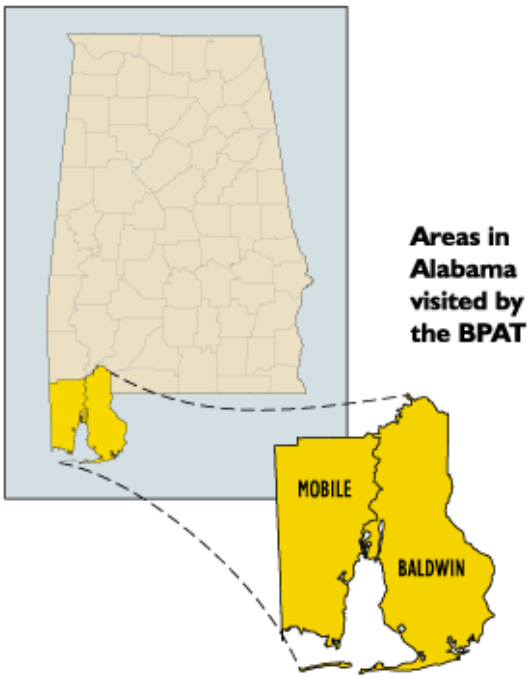
# 4 Alabama Observations

The BPAT conducted aerial and on-the-ground investigations of the damage that occurred along the coastal and riverine areas of Mobile and Baldwin Counties in southern Alabama. This area included Dauphin Island, eastern and western shores of Mobile Bay, and the Fort Morgan/Gulf Shores areas in Baldwin County. Buildings that successfully withstood Hurricane Georges were also assessed.




**Areas in Alabama visited by the BPAT**

## 4.1 Flood Observations: Damages and Successes

Flooding included riverine flooding due to excessive rainfall and inflow of coastal surge waters that prevented outflow from the rivers, creating a backup of waters along the coastal rivers. Coastal flooding was characterized by storm surge overwash and erosion along the barrier islands and wave action on Mobile Bay.

### 4.1.1 Riverine Flooding

Riverine flooding and subsequent damage was most evident in the lower reaches of the Dog River in Mobile County; the Fish River in Baldwin County; and in downtown areas adjacent to the Mobile port facilities in the upper Mobile Bay. The Fish River experienced flooding levels less than the 100-year event. A USGS gaging station on Fish River near Silver Hill recorded flood heights during Hurricane Georges that indicate discharges of approximately 6,400 cfs (cubic feet per second), corresponding to a recurrence interval of approximately 10 years [Pearman 1998]. In comparison, during Hurricane Danny in 1997 the Fish River flowed at a rate of approximately 16,900 cfs, which was estimated to have been approximately a 50-year flood event. No recorded discharge information for the Dog River watershed was available. However, based on rainfall and nearby river flow data, the recurrence interval on the Dog River is estimated at 25 to 50 years.

Estimates on the streams of the lower Mobile River which discharge into Mobile Bay indicate a 25- to 50-year recurrence interval. The gaging station at Chickasaw Creek north of Mobile recorded its second highest peak of record, exceeded only by a flood that occurred in 1955. A gage on the Styx River in southern Baldwin County recorded a peak stage that was

7 feet higher than the bridge deck. The peak discharge on this gage was 48,000 cfs, which corresponds to a recurrence interval of 100 to 200 years.

Damage consisted mostly of loss of contents; damage to exterior and interior finishes, including doors, cabinets, carpeting/flooring, and painted surfaces; inundation of air conditioning compressors; and damage to wallboard and insulation. In the Dog River area, houses experienced up to 5 feet of flooding (Figure 4-1). The Fish River area experienced 4 to 5 feet of flooding. In one instance, a pre-FIRM house built on a slab-on-grade foundation sustained damage while a post-FIRM elevated addition apparently was not affected (Figure 4-2).


**FIGURE 4-1 Homeowner removing damaged contents from house flooded along the Dog River.**


**FIGURE 4-2 Approximately 5 feet of flooding at this house along the Fish River caused no damage to the elevated addition.**

Acquisition and elevation projects in the riverine areas of Baldwin County preceded by a planning effort that identified properties repeatedly affected by flooding. As a result, the Baldwin County Government has been pursuing the enactment of ordinances to address riverine and coastal erosion and flood hazard reduction. Damages from Hurricane Georges have caused the county to strengthen its efforts on these proposed mitigation planning activities, which include:

- An erosion control ordinance (either as a supplement to the building code or a separate ordinance);
- A Flood Hazard Overlay (zoning) District, which will provide for setbacks from waterways and lot size and coverage requirements; and
- Subdivision regulations that will feature setback requirements and cluster development provisions.

A comprehensive house elevation and property acquisition effort is ongoing in the Dog and Fish River basins using funds from the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance Program (FMAP), as well as private funds. Property acquisitions and subsequent removal of the structures eliminated the potential for flooding and subsequent losses (Figure 4-3). Elevation of structures along the Dog River in Mobile County (Figure 4-4) and the Fish River in Baldwin County (Figure 4-5) to above the BFE resulted in reduced damages.

**FIGURE 4-3 The previous location of several repetitive-loss properties in Mobile County that had been acquired and demolished.**

**FIGURE 4-4 Elevated house along the Dog River that suffered minimal flood damage.**


**FIGURE 4-5 House along the Fish River, elevated through FEMA's HMGP that suffered minimal flood damage.**

Elevated structures still have some degree of residual flood risk. The house pictured in Figure 4-6 was previously elevated by the homeowner and subsequently was flooded approximately 1 inch to 2 inches above the first floor by Hurricane Danny. Fortunately, flood levels in this area during Hurricane Georges were less than those experienced during Hurricane Danny. The only damage to this home during Hurricane Georges was to the contents stored below the first floor.


**FIGURE 4-6 Previously elevated house along the Fish River suffered damage to contents below the first floor. Note that the homeowner also elevated utilities on the right side of house, preventing loss or damage.**

Located in Upper Mobile Bay, the Mobile Convention Center, which was constructed in 1993, is the centerpiece of downtown Mobile's revitalization efforts (Figure 4-7). Elevated above the BFE, the Convention Center received only minor damage from Hurricane Georges. Total damage — including flood fighting and cleanup costs — has been $156,000 to date with approximately $350,000 estimated for additional repairs. Most of the damage incurred was due to wind-driven rain that entered around windows and doors. Since the Convention Center was properly elevated, it was able to resume operations within three days after Hurricane Georges. In addition, the center received additional bookings from other


**FIGURE 4-7 Despite approximately 7 feet of flooding in this area, the Mobile Convention Center suffered only minor damage and was operational when the floodwaters receded.**

nearby facilities that were damaged by the storm. The design and elevation of this building was an economic success in terms of both the damage avoided and the business that was not interrupted (Figure 4-8).

**FIGURE 4-8 The area below the BFE is used for parking and required only minor clean-up following the flood.**

## 4.1.2 Coastal Flooding

By far, the most severe damage the BPAT observed was the result of coastal surge and flooding along the Alabama Gulf Coast, specifically Dauphin Island, the eastern and western shores of Mobile Bay, and the Fort Morgan/Gulf Shores areas. Damages included beach erosion and scour; washouts caused by channelized flow; complete and partial destruction of structures that included grade-level concrete slabs, pile foundations, walkways and on-site utility equipment; loss of roadways; and problems associated with the creation/accumulation of sand and debris.

Significant erosion of the Gulf Coast beach occurred on Dauphin Island. Overwash was evident across virtually the entire width of the western end of the island. The eastern end of the island, which has greater topographic relief, vegetation, and dunes, fared well. No significant shore-parallel dunes or other protective berm existed on the western beaches prior to the storm. Most overwashed sand ended up being deposited in the roads. Vertical beach loss due to erosion on the Gulf side was estimated to be 3 to 6 feet. Scour was localized around obstructions (posts/piles, abandoned concrete septic tanks). In addition, 3 to 6 feet of erosion occurred beneath several A-Zone houses located on the back-barrier shoreline across from shore-perpendicular streets (Figure 4-9). Side streets located perpendicular to the shoreline provided a preferred path for storm surge and retreat flow across the island.

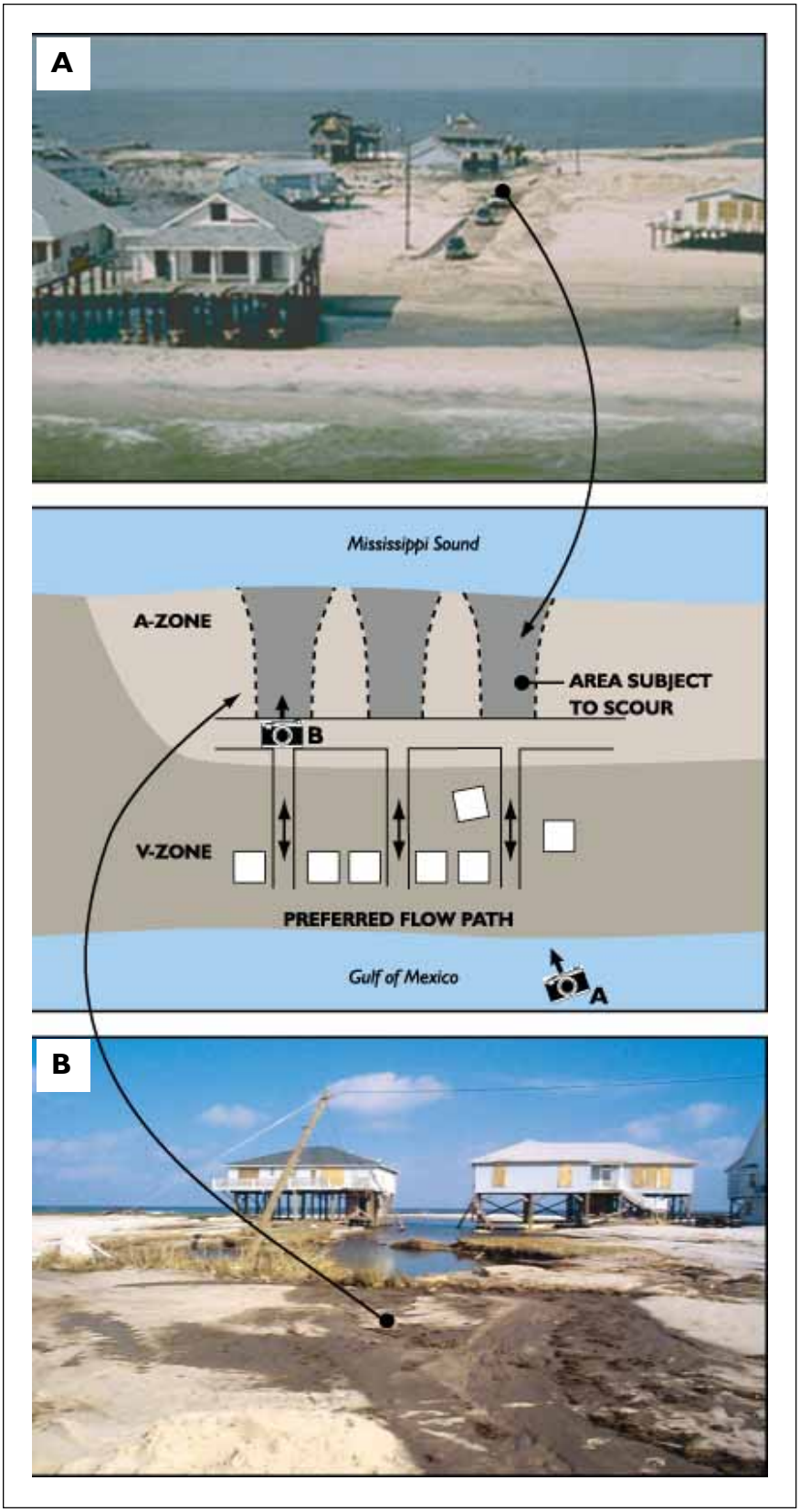



**FIGURE 4-9 Side streets perpendicular to the shoreline, combined with a break in the existing scattered dunes and vegetation where the side streets meet the main east-west road, provided a preferred path for storm surge and retreat flow across the island.**

A combination of inadequate pile embedment with erosion and scour resulted in the failure of several homes on pile foundations on the windward/southern side of Dauphin Island (Figure 4-10). While some structures did not suffer complete losses, they did suffer severe damage due to the surge. Damage included loss of piles, movement and/or settlement of piles, leaning or partial collapse of the structure, washout and scour around piles and around and under grade level concrete slabs, loss of exterior access stairways, and loss of lower level enclosures.

**FIGURE 4-10 The structure on the right lost its pile foundation system and was washed into the structure on the left.**

In some cases, pile failures were exacerbated by inadequate embedment depths and increased scour around piles as a result of concrete collars or slabs (Figures 4-11 to 4-14). The use of crossbracing was not widespread. Crossbracing observed was for serviceability and not intended to provide structural support or to prevent permanent deformation.

**FIGURE 4-11 This house lost its deck and sustained structural damage to the Gulf side of the house.**

**FIGURE 4-12 The BPAT observing a partially collapsed front-row structure.**

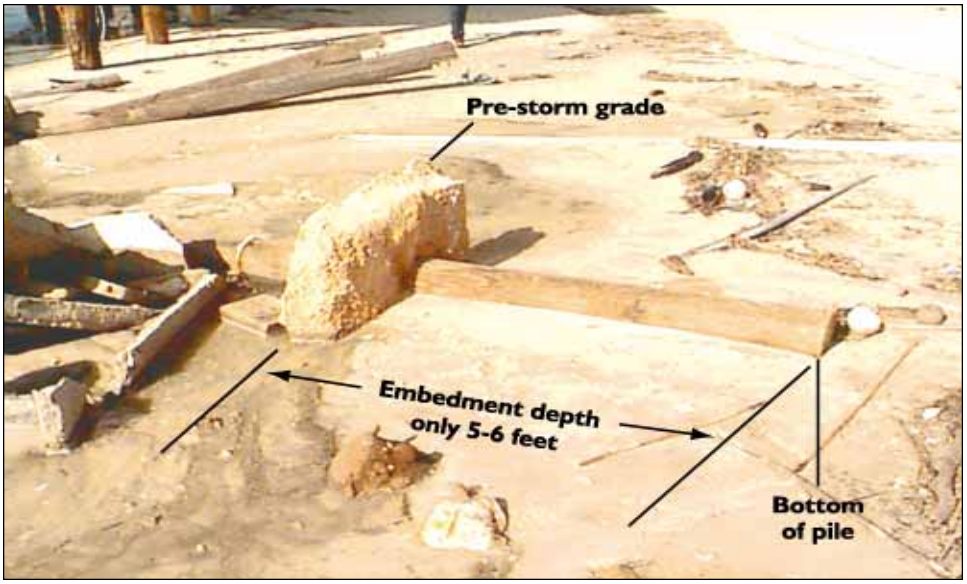



**FIGURE 4-13 Pile failure due to scour around concrete collar and inadequate embedment depth.**

**FIGURE 4-14 This house suffered pile settlement due to scour around piles with concrete collars. In addition, note the loss of stairs and damage to lower-level enclosed area.**

Waterborne debris impact caused a significant amount of damage. Several front row homes on Dauphin Island failed due to inadequate pile embedment and erosion/scour. The debris from these failed structures affected adjacent and landward structures (Figure 4-15 and 4-16). In most cases, the structure affected would not have been damaged otherwise or would have received only minor damage if it had not been impacted by waterborne debris. Debris impact from dislodged decks and stairs was more common than the debris impact from entire dislodged houses. This type of debris was carried by the storm surge and damaged buildings (Figure 4-17).

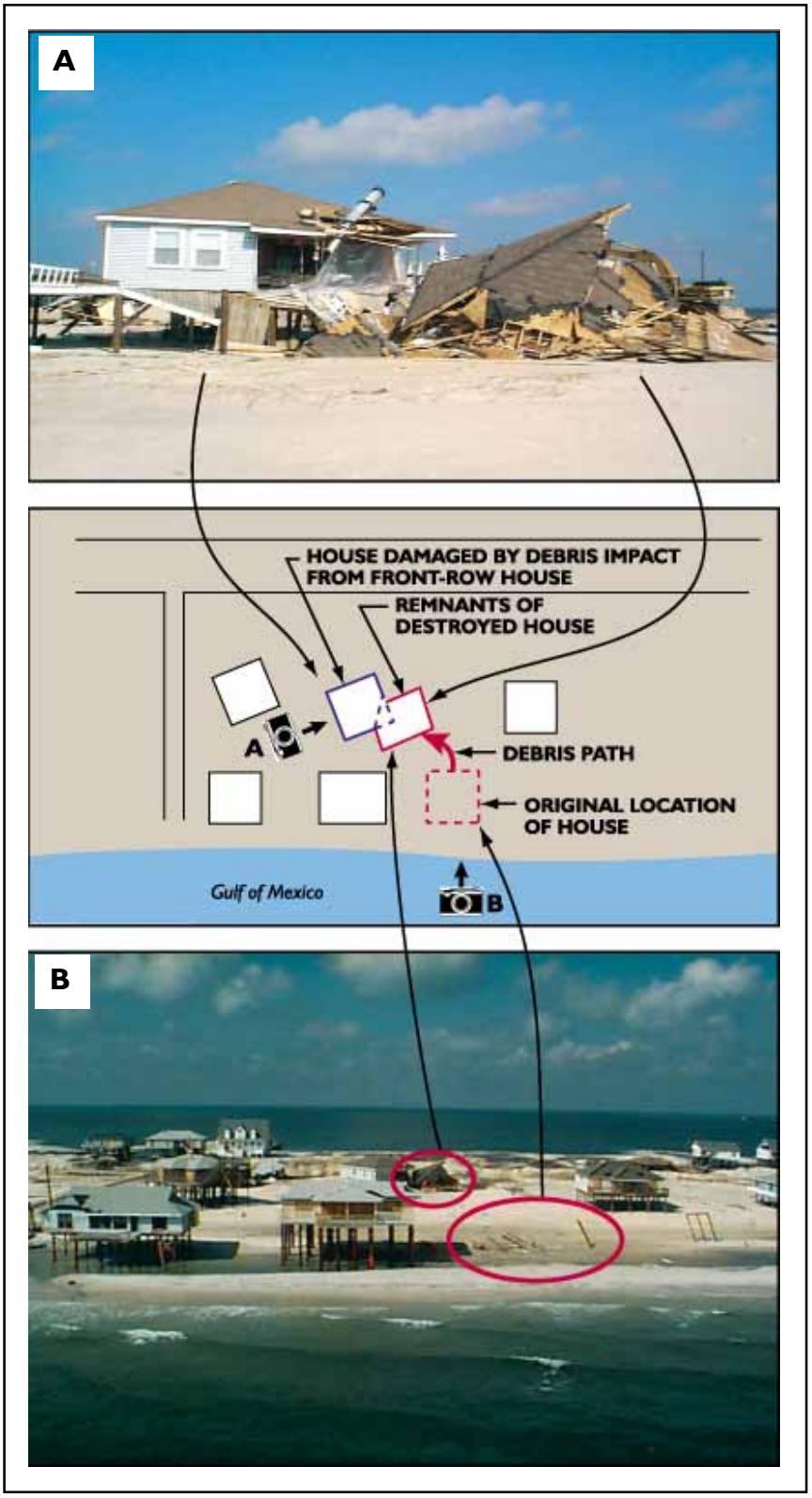



**FIGURE 4-15 Significant debris impact created by destruction of a front-row house.**


**FIGURE 4-16 House on back side of Dauphin Island suffered partial collapse when impacted by a dislodged house from the Gulf side of Dauphin Island.**


**FIGURE 4-17 Damage to piles of a newly constructed house caused by impact of waterborne debris from a nearby collapsed deck.**

Most homes and portions of the infrastructure on Dauphin Island performed well (Figure 4-18). This success can be attributed to sound local building code requirements, enforcement of 10-foot minimum pile depths, and compliance with NFIP V-Zone construction standards. The majority of the observed failures were to older houses built to lesser standards and lower elevations prior to FEMA's inclusion of wave height effects on the community's FIRM.

**FIGURE 4-18 This house sustained no damage with the exception of loss of stairs and items stored below the first-floor elevation.**

Dauphin Island's attention to utility systems was another example of successful mitigation. In response to repetitive damage to individual septic systems by past storms, the community installed a new municipal sewer system. The system performed well and suffered only minor damage as a result of the storm. Extensive beach erosion from Hurricane Georges would have required complete replacement of the individual septic systems for homes that were converted to the municipal system (Figure 4-19). In addition to the sanitary sewer system, the community is also elevating utility platforms for cable television and telephone switching stations to minimize damage due to coastal surge. As shown in Figure 4-20, the elevated platform performed well and adequately protected the utility boxes.

**FIGURE 4-19 Old concrete septic tanks (circled) and drain fields have been superceded by the new municipal sanitary sewer system. The old systems still create a hazard as waterborne debris.**

**FIGURE 4-20 Other than losing part of the lattice screening, this elevated utility platform performed well.**

In Fort Morgan, Gulf Shores, and Orange Beach, vertical beach loss was approximately 5 to 6 feet. Post-storm beach profiles taken at Orange Beach by the University of South Alabama showed a concave-up shape consistent with modeled profiles used by the Alabama Department of Environmental Management – Coastal Programs Division. Portions of the boardwalk and parking areas in Gulf Shores were undermined by wave action and storm surge, and additional scour occurred around buildings constructed at the minimum setback from the local CCCL. Overwash of sand was common, with some vertical accretion (1 to 3 feet) beneath structures. Some dunes persisted on the wide beach in unincorporated Baldwin County near Fort Morgan.

Although damage along the Fort Morgan/Gulf Shores shorelines was less severe than that observed on Dauphin Island, evidence of scour was more prevalent. This was due to more frequent use of at-grade concrete slabs and bulkheads in this area (Figure 4-21). While the depth of piles was not identified as a problem, concrete slab connections to piles or damage to piles as the slabs broke up was a concern due to the creation of unanticipated loads on the building foundations.

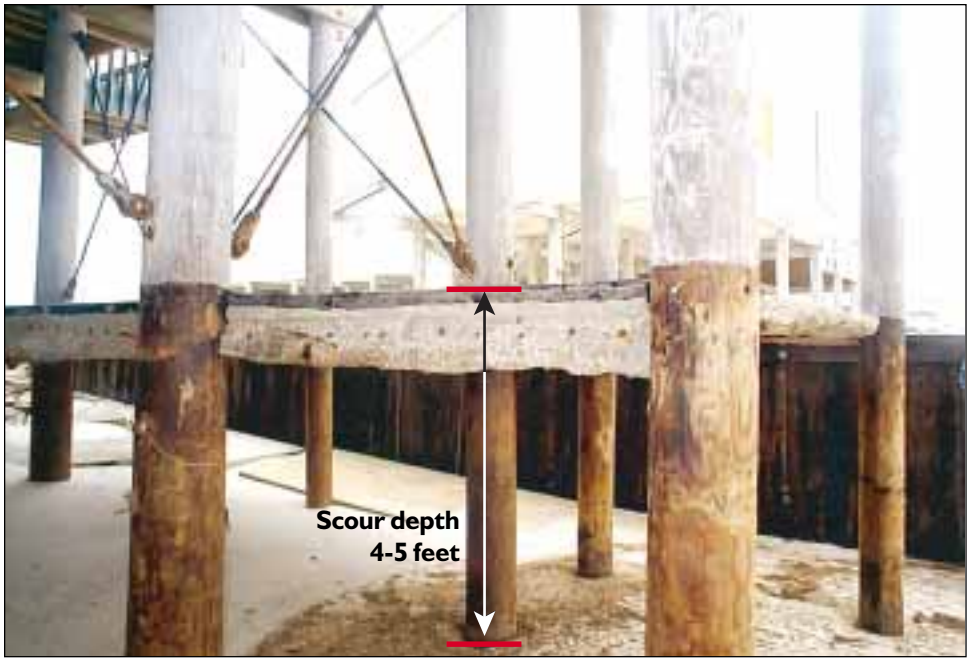



**FIGURE 4-21 Erosion/scour behind bulkhead and below the concrete slab caused by storm surge. Note the concrete slab did not completely detach from the piles.**

The placement of on-site exterior utility equipment (air conditioner/heat pump compressors) was a concern at both Dauphin Island and Fort Morgan/Gulf Shores areas. In several instances, damage occurred because these utilities were not elevated and not properly anchored.

For the most part, when structures were elevated an effort was also made to elevate air conditioning/heat pump compressors and other similar on-site utility equipment. When elevated to the BFE and placed on adequately supported platforms the facilities performed well (Figure 4-22). Where installation was inadequate, they generally failed (Figure 4-23).

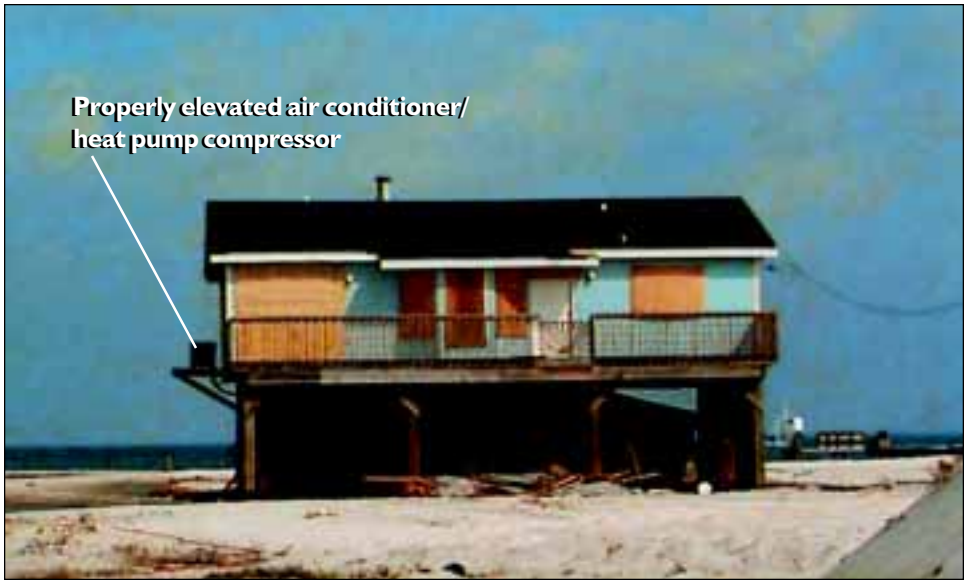



**FIGURE 4-22 This cantilever platform performed well.**

**FIGURE 4-23 These air conditioner/heat pump compressors in Gulf Shores were not elevated and therefore were severely damaged.**

Another issue of concern to the BPAT was the condition of metal hurricane straps, clips, and joist hangers. The salty coastal environment appeared to have caused deterioration of hurricane straps and clips. In some instances, the straps were completely corroded (Figure 4-24). In these cases, only the dead load of the building resisted the overturning or sliding of the building off its foundation.

**FIGURE 4-24 Only remnants of corroded hurricane straps remain.**

A number of buildings that withstood Hurricane Georges were observed in the Fort Morgan/ Gulf Shores areas (Figures 4-25 to 4-27). These successes are attributed to:

- Conformance with building requirements such as elevation of the first floor to the BFE, foundation systems with pile embedment depths capable of withstanding the loss of several feet of sand, and proper building setback from the shoreline; and
- Proper construction techniques such as selection of hip roof designs that minimize the use of vulnerable gable ends, and the proper selection and installation of hurricane-resistant construction materials, including siding and roofing materials.

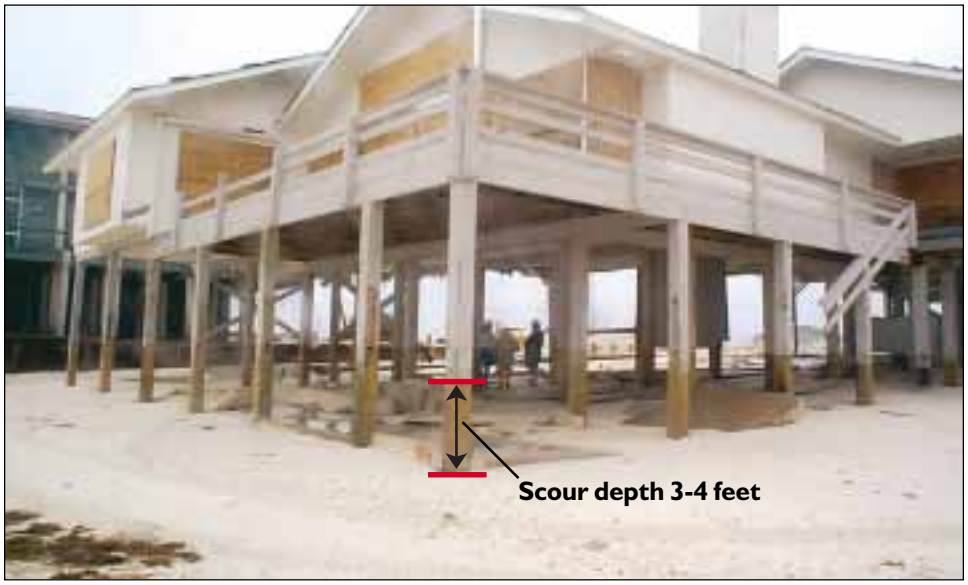



**FIGURE 4-25 Despite the loss of 3 to 4 feet of sand, this structure performed well. Note at-grade slabs broke away as intended.**

**FIGURE 4-26 These multi-family buildings in Fort Morgan suffered no damage from coastal storm surge. Proper elevation, siting, and building materials contributed to their success. Note roof design that minimizes the use of gable ends.**

**FIGURE 4-27 This properly elevated structure in Gulf Shores suffered no damage other than the loss of breakaway walls and slight damage to its stairs.**

Damages on the shores of Mobile Bay included loss of beach and shoreline, overwash and damage to bulkheads and seawalls, and loss of piles and wharves. A majority of the developed lots on the shoreline in the lower Mobile Bay are stabilized by bulkheads. Shoreline retreat distances (inland limit of erosion) were approximately the same for protected and natural beaches, with natural beaches retreating a little farther but maintaining a gentle slope (Figure 4-28). Other areas had moderate bluffs with a visible scarp (Figure 4-29).

**FIGURE 4-28 Typical shoreline erosion along low-lying areas adjacent to Mobile Bay.**

**FIGURE 4-29 Typical erosion along bluffed shoreline areas of Mobile Bay (western side).**

Wave action removed sand in front of bulkheads and overtopping removed much of the material from behind. Erosion was retarded by a relatively resistant, hard red clay layer located at a depth of 8 to 14 inches below grade. Following the hurricane, most bulkheads were still structurally sound as shown in Figure 4-30. Additional horizontal scour adjacent to bulkheads, caused by wrap-around/focusing of wave energy, was common along Mobile Bay.


**FIGURE 4-30 Bulkheads on Mobile Bay still in place after storm.**

Along the lower eastern shore of Mobile Bay, approaching Weeks Bay, the damages cited were evident (Figure 4-31). Other damages included significant loss of contents and personal possessions debris from bayfront homes washed across the roadway (Figure 4-32). Properly elevated and setback structures along Mobile Bay performed well and suffered only minor damage to areas below the first floor (Figure 4-33).

**FIGURE 4-31 Non-elevated pre-FIRM structure severely damaged by coastal storm surge.**

**FIGURE 4-32 Debris accumulation along coastal roadway.**

**FIGURE 4-33 A properly elevated post-FIRM front-row coastal house that suffered only minor damage to stairs. Note the storm shutter on the front window.**

## 4.2 Wind Observations: Damages and Successes

Wind effects along the Alabama Gulf Coast area generally were confined to damage to roofing shingles and metal roofing panels, exterior siding/sheathing, electrical power poles and power lines, signs, and trees. In addition, wind-driven rain resulted in damages to the interiors of structures, such as the Mobile Convention Center. The BPAT observed this damage to be less severe and extensive than flood damage. However, wind damage did occur throughout all of the coastal counties affected by the storm.

Wind damage to structures, although minimal, was observed along the western end of Dauphin Island. Several structures experienced damage to composition shingles and siding (Figure 4-34). Power poles and power lines on Dauphin Island were damaged, probably as a result of the combination of wind, coastal surge, and erosion effects (Figure 4-35). In the Fort Morgan area and the western end of Gulf Shores, wind damage to roof shingles and siding was evident (Figure 4-36).


**FIGURE 4-34 Wind damage to composition roof shingles and siding on newly built coastal home.**

**FIGURE 4-35 Utility poles damaged by wind, coastal surge, and erosion.**

**FIGURE 4-36 Houses in Gulf Shores with roof damage. Note loss of roof covering on front-row buildings.**

No significant wind damage was observed in Alabama's inland or coastal areas. In inland areas, roof damages were minor and buildings that did require repairs and cleanup were those infiltrated by wind-driven rain. The lack of significant wind damage along the Alabama Gulf Coast can be attributed to two factors: the wind velocities were not a design event, and improved building standards, methods and materials that were implemented as a result of past hurricanes performed successfully. For example, on Dauphin Island, the town developed specific requirements for the installation of asphalt/composition roof shingles, requiring six nails per shingle and the first two courses to be cemented to the roof underlayment. According to the local building official, implementation of these measures resulted in only minimal damage to asphalt/composition shingle roofs from Hurricane Georges (Figure 4-37). The BPAT was able to confirm that damage to roof shingles on Dauphin Island was, in fact, minimal.

**FIGURE 4-37 Fully exposed front-row houses that exhibited minimal wind damage.**

Metal roofs are becoming more common along the Alabama coastal and inland areas, specifically on Dauphin Island, Gulf Shores, and the Mobile Bay area. During this disaster, metal roofs appeared to have sustained little damage (Figure 4-38). However, since they are relatively new, their success must be further evaluated and based on longer exposure to salty, corrosive conditions and other environmental factors. The long-term performance of fasteners/connectors has been a particular concern in the past. In addition, most metal roofs the BPAT observed probably were not exposed to design level or greater winds.

**FIGURE 4-38 Metal roofing system on multi-family building in Fort Morgan performed well.**

The BPAT discovered two structures in the Fort Morgan area with fiber-reinforced concrete siding. Upon inspection, this siding appeared to suffer no wind damage. The strength and rigidity of the material, the use of stainless steel nails, and the adherence to a specified nailing pattern apparently contributed to the successful performance of the siding (Figure 4-39).

**FIGURE 4-39 Fiber-reinforced concrete siding suffered no damage.**