

HURRICANE HUGO IN THE CHARLESTON AREA

*John F. Townsend
National Weather Service Office
Charleston, South Carolina*

INTRODUCTION

Hurricane Hugo's passage through the Charleston (CHS) area was one of strong contrasts. While the heavily populated area of Charleston county was subjected to Saffir/Simpson Category 1-2 winds, with slightly offshore wind flow ahead of the eye, northern areas of the county suffered under Category 4 conditions, onshore winds, and associated high surge values.

STORM TRACK THROUGH THE AREA

Figure 1 shows the track of the eye through the Charleston area, taken from our WSR-57 radar. Throughout the period shown in Figure 1, the storm maintained a forward speed of about 25 knots and an average eye diameter of 26 nautical miles.

WINDS

Several anemometers were available and working throughout the storm in the immediate Charleston area, but regrettably, none were located in the area of strongest winds 20 miles to the northeast of the city.

The Charleston airport, Custom House (Peninsular City), and Folly Beach C-Man anemometers were remarkably consistent in their readings (Table 1), all indicating Category 1 wind conditions for a brief period as the eye wall passed through.

Some unofficial readings, obtained later, indicated higher winds in more exposed locations (higher or over water). The locations of these sensors in relation to the city and the eye are shown in Figure 2.

	SUSTAINED (mph)	GUST (mph)
Custom House	87	108
WSO CHS (airport)	78	98
Folly C-Man	85	107
Unofficial.....		
Post-Courier Bldg.		121
Mt. Pleasant	82	96
Coast Guard Cutter "Rambler" in Cooper River(8 ESE of CHS)		138

TABLE 1: Wind readings taken during the passage of Hurricane Hugo.

Figure 3 shows the winds from the Custom House anemometer, located at the end of the Port Authority Terminal pier in the city. This wind sensor has good exposure to northeast winds. After the eye passed, however, when the winds shifted to southwest, the observed gusts were dampened by the fact that the sensor was then on the leeward side of the city. At the airport, wind gusts were same or even slightly higher after the eye passage.

STORM TIDE READINGS

In Figure 4, the Storm Tide and Storm Surge at the Custom House tide gage are shown respectively. The surge heights were obtained by subtracting the astronomical tide from the observed storm tide.

Of interest in Figure 4 is the rapid rise in surge at approximately 2320 EDT. Note in Figure 3 that the wind at the site was blowing from an average of about 040°, and was therefore blowing slightly offshore until about 2320 EDT, when the eye wall reached the site. Winds in the harbor began to shift to a more onshore component and diminish in the eye. At this point, the surge pushed through the (initially) narrow harbor entrance and the winds subsided as the left side of the eye moved over the city.

The 9 ft surge, on top of the astronomical tide, which was one hour away from high, produced a total storm tide of 10.4 feet above Mean Sea Level or roughly 13 feet above Mean Low Water. As noted earlier, the peak tide was reached during calm winds, therefore little or no wave action damage was observed in the city until the back side of the eye wall came across. Considerable damage then occurred while the storm tide was dropping in the period from 0100-0400 EDT.

In 1984, the SLOSH (Sea Lake and Overland Surges from Hurricanes) model (Jelesnianski and Chen, 1984) was completed for the Charleston Basin. A SLOSH computer-generated time cross-section display for Charleston is shown in Figure 5 (Townsend 1984). Compare the SLOSH predicted values in Figure 5 with the observed storm tides in Figure 4. The SLOSH computed surges for our coastal locations for a Category 4 storm landfalling at CHS were very close to those observed (within a foot or two in most cases).

Figure 6 compares tides in the Charleston area with those along the coast to the northeast, as well as some historical readings from important past storms at Charleston.

Storm surges from Charleston northward were those that would normally be associated with a Category 3 (Charleston City), Category 4 (Sullivans Is./Isle of Palms), and Category 5 (Bull's Bay/Romain Retreat area).

The areas to the north and east of the city experienced onshore flow well before the eye arrival, and their surge profile, although higher, would not likely have been as abrupt as the Custom House profile in Figure 4, since winds were blowing onshore much earlier.

RETURN PERIODS

FOR WINDS - The return periods calculated for winds for a centrally located site-Sullivans Island, (Neumann and Pelissier, 1990) were used to determine the return periods for the range of 1-minute winds experienced (and estimated) in the Charleston area as follows:

Charleston City	60 yrs
Folly Beach	70 yrs
(Isle of Palms)	110 yrs
(Bulls Island)	400 yrs

FOR STORM TIDE - The return periods for storm tides observed at open coastal locations during Hugo by using Myers statistics (Myers, 1975) were as follows:

Folly Beach	80 yrs
Sullivans Island	100 yrs
Isle of Palms	180 yrs
McClellanville	320 yrs
Bulls Bay	500+ yrs

PRESSURE

Since the center of the eye was only a short distance northeast of the city of Charleston at its closest, pressure readings were quite representative in the Charleston harbor area and specifically at Mt. Pleasant which is about 6 miles east of the peninsular city. Table 2 gives the lowest sea-level pressure readings observed during Hugo.

	INCHES	MB
Charleston City	27.72	938.7
WSO CHS (airport)	27.85	943.2
Unofficial...		
Mt. Pleasant	27.55	933.0

TABLE 2: The lowest sea level pressures recorded during the passage of Hurricane Hugo.

The pressure readings were within Category 4 criteria (920-944mb) and, along with the storm surges of near 20 feet at Romain Retreat, seemed to support sustained winds of 120 knots (138mph) which were estimated at Bull's Island from Recon Data (Lawrence, 1989).

Figure 7 shows the barograph trace at WSO CHS. The actual barograph trace was transcribed to this chart because the barograph pen had to be reset twice, resulting in a discontinuous trace.

CONCLUSION

Although Hurricane Hugo struck in the vicinity of Charleston, the city and heavily populated areas were spared the worst of the storm. Had the eye of Hugo struck just 20 miles further south, full Category 4 conditions would have been felt in Charleston, and damage would have been catastrophic.

There is some evidence that winds in more exposed locations in the Charleston City area (higher and/or over water - Table 1) approached the values at Bull's Island estimated from the Recon. Data. An overland wind trajectory, and resulting friction was likely responsible for reducing the amount of damage in the more populated areas.

The SLOSH model, referenced earlier, as implemented for the Charleston basin by the National Hurricane Center, was quite accurate. It provided an excellent basis for the various Hurricane Evacuation Studies

(U.S. Army Engineer District, Charleston, 1986) that have been conducted for the Charleston area and the state of South Carolina.

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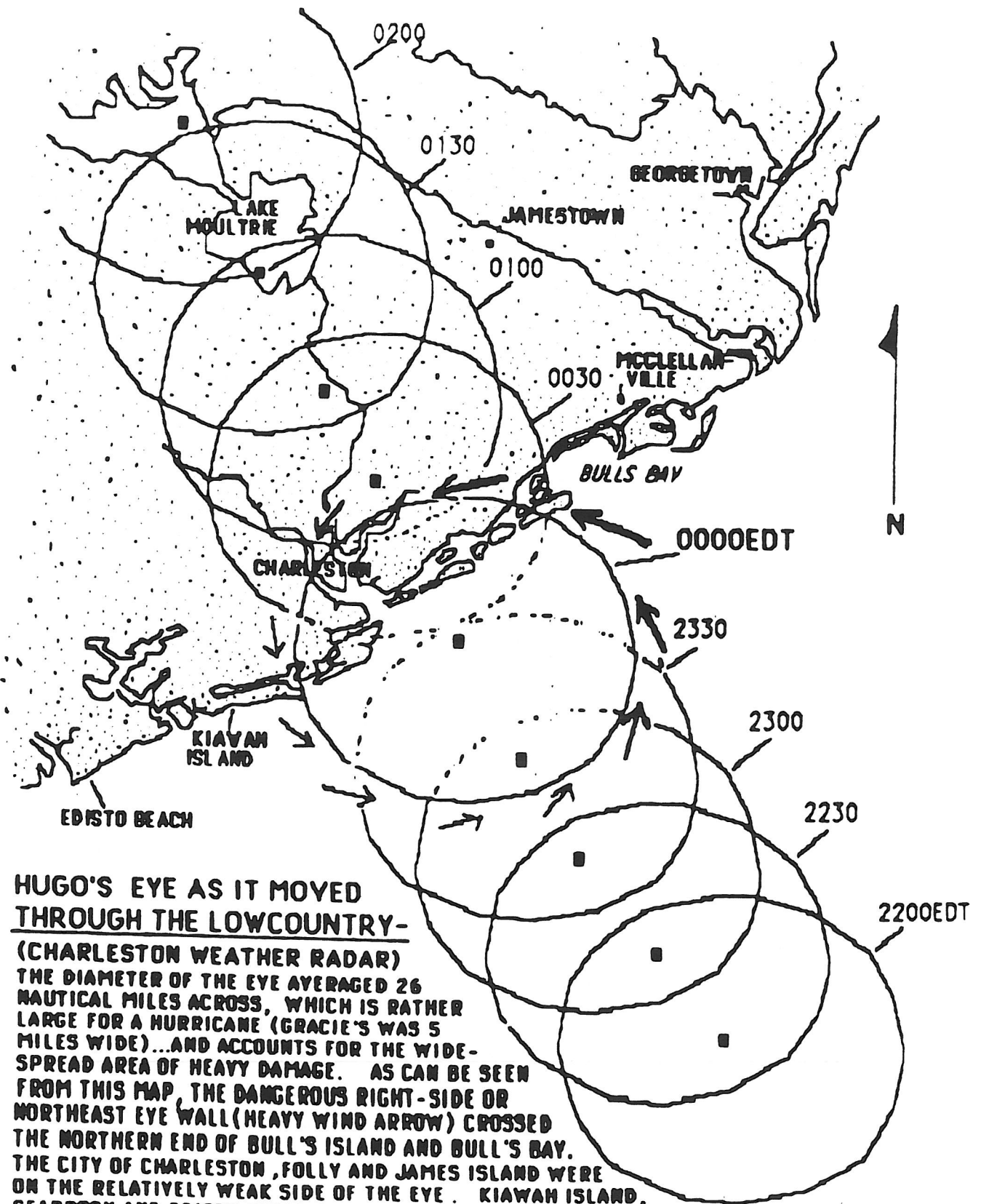
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HUGO'S EYE AS IT MOVED THROUGH THE LOWCOUNTRY-

(CHARLESTON WEATHER RADAR)

THE DIAMETER OF THE EYE AVERAGED 26 NAUTICAL MILES ACROSS, WHICH IS RATHER LARGE FOR A HURRICANE (GRACIE'S WAS 5 MILES WIDE)...AND ACCOUNTS FOR THE WIDE-SPREAD AREA OF HEAVY DAMAGE. AS CAN BE SEEN FROM THIS MAP, THE DANGEROUS RIGHT-SIDE OR NORTHEAST EYE WALL (HEAVY WIND ARROW) CROSSED THE NORTHERN END OF BULL'S ISLAND AND BULL'S BAY. THE CITY OF CHARLESTON, FOLLY AND JAMES ISLAND WERE ON THE RELATIVELY WEAK SIDE OF THE EYE. KIAWAH ISLAND, SEABROOK AND EDISTO RECEIVED NORTHWEST WINDS WHICH KEPT TIDES LOW THERE, WHILE STORM TIDES RANGED FROM 10 TO 13 FEET (MSL) IN THE CENTER OF THE EYE TO 16-20 FEET (MSL) WHERE THE NORTHEAST EYE WALL CROSSED THE COAST.

FIGURE 1
Path of Hugo in Charleston Area

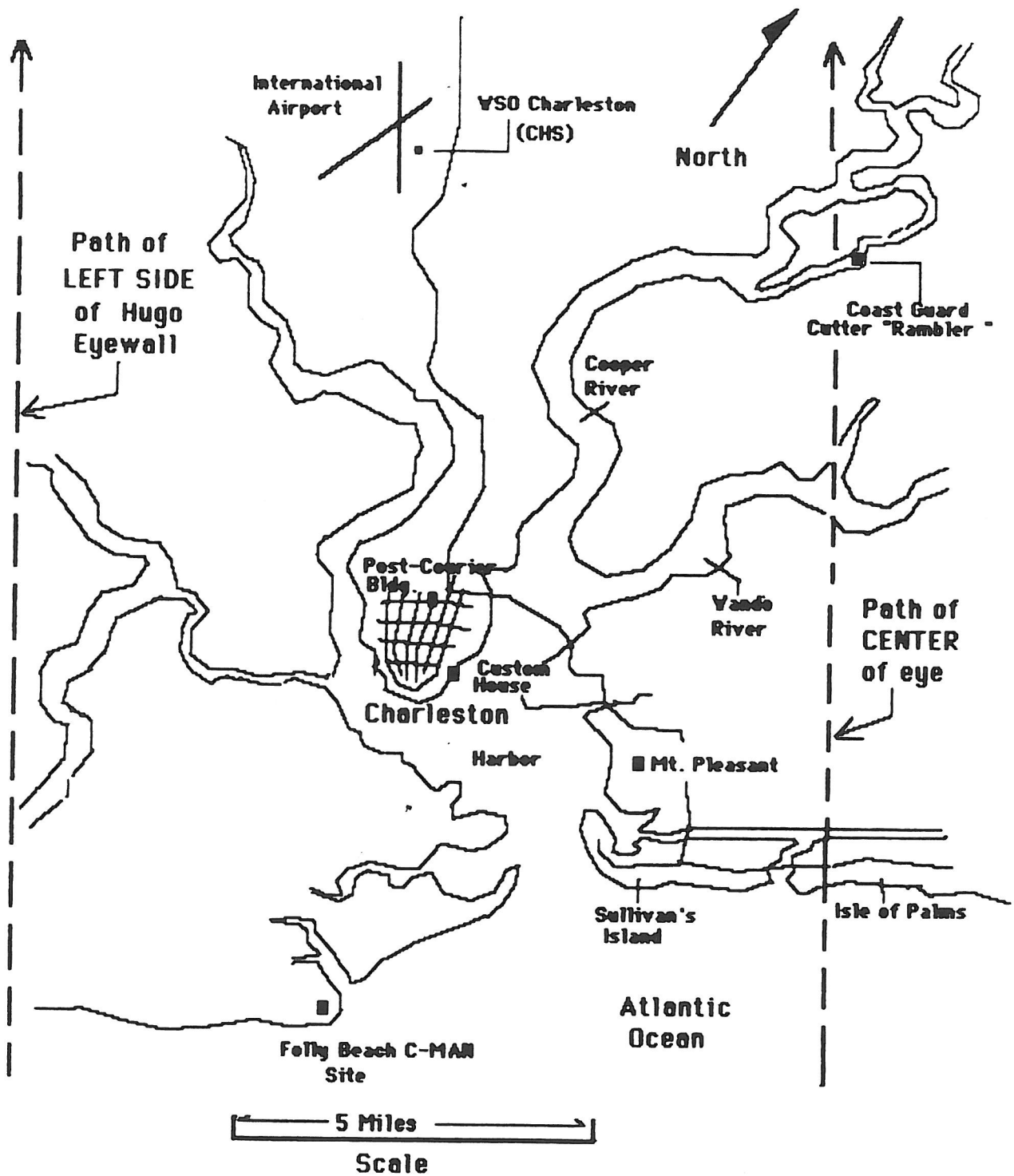


FIGURE 2
Detail of Charleston Area

WIND-HURRICANE HUGO

Chas. Custom House

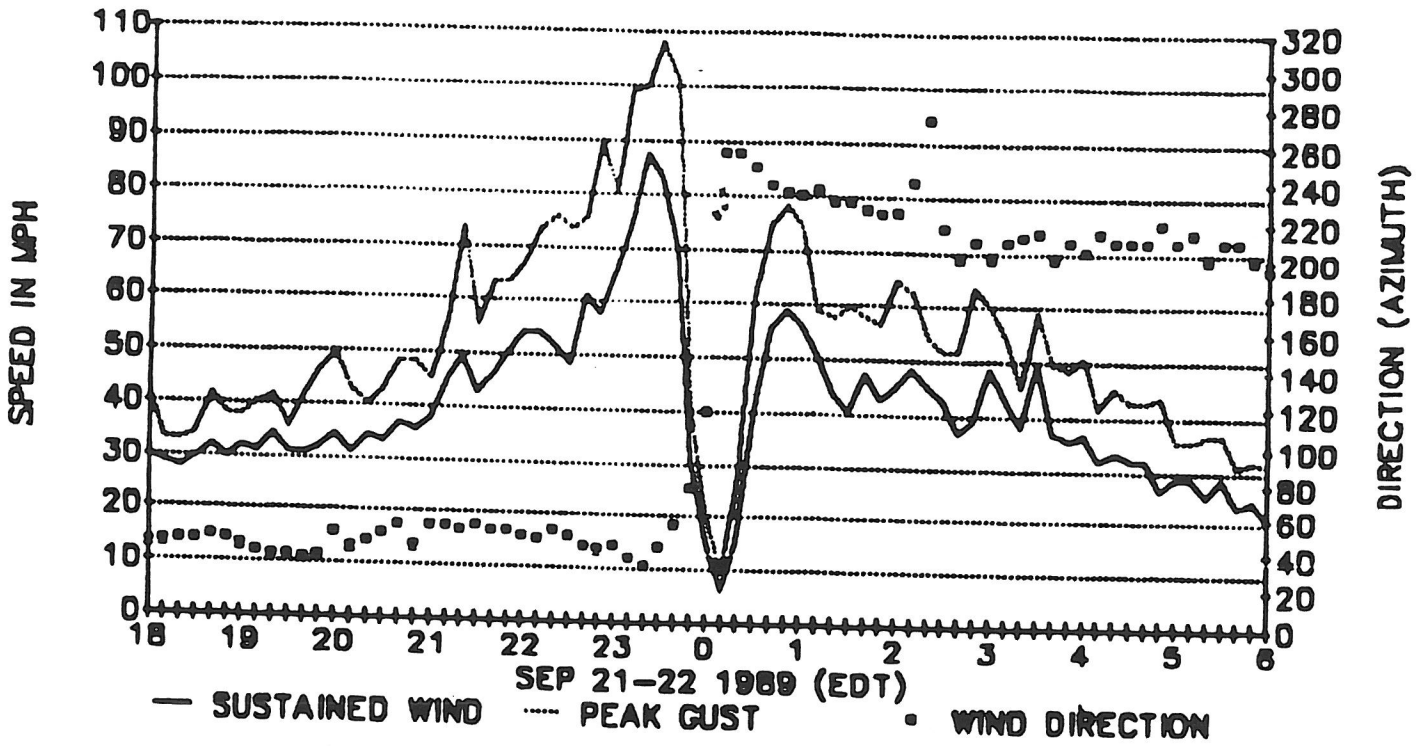
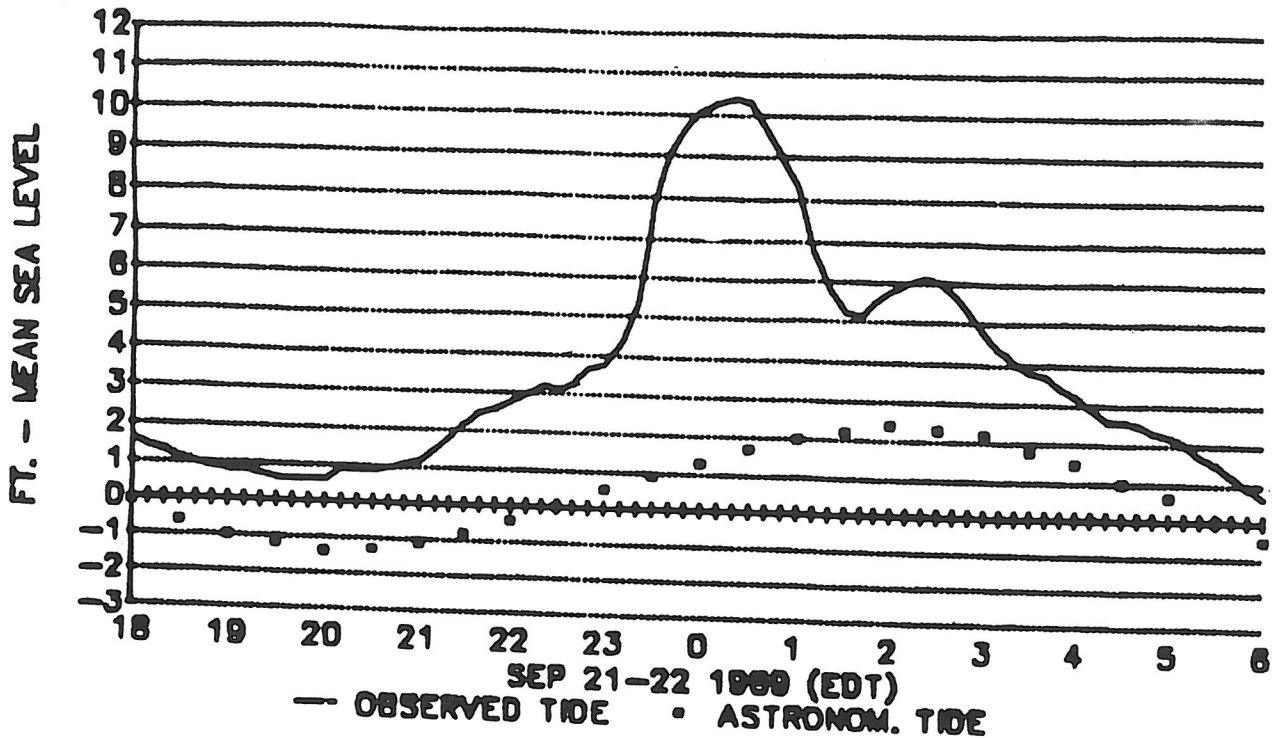


FIGURE 3
Winds from Custom House Anemometer

STORM TIDE - HUGO

Chas. Custom House



STORM SURGE - HUGO

Chas. Custom House

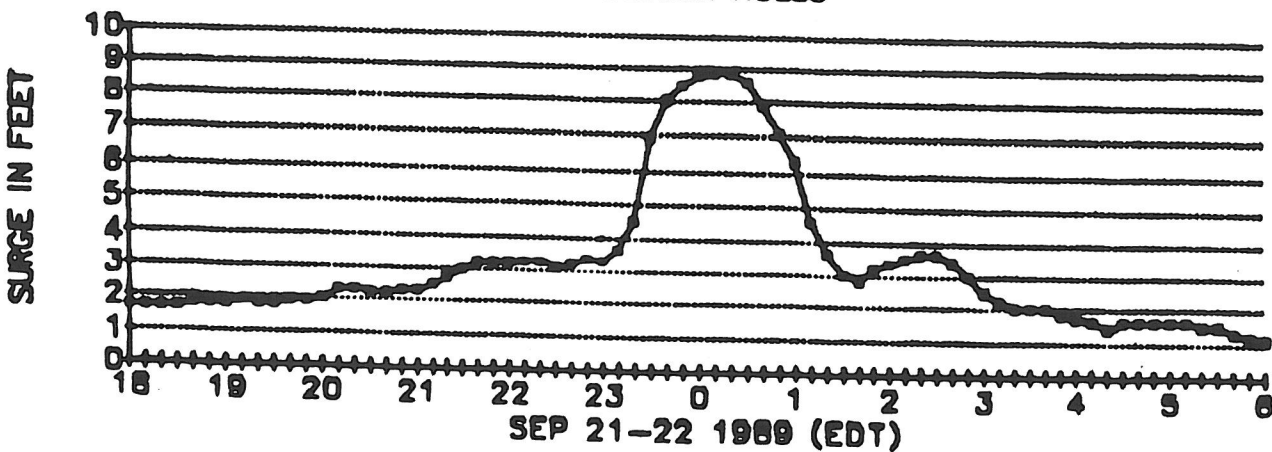


FIGURE 4
Observations from Custom House Tide Gage

HURRICANE SURGE PROGRAM
 CAT. 4 MOVING NW 12 AT/CHS

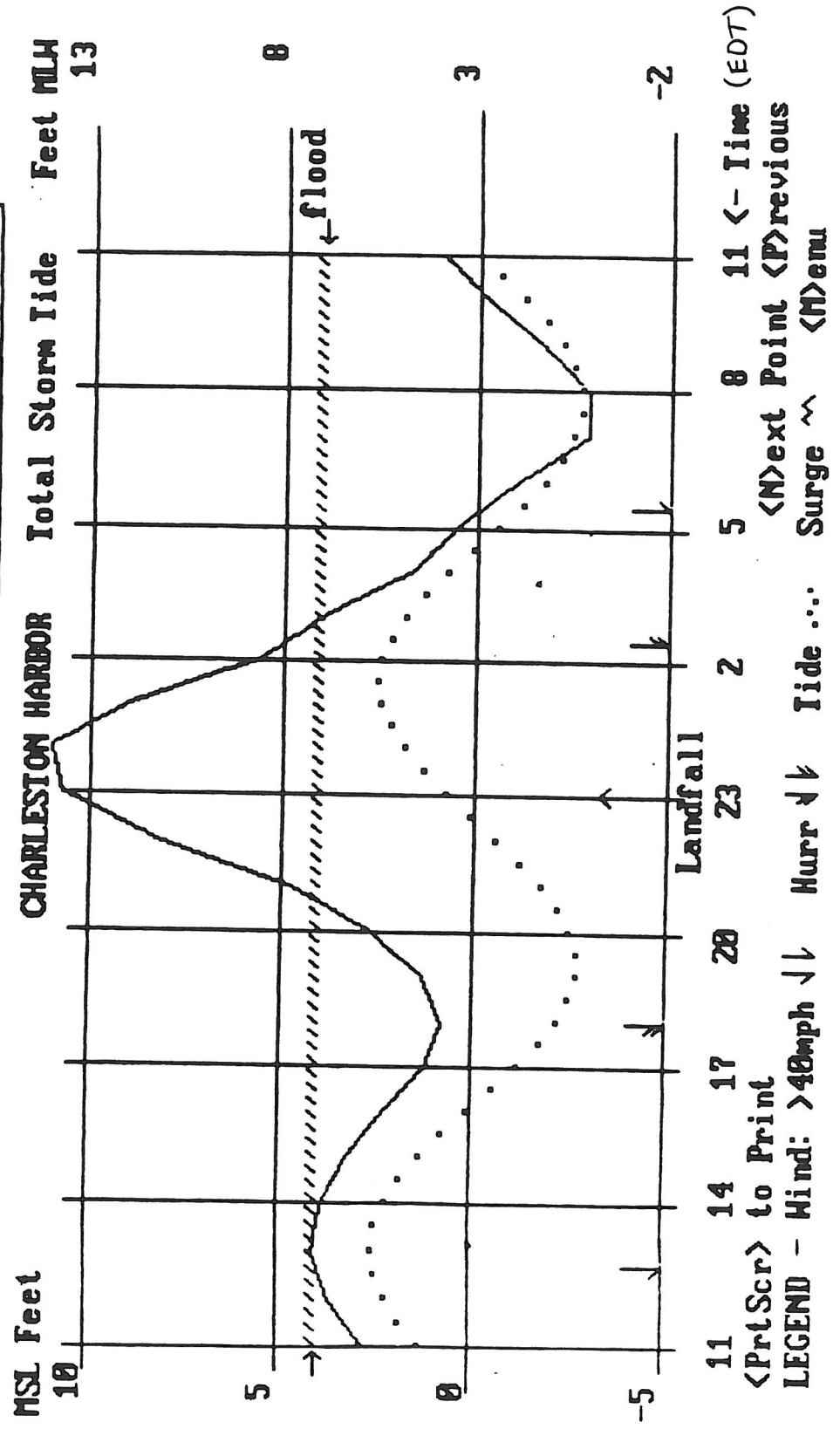


FIGURE 5
 SLOSH Computer Display Program - Hugo

HUGO'S STORM TIDE - IN PERSPECTIVE

The storm tide measured at Romain Retreat, at the southern end of Bulls Bay, was the highest recorded anywhere on the East Coast of the U.S. in this century, the highest on record for South Carolina, and approached only by a 19.5 MSL reading of Savannah Beach in the great 1893 storm, which killed 2000 on the barrier islands.

The readings in Charleston city and adjacent barrier islands, although much lower than the Bulls Bay levels, were the highest on record for the area, surpassing all previous major hurricanes and likely exceeded only by those in the great hurricane of 1752. The following are still water heights which do not include wave action.

DATA IN FEET ABOVE MEAN SEA LEVEL

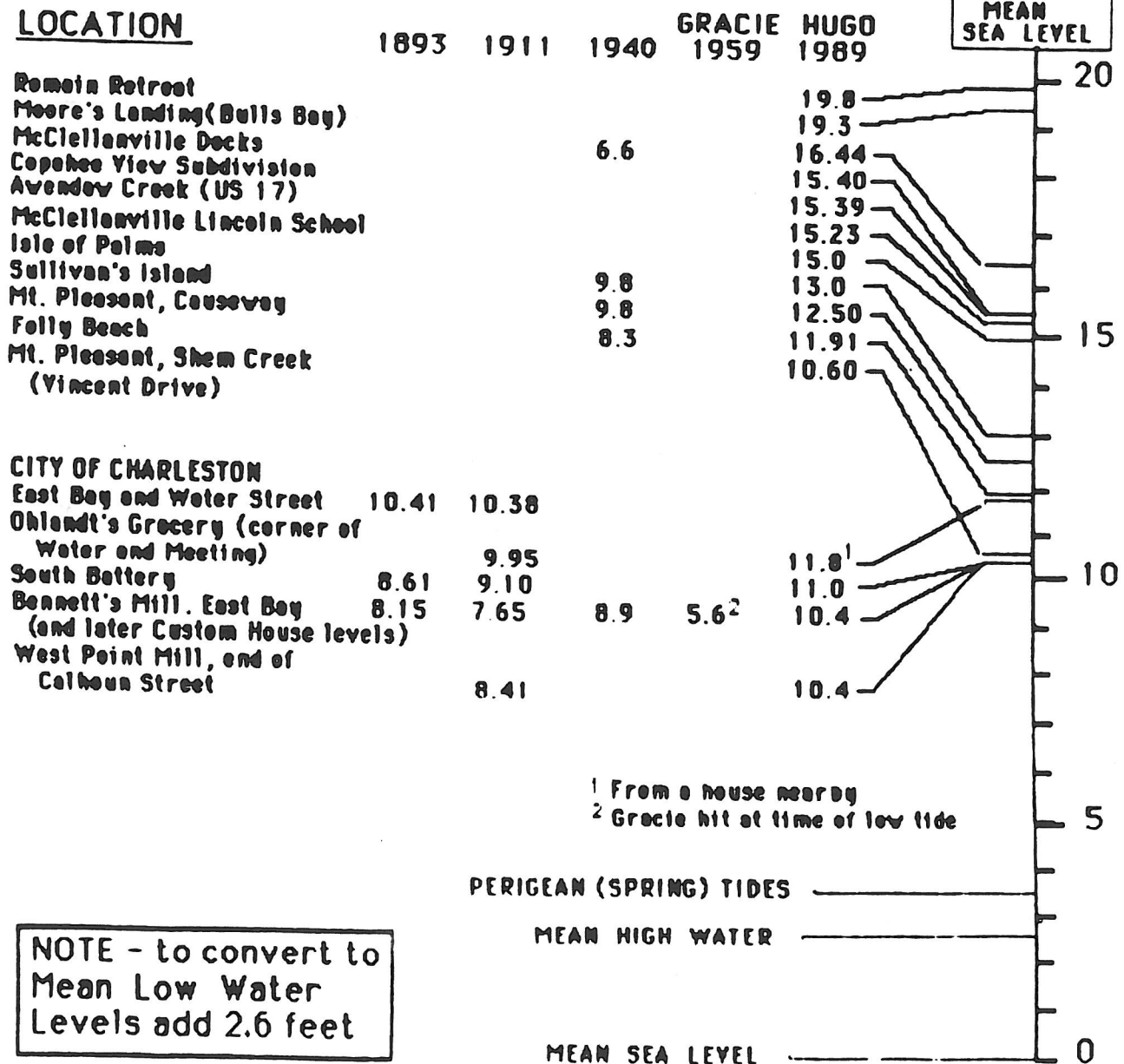


FIGURE 6
Area Storm Tide Comparisons

PRESSURE - HUGO
Charleston Airport

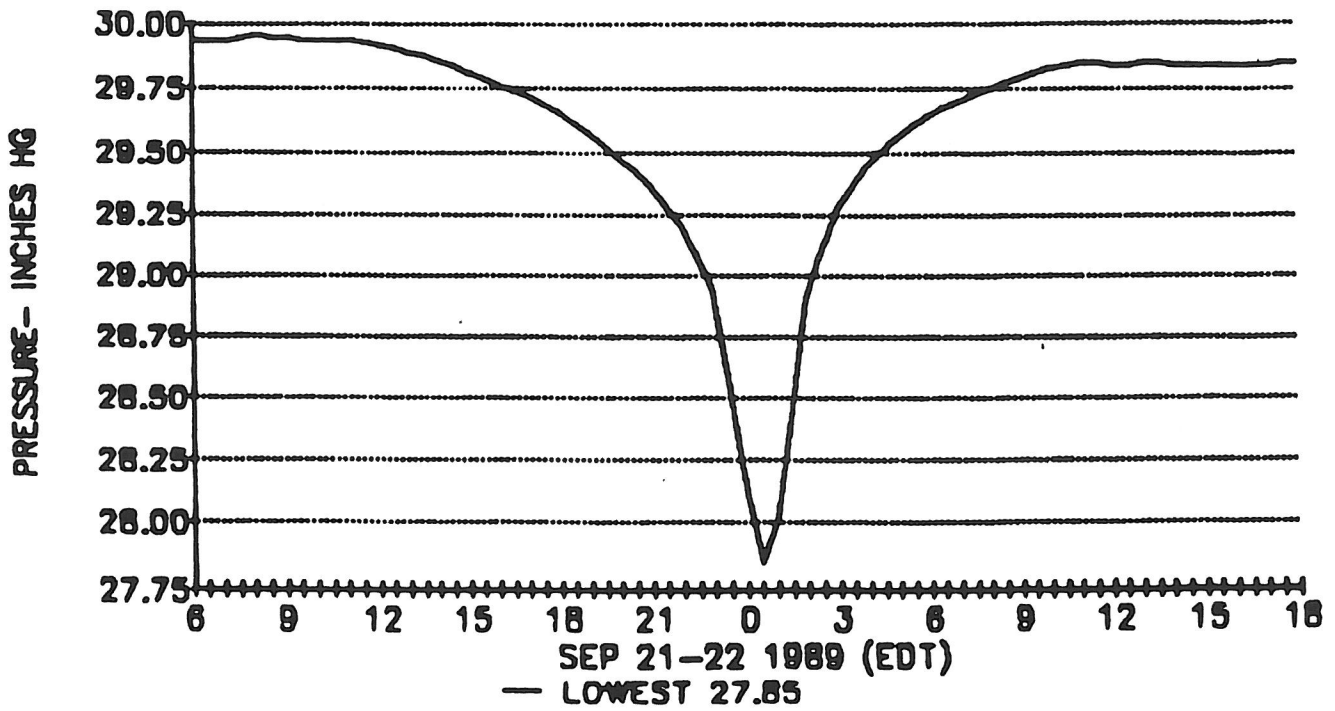


FIGURE 7
Sea Level Pressure at WSO CHS