Assessment of Wind and Surge Conditions 177 Holiday Drive Plaquemines Parish, Louisiana During Hurricane Katrina

By

Barry D. Keim, PhD
Consulting Climatologist
Baton Rouge, Louisiana

Barry Keim

Prepared For

Ryan Acomb
Porteous, Hainkel, and Johnson
Attorneys at Law

September 2007

4

This report examines wind, storm surge, and flooding associated with Hurricane Katrina with respect to the property located at 177 Holiday Drive in Plaquemines Parish, Louisiana. Sources of information for this report come from the following:

- National Hurricane Center
- National Weather Service Office-Slidell
- Hurricane Research Division of the Atlantic Oceanic and Meteorological Laboratory (AOML)
- National Climatic Data Center – *Storm Data*
- FEMA reports – High Water Mark Collection for Louisiana
- United States Army Corps of Engineers - Interagency Performance Evaluation Taskforce (IPET) Report
- LIDAR Data from archives at Louisiana State University
- Van Heerden, I., and M. Bryan. 2006. *The Storm*. Penguin Group (Viking): New York.

From these sources, this report will discuss the maximum sustained winds in the region, wind gusts, local storm reports (LSRs) of severe weather to investigate tornado occurrence, and the estimated storm surge.

Background

Hurricane Katrina made initial landfall near Buras, Louisiana near 0610 LDT, which was followed by a second landfall near the Louisiana-Mississippi border near 0942 LDT. Extreme winds associated with this hurricane are mostly estimates, because the storm was responsible for damaging most wind sensors and/or the communication links to relay, record, and otherwise document the relevant information. As a result, most of the winds associated with the storm are either modeled, or are estimated from measurements made by reconnaissance aircraft commissioned by the National Hurricane Center. The AOML, which is a branch of NOAA, contains a hurricane research division that gathers all available information on hurricanes – including flight-level reconnaissance data, satellite observations, pressure-wind relationships, and available surface data - and then estimates wind fields associated with each storm, including Hurricane Katrina. Wind information from these disparate sources are then adjusted to a standard elevation (10 meters) and duration (1-minute sustained winds), and are thereby synthesized into a single product called the H-winds project. Maps of Hurricane Katrina H-winds were produced for each NHC hurricane advisory as post-storm assessments, but the near-real time data are also available for other time intervals. However, the post-storm assessment data are considered more reliable and only these were used in this report.

The AOML post-storm assessment wind field for Hurricane Katrina at 0400 LDT in Figure 1 shows cyclonic (counter-clockwise) circulation around the center of the low pressure, located south of Plaquemines Parish, Louisiana. At this time, winds are estimated to be strongest over water on the northeast and eastern side of the eye over the southwestern shore of Plaquemines Parish and Gulf. After the eye passed over Lake

Borgne in southeastern Louisiana, the storm then made a second landfall near the mouth of the Pearl River. Figure 2 depicts the storm's location and wind field at 0700 LDT, shortly after landfall. At this time, winds are estimated to be strongest over water on the eastern side of the eye over Breton Sound and Chandeleur Sound. After the eye passed over Lake Borgne in southeastern Louisiana, the storm then made a second landfall near the mouth of the Pearl River. The overall maximum sustained 1-minute winds over the life of the storm according to the AOML maps are near 115 mph, which likely occurred near the mouth of the Mississippi River. Winds also reached near 110 mph at Bay St. Louis, Mississippi. Note that the wind speeds decline rapidly once the storm moves inland. This reduction is caused by friction from the surface in the form of houses, trees, telephone poles, etc.

Estimate of Winds at Site

In Plaquemines Parish, Louisiana, at 177 Holiday Drive, AOML estimates of maximum sustained winds are near 98 mph (85 kts) (Figures 1 and 2). This estimate was derived by propagating the wind north by approximately (+)1-hour from the AOML 0400 LDT 29 August, 2005 estimate (Figure 1). Wind gusts in the region were most assuredly higher, whereas peak gusts of 107 and 102 were measured at Buras and Belle Chasse, respectively – the closest locations to the site, 120 mph and 123 mph were measured in Eastern New Orleans at Michoud, 117 mph at Stennis, and 100 mph at Slidell, Louisiana (Table 1 and Figure 3). The highest observed peak wind gust from Hurricane Katrina was 135 mph measured by personnel from the Mississippi Emergency Operations Center (MS EOC) at Poplarville, Mississippi (Table 1). This measurement came from a sensor mounted on the rooftop of the MS EOC, which is not the best citing for accurate wind measurements, and according to sources at the NWS Office-Slidell, the gauge failed right after the measurement. Also note that these wind gusts persist for only a fleeting moment in time. Table 1 also shows estimated sustained winds and measured peak wind gusts at other sites along the Louisiana and Mississippi Coasts, near the landfall zone of Hurricane Katrina.

Figures 3 and 4 show plots of wind speeds recorded by Texas Tech personnel during the storm at Stennis and Slidell, respectively. At Stennis, their data show sustained winds of only 67 mph whereas AOML maps are closer to 85 mph. Furthermore, at Slidell, Texas Tech wind data show a 1-minute sustained wind of 69 mph, while AOML suggests a value closer to 84 mph. Closer to Empire an Buras, personnel from Florida International University mounted a weather observational tower at the Belle Chasse Naval Air Station and recorded maximum sustained 1-minute winds of 78 mph (Table 1). Data from these sites suggests that the AOML wind estimate of 98 mph for sustained 1-minute winds may be conservatively high in this region.

Nevertheless, from the totality of these data, and largely based on the AOML wind fields, I feel the best, conservatively high, estimates of extreme wind in the vicinity of 177 Holiday Drive would be maximum sustained winds near 98 mph, with potential for higher gusts, perhaps as high as 120-125 mph. The highest winds probably occurred between 0400-0600 LDT, before the storm made its official landfall near Buras.

Tornadoes

The official source of information for tornadoes comes from the NOAA publication *Storm Data*. Tornadoes, and other forms of severe weather, are verified by personnel from the National Weather Service and documented as a "local storm report," which are subsequently published in *Storm Data* by the National Climatic Data Center. *Storm Data* reports no tornadoes in Louisiana and 13 in Mississippi for the days 28-30 August 2005, the window of time covering Hurricane Katrina's Gulf Coast landfall and exit from the region. In fact, there were no confirmed tornadoes in the State of Louisiana during the entire month of August 2005 (Figure 5). During Katrina, a tornado occurrence in Hattiesburg, Mississippi, near 1025 LDT, was the southernmost location of the Mississippi tornadoes, hence there were no tornadoes documented in Hancock, Harrison, nor Jackson Counties – the coastal counties of Mississippi. This does not completely rule out the occurrence of tornadic activity within Louisiana or the coastal counties of Mississippi, but that no official reports were formerly filed. Furthermore, after many reconnaissance trips within Louisiana and coastal Mississippi, I have not seen any evidence on the landscape that is consistent with tornado damage. I therefore surmise that there was insufficient evidence on the landscape for NWS personnel to make such documentation. There may be a myriad of reasons for this, but one strong possibility is that no tornadoes were actually spawned in this region. Of the tornadoes that did occur at Hattiesburg and points north in Mississippi, the average path length was 3 miles long, with the longest being 13 miles and the shortest was 1 mile. The average width of the swath of damage was 75 yards, with the narrowest at 50 yards and widest at 150 yards. An example of damage caused by a tornado track is provided in Figure 6

Modeled Storm Surge

Given the dearth of available data for this storm, researchers are reliant on modeled data and information. As such, the modeled storm surge across the central Gulf Coast as presented in the U.S. Army Corps of Engineers - IPET Report using the ADCIRC model is examined here. ADCIRC is an acronym for Advanced Circulation model and is used by many entities involved in hurricane research, including the LSU Hurricane Center. Four time periods are presented as an example; 0600 and 0800 (Figure 7), just before and after the storm's first landfall near Buras, Louisiana, and 0900 and 1100 LDT (Figure 8), just before and after the second landfall at the Louisiana-Mississippi border. Storm surges as high as 27+ feet are shown along the Central Mississippi Coastline in Harrison County, with lower, though still impressive, values in Lake Pontchartrain, north of New Orleans (Figure 9). These results conform to other reports, i.e., the National Hurricane Center's final report on Katrina which states that the highest measured storm surge was 27.8 feet, measured in Pass Christian, Mississippi. Furthermore, comparison of measured and modeled data at selected locations show a good fit (see Figure 10 as an example). Note, however, that these surge values do not take into account any wave activity.

Wind and Surge Timeline at the Property

The elevation of the land at 177 Holiday Drive in Plaquemines Parish is estimated at 2.3 feet above mean sea level, based on LIDAR data from the Coastal Studies Institute at Louisiana State University. This same dataset shows Mississippi River levee elevations adjacent to this property at approximately 17 feet above mean sea level. Table 2 provides a timeline of sustained winds for 177 Holiday Drive, based on the Hurricane Research Division of the AOML, with estimated maximum winds in between. Winds increased over the early morning hours of 29 August 2005, and peaked near 98 mph at about 0500 LDT. U.S. Army Corps of Engineers IPET storm surge simulations are also noted in Table 2 and show modeled water elevations. At this time, no flooding was noted in the levee protected area that includes this property (Figure 11). However, at the time of the hurricane's landfall, the Van Heerden and Bryan timeline of significant events shows that the storm surge on the East Bank of the Mississippi River overtopped the levee on the Mississippi River - beginning near 0600 LDT on 29 August (Table 3), with estimated storm surge values near 20 feet above mean sea level (Figure 9). The surge then crossed the river, and then overtopped the Mississippi River levee from the channel side, to flood the west side of the River in Plaquemines Parish. Note the levee systems in Figure 11 (the West Bank levee on the Mississippi River and the levee designed to protect this area on the Barataria Bay side) then trapped the water between the two levees that were built to protect the towns of Buras, Empire, Nairn, Port Sulphur, etc., from such surges. Figure 11 also shows levee damage along the West Bank of the Mississippi River near the property.

Based on the timeline in Table 2, this property (land) – at 2.3 feet above mean sea level - would have been inundated near 0600 LDT, when the surge was near 5 feet above mean sea level. Winds at this time were just past their peak, and were falling, as the heart of the eye moved over the area. Modeled surge levels later peaked near 9 feet above mean sea level near 1100 LDT, and then receded over subsequent hours. The closest high water mark on the west bank of the Mississippi River shows a USGS-recorded value of 7.0 feet above mean sea level, though this recording is at some distance from the location in question. The Neil B. Hall Associates, LLC Report (from 12 July 2007) purports a surge elevation of 12 feet at this site. Given a land elevation of 2.3 feet above mean sea level, a 9 foot surge places 6.7 feet of water on the property, while a 12 foot surge places 9.7 feet of water on the property.

Conclusions:

- Maximum sustained winds in the area were likely near 98 mph (Category 2 hurricane-strength), with potential wind gusts up to 125 mph. The strongest winds probably occurred between 0400-0600 LDT on 29 August 2005.
- The National Weather Service did not document any tornadoes in Louisiana, nor in the coastal counties of Mississippi during passage of Hurricane Katrina.

- The land at this site – at 2.3 feet above mean sea level - was likely inundated just before 0600 LDT.
- Water levels (surge) probably peaked between 9-12 feet above mean sea level at approximately 1000 LST on 29 August 2005.
- Water on the property – at an elevation of 2.3 feet above mean sea level - was most likely between 6.7 and 9.7 feet deep.

Data sources are continuously being found regarding Hurricane Katrina. If any new data are found that change my opinion, I reserve the right to alter this report accordingly.

Table 1: Measured peak gusts (and measured sustained winds), in mph, from stations across southeastern Louisiana and Coastal Mississippi (from the Hurricane Katrina report compiled by NWS-Slidell).

LOCATION	MAX. SUSTAINED WINDS	MEASURED PEAK GUST	SOURCE – PEAK	TIME-PEAK LDT
Buras, LA	84	**107**	U.L.-Monroe	0608
East N.O.-Michoud 1	-	**123** (at 40 ft)	NASA-Michoud	0915
East N.O.-Michoud 2	-	**97** (at 40 feet)	NASA-Michoud	0559
Eastern N.O.	-	**120**	Air Prod. Fac.	0900
Mid-Lake-L.Pontch'n	69	**99** (at 50 feet)	NWS	1000
N.O.–Armstrong AP	-	**74**	LLWAS	0905
Belle Chase, LA	78	**102**	FL Int'l Univ	0632
Galliano, LA	77	**95**	FL Int'l Univ	0435
Hammond, LA	55	**76**	LSU	1143
Manchac, LA	68	**85**	LSU	1029
Slidell, LA	70	**100**	Texas Tech	-
Stennis, MS	68	**117**	Texas Tech	-
Poplarville, MS	-	**135**	MS EOC	-
Long Beach, MS	-	**122**	Amateur	-
Pascagoula, MS	-	**124**	MS EOC	-

Table 2: Wind and surge timeline. Data in bold are compiled from the Army Corps of Engineers IPET report (surge), and the POST STORM Assessment of the Hurricane Research Division of the Atlantic Oceanographic and Meteorological Laboratory (sustained winds). Data that are smaller and unbold are estimated or interpolated from the same maps. The conversion from knots to mph is: Knots X 1.15 = mph.

Time LDT (UTC) 28-29 August 2005	177 Holiday Drive , Plaquemines Parish, LA		
	Wind, in kts	Wind, in mph +Wind Direction	Surge, in feet
1900 (0000)	**32**	**37ne**	
2000 (0100)			
2100 (0200)			
2200 (0300)	**38**	**44ne**	
2300(0400)			
0000 (0500)			
0100 (0600)	**47**	**54ene**	
0200 (0700)			**0**
0300 (0800)			
0400 (0900)	**75**	**86e**	
0500 (1000)	85*	98*	**2**
0600 (1100)			**5**
0700 (1200)	**45 (eye)**	**52n**	**6**
0800 (1300)			**6**
0900 (1400)			**8**
1000 (1500)	**53**	**61sw**	**9**
1100 (1600)			**8.5**
1200 (1700)			**8**
1300 (1800)	**43**	**49sw**	
1400 (1900)			
1500 (2000)			**6**
1600 (2100)	**34**	**39sw**	
1700 (2200)			
1800 (2300)			**4.5**

*Peak sustained wind estimated as an approximate 1-hour propagation of wind contours from the AOML 0400 LDT 29 August, 2005 estimate.

Table 3: Times Picayune timeline of flooding due to Hurricane Katrina. From the following website http://www.nola.com/katrina/graphics/flashflood.swf and from Van Heerden and Bryan (2006).

Time	Comments
Aug 28	The day before landfall, unusually high tides had engulfed the wetlands outside of the levee systems
0430 – Aug 29	Rising waters in the Industrial Canal slowly leak into neighborhoods on both sides of the Canal – N.O. East and Gentilly
0500 –dawn on Aug 29	Katrina's surge pounds MRGO levee, levee fails in numerous places flooding wetland near St. Bernard Parish
0610 – Aug 29	Katrina makes landfall near Buras. Storm surge overtops levees on the East Bank of the Mississippi River in Plaquemines Parish, crosses the river, thereby overtopping levees on the West Bank.
0630 – Aug 29	Storm surge builds in "funnel" at MRGO and Intracoastal Waterway. Levees are overtopped and breached, thereby flooding N.O.-East; Also, 17th Street Canal levee showing signs of strain, with minor leaking
0650 – Aug 29	Water overtops floodwalls along Industrial Canal, on both sides
0730 – Aug 29	Levee on west side of Industrial Canal is breached flooding Upper 9th Ward, Bywater, and Treme
0745 – Aug 29	Two levee breaches occur on the east side of the Industrial Canal, flooding the Lower 9th Ward. Water also pours into Arabi and Chalmette in St. Bernard
0830 – Aug 29	Flooding from MRGO advances to 40-Arpent Canal, easily overtopping the 7-9 foot levee, thereby flooding St. Bernard Parish; Levee by Lakefront Airport fails allowing Lake Pontchartrain to also flood eastern New Orleans
0900 – Aug 29	Surge rises to 10 feet in the London Ave. Canal. Small leaks begin as levees are stressed.; Orleans Ave. Canal overtops embankment and floods City Park
0930 – Aug 29	Levee on east side of the London Canal fails, further flooding Gentilly
0945 – Aug 29	Levee on east side of the 17th Street Canal fails flooding Lakeview, Mid-town, and part of Metairie in Jefferson Parish; Katrina makes second landfall near the Pearl River, bringing 15 foot surge to Slidell region – Madisonville to the Rigolets
1030 – Aug 29	Levee on west side of the London Ave Canal fails further adding water to Gentilly and the city in general; Parts of Jefferson Parish see flooding from rainfall as pumps are unstaffed
Aug 29 – Sep 1	Surge levels slowly drop, and levee overtopping ceases. Lake Pontchartrain remains swollen and water continues to flow into the city until near midday on Sep 1

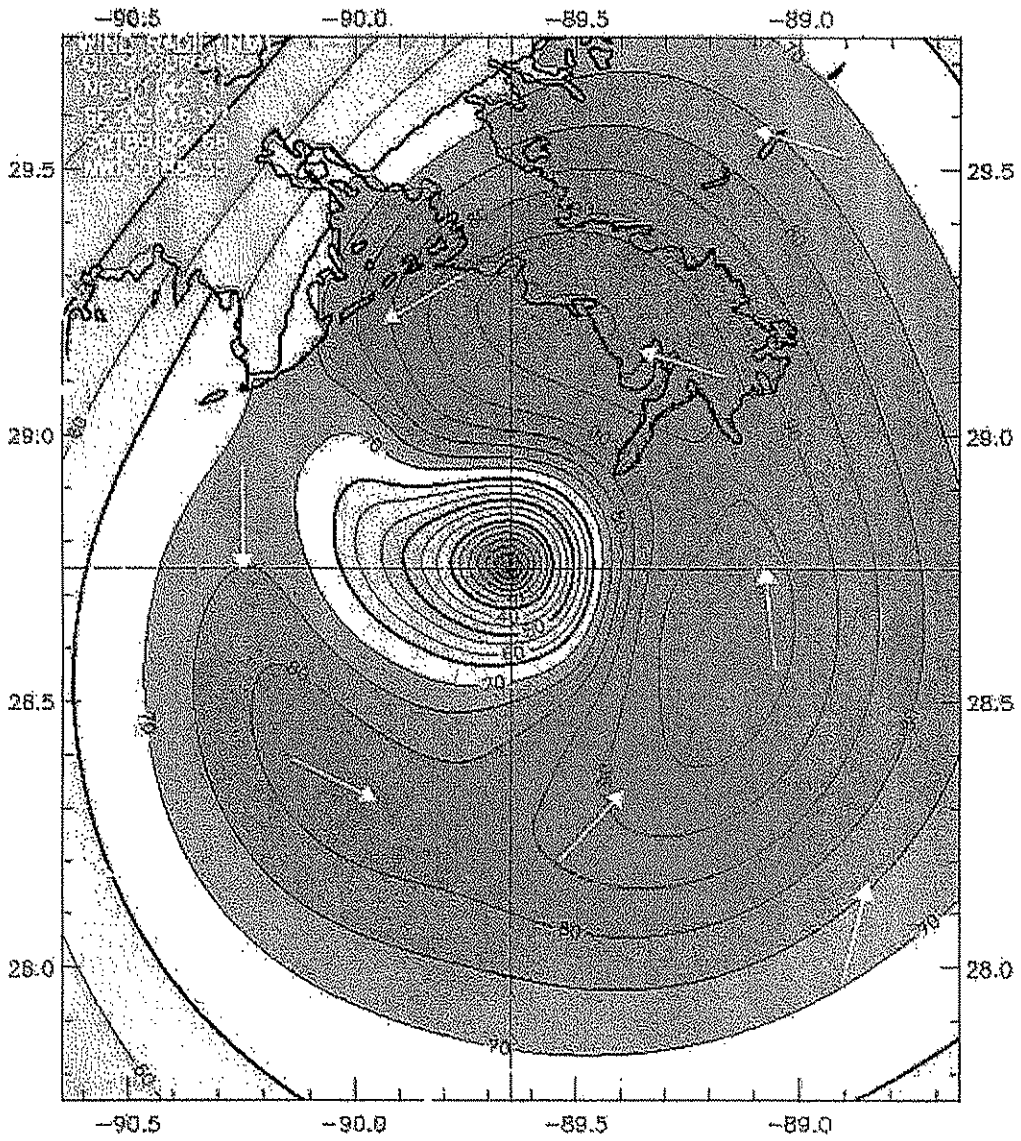
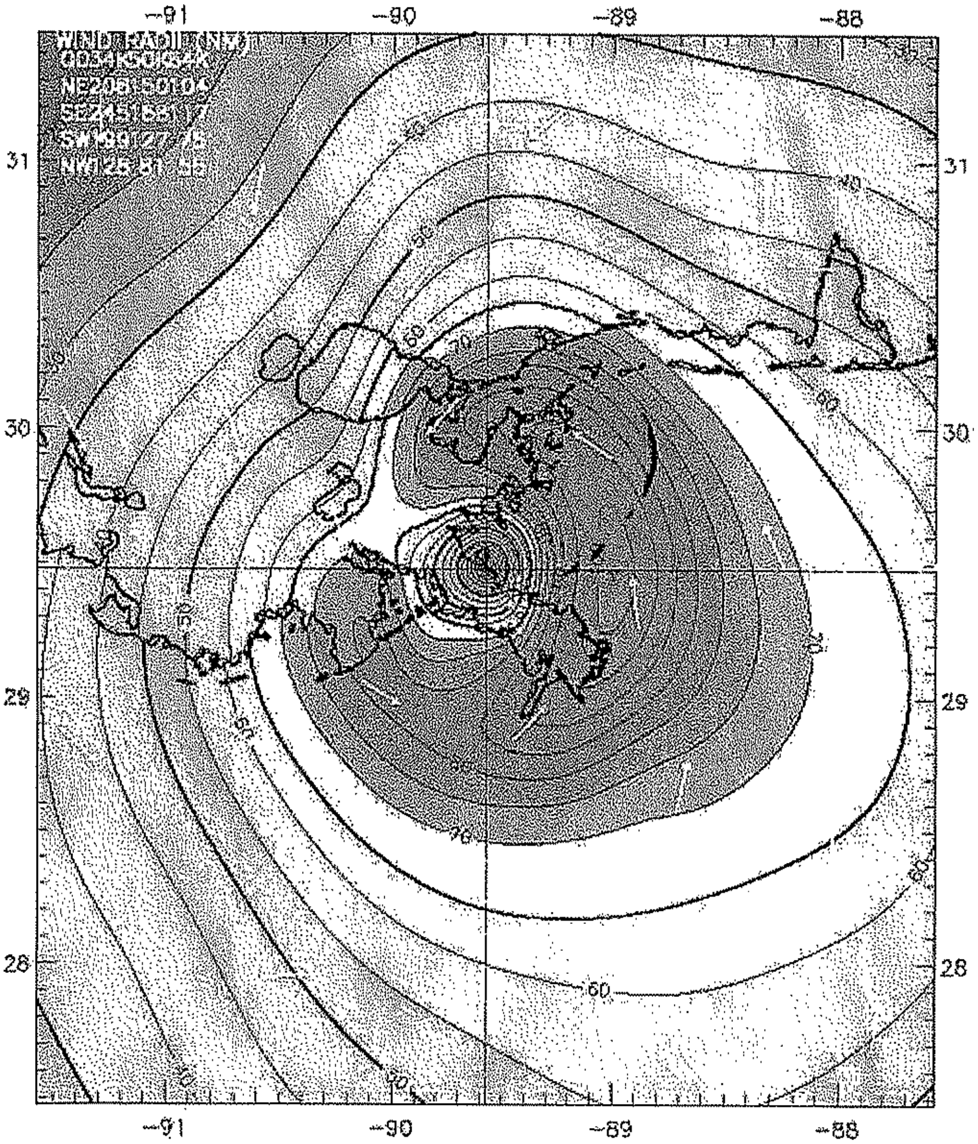


Figure 1: Estimated wind field associated with Hurricane Katrina at 0400 LDT, shortly before its initial landfall near Buras, Louisiana.



Observed Max. Surface Wind: 102 kts, 35 nm SE of center based on 1020 z TAIL_DOPPLER43 sfc measurement
Analyzed Max. Wind: 102 kts, 36 nm NE of center

Figure 2: Estimated wind field associated with Hurricane Katrina shortly after its initial landfall near Buras, Louisiana at 0700 LDT with the eye located over the property.

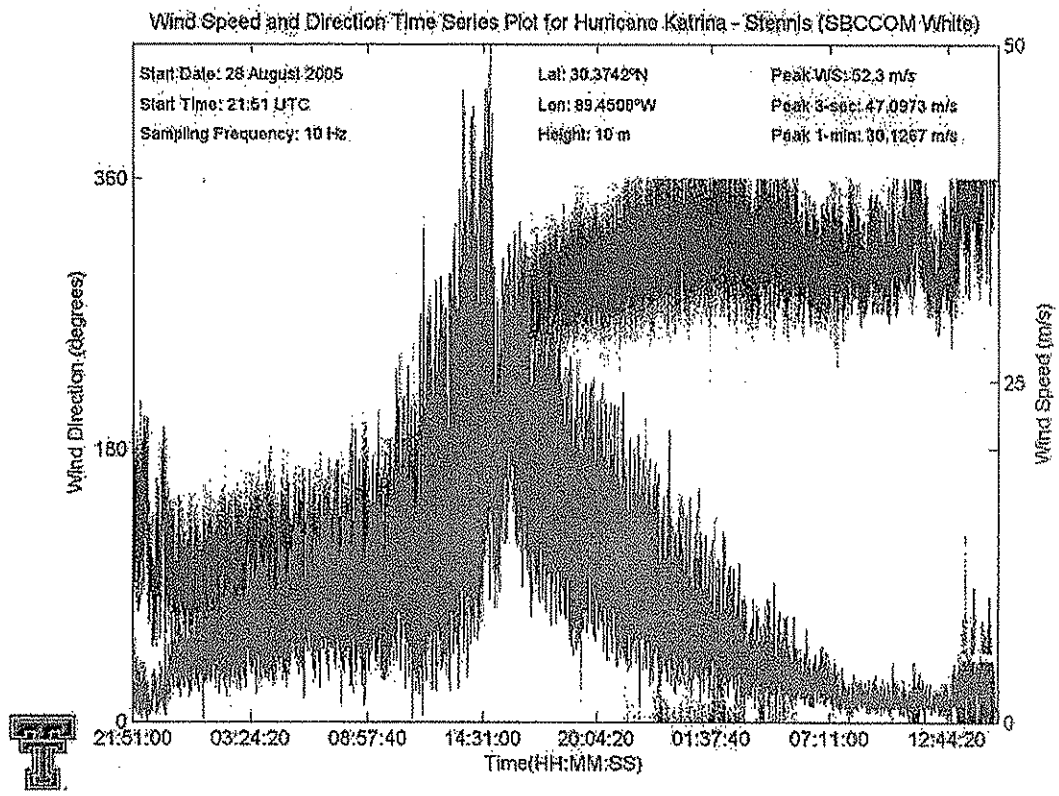


Figure 3: Plot of winds from Stennis. Instrumentation deployed by personnel from Texas Tech University.

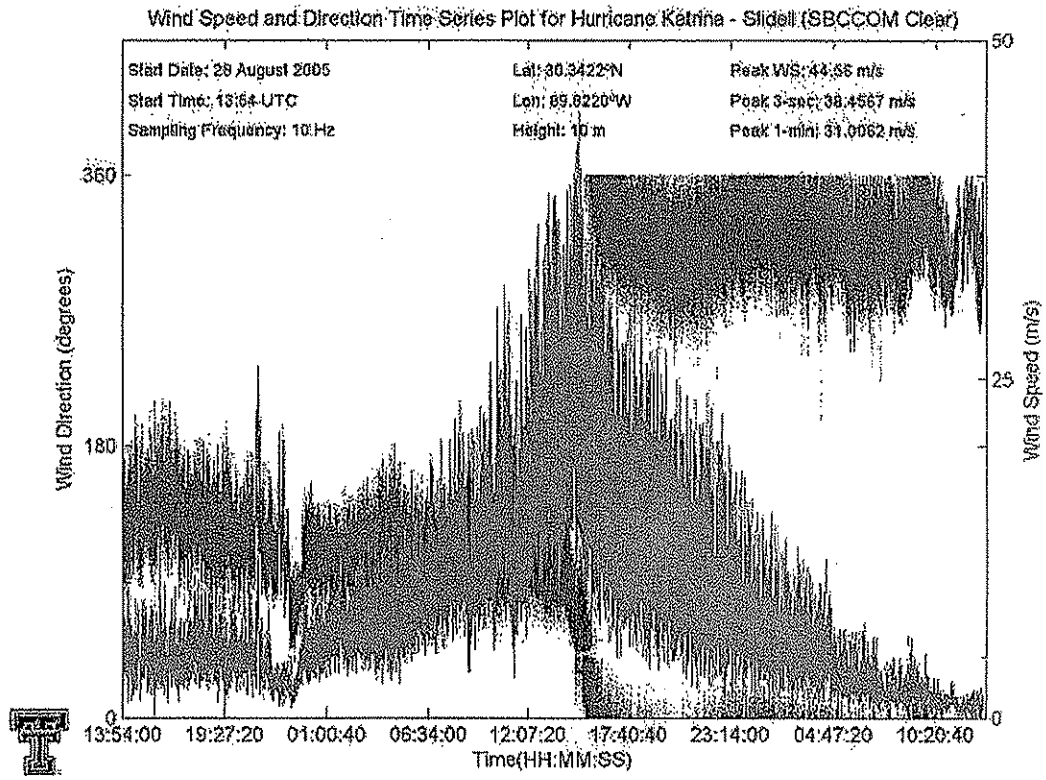
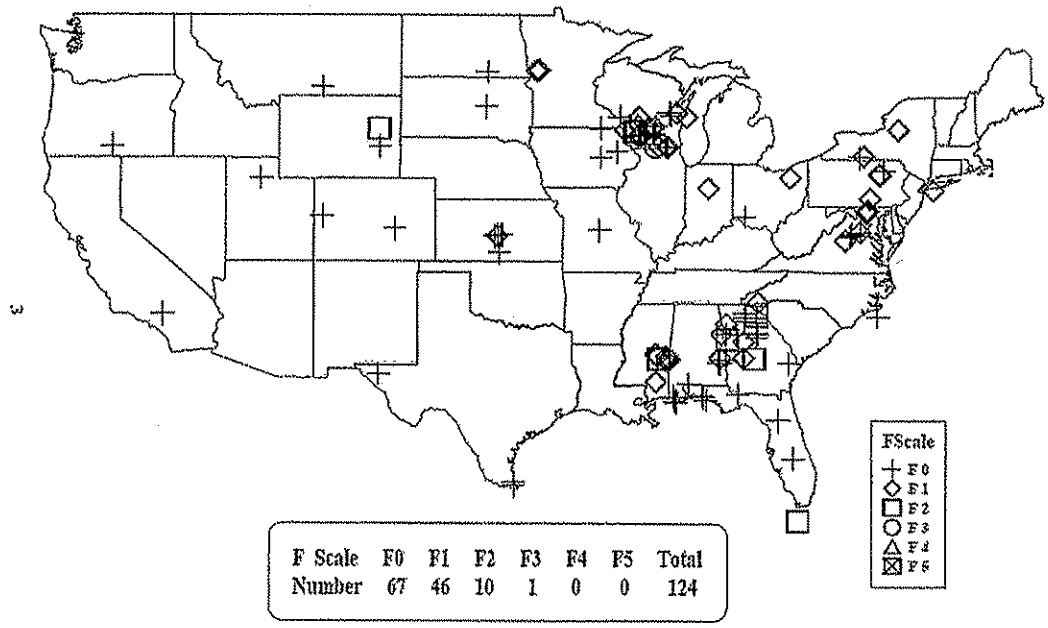


Figure 4: Plot of winds from Slidell, LA. Instrumentation deployed by personnel from Texas Tech University.

August 2005 Confirmed Tornadoes



F Scale	F0	F1	F2	F3	F4	F5	Total
Number	67	46	10	1	0	0	124

Figure 5: Confirmed tornadoes in the Conterminous United States in August 2005. Source is *Storm Data*, published by the National Climatic Data Center.

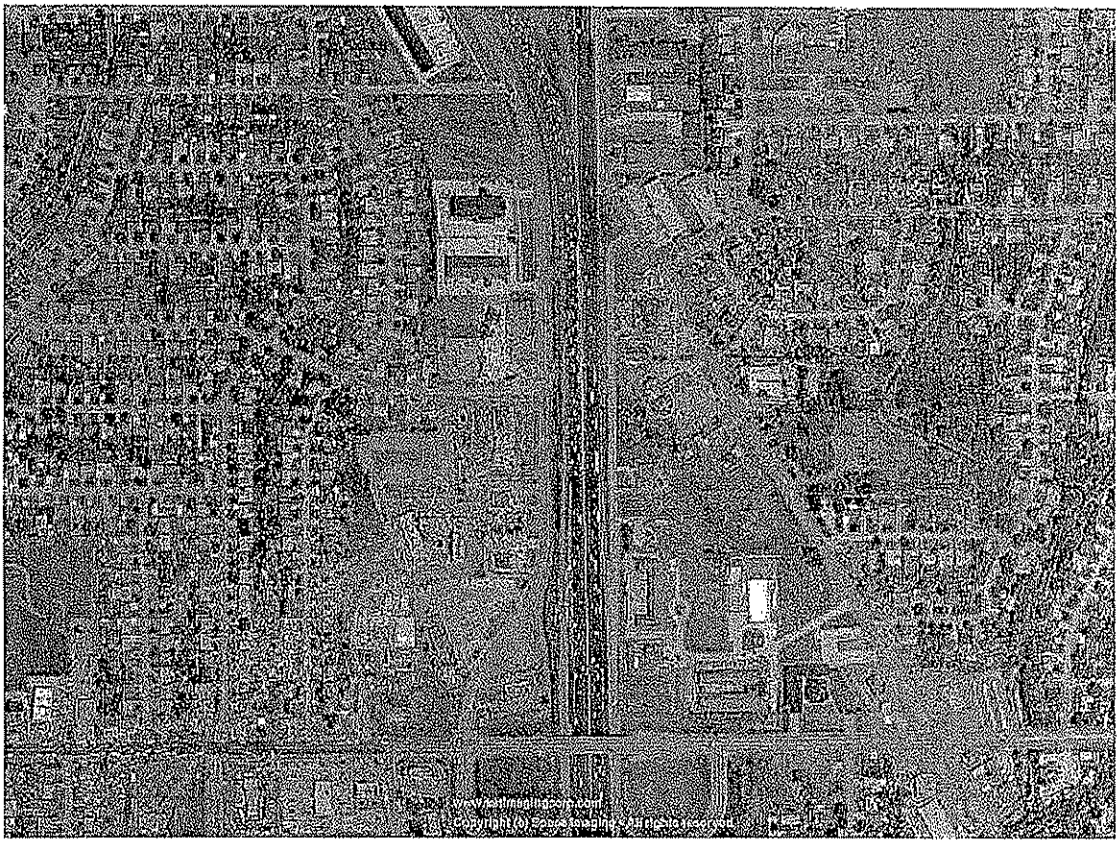


Figure 6: Swath of damage caused by a tornado on 8 May 2003 in Oklahoma City, Oklahoma. Image used with permission from Satellite Imaging Corporation, Houston, Texas.

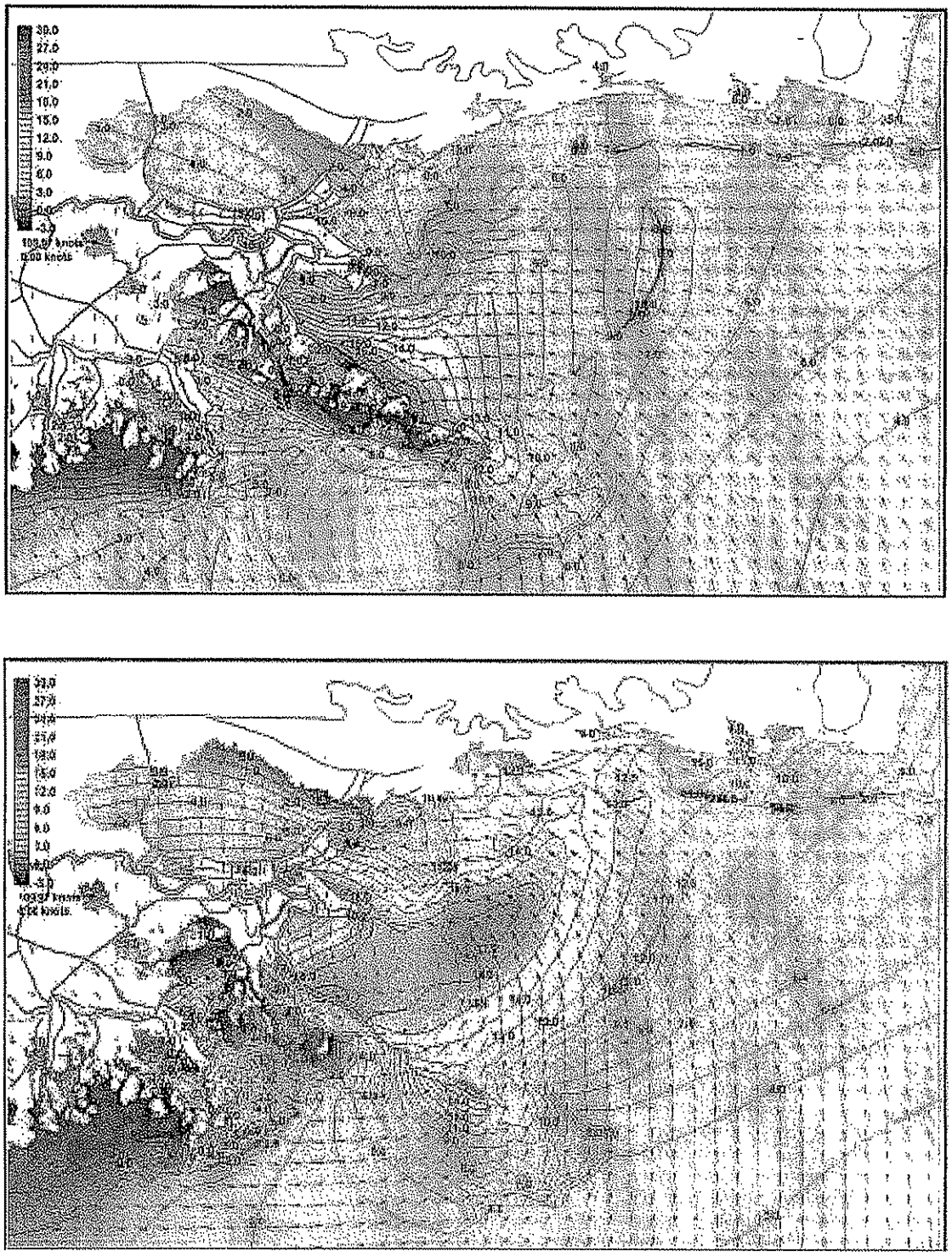


Figure 7: Modeled storm surge estimates using the ADCIRC with wind fields for 0600 LDT (top), 0800 LDT (bottom) on 29 August 2005. Source for figure is the U.S. Army Corps of Engineers IPET Report.

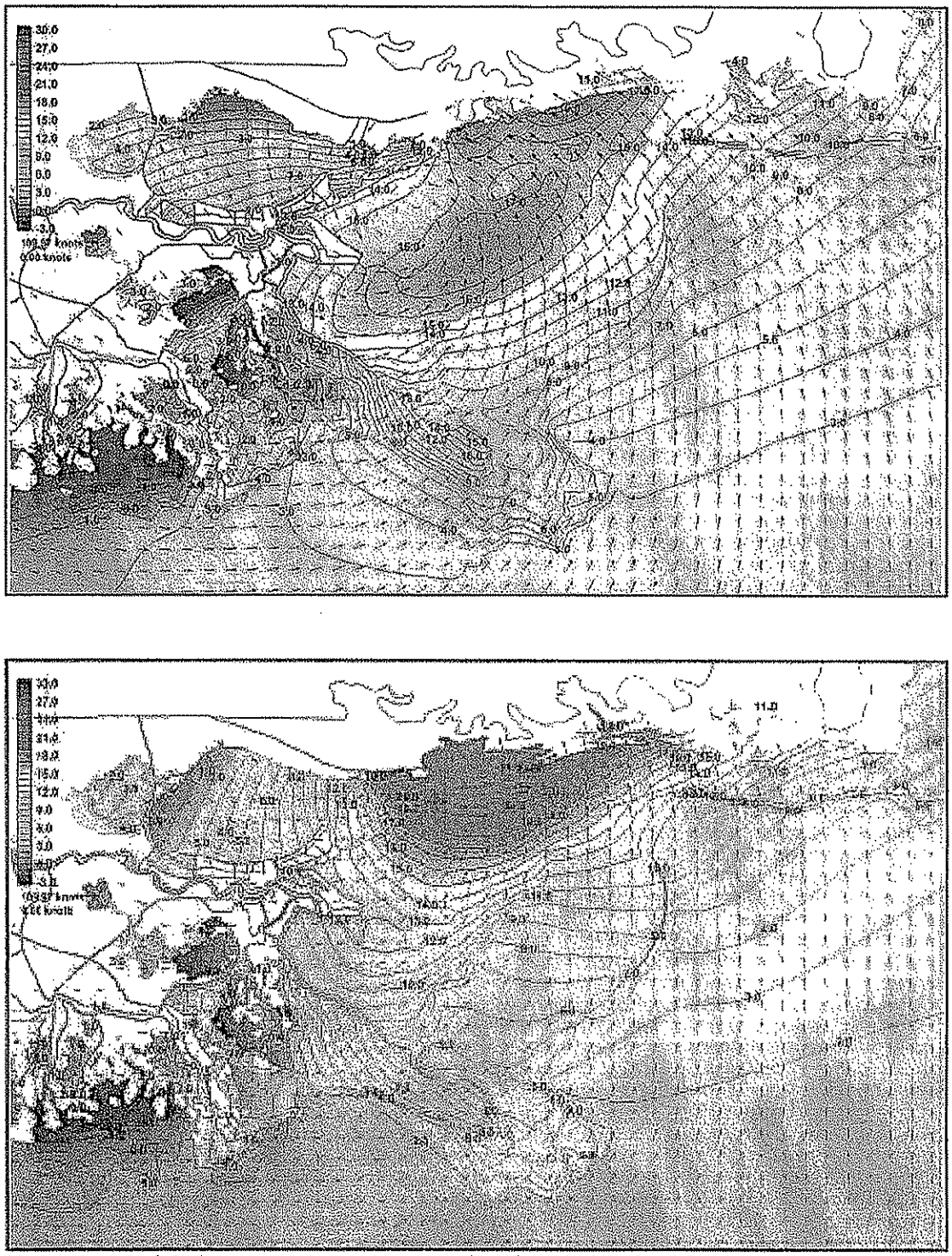


Figure 8: Modeled storm surge estimates using the ADCIRC with wind fields for 0900 LDT (top) and 1100 LDT (bottom) on 29 August 2005. Source for figure is the U.S. Army Corps of Engineers IPET Report.

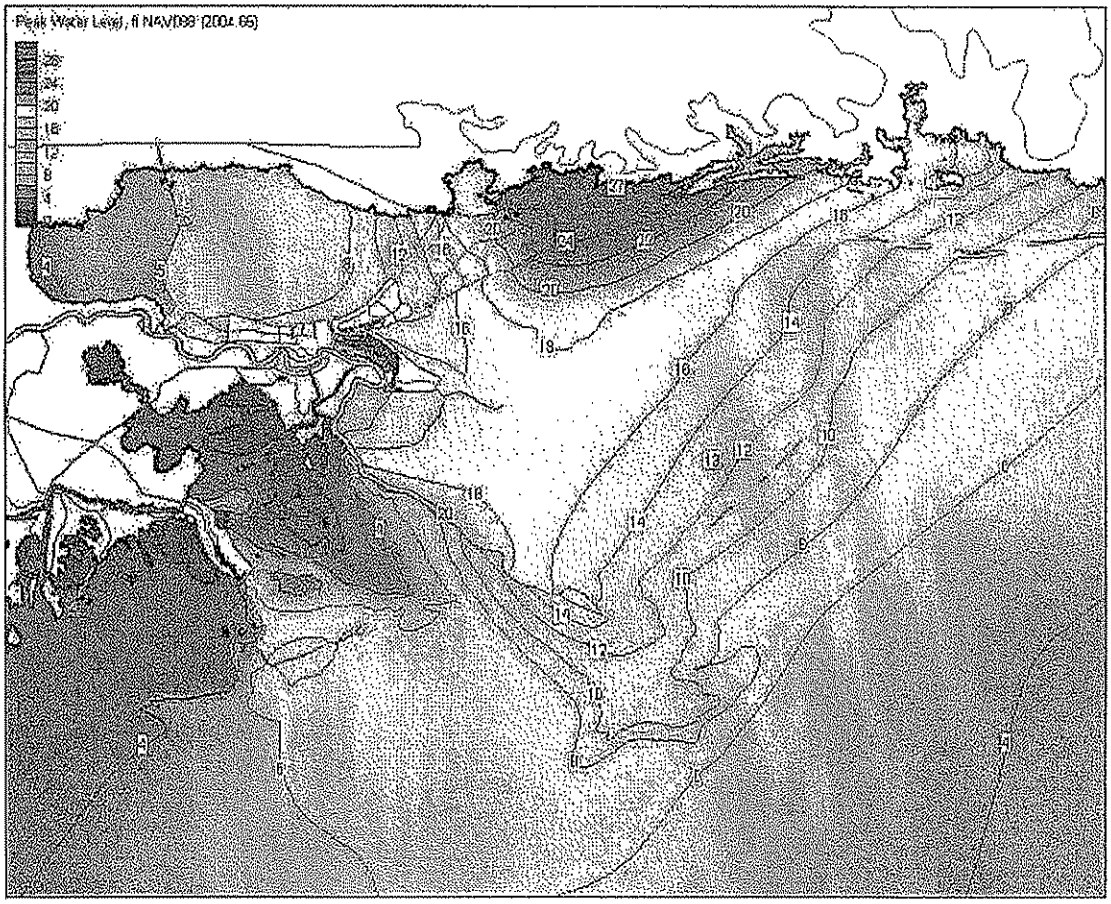


Figure 9: Hurricane Katrina peak storm surge as estimated by the ADCIRC Model. Source for figure is the Executive Summary of the US Army Corps of Engineers IPET Report.

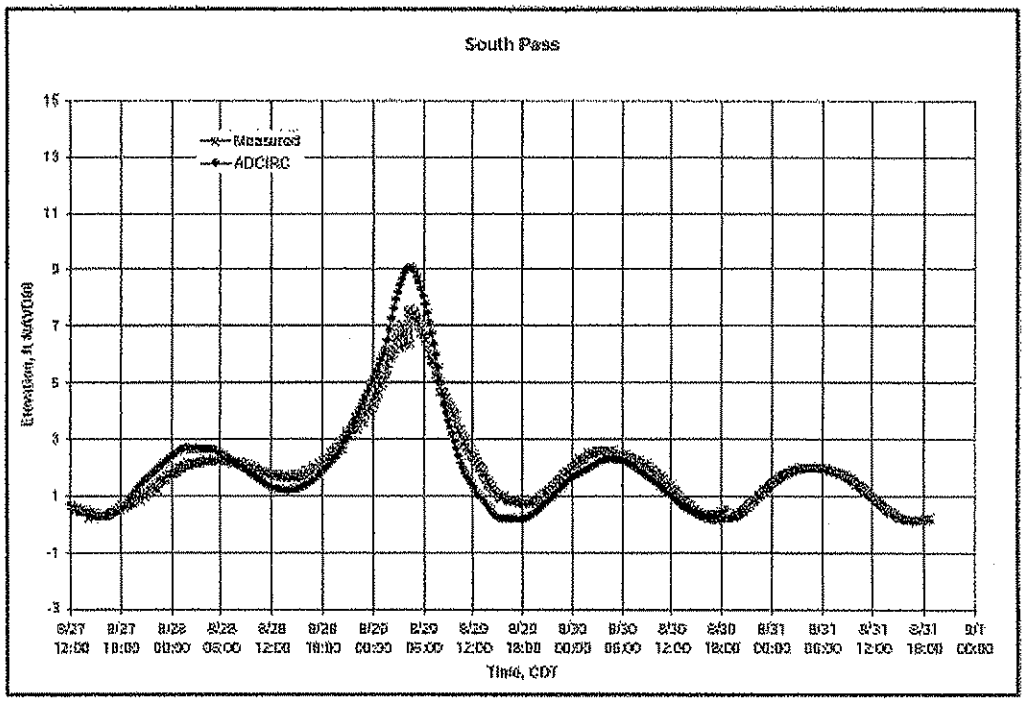


Figure 10: Comparison of measured and ADCIRC-modeled storm surge at Southwest Pass at the mouth of the Mississippi River. Source is the IPET Report.

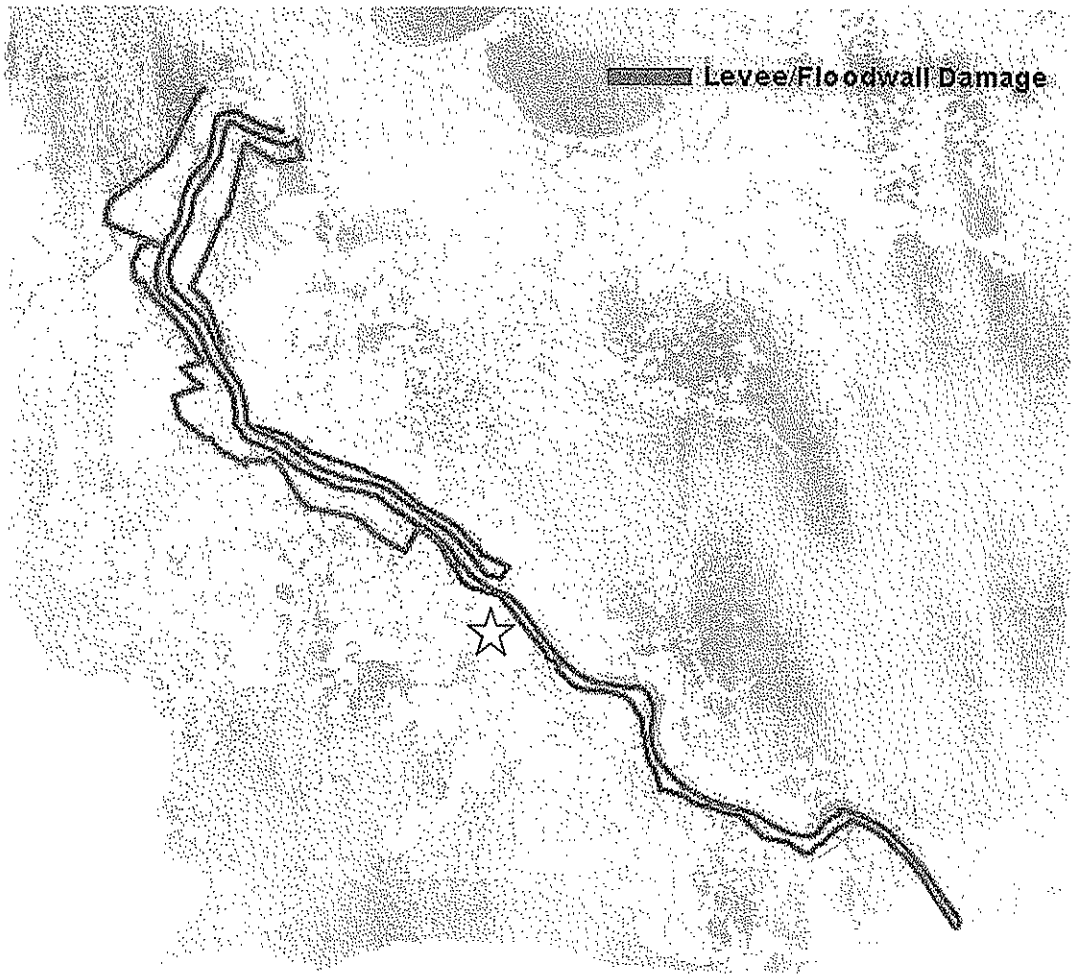


Figure11: Levee system of Plaquemines Parish maintained by the U.S. Army Corps of Engineers. The property is near the star, inside the polder along the Mississippi River. Map modified from the US Army Corps of Engineers website version at: http://www.mvn.usace.army.mil/hps/plaquimines_breach.htm

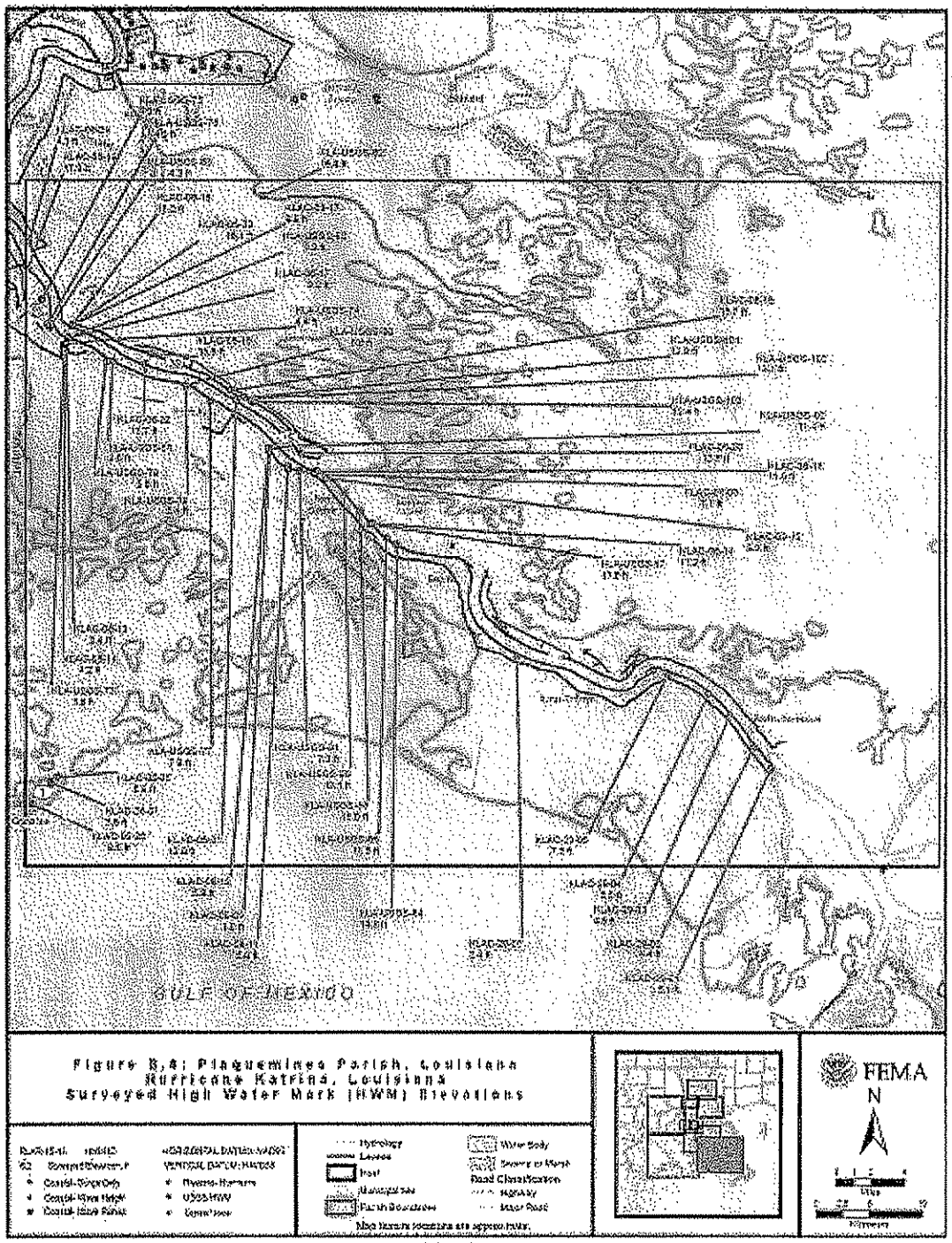


Figure 12: High water marks measured by FEMA and USGS. Source is FEMA's *High Water Mark Collection for Hurricane Katrina in Louisiana.*