Technical Report No. V.

TECHNICAL GUIDANCE AVAILABLE FOR DESIGN, CONSTRUCTION, AND MAINTENANCE OF THE MR-GO AND LPV

Expert Report prepared for

Katrina Canal Breaches Consolidated Litigation
[Civil Action Number: 05-4182 "K" (2)]

United States District Court
Eastern District of Louisiana

Pertains to MR-GO, Robinson

(C. A. No. 06-2268)

By

Robert G. Bea, Ph.D., P.E.
and
Jesse L. Arnold, P.E.

July 14, 2008

TECHNICAL GUIDANCE AVAILABLE FOR DESIGN, CONSTRUCTION, AND MAINTENANCE OF THE MR-GO AND LPV

Introduction

The death and destruction wrought by Hurricane Katrina prompts questions regarding the design, construction, and maintenance practices employed by the USACE to implement the Mississippi River Gulf Outlet (MR-GO) development plan and the Lake Ponchartrain and Vicinity Hurricane Protection System (LPV) plan. Because the LPV hurricane flood protection structures and the MR-GO channel are proximate and parallel, concern extends to their combined effects.

A review of the guidance documents available on the USACE website (http://www.usace.army.mil/publications/eng-manuals/) reveals an extensive collection of publications covering a broad range of design, construction, and maintenance topics related to civil works, including the MR-GO and coastal flood protection levees. Furthermore, reading some of these publications discloses substantial depth of technical knowledge formatted for practical application to projects of this scope. How then, one could ask, did the LPV hurricane flood protection structures suffer such devastation in the course of Hurricane Katrina?

To address this question, this report identifies particular guidance documents, primarily Engineering Manuals, within the USACE library for use in design, construction, and maintenance of the MR-GO channel and the LPV flood protection structures. These manuals,

representing a part of the body of knowledge, are relevant to performance of the MR-GO and LPV hurricane flood protection structures in at least four ways:

1. Knowledge used to anticipate the environmental effects of the projects,
2. Knowledge used to anticipate storm effects contributory to destruction of levees,
3. Knowledge used to design and construct levees to resist the anticipated storm effects,
4. Knowledge acquired over time to improve performance of hurricane flood protection structures to the anticipated storm effects.

Other parts of the body of knowledge existed and were applied in practice. One part is the broader collection of literature available in the public domain, much of which is referenced in the bibliographies within the engineering manuals. A second, more important part is the network of practitioners (engineers and scientists) available both within the USACE and in the broader technical community (university level researchers, local, state, national, and international engineers and scientists in private practice). This latter resource, available to the USACE, is the resource capable of exercising judgment and decision regarding the complex problems posed by the scope of this project.

The remainder of this report discusses application of the body of knowledge to these projects with a view toward the consequences culminating in the effects of Hurricane Katrina.

Anticipating Project Environmental Effects

In this regard, the following chronological sequence should be recognized: the MR-GO was constructed and operating prior to construction of the LPV flood protection structures. Before construction of the MR-GO practically all of the alignment of interest in this report (Reach 2 of the MR-GO) was a coastal wetland consisting of freshwater - intermediate cypress swamps and marsh. Historical photographs (New Orleans Public Library 2008), taken in course of channel dredging, show the cypress trees to be a thick and mature forest, often on both sides of the channel (Reach 1). In some stretches near Lake Borgne, the channel cuts through fresh water and brackish water marshes (Reach 2).

The dredging operation was conducted in two stages. The first stage, an access channel, 18 feet deep by 140 feet wide, was cut along the proposed alignment. After that, the access channel was widened to 500 feet and deepened to 36 feet to form the MR-GO. Spoil from dredging was deposited in dike enclosed areas on the west bank of the MR-GO. This required clearing of trees and other obstacles to the dredging to a distance of 1500 feet from the west bank of the MR-GO. Spoil, being suspended in wash water, was allowed to pool to form a low elevation platform comprised primarily of sands and silts.

This activity is widely recognized to have accelerated degradation of the swamps and marshes between Lake Borgne and communities along the east bank of the Mississippi River. Immediate degradation is attributable to removal of trees over many acres and placement of an open and deep channel of water. Since swamp and marsh coastline were commonly known to serve as buffer to mitigate advance of surge water and wind of hurricanes, this construction represented loss of protection from approach of a hurricane.

That point does not appear to have been a consideration in design of the MR-GO project. If considered, the designer would probably have thought in terms of protective beaches as described in Technical Report No. 4, Shore Protection, Planning and Design (hereafter cited as TR-4). Sections 3.3 and 5.4 present the concepts then guiding design. Although that section considers sand as the prevailing beach material, the concepts can be extended with judgment to shoreline conditions such as that east of the MR-GO. The primary concepts applied would have been focused on re-establishing vegetation and shaping of a mound, similar to a dune.

Beyond construction, the design team should have considered channel bank erosion contributory to further environmental degradation. Note is made today that the original channel width of 500 feet has increased to more than 2000 feet. This observation suggests that measures to control bank degradation were not well addressed. The designer would have used one or more of several manuals depending on the problem at hand or availability at the time:

1. EM 1110-2-1613, Hydraulic Design of Deep Draft Navigation Projects.
2. EM 1110-2-1418, Channel Stability Assessment for Flood Control Projects.
3. EM 1110-2-5025, Dredging and Dredging Material Disposal.

Given the long history of Corps involvement in navigation projects, including dredged channels (e.g., the Intra-Coastal Waterway and the Mississippi River), one would expect a long-standing and well developed base of knowledge and experience at that time (circa 1958) applicable to the MR-GO. If there were no levee planned on the bank, the easement for channel unlimited, and funds for dredging were endless, then one could reason that control of bank degradation would be unimportant. That is not the case today since it can be seen that bank degradation has now encroached on the toe to the LPV hurricane flood protection structures in several locations. All other issues aside, this situation represents a threat to the integrity of a

flood protection structure. To date it does not appear that measures to address this situation have been implemented. A designer working this problem at any time since construction could refer to EM 1110-2-1614, Design of Coastal Revetments, Seawalls, and Bulkheads, for guidance to design at least one countermeasure for channel slope degradation.

Anticipating Storm Effects

With respect to the LPV hurricane flood protection structures, the principal storm effects of interest are storm surge and wave action. Storm surge degrades earthen levees by erosion after overtopping or by through seepage. Wave action on the unprotected side degrades the earthen levee by incessant pounding from breaking waves, scour and erosion. It is common that these effects occur simultaneously, as illustrated in the instance of Hurricane Katrina.

These effects were known at the time design of the LPV hurricane flood protection structures was undertaken. The primary reference document for use in design at that time was TR-4. TR-4 provided rational means to predict storm surge (Section 1.32). Thus, a person designing the LPV hurricane flood protection structures would have an indication of the height and duration of inundation on the flood-side of the levee.

Extensive design information was provided in TR-4 for characterization of wave forms and effects for use in design to resist action against manmade structures such as groins, jetties, seawalls, etc. The forces, frequencies, and duration of waves, as well as estimated run-up, derived could be used to select a levee configuration, including core materials, and would indicate the type of armoring needed.

Guidance for Design and Construction

The TR-4 document provides no information on design methods applicable to levees. Thus, for design and construction of the LPV hurricane flood protection structures, it is expected that the designer would refer to the current edition of EM 1110-2-1913, Design and Construction of Levees. This document provides a well developed discussion of all elements of levee design and construction along with references to other publications to detail particular features of the work. Those references include guidance for protection of exposed slopes by grass and armoring. Much of this could be applied to levees in the coastal environment by application of engineering judgment.

Two aspects of levee design addressed in EM 1110-2-1913, settlement and stability, are particularly relevant to the LPV hurricane flood protection structures. Since the levee represents a heavy load on the soft deposits underlying this alignment, significant settlement is anticipated. This settlement results in lowering of crest elevation planned to meet the storm surge level predicted for this locale. Application of the procedures of analysis cited in EM 1110-2-1913 and detailed in EM 1110-1-1904, Settlement Analysis, provides a means to predict and plan for settlement. Simply stated, settlement is accommodated by selecting higher crest elevation and then maintaining that elevation.

Similar comment is made relative to stability analysis. The detailed means to perform these analyses are presented in EM 1110-2-1902, Stability of Earth and Rock-Fill Dams. The findings of stability analysis are represented in terms of slope grades selected. Poor soils such as those found at this site require that low profile slopes are required to achieve stability.

Since the Reach 2 EBSBs (Earthen Berm – Spoil Banks) are proximate to the MR-GO channel, part of this analysis should be directed toward checking the potential for sliding into the channel. Recognizing that the MR-GO channel has widened due to submarine slope and bank degradation, the indication is that the analysis should be repeated as the bank encroaches on the toe of the levee. At least some portions of levee stability analyses (about 275 pages of profiles, notes, and computer print-out, referenced as Stability Analyses Papers) were made available to us. These analyses were checked page by page to see if this analysis was done. There was no indication that this had been done as indicated earlier in this text.

In the case of an embankment, such as these EBSBs, subject to transient and infrequent impounding of water (the storm surge) the stability analysis also considers seepage through the levee. That aspect of the analysis is detailed in EM 1110-2-1901, Seepage Analysis and Control for Dams. There are no such analyses in the information provided us.

Another component of design is selection of earthen materials to form the levee. This is also addressed in EM 1110-2-1913. At this location the selection favors use of materials less susceptible to erosion, primarily clays. In addition, the expectation of moving water and breaking waves favors the choice of armoring to protect the slope facing the MR-GO. The materials observed by numerous investigators following Hurricane Katrina included significant quantities of sand and shell in the levee debris (ILIT, page 6-21, first paragraph). It is now understood that these Reach 2 EBSBs were constructed of recycled dredge spoil. Thus it appears that this aspect of design and construction was not performed with full regard of guidance in EM 1110-2-1913. One suggestion derived from this document would favor the use of more clayey borrow to the exclusion of sand and shell and organic detritus. Contrary to that, it appears that the EBSBs were constructed using dredged spoil materials as borrow, placed as hydraulic fill. This method of

construction renders the choice and quality material placed impractical. In other words, a high bank of dredge spoil was constructed rather than a levee.

Improving Performance

The foregoing design and construction of the LPV hurricane flood protection structures were accomplished during the period 1965 through 2005 (still under construction at the time of Hurricane Katrina). Note is also made that the MR-GO was completed in 1968. Thus design and construction methods prevailing during that interval could have been used. Subsequent to that interval the base of knowledge continued to increase. One significant area of advance is in the arena of environmental impact of projects. This point is marked by the passage of the National Environmental Policy Act, NEPA, in 1969. After that date, a broad array of environmental legislation was enacted. EM 1110-2-38, Environmental Quality in Design of Civil Works, dated May 3, 1971 recognizes this area of advance and indicates the intent of the USACE to include environmental considerations in their projects.

Consequently, other manuals, such as EM 1110-2-1202, Environmental Engineering for Deep Draft Navigation Projects, dated May 29, 1987 and EM 1110-2-1204, Environmental Engineering for Coastal Shore Protection, dated July 10, 1989, reveal the application of this intent to projects such as the MR-GO and coastal design, in general. With regard to the MR-GO, another document, EM 1110-2-5025, Dredging and Dredged Material Disposal, dated March 25, 1983 is relevant to the periodic maintenance of the channel by dredging. Even though it appears that the environmental considerations contained within these manuals post-date construction, there remains the opportunity to implement environmentally favorable practices in the course of on-going maintenance. One such opportunity arose following the destruction of these levees by

Hurricane Katrina. In brief, repair of the levee could be viewed as maintenance. It appears that rebuilding of the levee was undertaken posthaste – possibly with reasonable intentions. Unfortunately, that also appears to disregard the possibility of considering other more environmentally beneficial measures such as marsh or swamp restoration toward Lake Borgne. This is a comprehensive suggestion that merits some further consideration in the public arena.

Another significant area of advance is in the area of design practice for coastal defense structures and works. This advance is illustrated by progressive, rapid, and dramatic expansions of the TR-4 document into the current Coastal Engineering Manual, dated June 1, 2006. This larger manual suggests that a greater body of knowledge has been made available for design, construction, and maintenance of coastal facilities and features. Noteworthy in the current CEM is the guidance provided for design and construction of dikes (the embankment for flood protection previously called levees). An aspect of dike design relevant to the LPV hurricane flood protection structures is the provision of slope armoring to resist direct action of waves. This improvement of the knowledge base raises the question, "Why were the EBSB slopes not armored as part of on-going maintenance of the LPV hurricane flood protection structures?" This question becomes more relevant when it is recognized that levee design as described in EM 1110-2-1913 has long included the use of armoring along streams such as the Mississippi River.

Conclusions

The Engineering Manuals (EM) cited in the foregoing text shows that a significant body of knowledge has been available from USACE libraries since the inception of the LPV project. In addition it is also reasoned that other publications in the private sector are also available (many are referenced in the USACE manuals). Yet the availability of this body of increasingly

broader knowledge did not prevent the destruction of the LPV hurricane flood protection structures. Instead, it appears that significant portions of this knowledge base were ignored or mis-applied. The conclusions reported by the ILIT report (Section 11.3.1, fourth paragraph and Section 11.3.3) favor this conclusion. In brief, the ILIT points to several design and maintenance deficiencies: erosion susceptible soils in the levee section, failure to maintain levee crest grade, and failure to use certain engineered features (including slope face armoring) at selected locations. To that we add the conclusion that Corps work on the MR-GO initiated the degradation of the local swamp/marsh environment as described herein. To date, that damage has progressed and yet remains unaddressed despite a wealth of information enabling corrective work.

We declare under the penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on July 11, 2008 in Moraga, California.



Robert Bea, Ph.D, PE

References

New Orleans Public Library. Historical photographs of the construction of the MR-GO.

USACE, Technical Report No. 4, Shore Protection, Planning and Design, first issued in 1954, subsequently revised and improved until replaced by the Shore Protection Manual in 1973.

EM 1110-2-1613, Hydraulic Design of Deep Draft Navigation Projects

EM 1110-2-1418, Channel Stability Assessment for Flood Control Projects

EM 1110-2-5025, Dredging and Dredging Material Disposal

EM 1110-2-1614, Design of Coastal Revetments, Seawalls, and Bulkheads

EM 1110-2-1913, Design and Construction of Levees

EM 1110-1-1904, Settlement Analysis

EM 1110-2-1902, Stability of Earth and Rock-Fill Dams

Stability Analyses Papers, titled Chalmette Area Plan (Paris Road to Bayou Bienvenue), 2nd and 3rd Lifts, Stations 277+75 to 359+00, SOILS REPORT, October 1984 (Desk Copy).

EM 1110-2-1901, Seepage Analysis and Control for Dams

EM 1110-2-38, Environmental Quality in Design of Civil Works

EM 1110-2-1202, Environmental Engineering for Deep Draft Navigation Projects

EM 1110-2-1204, Environmental Engineering for Coastal Shore Protection

EM 1110-2-1100, Coastal Engineering Manual

U.S. Army Coastal Engineering Research Center, Fort Belvoir, Virginia, Shore Protection Manual

ILIT (2006). Independent Levee Investigation Team, Investigation of the Performance of the New Orleans Flood Protection Systems in Hurricane Katrina on August 29, 2005, University of California Berkeley, Berkeley, CA.