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FIGURE 4-19 Old concrete septic tanks (circled) and drain fields have been superceded by the new municipal sanitary sewer system.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.

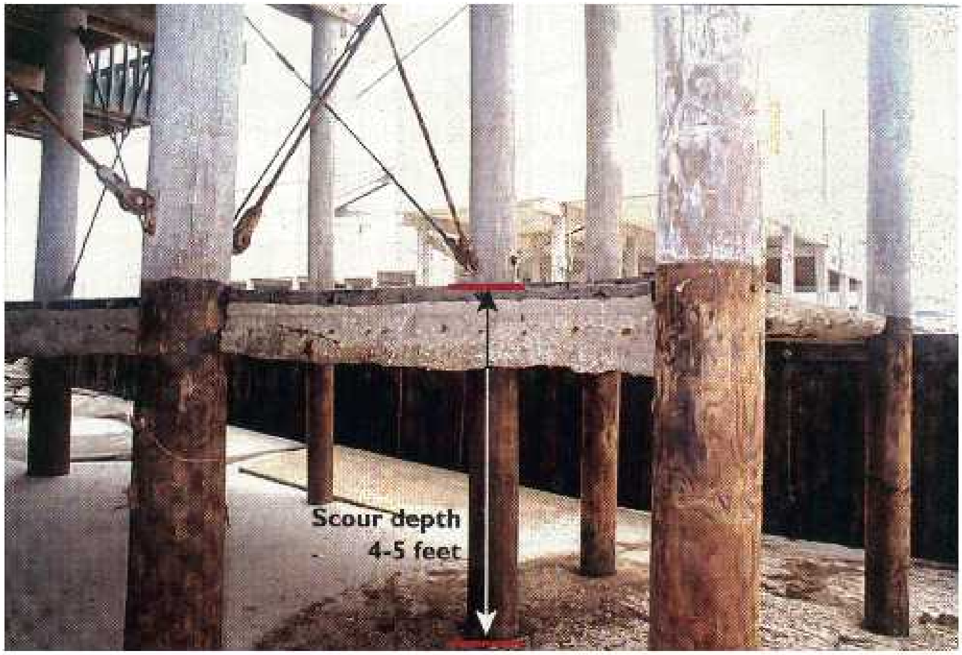

FIGURE 4-21 **Erosion/scour behind bulkhead and below the concrete slab caused by storm surge. Note the concrete slab did not completely detach from the piles.**

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)

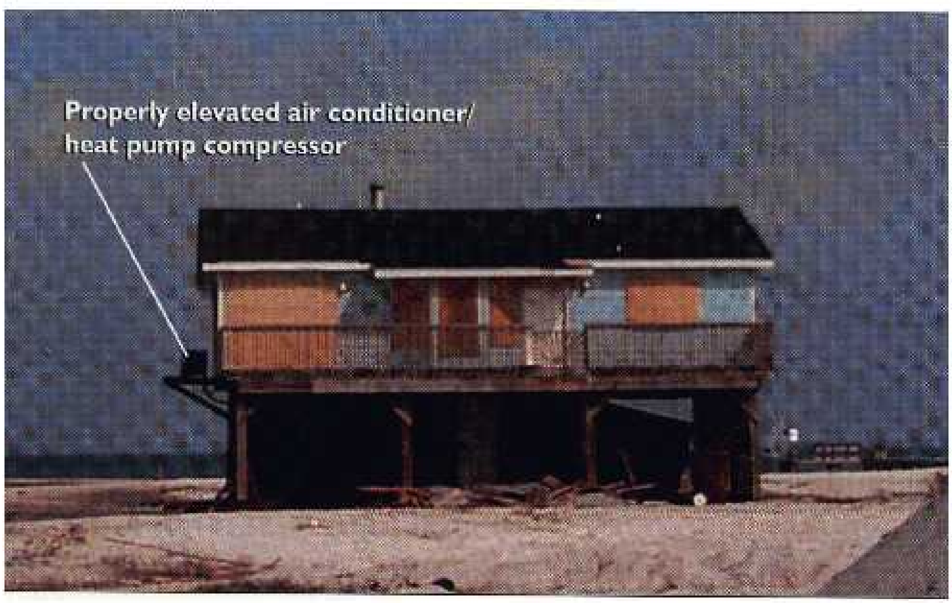

FIGURE 4-22 **This cantilever platform performed well.**

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.