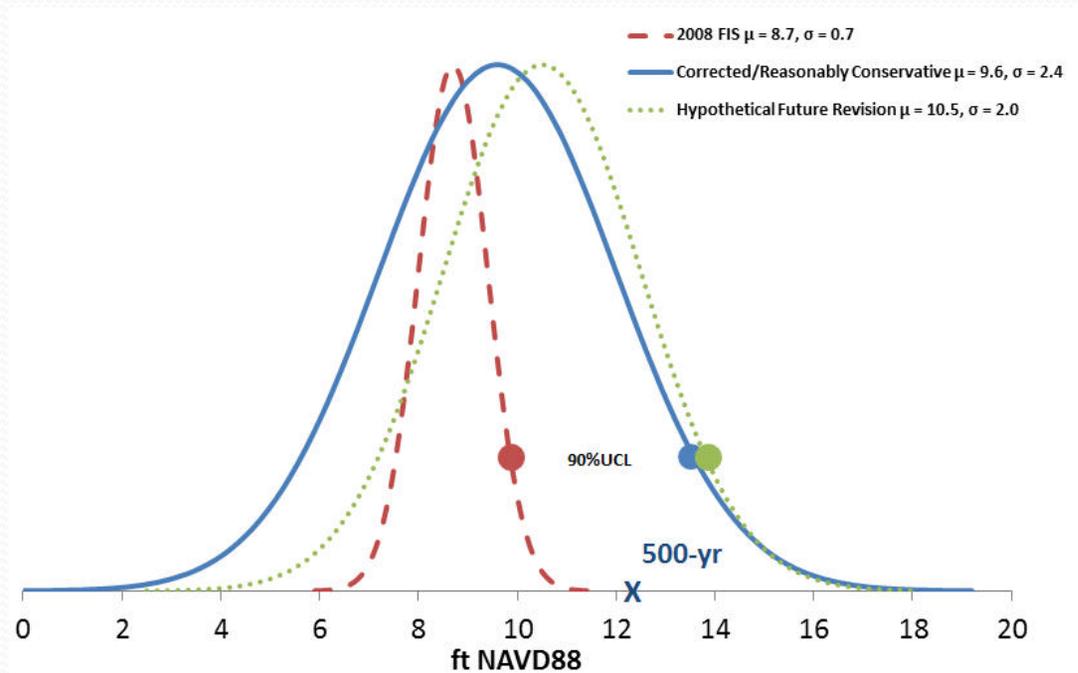


# Hurricane Katrina 10<sup>th</sup> Anniversary Test



**Bob Jacobsen PE, LLC**  
Coastal Hydrologist  
June 2015

# About the Author

- Raised in Metairie; family still lives in home they moved into in Aug 1965, 2 weeks before Betsy.
- Family experienced hurricanes Hilda, Betsy, Camille, Juan, Andrew, Katrina, Gustav, & Isaac.
- MSCE LSU; Environmental PE; 35 yrs Southeast Louisiana experience.
- Last 12 yrs in HPC/High-Resolution Coastal Hydrodynamics:
  - Began working with authors of ADCIRC in 2004 & has attended last 9 ADCIRC User's Workshops.
  - Maurepas Diversion (2007); Lake Pontchartrain Tidal Circulation (2007).
  - Hurricane surge studies for MRGO (2006) and Alliance Refinery (2007).
  - Supporting surge studies for LaCPR (2007) and NEFL/GA FIS (2010).
  - Independent surge consultant to SLFPA-E & CPRA (since 2011). Author of 2013 SOP review & several major reports.
- 2013-14 President of ASCE Louisiana Section.





This test was prepared by Bob Jacobsen PE ([bobjacobsenpe@gmail.com](mailto:bobjacobsenpe@gmail.com)) to stimulate discussion and appreciation of very complex issues. To learn more see the free Short Course “New Orleans Hurricane Surge Risk Management,” available at [bobjacobsenpe.com](http://bobjacobsenpe.com). The test and Short Course do not represent the opinions of any agency, association, or other person.

Multiple choice questions have only one correct answer.



1. Hurricane Katrina directly or indirectly caused the deaths of \_\_\_ Southeast Louisiana people:

- a. Less than 100.
- b. Between 100 and 500.
- c. Between 500 and 1,000.
- d. Over 1,400



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*The Corps of Engineers set elevations for the pre-Katrina surge protection project in the mid-1960s based on a 1959 US Weather Bureau characterization of a Standard Project Hurricane (SPH). SPH surge was considered to have a return period of 200- to 300 years. The elevation was expected to protect the lives of interior residents. The design plan for major portions of the East Bank based on these elevations wasn't finalized until the mid-1980s. By the late 1990s, the Corps as well as State and local officials all understood that surge hazards could be much higher than previously estimated. In 2005 the project was still substantially unfinished.*



## 2. Which of the following could have reduced breaching of the SPH surge system that occurred during Hurricane Katrina?

- a. Commitment on the part of the federal administration, Congress, as well as State and local officials, to timely completion of a true SPH surge protection project—above other priorities such as SELA drainage and navigation projects.
- b. Corps management insistence on proper engineering consideration of I-Wall subsurface conditions, levee materials, and elevation surveying for meeting SPH surge conditions—despite extreme cost and schedule overruns and competing priorities.
- c. Addition of an Elevation Factor of Safety (FOS) in the finalized plan to address uncertainty about the SPH surge. An Elevation FOS would have required additional funding.
- d. Addition of resiliency measures in the finalized plan to reduce breaching during surges greater than the SPH surge. Resiliency measures would have required additional funding and may have required additional federal authorization.
- e. All of the above.



## 2. Which of the following could have reduced breaching of the SPH surge system that occurred during Hurricane Katrina?

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- e. **All of the above.**



3. Many breaches occurred prior to Katrina's surge peaking. However, ultimately, Katrina's peak surge along the MRGO, GIWW, IHNC, and New Orleans Lakefront did exceed the SPH surge. If all I-Wall collapses had happened to be delayed until the peak surge, post-disaster analysis would have focused more on failures in evacuation and appropriate surge hazard targets for New Orleans perimeter protection.

**True or False?**



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**True** or False?



## 4. How rare was Hurricane Katrina?

- a. In the Western Atlantic Basin, Katrina at its peak is considered the most extreme hurricane ever. Its strong Category 5 eye coupled with a very large and strong extended wind-field made it the hurricane with the greatest Integrated Kinetic Energy ever observed.
- b. Katrina's near-eye wind-field has less than a 100-yr return period for the Southeast Louisiana region as a whole, especially factoring in the fairly rapid forward speed. Katrina's near-eye maximum winds and associated wind-driven surge approached a 400-yr return period event only at specific locations exposed to peak conditions on the particular track (e.g., the peak surge along the MRGO near Bayou Dupre).
- c. Katrina's near-eye wind-field had the most extreme combination of wind speed and size of any hurricane ever to make landfall in Southeast Louisiana; this plus the size and strength of the extended wind-field makes Katrina about a 400-yr event for the region as a whole.



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## 5. Which of the following is false?

- a. Katrina's maximum 1-min wind at the New Orleans Lakefront was about 70 mph.
- b. The estimated 100-yr 1-min wind for the New Orleans Lakefront is about 100 to 118 mph.
- c. Local winds across Lake Pontchartrain are not important because surge at the New Orleans Lakefront is primarily caused by water pushed into the Lake through the passes from the Gulf.



## 5. Which of the following is false?

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6. Which hurricane probably pushed the least amount of Gulf water into Lake Pontchartrain?

- a. Katrina
- b. Rita
- c. Ike
- d. Isaac



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7. The concept of “Surge-Response” has been introduced since Katrina to quantify hurricane surge/landscape interactions. Which does it not help explain:

- a. How changes in hurricane characteristics—such as intensity, core size, forward speed, track, extended wind-field, and decay—affect surge at a given coastal location.
- b. How coastal features—wetlands, ridges, barrier islands, bays, lakes, canals, etc.—affect various surges, both at nearby and more distant locations.
- c. How coastal features significantly affect surge height regardless of the depth and speed of surge.



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- c. How coastal features significantly affect surge height regardless of the depth and speed of surge.



## 8. The East-Bank of New Orleans is highly vulnerable to extreme storm surge because:

- a. The Gulf of Mexico Loop Current energizes storms.
- b. The eastern Mississippi River Delta is a natural surge trap, blocking westward surge driven by the counter-clockwise winds of an approaching hurricane and causing surge to pile-up against the eastern flank (and western State of Mississippi Coast).
- c. The presence of levees exacerbates the trap and surge heights.
- d. Large regional shallow coastal shelf, sounds, bays, and lakes enable extreme wind-driven setup.
- e. Geologic subsidence, sea level rise, and coastal erosion are expanding shallow fetch.
- f. Surge can propagate up the Mississippi River, threatening River levees if the River is in flood.
- g. All of the above.



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- g. All of the above.



## 9. In 2008 the Corps developed new 100- & 500-yr surge hazard estimates. These estimates

(only one statement is true; the others are false)

- a. Were prepared for the NFIP Flood Insurance Rate Maps as part of a Southeast Louisiana regional Flood Insurance Study, but were not affected by any Program limitations.
- b. Have similar accuracy and precision for all locations within the region.
- c. Incorporated some variability for tides, wind conditions, and surge modeling accuracy into the actual 100- & 500-yr surge estimates.
- d. Evaluated surge hazard uncertainty by considering all relevant factors that would apply to any location in the region and used a reasonably conservative approach to characterize the overall uncertainty in the surge hazard estimate (100- & 500-yr surge).

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- d. Evaluated surge hazard uncertainty by considering all relevant factors that would apply to any location in the region and used a reasonably conservative approach to characterize the overall uncertainty in the surge hazard estimate (100- & 500-yr surge).

Uncertainty is characterized using the standard deviation ( $\sigma$ ). A reasonably conservative value for  $\sigma$  is 25%. A useful upper estimate for the 100-yr surge level is the “90% Upper Confidence Limit” (90%UCL). With  $\sigma$  of 25%, the 90%UCL is about 1.4 times the base estimate: a 100-yr surge of 10 ft has a 90%UCL of 14 ft.



10. The estimates of the 500- and 100-yr surge differ at many locations by less than 3 ft. A 90%UCL of the 100-yr surge estimate (with a reasonably conservative  $\sigma$ ) can be greater than the base 500-yr surge estimate, and can provide a better Elevation FOS.

True or False?



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True or False?



11. Given a reasonably conservative consideration of uncertainty, surge return periods should be regarded as “*scientific guesstimates*”—they could easily be off by a factor of two. Thus, the surge elevations estimated as having “Nominal” 100- and 500-yr return periods could really have 50- and 250-yr return periods.

True or False?



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True or False?



## 12. Any update to the surge hazard estimates in the near future will probably:

- a. Add up to 1 ft to correct for errors with a special statistical code that was developed for the 2008 analysis.
- b. Further modify estimates due advances in surge science; such as a more detailed analysis of Surge-Response and the effect of Isaac-type storms.
- c. Have its level of rigor depend on its risk management purpose. For NFIP purposes an update could be deferred for many years until FEMA determines a new FIS is needed; an NFIP update is not likely to follow the same practices as an analysis focused on 500-yr surge protection.
- d. Not substantially reduce the size of a reasonably conservative confidence interval.
- e. All of the above.



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- e. All of the above.



13. The post-Katrina base estimate of the 100-yr surge along the New Orleans Lakefront is \_\_\_ with respect to the pre-Katrina SPH surge:

- a. Lower by more than 2 ft.
- b. Lower by 2 ft or less.
- c. Exactly the same.
- d. Higher by 2 ft or less.
- e. Higher by more than 2 ft.



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- e. Higher by more than 2 ft.



14. The post-Katrina base estimate of the 100-yr surge along the New Orleans Lakefront is \_\_\_ with respect to Katrina's surge:

- a. Lower by more than 3 ft.
- b. Lower by 3 ft or less.
- c. Exactly the same.
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- e. Higher by more than 3 ft.



14. The post-Katrina base estimate of the 100-yr surge along the New Orleans Lakefront is \_\_\_ with respect to Katrina's surge:

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- c. Exactly the same.
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- e. Higher by more than 3 ft.



15. In the wake of Katrina, Congress agreed to fund 70% of an “upgraded” surge system that would:

- a. Achieve true SPH surge protection for the lives of interior residents.
- b. Prevent a Hurricane Katrina catastrophe from ever happening again.
- c. Maintain the reduced NFIP property insurance mandates, premiums, and flood-proofing requirements within the system interior that are associated with having a perimeter barrier to 100-yr exterior surge.
- d. Minimize inundation from a 500-yr surge.



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## 16. The post-Katrina surge system:

- a. Design elevation is set per NFIP accreditation requirement to minimize 100-yr overtopping to a small amount.
- b. Considers uncertainty in the 100-yr overtopping rate—factoring in uncertainty in the 100-yr surge & waves. A limit for the 100-yr overtopping 80%UCL provides the design Elevation FOS.
- c. Elevation FOS is significantly affected by NFIP programmatic limitations in assessing 100-yr surge/waves & their uncertainty; FOS is not reasonably conservative for purposes of local surge risk management.
- d. Design elevation is everywhere higher than previous SPH surge project elevation, but only by  $\frac{1}{2}$  ft at the NO Lakefront levee.
- e. Replaces perimeter I-Walls with stronger batter-pile supported L- & T-Walls, which were overbuilt to account for relative sea level rise through 2057.
- f. Employs stronger, compacted clay material in all levees, which were overbuilt for anticipated post-construction consolidation & settlement, but not relative sea level rise . However, supplemental lifts are or will soon be required for many reaches and are currently not federally funded.
- g. All of the above.

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- d. Design elevation is everywhere higher than previous SPH surge project elevation, but only by ½ ft at the NO Lakefront levee.
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17. Over the next 10 years, which of the following most and least affects the ability of the post-Katrina surge system to meet NFIP elevation requirements based on the 100-yr overtopping limit? *select both a most and least*
- a. Correcting errors with the 2008 100-yr surge estimate, as well as revising the overtopping calculation.
  - b. Updating the 100-yr overtopping estimate for advances in surge science.
  - c. Deciding whether to substitute a more reasonably conservative treatment of uncertainty in assessing the Elevation FOS.
  - d. Re-evaluating 100-yr surge for long-term, background, sea level rise.
  - e. Re-evaluating 100-yr surge for anthropogenic climate change and sea level rise.
  - f. Re-evaluating 100-yr surge for regional deltaic subsidence and landscape changes.
  - g. Levee consolidation and settlement.
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- a. Correcting errors with the surge estimate, as well as revisiting the surge estimate.
- b. Updating surge science to reflect advances in surge science.
- c. Deciding on more conservative treatment options for the surge estimate.
- d. Re-evaluating 100-yr surge for long-term, background, sea level rise.
- e. Re-evaluating 100-yr surge for anthropogenic climate change and sea level rise.
- f. Re-evaluating 100-yr surge for regional deltaic subsidence and landscape changes.
- g. **Levee consolidation and settlement.**
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**A bit tricky! These could be greater than levee consolidation and settlement. However, the NFIP may not require them to be addressed in the next 10 years!**



*Polders and regions can have multiple independent exposures. For local 100-yr surges, a polder that has two independent exposures has a polder-wide return period of 50 years, and a region with five independent exposures has a regional return period of 20 years.*

18. For a region with five independent exposures, if a local “Nominal” 500-yr surge event has an actual return period of 250 years, such an event could be expected to have an average regional return period of about \_\_\_\_\_ years
- a. 200
  - b. 100
  - c. 50
  - d. 10

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19. Which of the following statements is true for the post-Katrina surge system “resiliency?”

- a. NFIP accreditation does not require resiliency for overtopping during storms more extreme than 100-yr. Nevertheless, Congress authorized and funded some resiliency (armoring) to provide additional risk reduction based on Katrina breach experience.
- b. The current armoring design addresses estimated “Nominal” 500-yr overtopping, and includes an Armoring FOS to reflect uncertainty in “Nominal” 500-yr overtopping. However, the Armoring FOS does not reflect reasonably conservative treatment of uncertainty.
- c. Levee erosion on the inward slope during overtopping is generally regarded as the most significant erosion breach vulnerability. However, wave-induced erosion on the outward facing slope can also cause embankment damage and possible breaching under some scenarios (without overtopping occurring). Current resiliency plans do not address wave-induced erosion.
- d. A recent review of 500-yr overtopping using a reasonably conservative cushion for uncertainty indicates that some levee reaches have much higher overtopping vulnerability. For example, the East-Bank St. Charles levee could have 500-yr negative freeboard exceeding 5 ft and overtopping rates more than 10 times suggested limits for recommended armoring. This vulnerability is made worse by levee consolidation, settlement, and subsidence.
- e. Although the system has been rebuilt to much higher geotechnical standards, the risk of collapse breaches (without overtopping) is not zero.
- f. All of the above.



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20. Factoring in a reasonably conservative treatment of uncertainty, the I-Walls still present within the IHNC Basin—behind the new East-Bank Surge Barrier—remain a breach vulnerability for a 500-yr event. This vulnerability is made worse by the potential for unrestrained vessels and floating structures.

True or False?



20. Factoring in a reasonably conservative treatment of uncertainty, the I-Walls still present within the IHNC Basin—behind the new East-Bank Surge Barrier—remain a breach vulnerability for a 500-yr event. This vulnerability is made worse by the potential for unrestrained vessels and floating structures.

**True** or False?



21. IF the post-Katrina 100-yr NFIP surge system and 500-yr resiliency perform “as advertised,” overtopping alone from a true 500-yr surge event would produce less water for the interior than a 100-yr/24-hr rainfall event.

True or False?



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**True** or False?



22. Which of the following is the most, and which is the least, crucial for state and local officials to insist on in order to complement an NFIP accredited surge system: *select both a most and least.*

- a. Adequate funding of O&M program for gates and pump stations.
- b. Adequate funding of program to maintain levees (lifts) and armoring.
- c. Expanding participation in flood insurance.
- d. Upgrading to a reasonably conservative 100-yr surge elevation FOS.
- e. Upgrading to a reasonably conservative 500-yr resiliency/armoring FOS.
- f. Coastal protection and restoration.
- g. Enhancing the legacy East Jefferson-St. Charles Parish interior levee; upgrading IHNC Basin I-Walls; and enabling use of the Central Wetlands for diversion of extreme surge in the IHNC Basin.
- h. Effective plans to assist those with health, financial, and logistical challenges to self-evacuation.



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*Flood tragedies are due to underestimating the hazard and failure to prioritize appropriate risk management measures, with the former heavily influencing the latter.*

23. Vastly improved surge modeling with Supercomputers and high geographic resolution means that we will never have to worry about this anymore.

True or False?



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True or **False?**



24. Lake Okeechobee in Florida is similar in size and depth to Lake Pontchartrain. In 1928 a severe hurricane tilted Lake Okeechobee (with no filling from the ocean), creating an extreme surge and killing over 2,500 people. The lake's Herbert Hoover Dike was rebuilt after the storm and has been upgraded over the years.

This dike provides about \_\_\_ ft *more* freeboard above the 100-yr surge when compared to the New Orleans Lakefront levee.

a. 0

b. 2

c. 4

d. 6

e. 8

f. 10



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This dike provides about \_\_\_ ft *more* freeboard above the 100-yr surge when compared to the New Orleans Lakefront levee.

a. 0

b. 2

c. 4

d. 6

e. 8

f. 10



25. Over the years, New Orleans perimeter surge projects have significantly exacerbated surge damage outside the system—both to communities and wetlands.

True or False?



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**True** or False?



## *Bonus Question*

Provide your opinion on the following:

Should uncertainties be treated reasonably conservatively for purposes of NFIP Flood Insurance Studies?

For non-urban flood levee systems?

For the New Orleans post-Katrina surge system Elevation FOS?

For the New Orleans post-Katrina surge system Armoring FOS?

For evacuation planning?



## *Bonus Points*

Discuss the following statement with family and friends over the next several weeks:

100-yr NFIP levee systems are to surge  
what fire departments are to fires—  
they are complements to effective  
evacuation and property insurance.