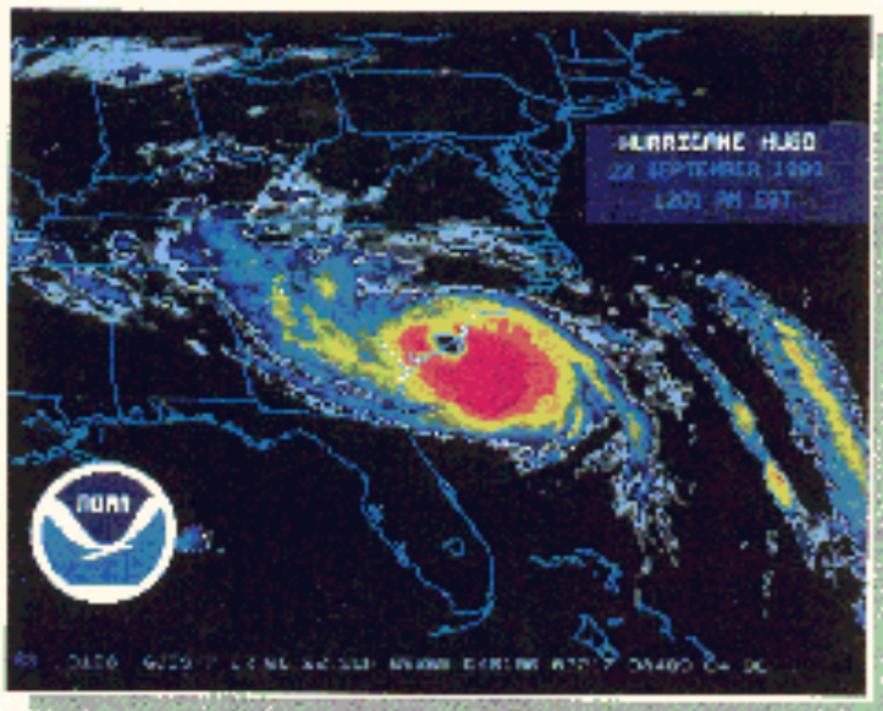


# HURRICANE HUGO ASSESSMENT

REVIEW OF HURRICANE EVACUATION STUDIES  
UTILIZATION AND INFORMATION DISSEMINATION



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US Army Corps  
of Engineers



Hurricane Hugo Assessment  
Review of Hurricane Evacuation Studies Utilization  
and Information Dissemination  
Prepared for  
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## CHAPTER 1 INTRODUCTION

At midnight Friday, September 22, 1989, the costliest and one of the strongest hurricanes of the century made landfall along the South Carolina coast. Hugo, a storm that began southeast of the Cape Verde Islands, left a path of destruction across the Leeward Islands, the Virgin Islands, and Puerto Rico before slamming into the U.S. mainland. An estimated one-half million people evacuated in coastal areas of Georgia, South Carolina, and North Carolina. According to the National Hurricane Center, Hugo had the highest recorded storm surge heights on the east coast this century. Damage estimates from some sources have been placed as high as seven billion dollars for the U.S. mainland. Of only about forty U. S. mainland deaths attributed to Hugo, very few were from drowning - a testament to successful evacuation carried out by local and state officials throughout the threatened areas.

Prior to Hurricane Hugo and even before the onset of the 1989 hurricane season, comprehensive hurricane evacuation studies had been completed for South Carolina and North Carolina and a study for Georgia neared completion. These studies were jointly funded by FEMA, the Corps of Engineers, state governments, NWS, and the South Carolina Coastal Council with local districts of the Corps serving as project managers for each study. With these studies in hand and a severe storm making landfall along the eastern seaboard a perfect opportunity was available to answer several key questions regarding these major FEMA/Corps planning efforts:

- Were local and state officials using the products produced by these major studies?
- Were the data in the studies related to storm hazards, behavioral characteristics of the evacuees, shelter information, evacuation times, and decision-making, accurate and reliable?
- Which study products were most useful and least useful - what improvements could be made to current methodologies and products?

To answer these questions, a study team comprised of William G. Massey representing FEMA and John K. Graham representing the Corps of Engineers visited with local and state officials throughout the threatened areas of Georgia, South Carolina, and North Carolina. Donald C. Lewis representing Post, Buckley, Schuh and Jernigan, Inc. was retained to accompany the study team and document all relevant findings. Approximately one hundred local and state officials were visited. County and city emergency management directors, law enforcement officers, Red Cross personnel, and state emergency preparedness division staff were primarily involved in meetings held in each area that responded to Hurricane Hugo. Two separate meetings were held in the major media markets of Savannah and Charleston to discuss study product usage with local media representatives.

Discussion with local emergency management officials focused on study products and their use relative to the evacuation decision process, evacuation/traffic control and clearance, sheltering, and public information. In meetings with state officials discussions centered on the role the state played in the evacuation process including the use (or non-use) of study products in communicating with local

officials. Media representatives in Savannah and Charleston were asked to focus on study related materials that they possessed and that were broadcast to the general public. They also addressed the types of materials and public information they could have used that had not been developed or delivered to them as of yet.

In addition to the meetings held with state and local officials, a residential sample survey was accomplished and analyzed by Hazards Management Group for selected communities in the directly affected South Carolina coastal area. Telephone interviews were conducted in Myrtle Beach, Charleston, and Beaufort County, to compare actual evacuation response in Hugo, to predicted evacuation response developed in the original comprehensive hurricane evacuation study. The behavioral analysis focused on the actual percent of the affected population that evacuated during Hugo, when the evacuees left their residence, what sort of refuge evacuees used, where the refuge was located and the number of vehicles used by evacuating households.

This report documents the findings of the study team and is organized by general category of hurricane evacuation study product. Those general categories that are addressed include:

- Hazards/Vulnerability Data
- Behavioral Characteristics of Evacuees
- Shelter Issues
- Transportation/Clearance Time Data
- Evacuation Decision-Making
- Public Information

Each chapter describes typical study components and products produced in a comprehensive hurricane evacuation study. The chapter then summarizes actual data related to Hugo and compares it with study produced data for a relevant storm scenario. Recommendations are then given for future study efforts relative to that study topic.

## CHAPTER 2

### HAZARDS/VULNERABILITY DATA

In FEMA/Corps comprehensive hurricane evacuation studies, the primary objective of the hazards analysis is to determine the probable worst-case effects from the various intensities of hurricanes that could strike an area. Specifically, a hazards analysis quantifies the expected hurricane-caused inundation and wind impacts that would require emergency evacuation of the population. The National Weather Services' SLOSH numerical storm surge prediction model was used as the basis of the hazards analysis for studies completed in North Carolina, South Carolina, and Georgia.

A vulnerability analysis performed for these studies takes the hazards analysis and identifies the population-at-risk from coastal flooding caused by the hurricane storm surge. Inundation maps are produced showing surge limits for various hurricane intensities with and without consideration of storm direction.

Hazards and vulnerability issues related to Hugo and discussed by the study team with local and state officials included the following:

- What technical data/mapping was used to choose the areas to evacuate?
- Did the technical data provide a good depiction of the hazard area?

Without question, the SLOSH model and inundation maps developed from the SLOSH model output were some of the most heavily utilized study products during Hugo. Although some local directors asked barrier islands and low lying areas to evacuate (rather than specific zones), most directors based their decision of who to evacuate primarily on the inundation maps. Evacuation zone maps which depict the inundation areas in a more generalized, "easier to describe" manner were used heavily in the Charleston and Beaufort County areas of South Carolina. Cable News Network (CNN) and the local newspaper in Charleston both showed the zone map to give viewers and readers an idea of the extent of evacuation that would be required just in the Charleston area. In the Beaufort County area, evacuation zones were used operationally by officers to warn specific areas of people of their need to evacuate.

In those areas that were directly affected by Hugo, officials had great confidence in the SLOSH model before the storm and even more importantly after the storm. In general, local and state officials felt that the hazards areas had been accurately depicted in the study data and products provided by FEMA and the Corps. The most exciting and important comparison of the SLOSH data and Hugo's effects occurs in the area where the eye of Hugo made landfall as well as those areas 30 to 40 miles north and south of landfall. [Figure 1](#) graphically portrays a profile of SLOSH predicted storm tide values at key locations north and south of eye landfall. Observed high water marks from field reports are also plotted on the figure providing an amazing comparison of how well the SLOSH model worked in predicting maximum surge levels in Hurricane Hugo. Much of the success in minimizing loss of life during Hugo can be attributed to local directors taking the SLOSH values seriously and evacuating those areas that the

SLOSH data and associated mapping said would need to be evacuated.

The most difficult issue regarding Hugo's hazards characteristics revolved around the storm's reported change from a Category 2 to a Category 4 hurricane in such a short period of time immediately before landfall. Fortunately many local directors took action for a Category 3 hurricane and had completed evacuation of the coastal barrier islands several hours before landfall. Miles Lawrence of the National Hurricane Center in his October 1989 preliminary forecast and warning critique of Hugo, noted that the highest sustained winds increased from 105 to 135 mph from 6:00 PM on the 20th of September to 6:00 PM on the 21st of September. During this same period, the wind forecast contained in all of the public advisories was "little significant change in strength is likely". This coupled with a slight right bias for two track forecasts just before landfall on September 21st accentuate the importance of all emergency officials recognizing the limitations in tropical cyclone intensity forecasting. Some officials indicated it may be prudent in some situations to take action for one category above that of the threatening hurricane. This proved wise on the part of local officials in Hugo.

## **RECOMMENDATIONS**

Some local officials needed the inundation mapping at a larger scale. This problem could be easily rectified in the future if SLOSH surge mapping is produced on CADD (Computer Aided Drafting and Design) systems. Products can then be output at whatever scale the user desires irregardless of the scale limitations of a printed atlas. The development of a SLOSH model for the Myrtle Beach area would greatly help in defining expected storm tide heights for the upper South Carolina coast and the southeast North Carolina coast in a Hugo event.

## CHAPTER 3

### BEHAVIORAL ANALYSIS-PUBLIC RESPONSE IN HUGO

Approximately three months following Hugo's landfall in South Carolina, telephone interviews were conducted with residents in Myrtle Beach, the Charleston area, and Beaufort. Survey results were compared with responses in previous behavioral studies in the area regarding hypothetical hurricane threats. Behavioral responses in Hurricane Diana were also compared with the post-Hugo survey results. In Myrtle Beach and Beaufort a total of 150 post-Hugo interviews were completed, and in Charleston, on the peninsula and west of the Ashley, 200 households were interviewed. In addition, a combined 100 interviews were completed in Mt. Pleasant, Sullivan's Island, and Isle of Palms. The great majority of respondents in all areas were in category 1, 2, or 3 surge zones. No post-Hugo surveys were outside category 4 zones.

#### **Evacuation Rates**

In none of the primary sample locations was evacuation complete. In Beaufort 72% left, in Charleston 62%, Mt. Pleasant/Sullivan's 81%, and Myrtle Beach, 79%. There were, however, variations within these areas. From Sullivan's Island and Isle of Palms 96% left, and there were probably comparable successes in other high-risk barrier islands. It would be inaccurate to say that everyone in the sample should have evacuated or that officials indicated that they should. A small minority in fact lived outside areas advised or ordered to leave. Taking just the category 1, 2, and 3 surge areas, it is unlikely that more than 75% to 80% evacuated from most areas other than barrier islands and beachfronts.

Most but not all respondents believed they had been told by officials to leave (71% in Beaufort, 64% in Charleston, 72% in Mt. Pleasant/Sullivan's, and 73% in Myrtle Beach). Very few respondents interpreted the evacuation notices as being mandatory. Of the total sample, 30% in Beaufort and Myrtle Beach and 15% to 20% in Charleston said they heard an order to evacuate. Overall 89% of those who said they heard an order evacuated, compared to 70% who said they heard a recommendation. Surprisingly, of those saying they heard neither, 61% evacuated.

This is relatively high for people not hearing official evacuation notices. Many did, however, hear from other sources that they should leave and were aware that neighbors were leaving.

Those saying they lived within a block of most types of water bodies were most likely to evacuate (84%). Of the respondents saying they lived more than a block but less than a mile from water, 73% left, compared to 65% who said they lived more than a mile from water. The exception to this trend were respondents living within a block of rivers, of whom 67% left. Respondents were asked whether they thought their homes would have flooded if Hugo had struck their location directly. If they believed their homes would have flooded, 83% left, compared to 65% of those who felt their homes would not have flooded.

## Evacuation Timing

[Figure 2](#) depicts the cumulative evacuation curves for five of the survey areas (with Mt. Pleasant and Sullivan's/Isle of Palms shown separately). When a watch was issued Wednesday at 6 PM, fewer than 10% of the eventual evacuees from most areas had left. The percentage was slightly higher in Beaufort (17%) where officials indicated they had suggested to residents earlier in the day that a visit to friends or relatives in safer locations might be prudent. By midnight, following the earlier voluntary evacuation notice in the Charleston area and statements by the Governor, additional evacuees had left, between 10% and 20% of the eventual totals.

When the warning was issued at 6 AM Thursday morning, and the governor ordered evacuation from the most vulnerable coastal areas, 50% of the evacuees from Sullivan's Island and the Isle of Palms said they had already left. In Charleston 30% of the evacuees said they had gone when the warning was issued, followed by 25% from Mt. Pleasant, 22% from Beaufort, and 10% from Myrtle Beach, farther to the north and away from the storm. These figures indicate that a significant number of people evacuated during the nighttime.

Throughout Thursday morning most evacuees departed, and by noon between 75% and 90% had left from all the survey areas except Myrtle Beach, from which only 35% had gone. By 4 PM almost everyone who left had already done so except in Myrtle Beach where departures continued until 7 PM. Almost two-thirds of the Myrtle Beach evacuees said they left between noon and 7 PM.

## Type of Refuge

Very few evacuees went to public shelters (9% in Beaufort, 7% in Charleston, 2% in Mt. Pleasant/Sullivan's, and 13% in Myrtle Beach). Across the four sites more people went to motels than shelters, ranging from 15% in Myrtle Beach to 26% in Mt. Pleasant/Sullivan's. More than half the evacuees from all areas (56% to 66%) went to the homes of friends or relatives.

Shelter use is usually associated with income, and such was the case in Hugo. In households reporting annual incomes below \$10,000, 25% used public shelters. In no other income group did more than 8% go to shelters. Non-whites -- primarily blacks -- were much more likely to use public shelters than whites (31% vs. 5%). There was a difference even within most income groups 39% vs. 9% for incomes less than \$10,000/year, 27% vs. 3% for incomes between \$10,000 and \$25,000/year, and 22% vs. 3% for incomes from \$25,000 to \$40,000/year.

Respondents living in mobile homes were slightly more likely to use public shelters than other residents (14% vs. 8%). Evacuees living within a mile of water bodies other than rivers were less likely than other groups to use public shelters. Of the evacuees staying in their own county 25% went to public shelters, compared to only 2% of those going out-of-county. However, breakdowns by county for in-county evacuees going to public shelters are unreliable due to the small sample sizes involved.

## **Evacuation Destinations**

In all primary sample locations between 64% and 78% of the evacuees went to out-of-county destinations. Roughly a fifth of all evacuees reached their destinations in less than 30 minutes, indicating very short trips. Between 28% (Mt. Pleasant/Sullivan's) and 49% (Myrtle Beach) took an hour or less. Beaufort (16%), Charleston (20%), and Mt. Pleasant/Sullivan's (29%) all had substantially more evacuees requiring over five hours to reach their destinations than Myrtle Beach (3%).

## **Number of Vehicles**

The number of evacuating vehicles per household ranged from 1.1 in Charleston to 1.4 in Beaufort and Mt. Pleasant/Sullivan's. This represented 59% of, all available vehicles in Charleston to 71% in Beaufort.

## **Comparison to Behavioral Assumptions Derived Before Hugo**

### **Evacuation Rates**

In hypothetical response surveys conducted before Hugo very few people said they would refuse to evacuate even if ordered (1% to 4%). The behavioral analysis indicated that without disseminating evacuation orders door-to-door 35% would not leave in Beaufort, 35% in Charleston west of the Ashley River, 20% in the Charleston peninsula, 20% in moderate-risk areas in Myrtle Beach, and less than 10% in high-risk islands and beachfronts. Evacuation rates in Hugo were extremely close to those indicated in the behavioral analysis. Exact comparisons are not possible without further disaggregating the Charleston sample east and west of the Ashley and without more precise determination of respondents' evacuation zones.

### **Evacuation Timing**

In responses to hypothetical hurricane scenarios, 40% to 50% of those interviewed before Hugo said they would evacuate when a watch was posted, before officials indicated they should leave. The behavioral analyses indicated that a variety of response curves were plausible, depending upon various warning scenarios, but suggested that not more than 10% to 15% of the evacuees were likely to leave before evacuation notices were issued by officials. In Hugo, officials in different locations said various things at certain times, but overall the behavioral analysis figures were very close to the mark. If anything there was slightly more early response in Hugo than behavioral analysis guidelines suggested.

### **Type of Refuge**

In hypothetical response surveys 37% in Beaufort, 40% in Charleston west of the Ashley, 49% on the Charleston peninsula, and 35% in Myrtle Beach said they would go to public shelters if they evacuated. The behavioral analyses cautioned that hypothetical shelter use is normally twice actual. Shelter use

assumptions in the behavioral analysis labeled "cautious" (i.e., attempting not to underestimate demand in normal circumstances) were 15% for Beaufort, 15% for Charleston west of the Ashley, 30% for the Charleston peninsula, 20% for moderate-risk areas of Myrtle Beach, and 5% to 10% for high-risk barrier island and beaches. (The exception to the last case was St. Helena island, a socially close-knit, predominantly black community, where shelter use was projected at 40%, compared to 62% who said they would use shelters). Shelter use in Hugo was generally lower than the numbers cited in the behavioral analyses, particularly in moderate-risk to low-risk predominantly white areas. The behavioral analyses did, however, point out that in early evacuations for severe storms more evacuees would leave the local area, causing shelter use to be lower, and that if officials took actions to discourage shelter use, it would be lower. Both conditions appeared to pertain in most locations during Hugo, especially in Charleston and Beaufort where shelter use was lowest and deviated most from the norms cited in the behavioral analysis. In Myrtle Beach 18% of the post-Hugo survey respondents used public shelters, almost exactly the figure indicated by the study behavioral analysis.

South Carolina officials have estimated that 256,000 people evacuated in the state during the Hugo threat, and Red Cross records indicated that 94,000 were registered in public shelters, almost half in inland shelters. Those figures seem to imply that 37% of South Carolina's evacuees went to public shelters, which is almost certainly not the case. The figures also appear to conflict with the survey data indications that only 2% of the evacuees who went out-of-county went to public shelters. It is possible that there were substantially more than 256,000 evacuees, including many from low-risk areas not included in the statistics. It is also possible that those in shelters included inland county mobile home residents and people seeking refuge after the storm.

## **Destinations**

The behavioral analyses indicated that 40% from Beaufort, 45% from Charleston west of Ashley, 35% from the Charleston peninsula, and 60% and 70% in Myrtle Beach (the latter for a severe storm with a timely evacuation) would leave the local area. The behavioral assumptions were very close in Myrtle Beach, but low for the other areas. Here too the analyses indicated that early evacuations would see more people going inland, but no numerical guidelines were given except for Myrtle Beach. The effect of actions by public officials, which was largely responsible for the large out-of-town evacuation in Hugo, was not addressed explicitly in the behavioral analyses as it was in the discussion of shelter demands.

## **Vehicle Use**

Hypothetical response data indicated that about 65% of all available vehicles would be used in evacuating households, and the behavioral analyses recommended using that figure for Charleston and Beaufort and using 70% and 75% for Myrtle Beach. Actual use was within five percentage points.

## **Response Outside South Carolina**

No behavioral surveys were conducted for Hugo in North Carolina or Georgia, therefore no firm conclusions are possible for public response in those states. The evacuation in some counties of North Carolina appears to have been partially implemented, making comparison between actual response and that projected in behavioral analyses for that area difficult.

### **Summary and Recommendations**

Public response to the Hugo threat was extremely good and demonstrated once again the impact public officials can have on evacuation behavior. Over 90% of the respondents felt that officials had handled the evacuation well. Relatively few evacuees left prior to explicit recommendations or orders from public officials, but in some locations a substantial portion of the eventual evacuees had already left when the warning was posted Thursday morning. Public shelter use and local refuge demand were relieved considerably by officials' urging evacuees to seek other alternatives. Behavioral analyses upon which evacuation studies were based for South Carolina were quite accurate for most locations and most behaviors but would have been more useful had they provided numerical guidelines for planning for a greater variety of scenarios.

Behavioral analyses should provide a numerical adjustment for special circumstances affecting shelter use rather than simply a directional adjustment, and more situational guidelines rather than place-specific estimates should be provided in the analyses. Those practices are in fact the norm in most contemporary behavioral analyses, the process having evolved since the South Carolina studies were completed. Behavioral analyses should also project demand for in-county and out-of-county public shelter separately. The bulk of public shelter demand was assumed in the behavioral analyses to be in-county, but a numerical distinction was not made in the report. The issue of non-white demand for shelters being greater than white demand across income- groups is a factor that needs further consideration.

## CHAPTER 4 SHELTER ISSUES

The primary objectives of shelter analyses prepared for FEMA/Corps comprehensive hurricane evacuation studies are to list public shelter locations, assess their vulnerability relative to storm surge flooding, and to estimate the numbers of people who would seek local public shelter for a particular hurricane intensity or threat. Shelter location/capacity data are obtained from Red Cross, schoolboard or other local agencies. Comparisons are then made with SLOSH data to assess flooding potential. Public shelter capacity is usually compared to public shelter demand figures generated in the transportation analysis to determine potential deficits or surpluses in sheltering. The behavioral analysis is important to this process as assumptions for the transportation analysis (regarding the percent of evacuees going to public shelter) come from the behavioral analysis results or behavioral parameters recommended by the local directors.

Public shelter issues related to Hugo were discussed with local and state officials by the study team. Discussions focused on the following topics:

When were shelters opened and when did evacuees arrive/stop arriving?

How many shelters were opened and how many sheltered?

Were any flooding, wind, or loss of power problems encountered with shelters during the storm?

Tables 1, 2, and 3 summarize the responses to each of these topics gathered from discussions with shelter officials in each area. In Georgia, public shelters within the coastal counties were opened Thursday morning at 0800 and remained open for approximately 24 hours at which time it was clear that Georgia would be spared the brunt of Hurricane Hugo. Shelters in inland Georgia counties were opened throughout the day (Thursday September 21st) as evacuees began to arrive from the coastal areas. No flooding, wind, or loss of power problems were cited for public shelters in Georgia although one shelter in Savannah was closed because of a concern of too much glass exposure for evacuees. Evacuees were moved to another shelter with adequate capacity and less glass exposure. As shelters opened in the coastal areas of Georgia, some evacuees were ready to go in. Evacuees arrived throughout the day until late afternoon/early evening.

### Table 1 Hurricane Hugo Public Shelter Data - Georgia

<u>Location</u>	<u>Number of Shelters Opened</u>	<u>Number of People Sheltered in County</u>	<u>Number of Shelters/ Expected Public Shelter Evacuees- Tech. Data Report*</u>	<u>Time Shelter Opened/Shelter Duration</u>	<u>Flooding, Wind, or Loss of Power Problems</u>
<b>GEORGIA</b>					
Camden Co.	1	150	6 shelters/2,355 people	Wednesday night 20th/24 hours	none
Glynn Co./ Brunswick	4	308	8 shelters/1,950 people	8 AM Thursday 21st/24 hours	none
McIntosh Co.	-	-	3 shelters/1,200 people	-	-
Liberty Co.	4	880	9 shelters/7,200 people	8 AM Thursday 21st/22 hours	none
Bryan Co.	1	100	8 shelters/1,990 people	8 AM Thursday 21st/24 hours	none
Chatham Co./ Savannah	6	1,850	11 shelters/10,900 people	8 AM Thursday 21st/24 hours	none, decided to close one shelter because of too much glass
inland counties	-	2,700	-	-	none

\*In Georgia, coastal counties took action for a Category 2 hurricane - therefore, data for a Category 2 scenario (low tourist occupancy) from the Technical Data Report is presented here for comparison to Hugo data.

**Table 2**  
**Hurricane Hugo**  
**Public Shelter Data - South Carolina**

<u>Location</u>	<u>Number of Shelters Opened</u>	<u>Number of People Sheltered in County</u>	<u>Number of Shelters/ Expected Public Shelter Evacuees- Tech. Data Report*</u>	<u>Time Shelter Opened/Shelter Duration</u>	<u>Flooding, Wind, or Loss of Power Problems</u>
<b>SOUTH CAROLINA</b>					
Jasper Co.	3	600	9 shelters/1,600 people	9 AM Thursday 21st/26 hours	none
Beaufort Co./ Hilton Head	7	5,500	13 shelters/11,700 people	6 AM Thursday 21st/30 hours	loss of power at shelters
Colleton Co.	3	1,000	11 shelters/5,200 people	6 AM Thursday 21st/30 hours	-

Charleston Co.	52 plus auditorium in Tri-County area (including Berkeley and Dorchester)	35,000 in Tri-County area	16 - Berkeley/ 8,590 people 45 - Charleston/ 44,720 people 18 - Dorchester/ 4,300 people	11 PM Wednesday 20th/12 shelters open 1 week, 1 shelter 2 1/2 weeks, others - 1/2 week	Lincoln High in McClellanville flooded, several shelters lost roof, loss of power in all shelters
Georgetown Co.	8	2,959	17 shelters/4,000 people	9 AM Thursday 21st/ most shelters 30 hrs., 1 shelter 1 month	3 shelters experienced wind damage, other shelters lost power except for a high school which had emergency power
Horry Co./ Myrtle Beach	19	9,000	38 shelters/40,000 people	4 PM Thursday 21st/24 hours	all shelters lost power, however 9 shelters have emergency power
inland counties	-	44,000	-	-	-

\*In South Carolina, the level of evacuation carried out in Hugo was directly related to a Category 3 low tourist occupancy situation as presented in the Technical Data Report. the exception to this was in Jasper and Horry Counties where evacuation level resembled the Category 2 low tourist occupancy scenario.

**Table 3**  
**Hurricane Hugo**  
**Public Shelter Data - North Carolina**

<u>Location</u>	<u>Number of Shelters Opened</u>	<u>Number of People Sheltered in County</u>	<u>Number of Shelters/ Expected Public Shelter Evacuees- Tech. Data Report*</u>	<u>Time Shelter Opened/Shelter Duration</u>	<u>Flooding, Wind, or Loss of Power Problems</u>
<b>NORTH CAROLINA</b>					
Brunswick Co.	7	2,485	10 shelters/3,250 people	1 PM Thursday 21st/24 hours	none, loss of power only in Southport
New Hanover Co./Wilmington	5	1,100	5 shelters/2,940 people	4 PM Thursday 21st/17 hours	none

Pender Co.	-	-	13 shelters/2,290 people	-	-
Onslow Co.	6 plus 8 military shelters	987 plus 408 in military shelters	18 shelters/9,360 people	6 PM Thursday 21st/12 hours	none
Carteret Co.	4	3,000	7 shelters/4,080 people	4 PM Thursday 21st/17 hours	none
Dare Co.	none	-	-	-	-

\*In North Carolina, the level of evacuation carried out in Hugo was a scenario A type situation as presented in the Technical Data Report. This corresponds to a Category 1-3 Hurricane, low tourist occupancy.

In South Carolina, public shelters were generally opened early Thursday morning the 21st although officials in Charleston opened some shelters at midnight Wednesday the 20th due to their need to accommodate longer evacuation times. Shelters generally remained open 24 hours except in the heaviest hit areas of Charleston and Georgetown Counties. In Charleston County most shelters were open 1/2 week with 12 shelters open a week. To accommodate those residents devastated from the McClellanville area a shelter in Georgetown County was open for a month. Evacuees generally arrived as soon as shelters opened and continued until early Thursday evening. Inland shelters in South Carolina handled thousands of coastal residents as well as their own mobile home residents - these shelters opened throughout the day Thursday the 21st. Most shelters in coastal South Carolina experienced loss of power. In addition, several shelters in Charleston and Georgetown Counties suffered wind damage including loss of roofs. Lincoln High School in McClellanville experienced severe flooding. Officials reviewing this unfortunate situation determined that the elevation reported in the study produced Technical Data Report was based on an elevation shown on school board drawings and was roughly two times the actual land elevation.

Public shelters in coastal North Carolina were opened Thursday afternoon and remained open for approximately 12 to 17 hours. Evacuees arrived immediately upon shelters opening and most left by early Friday morning as it was obvious that the North Carolina coast would be missed by the direct fury of Hugo. No problems were encountered with public shelters except for the Southport area of Brunswick County, North Carolina where loss of power occurred.

As can be seen in Tables 1, 2, and 3 the number of public shelter evacuees in coastal county shelters during Hugo was significantly less than what was anticipated through statistics generated in study products. Local officials had a fairly good and reliable estimate of the number of people in public shelters. However, estimates of the total number of people evacuating dwelling units within each county are rough at best. Therefore it is hard to get an accurate handle on the exact percent of total evacuees that

went to local public shelters. State officials estimate that approximately 265,000 people evacuated dwelling units in coastal South Carolina. The Red Cross statistics imply that 50,000 of these were in public shelters in the coastal counties and another 44,000 evacuees went to public shelters in inland counties. In Georgia, of approximately 175,000 people evacuating only 6,000 went to public shelters throughout the state (see notes below). In North Carolina it is difficult to make comparisons between Hugo figures and study report figures due to the limited evacuations that were carried out (relative to scenarios in the Technical Data Report). The exception to this is Brunswick County where actual shelter demand was about 75% of study generated shelter demand.

There are several important reasons why anticipated in-county shelter demand was much lower than actual shelter demand:

- 1) In many cases, local officials discouraged evacuees from going to local shelter by pointing out the discomforts of such or by encouraging people to go to the home of a friend/or relative or an inland - public shelter.
- 2) Many people went to or sought public shelter in inland counties as opposed to local coastal public shelters.
- 3) Many churches and union halls served people who would be expected to be in public shelters.
- 4) Due to the excellent publicity by the media, early evacuation action of local officials, and general fear of the storm, evacuees were able and certainly willing to leave the threatened counties and go inland.
- 5) Compared to the number of shelter locations identified in each county (in the Technical Data Reports) a limited number of shelters were opened.
- 6) In Georgia coastal evacuees were unable to find out the location and availability of inland shelters as evidenced by evacuees at tourist information centers along 1-16.

## **RECOMMENDATIONS**

Based on the Hugo Experience, it is recommended that future Corps/FEMA hurricane studies incorporate the following:

- 1) Monies must be budgeted for the shelter analysis to include surveys of all public shelter first floor elevations and notes of general architectural features regarding wind vulnerability. Secondary sources must not be relied upon for elevation and flooding considerations.
- 2) Local officials should be encouraged to work with inland county or host county shelter officials regarding expected shelter demand and resource needs.

- 3) Public shelter destination percentages should be varied or additional scenarios considered in the transportation analysis reflecting a "Hugo event" where most public shelter evacuees go inland to a host county. Behavioral analyses and recommendations should also anticipate this type of response.
- 4) Study managers should confirm with shelter officials whether an identified shelters will be open for a particular scenario.

## CHAPTER 5 TRANSPORTATION/CLEARANCE TIME DATA

In FEMA/Corps comprehensive hurricane evacuation studies, the primary objective of the transportation analysis is to determine the clearance times needed to conduct a safe and timely evacuation for a range of hurricane threats. Information from the vulnerability, shelter, and behavioral analyses are directly input as well as various sources of permanent and seasonal population data. For the North Carolina, South Carolina, and Georgia studies, clearance times were developed by county for two or three storm intensity groups (eg. Category 1-2, Category 3-5), several seasonal occupancy assumptions, and three to four rates of mobilization on the part of the evacuating population. The number of scenarios for a particular county was obviously dependent upon the flooding and population characteristics of that locality.

Transportation and clearance time issues related to Hugo and discussed by the study team with local and state officials included the following:

Was the evacuation roadway network accurate - did evacuees use projected routes?

Were any traffic control actions taken to speed up flow?

When was the evacuation essentially complete - how long did the evacuation take?

Were any major problems encountered in the evacuation?

Tables 4, 5, and 6 summarize the responses to each of these issues gathered from discussions with local emergency and law enforcement officials in each area. In Georgia, clearance times calculated for FEMA/Corps studies compared well with the actual times experienced in Hurricane Hugo. For those counties carrying out major evacuations, study produced times were within an hour of actual times. In Liberty and Bryan Counties, it was difficult to determine actual clearance times due to lack of information available - potential flooded areas of these two counties have relatively low population levels and therefore can evacuate in short periods of time depending on the mobilization rate of evacuees. Limited special traffic control measures were taken in coastal Georgia. No major traffic problems were reported except along 1-16 where congestion was significant at 1-95 and as far west as Macon, Georgia. No information was provided by McIntosh County for evacuation related to Hugo.

### **Table 4 Hurricane Hugo Transportation/Clearance Data - Georgia**

<u>Location</u>	<u>Evacuation Roadway Network Accurate?</u>	<u>Special Traffic Control Actions</u>	<u>Clearance Time Experienced in Hugo</u>	<u>Study Calculated Clearance Time*</u>	<u>Problems Encountered</u>
<b>GEORGIA</b>					
Camden Co.	Yes	None	7 hours	6 hours	none
Glynn Co./ Brunswick	Yes	Stopped incoming traffic Jekyll Island	8 hours	8 3/4 hours	none
McIntosh Co.	-	-	-	6 hours	-
Liberty Co.	Yes	None	Not discernable	6 1/4 hours	none, traffic like a normal day
Bryan Co.	Yes	None	Not discernable	6 1/2 hours	none, traffic like a normal day
Chatham Co./ Savannah	Yes, Bay Street blocked by a fire	Traffic control points manned in some locations	10 hours	9 hours	Not all critical intersections were manned by police; congestion on I-16

\*In Georgia, coastal counties took action for a Category 2 hurricane - therefore, data for a Category 2 scenario (low tourist occupancy) from the Technical Data Report is presented here for comparison to Hugo data.

**Table 5**  
**Hurricane Hugo**  
**Transportation/Clearance Data - South Carolina**

<u>Location</u>	<u>Evacuation Roadway Network Accurate?</u>	<u>Special Traffic Control Actions</u>	<u>Clearance Time Experienced in Hugo</u>	<u>Study Calculated Clearance Time*</u>	<u>Problems Encountered</u>
<b>SOUTH CAROLINA</b>					

Jasper Co.	Evacuees came directly into Ridgeland on U. S. 278 due to new access ramps with I-95	Law enforcement stationed at key locations	5 hours	8 hours	congestion at Ridgeland
Beaufort Co./ Hilton Head	Yes	law enforcement stationed at traffic control points, highway patrol back-up	9 hours	9 1/4 hours	trouble getting generators into county
Colleton Co.	Yes	law enforcement on Hwy. 174 of Edisto area	2 hours for Edisto Beach, not discernable for remainder of county, campers evacuated Wed.	6 hours for locals/11 3/4 for S.R. 61 traffic out of Charleston	congestion on I-95
Charleston Co.	Yes, some improvements to Mark Clark Expressway since original study	locked down bridges as appropriate with Coast Guard and highway dept.; some critical roadway points manned; considered reverse laning of I-26 but did not do it	15 hours (2 AM - 5 PM Thursday 21st)	16 3/4 hours	I-26 congestion; I-26/I-95 interchange; many traffic control points not manned alt. routes to I-26 not used enough
Georgetown Co.	Yes	Critical intersections manned; state highway patrol back-up	6 1/2 hours	6 1/4 hours	None
Horry Co./ Myrtle Beach	Yes	officers manned checkpoint	9 hours	12 1/4 hours	motels evacuated late, congestion at Florence

\*In South Carolina, the level of evacuation carried out in Hugo was directly related to a Category 3 low tourist occupancy situation as presented in the Technical Data Report. The exception to this was in Jasper and Horry Counties where evacuation level resembled the Category 2 low tourist occupancy scenario.

**Table 6**  
**Hurricane Hugo**  
**Transportation/Clearance Time Data - North Carolina**

<u>Location</u>	<u>Evacuation Roadway Network Accurate?</u>	<u>Special Traffic Control Actions</u>	<u>Clearance Time Experienced in Hugo</u>	<u>Study Calculated Clearance Time*</u>	<u>Problems Encountered</u>
<b>NORTH CAROLINA</b>					
Brunswick Co.	Yes	fire and police manned traffic control points; preferences given to outgoing traffic on Sunset bridge	5 hours	6 1/2 hours	None
New Hanover Co./Wilmington	Yes	none	5 hours	6 1/4 hours	None
Pender Co.	-	-	-	6 hours	-
Onslow Co.	Yes	state highway patrol helped at several key intersections	4 hours	9 hours	None
Carteret Co.	Yes	local police and highway patrol manned traffic control points	5 hours	8 1/2 hours	None
Dare Co.	Yes	local law enforcement manned highways	10 hours	11 1/2 hours	None

\*In North Carolina, the level of evacuation carried out in Hugo was a scenario A type situation as presented in the Technical Data Report. This corresponds to a Category 1-3 Hurricane, low tourist occupancy.

In South Carolina study produced clearance times compared very well with actual times for those areas that had the most direct effects from Hugo. Based on the clearance times incorporated from the study into HURREVAC (see Chapter 6) Charleston County officials had to decide to start their evacuation well before a hurricane warning was issued for the area. In retrospect, this difficult decision proved to be extremely wise on the part of local officials as evidenced by the successful evacuation of thousands of residents before the onset of hazardous conditions from Hugo. Clearance times for Beaufort County and Georgetown County were very close to actual times as well. Clearance times for Jasper County and Horry County were significantly lower than study produced times. Review of available information indicates that the evacuation in Horry County was focused on beachfront, low lying areas, and mobile homes. Hotels and motels appeared to be reluctant to advise residents to leave. Thus somewhat of a partial evacuation appears to have taken place in Horry County relative to scenarios in the Technical Data Report. Jasper County reported a clearance time of between 4 and 5 hours for local residents. The 8-hour study produced time includes a significant amount of Beaufort County "pass through traffic". It

is difficult to make a meaningful comparison of times in Colleton County as the Technical Data Report reflects times for roads traveled by Charleston County evacuees (e.g. Highway 61). In addition, the only area where a good estimate of actual clearance time can be determined is Edisto Beach which evacuated in approximately 2 hours.

Special traffic control measures in South Carolina coastal counties during Hugo, primarily involved law enforcement officers staffing critical intersection and roadway segments. State highway patrol assisted coastal counties with this task while also dealing with major congestion problems along 1-26 near 1-95. Bridges in Charleston County (such as the Ben Sawyer) were locked down with cooperation from the Coast Guard and state highway department. As traffic came to a crawl (late Thursday September 21 AM) on 1-26 out of Charleston, officials considered reverse laning the eastbound lanes from Charleston to Columbia. However, by early afternoon traffic began to flow more smoothly and a determination was made not to go through with the reverse laning.

In North Carolina, clearance times compared favorably with study produced clearance times in Brunswick, New Hanover, and Dare Counties. No information was reported for Pender County. Times in Onslow and Carteret were significantly below those in the Technical Data Report. Onslow County carried out a very limited evacuation compared to scenarios analyzed in the North Carolina study. Carteret County reported a five hour clearance time for local traffic but did not know how long it took for traffic to clear Craven County. Clearance times reported in the Technical Data Report for Carteret County reflect getting traffic through Craven County's critical links. Traffic control primarily involved police officers manning key intersections and no major traffic problems were encountered.

## **RECOMMENDATIONS**

Based on Hurricane Hugo, it is recommended that the following items be considered for future transportation analysis studies:

- 1) Enlarge the study area boundaries to include potential traffic problem spots in inland counties. For example, the 1-95/1-26 interchange in South Carolina was outside the original study area.
- 2) Stress the importance of all critical intersections being staffed by law enforcement officials to keep traffic moving.
- 3) Remind public officials that major congestion will occur on evacuation routes during the middle of the evacuation and that this will dissipate as traffic loadings decrease during the last third of an evacuation.
- 4) Run a scenario where only a small percent of evacuees go to local public shelter versus leaving the county and going inland.
- 5) Encourage the use of secondary roads by evacuees through public information and/or signage.

## CHAPTER 6

### EVACUATION DECISION MAKING

Some of the most important products developed as a part of the FEMA/ Corps of Engineers hurricane studies and delivered to local state officials have been evacuation decision making tools. These tools have been decision arc maps and tables as well as computer software such as HURREVAC. Products such as these graphically tie together real-time storm characteristics with clearance time data. Their purpose is to give directors a means of retrieving Technical Data Report information without having to dig through a report during an emergency. Evacuation decision tools suggest when an evacuation should begin relative to a specific hurricane, its associated wind field, forward speed, probabilities, forecast track, and intensity.

In February of 1989, FEMA provided state and local officials in South Carolina a computerized informational model which utilizes technical data contained in the study along with information contained in the marine and public advisories from the National Hurricane Center. The model, called HURREVAC, is a tool to assist local officials in making hurricane evacuation decisions. HURREVAC has since been adapted to Georgia and its data base and was delivered to county officials just days before Hugo threatened the area. North Carolina and Georgia both were provided with a set of decision arcs and tables during FEMA/Corps study efforts. These products were the primary evacuation decision making tools used for Hugo in those two states.

Discussions initiated by the FEMA/Corps study team with local and state officials regarding the evacuation decision process focused on the following questions:

When was the EOC fully activated and what prompted this decision?

In deciding when to evacuate and who should evacuate what study products/decision aids were used?

When was the evacuation order or request made?

Did technical data/decision tools work well and did mapping provide a good depiction of the hazard areas?

Tables 7, 8, and 9 provide data for each state and county related to the above issues. In Georgia, counties generally activated their EOCs based on weather service information and decision arc considerations. In addition to the decision arcs, surge inundation mapping developed in the FEMA/ Corps studies was used extensively. Since HURREVAC had just been delivered to the local counties a couple of days before Hugo it was used sparingly in most counties. However, Liberty and Glynn Counties were able to get it up and running and relied upon it during Hugo. Corps of Engineers staff in Savannah assisted Chatham County during the Hugo threat with HURREVAC runs produced on computers at the Corps' offices. Local officials in coastal Georgia counties were pleased with the

decision arc system. Glynn County officials feel the ability to get timely marine advisories would have helped their decision making. Chatham county officials were impressed with the accuracy of timing data but would have preferred larger scale surge maps for some of their decision making.

**Table 7**  
**Hurricane Hugo Assessment**  
**Evacuation Decision Process Data - Georgia**

- - - - - <u>Location</u>	<u>Time EOC was fully activated</u>	<u>What prompted the decision to activate</u>	<u>What study products/ decision aids were used in deciding when and who should evacuate</u>	<u>Time of Evacuation Order or Request</u>	<u>How well did study Products work?</u>
<b>GEORGIA</b>					
Camden Co.	1200/Wed. 20th	weather information	surge inundation mapping; decision arcs	0700/Thurs. 21st; some voluntary evac. Wed. PM	good
Glynn Co./ Brunswick	1200/Wed. 20th	weather service information	decision arcs, surge inundation mapping, HURREVAC	at hurricane watch posting on Wed.	decision arcs-worked well; need to be able to retrieve marine advisory better to use HURREVAC effectively
McIntosh Co.	-	-	-	-	-
Liberty Co.	at hurricane watch Wed. 20th	weather service information	HURREVAC primarily; decision arcs on wall to show people	0700/Thurs. 21st	very well
Bryan Co.	0600/Wed. 20th	weather service information	surge inundation mapping; decision arcs	0800/Thurs. 21st	OK
Chatham Co./ Savannah	0430/Thurs. 21st	weather service information	decision arcs; SLOSH program; surge inundation mapping; HURREVAC runs from Corps staff	0600/Thurs. 21st	well, concerned initially that decision arcs prompted evac. too early but it was "right on target"; would like larger scale surge/zone maps

**Table 8**  
**Hurricane Hugo Assessment**  
**Evacuation Decision Process Data - South Carolina**

<u>Location</u>	<u>Time EOC was fully activated</u>	<u>What prompted the decision to activate</u>	<u>What study products/ decision aids were used in deciding when and who should evacuate</u>	<u>Time of Evacuation Order or Request</u>	<u>How well did study Products work?</u>
<b>SOUTH CAROLINA</b>					
Jasper Co.	0900/Thurs. 21st	storm information; call from William Winn of Beaufort Co.	surge inundation and zone maps	0930/Thurs. 21st	OK
Beaufort Co./ Hilton Head	2400/Wed. 20th	weather service information	HURREVAC, zone maps	0600/Thurs. 21st	very well, timing data on target
Colleton Co.	0500/Thurs. 21st	weather service; information; discussions with William Winn of Beaufort Co.	GDS used until HURREVAC could pick up the storm; HURREVAC	0600/Thurs. 21	good; HURREVAC needs to be sensitive to Weatherwire every 3 hour reports
Charleston Co.	2400/Wed. 20th	weather service information; Dennis Clark's timing wheel	GDS, HURREVAC, zone maps, slosh program, marine advisory; weather channel	2300/Wed. 20th went on 11 PM news and asked for voluntary evac. to begin; 0600/Thurs. 21st mandatory	generally worked well; nervous using storm information but it worked out to be on target; products provided credibility
Georgetown Co.	Wed. 20th PM	weather service information	HURREVAC, zone maps	0900/Thurs. 21st	worked well; would like larger maps and a high tourist occ. situation re-addressed
Horry Co.	Wed. 20th	weather service information	zone maps	1200/Thurs. 21st	good

**Table 9**  
**Hurricane Hugo Assessment**  
**Evacuation Decision Process Data - North Carolina**

<u>Location</u>	<u>Time EOC was fully activated</u>	<u>What prompted the decision to activate</u>	<u>What study products/ decision aids were used in deciding when and who should evacuate</u>	<u>Time of Evacuation Order or Request</u>	<u>How well did study Products work?</u>
<b>NORTH CAROLINA</b>					
Brunswick Co.	1000/Thurs. 21st	weather service information; decision arcs	decision arcs; surge inundation maps	1400/Thurs. 21st	excellent; decision arcs on target
New Hanover Co./Wilmington	1500/Thurs. 21st	weather service information timing data	decision arcs; surge inundation maps	1300/Thurs. 21st	good
Pender Co.	-	-	-	-	-
Onslow Co.	Thurs. 21st afternoon	state area office	surge inundation maps	1600/Thurs. 21st	OK; didn't have time to use decision arcs
Carteret Co.	Thurs. 21st morning	weather service information; Skip the weatherman	decision arcs, surge inundation maps, Skip's forecasted storm track	1500/Thurs. 21st	OK; storm didn't really affect area
Dare Co.	Thurs. 21st	National Weather Service advisories; threat of northern turn by Hugo	decision arcs; surge	1400/Thurs. 21st	good

In South Carolina, local officials fully activated EOCs in response to close communications with Dick Shenot of the National Weather Service. Coordination among counties in each "emergency preparedness conglomerate" also prompted activation such as the discussions in Jasper and Colleton Counties with William Winn of Beaufort County. Decision tools used for Hugo included Hazards Management Groups' GDS, HURREVAC, zone maps, surge inundation mapping, and a SLOSH program installed on local personal computers several years ago. GDS was used up until HURREVAC could show the storm on the computer screen. At that point, officials indicated that HURREVAC was used primarily with marine advisories being directly fed into the program every 3 to 6 hours. Local officials were pleased with the study products and decision aids provided. The products provided credibility to local emergency managers in the eyes of local county commissioners and other decision makers.

Local counties in North Carolina fully activated their EOCs based on the prompting of several different factors. These included weather service information, decision arc considerations, state area office advice, and Skip Waters, a local weatherman in New Bern. Study tools used were the decision arcs and the surge inundation mapping. Local officials were very pleased with the decision arc system.

## RECOMMENDATIONS

Products being provided by FEMA/Corps hurricane studies regarding evacuation decision making seem to be working well. Officials like the ability to show decision makers a "computerized" data base that ties together Technical Data Report information. The only improvement which was previously discussed in Chapter 2 is surge mapping and zone maps at a larger scale. Excellent working relationships between local emergency directors and NWS staff is important to good decision-making. Local officials should be encouraged to continue to develop these relationships with NWS staff.

## CHAPTER 7 PUBLIC INFORMATION

Although not a major part of previous FEMA/Corps of Engineers hurricane evacuation study efforts, public information is becoming recognized as an important final element that must be addressed. Study products and data must ultimately be in a format that the media and general public can understand so that correct evacuation decisions and preparations can be made at the household level. Hugo provided a glimpse of what current means of getting hurricane evacuation information into the hands of the general public is available. It also provided local and state officials with an opportunity to assess additional needs in regards to public information.

Current methods used in Georgia, South Carolina, and North Carolina for informing the public in Hugo included the following:

- 1) the most important means was through radio and television - some communities used cable TV overrides to alert the public of evacuation advisories.
- 2) press briefings with national and local media to insure that they (radio, TV, newspapers) disseminate consistent information to the public - media was given packets of hurricane materials early in the season by some emergency officials.
- 3) law enforcement officials drove through neighborhoods with sirens and p.a. systems to encourage people to evacuate - this technique was used in most beach and barrier island communities - some officials went door to door.
- 4) some communities were able to provide evacuation information to the public through an insert in the local phone book.
- 5) information was provided several days before the arrival of Hugo through newspaper articles.
- 6) hurricane evacuation brochures published by the state (e.g. North Carolina) were picked up by residents.
- 7) meetings had been held with civic groups early in the season at which local emergency directors made presentations on hurricane preparedness including wind and flooding potential.
- 8) in some inland rural areas, mobile home residents were phoned to make sure they understood the threat (e.g. Colleton County, S.C.).
- 9) prepared announcements given to media in advance - these were relayed to public upon prompting by emergency officials (e.g. Georgetown County, S.C., Carteret County, N.C.).

10) late in the. Hugo situation, WPDQ in Jacksonville, Florida broadcast public information to coastal areas in Georgia, South Carolina, and North Carolina as local radio stations lost broadcasting ability during Hugo (loss of power, towers).

11) public was alerted that power would be turned off in their area even if they stayed - this encouraged people to evacuate (e.g. Tybee Island, Ga.).

12) recommendations from Governor's office for people to evacuate.

13) civil defense sirens (e.g. Savannah, Georgia).

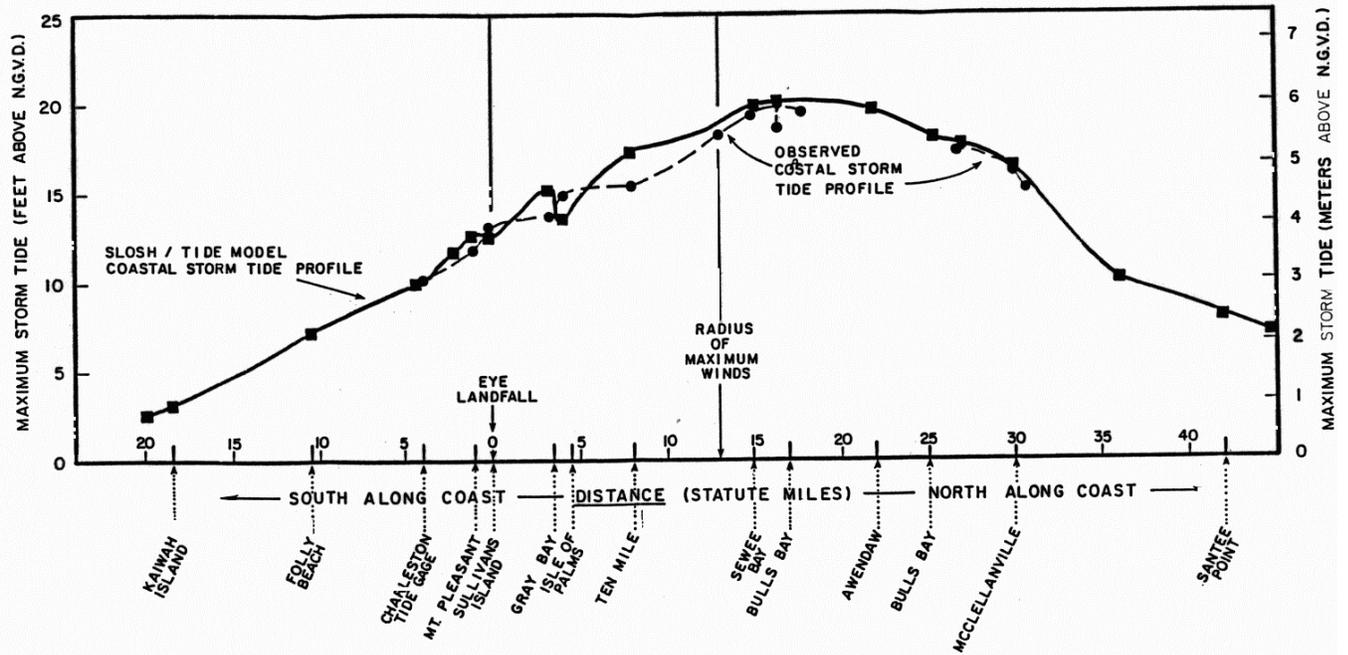
## **RECOMMENDATIONS**

In discussions with media representatives in the Savannah, Georgia and Charleston, South Carolina markets and with all of the local and state emergency officials, the following ideas and resources were identified as needs in the area of public information:

- more camera ready/computerized mapping of surge areas, routes, and shelter locations for media
- computerized "billboard" only available to media via modem - emergency officials would provide notices and information through this
- need to address EBS operations - most stations participate now due to financial concerns
- need more phone lines/staff for public to call into EOC's for information
- prepare newspaper supplement in advance that could be inserted a day before projected landfall
- beef-up phone book materials and inserts that can be used in a real time event
- produce canned videos for TV's to broadcast
- print more state brochures
- provide more local information (surge heights imposed on pictures of local landmarks)
- install uniform evacuation route signs
- put up signs giving inland shelter/EBS station information

Figure 1

# SLOSH Tide Values/Hugo High Water Mark Comparison



NOTE: Data plotted above is preliminary NHC/USGS data regarding Hugo.

**Figure 2**  
**Cumulative Evacuation Curves**

