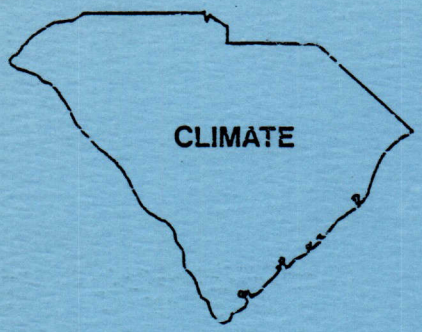

CLIMATE REPORT NO. G14

HURRICANE VULNERABILITY FOR CHARLESTON COUNTY

STATE OF SOUTH CAROLINA
WATER RESOURCES COMMISSION
STATE CLIMATOLOGY OFFICE

MAY 1985

HURRICANE VULNERABILITY
FOR
CHARLESTON COUNTY

by
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INTRODUCTION

The purpose of this narrative is to provide a ready reference of tropical cyclone statistics adapted to the various counties along the South Carolina coastline. These data were extracted from either climatological data, information provided by Dr. Brian Jarvinen of the National Hurricane Center, or material specifically computed by Mr. Charlie Neuman for inclusion into this study. Mr. Neuman conducts research at the National Hurricane Center.

HISTORICAL HURRICANE ACTIVITY

Hurricanes are an annual threat to Charleston County. Figure No. 1 shows the years from 1886 through 1983 when tropical cyclones with a wind speed of 34 knots or higher passed within 75 nautical miles of Charleston County. Figure No. 2 lists the probability of at least one or more tropical cyclones of 34 or more knots passing within 75 miles of Charleston County. An inspection of the latter figure shows that on any particular year there is a 43 percent chance of an occurrence of one tropical cyclone and an 11 percent chance of two such storms per year with wind speeds of 34 knots or higher. There is a much lower probability, less than one percent, that four such events will occur during any particular year. Figure No. 3 gives the corresponding probabilities for tropical cyclones of hurricane intensity ranging from 18 percent for one occurrence, as compared to a 2 percent chance for two tropical cyclones of hurricane intensity per year. The return periods of tropical cyclones affecting the Charleston County area are summarized in Figure No. 4. This figure is particularly useful since it gives the intensity of the cyclone and the return period versus the distance of the storm from Charleston County.

The direction of movement of tropical cyclones affecting Charleston County has an important bearing on the amount of damage that the storm produces. For example, if a hurricane moves northeastward along and off the coast the amount of damage is usually minimized. On the other hand, a northeastward or westward moving storm would cause considerably more damage. Figure No. 5 indicates that the largest percentage of tropical storms and hurricanes are from the southwest or are moving northeast, although it does show that a significant percentage approaching Charleston County are from the more dangerous east to southeast quadrant. Such was the case in 1959 when hurricane Gracie caused major damage to the Charleston area. The hurricane season along the South Carolina coast officially covers the June through October period. Figure No. 6 however, shows that tropical cyclones have affected Charleston County as early as May 21st-27th and as late as October 29th-November 4th. The maximum frequency however has been from September 24th-30th.

Figure No. 7 indicates that the usual forward speed of tropical cyclones of 34 or more knots moving near Charleston County is from 10 to 15 miles per hour. However, speeds actually vary from near zero to more than 40 miles per hour. Storms of hurricane intensity, as shown in Figure No. 8, move slightly slower on the average, but still exhibit a wide range of translational speeds. The most likely wind speed is from 34 to 44 knots but the maximum wind speeds have exceeded 114 miles per hour. Figure No. 9 lists the observed, as well as the fitted gamma distribution of maximum winds for the period 1886 through 1983.

The paths of all tropical storms that have passed within 75 nautical miles of Charleston are shown on Figures 10 and 11. While it is impossible to distinguish between the different storm tracks, it is obvious that the area may be affected by storms approaching from a wide range of directions.

STORM SURGE ELEVATION

The maximum area that may be flooded by a hurricane was calculated using the SLOSH computer model. The data have been transferred to hurricane evacuation maps and are on file in the various Emergency Preparedness Offices as "MEOW" maps or maps of maximum elevation of highwater that may be expected during the passage of hurricanes of the category and direction indicated. Vance A. Myers completed a study dealing with the return period of various storm tide frequencies along the South Carolina coast. His study indicates that at any one location the likelihood of a 14 foot storm surge is approximately a 100 year event. Myers' frequency chart is shown as Figure No. 12.

HEAVY RAIN

Heavy rains associated with the passage of tropical cyclones produce localized flooding as well as other problems affecting evacuation. The following chart gives the frequency distribution of the maximum rainfall intensity for Charleston County for time intervals from five minutes through twenty-four hours.

Return Period	5 min	10 min	15 min	30 min	60 min	6 hr	12 hr	24 hr
2 yr	.511	_____	1.15	1.65	2.27	3.25	4.00	4.60
5 yr	_____	_____	_____	2.05	2.62	4.20	5.10	5.90
10 yr	_____	_____	_____	2.35	2.92	4.80	5.90	7.00
25 yr	_____	_____	_____	2.65	3.35	5.60	6.75	8.00
50 yr	_____	_____	_____	2.95	3.73	6.40	7.45	8.90
100 yr	.795	_____	1.88	3.14	4.34	7.00	8.50	10.20

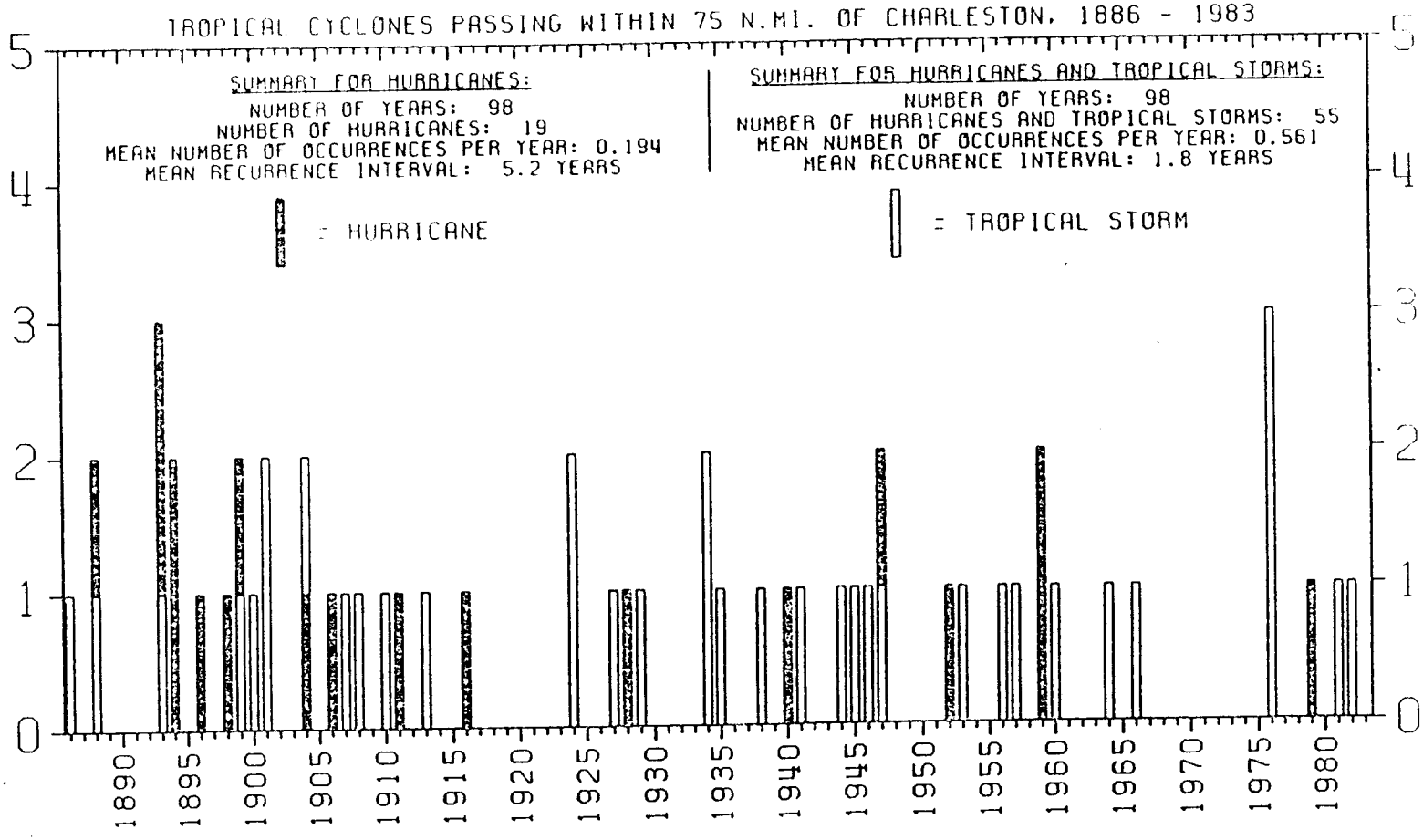

TROPICAL CYCLONES PASSING WITHIN 75 N.MI. OF CHARLESTON, 1886 - 1983
SUMMARY FOR HURRICANES:
NUMBER OF YEARS: 98
NUMBER OF HURRICANES: 19
MEAN NUMBER OF OCCURRENCES PER YEAR: 0.194
MEAN RECURRENCE INTERVAL: 5.2 YEARS
= HURRICANE
SUMMARY FOR HURRICANES AND TROPICAL STORMS:
NUMBER OF YEARS: 98
NUMBER OF HURRICANES AND TROPICAL STORMS: 55
MEAN NUMBER OF OCCURRENCES PER YEAR: 0.561
MEAN RECURRENCE INTERVAL: 1.8 YEARS
= TROPICAL STORM
0
1
2
3
4
5
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980

Figure 1.

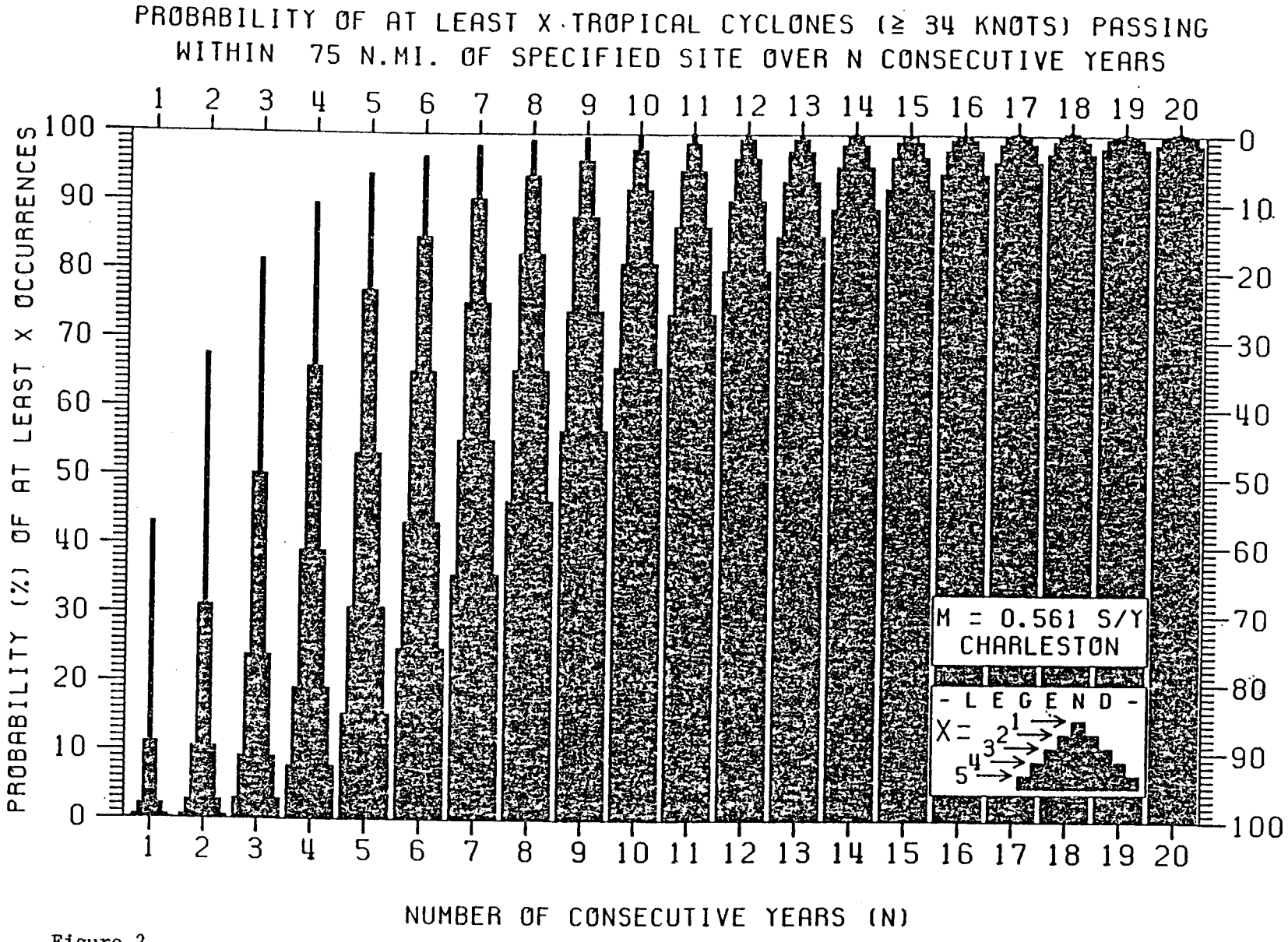

PROBABILITY OF AT LEAST X TROPICAL CYCLONES (≥ 34 KNOTS) PASSING
WITHIN 75 N.MI. OF SPECIFIED SITE OVER N CONSECUTIVE YEARS
PROBABILITY (%) OF AT LEAST X OCCURRENCES
PROBABILITY (%) OF NO OCCURRENCES
NUMBER OF CONSECUTIVE YEARS (N)
M = 0.561 S/Y
CHARLESTON
- LEGEND -
X = 1
2
3
4
5

Figure 2.

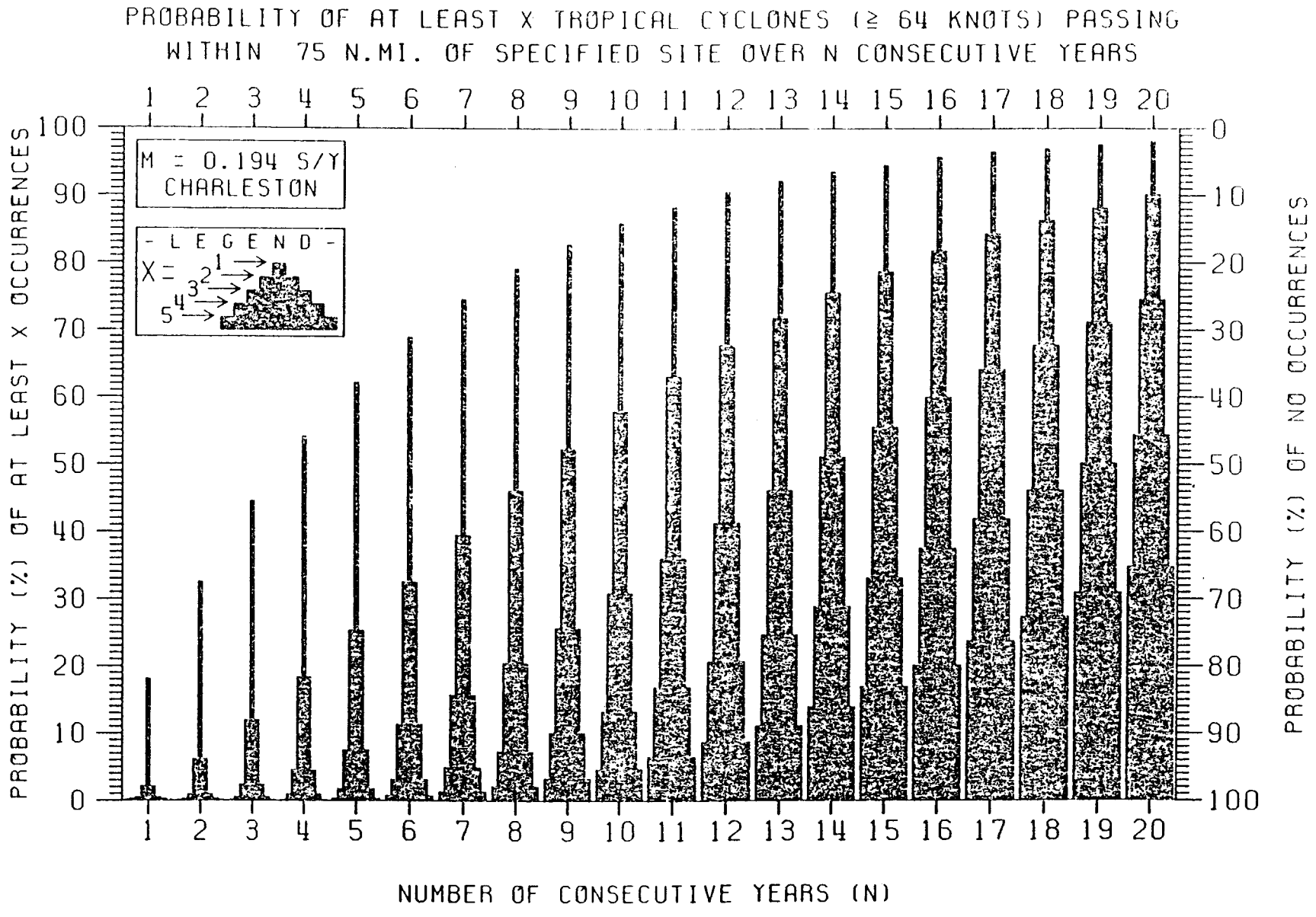

PROBABILITY OF AT LEAST X TROPICAL CYCLONES (≥ 64 KNOTS) PASSING
WITHIN 75 N.MI. OF SPECIFIED SITE OVER N CONSECUTIVE YEARS
M = 0.194 S/Y
CHARLESTON
- L E G E N D -
X = 1 2 3 4 5
PROBABILITY (%) OF AT LEAST X OCCURRENCES
PROBABILITY (%) OF NO OCCURRENCES
NUMBER OF CONSECUTIVE YEARS (N)

Figure 3.

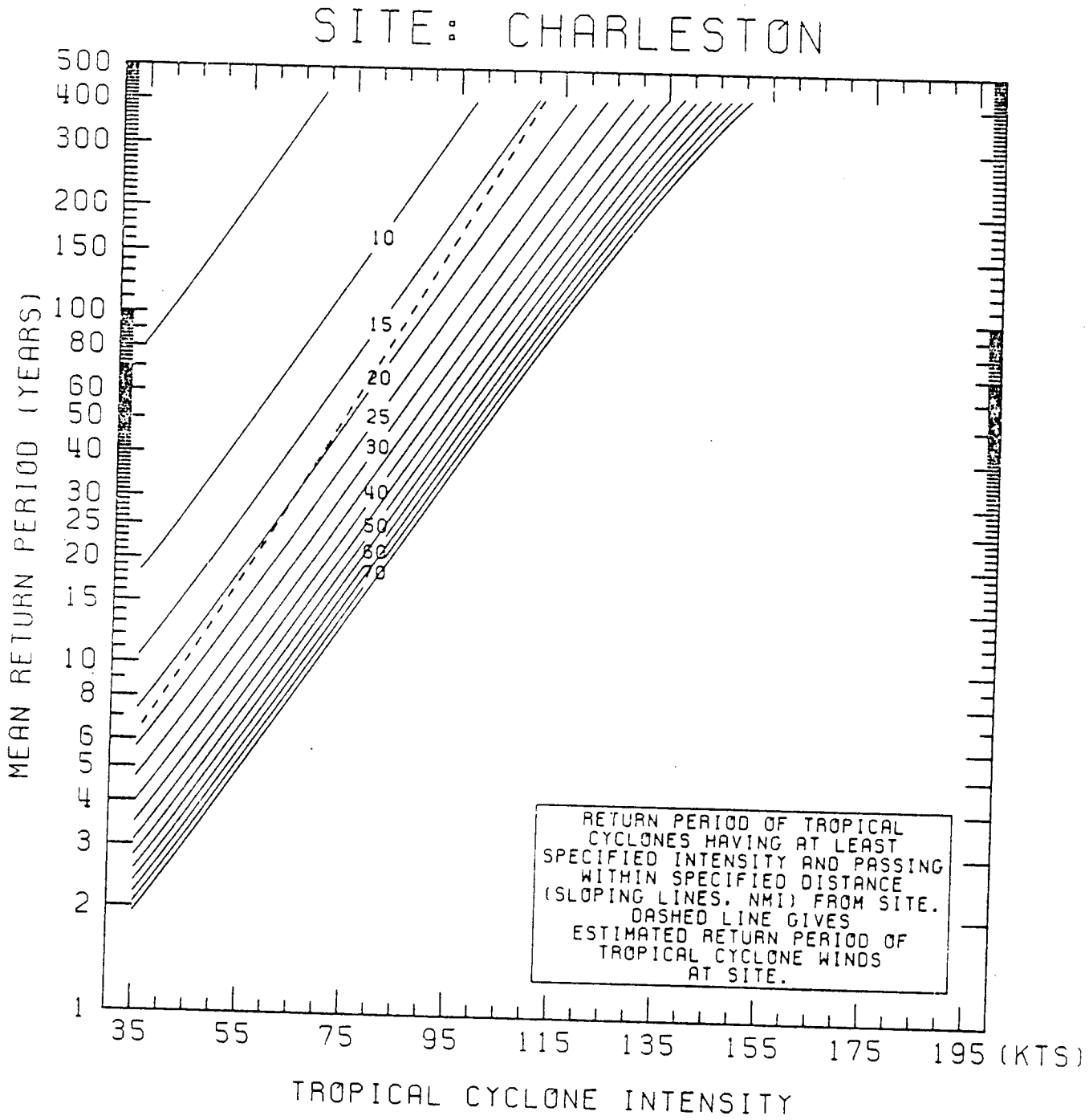

SITE: CHARLESTON
MEAN RETURN PERIOD (YEARS)
500
400
300
200
150
100
80
60
50
40
30
25
20
15
10
8
6
5
4
3
2
1
10
15
20
25
30
40
50
60
70
RETURN PERIOD OF TROPICAL CYCLONES HAVING AT LEAST SPECIFIED INTENSITY AND PASSING WITHIN SPECIFIED DISTANCE (SLOPING LINES, NMI) FROM SITE. DASHED LINE GIVES ESTIMATED RETURN PERIOD OF TROPICAL CYCLONE WINDS AT SITE.
35
55
75
95
115
135
155
175
195 (KTS)
TROPICAL CYCLONE INTENSITY

Figure 4.

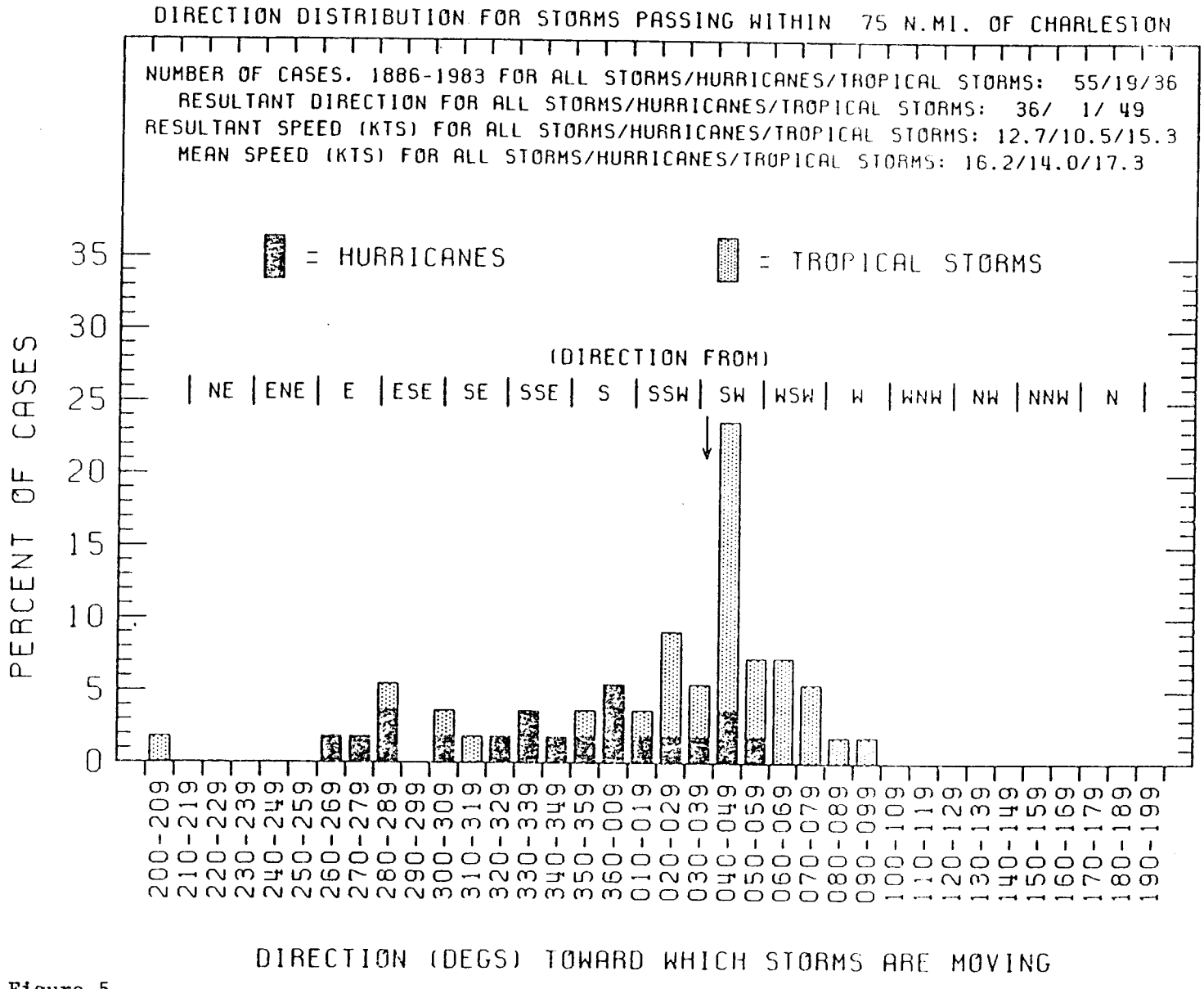

DIRECTION DISTRIBUTION FOR STORMS PASSING WITHIN 75 N.MI. OF CHARLESTON
NUMBER OF CASES. 1886-1983 FOR ALL STORMS/HURRICANES/TROPICAL STORMS: 55/19/36
RESULTANT DIRECTION FOR ALL STORMS/HURRICANES/TROPICAL STORMS: 36/ 1/ 49
RESULTANT SPEED (KTS) FOR ALL STORMS/HURRICANES/TROPICAL STORMS: 12.7/10.5/15.3
MEAN SPEED (KTS) FOR ALL STORMS/HURRICANES/TROPICAL STORMS: 16.2/14.0/17.3
= HURRICANES
= TROPICAL STORMS
(DIRECTION FROM)
NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW N
PERCENT OF CASES
0 5 10 15 20 25 30 35
200-209 210-219 220-229 230-239 240-249 250-259 260-269 270-279 280-289 290-299 300-309 310-319 320-329 330-339 340-349 350-359 360-009 010-019 020-029 030-039 040-049 050-059 060-069 070-079 080-089 090-099 100-109 110-119 120-129 130-139 140-149 150-159 160-169 170-179 180-189 190-199
DIRECTION (DEGS) TOWARD WHICH STORMS ARE MOVING

Figure 5.

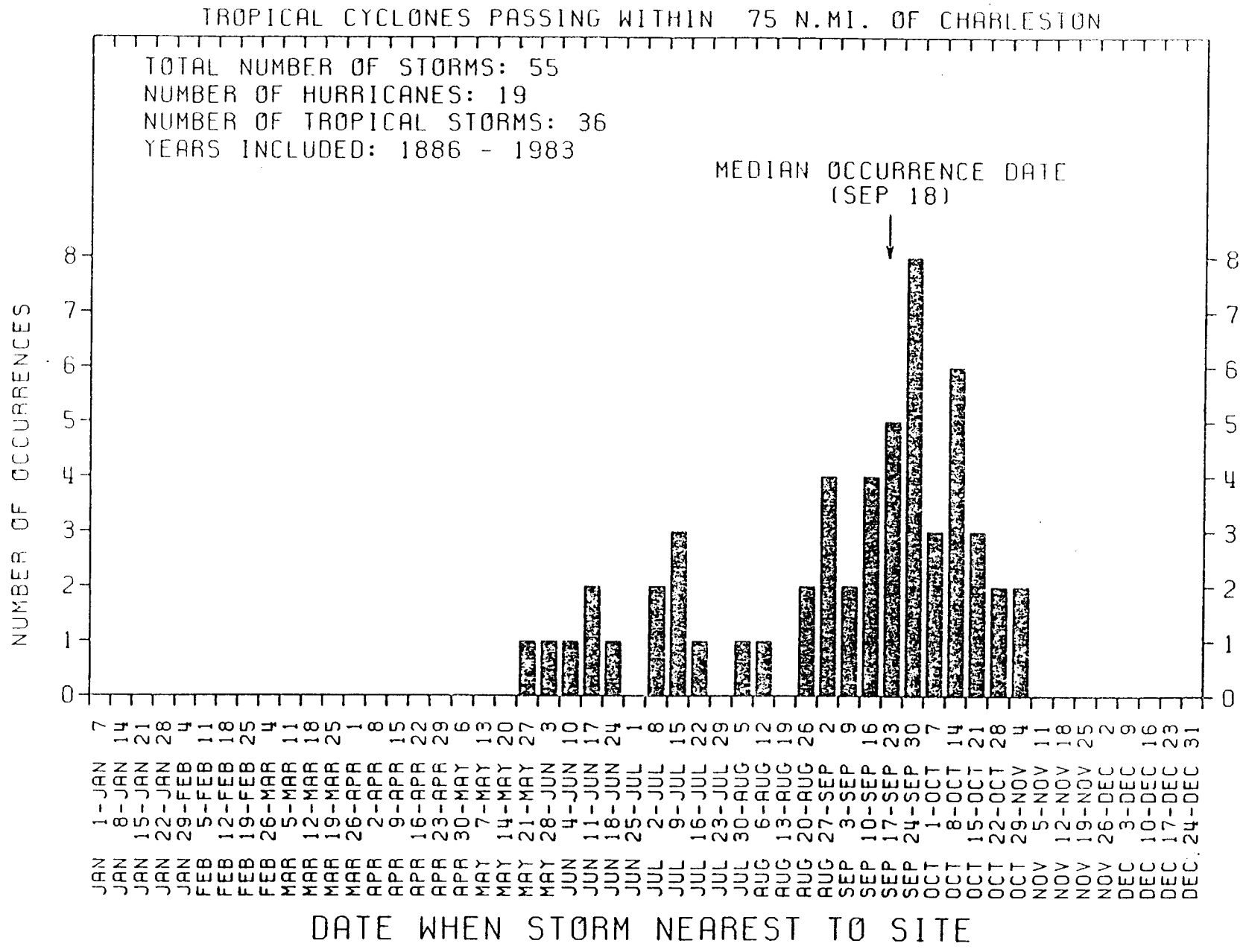

TROPICAL CYCLONES PASSING WITHIN 75 N.MI. OF CHARLESTON
TOTAL NUMBER OF STORMS: 55
NUMBER OF HURRICANES: 19
NUMBER OF TROPICAL STORMS: 36
YEARS INCLUDED: 1886 - 1983
MEDIAN OCCURRENCE DATE
(SEP 18)
NUMBER OF OCCURRENCES
0
1
2
3
4
5
6
7
8
DATE WHEN STORM NEAREST TO SITE

Figure 6.

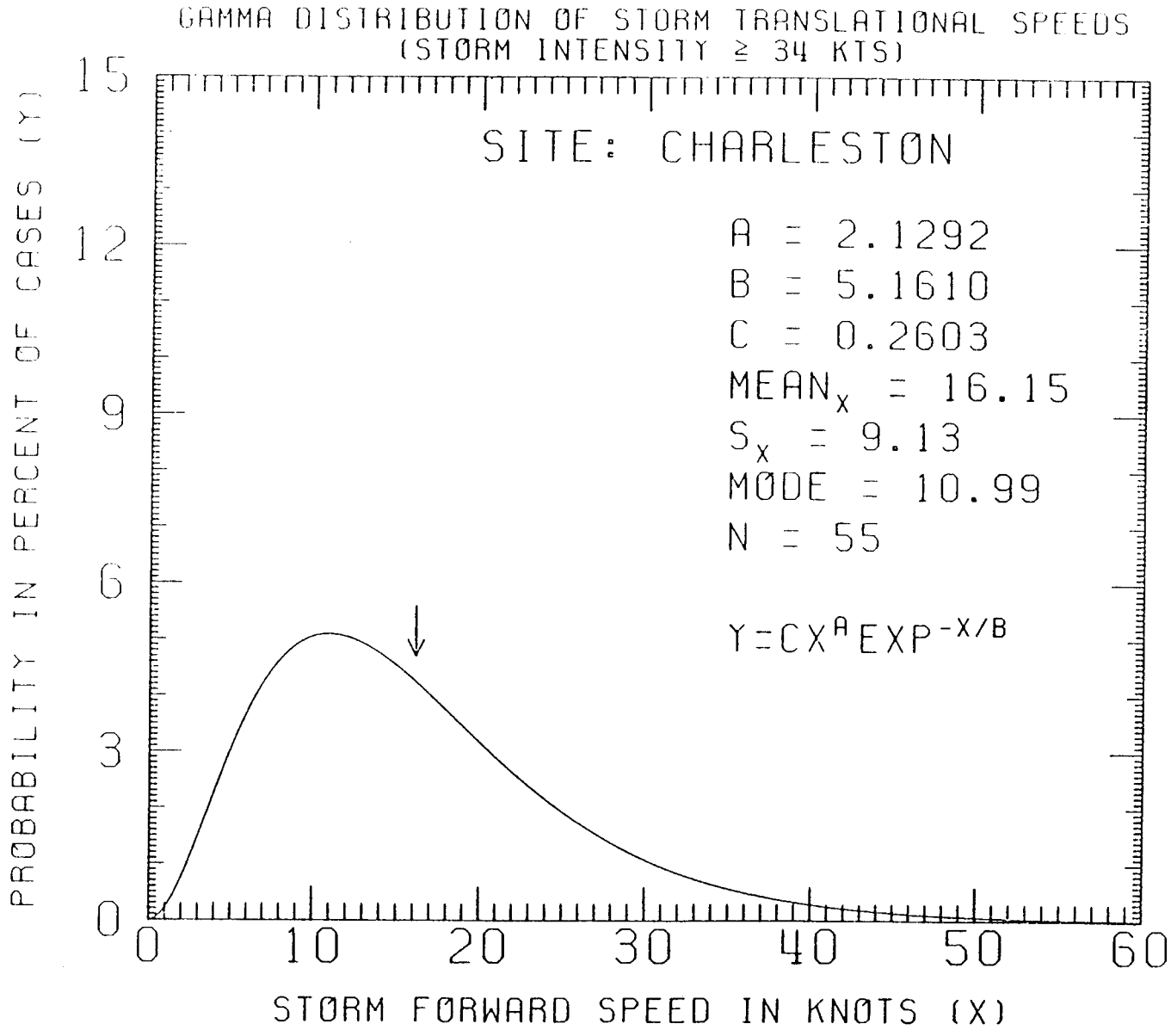

GAMMA DISTRIBUTION OF STORM TRANSLATIONAL SPEEDS
(STORM INTENSITY ≥ 34 KTS)
SITE: CHARLESTON
A = 2.1292
B = 5.1610
C = 0.2603
MEAN$_X$ = 16.15
S_X = 9.13
MODE = 10.99
N = 55
$Y=CX^A EXP^{-X/B}$
PROBABILITY IN PERCENT OF CASES (Y)
0
3
6
9
12
15
0
10
20
30
40
50
60
STORM FORWARD SPEED IN KNOTS (X)

Figure 7.

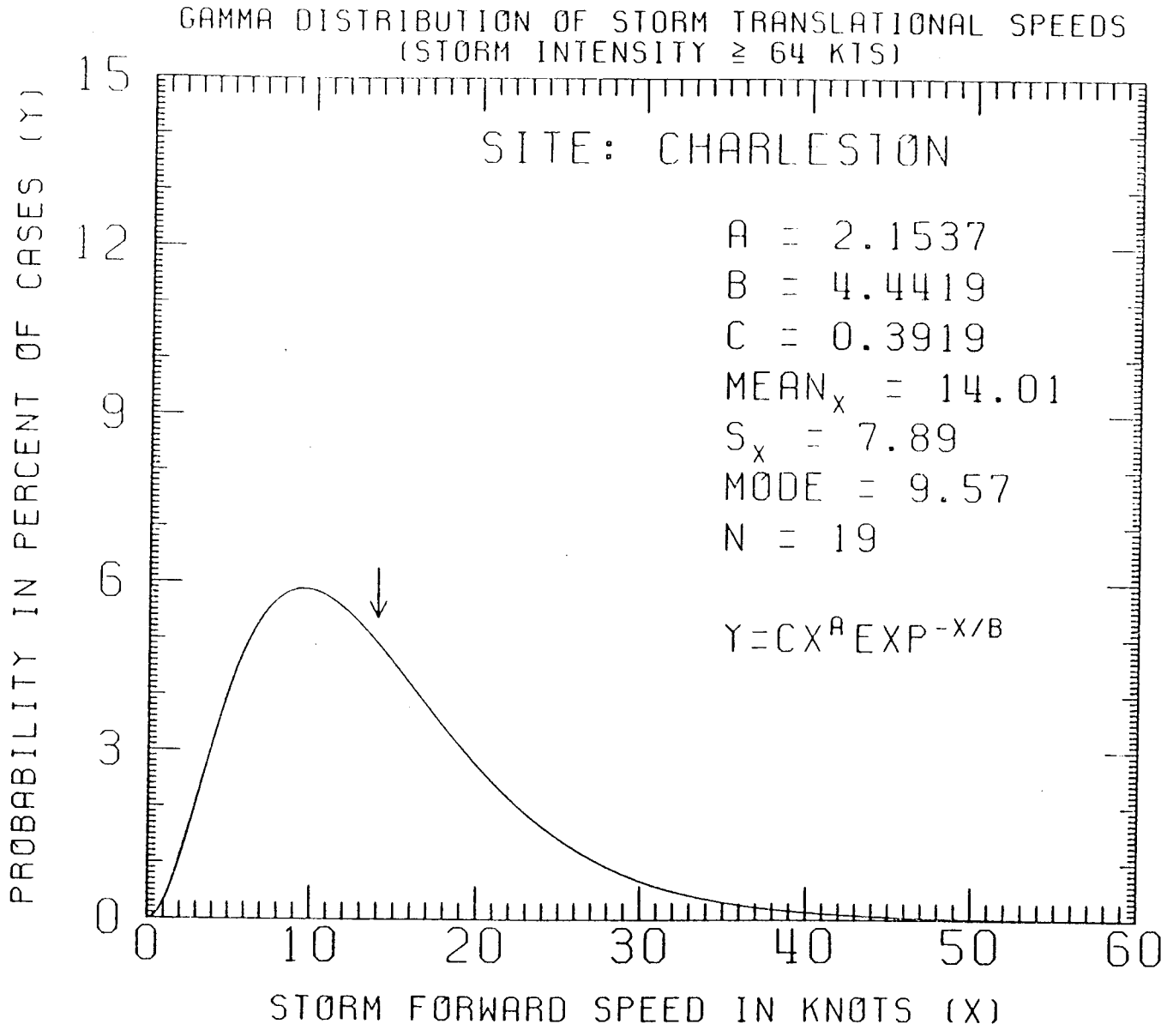

GAMMA DISTRIBUTION OF STORM TRANSLATIONAL SPEEDS
(STORM INTENSITY ≥ 64 KTS)
SITE: CHARLESTON
A = 2.1537
B = 4.4419
C = 0.3919
MEAN$_X$ = 14.01
S_X = 7.89
MODE = 9.57
N = 19
$Y=CX^A EXP^{-X/B}$
PROBABILITY IN PERCENT OF CASES (Y)
0
3
6
9
12
15
0
10
20
30
40
50
60
STORM FORWARD SPEED IN KNOTS (X)

Figure 8.

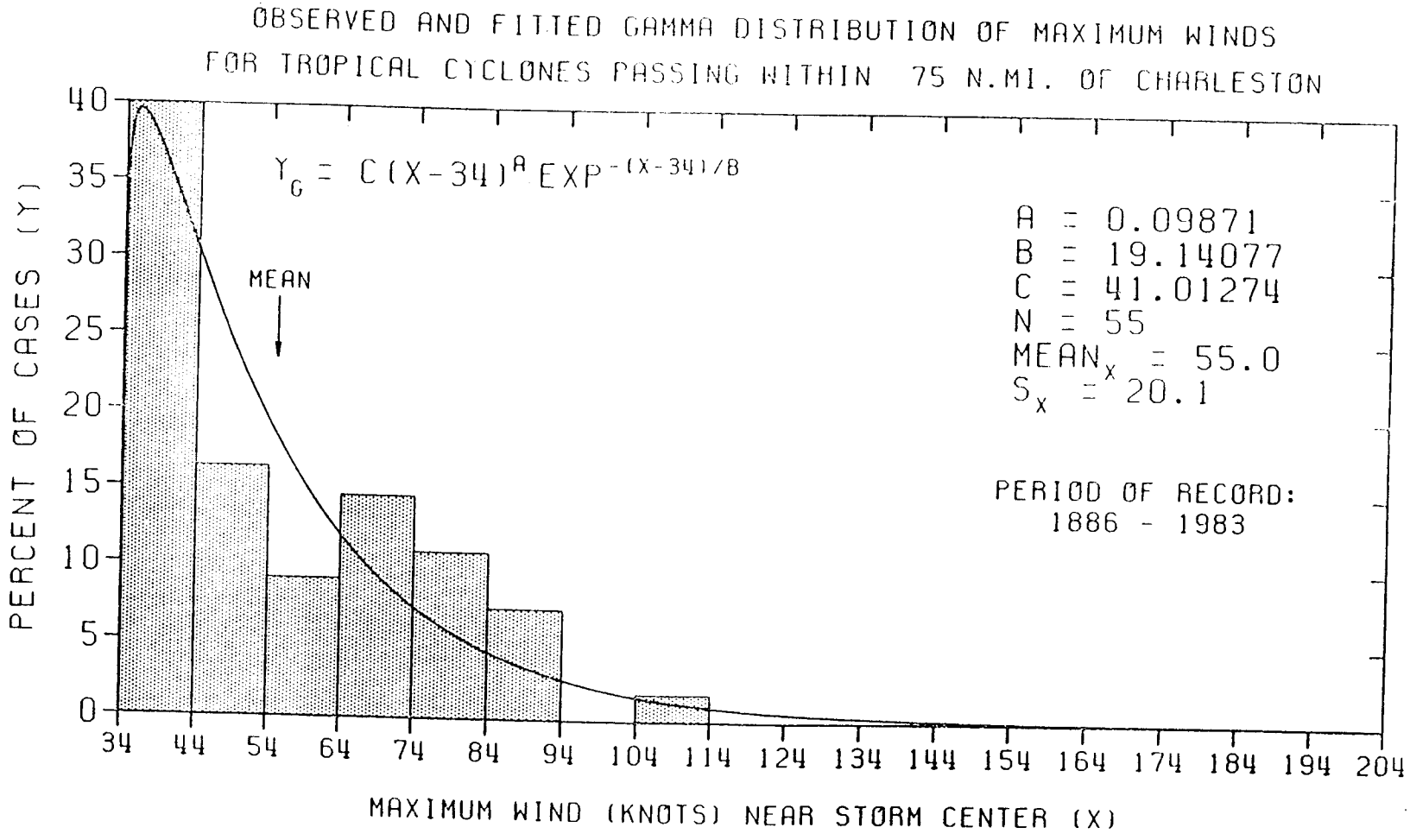

OBSERVED AND FITTED GAMMA DISTRIBUTION OF MAXIMUM WINDS
FOR TROPICAL CYCLONES PASSING WITHIN 75 N.MI. OF CHARLESTON
$Y_G = C(X-34)^A EXP^{-(X-34)/B}$
A = 0.09871
B = 19.14077
C = 41.01274
N = 55
$MEAN_X$ = 55.0
S_X = 20.1
PERIOD OF RECORD:
1886 - 1983
MEAN
PERCENT OF CASES (Y)
0
5
10
15
20
25
30
35
40
34
44
54
64
74
84
94
104
114
124
134
144
154
164
174
184
194
204
MAXIMUM WIND (KNOTS) NEAR STORM CENTER (X)

Figure 9.

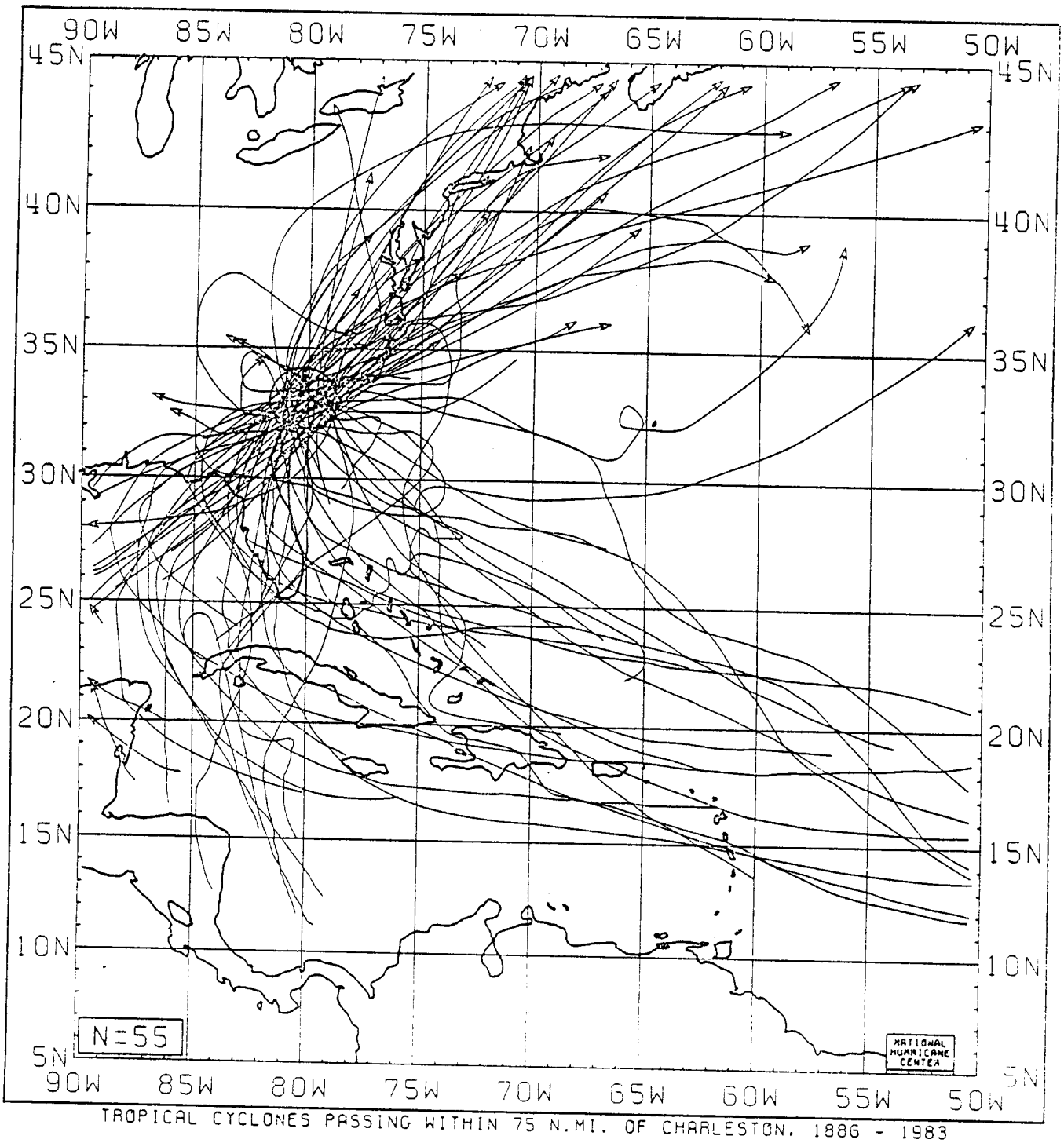
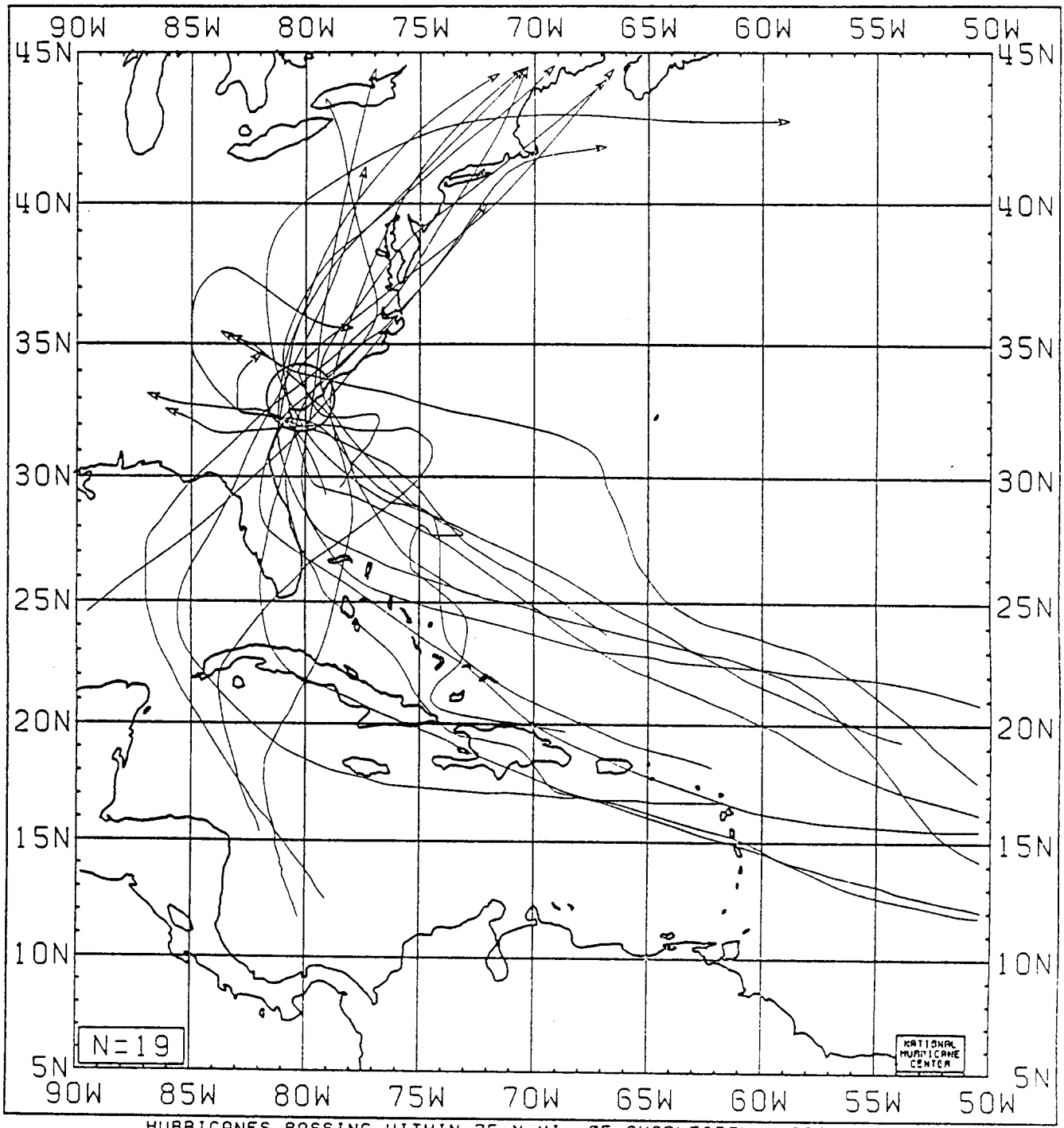

90W
85W
80W
75W
70W
65W
60W
55W
50W
45N
40N
35N
30N
25N
20N
15N
10N
5N
N=55
NATIONAL HURRICANE CENTER
TROPICAL CYCLONES PASSING WITHIN 75 N.MI. OF CHARLESTON, 1886 - 1983
(SITE LOCATION MOVED TO 33.0, 80.2)

Figure 10.



HURRICANES PASSING WITHIN 75 N.MI. OF CHARLESTON. 1886 - 1983

(SITE LOCATION MOVED TO 33.0. 80.2)

Figure 11.

Definition of "open coast"

The Charleston curve of Figure 12 applies to the entrance to the harbor on the outer beaches of Sullivans Island and Morris Island. The 100-yr return period tide level is calculated at 13 ft MSL. The flood insurance maps, which depict "base flood elevation" (100-yr) to the nearest 1 ft, show 1 ft less flood elevation at the Battery and at the NOS Customhouse tide gage site in the City of Charleston than at these open coast locations.

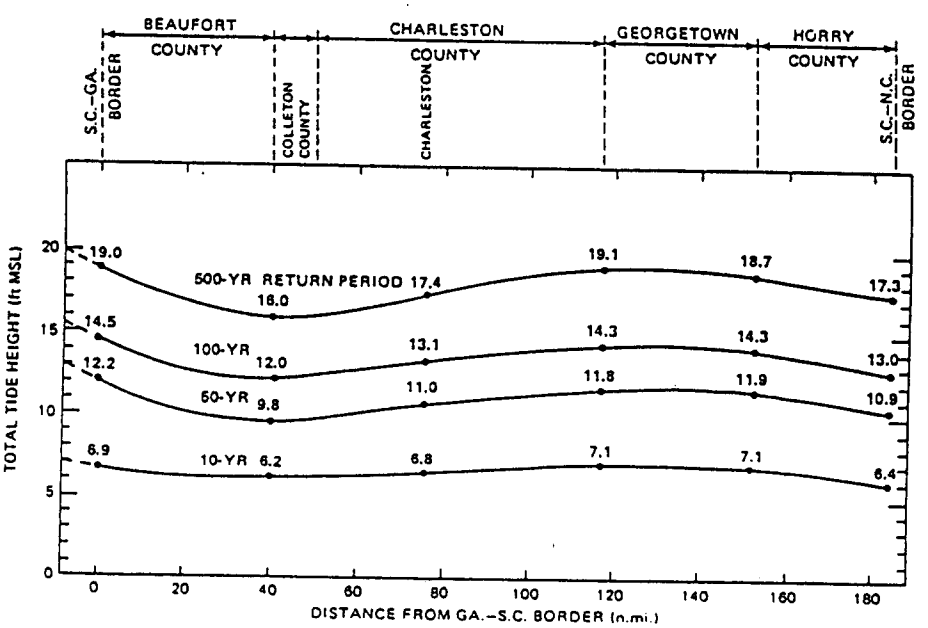


Figure 12. --Coastal tide frequencies, South Carolina.

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Myers, Vance A., 1975: "Storm Tide Frequencies on the S.C. Coast", NOAA Technical Report NWS-16.. National Weather Service, U.S. Department of Commerce, Silver Spring, Maryland, 79pp.

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