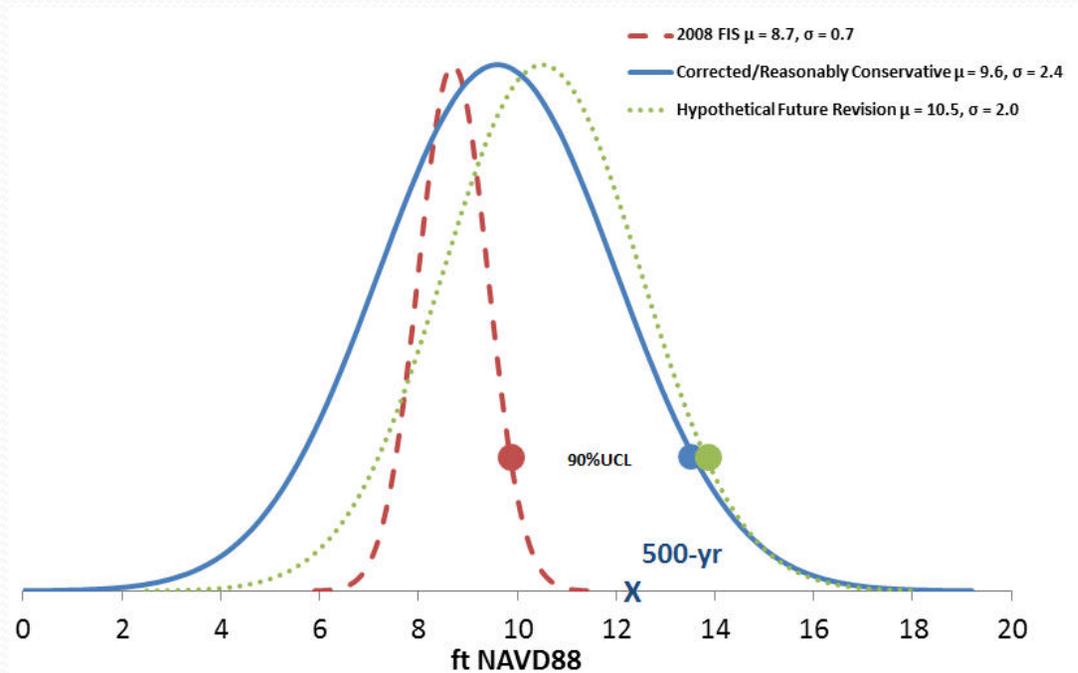


Hurricane Katrina 10th Anniversary Test



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; Lake Pontchartrain Tidal Circulation.
 - Hurricane surge studies for MRGO (2006); Alliance Refinery (2007); LaCPR (2007); SC (2009); NEFL/GA (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) 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. 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 exceeded the SPH surge.

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 is 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 though the passes from the Gulf.



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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 interaction. 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 post-Katrina surge hazard estimates (e.g., 100-yr surge).

These estimates:

- 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 additional potential variability for the timing of tides, wind-field conditions, and surge modeling accuracy into the 100-yr surge estimate.
- d. Included an evaluation of surge uncertainty (standard deviation, σ) addressing all relevant uncertainty factors that would apply to any location in the region.
- e. Used a reasonably conservative approach when examining the various surge uncertainty factors.

Note: A reasonably conservative value for σ is 25%. A useful upper estimate for the 100-yr surge level is the “90% Upper Confidence Limit” (90%UCL). With σ 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.



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10. With a reasonably conservative consideration of uncertainty, the 2008 estimates of surge return period should be recognized as easily being off by a factor of two. Thus, the surge elevation estimated as having a 100-yr return period could really have a 50-yr return period and a “Nominal” 500-yr surge could really have a 250-yr return period.

True or False?



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True or False?



11. The 90%UCL estimate of the 100-yr surge with a reasonably conservative σ is less than the base estimate of the 500-yr surge (without a confidence interval).

True or False?



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True or False?



12. An update to the surge hazard estimates in the near future will probably not:

- a. Increase estimates by up to 1 ft to correct errors with a special statistical code that was developed for the 2008 analysis.
- b. Further increase estimates at some locations 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. Substantially reduce the size of a reasonably conservative cushion.



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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.



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.



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.



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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. Allow the NFIP to reduce premiums, and building and insurance requirements, associated with exposure to a 100-yr surge event within the system interior.
- d. Minimize inundation from a 500-yr surge.



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16. The post-Katrina surge system:

- a. Has a design elevation set to minimize 100-yr overtopping to a small amount, per an NFIP requirement. This elevation is everywhere higher than the previous SPH surge project elevation.
- b. Has a design height a half foot higher than the pre-Katrina SPH for the NO Lakefront levee.
- c. Considers uncertainty in the 100-yr overtopping rate and thereby provides an Elevation FOS.
- d. Has an Elevation FOS that is significantly affected by the NFIP programmatic limitations in assessing 100-yr surge and waves, as well as uncertainty. The Elevation FOS is not reasonably conservative for purposes of local surge risk management.
- e. Replaces perimeter I-Walls with much stronger batter-pile supported L- and T-Walls, which have been overbuilt to account for sea level rise and regional subsidence through 2057.
- f. Now employs stronger, compacted clay material in all levee reaches. Levee reaches were overbuilt to compensate for some anticipated post-construction consolidation and settlement. 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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- g. All of the above.



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 of the 100-yr overtopping estimate for advances in surge science.
- c. Decision of whether to substitute a more reasonably conservative treatment of uncertainty in assessing the Elevation FOS.
- d. Re-evaluating the 100-yr surge for long-term, “background,” sea level rise.
- e. Re-evaluating the 100-yr surge for anthropogenic climate change and sea level rise.
- f. Re-evaluating the 100-yr surge for regional deltaic subsidence and landscape changes.
- g. Levee consolidation and settlement.
- h. Surveying issues.



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- a. Correcting errors with the 2008 100-yr surge, as well as revising the elevation FOS.
- b. Updating scientific data on consolidation and settlement but NFIP does not require them to be addressed in surge.
- c. Decisions on conservative treatment of the surge.
- d. Re-evaluating the 100-yr surge for long-term, "background," sea level rise.
- e. Re-evaluating the 100-yr surge for anthropogenic climate change and sea level rise.
- f. Re-evaluating the 100-yr surge for regional deltaic subsidence and landscape changes.
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These could be greater than levee consolidation and settlement but 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 false 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. Although the system has been rebuilt to much higher geotechnical standards, the risk of collapse breaches like those seen during Hurricane Katrina is not zero.
- d. 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 (without overtopping occurring) under some scenarios. Current resiliency plans do not address wave-induced erosion.
- e. 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.
- f. Current plans to employ Enhanced Turf and High Performance Turn Reinforcement Mats can be reliably considered to provide true 500-yr resiliency at the respective levee reaches.

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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?



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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. Well-funded operation & maintenance program for gates and pump stations.
- b. Well-funded program to maintain levee elevations (lifts) and armoring.
- c. Broad participation in flood insurance.
- d. A reasonably conservative Elevation FOS.
- e. Selection of appropriate armoring to provide true 500-yr resiliency.
- f. Coastal protection and restoration.
- g. Enhancing the legacy East Jefferson-St. Charles Parish 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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|------|-------|
| a. 0 | d. 6 |
| b. 2 | e. 8 |
| c. 4 | 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.