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Hearing on
Hurricane Katrina: Why did the Levees Fail?

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Madame Chair and Members of the Committee

Introduction

I am Dr. Paul F. Mlakar, Senior Research Scientist at the US Army Engineer Research and Development Center (ERDC) in Vicksburg, Mississippi, which is a component of the US Army Corps of Engineers (the Corps). I have spent most of my professional career spanning four decades in the Corps studying the response of structures to extreme loadings. This has included the performance of the Murrah Building in the Oklahoma City bombing and the performance of the Pentagon in the 9/11 crash. I am a Registered Professional Engineer, a Fellow of the American Society of Civil Engineers, and received their Forensic Engineering Award in 2003.

As some of you know, the ERDC conducts research and development to enable the Corps to better perform its military and civil missions in service to the Nation. We employ some 2548 people in seven laboratories located in four states. This staff is recognized nationally and internationally for its expertise in civil engineering and related disciplines. Our facilities include a number of unique devices that allow us to conduct analyses and experiments on the leading edge of technology.

I am pleased to appear today on behalf of the ERDC and the Corps to provide information as requested in your letter of invitation dated 27 October 2005. The Congressional interest in the performance of the storm damage reduction infrastructure in Hurricane Katrina is much appreciated and shared by the Corps. While we do not yet have the answers to all of the questions, we welcome this opportunity to share our progress with you.

The Corps takes its responsibility for the safety and well-being of the Nation's citizens very seriously. In the case of the New Orleans area, we are determined to learn what failed, how it failed, why it failed, and to recommend ways to reduce the risk of failure in the future.

On September 22, 2005, the Corps asked me to lead in the collection of data for the study of the storm damage reduction infrastructure affected by Hurricane Katrina. On September 26, 2005, I deployed to New Orleans on the heels of Hurricane Rita and have spent most of the intervening time in the region. At various times I have been joined by some thirty colleagues from the Corps. Our priority has been on the breaches in the metropolitan area that caused the greatest devastation, i.e. the 17th Street Canal, the London Canal, and the Inner Harbor Navigation Canal.

We have been diligently recording the damages and measuring the post-Katrina conditions. We have examined physical evidence to establish the maximum water elevations at various locations. To establish the timeline of events, we have conducted detailed interviews with about 70 people who sat out the storm. To establish the soil properties, we have pushed a state of the art instrumented cone to a depth of 80 feet at 56 locations. We further collected samples of the soil at depth in 10 locations. We have also electronically scanned 63 out of 235 boxes of documents dealing with the design, construction, and maintenance of the projects involved.

As we deployed, the American Society of Civil Engineers and a University of California team sponsored by the National Science Foundation approached the Corps about similar studies of infrastructure performance they were undertaking in hopes of applying lessons learned to the levee systems in California. In the spirit of openness and full transparency, we invited these teams to join us beginning on September 29, 2005 for inspections of the projects involved. On September 30, 2005, we learned that the State of Louisiana would soon establish its own study team and we invited the researchers from the Louisiana State University Hurricane Research Center to join us in advance of this official establishment. The Corps gratefully acknowledges the assistance provided by these teams in the collection of the data.

Over the next eight months, an Interagency Performance Evaluation Team commissioned by the Chief of Engineers will examine and analyze these data, and rationally test various hypotheses about the behavior of the infrastructure. The work currently planned will include the following tasks:

Geodetic Reference Datum
Storm Surge and Wave Modeling
Hydrodynamic Forces
Floodwall and Levee Performance
Pumping Station Performance
Interior Drainage/Flooding Modeling
Consequence Analysis
Risk and Reliability Assessment

We will seek the collaboration of other agencies and academia as we proceed with this factual study.

The final results will include conclusions as to the causes of the failures and recommendations for the future design and construction of such infrastructure nationwide. These results will be independently reviewed by the American Society of Civil Engineers and, at the request of the Secretary of Defense, the National Academies/National Research Council will independently review the results as well. Our scheduled completion date is July 1, 2006. In the meantime, our interim results are being shared with our colleagues in the Corps responsible for the repair of the storm damage reduction system in New Orleans and will be taken into consideration in the design and repair of the existing levees and floodwalls.

In response to your specific questions we are able to offer the following responses at this time:

Why did the levees fail?

There is no single answer to this question as there were multiple breaches of levees and floodwalls at a number of locations and the exact failure mechanism of each is likely to be different. The answer to this will follow from a thorough analysis of the data we are now collecting. In some cases, e.g. the Inner Harbor Navigation Canal, we have observed evidence of overtopping that may have played a role. In other cases, e.g. the 17th Street Canal, we have observed evidence of massive soil movement that could have been a factor in how these levees

failed. There is a need for considerable analysis to answer this question. Until we can compare the evidence to an understanding of the hydrodynamic environment that resulted from the storm, the forces generated by the resulting surge and waves, how those forces were applied to individual structures and how the structures, given their design intent and capacities, should respond to those forces, we will only be speculating as to why they failed.

What was the physical process that caused these failures?

The physical processes that caused the breaches will be determined from the comprehensive analysis of the data that we are collecting. What we have to date is evidence of what happened; we can see the final result of the structural behavior, but we cannot yet determine why. That will require more understanding of the design intent of each structure, its condition prior to the storm, the forces to which it was subjected (static and dynamic) and the ability to at least simulate how the structure would respond to those forces. This is the objective of our current interagency analysis efforts.

What role did human error play in these failures?

Through a thorough analysis of the data that we are collecting, we will explore whether human error played any role in the performance of the infrastructure.

Have we found any errors in the design or construction of these systems?

We have not yet determined whether the failures were caused by errors in the design or construction of these systems, or by some other means. Our analysis will help establish the cause. We are examining the ability of the structures as designed to deal with the forces applied by the storm. Those forces in some cases may have been well beyond the design capacity. In other cases, the structure may not have performed as expected and we will determine why. Until we can relate the performance to the forces, with accepted engineering analysis, we are not comfortable speculating on the adequacy of a design.

What can these failures and the efforts to repair them tell us about the level of protection the remaining flood and hurricane protection systems provide to residents of New Orleans and the surrounding parishes?

The results of our study will provide a better indication of the extent to which the remaining system can be expected to reduce the risk of future storm damage. We will be examining and providing analysis on the performance of the entire storm damage reduction system, to understand the failures that occurred, to understand other components of the system that may have been degraded in their capacity to protect against future storms and to understand where the system performed successfully. We will be developing information on risk and reliability of the system as it will be after we complete repairs.

In conclusion, I want to caution against reaching conclusions to your very important questions before appropriate analysis is accomplished. Speculation concerning observed damage is one thing, but we are not yet in a position to understand why that damage occurred. I hope that my

testimony illustrates the Corps' past and continuing commitment to the pursuit and use of sound science and engineering principles in the execution of our civil works missions.

On behalf of the Corps, thank you for allowing me the opportunity to present this testimony today.