II. Introduction

Background

The Interagency Performance Evaluation Task Force, IPET, was initiated by the Chief of Engineers to determine the facts concerning the performance of the New Orleans hurricane protection system (HPS) in response to Hurricane Katrina. IPET has over 150 experts from 50 organizations conducting in-depth analyses that includes understanding the surge and wave levels resulting from the storm, determining the forces experienced by the HPS, understanding the design, as-built and as-maintained character of the HPS, determining the most likely causes and mechanisms for observed behavior (failure and success), characterizing the extent and consequences of flooding to include the influence of the pumping stations, and performing a risk and reliability assessment of the HPS.

> *…"to provide credible and objective scientific and engineering answers to fundamental questions about the performance of the hurricane protection and flood damage reduction system in the New Orleans metropolitan area."*
> LTG Carl A. Strock, Chief of Engineers, 10 Oct 2005

Fundamentally, the IPET analysis will assist the Corps and other responsible agencies in understanding why various components of the hurricane protection system performed as they did during Katrina, providing input to all of the ongoing efforts to reconstitute the Hurricane Protection System. This includes support to the three main efforts to fully achieve the authorized levels of protection, repair of the areas seriously damaged by Hurricane Katrina, the design and construction efforts to restore the HPS to authorized elevations of protection (one third is estimated to be below authorized levels due to settling and subsidence) and the design and construction for the completion of the previously authorized hurricane protection system (not yet completed because of lack of funds). The goal is to be able to use these lessons learned to reconstitute a more resilient and capable HPS than that which existed prior to Katrina. The extensive information repository, analytical tools and analysis results will also provide a significant new body of knowledge and analytical capability from which the Corps can begin evaluation of alternative approaches to providing higher levels of protection in the future. It is also hoped that the findings of the IPET efforts, coupled with the insights and interpretations of the ASCE External Review Panel and the NRC Committee on New Orleans Regional Hurricane

Protection Projects will contribute to positive changes in engineering practice and water resources policy for the future.

During the conduct of the IPET studies, there has been continuous interaction with the Corps of Engineers entities in New Orleans responsible for the repair and reconstitution of hurricane protection in the New Orleans region. These organizations, Task Force Hope, Task Force Guardian and the New Orleans District, have representatives embedded in the IPET Teams and provide an effective two-way conduit for information and rapid transfer of results and lessons learned. It is imperative that the knowledge gained by the IPET and others be immediately made available to those responsible for repair and reconstruction.

IPET Report 1, Performance Evaluation Plan and Interim Status, published on 10 January, 2006, documented the IPET scope of work and analysis methods that resulted from significant interaction with the individual experts and the collective body of the External Review Panel. ASCE provided their formal review of IPET Report 1 in a letter report to the Chief of Engineers on 20 February 2006, available on the ASCE Web Site. The National Research Council Committee published their comments and review of the IPET activities and Report 1 in a letter report to the Assistant Secretary of the Army for Civil Works on 21 February, 2006, available on the National Academies of Engineering Web Site.

IPET Report 1, available on the IPET Web Site, *https://IPET.wes.army.mil*, also provided a status report of the analysis in the various task comprising the IPET plan with a limited number of example products, mostly related to the initial storm surge and wave modeling. It included significant background information concerning the organization of the IPET activities, the participants and their affiliations, information sources and management and the general approach for accomplishing the scopes of work. The primary reference information in Report 1 will not be duplicated in this report. Some common components will appear in Report 2 if they required update or expansion to provide complete documentation for this effort. This will mostly be in the form of Appendices that provide detail for the discussions in the main body of the report.

Objective and Scope

The objective of Report 2, Performance Evaluation and Interim Results, is to present a synopsis of analyses to date and present the results of those analyses. A secondary objective is to provide at least a full prototype of the analysis that will be achieved for all aspects of the effort to allow the ERP and NRC reviewers a greater opportunity to provide feedback and advice to enhance the ultimate impact and value of the IPET efforts.

This report is structured around the five major questions that comprise the IPET mission. It will for the first time present some significant results of analysis that will form the basis for the findings in the IPET Final Report, Report 3,

scheduled for 1 June, 2006. These results will range from the relatively complete products of some aspects of the performance evaluation to prototypes of products for other tasks. The geodetic vertical and water level datum and the storm surge and wave condition analyses are examples of areas where the full scope of the work is nearly complete.

In other areas the analysis is nearly complete for a portion of the scope of work, for example the structural performance analysis of the 17th Street drainage canal breach. This represents a relatively complete picture of the extent and detail of the analyses being conducted for other components of the system and will be the basis for extension of the results to the evaluation of other areas of the HPS with similar characteristics or conditions. While the final report will contain some additional information concerning the 17th Street breach, the results presented in this report are considered validated and credible.

The information for other tasks, for example the risk and reliability analysis, will be prototypes for the final products that are under development. The intent for these areas is to document and describe how these products are being developed and what they will look when published in the final report. In the case of the consequence analysis and the risk and reliability analyses, Orleans East will be used to demonstrate and describe prototype products. The prototype products will be configured with actual data, however, the data and analysis may not be complete enough to make these products suitable for application. The report will be provided to the ASCE External Review Panel on 9-10 March, 2006 in Vicksburg, MS and to the NRC Committee on New Orleans Regional Hurricane Protection Projects on 20 March, 2006 in New Orleans, LA.

Approach

This report, expected to represent the general architecture for the IPET final report, will focus on the answers to the five fundamental questions posed in Report 1 as the primary focus of the IPET activities:

- **Hurricane Protection System:** What were the design criteria for the pre-Katrina hurricane protection system, and did the design, as-built construction, and maintained condition meet these criteria?

- **Storm:** What were the storm surges and waves used as the basis of design, and how do these compare to the storm surges and waves generated by Hurricane Katrina?

- **Performance:** How did the floodwalls, levees, pumping stations, and drainage canals, individually and acting as an integrated system, perform in response to Hurricane Katrina, and why?

- **Consequences:** What have been the societal-related consequences of the Katrina-related damage?

- **Risk:** Following the immediate repairs, what will be the quantifiable risk to New Orleans and vicinity from future hurricanes and tropical storms?

To answer these questions, there has been a considerable effort in developing the baseline information to support the specific analyses that they imply. A significant component of that effort has been the development of a data repository and data management capability to ensure the quality of the data used in the IPET analyses as well as making a comprehensive data and information source available for this and other applications concerning hurricane protection in the New Orleans area. This effort was driven by a data requirements matrix that defined the information critical to the successful completion of the planned scopes of work, the proposed sources of that information and the time schedule for when it was needed. An updated Data Requirements Matrix is provided in Appendix A. The IPET Data Repository was documented in Report 1 and will not be described herein with the exception of the update with regard to its status and general content provided in Appendix B. In addition, Appendix C updates the information concerning the IPET public web site, *https://IPET.wes.army.mil*, the principal mechanism to rapidly distribute IPET information and results to the public.

The first major section of the report deals with the development of a new Geodetic Vertical and Water Level Datum. This represents an acceleration of efforts that were ongoing between the Corps of Engineers and the NOAA National Geodetic Survey. This effort supports all other efforts by providing a modern and validated datum for referencing all measurements, the relative positions of all features and products of the analyses that are sensitive to geo-position. It was an essential because of the complex legacy of multiple reference frameworks and the very significant and variable subsidence that pervades South East Louisiana.

The second major section deals with description of the Hurricane Protection System (HPS). This section focuses on the character of the HPS starting with the definition of the Standard Project Hurricane (SPH), translation of the SPH into authorized levels of protection, design criteria and assumptions for the structures proposed to provide that protection, as-built character flowing construction and the maintained condition of the structures. This section includes a description of the geotechnical information available to and used for the design and construction. This is the first step in understanding and examining the performance of the entire HPS and its status just prior to Hurricane Katrina. To augment this information a chronology of the significant decisions and communications are presented in Appendix C. This report uses the 17th Street Drainage Canal as a first example of this chronology. The final report will include similar information for a broader segment of the HPS.

The third section deals with characterization of Hurricane Katrina. This involves regional and high resolution modeling of the surge and waves generated by the storm to understand the time history of the water levels and static and dynamic forces that impacted the HPS. The regional modeling provided a perspective of the surge and wave environments for all locations around the HPS. The high resolution hydrodynamic modeling was focused on creating a more

accurate representation of these water levels and forces in the confined areas of the drainage canals, the Inner Harbor Navigation Canal (IHNC) and the Gulf Intra-coastal Water Way (GIWW). A time history of water conditions and the resultant forces are essential to conducting a credible performance analysis, allowing the level of forces appropriate to be used in evaluation of structure performance based on the established timing of events. The second component documents the establishment of a time line of events, essentially the timing of the breaching and overtopping of the HPS components and flooding of various drainage areas relevant to the timing of the storm. This is an essential input to both the high resolution hydrodynamics work and the structural performance analysis. The time line provides guidelines for when water in the canals would be lost to flooding, impacting water levels and subsequent forces in the canals. It also allows accurate determination of the time history and character of water levels and related forces to which structures were subjected at the time of overtopping or breaching.

The next section documents the structural performance of the HPS. The performance analysis is presented for the 17th Street Drainage Canal breach. While this analysis is still not final, the results to date, specifically the depiction of the failure mechanism for the event, are considered valid and the most likely cause of the breach. This description represents the approach and methods that are being used for understanding the breaching and overtopping events for other parts of the HPS. This section will also provide a status of work under way to analyze other components of the system. Finally, this section will address how the information concerning performance at specific locations is being used to address the assessment of the capacity of other similar reaches or structures within the HPS.

The Consequence section will document the status of efforts to model the flooding resulting from overtopping and breaching and the losses due to that flooding. The flooding analysis includes characterization of the pump station performance from the perspectives of evacuation of water during and after the storm and as a source of water fro flooding via backflow through idle pumping facilities. Prototype products from the pump station analysis and interior drainage analysis are provided as representative of the analysis being accomplished for the entire area of interest. The consequence analysis of losses for input to risk and reliability analysis will use Orleans East as a prototype for developing sample products. The consequence analysis is in the process of determining the likely extent of flooding and losses if there had been no catastrophic breaching of the HPS, the prototype analysis presented her is limited to the actual flooding and losses resulting from Katrina for one polder.

The final section deals with the risk and reliability analysis and will document the methodology developed and present an example application of the methodology for Orleans East. This example is not considered a validated result, simply a representative example of the types of risk products and information that will be available in the final report. This section is also intended to demonstrate the value of the risk approach as a means of evaluating the system-wide performance of the HPS.