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TECHNICAL COMMUNICATION

Shoreline Response to Hurricane Hugo

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Hurricane Hugo made landfall on the South Carolina coast on 22nd September 1989 at high tide. Maximum sustained winds near the eye of the storm were 217 kph. Maximum storm surge in areas near the eye reached 6 m. A team from the Duke University Program for the Study of Developed Shorelines observed storm response along a stretch of coastline from the North Carolina border to Folly Island.

Hurricane Hugo has provided an excellent opportunity to observe the varying responses of developed and undeveloped shorelines to a major storm event. Important processes include overwash, storm surge, storm surge ebb, beach and dune erosion, and shoreline retreat. The interaction of storm processes with developed and undeveloped shorelines was markedly different. Shoreline development intensified natural storm processes. Seawalls caused beach scour; shore perpendicular roads allowed greater penetration of overwash; and buildings channelled storm surge ebb. Post-storm beaches were narrower on developed shorelines than on undeveloped shorelines as buildings and shoreline structures impeded shoreline retreat.

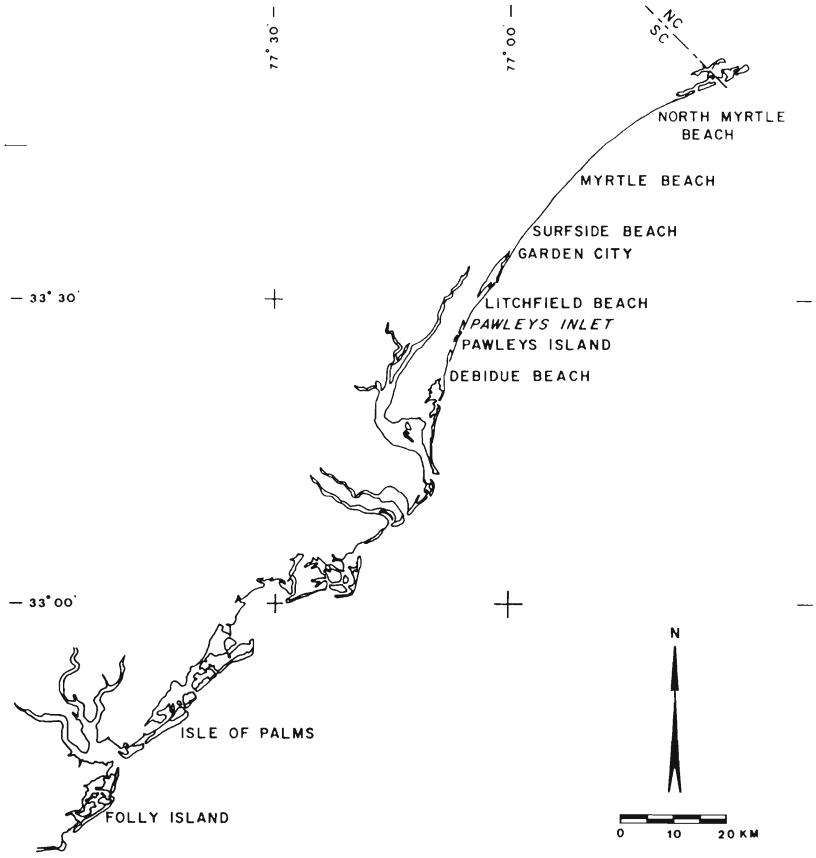

Figure 1. Locations along the South Carolina coast inspected following hurricane Hugo.

Figure 2a. This photo was taken the day before the hurricane on Litchfield spit. The dune was constructed three years ago by bulldozing sand from the beachface and was stabilized by vegetation. This 4 m high, 275 m long dune cost about $29,000.

Figure 2b. On Litchfield spit one day after Hugo's passage, the storm has removed the entire dune ridge and all of the introduced vegetation. To the north, houses behind the dune were severely damaged. There is no evidence of significant sand deposition in the backbarrier, suggesting either offshore or longshore transport.

Figure 3a. On Litchfield spit one week after the hurricane, wind-blown sand has begun to heal the scarped beach. Given time, natural processes will reestablish a new dune landward of the old artificial dune ridge.

Figure 3b. Unfortunately, man did not wait for nature to construct a dune. In order to protect property from the October 14th perigean high tide, a massive project to build 65 km of dune ridge was undertaken by the state of South Carolina in conjunction with Federal Emergency Management Agency. The estimated cost of this project was $1.4 million. At South Litchfield, bulldozers removed sand from the lower beachface to replace the dunes. During construction the shoreline moved landward 10-15 m due to bulldozer-induced erosion.

Figure 3c. One day after construction of the dune in Figure 3b, the toe has been scarped by wave attack. Two reasons can be given for the poor performance of the new dune: the beach profile was lowered by removal of sand from the lower beachface; the dune was reestablished along the axis of the old dune, rather than a more landward position in equilibrium with the post-storm conditions.

Figure 4a. The spit at Garden City was completely overwashed. In places, overwash sand was over 1 m deep. This photo, taken near the time of low tide the day after the storm, shows no preferential accretion on either side of the groins. This indicates that the dominant sand transport processes during the storm were onshore-offshore as opposed to alongshore. This phenomenon was observed along much of the coast. If indeed sand were moved offshore, some natural beach recovery can be expected as fairweather waves return sand to the subaerial beach.

Figure 4b. Overwash sand has been bulldozed to uncover the beach road in Garden City. The ocean is to the left.

Figure 5. Shore perpendicular streets, such as this one in Surfside Beach, served as channels for overwash and storm surge. Overwash was up to an order of magnitude greater along such streets. High-rise buildings on either side of these streets appeared to further intensify overwash.

Figure 6. On Pawley's Island, storm surge not only destroyed houses, but also moved several across the island and into the backbarrier marsh (white arrows). Storm surge ebb added to beach erosion through channels incised into the back of the beach (black arrows). Channels were up to 7 m wide and nearly 1 m deep.

Figure 7. On Folly Island, storm surge ebb flow driven by gravity and offshore winds south of the eye of the hurricane resulted in a deep scour channel between these two houses. Storm surge ebb was further intensified in some areas where flow was funnelled between shorefront buildings and shoreline engineering structures (bulkheads and revetments). This channel is approximately 7 m wide and 2 m deep.

Figure 8. At the south end of Pawley's Island, storm surge ebb opened a new inlet approximately 1 km north of Pawley's Inlet. The tidal prism was large enough to maintain the new inlet until it was closed artificially.

Figure 9. This scene from Surfside Beach was a familiar one along the post-storm beach. In many places, seawalls and bulkheads backed by swimming pools failed.

Figure 10. In Myrtle Beach, exposed foundations of many beachfront hotels and condominiums indicate beach profile lowering of up to 2 m. In addition, a riprap revetment in front of this hotel was destroyed, and is now spread out across the recreational beach. In some areas, water-borne riprap caused damage to oceanfront buildings and wooden bulkheads.

Figure 11. Storm surge overstepped the bulkhead at Debidue Beach, carrying wave activity inland. The bulkhead was left intact.

Figure 12. The post-storm beach is narrower on stabilized shorelines than on unstabilized shorelines, as shown in this example from North Myrtle Beach.

Figure 13. These two houses on Pawley's Island highlight the site-specific nature of storm response in developed areas. The house on the left was sited at low elevation; preexisting dunes were likely removed for its construction. The house on the right, however, was built on top of and behind the dune; maritime forest was left intact around the house. While the storm destroyed the house on the left, the one on the right sustained minimal damage.