underseepage.

60. The use of sublevees in relieving dangerous boil areas at the landside toe is feasible, from the standpoint of both economy and reduction of pressures. A sublevee system may have little effect on the total amount of underseepage. The use of adequately designed sublevee systems should be encouraged. Practically the only hazard existing in sublevees can be alleviated by proper compaction and the installation of adequate spillways and cross-drainage culverts in the sublevee systems.

61. The strategic location of levees with respect to the soil profile as indicated by geological and soil investigations is quite important. The proper location of a levee with respect to channel fillings should always be given consideration; also, weak foundations should be avoided, or, if not possible, the shortest path across should be chosen. If feasible, the location of levees on crevasse sands should be avoided, but where it is necessary, adequate cutoffs should be provided. Cognizance should always be given to the favorable location of levees with respect to surface topographic conditions.

62. Study should be given to the engineering feasibility of all the above features, and, in general, selection should be made on the basis of economic considerations.

63. Where obviously critical areas exist on a new levee location, the most effective and economical method of underseepage control should be included in the design and piezometers installed as a check.

Stability

64. Certain minimum stability requirements, previously stated, imply certain shear strength values. These values can be approximated by field moisture contents and Atterberg limits. If certain conditions are met, as stated in paragraph 25, it is not necessary to calculate the stability of the embankment and/or foundation of the levee. The stability of the embankment and foundation should be such that on sudden drawdown (where applicable) the factor of safety should be at least 1. In other cases where drawdown does not apply, the minimum factor should be 1.3, except that where extremely weak materials make this impracticable, a lower safety factor may be used.

65. Where feasibly and necessary, the procedure for constructing levees over very weak foundations in two or more stages is warranted and should be continued. On occasion it may be necessary to use two or more stage construction, due to very wet levee material. No change in

construction procedure is necessary or contemplated over that for a levee constructed in one stage. Due cognizance should be taken of shrinkage factors. In general, the use of berms for increasing stability has proven satisfactory.

66. On weak foundations, in rehandling materials at the levee toes or within the levee base, the height of stock piles or embankment should be carefully controlled so as to avoid failures, which can be induced by comparatively small loads.

Inspection ditches

67. Inspection ditches have been provided in all prior levee construction. Future new levees on the main stem of the river will be limited to setbacks made necessary by caving banks. Inspection ditches should be provided as they have in the past.

Plans and Specifications

Standard project drawings

68. The size of project drawings should conform to the dimensions prescribed in Orders and Regulations. If all pertinent data cannot be clearly shown on one sheet, additional sheets should be used. Scales should be in tenths of a foot and not in inches. Scales of 1:10,000; 1:5,000; or 1:2,000 are desired and may be used, as best suited to the particular job in hand. A graphic scale should be shown on each map. A standard title block should be adopted for use in all three Districts.

Information required by contractor

69. In general, the plans and specifications prepared by the three Districts give sufficient information to enable contractors to make intelligent bids. However, for the sake of uniformity, and to avoid possible controversies, the following procedures are considered worthy of adoption:

a. In most cases where selected material is to be used, right-of-way limits should be shown on drawings. If the material is to be procured from side borrow without selection, right-of-way limits need not be shown, unless it is definitely known that the necessary amount of material can be obtained from within those limits.

b. Where the water content of the material available for borrow is known to remain nearly constant, it is satisfactory to indicate on the plans the water content determined from soil samples. However, where the water content may change materially, it should not be shown. Where water content is shown, the date of borings, method of taking, and a statement that the data are not guaranteed should also be indicated.

c. In cases where selection of material is required, the specifications should state that the location of materials as shown by borings is not guaranteed and the contractor may have to drift material, due to variations from those shown, but pits should be so laid out that the contractor will know the maximum limits of drifting to be required.

d. All three Districts should adopt the same abbreviations and symbols for showing soil types.

e. When practicable, the permissible depth of borrow should be shown on logs of borings taken in the borrow areas.

Applicability of present specifications

70. The present standard levee specifications, developed from experience gained during many years of levee construction, are generally applicable and should be retained in their present form. Adoption of certain changes discussed in other parts of this report would necessarily involve changes in the specifications. Also, there are a few modifications which appear justifiable in order to clarify questionable points or better suit modern construction practices. The more important of these are:

a. Preparation of foundation. Specifications for this phase of the construction, as now written, were applicable years ago when it was contemplated that the base would first be cleared and grubbing operations would follow later. Now, practically all clearing and grubbing are done with bulldozers or similar equipment, and a satisfactory job can be done in this manner. However, when clearing, grubbing and refill of stump holes are practically simultaneous operations it is impossible to make a reasonably accurate estimate of yardage required for refill of the stump holes. The specifications should be revised to provide that where clearing and grubbing are performed by bulldozers or similar equipment, no separate payment will be made for refill of stump holes.

b. Dressing and sodding. Frequently, trouble is experienced in getting contractors to maintain the rate of progress in dressing and sodding required by the specifications. To avoid this difficulty the specifications should be made more stringent. The following sentence should be added to the specifications: "Sod shall not be obtained from the existing levees for sodding the new work, unless such procurement has been approved by the contracting officer."

c. Removal of debris. The specifications provide that all clearing or grubbing debris shall be destroyed or disposed of within the right-of-way limits, but there is no clause which precludes the disposition of material outside these limits. Very frequently the debris is disposed of landward of the 5-foot limit. Not only is it an eyesore, but it may cover an area which could be troublesome during high-water periods. If trouble should develop, it would be difficult to detect and correct,

due to the presence of debris. On work where it is objectionable, provisions should be incorporated in paragraph 34 of the specifications to prohibit disposal of clearing and grubbing debris landward of the levee in areas where it would hinder maintenance during high water.

71. The above changes are in addition to those made necessary by the adoption of the new Code.

Freeboard

INSERT

72. Project authorizations (provide for freeboard. Levees have freeboards ranging from 1 to 5 feet. ~~X~~ All main river levees below New Orleans and the levees below Morgan City should have a freeboard of 5 feet, to provide protection against high waves and tides during tropical storms. On tributary levees, where the project grades are based on experienced floods, the freeboard should not be less than 3 feet. Whenever it is predicted that a flood crest will reduce the freeboard of the main line levees to less than 3 feet, steps should immediately be taken to top out the levee to provide a 3-foot freeboard. In view of the apparent need for a minimum freeboard of 3 feet, serious consideration should be given to raising all main river levee freeboards to at least 3 feet by topping out levees now constructed to project grades. Where levees are not now up to the project grade and cross section, consideration should be given to enlarging the base to obtain that freeboard.

Future Activities of the Board

Standing committee

73. A standing committee should be appointed, with its general function that of keeping the Code current. This should consist of one member each from the Office, Chief of Engineers, Mississippi River Commission, Waterways Experiment Station and the three Districts. Specifically, this committee should have the following authority: (1) To study and coordinate all phases of planning, investigations and testing, design and construction; (2) wherever problems of considerable magnitude are encountered, the standing committee should be empowered to appoint temporary committees by proper representation to adequately study and report on the particular problem in question; (3) power to initiate, subject to the approval of the President, Mississippi River Commission, the necessary studies and tests to obtain factual information concerning specific problems, and (4) to travel as necessary to prosecute the above-listed functional duties.

Preparation of Commission manuals

74. The Exploration and Testing Committee should be allowed to function to prepare the Field Exploration Manual and Laboratory Testing

due to the presence of debris. On work where it is objectionable, provisions should be incorporated in paragraph 34 of the specifications to prohibit disposal of clearing and grubbing debris landward of the levee in areas where it would hinder maintenance during high water.

71. The above changes are in addition to those made necessary by the adoption of the new Code.

Freeboard

The remainder of this paragraph indicates the expressed desires of the Code Committee; however, their statements cannot be held to violate officially prescribed freeboards.

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Preparation of Commission manuals

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Manual. This committee would cease to function upon completion and acceptance of the manuals. Travel for members of this committee should be authorized any time necessary in connection with the preparation of the manuals.

Table 1

UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbols	Symbol		Typical Names	Laboratory Classification Criteria	
1	2	3	Hatching	Color	6	7	
Coarse-grained Soils More than half of material is larger than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Gravels More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size)	Clean Gravels (little or no fines)	GW	Red	Well-graded gravels, gravel-sand mixtures, little or no fines.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3 Not meeting all gradation requirements for GW	
					Poorly-graded gravels, gravel-sand mixtures, little or no fines.		
		Gravels with Fines (Appreciable amount of fines)	GM	Yellow	Silty gravels, gravel-sand-silt mixtures.		
					Clayey gravels, gravel-sand-clay mixtures.	Atterberg limits below "A" line or PI less than 4 Above "A" line with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols.	
		Clean Sands (little or no fines)	SW	Red	Well-graded sands, gravelly sands, little or no fines.		
					Poorly-graded sands, gravelly sands, little or no fines.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3 Not meeting all gradation requirements for SW	
	Sands More than half of coarse fraction is smaller than No. 4 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size)	Sands with Fines (Appreciable amount of fines)	SM	Yellow	Silty sands, sand-silt mixtures.		
					Clayey sands, sand-clay mixtures.	Atterberg limits below "A" line or PI less than 4 Limits plotting in hatched zone with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols.	
		Clean Sands (little or no fines)	SP	Red	Well-graded sands, gravelly sands, little or no fines.		
					Poorly-graded sands, gravelly sands, little or no fines.	Atterberg limits above "A" line with PI greater than 7	
Fine-grained Soils More than half of material is smaller than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Silt and Clays Liquid limit less than 50	ML		Green	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.		
		OL			Organic silts and organic silty clays of low plasticity.		
	Silt and Clays Liquid limit greater than 50	MH		Blue	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.		
		CH			Inorganic clays of high plasticity, fat clays.		
		OH			Organic clays of medium to high plasticity, organic silts.		
	Highly Organic Soils	Pt		Orange	Peat and other highly organic soils.		

- (1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols.
For example GW-GC, well-graded gravel-sand mixture with clay binder.
- (2) All sieve sizes on this chart are U. S. standard.

Adopted by Corps of Engineers and Bureau of Reclamation, January 1952

May 1946

Q_c DIRECT SHEAR TESTS

Borrow Area "A"

Boring A- 100 - Elev. 200.9 to 195.9

Sample 1 - Silty Sand

Fig. 3

LEGEND

—▲—▲—▲—	Item R-69 - +3.5 [●]	—.....—	Item R-48 - +7.5 [●]
—●—●—●—	Item R-206 - +8.5 [●]	—...—	*Item R-6 - +7.0 [●]
—▲—▲—▲—	Item R-208 - +6.5 [●]	—.....—	*Item R-12 - +5.0 [●]
—■—■—■—	Item R-215 - +7.5 [●]	—.....—	Item R-198 - +2.5 [●]
—x—x—x—	Item R-107 - +10.0 [●]	—.....—	Item R-166 - +4.0 [●]
—○—○—○—	*Item R-0.4.5 A.C. +7.0 [●]		

Note: Average borrow pit moisture % under or over optimum is marked thus [●]. All items were haul-in jobs. Bulldozer was used on all jobs and sheepsfoot on items marked *

Soils range from clay silt to fat clay with some sandy clay. Predominant soil, by far, was medium clay. Ave. actual opt. wc. = 25 %

GRAPH SHOWING DECREASE IN COMPACTION DENSITY
WITH INCREASING BORROW PIT MOISTURE

LEGEND
 x — x Compacted
 o — o Uncompacted

Note: Points plotted are the average of data furnished by the New Orleans and Vicksburg Districts.

GRAPH SHOWING TIME LOST DUE TO WEATHER
 FOR COMPACTED AND RANDOM FILL
 (DRAGLINE) METHODS OF CONSTRUCTION

LMVCC

5 Sep 63

RDK
Kaufman/hm/314

SUBJECT: Soil and Rock Boring Legends

TO: District Engineer
U. S. Army Engineer District
St. Louis
Memphis
Vicksburg
New Orleans

1504-26 (S) 57

1. In a recent discussion with Mr. Prescott, OCE, we were advised that the portion of the note on our boring legends pertaining to the representativeness of borings should be revised to read as follows:

While the borings are representative of subsurface conditions at their respective locations and for their respective vertical reaches, local variations characteristic of the subsurface materials of the region are anticipated and, if encountered, such variations will not be considered as differing materially within the purview of clause 4 of the contract.

G.B.
G.B. Davis

2. Please revise your soil and rock boring legends accordingly.

A.J.
A.J. Davis

FOR THE DIVISION ENGINEER:

A. J. DAVIS
Chief, Engineering Division

*file
error*

Appendix D: 1929 Vicksburg District Levee Handbook

0270
E H Bourquard

E H Bourquard

Standard Instructions
for

Levee Inspectors,

Dec for use in

Vicksburg Engineer District

1929

E. H. Bourquard U. S. Engineers

2110
5-8

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FOREWORD

It has been the intention in preparing this set of instructions to foresee the problems with which the field inspectors will be confronted. There are, no doubt, many problems which will arise from time to time in the prosecution of the work which could not be treated in a general manner, but it is expected that the inspector will consult his immediate superior, when there is any doubt as to the procedure to be followed.

John C. H. Lee,
Major, Corps of Engineers,
District Engineer.

INSTRUCTIONS TO FIELD INSPECTORS OF LEVEE SURVEYS, CONSTRUCTIONS,
AND REPORTS.

In order to guarantee a thoroughly efficient inspection system, the inspector will see that the following instructions are carried out in detail. To permit the use of a general term, the levee contractor or machine foreman, as the case may be, shall be hereinafter known as "the representative in charge." Any other designation shall be made in accordance with the work being done, as "the clearing contractor."

DUTIES

1. The inspector's first duty is to know the specifications, and allied data which is on file at the Area Engineer Office. As the work progresses the inspector must know whether or not it is being performed in accordance with the specifications and, if not, to notify immediately the representative in charge, and if deficiencies are not fully corrected, to notify the Area Engineer. The inspector must also know from day to day the percentage of completion as against time remaining and funds available. An inspector must be present during construction work and his reports must be faithfully, fairly and accurately submitted. Survey notes are regarded as important in all respects as financial accounts or legal affidavits. An inspector's work must be entirely trustworthy, if his services are of any value whatever. When the inspector is assigned to his station, he will see that he has the required equipment (List of equipment given on page 12), and he will maintain it in serviceable conditions at all times.

2. On arrival at assigned station, the inspector will locate hubs every 100 feet, for enlargement, along the top of the existing levee over which he will run a line of levels and establish T. B. Ms. on trees to the land-

side of the levee at each 1,000 feet. For new levee, he will relocate, chain and check the proposed center line, along which he will set hubs every 100 feet and reference P. Cs. and all changes indicative. (See paragraph 12). He will then run a line of levels over these hubs and establish T. B. Ms. on trees to the landside of the proposed new levee at each 1,000 feet. In both cases, this line of levels will be tied into some known U. S. P. B. M. This work is to be kept well in advance of all construction work and will be completed for the season's proposed work as early as possible, consistent with the other work of the inspector.

3. When the levee construction is to be done by hired labor with government equipment and the clearing is to be done under a separate contract, the inspector, on receipt of a clearing contract, will show the clearing contractor, or his representative, over the area to be cleared, indicating the starting and finishing points. He will then issue to the clearing contractor, or his representative, notes by stations showing the distances from the toe of the existing levee (for enlargement), or from center of levee (new levee) of the area to be cleared. Check measurements will be made of the right of way cleared before the levee construction work is begun, and before Form 13 is submitted.

4. The representative in charge will keep the clearing 1,000 feet in advance of construction, and the inspector will take cross section notes for the proposed new levee, or enlargement, and across pits to the back of the right of way as early as possible thereafter (see paragraph 11, 13 and 14). When the notes are taken they are to be plotted on "Perfect" cross section paper using a scale, 20 feet equals one inch, and plotting nine sections on each sheet. (See typical sections page 36). These sections will show (for enlargement) the existing levee, the proposed enlargement,

the old pits and the proposed new pits, or (New levee) the ground surface, the proposed new levee and new pits. When each sheet is plotted and inked, it will be promptly mailed to the Area Engineer.

5. Construction Notes. As the work progresses, the inspector will issue to the representative in charge a set of notes showing the landside and river side toe distances and the net and gross fill at the center (see Plate I, page 13, and page 61). The gross fill equals net fill plus the allowance for shrinkage which varies according to the method of handling. For levee machines, 25% is added; dump wagons, 20%; wheelers and fresnos, 15%. Borrow pit notes show the distance out and the cut allowed at that point. All distances are measured from center of levee. These notes are to be issued on standard approved forms Nos. 2704 and 2705, the inspector retaining a copy for file. The representative in charge shall set all slope and grade stakes and set all crow's feet, and they shall be checked by the inspector.

6. On completion of each 100 feet of levee, the inspector will run grades and test slopes (see page 61) and submit same on standard approved form No. 2706 to the representative in charge, a copy to the Area Engineer, and a copy to be kept on file by the inspector.

7. A line of levels will be run at the end of each month over all completed levees constructed, notes to be mailed to the Area Engineer.

8. Inspectors are required to keep full notes of borrow pit material classification, wetness, and movements of the embankment, if any, and cross sections will be taken immediately, plotted and mailed to the Area office. (See paragraph 21).

9. Especial care will be taken that the clearing of the levee base five feet beyond the toe of the enlargement, or new levee, as well as the grubbing,

and breaking of the ground or old levee surface will be performed according to specifications.

10. All reports shall be submitted as shown under REPORTS.

METHODS

11. Method of keeping notebook. To expedite the work of those who have to interpret and plot maps from the field notes it is necessary that all notes be kept in a standard form (See Plates III and IV) pages 17 and 18. Whenever a notebook is first started the general location and the return address of the inspector must be entered on the flyleaf; i. e., "Levee notes, Panther Forest new loop 1929. Return to Inspector John Jones, Camp C-2, Luna, Ark." First and very essential is the heading of each day's work, the names of the instrumentman, tapeman, rodman, and axeman; the place, kind of work, weather conditions and the date. At the end of each day's work, the inspector will sign his notes giving the name of the contractor's superintendent on the job that day. Notes for enlargement include original levee and ground elevations of right of way (Plate III, page 17). Notes on the completed work show elevations from the landside toe to the riverside toe to the back of the new borrow pits. (Plate IV, page 18). Notebook will show M. R. C. grade on each page, all elevations to tie in cross sections to known elevations. All T. B. Ms. and P. B. Ms. will be correctly described. Original notebook will be turned in to the Area Office at the end of the season, indexed and with proper title on the cover.

NOTE: - All elevations must be referred to Mean Gulf Level.

12. Method of running curves for alignment. In order to eliminate sharp angles in the levee system, tangents will be joined with simple curves. Reference is made to Plates VI and VII, pages 19 and 20, which show the method of running curves by deflection angles and offsets. Since the method

of running curves by deflection angles cannot be covered in detail in this manner the elementary functions are as follows:

The Simple Curve

The elements of a simple curve which are useful in levee location and construction are the following: (1) the angle Δ , known as the intersection angle, central angle, or the deflection angle of the two tangents. Since the formulae for the computation of curve data are expressed in terms of trigonometric functions of Δ , those which will be used more commonly are:

(a) The "tangent distance"	$T = R \tan 1/2 \Delta$
(b) The "long chord"	$C = 2R \sin 1/2 \Delta$
(c) The "external distance"	$E = R \text{ ex-sec } 1/2 \Delta$

in which R is the radius of the curve. (External secant = secant minus 1).

(2) Curves are known by their "degrees." The degree of a curve is the angle subtended at the center by a chord of 100 feet. Thus, in a four degree curve a chord of 100 feet subtends four degrees at the center of the curve.

(3) From the definition in paragraph (2), if D be the degree of any curve,

$$R = \frac{50}{\sin 1/2 D}$$

Hence, when D is known R may be found.

The degree of the curve is determined by judgment or by topography. This is generally determined from the external distance which can be used in either case. In this district the allowable maximum degree of curvature shall be 10 degrees.

Curves are usually laid out on the ground by "deflection angles." The three points on the two tangents which are used are:

P. I. Point of intersection of the two tangents.

P. C. Point of curve (the beginning of the curve).

P. T. Point of tangency (the end of the curve).

Curves do not usually begin or end with a whole station. To determine the P. C., the tangent distance is computed and measured from the P. I. along the tangent. Thus, if the station of the P. I. is 647/18.8 and T, the tangent distance, from the formula, $T = R \tan 1/2 \triangle$, is 371.8 feet, the station of the P. C. is 643/47. A stake may also be set on the forward tangent 371.8 feet from the P. I. which point is the P. T., but its station is determined from the P.C. along the curve and not from the P. I.

From the definition in paragraph (2) it is assumed that any chord less than 100 feet will subtend an angle at the center proportional to its length; a fifty foot chord will subtend an angle of $1/2 D$, a twenty-five foot chord will subtend an angle of $1/4 D$, etc. From this proportion the length in stations of a curve of D degrees is

$$L = \frac{\triangle}{D}$$

The length of the curve thus found added to the station of the P. C. gives the station of the P. T.

As

$$\triangle = 32^{\circ} 33' = 32.55^{\circ}$$

$$D = 4^{\circ} 30' = 4.50^{\circ}$$

$$L = \frac{32.55}{4.50} = 7.233 \text{ stations}$$

$$P. C. = 643 \text{ } \nearrow \text{ } 47$$

$$L. = \frac{7 \text{ } \nearrow \text{ } 23.3}{P. T. \quad 650 \text{ } \nearrow \text{ } 70.3}$$

With the instrument set up at the P. C. with a foresight along the tangent, deflections for the location of stations are taken in the following manner - the deflection for a 100 foot chord = $1/2 D$; the first chord to station 644 will be 53 feet and the deflection angle will be $\frac{53 \times 2^{\circ} 15'}{100} =$

$1.1925^{\circ} = 1^{\circ} 11' 33''$. Deflections for the succeeding stations will be:

Station	Deflection
644	$1^{\circ} 11' 33''$
645	$3^{\circ} 26' 33''$
646	$5^{\circ} 41' 33''$
647	$7^{\circ} 56' 33''$
648	$10^{\circ} 11' 33''$
649	$12^{\circ} 26' 33''$
650:	$14^{\circ} 41' 33''$
650/70.3 (P.T.)	$16^{\circ} 16' 30''$

As a check on the computation, the total deflection angle equals $1/2 \Delta$ which is $16^{\circ} 16' 30''$. The last sub-chord should close in both distance and direction on the stake previously set from the P. I.

13. Method of taking cross sections notes. Due to the fact that the procedure varies for new levee and enlargement, they will be treated separately. To avoid confusion, the new Class "B" section, which will be used for the most part throughout this district, is used for illustration. The same general principles will be followed where specifications require the use of Classes "A" and "C" (See Dr. No. 100/40, page 25). Class "B" has a 10 foot crown with a 1 on 3-1/2 riverside slope and a landside slope to contain a seepage line of 1 on 6-1/2. The seepage line springs from the riverside slope, at the elevation of the assumed maximum flow line. The landside slope of the levee shall extend in a straight line from the crown elevation to a point where the seepage line intersects the original surface of the ground.

NEW LEVEE. The proposed center line having previously been determined (par. 2), the inspector will take cross sections, all distances being

measured from the center of the crown, which shall be known as, or designated as, center (see Plate I, page 13). Starting at the center with a known constant (difference between M.R.C. grade and H. I.), readings will be taken at all breaks in the ground surface to that point where the proposed new levee will intersect the natural ground surface. These readings are called fills (rod reading plus or minus the constant), and for each reading the distance is taken from the center, the distance being recorded over fill in the notebook. To determine the riverside toe, test readings will be taken until such a reading is found that the fill multiplied by $3\frac{1}{2}$ (1 on $3\frac{1}{2}$ slope) plus 5' (half crown) equals the tape reading. Similarly, to determine the landside toe, test readings will be taken until such a reading is found that the fill minus 1' multiplied by $6\frac{1}{2}$ (1 on $6\frac{1}{2}$ seepage slope) minus $8\frac{1}{2}$ ' ($\frac{1}{2}$ width of crown plus distance to point where seepage line springs from riverside slope one foot below crown elevation) equals the tape reading. For borrow pits, the inspector will refer to paragraph 14.

ENLARGEMENT. To determine the center of the proposed enlargement, the inspector will plot the existing levee, (as shown in par. 4), and superimpose the proposed enlargement so that the cut and fill on the landside slope will balance 25% allowed for shrinkage in the fill. This will have to be done by trial as the landside slope is variable for various heights. The center having been determined by this method (being for riverside enlargement at some point on the riverside slope of the existing levee), the inspector will take cross section notes; starting at the center of the new crown with a known constant (difference between M.R.C. grade and H. I.) and measuring all distances from that point. Readings will be taken at all breaks in the surface of the existing levee and to that point where the

proposed enlargement intersects the natural ground surface. The method of determining the landside and riverside toes is the same as shown under NEW LEVEE.

The inspector will then take cross section notes from the riverside toe to the back of the right of way across the old pits. Readings will be taken at each break in the ground surface, the readings to be recorded as distances (from center) over actual elevations.

14. Borrow Pits. "No material shall be obtained within 40 feet of the base of levee on the riverside nor within 100 feet on the landside" Par. 25, Standard Specifications. As no material is obtained from landside pits except under exceptional circumstances and approved by the Chief of Engineers, riverside pits only will be considered.

New Levee. Cross sections will be taken over the ground surface to the back of the right of way, and will be recorded in the note book as distance (from center) over actual elevation. These notes will be plotted (par. 4), and the proposed pit superimposed thereon. Starting at a point 40 feet from the riverside toe, the side slope of the pit shall be 1 on 2 to a depth of 3 feet below the natural ground surface; from that point outward the pit may be deepened on a slope of 1 on 25 to such distance as to procure the required yardage of the new levee plus 25%.

Enlargement. The inspector will first plot the notes showing the existing levee, the proposed enlargement and the ground surface to the back of the right of way (see Plate I, page 13). The next step is to plot the proposed pit; starting at a point 40 feet from the riverside toe, the side slope of the pit shall be 1 on 2 to a depth of 3 feet below the natural ground surface; from that point outward the pit may be deepened on a slope of 1 on 25 to such distance as to procure the required material for the

enlargement plus 25%. Care should be exercised where the material is to be taken from old pits that the pits are not deepened more than is allowed.

15. Ratio of Gross and Net levee section to borrow pits. Wherever designated, tests will be conducted and detailed instructions will be given by the Area Engineer.

16. Computation of cross section notes. The standard method of computing cross section notes in this district is the double triangular formula, with the average end area method for computing yardage (See Plates I, II and II (a), pages 13, 14 and 15). All cross section notes will be computed and submitted to the Area office as early as possible, consistent with the other work of the inspector, in order that they may be checked and rechecked well in advance of payment on estimates.

REPORTS AND GENERAL .

17. Progress reports (page 53) and weather reports (page 54), and progress profiles Plate XV and XVI (pages 37 and 38) will be mailed to the Area office on the first of each month.

18. Daily reports for day forces (page 56) shall be mailed to the Area office. The name of the contractor's superintendent on the job for each day will be given and the report shall be signed by the inspector.

19. At the end of each month and on the completion of contract, the inspector will make up a bill (page 57) which he will sign with the representative in charge, and in case of clearing, the clearing contractor will also sign (page 59).

20. In case of disputes or when important instructions are issued in the field these shall be given in writing; a carbon copy being retained for reference and file and a copy to the Area Engineer.

21. A daily log (page 63) will be kept by the field inspector showing important happenings in connection with his work (See par. 8). This log is to be turned in at the end of the season, and it is to be subject to inspection at any time.

22. It is essential that all forms, reports, and cross section notes be mailed to the Area office promptly to facilitate the work of the office inspector.

John C. H. Lee,
Major, Corps of Engineers,
District Engineer.

Vicksburg Engineer District,
Vicksburg, Mississippi.
July 16, 1929.

EQUIPMENT
for
U. S. LEVEE INSPECTORS

Field and Office Equipment:

- (a) 1 Transit and tripod
- (b) 1 Level and tripod
- (c) 2 Transit rods
- (d) 2 Level rods (1 - 20' triangular & 1 - Philadelphia)
- (e) 1-100 foot steel tape (to be checked regularly)
- (f) 2 Triangles (1-45° and 1- 60°)
- (g) 10 Chaining pins
- (h) 2 Metallic tapes (100') without case
- (i) 1 triangular boxwood scale #1682
- (j) 1 Ruling pen
- (k) 1 Drafting table
- (l) 1 Straight edge
- (m) 1 Protractor
- (n) 1 Pen staff

The above list is chargeable as Property, with the exception of (h) Metallic tapes.

The following list of supplies is not chargeable as Property.

- (a) 1 Roll of "Perfect" cross-section paper
- (b) 4 Field sheets
- (c) 2 Bottles of India ink
- (d) 1 Box of lumber crayon (blue)
- (e) 6 Pencils (assorted)
- (f) 3 Erasers
- (g) Penpoints

The inspector will be supplied with the following books:

- (a) 1 Instruction book
- (b) 1 Transit book
- (c) 2 Levee Books
- (d) 2 Progress books
- (e) Daily Report for Day Forces (when required)
- (f) 1 Log book

The inspector will be supplied with the following forms:

- (a) Level Notes and Estimates (1 Pad).
- (b) Progress reports (Form 12) "
- (c) " " (Form L-12) " (when required)
- (d) Weather reports (24)
- (e) Construction notes (Form 2704)
- (f) Borrow pit notes (Form 2705)
- (g) Grades (Form 2706)
- (h) Daily report for day forces (when required)
- (i) Set of specifications and Blue prints

COMPUTATION

$\frac{89}{256}$	$\frac{52}{255}$	$\frac{121}{193}$	$\frac{81}{126}$	$\frac{54}{107}$	$\frac{40}{59}$	$\frac{16}{17}$	$\frac{0}{65}$	$\frac{50}{234}$	$\frac{73}{251}$	$\frac{5}{0}$
-3.632	$+.9690$	$+.13705$	$-.8442$	$+.4387$	$+.2301$	$+.280$	$+.4225$	$+.21762$	$-.1295$	

$$\begin{array}{r} + 9690 \\ 13703 \\ \hline 8442 \\ 4387 \\ \hline 2301 \\ 680 \\ \hline 4225 \\ 2762 \\ \hline + 25790 \end{array} \quad \begin{array}{r} - 37632 \\ 11295 \\ \hline - 18927 \\ \hline + 65190 \\ - 48927 \\ \hline + 271623 \end{array} \quad \begin{array}{l} \text{Double area} \\ \text{Area} \end{array}$$

CONSTRUCTION NOTES

Enlargement					
Station	Top of Slope Landside	Center Fill		Top of Slope Riverside	Cu. Yds.
		Net	Gross		
579	1590'	6.5'	8.1'	93.0'	3057

25 % Shrinkage used

Station	Grade Pt.	Dist. cut over: Depth of cut	Back of Pit	Cu. Yds.
579	297 6.0	330 438 6.7 8.7	468 58	3821

COMPUTATION

COMPUTATION

$$\begin{array}{r} \begin{array}{r} 5 \\ 0 \end{array} \begin{array}{r} 139 \\ 228 \\ 12 \\ -24976 \end{array} \begin{array}{r} 117 \\ 247 \\ 65 \\ -16052 \end{array} \begin{array}{r} 74 \\ 221 \\ 87 \\ -19227 \end{array} \begin{array}{r} 30 \\ 237 \\ 74 \\ -7538 \end{array} \begin{array}{r} 0 \\ 238 \\ 119 \\ -28322 \end{array} \begin{array}{r} 89 \\ 240 \\ 5 \\ -1200 \end{array} \begin{array}{r} 6 \\ 0 \end{array} \end{array}$$

$$\begin{array}{r}
 +16055 \\
 19227 \\
 17538 \\
 28322 \\
 12000 \\
 \hline
 +82342
 \end{array}$$

$$\begin{array}{r}
 +82342 \\
 -24976 \\
 \hline
 +57366 \\
 28683
 \end{array}$$

Double. area.
 Area

CONSTRUCTION NOTES

Station	New Levee		Toe of Slope Riverside	Cu Yds.
	Toe of Slope Landside	Center Fill Net Gross		
1021	132.0	23.8 29.8	89.0	10.714

25% Shrinkage used

Borrow Pits				
Station	Grade Pt.	Dist. out over Depth of cut	Back of Pit	Cu. Yds.
1021	$\frac{18}{50}$	$\frac{130}{70}$ $\frac{450}{70}$	$\frac{500}{70}$	13,393

METHOD FOR
CROSS-SECTIONING. COMPUTATION
AND CONSTRUCTION NOTES.
VICKSBURG ENGINEER DISTRICT
VICKSBURG, MISSISSIPPI.
Feb. 1929.

ENLARGEMENT

	abh	abc	bcd	cde	def	efg	ghi	him	iklm	jkl	
$\frac{5}{0}$	$\frac{159}{256}$	$\frac{162}{255}$	$\frac{121}{193}$	$\frac{81}{126}$	$\frac{54}{107}$	$\frac{40}{59}$	$\frac{15}{17}$	$\frac{0}{65}$	$\frac{50}{234}$	$\frac{93}{251}$	$\frac{5}{0}$
	147	38	71	67	41	39	40	65	93	45	
	-3763.2	+969.0	+1370.3	+844.2	+438.7	+230.1	+68.0	+422.5	+2176.2	-1129.5	

+969.0	-3763.2
+1370.3	+1129.5
+844.2	-4892.7
+438.7	
+230.1	
+68.0	+6519.0
+422.5	-4892.7
+2176.2	+2/16263 Double area
+6519.0	813.2 Area

NEW LEVEE

	abh	abc	bcd	cde	def	efg	
$\frac{5}{0}$	$\frac{117}{247}$	$\frac{74}{221}$	$\frac{30}{237}$	$\frac{0}{238}$	$\frac{89}{240}$	$\frac{5}{120.0}$	$\frac{5}{0}$
	117	65	87	74	119	5	
	-2497.6	+1605.5	+1922.7	+1753.8	+2832.2	+120.0	

+1605.5	+8234.2
+1922.7	-2497.6
+1753.8	+2/5736.6 Double area
+2832.2	2868.3 Area
+120.0	
+8234.2	

PROOF OF COMPUTATION
OF LEVEE CROSS-SECTIONS BY
DOUBLE TRIANGULAR FORMULA

VICKSBURG ENGINEER DISTRICT.

VICKSBURG, MISSISSIPPI

Feb. 1929

LANDSIDE ENLARGEMENT

	<i>abh</i>	<i>abc</i>	<i>bcd</i>	<i>cde</i>	<i>def</i>	<i>efg</i>	<i>fgh</i>	
$\frac{5}{0}$	$\frac{159}{25.6}$	$\frac{152}{25.5}$	$\frac{121}{19.3}$	$\frac{81}{12.6}$	$\frac{54}{10.7}$	$\frac{40}{5.9}$	$\frac{15}{1.7}$	$\frac{5}{0}$
	147	38	71	67	41	39	35	
	-3763.2	+969.0	+1370.3	+844.2	+438.7	+230.1	+59.5	

+ 969.0	
1370.3	
844.2	
438.7	
230.1	
59.5	
+3911.8	
-3763.2	
+2148.6	Double area
74.3	Area

RIVERSIDE ENLARGEMENT

	<i>abc</i>	<i>bcd</i>	<i>cdef</i>	<i>gef</i>	
$\frac{5}{0}$	$\frac{15}{1.7}$	$\frac{0}{6.5}$	$\frac{50}{23.4}$	$\frac{93}{25.1}$	$\frac{5}{0}$
	8.5	6.5	93	45	
	+8.5	+422.5	+2176.2	-1129.5	

+ 2176.2	
422.5	
8.5	
+2607.2	
-1129.5	
+2147.7	Double area
738.9	Area

PROOF OF COMPUTATION
OF LEVEE CROSS-SECTIONS BY
DOUBLE TRIANGULAR FORMULA

VICKSBURG, ENGINEER DISTRICT

VICKSBURG, MISSISSIPPI

Feb. 1929.

SUPPLEMENTARY REMARKS

Standard Instructions for Levee Inspectors, - The Inspector will locate hubs every 100 feet for enlargement along the top of the existing levee over which he will run a line of levels and establish T.B.M.'s on trees to the landside of the levee of each 1000 feet. (For hydraulic work this line shall be referenced to points to the landside of the levee.) He will take cross-section notes for the proposed enlargement and across pits to the back of the right of way. When the notes are taken they shall be plotted on 'Perfect' cross-section paper, using a scale of 1"=20', and plotting nine sections on each sheet (Paragraph 13 gives the method of computing the enlargement.)

When the required yardage is determined, the Inspector will compute the area of the hydraulic fill and set grade stakes to conform with the approved plan of placing the material.

To determine the progress each month, the Inspector will run levels over the area being filled, care being taken that the elevations are taken directly above the initial readings, and at all breaks in the surface of the hydraulic fill. These readings will be taken as distance over actual elevation. (Standard Borrow Pit practice), the fill measured from the initial elevation shown on the cross-section sheets, and the areas computed by the double triangular formula.

Upon completion of the work the Inspector will submit notes as computed on this plate, and the note book will show distance over actual elevation and fill.

COMPUTATION OF NOTES OVER COMPLETED FILL

Section 1 -	12	77	100	102	103	105	141		1487.2
	0	16.9	16.0	15.5	17.4	17.3	0		400.0
		8.8	25	3	3	38			52.2
		1487.2	400.0	465	522	657.4			657.4
									2) 2643.3 Double Area
									1321.65 Area
Section 2 -	48	77	100	139	233	234	236	250	426.4
	0	82	96	85	59	70	71	0	595.2
		52	62	133	95	3	16		1130.5
		426.4	595.2	1130.5	560.5	210	1136		560.5
									210
									113.6
									2) 2847.2 Double Area
									1423.6 Area
Section 3 -	59	77	100	139	257	335	344	350	237.8
	0	58	72	71	85	48	26	0	446.4
		41	62	157	96	87	15		1114.7
		237.8	446.4	1114.7	816.0	417.6	390		816.0
									417.6
									390
									2) 3071.5 Double Area
									1535.8 Area

Sections 1, 2, and 3 are computed for Class "B" section. The center line of the enlargement is 28 ft. riverward from existing center line. Section 1 has the toe of the fill 141 ft. from center, which point is the riverside toe of the enlargement. The landside toe is 145 ft. from center. The hydraulic fill for sections 2 and 3 extend 250' and 350' respectively, from center.

VICKSBURG ENGINEER DISTRICT.
MISSISSIPPI RIVER & TRIBUTARIES FLOOD CONTROL.

Method
of
Computing Hydraulic Fill
WITH

SUPPLEMENTARY REMARKS

SCALE: 1"=20'

FIELD NOTES
FOR
CROSS SECTION
OF
LEVEE ENLARGEM'T

PLATE IV

INSTRUMENT MAN	
RÖDMAN	
AXEMAN	

INSTRUMENT MAN						ROD MAN						AXEMAN						WEATHER CONDITIONS						PLACE						DISTRICT						DATE						CONTRACTORS						SUPT.						RD.						A						A.A.						Cu Yds.					
Sta.	B.S.	H.I.	F.S.	Elev.	Grade	REMARKS	Ref.	L.D.	LE	L.Int.	C.E.	B.Int.	R.E.	R.D.	A	A.A.	Cu Yds.																																																												
T.B.M.	10.6	181.9		171.3	188.5	T.B.M. Spike in 10" Pecan Tree 200' Left of Sta. 575+00.																																																																							
579										159. 12.7 162.9	82 6.2 175.7						Distance: Rod Readings: Elevation.																																																												
I.P.	9.4	190.1	1.2	180.7							5 1.6 188.5	0 1.6 188.5	5 1.6 188.5																																																																
I.P.	0.5	177.7	12.9	172.2						49 1.8 175.9	93 14.3 163.4																																																																		
I.P.	1.4	167.6	11.5	166.2						136 4.8 162.8	177 8.2 159.4	288 11.8 155.8	300 9.4 158.2	400 11.4 156.2	455 12.5 155.1	462 4.6 163.0	Back of pit.																																																												
<p>Note:- The above column headings are to be disregarded as it is the standard Levee Book heading.</p>																																																																													

FIELD NOTES
FOR
LEVELS OVER COMPLETED
WORK FROM LANDSIDE
TOE TO BACK
OF
RIVERSIDE PIT

PLATE V

Note:- The above column headings are to be disregarded as it is the standard Levee Book heading.

FIELD NOTES
FOR
LEVELS OVER COMPLETED
WORK FROM LANDSIDE
TOE TO BACK
OF
RIVERSIDE PIT

PLATE V

19

19

PLATE VI

METHOD OF LOCATING CURVES BY OFFSETS ON LEVEE LOCATION SURVEYS

Date-8-9-29

Instrumentman-Davis

Tape-Tompkins & Lewis

Gurley 17503

Weather - Hot

Find the length of curve, the tangent offset "t", and the chord offset "d" when the tangent $T=220.5'$ Intersection angle $I=60^\circ$, and the degree of curve $D=15^\circ$.

$$L = \frac{I}{D} = \frac{60}{15} = 4 \text{ stations} \quad t = \frac{.873}{16} D = \frac{.873}{16} \times 15 = .818 \text{ feet, from formula } t = \frac{C^2}{2R}; C = \text{lg. of chord}, R = \frac{5730}{D}$$

$$d = \frac{1.745}{16} D = \frac{1.745}{16} \times 15 = 1.636 \text{ feet, from formula } d = \frac{C^2}{2R}$$

With A as center describe an arc with a radius equal to 25 feet, or chord length, then with B as a center and $t=.818$ feet as a radius describe an intersecting arc through C. Set stake at C and produce AC to D making $CD=AC$. From D describe an arc through E making $DE=1.636$. Set stake at E and produce CE to F. Proceed in like manner to K where $HK=t$.

FIELD NOTES
FOR

LOCATING CURVES
BY OFF SETS ON
LEVEE LOCATION
SURVEYS

PLATE VII

VICKSBURG ENGINEER DISTRICT
 MISSISSIPPI RIVER & TRIBUTARIES FLOOD CONTROL
 NEW LEVEE CLASS "A"
 RIGHT OF WAY & DEPTHS AT BACK OF PITS

10' Crown 1 on 3 riverside slope 40' riverside berme and 1 on 6 land-side slope from seepage line 1' below crown; 100' landside berme. Riverside pit 1 on 2 for 6', then 1 on 50, and 1 on 2 for 6', then 1 on 25, with 75' added for right of way from back of pits riverward.

VICKSBURG ENGINEER DISTRICT
MISSISSIPPI RIVER & TRIBUTARIES FLOOD CONTROL
NEW LEVEE CLASS "B"
RIGHT OF WAY & DEPTHS AT BACK OF PITS

10' crown 1 on 3 1/2 riverside slope,
40' Riverside berme and 1 on 6 1/2
landside slope from seepage
line 1' below crown, 100' land-
side berme. Riverside pit 1 on 2
for 6', then 1 on 50, and 1 on 2 for
6', then 1 on 25, with 75' added
in each case for Right of way
from back of pits riverward.

VICKSBURG ENGINEER DISTRICT

MISSISSIPPI RIVER & TRIBUTARIES FLOOD CONTROL

NEW LEVEE CLASS "C"

RIGHT OF WAY & DEPTHS AT BACK OF PITS

2' Crown 5:1 Riverside slope, 40' Riverside berme and 8:1 land-side slope from seepage line 1' below Crown, 100' Landside berme Riverside Pit 2:1 for 6' then 1 on 25, and 1 on 2 for 6' then 1 on 50. With 75' added in each case for Right of way from back of pits river-ward

MAXIMUM LEVEE SECTIONS FOR EACH CLASS OF MATERIAL
VICKSBURG ENGINEER DISTRICT

Dr. by J.R.T. 10/28

File: M.R. 100/40

LEVEE WITH 40' BANQUETTE

Cubic yards per station. Crown 8'. Slopes 3:1 & 3:1, 10:1 & 5:1
Banquette 8' below grade

Feet	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Feet
16	4000	4052	4104	4157	4210	4263	4316	4370	4424	4479	16
17	4533	4588	4644	4699	4755	4811	4868	4924	4981	5039	17
18	5096	5154	5213	5271	5330	5389	5448	5508	5568	5628	18
19	5689	5750	5811	5872	5934	5996	6059	6121	6184	6248	19
20	6311	6375	6439	6504	6568	6633	6699	6764	6830	6896	20
21	6963	7030	7097	7164	7232	7300	7368	7437	7506	7575	21
22	7644	7714	7784	7855	7925	7996	8068	8139	8211	8283	22
23	8356	8428	8501	8575	8648	8722	8796	8871	8946	9021	23
24	9096	9172	9248	9324	9401	9478	9555	9632	9710	9788	24
25	9867	9945	10024	10104	10183	10263	10343	10424	10504	10585	25
26	10667	10748	10830	10912	10995	11078	11161	11244	11328	11412	26
27	11496	11581	11666	11751	11836	11922	12008	12095	12181	12268	27
28	12356	12443	12531	12619	12708	12796	12885	12975	13064	13154	28
29	13244	13335	13426	13517	13608	13700	13792	13884	13997	14070	29
30	14163	14256	14350	14444	14539	14633	14728	14824	14919	15015	30
31	15111	15208	15304	15401	15499	15596	15694	15792	15891	15990	31
32	16089	16188	16288	16388	16488	16589	16690	16791	16892	16994	32
33	17096	17199	17301	17404	17508	17611	17715	17819	17924	18028	33
34	18133	18239	18344	18450	18556	18663	18770	18877	18984	19092	34
35	19200	19308	19417	19526	19635	19744	19854	19964	20075	20185	35
36	20296	20408	20519	20631	20743	20856	20968	21081	21195	21308	36
37	21422										

LEVEE BORROW PIT YARDAGE TABLE

Dist. from berme feet	Cu. yds. per 100' station in pit.	Dist. from berme feet	Cu. yds. per 100' station in pit	Dist. from berme feet	Cu. yds. per 100' station in pit.	Dist. from berme feet	Cu. yds. per 100' station in pit.
6	33	166	2759	326	7381	486	13900
16	148	176	2993	336	7733	496	14370
26	270	186	3233	346	8093	506	14848
36	400	196	3431	356	8459	516	15333
46	537	206	3737	366	8833	526	15826
56	681	216	4000	376	9215	536	16326
66	833	226	4270	386	9493	546	16833
76	993	236	4548	396	10000	556	17348
86	1159	246	4833	406	10403	<p>Table showing available material from edge of riverside, which is 40' from toe of levee.</p> <p>Distances measured from edge of berme.</p> <p>Slopes 2:1 for 6', then 1 to 50'.</p>	
96	1333	256	5126	416	10815		
106	1515	266	5426	426	11233		
116	1707	276	5733	436	11659		
126	1900	286	6048	446	12093		
136	2104	296	6370	456	12533		
146	2315	306	6700	466	12981		
156	2533	316	7037	476	13437		

CUBIC YARDS PER STATION

CLASS "A" SECTION

Fill	.0	.1	.2	.3	.4	Fill	.5	.6	.7	.8	.9	Fill
8	1081	1109	1136	1164	1192	8	1220	1249	1278	1307	1337	8
9	1367	1397	1428	1459	1490	9	1522	1554	1586	1619	1652	9
10	1685	1719	1753	1787	1822	10	1857	1892	1928	1964	2000	10
11	2037	2074	2111	2149	2187	11	2225	2264	2303	2343	2382	11
12	2422	2463	2503	2544	2586	12	2627	2669	2712	2754	2797	12
13	2841	2884	2928	2973	3017	13	3063	3108	3154	3200	3246	13
14	3293	3340	3387	3435	3483	14	3531	3580	3629	3678	3728	14
15	3778	3828	3879	3930	3981	15	4033	4085	4137	4190	4243	15
16	4296	4350	4404	4458	4513	16	4568	4623	4679	4735	4791	16
17	4848	4905	4963	5020	5078	17	5137	5195	5254	5314	5373	17
18	5433	5494	5554	5615	5677	18	5738	5800	5863	5925	5989	18
19	6052	6116	6180	6244	6309	19	6374	6439	6505	6571	6637	19
20	6704	6771	6838	6906	6974	20	7042	7111	7180	7249	7319	20
21	7389	7459	7530	7601	7672	21	7744	7816	7888	7961	8034	21
22	8107	8181	8255	8329	8404	22	8479	8555	8630	8706	8783	22
23	8859	8936	9014	9091	9169	23	9248	9326	9405	9485	9564	23
24	9644	9725	9805	9886	9968	24	10050	10132	10214	10297	10380	24
25	10463	10547	10631	10715	10800	25	10885	10970	11056	11142	11228	25
26	11315	11402	11489	11577	11665	26	11753	11842	11931	12020	12110	26
27	12200	12290	12381	12472	12563	27	12655	12747	12839	12932	13025	27
28	13119	13212	13306	13401	13495	28	13590	13686	13781	13877	13974	28
29	14070	14167	14265	14362	14460	29	14559	14657	14757	14856	14956	29
30	15056	15156	15257	15358	15459	30	15561	15663	15765	15868	15971	30
31	15074	16178	16282	16386	16491	31	16596	16701	16807	16913	17019	31
32	17126	17233	17340	17448	17556	32	17664	17773	17882	17991	18101	32
33	18211	18321	18432	18543	18655	33	18766	18878	18991	19103	19216	33
34	19330	19443	19557	19672	19786	34	19901	20017	20132	20248	20365	34
35	20481	20599	20716	20834	20952	35	21070	21189	21308	21427	21547	35
36	21667	21787	21908	22029	22150	36	22272	22394	22516	22639	22762	36
37	22885	23009	23133	23257	23382	37	23507	23632	23758	23884	24010	37
38	24137	24264	24391	24519	24647	38	24775	24904	25033	25163	25292	38
39	25422	25553	25683	25814	25946	39	26077	26209	26342	26474	26607	39
40	26741	26874	27008	27143	27277	40	27413	27548	27684	27820	27956	40

CUBIC YARDS PER STATION

CLASS "B" SECTION

Fill	.0	.1	.2	.3	.4	Fill	.5	.6	.7	.8	.9	Fill
8	1185	1215	1245	1276	1307	8	1338	1370	1402	1434	1467	8
9	1500	1534	1567	1602	1636	9	1671	1707	1742	1779	1815	9
10	1352	1889	1927	1965	2003	10	2042	2081	2120	2160	2200	10
11	2241	2282	2323	2365	2407	11	2449	2492	2535	2578	2622	11
12	2667	2711	2756	2802	2847	12	2894	2940	2987	3034	3082	12
13	3130	3178	3227	3276	3325	13	3374	3425	3475	3526	3578	13
14	3630	3682	3734	3787	3840	14	3893	3947	3991	4056	4111	14
15	4167	4223	4279	4335	4392	15	4449	4507	4565	4623	4682	15
16	4741	4800	4860	4920	4981	16	5042	5103	5165	5227	5289	16
17	5352	5415	5479	5542	5607	17	5671	5736	5802	5867	5934	17
18	6000	6067	6134	6102	6269	18	6337	6406	6475	6544	6615	18
19	6685	6756	6827	6898	6970	19	7042	7114	7187	7260	7334	19
20	7407	7482	7556	7631	7707	20	7782	7859	7935	8012	8089	20
21	8167	8245	8323	8402	8481	21	8560	8640	8720	8801	8882	21
22	8963	9045	9127	9209	9292	22	9375	9459	9542	9627	9711	22
23	9796	9882	9967	10054	10140	23	10227	10314	10402	10490	10578	23
24	10667	10756	10845	10935	11025	24	11116	11207	11298	11390	11482	24
25	11574	11667	11760	11854	11947	25	12042	12136	12231	12327	12422	25
26	12519	12615	12712	12809	12907	26	13005	13103	13202	13301	13400	26
27	13500	13600	13701	13802	13903	27	14005	14107	14209	14312	14415	27
28	14519	14622	14727	14831	14936	28	15042	15147	15254	15360	15467	28
29	15574	15682	15790	15898	16007	29	16116	16225	16335	16445	16556	29
30	16667	16778	16890	17002	17114	30	17227	17340	17454	17567	17682	30
31	17796	17911	18027	18142	18259	31	18375	18492	18609	18727	18845	31
32	18963	19082	19201	19320	19440	32	19560	19681	19802	19923	20045	32
33	20167	20289	20412	20535	20659	33	20783	20907	21031	21156	21282	33
34	21407	21534	21660	21787	21914	34	22042	22170	22298	22427	22556	34
35	22685	22815	22945	23076	23207	35	23338	23470	23602	23734	23867	35
36	24000	24134	24267	24402	24536	36	24671	24807	24942	25079	25215	36
37	25352	25489	25627	25765	25903	37	26042	26181	26320	26460	26600	37
38	26741	26882	27023	27165	27307	38	27449	27592	27735	27879	28022	38
39	28167	28311	28456	28602	28747	39	28894	29040	29187	29334	29482	39
40	29630	29778	29927	30076	30225	40	30375	30525	30676	30827	30978	40
41	31130	31282	31434	31587	31740	41	31893	32048	32203	32357	32412	41
42	32667	32822	32979	33135	33292	42	33559	33607	33765	33923	34082	42
43	34241	34400	34560	34720	34881	43	35042	35203	35365	35527	35689	43
44	35852	36015	36179	36342	36507	44	36671	36836	37002	37167	37334	44
45	37500	37667	37834	38002	38170	45	38338	38507	38676	38845	39015	45
46	39185	39356	39527	39698	39870	46	40042	40214	40387	40560	40733	46
47	40907	41082	41256	41431	41607	47	41782	41959	42135	42312	42489	47
48	42667	42845	43023	43202	43381	48	43560	43740	43920	44101	44282	48
49	44463	44645	44827	45009	45192	49	45375	45559	45742	45927	46111	49

CUBIC YARDS PER STATION

CLASS "C" SECTION

Fill	.0	.1	.2	.3	.4	Fill	.5	.6	.7	.8	.9	Fill
8	1526	1565	1604	1643	1683	8	1724	1765	1806	1848	1890	8
9	1933	1977	2021	2065	2110	9	2155	2201	2247	2294	2341	9
10	2389	2437	2486	2535	2585	10	2635	2685	2736	2788	2840	10
11	2893	2946	2999	3053	3108	11	3162	3218	3274	3330	3387	11
12	3444	3502	3561	3619	3679	12	3738	3799	3859	3921	3982	12
13	4044	4107	4170	4234	4298	13	4362	4428	4493	4559	4626	13
14	4693	4760	4828	4896	4965	14	5035	5106	5175	5246	5317	14
15	5389	5461	5534	5607	5681	15	5755	5830	5905	5981	6057	15
16	6133	6210	6288	6366	6445	16	6524	6603	6683	6763	6844	16
17	6926	7008	7090	7173	7256	17	7340	7424	7509	7595	7680	17
18	7767	7853	7941	8028	8116	18	8205	8294	8384	8474	8564	18
19	8656	8747	8839	8932	9025	19	9118	9212	9307	9402	9497	19
20	9593	9689	9786	9883	9981	20	10079	10178	10277	10377	10477	20
21	10578	10679	10781	10883	10985	21	11089	11192	11296	11401	11506	21
22	11611	11717	11824	11931	12038	22	12146	12254	12363	12473	12582	22
23	12693	12803	12915	13026	13139	23	13251	13365	13478	13592	13707	23
24	13822	13938	14054	14171	14288	24	14405	14523	14642	14761	14880	24
25	15000	15120	15241	15363	15485	25	15607	15730	15853	15977	16101	25
26	16226	16351	16477	16603	16730	26	16857	16985	17113	17241	17371	26
27	17500	17630	17761	17892	18023	27	18155	18288	18421	18554	18688	27
28	18822	18957	19092	19228	19365	28	19502	19639	19777	19915	20054	28
29	20193	20332	20472	20613	20754	29	20896	21038	21181	21324	21467	29
30	21611	21756	21901	22046	22192	30	22338	22485	22633	22781	22929	30
31	23078	23227	23377	23527	23678	31	23829	23981	24133	24286	24439	31
32	24593	24747	24901	25056	25212	32	25368	25525	25681	25839	25997	32
33	26156	26315	26474	26634	26794	33	26955	27117	27278	27441	27604	33
34	27767	27930	28095	28259	28425	34	28590	28757	28923	29090	29258	34
35	29426	29594	29763	29933	30103	35	30274	30444	30616	30788	30960	35
36	31133	31307	31481	31655	31830	36	32005	32181	32357	32534	32711	36
37	32889	33067	33246	33425	33605	37	33785	33965	34146	34328	34510	37
38	34693	34876	35059	35243	35427	38	35612	35798	35984	36170	36357	38
39	36544	36732	36921	37109	37299	39	37489	37679	37870	38061	38252	39
40	38444	38637	38830	39024	39218	40	39413	39608	39803	39999	40196	40
41	40393	40590	40788	40986	41185	41	41385	41585	41785	41986	42187	41
42	42389	42591	42794	42997	43201	42	43406	43610	43816	44021	44228	42
43	44433	44641	44848	45056	45265	43	45474	45683	45893	46104	46315	43
44	46526	46738	46950	47163	47376	44	47590	47804	48019	48235	48450	44
45	48667	48883	49101	49318	49536	45	49755	49974	50194	50414	50634	45
46	50856	51077	51299	51522	51745	46	51968	52192	52416	52641	52867	46
47	53093	53319	53546	53773	54001	47	54229	54458	54687	54917	55147	47
48	55378	55609	55841	56073	56805	48	56538	56772	57006	57241	57476	48
49	57711	57947	58184	58421	58658	49	58896	59134	59373	59612	59852	49

6/055 B
8

LEVEE WITH 10' CROWN

Cubic yards per station						Slopes 3 1/2 : 1 & 4 : 1					
Feet	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Feet
0	0	4	8	12	17	22	27	33	39	45	0
1	51	58	64	72	79	87	95	103	112	121	1
2	130	139	149	159	169	180	190	201	213	224	2
3	236	246	260	274	287	300	313	327	341	356	3
4	370	385	400	416	432	448	464	481	498	515	4
5	532	550	568	587	605	624	643	662	682	702	5
6	722	743	764	785	806	828	849	872	894	917	6
7	940	963	987	1011	1035	1059	1084	1109	1134	1159	7
8	1185	1215	1245	1276	1307	1338	1370	1402	1434	1467	8

(NOTE: - This table is to be used in conjunction with the tables for New Tentative Section, Class "B", for levees less than 8' in height.)

CUBIC YARDS PER STATION FOR NEW TENTATIVE SECTION =

$$H \left[(H - 1) \frac{S}{2} + \frac{C}{2} \right] \left(\frac{100}{27} \right)$$

H = Height of levee 26

S = Sum of riverside slope and seepage line slope

C = Width of crown

100 = Length of one station in feet.

27 = Number of cubic feet in one cubic yard

LEVEE WITH 8 FOOT CROWN

Cubic Yards per Station. Slopes 3:1 & 3:1.

Feet	0	1	2	3	4	5	6	7	8	9	Feet
0	0	3	6	10	14	18	22	26	31	36	0
1	41	46	52	57	63	69	76	82	89	96	1
2	104	111	119	127	135	144	152	161	170	179	2
3	189	199	209	219	229	240	251	262	273	285	3
4	296	308	320	333	345	358	371	385	398	412	4
5	426	440	455	469	484	499	514	530	546	562	5
6	578	594	611	628	645	662	680	697	715	733	6
7	752	770	789	808	828	847	867	887	907	928	7
8	948	969	990	1011	1033	1055	1077	1099	1121	1144	8
9	1167	1190	1213	1237	1260	1284	1308	1333	1357	1382	9
10	1407	1433	1458	1484	1510	1536	1563	1589	1616	1643	10
11	1670	1698	1726	1754	1782	1810	1839	1868	1897	1926	11
12	1956	1985	2015	2045	2076	2106	2137	2168	2200	2231	12
13	2263	2295	2327	2360	2392	2425	2458	2491	2525	2559	13
14	2593	2627	2661	2696	2731	2766	2801	2837	2872	2908	14
15	2944	2981	3017	3054	3091	3129	3166	3204	3242	3280	15
16	3319	3357	3396	3435	3474	3514	3554	3594	3634	3674	16
17	3715	3756	3797	3838	3880	3921	3963	4005	4048	4090	17
18	4133	4176	4220	4263	4307	4351	4395	4440	4484	4529	18
19	4574	4620	4667	4713	4759	4805	4852	4898	4944	4991	19
20	5037	5086	5134	5183	5231	5280	5328	5377	5425	5474	20
21	5522	5573	5624	5674	5725	5776	5827	5878	5928	5979	21
22	6030	6083	6136	6189	6242	6295	6347	6400	6453	6506	22
23	6559	6614	6669	6725	6780	6835	6890	6945	7001	7056	23
24	7111	7168	7226	7283	7341	7398	7455	7513	7570	7628	24
25	7685	7745	7805	7864	7924	7984	8044	8104	8163	8223	25
26	8283	8345	8406	8468	8530	8592	8653	8715	8777	8838	26
27	8900	8964	9028	9092	9156	9221	9285	9349	9413	9477	27
28	9541	9607	9674	9740	9806	9873	9939	10005	10071	10138	28
29	10204	10273	10341	10410	10478	10547	10615	10683	10752	10821	29
30	10889	10960	11030	11101	11172	11243	11313	11384	11455	11525	30
31	11596	11669	11742	11815	11888	11961	12034	12107	12180	12253	31
32	12326										

LEVEE WITH 6' CROWN

CUBIC YARDS PER STATION

SLOPES 3:1 & 4:1

Fill 0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Fill
0	3	6	10	14	18	22	27	32	37	0
1	43	48	54	60	67	74	81	88	95	1
2	111	119	128	137	146	155	165	174	185	2
3	206	216	228	239	251	263	275	287	300	3
4	326	339	353	367	381	396	411	426	441	4
5	472	488	505	521	538	555	572	590	608	5
6	644	663	682	701	721	740	760	780	801	6
7	843	864	885	907	929	951	974	997	1020	7
8	1067	1091	1115	1159	1183	1214	1239	1265	1290	8
9	1317	1343	1370	1397	1424	1452	1480	1508	1536	9
10	1587	1617	1647	1677	1707	1737	1767	1797	1827	10

2' added to crown
(cu. yds - per station
additionally)

10 = 74 ✓
 11 = 81 ✓
 12 = 89 ✓
 13 = 96 ✓
 14 = 104 ✓
 15 = 111 ✓
 16 = 119 ✓
 17 = 126 ✓
 18 = 133 ✓
 19 = 141 ✓
 20 = 148 ✓
 21 = 156 ✓
 22 = 163 ✓

0.1 = 1 ✓
 0.2 = 1 ✓
 0.3 = 2 ✓
 0.4 = 3 ✓
 0.5 = 4 ✓
 0.6 = 4 ✓
 0.7 = 5 ✓
 0.8 = 6 ✓
 0.9 = 7 ✓

296
 770
 444
 8
 618

LEVEE WITH 8' CROWN

CUBIC YARDS PER STATION

SLOPES 3:1 & 4:1

Fill 0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Fill
0	0	3	6	10	14	18	22	27	32	0
1	43	48	54	60	67	74	81	88	95	1
2	111	119	128	137	146	155	165	174	185	2
3	206	216	228	239	251	263	275	287	300	3
4	326	339	353	367	381	396	411	426	441	4
5	472	488	505	521	538	555	572	590	608	5
6	644	663	682	701	721	740	760	780	801	6
7	843	864	885	907	929	951	974	997	1020	7
8	1067	1091	1115	1159	1164	1188	1214	1239	1265	8
9	1317	1343	1370	1397	1424	1451	1479	1507	1535	9
10	1593	1622	1651	1680	1710	1740	1771	1801	1832	10
11	1894	1926	1958	1990	2022	2055	2088	2121	2155	11
12	2222	2256	2291	2326	2361	2396	2431	2467	2503	12
13	2576	2615	2650	2687	2725	2763	2801	2839	2878	13
14	2956	2995	3033	3075	3115	3155	3196	3237	3278	14
15	3361	3403	3445	3488	3531	3574	3617	3660	3704	15
16	3793	3837	3882	3927	3972	4018	4064	4110	4156	16
17	4250	4297	4345	4392	4440	4488	4537	4586	4635	17
18	4733	4783	4833	4883	4934	4985	5036	5087	5139	18
19	5243	5295	5348	5400	5454	5507	5561	5615	5669	19
20	5778	5833	5888	5943	5999	6055	6111	6168	6225	20
21	6339	6396	6454	6512	6571	6629	6688	6747	6806	21
22	6926	6986	7046	7107	7168	7229	7291	7352	7414	22
23	7539	7602	7665	7728	7791	7855	7919	7983	8048	23
24	8178	8243	8309	8375	8441	8507	8574	8640	8708	24
25	8843	8910	8979	9047	9116	9185	9254	9323	9393	25
26	9533	9604	9675	9746	9817	9888	9960	10032	10104	26
27	10250	10323	10396	10470	10544	10618	10692	10767	10842	27
28	10993	11068	11144	11220	11297	11374	11451	11528	11605	28
29	11761	11839	11918	11997	12076	12155	12235	12314	12395	29
30	12556	12636	12716	12799	12881	12962	13045	13127	13210	30
31	13376	13459	13543	13627	13711	13796	13881	13966	14051	31
32	14222	14308	14395	14481	14568	14655	14741	14830	14918	32

BORROW PIT YARDAGE TABLE FOR LEVEES 1 on 25 SLOPES

Dist. from berme feet	Cu. Yds. per 100' Station in pit.	Dist. from berme feet	Cu. yds. per 100' station in pit.	Dist. from berme feet.	Cu. yds. per 100' station in pit.
6	33	256	7441	506	24107
31	394	281	8671	531	26200
56	778	306	10033	556	28551
81	1283	331	11469	581	30913
106	1805	356	12996	606	33366
131	2500	381	14617	631	35413
156	3367	406	16330	656	38552
181	4247	431	18135	681	41283
206	5219	456	20033	706	44107
231	6283	481	22020		

Table showing available material from the edge of the riverside berme, which is 40' from the toe of the levee. Distances measured from edge of berme. Slopes 2:1 for 6 feet, then 25:1.

SPECIAL BORROW PIT YARDAGE TABLE FOR LEVEES 1 ON 15 SLOPE

Dist. from berme feet	Cu. yds. per 100' station in pits.	Dist. from berme feet	Cu. yds. per 100' station in pits.	Dist. from berme feet	Cu. yds. per 100' station in pit.
6	33	171	5223	336	17145
21	227	186	6033	351	18562
36	477	201	6895	366	20035
51	783	216	7811	381	21563
66	1144	231	8784	396	23146
81	1561	246	9812	411	24785
96	2033	261	10895	426	26480
111	2561	276	12034	441	28230
126	3144	291	13229	456	30035
141	3783	306	14479	471	31897
156	4478	321	15784	486	33813

Table showing available material from edge of riverside berme which is 40' from the toe of the levee. Distances measured from the edge of the berme. Slopes 1 on 2 for 6', then 1 on 15.

Scale:-
Horizontal:- 1:1000.
Vertical:- 1:400.

Typical Borrow Pit Sections of the Standard Pit deepened on 1 on 50 slope and on 1 on 25 slope and a special pit deepened on 1 on 15 slope.

VOLUME OF CYLINDERS IN CUBIC YARDS

Diam. ft.	Depth in feet																		
	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
3			1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3
4		1	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	4	5
5	1	1	1	2	2	3	3	3	4	4	4	5	5	5	6	6	7	7	7
6	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10
7	1	2	3	4	4	5	6	6	7	8	9	9	10	11	11	12	13	14	14
8	2	3	4	5	6	7	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	4	5	6	7	8	9	11	12	13	14	15	16	18	19	20	21	22	24
10	3	4	6	7	9	10	12	13	15	16	17	19	20	22	23	25	26	28	29
11	4	5	7	9	11	12	14	16	18	19	21	23	25	26	28	30	32	33	35
12	4	6	8	10	13	15	17	19	21	23	25	27	29	31	34	36	38	40	42
13	5	7	10	12	15	17	20	22	25	27	29	32	34	37	39	42	44	47	49
14	6	9	11	14	17	20	23	26	29	31	34	37	40	43	46	48	51	54	57
15	7	10	13	16	20	23	26	29	33	36	39	43	46	49	52	56	59	62	65
16	7	11	15	19	22	26	30	34	37	41	45	48	52	56	60	63	67	71	74
17	8	13	17	21	25	29	34	38	42	46	50	55	59	63	67	71	76	80	84
18	9	14	19	24	28	33	38	42	47	52	57	61	66	71	75	80	85	90	94
19	11	16	21	26	32	37	42	47	53	58	63	68	74	79	84	89	95	100	105
20	12	17	23	29	35	41	47	52	58	64	70	76	81	87	93	99	105	111	116
21	13	19	26	32	38	45	51	58	64	71	77	83	90	96	103	109	115	122	128
22	14	21	28	35	42	49	56	63	70	78	85	92	99	106	113	120	127	134	141
23	15	23	31	38	46	54	62	69	77	85	92	100	108	115	123	131	138	146	154
24	17	25	34	42	50	59	67	75	84	92	101	109	117	126	134	142	151	159	168
25	18	27	36	45	55	64	73	82	91	100	109	118	127	136	145	155	164	173	182

TYPICAL SECTION FOR NEW LEVEE

TYPICAL SECTION OF ENLARGEMENT

Note to Inspectors -
Plot nine sections to the sheet
Scale
Vertical 1"=20'
Horizontal 1"=20'

CATFISH NEW LEVEE

STATION 945-1163

WEST BANK MISSISSIPPI RIVER IN ARKANSAS
CONTRACTOR

LEGEND:-

- ORIGINAL SURFACE
- - - THEORETICAL GROSS LEVEE SECTION
- · · NET LEVEE SECTION
- - - ACTUAL LEVEE SECTION

Date _____ Signed _____

Sheet No. 1.

U.S. Inspector
Sta. 945-952.

WAR DEPARTMENT

Note to Inspectors: The abbreviation of the month shall be lettered in the space covered by work done as shown. This Profile shall be submitted with sections every ten stations at the commencement of the work. A blue print will be returned each month and the progress plotted on the blue-print which will be submitted with other monthly reports. The legend shown shall be strictly adhered to.

LEGEND:

- ☐ Dredge
- ☐ Machine
- ☐ Teams & Tractors

VICKSBURG ENGINEER DISTRICT
MISSISSIPPI RIVER & TRIBUTARIES FLOOD CONTROL

Progress Profile

of
Levee Construction

By Months

CATFISH ENLARGEMENT
W. Bank Mississippi River in Arkansas
Sta. _____ to Sta. _____

John. Doe, Contractor
Date Commenced _____
Date Completed _____

Signed _____
U.S. Inspector

Note to Inspectors:— The abbreviation of the month shall be lettered in the space covered by work done as shown. This Profile shall be submitted with sections every ten stations at the commencement of the work. A blue print will be returned each month, and the progress plotted on the blue print which will be submitted with other monthly reports. The Legend shown shall be strictly adhered to.

LEGEND—

- MACHINE
- DREDGE
- TEAMS & TRACTORS

VICKSBURG ENGINEER DISTRICT

MISSISSIPPI RIVER & TRIBUTARIES FLOOD CONTROL

Progress Profile
of
Levee Construction
By Months

CATFISH NEW LEVEE

Sta. _____ to Sta. _____
West Bank Mississippi River in ARK.
John Doe, Contractor

Date Commenced

" Completed

Signed

U.S. Inspector

EAST BANK OF THE MISSISSIPPI RIVER IN MISSISSIPPI

Station	Old Grade	New Grade
0	179.3	184.0
20	179.2	183.9
30	179.1	183.8
40	179.0	183.7
50	178.9	183.6
60	178.8	183.5
70	178.7	183.4
80	178.6	183.2
90	178.5	183.1
100	178.4	183.0
120	178.4	183.0
140	178.4	183.0
180	178.3	182.9
200	178.2	182.8
220	178.1	182.6
250	178.0	182.5
280	177.9	182.3
320	177.8	182.2
350	177.7	182.1
370	177.6	182.0
390	177.5	181.8
420	177.5	181.8
450	177.5	181.8
470	177.4	181.7
490	177.4	181.6
561/80 580	177.3	181.4
600	177.1	181.1
620	176.9	180.9
630	176.7	180.7
650	176.5	180.5
670	176.3	180.3
680	176.2	180.1
700	176.0	179.9
710	175.9	179.8
730	175.7	179.6
740	175.5	179.4
770	175.1	179.0
800	174.8	178.6
850	174.6	178.4
880	175.1	178.8
930	174.2	177.8
960	174.1	177.7
1010	174.0	177.5
1050	173.9	177.4
1070	173.8	177.3
1090	173.7	177.1
1110	171.7	175.1
1160	171.6	175.0
1280	171.5	174.6
1290	170.1	173.2
1300	171.1	174.2
1310	170.0	173.2

EAST BANK OF THE MISSISSIPPI RIVER IN MISSISSIPPI

Station	Old Grade	New Grade
1314 = 1290/47	170.0	175.1
1320	170.0	173.1
1330	170.0	173.1
1340	169.9	173.0
1350	169.9	173.0
1360	169.8	172.9
1390	169.7	172.8
1410	169.7	172.8
1430	169.6	172.7
1460	169.5	172.6
1490	169.3	172.4
1510	169.2	172.3
1666 = 1632/80	168.9	172.0
2010	167.4	170.5
2020	167.4	170.5
2030	167.4	170.5
2040	167.3	170.4
2050	167.2	170.3
2100	166.3	169.4
2130	165.8	168.9
2150	165.2	168.3
2180	164.9	168.0
2200	164.9	168.0
2230	164.7	167.8
2260	164.5	167.6
2320	164.3	167.3
2350	164.1	167.1
2380	164.0	164.0
2410	163.9	166.9
2440	163.5	166.5
2470	163.4	166.4
2480 = 2481	163.4	166.4
2500	163.3	166.3
2520	163.2	166.2
2540	163.2	166.2
2570	163.1	166.1
2610	163.0	166.0
2630	162.9	165.9
2640 = 2636	162.9	165.9
2650	162.9	165.9
2670	162.9	165.9
2690	162.8	165.8
2710	162.7	165.7
2740	162.7	165.7
2760	162.7	165.7
2770	161.0	164.0
2780	160.8	163.8
2790	160.7	163.7
2800	160.6	163.6
2810	160.5	163.5
2820	160.3	163.3
2830	160.3	163.3
2849 = 2832/72	160.2	163.2

EAST BANK OF THE MISSISSIPPI RIVER IN MISSISSIPPI

Station	Old Grade	New Grade
2860	160.1	163.1
2890	159.9	162.9
2920	159.7	162.7
2980	159.3	162.3
3050	159.1	162.1
3190	158.7	161.0
3200	158.7	161.0
3210	157.6	160.9
3220	157.6	161.0
3230	157.6	161.0
3240	157.6	161.0
3250	157.6	161.0
3258/50 = 3261/65	157.6	161.0
3300	157.6	161.2
3330	157.6	161.4
3390	157.3	161.2
3400	157.3	161.2
3414	151.3	155.2
3430	151.2	155.2
3450	151.1	155.2
3452 Bolivar - Washington County Line		
3460	151.1	155.1
3480	151.1	155.1
3500	151.1	155.1
3510	151.1	155.1
3540	151.1	155.1
3560	150.9	154.9
3580	150.8	154.8
3620	150.8	154.8
3640	150.8	154.8
3660	150.7	154.7
3680	150.7	154.7
3710	150.7	154.7
3750	150.6	154.6
3760	150.1	154.1
3780	148.7	152.7
3790	148.0	152.0
3800	147.3	151.3
3810	146.8	150.8
3820	146.8	150.8
3830	146.8	150.8
3840	146.8	150.8
3860	146.7	150.7
3870	146.7	150.7
3880	146.7	150.7
3920	146.6	150.6
3930	146.6	150.6
3960	146.5	150.5
3970	146.3	150.3
4000	146.2	150.2
4010		

EAST BANK OF THE MISSISSIPPI RIVER IN MISSISSIPPI

Station	Old Grade	New Grade
4020	146.1	150.1
4030	146.0	150.0
4040	145.9	149.9
4050	145.9	149.9
4060	145.8	149.8
4070	145.7	149.7
4080	145.4	149.4
4090	145.3	149.3
4100	145.2	149.2
4110	145.1	149.1
4120	145.0	149.0
4130	144.9	148.9
4143	144.3	148.3
4150	144.3	148.3
4160	144.3	148.3
4180	144.3	148.3
4340	143.2	147.2
4390	142.9	146.9
4400	142.8	146.8
4410	142.7	146.7
4430	142.5	146.5
4449/40 = 4441/80	142.3	146.3
4510	141.7	145.7
4520	141.6	145.6
4530	141.5	145.5
4540	141.4	145.4
4560	141.2	145.2
4570	141.1	145.1
4590	140.9	144.9
4600	140.8	144.8
4620	140.6	144.6
4630	140.5	144.5
4660	140.2	144.2
4670	140.1	144.1
4690	139.9	143.9
4900	139.5	143.5
4940	139.4	143.4
5230	138.7	142.7
5320	138.1	142.1
5330	137.9	141.9
5340	137.6	141.6
5350	137.4	141.4
5360	137.3	141.3
5370	137.2	141.2
5390	137.2	141.2
5400	137.1	141.1
5410	137.1	141.1
5430	137.1	141.1
5450	137.0	141.0
5470	137.0	141.0
5480	137.0	141.0

EAST BANK OF THE MISSISSIPPI RIVER IN MISSISSIPPI

Station	Old Grade	New Grade
5560	136.9	140.9
5600	136.9	140.9
5630	136.8	140.8
5640	136.8	140.8
5660	136.7	140.7
5690	136.7	140.7
5710	136.6	140.6
5750	136.6	140.6
5760	136.5	140.5
5780	136.5	140.5
5800	136.4	140.4
5820	136.3	140.3
5850	136.1	140.1
5880	135.4	139.4
5900	135.2	139.2
5910	135.1	139.1
5920	135.0	139.0
5930	134.9	138.9
5940	134.7	138.7
5950	134.6	138.6
5960	134.4	138.4
5970	134.2	138.2
5980	134.1	138.1
5990	134.0	138.0
6000	133.9	137.9
6020	133.7	137.7
6040	133.5	137.5
6070	133.3	137.3
6110	133.2	137.2
6254/65 = 6256/70	132.0	136.0
6270	132.3	136.3
6290	132.2	136.2
6300	132.1	136.1
6310	132.0	136.0
6320 = 6317/40	132.0	136.0
6330	131.9	135.9
6350	131.8	135.8
6370	131.7	135.7
6390	131.6	135.6
6400	131.5	135.5
6405/50 Washington - Issaquena County Line	131.4	135.4
6410	130.8	134.8
6430	130.6	134.6
6450	130.3	134.3
6470	130.0	134.0
6490	129.7	133.7
6510	129.3	133.3
6530	129.0	133.0
6550	128.5	132.5
6570	128.3	132.3
6590		

EAST BANK OF THE MISSISSIPPI RIVER IN MISSISSIPPI

Station	Old Grade	New Grade
6610	128.3	132.3
6630	128.2	132.2
6650	128.2	132.2
6670	128.1	132.1
6690	128.0	132.0
6710	127.8	131.8
6730	127.7	131.7
6750	127.3	131.3
6770	127.0	131.0
6799 = 6800	126.9	130.9
6840	126.8	130.8
6860	126.8	130.8
6880	126.7	130.7
6950	126.7	130.7
6970	126.5	130.5
7010	126.6	130.6
7030	126.5	130.5
7050	126.5	130.5
7070	126.4	130.4
7090	126.4	130.4
7110	126.3	130.3
7130	126.2	130.2
7133 = 7130 + 60	126.2	130.2
7150	126.1	130.1
7170	126.0	130.0
7190	125.9	129.9
7210	125.8	129.8
7230	125.7	129.7
7250	125.7	129.7
7270	125.6	129.6
7290	125.5	129.5
7330	125.4	129.4
7350	125.3	129.3
7390	125.2	129.2
7400	124.9	128.9
7420	124.6	128.6
7440	124.4	128.4
7470	124.2	128.2
7490	124.0	128.0
7510	123.8	127.8
7530	123.6	127.6
7540	123.4	127.4
7600	123.0	127.0
7620	122.8	126.8
7640	122.7	126.7
7660	122.6	126.6
7680	122.4	126.4
7700	122.3	126.3
7720	122.1	126.1
7740	122.0	126.0
7760	121.9	125.9

EAST BANK OF THE MISSISSIPPI RIVER IN MISSISSIPPI

Station	Old Grade	New Grade
7770	121.7	125.7
7790	121.5	125.5
7810	121.3	125.3
7850	121.2	125.2
7890	121.2	125.1
7910	121.1	125.0
7970	121.0	124.9
7990	120.9	124.8
8030	120.8	124.7
8050	120.8	124.7
8080	120.6	124.5
8120	120.5	124.4
8140	120.4	124.3
8170	120.3	124.2
8189/20 = 8187	120.2	124.0
8190	120.1	123.9
8210	120.0	123.8
8230	119.8	123.6
8250	119.5	123.3
8270	119.3	123.1
8310	119.1	122.9
8350	118.9	122.7
8370	118.7	122.5
8390	118.5	122.3
8410	118.3	122.1
8430	118.1	121.9
8450	117.9	121.7
8470	117.8	121.6
8490	117.6	121.3
8520	117.5	121.2
8550	116.7	120.4
8570	115.8	119.5
8590	115.2	118.9
8610	115.0	118.7
8640	114.8	118.5
8660	114.6	118.3
8680	114.5	118.2
8700	114.4	118.1
8720	114.3	118.0
8729/80 = 8727/85	114.3	118.0
8740	114.2	117.9
8760	114.1	117.8
8800	114.0	117.6
9040	113.9	117.5
9220	113.8	117.3
9240	113.7	117.2
9260	113.6	117.1
9280	113.5	117.0
9286/35 Issaquena - Warren County Line	113.4	116.9
9300	113.4	116.8
9441/25 = 9432/50		

EAST BANK OF THE MISSISSIPPI RIVER IN MISSISSIPPI

Station	Old Grade	New Grade
9460	113.3	116.7
9470	113.3	116.7
9470 = Station 0 of Brunswick Levee Extension		
0	114.3	117.7
50	114.0	117.4
100	113.7	117.1
150	113.4	116.8
200	113.1	116.5
250	112.8	116.1
300	112.5	115.8
350	112.2	115.5
400	111.9	115.2
450	111.6	114.9
500	111.3	114.6
550	111.0	114.2
563	111.0	114.2
600	110.7	113.9
650	110.4	113.6
700	110.1	113.3
750	109.8	113.0
800	109.5	112.6
850	109.2	112.3
900	108.9	112.0
950	108.6	111.7
1000	108.3	111.4
1050	108.0	111.1
1100	107.7	110.7
1150	107.4	110.4
1200	107.1	110.1
1250	106.8	109.8

West Pass Levee

SOUTH BANK OF THE ARKANSAS RIVER IN ARKANSAS

Station	Old Grade	New Grade
Pine Bluff	215.4	218.4
Frenchtown Levee District		
0	215.3	218.3
50	214.5	217.5
100	213.8	216.8
150	213.1	216.1
204	212.2	215.2
Linwood-Auburn Levee District		
0	208.1	211.1
50	207.4	210.4
100	206.6	209.6
150	205.9	208.9
200	205.2	208.2
250	204.3	207.3
300	203.4	206.4
350	202.7	205.7
400	201.8	204.8
450	201.2	204.2
500	200.3	203.3
550	199.6	202.6
602 15 0 Arkansas River Levee	199.3	203.3
Arkansas River Levee		
0	199.3	202.3
50	199.1	202.1
89	198.8	201.8
100	198.7	201.7
150	198.5	201.5
188	198.3	201.3
200	198.2	201.2
250	198.0	201.0
288	197.8	200.8
300	197.8	200.8
350	197.7	200.7
388	197.6	200.6
400	197.6	200.6
450	197.5	200.5
488	197.4	200.4
500	197.2	200.2
530	196.4	199.4
550	195.7	198.7
580	195.3	198.3
600	195.1	198.1
630	194.9	197.9
650	194.7	197.7
680	194.5	197.5
700	194.4	197.4
730	194.2	197.2
750	194.0	197.0
780	193.8	196.8

SOUTH BANK OF THE ARKANSAS RIVER IN ARKANSAS

Station	Old Grade	New Grades
800	193.6	196.6
829	193.4	196.4
850	192.7	195.7
880	191.6	194.6
900	191.5	194.5
931	191.3	194.3
950	191.2	194.2
1000	190.9	193.9
1031	190.7	193.7
1050	190.6	193.6
1100	190.2	193.2
1130	190.0	193.0
1150	189.8	192.8
1180	189.6	192.6
1200	189.5	192.5
1230	189.3	192.3
1250	188.8	191.8
1287	188.5	191.5
1300	188.4	191.4
1337	188.0	191.0
1350	187.7	190.7
1364	187.4	190.4
1400	187.2	190.2
1425	187.1	190.1
1450	186.4	189.4
1475	185.7	188.7
1500	185.0	188.0
1525	184.3	187.3
1550	183.5	186.5
1572	182.7	185.7
1600	182.4	185.4
1621	182.0	185.0
1650	181.7	184.7
1700	181.1	184.1
1721	180.9	183.9
1750	180.5	183.5
1800	179.9	182.9
1821	179.6	182.6
1850	179.1	182.1
1871	178.8	181.8
1900	178.3	181.3
1918	177.9	180.9
1950	177.3	180.3
1972	176.9	179.9
2000	176.3	179.3
2022	175.9	178.9
2050	175.6	178.6
2100	175.1	178.1
2122	174.9	177.9
2150	174.6	177.6
2172	174.4	177.4
2200	174.2	177.2

SOUTH BANK OF THE ARKANSAS RIVER IN ARKANSAS

Station	Old Grade	New Grade
2222	173.9	176.9
2250	173.8	176.8
2300	173.6	176.6
2322	173.5	176.5
2350	173.4	176.4
2400	173.0	176.0
2422	172.8	175.8
2450	172.9	175.9
2471	173.0	176.0
2500	173.1	176.1
2521	173.1	176.1
2550	173.2	176.2
2571	173.3	176.3
2600	173.3	176.3
2621	173.2	176.2
2650	173.1	176.1
2671	173.1	176.1
2700	173.0	176.0
2726	173.0	176.0
2750	172.9	175.9
2776	172.9	175.9
2800	172.7	175.7
2826	172.6	175.6
2850	172.1	175.1
2876	171.6	174.6
2900	171.2	174.2
2930	170.7	173.7
2950	170.7	173.7
2980	170.6	173.6
3000	170.5	173.5
3030	170.3	173.3
3050	170.0	173.0
3080	169.5	172.5
3100	169.2	172.2
3130	168.8	171.8
3150	168.6	171.6
3180	168.2	171.2
3200	167.6	170.6
3220	167.0	170.0
3240	166.5	169.5
3250	166.4	169.4
3290	166.2	169.2
3300	166.1	169.1
3350	165.7	168.7
3380	165.5	168.5
3400	165.4	168.4
3450	165.3	168.3
3500	165.2	168.2
3511/16	165.1	168.1

1914 PROVISIONAL & 1928 TENTATIVE GRADES

WEST BANK OF THE MISSISSIPPI RIVER IN ARKANSAS

Old Station	New Station	Old Grade	New Grade
0		165.1	168.1
50		164.7	167.7
100		164.6	167.6
150		164.6	167.6
200		164.3	
250		164.2	
300		164.1	
350		164.0	
400		163.1	
450		162.2	
500		161.7	
550		161.5	
600		160.5	
650		160.0	
700		159.3	
750		158.8	
800		158.6	
850		158.5	
900		157.9	Fuse
950		157.2	Plug
1000		156.8	Levee
1050		156.7	
1100		156.6	
1150		156.5	
1173/15	1173/15	156.4	
1303			
1329/85	1200	156.3	
1380/85	1250	155.9	
1430/35	1300	155.3	
1481/35	1350	154.9	
1511/35	1380	154.8	
1531/65	1400	154.7	
1582/35	1450	154.1	
1632/35	1500	154.1	
1688/50	1550	153.8	
1738/50	1600	153.6	
1788/50	1650	153.6	
1828	1700	150.3	154.3
1878	1750	149.2	153.2
1928	1800	148.6	152.6
1989	1850	148.5	152.5
2040	1900	148.3	152.3
2091	1950	148.1	152.1
2142	2000	148.1	152.1
2175	2033	148.1	152.1
2276	2050	142.8	146.8
2326	2100	142.3	146.3
2376	2150	141.9	145.9
2426	2200	141.8	145.8
2476	2250	141.7	145.7
2526	2300	141.4	145.4
2576	2350	141.1	145.1

WEST BANK OF THE MISSISSIPPI RIVER IN ARKANSAS

Old Station	New Station	Old Grade	New Grade
2626	2400	140.8	144.8
2676	2450	140.5	144.5
2727	2500	140.2	144.2
2777	2550	139.9	143.9
2827	2600	139.6	143.6
2877	2650	139.3	143.3
2927/70	2700	139.0	143.0
3028	2800	138.7	142.7
3078	2850	138.4	142.4
3128	2900	138.1	142.1
3178	2950	137.8	141.8
3228	3000	137.5	141.5
3273	3050	137.2	141.2
3328	3100	136.9	140.9
3378	3150	136.3	140.3
3429	3200	135.4	139.4
3479	3250	134.7	138.7
3529	3300	134.7	138.7
3579	3350	134.7	138.7
3630	3400	134.5	138.5
3681	3450	134.3	138.3
3732	3500	133.9	137.9
3742	3550	133.9	137.9
3834	3600	133.1	137.1
3886	3650	132.5	136.5
3937/25	3700	132.1	136.1
3988	3750	131.6	135.6
4039/72	3800	130.8	134.8
4088/72	3850	130.7	134.7
4138/72	3900	130.5	134.5
4187	3950	130.4	134.4
4208	3973	130.3	134.3

WEST BANK OF THE MISSISSIPPI RIVER IN LOUISIANA

Old Stations	New Stations	1914 (Old Grade)	1928 New Grade
0		130.3	134.3
50		130.3	134.3
100		130.1	134.1
150		130.1	134.1
200		129.9	133.9
250		129.9	133.9
300		129.8	133.8
350		129.6	133.6
400		129.1	133.1
450		129.1	133.1
500		129.0	133.0
550		128.8	132.8
600		128.8	132.8
650		128.6	132.6
700		128.6	132.6
750		128.4	132.4
800		128.2	132.2
850		127.1	131.1
900		126.6	130.6
950		126.1	130.1
1000		125.4	129.4
1050		125.4	129.4
1100		125.2	129.2
1150		125.1	129.1
1200		125.1	129.1
1250		124.7	128.7
1300		124.5	128.5
1350		124.3	128.3
1400		124.0	128.0
1450		123.9	127.9
1500		123.4	127.4
1550		123.4	127.4
1600		123.3	127.3
1650		123.3	127.3
1700		123.0	127.0
1750		123.0	127.0
1800		122.7	126.7
1850		122.4	126.3
1900		121.6	125.5
1950		120.2	124.1
2000		119.8	123.7
2050		119.2	123.1
2100		118.7	122.6
2150		118.7	122.5
2200		117.9	121.7
2250		117.6	121.4
2300		117.4	121.2
2309 = 2260	2309	117.2	121.0

WEST BANK OF THE MISSISSIPPI RIVER IN LOUISIANA

Old Station	New Station	Old Grade	New Grade
2301	2350	117.1	120.9
2352	2400	116.9	120.7
2402	2450	116.9	120.6
2452	2500	116.4	120.1
2502	2550	116.3	120.0
2552 27	2600	116.3	120.0
2578	2650	115.2	118.9
2628	2700	115.2	118.9
2678	2750	115.2	118.8
2728	2800	114.1	117.7
2739	2850	114.1	117.7
2789	2900	113.1	116.7
2839	2950	113.1	116.7
2889	3000	112.6	116.2
2936	3050	112.6	116.1
2988	3100	112.3	115.8
3037	3150	112.0	115.5
3087	3200	111.9	115.4
3137	3250	111.7	115.2
3187	3300	111.3	114.8
3237	3350	110.8	114.2
3287	3400	110.7	114.1
3337	3450	110.4	113.8
3388	3500	110.3	113.7
3438	3550	109.9	113.3
3478	3600	109.9	113.3
3528	3650	109.2	112.5
3578	3700	108.2	111.5
3628	3750	108.1	111.4
3678	3800	107.8	111.1
3728	3850	106.8	110.0
3778	3900	106.6	109.9
3828	3950	106.6	109.8
3878	4000	106.3	109.5
3928	4050	105.9	109.1
3978	4100	105.9	109.1
4028	4150	105.8	109.0
4078	4200	105.7	108.9
4129	4250	105.4	108.5
4180	4300	105.1	108.2
4230	4350	104.6	107.6
4281	4400	102.8	105.9
4332	4450	102.7	105.8
4383	4500	102.3	105.4
4434	4550	101.9	104.9
4485	4600	101.5	104.5
4536	4650	101.1	104.1
4587	4700	100.8	103.8
4638	4750	100.8	103.8

VICKSBURG ENGINEER DISTRICT

Day of Month	Number of Laborers, All Grades	Number of Teams	Wheel Scrapers	Dump Wagons	Drag Scrapers	Elevating Graders	Weather, etc.
--------------	--------------------------------	-----------------	----------------	-------------	---------------	-------------------	---------------

Cu. yds. per team	Avg. lgth. of haul
-------------------	--------------------

Station to Station

**Total
Cubic Yards**

IN PLACE TO DATE

Per cent	Cubic Yards
----------	-------------

DRESSED AND SODDED—Station to Station

This report

To date

General Remarks Concerning Work

GRAND TOTAL,
Increase Since Last Report

Report of weather and working conditions for the month of1928.....Contractors

.....Levee DistrictContract. Stations.....to.....R.D.....Cu.Yds. moved this month

D A Y	TEAMS			MACHINES						ELEVATIONS			Progress delayed approximate percent			CONDITIONS			REMARKS
	Avail- able.	Worked worked	%of day worked	Avail- able.	Worked worked	%of day worked	Avail- able	Worked worked	% of day worked	Natural surface	Bottom of pit	River	Rain	Seepage	Break- downs	Pit	Labor	Weather	
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
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23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			

Inspector: _____

Chief Inspector: _____

55

VICKSBURG ENGINEER DISTRICT

Report No.....

..... Area Levee District,

Levee Machine..... at Stations.....(Miles below Cairo).
Summary of Levee Operations during the month of.....1

..... Stations..... (Miles from.....)
Summary of Levee Operations during the month of.....192

		DESCRIPTION		OF		WORK		DONE		
Stations	%	Embankment	Road Crossing	Muck Ditch	Stump Holes	False Berme	Drain Ditch			Total
		Cu. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.			

I have measured and computed the above work and certify it was performed in accordance with approved plans and specifications.

I certify the above work was performed in accordance with approved plans and specifications.

Submitted as correct
to the best of my
knowledge and belief.

Surveyman

Chief of Party

Area Engineer

DAILY REPORT FOR _____ HIRE
 Local name of levee Stations
 Contractor Date of contract

Address.....Date.....
 District
 Total liability.....Total expended.....

	Unit		Prices				Weather Condition	REMARKS				
	\$	\$	\$	\$	\$	\$						
Units												
Hours												
1st												
2nd												
3rd												
4th												
5th												
6th												
7th												
8th												
9th												
10th												
Unit Hra.												
Unit days							Total ex-	Today	To-date			
Previous							penditures	cu.yds.	cu.yds.	Ave.	cu.yds.	Ave.
To date							\$	pr.team	pr.team	Haul	pr.team	Haul
Value today	\$	\$	\$	\$	\$	\$	\$					
Previous	\$	\$	\$	\$	\$	\$		Stas.				
To date	\$	\$	\$	\$	\$	\$	\$					

Chief Inspector _____

Inspector _____

Mail check to _____
Date _____

TO

DR.

19__ For hire of teams and extra labor repairing _____
 Date _____ Sta. _____ to Sta. _____
 to _____ under informal agreement of _____ 19__ during _____
 Date _____ 19__ as follows:

[illegible]

wheeler team days	⊙ \$	_____	per wheeler team day of 10 hrs.....	\$
fresno team days	⊙ \$	_____	per fresno team day of 10 hrs.....	\$
hook team days	⊙ \$	_____	per hook team day of 10 hrs.....	\$
plow team days	⊙ \$	_____	per plow team day of 10 hrs.....	\$
wagon team days	⊙ \$	_____	per wagon team day of 10 hrs.....	\$
tractor & grader days	⊙ \$	_____	per tractor & grader day of 10 hrs.	\$
labor days	⊙ \$	_____	per labor day of 10 hrs.....	\$
	⊙ \$	_____		\$
	⊙ \$	_____		\$
	⊙ \$	_____		\$
	⊙ \$	_____		\$

TOTAL

Articles received in good condition, or services rendered. All as per agreement M. R. _____
and this bill. Date _____

Certified correct and just
Payment not received.

Designation _____

By _____
One of the firm.

LEVEL NOTES AND ESTIMATES

of Levee. County.

Contractor.

Crown feet. Slopes, to 1 front, and to 1 back.

Form No. 2704

VICKSBURG ENGINEER DISTRICT

CONSTRUCTION NOTES

Stations (.....), Contractor.

Kind of Work,

Crown, Ft. Landside Slope to 1. Riverside Slope, to 1.

U. S. GOVERNMENT PRINTING OFFICE: 1920

STATIONS	GROSS FILLS AT		DISTANCES		REMARKS
	FEET	FEET	LEFT SLOPE	RIGHT SLOPE	

The above is a copy of the official construction notes for the stations shown; the contractor is expected to construct the levee in accordance therewith, and as specified in the specifications.

I certify that the above construction notes are computed from the field cross-section notes, and they have been checked and found correct.

WAR DEPARTMENT
Mississippi River Commission
Vicksburg Engineer District

BORROW PIT CONSTRUCTION NOTES

Place Levee District

Pit Slope to 1 All distances measured from center of new levee

To: In Charge Contractor

Sta.	N.S. Elev. used	Dist edge berm	Front of Pit				INTERMEDIATES							
			Dist Out	Actual Elev.	Grade Elev.	Cut	Dist Out	Actual elev.	Grade elev	Cut	Dist Out	Actual elev.	Grade elev	Cut
.....														
.....														
.....														
.....														
.....														
.....														

INTERMEDIATES (Continued)				BACK OF PIT				Pit	Levees	Distance
Dist Out	Act'l elev	Grade elev	Cut	Dist Out	Act'l elev	Grade elev	Cut	yard age	yard- age	to back of R. of Way
.....										
.....										
.....										
.....										
.....										
.....										
.....										

These notes to be made in triplicate, the original to be issued to contractor or machine foreman, one copy to the Area Engineer and one copy to be kept on file by the inspector.

Remarks:

Date 19

P. O.

.....
U. S. Inspector.

Levee District

Places: _____

Total _____, In charge

Contractor _____

I have run grades over stations below on dates indicated and found the following:

[illegible]

BORRO, PITS

[illegible]

(All distances measured from center of new enlargement. These notes to be made in triplicate, the original to be issued to contractor or machine foreman, one copy to the Area Engineer and one copy to be kept on file by the inspector).

Remarks:

Date _____ 19____

P.O. _____

U. S. Inspector.

DAILY LOG REPORT
(To be mailed to the Area Office at close of each day.)

Levee XSectioned Sta. - Sta.		Pits XSectioned Sta. - Sta.		XSection Computed Sta. - Sta.		XSection Platted Sta. - Sta.		Date
								Name of Machine or Contract
Const. Notes issued Sta. - Sta.		Grades Run Sta. - Sta.		XSection Notes Sta. - Sta.		Mailed to Senior Inspector Plotted Section Sta. - Sta.		
Weather	Pits	Change in Force		Breakdowns		Miscellaneous		
REMARKS								

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Area Inspector

Date received

Area Engineer

Inspector

VICKSBURG ENGINEER DISTRICT

COMPARISON OF MEMPHIS AND CAIRO DATUMS WITH MEAN GULF LEVEL

THE MEAN GULF LEVEL, WHICH WAS ADOPTED BY RESOLUTION BY THE MISSISSIPPI RIVER COMMISSION JUNE 21st., 1899, AS THE REFERENCE PLANE FOR ELEVATIONS OF ALL PERMANENT SURVEY MARKS OF THE COMMISSION, READS 6.083 FEET ON THE STAFF GAGE AT BILOXI, MISSISSIPPI. THIS VALUE WAS DERIVED FROM FIVE YEARS RECORD ON THE AUTOMATIC GAGE AT THIS STATION.

EFFECTIVE SINCE 1912

ELEVATION OF THE ZERO OF GAGES
IN THE VICKSBURG ENGINEER DISTRICT

GAGE	ELEVATION OF ZERO OF GAGE	
	M.G.L.	M.D.
WHITE RIVER	108.86'	115.49'
ARKANSAS CITY	96.75'	103.38'
GREENVILLE	88.53'	95.16'
LAKE PROVIDENCE	69.77'	76.40'
VICKSBURG	46.16'	52.79'

File No. 99/48

REPORT DOCUMENTATION PAGE

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				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Joseph B. Dunbar, Amber L. Ensign, Nalini Torres, and Maureen K. Corcoran				5d. PROJECT NUMBER J8D2HJ	
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14. ABSTRACT The following study examines the occurrence of seepage incidents and sand boils observed and documented during the 2011 Mississippi River Flood in the lower Mississippi River valley within the boundaries of the U.S. Army Corps of Engineers (USACE), Mississippi Valley Division (MVD), Vicksburg District (MVK). This study examines the occurrence of sand boils in relationship to the underlying floodplain geology and identifies locations where large sand boils occurred. Large sand boil areas will be the focus for additional detailed study to better understand the mechanics of underseepage and internal erosion in USACE flood control levees. Seepage and sand boil incidents documented during the 2011 Flood are presented in this report on geologic base maps and pre-flood imagery to compile a record of their occurrence and identify geologic relationships, as well as spatial patterns associated with the underlying fluvial landforms. A review of levee evolution within the lower Mississippi River valley is summarized here along with past research studies of seepage involving major historic floods and their control.					
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