Mitigation Assessment Team Report

Hurricane Ian in Florida

Building Performance Observations, Recommendations, and Technical Guidance

FEMA P-2342/December 2023

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Executive Summary

Hurricane Ian made landfall in southwestern Florida on the barrier island of Cayo Costa, FL, near Fort Myers on September 28, 2022, as a Category 4 hurricane with maximum sustained winds of 150 miles per hour (mph) over open water and a minimum pressure of 945 millibars (NHC 2023). It is (at time of publication) tied as the fourth strongest hurricane to make landfall on the continental United States based on wind speed on record over open water and was the ninth named storm of the 2022 Atlantic hurricane season (NCEI 2022).

Following its northeastern passage over the Florida peninsula, the hurricane experienced a decrease in intensity, subsequently transitioning into a tropical storm. However, the storm later passed over the Atlantic waters east of Florida and escalated into a Category 1 hurricane. The storm continued to travel north and made a second landfall near Georgetown, South Carolina, on September 30.

Hurricane Ian produced catastrophic storm surge, powerful winds, and unprecedented freshwater flooding that caused considerable damage throughout central and northern Florida and significant harm to the region's infrastructure and communities (NHC 2023).

The storm resulted in the loss of over 150 lives and significant economic damage exceeding $112 billion, making it the costliest hurricane to strike the State of Florida and the third costliest in United States history. Approximately 3.28 million customers in Florida were left without power, and an additional 1.7 million customers in six other states lost power (NHC 2023).

Mitigation Assessment Team Deployment

Approximately 14 days after Hurricane Ian struck the Florida coast, the Federal Emergency Management Agency (FEMA) deployed a pre-Mitigation Assessment Team (pre-MAT) on October 11–15, 2022, to perform a preliminary field assessment of building damage in limited areas of Charlotte, Collier, DeSoto, Highlands, Lake, Lee, Orange, Osceola, Sarasota, Seminole, and Volusia Counties.

Following the pre-MAT, in response to a request for technical support from the Joint Field Office, FEMA deployed the full MAT in January 2023 to assess the performance of buildings and building-related damage from Hurricane Ian. A MAT conducts building performance assessments of buildings and related infrastructure to determine both the causes of damage and results of successful mitigation. It also recommends actions that federal, state, and local governments; building officials and floodplain administrators and regulators; the design and construction industry; building code and standard organizations; academia; emergency managers; building owners and operators; or other stakeholders can take to mitigate damage from future natural hazard events.

The MAT was deployed on January 15–25, 2023, 110 days after the storm made landfall, which is outside the preferred 30- to 45-day window following an event. During the 110 days between Ian's landfall and the MAT deployment, many areas had already initiated the process of rebuilding and repairing. Some sites and structures were demolished, while many buildings, roofs, windows, doors, and walls, among other systems, were either already repaired, being repaired, or temporarily covered with tarps, hindering thorough observations. By the time the MAT arrived, a significant portion of the debris had already been cleared, which presented a challenge for the team to accurately distinguish between instances of repaired damage and successful building performance. Although the reduced data available as a result of the debris collection posed a challenge, the MAT was able to perform its primary mission of performing building assessments, drawing conclusions, and developing recommendations to improve building and community resilience to help strengthen nationwide capability for superior building performance.

This report outlines the observations of the MAT during field assessments carried out in Florida. The purpose of this report is to provide recommendations and conclusions based on these observations, with the objective of enhancing short-term recovery and long-term disaster resilience in the face of natural hazard events. The principal objectives of these recommendations are to improve building and community resilience and minimize the loss of life, injuries, and property damage that could result from future natural hazard events similar to Hurricane Ian.

Summary of Damage Observed by the MAT

Hurricane Ian caused extensive damage to residential and commercial buildings, infrastructure, critical facilities, and their associated utility systems. Additional long-term consequences include housing loss, damage to wastewater and potable water infrastructure, and various levels of erosion. The extent of the flooding and/or wind damage varied depending on building design, siting, and construction.

Flood – Hurricane Ian storm surge caused extensive flood damage to residential, commercial, public, and private infrastructure. The storm surge in Fort Myers Beach ranged between 10 to 15 feet above ground level. Significant storm surge was experienced along the northeast coast of Florida and South Carolina during Hurricane Ian's final landfall. The maximum reported total rainfall for the storm was approximately 27 inches in Grove City, just north of where Hurricane Ian made landfall. Hurricane Ian high water marks exceeded the base flood elevation in numerous coastal locations.

Flood-related topics studied and observed by the MAT include the following:

- Comparison of coastal construction dating from the 1970s to that of the 2010s and beyond
- Performance of breakaway walls
- Performance of wet and dry floodproofing measures
- Performance of grant projects
- Performance of decks and porches
- Scour and erosion
- Performance of coastal armoring and temporary coastal armoring measures
- Corrosion and deterioration of building components
- Flood-borne debris
- Comparison of building performance and nearby vegetation density
- Comparison of performance of *elevated* and *non-elevated buildings*
- Performance of commercial and multi-family buildings

Wind – Hurricane Ian was classified as a Category 4 Hurricane with estimated sustained winds of 150 mph over water when it made landfall on Cayo Costa, FL. However, estimated 3-second gust wind speeds in all areas visited by the MAT were well below the design-level, 3-second gust wind speeds specified by the 2020 Florida Building Code 7th Edition (FBC 2020) and American Society of Civil Engineers (ASCE) Standard 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 7-16) (ASCE 2017).

Wind-related topics studied and observed by the MAT include the performance of the following:

- Exterior soffits and installation methods
- Exterior wall coverings
- Windows and doors
- Roof coverings and underlayment
- Structural systems (main wind force resisting system)
- Manufactured homes

MAT wind observations focused on residential buildings built to the FBC (constructed post-FBC), but also included recent roof replacements on many pre-FBC buildings. Although structural observations were not a primary focus on the MAT, the MAT did not observe any structural damage caused by wind on post-FBC buildings in the areas visited, as expected since the Hurricane Ian wind speeds were far less than design level wind speeds. Wind-related structural damage to pre-FBC buildings was isolated to a few areas. However, failure of building envelope components was observed to some degree at all sites visited. The most common building envelope damage observed was roof covering failure, although the extent of damage varied significantly across all structures in the areas visited by the MAT.

Critical Facilities – The MAT critical facilities observations focused on hurricane evacuation shelters, hospitals and medical facilities, fire stations, police stations, and schools that were subjected to wind and flooding effects from Hurricane Ian. In addition to building performance observations, the MAT assessed operational performance of these facilities and documented how the facilities handled the loss of utility service, including the loss of potable water. The loss of potable water resulted in the evacuation of three hospitals in Lee County.

To mitigate potential flood damage of these critical facilities, mechanical and electrical equipment had been either elevated or located in dry-floodproofed areas. Where water infiltration from flooding did occur, materials in wet-floodproofed areas and most materials in dry-floodproofed areas did not require replacement because they were flood damage-resistant. The majority of damage to electrical equipment was limited to minor electrical components; critical electrical equipment was observed to be elevated above flood levels to prevent damage.

All the critical facilities visited experienced wind loads that were well below the 7th Edition (2020) FBC and ASCE 7-16 design wind speeds for Risk Category IV (essential facilities) structures. The high winds of the storm resulted in varying roof covering damage and evidence of water infiltration through the damaged roof coverings and other building envelope components from wind-driven rain.

In some instances, the water infiltration led to damage to utilities and electrical components and even loss of power.

MAT Recommendations

The recommendations presented in this report were developed based on the MAT’s field observations and informed by the MAT members’ expertise. The recommendations are directed to design professionals, contractors, building officials, facility managers, floodplain administrators, regulators, emergency managers, building owners and operators, academia, select industries and associations, local officials, planners, FEMA, and other interested stakeholders.

Table of Contents

1. Introduction 1-1
  1.1. Organization of Report 1-5
  1.2. BSDS Program 1-5
    1.2.1. Importance of BSDS Program Efforts 1-6
    1.2.2. Regional Response Coordination Center Building Science Liaison 1-7
  1.3. BSDS Program's Mitigation Assessment Team 1-8
  1.4. Hurricane Ian MAT 1-9
  1.5. Hurricane Ian: The Event 1-9
  1.6. Hurricane Ian: The Impact 1-12
    1.6.1. Coastal Storm Surge Flooding 1-15
    1.6.2. Rainfall and Flooding 1-19
    1.6.3. Wind 1-21
    1.6.4. Hurricane Ian versus Hurricane Charley 1-22

2. Building Codes, Standards, and Regulations 2-1
  2.1. Building Codes in Florida and the Florida Building Commission 2-1
    2.1.1. Florida Building Commission 2-3
  2.2. Floodplain Management in Florida 2-6
    2.2.1. History of Flood Provisions in the Florida Building Code 2-8
    2.2.2. Flood Provisions in the Florida Building Code 2-9
    2.2.3. Local Amendments to the Flood Provisions of the FBC 2-12
    2.2.4. Other Local Requirements 2-15
    2.2.5. Coastal Construction Requirements 2-17
    2.2.6. Coastal Construction Control Line 2-17
  2.3. Key Wind Provisions of the Florida Building Code 2-19
    2.3.1. Wind Loads and Wind Design in the FBC 2-20
    2.3.2. Wind-Borne Debris Region 2-24
    2.3.3. Florida-Specific Amendments for Wind and Water Intrusion 2-25
    2.3.4. Reroofing and the 25% Rule in the FBC 2-28
  2.4. Florida Evacuation Shelter Program 2-29
    2.4.1. Enhanced Hurricane Protection Areas in the Florida Building Code 2-29
    2.4.2. State Emergency Shelter Plan Options: EHPA or Retrofit 2-30
  2.5. Manufactured Home Requirements (HUD) 2-31
  2.6. Disaster Recovery Reform Act 1206 Policy 2-34

3. Flood-Related Observations 3-1
  3.1. Comparison of Coastal Construction in the 1970s and 2010s 3-8
  3.2. Performance of Breakaway Walls 3-13
  3.3. Performance of Decks and Porches 3-18
  3.4. Scour and Erosion 3-22

- 3.4.1. Fort Myers Beach 3-22
- 3.4.2. Sanibel Island 3-23
- 3.4.3. Bonita Beach 3-26
- 3.4.4. Matlacha 3-27
- 3.4.5. Wilbur-By-The-Sea/Port Orange 3-29

3.5. Coastal Armoring 3-34
- 3.5.1. Coastal Armoring Performance 3-34
- 3.5.2. Temporary Erosion Control Measures 3-38

3.6. Corrosion and Deterioration of Building Components 3-42

3.7. Flood-Borne Debris 3-43

3.8. Comparison of Building Performance and Vegetation Density 3-49

3.9. Comparison of Elevated and Non-Elevated Single-Family Houses 3-54
- 3.9.1. Comparison of Hurricane Ian NFIP Insurance Claims in Representative Areas 3-60

3.10. Performance of Commercial and Multi-Family Buildings 3-68
- 3.10.1. Dry Floodproofed Buildings 3-71
- 3.10.2. Multi-Family Apartments and Mixed-Use Buildings in Naples 3-83
- 3.10.3. Fort Myers Beach Library 3-88
- 3.10.4. Jerry’s Food Center in Sanibel Island 3-92
- 3.10.5. Luminary Hotel in Fort Myers 3-96
- 3.10.6. Chapel by the Sea Presbyterian Church in Fort Myers Beach 3-98
- 3.10.7. Biomat USA Plasma Center in Kissimmee 3-104
- 3.10.8. Public Restrooms 3-106

3.11. Performance of Manufactured Homes 3-113
- 3.11.1. North Fort Myers – Old Bridge Village 3-115
- 3.11.2. San Carlos Island – Port Carlos Cove 3-125
- 3.11.3. Fort Myers Beach – Gulf View Colony 3-131
- 3.11.4. Naples – Land Yacht Harbor 3-134

4. Wind-Related Observations 4-1

4.1. Estimated Wind Speeds/Design Wind Speeds 4-1

4.2. Building Envelope 4-2
- 4.2.1. Exterior Soffits 4-2
- 4.2.2. Exterior Wall Coverings 4-6
- 4.2.3. Windows and Doors 4-8
- 4.2.4. Roof Coverings 4-12

4.3. Structural Systems 4-46

4.4. Manufactured Homes 4-49
- 4.4.1. Post-HUD Construction Performance versus Older Manufactured Homes 4-50
- 4.4.2. Appurtenance Damage to Post-HUD Manufactured Homes 4-54
- 4.4.3. Anchoring 4-58

5. Critical Facility–Related Observations ... 5-1
- 5.1. Utilities ... 5-4
  - 5.1.1. Loss of Potable Water ... 5-5
  - 5.1.2. Loss of Sewage Service ... 5-6
- 5.2. Health Care ... 5-8
  - 5.2.1. Loss of Potable Water/Need to Evacuate ... 5-8
  - 5.2.2. Building Performance ... 5-10
- 5.3. Hurricane Evacuation Shelters ... 5-23
  - 5.3.1. Building Performance and the Shelter Deficit ... 5-28
  - 5.3.2. Operational Challenges ... 5-45
- 5.4. Fire Stations ... 5-47
  - 5.4.1. Flood Performance ... 5-48
  - 5.4.2. Wind Performance ... 5-77
- 5.5. Police Stations ... 5-97
  - 5.5.1. Naples Police Department ... 5-97
- 5.6. Schools ... 5-99
  - 5.6.1. Everglades City School ... 5-99

6. Conclusions and Recommendations ... 6-1
- 6.1. Overview of Conclusions and Recommendations ... 6-1
- 6.2. Floodplain Management and Flood-Related Building Codes, Standards, and Regulations Conclusions and Recommendations ... 6-2
- 6.3. Wind-Related Building Codes, Standards, and Regulations Conclusions and Recommendations ... 6-9
- 6.4. Manufactured Homes-Related Conclusions and Recommendations ... 6-11
- 6.5. Flood-Related Building Performance Conclusions and Recommendations ... 6-14
- 6.6. Wind-Related Building Performance Conclusions and Recommendations ... 6-18
- 6.7. Critical Facility– and Sheltering-Related Conclusions and Recommendations ... 6-20
- 6.8. Crosswalk/Matrix of Conclusions and Recommendations with MAT Observations ... 6-31

Figures

Figure 1-1: Pre-MAT areas visited ... 1-2
Figure 1-2: MAT area of focus / counties visited by the MAT ... 1-3
Figure 1-3: Hurricane Ian tracks ... 1-10
Figure 1-4: Power outage satellite imagery (left: August 2022, right: September 30, 2022) ... 1-15
Figure 1-5: USGS HWMs ... 1-18
Figure 1-6: Estimated return period for Hurricane Ian HWMs ... 1-19
Figure 1-7: Rainfall Totals for Hurricane Ian ... 1-20
Figure 1-8: Hurricane Ian wind speeds vs design wind speeds ... 1-22
Figure 1-9: Hurricane Charley (left) vs Hurricane Ian (right) ... 1-23
Figure 1-10: Hurricane Ian vs Charley landfall and path comparisons ... 1-24
Figure 2-1: FBC and local regulations meet or exceed the NFIP requirements ... 2-9

Figure 2-2: Wind speed map for Risk Category II buildings and other structures 2-21
Figure 2-3: Wind speed map for Risk Category III buildings and other structures 2-22
Figure 2-4: Wind speed map for Risk Category IV buildings and other structures 2-23
Figure 2-5: Wind speed map and WBDR for FBCR buildings 2-24
Figure 2-6: Basic wind speed map for manufactured homes 2-32
Figure 2-7: Typical ground anchor supports for HUD Zone I manufactured homes (top) and HUD Zone II and Zone III manufactured homes (bottom) 2-33
Figure 3-1: Lee County's Hurricane Ian Initial Damage Assessment Dashboard 3-1
Figure 3-2: Example FDEP Office of Resilience and Coastal Protection videography 3-2
Figure 3-3: Example NSF StEER streetview imagery (Lee County, Zone VE) 3-2
Figure 3-4: House in the process of being elevated (Volusia County, Zone AE) 3-4
Figure 3-5: View of house elevation foundation preparation and support cribbing 3-5
Figure 3-6: House destroyed by fire spread from an EV fire in a neighboring house (Lee County, Zone AE and VE) 3-6
Figure 3-7: Graph of quantity of construction and demolition debris loads from developed parcels versus year built 3-7
Figure 3-8: Two houses, one constructed in the 1970s (left) and one constructed in the 2010s (right) 3-9
Figure 3-9: New concrete construction on coast (#1) could have provided shelter against waves to older, vulnerable structure (#3) on Fort Myers Beach (Lee County, Zone VE) 3-11
Figure 3-10: Large CMU structure on Sanibel Island (Lee County, Zone VE, Seaward of CCCL) 3-12
Figure 3-11: Large CMU structures on Bonita Beach (Lee County, Zone VE, Seaward of CCCL) 3-13
Figure 3-12: CMU breakaway wall in Fort Myers Beach (Lee County, Zone VE, Seaward of CCCL) 3-14
Figure 3-13: Comparison of nearby breakaway walls in Fort Myers Beach (Lee County, Zone VE, Seaward of the CCCL) 3-15
Figure 3-14: Partial failure of shore-parallel breakaway wall on Sanibel Island (Lee County, Zone VE, Seaward of CCCL) 3-16
Figure 3-15: Partial failure of shore-perpendicular breakaway wall on Sanibel Island (Lee County, Zone VE, Seaward of CCCL) 3-17
Figure 3-16: Staging of repairs to CMU breakaway walls in Bonita Beach (Lee County, Zone VE, Seaward of CCCL) 3-18
Figure 3-17: Single-family house (built in 1982) in Bonita Springs with porch damage and structural damage to column (Lee County, Zone VE, Seaward of the CCCL) 3-20
Figure 3-18: Structure (built in 2022) in Fort Myers Beach with damaged porch that cleanly separated from the main structure (Lee County, Zone VE, Seaward of the CCCL) 3-21
Figure 3-19: Single-family houses built in 2000 (left) and 1994 (right) in Fort Myers Beach with intact decks and porches (Lee County, Zone VE, Seaward of the CCCL) 3-22
Figure 3-20: Frangible concrete slabs breaking up as intended due to the erosion of sand supporting them on Fort Myers Beach (Lee County, Zone AE, Seaward of CCCL) 3-23
Figure 3-21: Scour channel depiction, captured October 2, 2022 3-24
Figure 3-22: Scour channel and debris near deep pile foundation (Lee County, Zone VE, Seaward of CCCL) 3-24
Figure 3-23: Imagery of the scour channel location before (left) and after (right) Hurricane Ian 3-25
Figure 3-24: Scour resulting in the collapse of a platform supporting an air conditioning unit 3-25
Figure 3-25: Scour beside and under houses in Bonita Beach (Lee County, Zone VE, Seaward of CCCL) 3-26

Figure 3-26: Photos before and after Hurricane Ian depicting significant scour on Bonita Beach (Lee County, Zone VE, Seaward of CCCL) 3-26
Figure 3-27: Scour surrounding a house and undermining the foundation in Matlacha (Lee County, Zone AE) 3-27
Figure 3-28: Map depicting the location of the house shown in Matlacha in Figure 3-27 3-28
Figure 3-29: Dune erosion, bulkhead failures, and impacts on multiple structures in Wilbur-by-the-Sea (Volusia County, Zone VE/Unshaded Zone X) 3-30
Figure 3-30: Map depicting the SFHA for the area shown in Figure 3-29 3-31
Figure 3-31: Dune erosion in Wilbur-by-the-Sea resulting in exposed foundation micropiles 3-31
Figure 3-32: 0.2-percent-annual-chance eroded profiles for the northern (left) and southern (right) transects on either side of Figure 3-31 3-32
Figure 3-33: Significant erosion occurred around and under the foundation of a condominium structure (Volusia County, Zone VE/Unshaded Zone X) 3-33
Figure 3-34: Failed coastal protection wall rotating seaward (Volusia County, Zone VE) 3-35
Figure 3-35: Corroded tie-back system of a coastal protection structure (Volusia County, Zone VE) 3-35
Figure 3-36: Example of exposed, newly installed, tie-back rods in Matlacha Isles (Lee County, Zone VE) 3-36
Figure 3-37: New seawall under construction after Hurricane Ian on Matlacha Isle (Lee County, Zone VE) 3-37
Figure 3-38: Emergency repairs to account for corroded tie-backs (Lee County, Zone VE) 3-38
Figure 3-39: Temporary erosion control installed along Daytona Beach Shores to help counteract further coastal erosion in an area where seawalls were destroyed (Volusia County) 3-39
Figure 3-40: Large sediment-filled bags used to counteract further coastal erosion along an area of Daytona Beach Shores where seawalls were destroyed (Volusia County) 3-40
Figure 3-41: Sediment-filled bags used to counteract further coastal erosion in an area of Port Orange where seawalls were destroyed (Volusia County) 3-41
Figure 3-42: Vertical vinyl sheet wall piles installed along Daytona Beach to replace destroyed seawalls (Volusia County) 3-41
Figure 3-43: Two locations on Fort Myers Beach with examples of rusted straps or ties 3-42
Figure 3-44: Deteriorated wood supports in Bonita Springs that failed during Hurricane Ian 3-43
Figure 3-45: Example of new hurricane ties installed near old, rusted ties on Sanibel Island 3-43
Figure 3-46: Overview of various displaced buildings on Fort Myers Beach 3-45
Figure 3-47: House with a failed porch and debris piled against the house in Fort Myers Beach (Lee County, Zone VE) 3-46
Figure 3-48: House with missing column and temporary support structure in Sanibel (Lee County, Zone VE, Seaward of CCCL) 3-47
Figure 3-49: Driftwood lying between the piles of a foundation without a structure in Sanibel (Lee County, Zone VE, Seaward of CCCL) 3-47
Figure 3-50: Examples of automobiles transported by flood waters 3-48
Figure 3-51: Before and after images of a houseboat that was transported by floodwater 3-48
Figure 3-52: Comparison of house performance on Sanibel (Zone VE/AE) 3-50
Figure 3-53: Two areas in Fort Myers Beach; Area B is surrounded by dense vegetation (Zone VE) 3-52
Figure 3-54: Enlarged views of pre- and post- Hurricane Ian imagery for the areas shown in Figure 3-53 3-53

Figure 3-55: Example of side-by-side construction that the MAT compared (Lee County, Zone AE) 3-54
Figure 3-56: Map of an area with different eras of construction for seven elevated single-family houses (Lee County, Zone VE/AE, seaward of the CCCL) 3-55
Figure 3-57: Seven elevated single-family houses in Lee County, built to different elevations 3-57
Figure 3-58: Field measurements of the four waterfront structures 3-58
Figure 3-59: Examples of damage observed for each of the three remaining waterfront structures 3-60
Figure 3-60: Locations of the representative areas 3-61
Figure 3-61: Estimated annual exceedance probability for Areas of Interest 2 through 12 3-62
Figure 3-62: Average building claim in *elevated* versus *non-elevated buildings* by decade 3-65
Figure 3-63: Average building flood insurance claim per square foot in *non-elevated buildings* versus depth of flooding 3-66
Figure 3-64: Downtown Naples (Collier County, Zone AE) 3-69
Figure 3-65: Anchors for active dry floodproofing measures on building in downtown Naples (Collier County, Zone AE) 3-70
Figure 3-66: Building elevated on fill and foundation walls in downtown Naples (Collier County, Zone AE) 3-70
Figure 3-67: Below-grade parking with elevated ramp access in the building elevated on fill and foundation walls (Collier County, Zone AE) 3-71
Figure 3-68: Dry floodproofed office building; note anchors on each side of door frame to support opening barriers (Collier County, Zone AE) 3-72
Figure 3-69: Dry floodproofed retail building; note anchors on each side of the window frame to support opening barriers (Collier County, Zone AE) 3-73
Figure 3-70: Office building where dry floodproofing measures were not deployed; note HWM (arrow) and posts for dry floodproofing measures (circled) (Collier County, Zone AE) 3-74
Figure 3-71: Opening barriers for an office building that were not deployed (Collier County, Zone AE) 3-75
Figure 3-72: Opening barriers for a post office facility that were not deployed (Collier County, Zone AE) 3-76
Figure 3-73: Mixed-use building with wet floodproofing measures (arrow) in residential access area and dry floodproofing measures (circle) in retail space/non-residential area (Collier County, Zone AE) 3-77
Figure 3-74: Inconsistent and counterproductive floodproofing measures in a mixed-use building (Collier County, Zone AE) 3-78
Figure 3-75: Fort Myers Beach Town Hall south-facing wall 2015 through present (Lee County, Zone AE) 3-79
Figure 3-76: Fort Myers Beach Town Hall south-facing wall following Hurricane Ian (Lee County, Zone AE) 3-80
Figure 3-77: November 2022 effective FIRM for Fort Myers Beach Town Hall (Lee County, Zone AE) 3-81
Figure 3-78: Dry floodproofing measures implemented (barriers circled) at Fort Myers Beach Town Hall (Lee County, Zone AE) 3-81
Figure 3-79: Dry floodproofing measures along north-facing wall at Fort Myers Beach Town Hall were blown out (Lee County, Zone AE) 3-82

Figure 3-80: Employee entrance door blown out by flood loads at Fort Myers Beach Town Hall (Lee County, Zone AE) 3-83
Figure 3-81: Mixed-use building with retail space and parking at grade, with residential apartments above (Collier County, Zone AE) 3-84
Figure 3-82: Older condominium complex to the left, newer building on the far right (Collier County, Zone AE) 3-85
Figure 3-83: The rear of an elevated on fill, mixed-use building with parking (Collier County, Zone AE) 3-86
Figure 3-84: Newer multi-family building with parking enclosure below DFE and residential apartments above (Collier County, Zone AE) 3-87
Figure 3-85: Multi-family building with parking and storage enclosures below the DFE along with elevated residential condominiums (Collier County, Zone AE) 3-88
Figure 3-86: FIRM for the Fort Myers Beach Library (Lee County, Zone AE) 3-89
Figure 3-87: Fort Myers Beach Library (Lee County, Zone AE) 3-90
Figure 3-88: HWM observed at the Fort Myers Beach Library lowest floor of the 1994 building (Lee County, Zone AE) 3-91
Figure 3-89: Representative interior flood damage within the 1994 portion of the Library (Lee County, Zone AE) 3-92
Figure 3-90: Jerry’s Food Center underground parking on Sanibel Island (Lee County, Zone AE) 3-93
Figure 3-91: A red pin designates the location of Jerry’s Food Center along with nearby diamond shaped USGS HWMs (Lee County, Zone AE) 3-94
Figure 3-92: Vaulted doors prevented floodwater from entering the equipment rooms (Lee County, Zone AE) 3-95
Figure 3-93: Ground level storage room was not floodproofed and sustained flood damage (Lee County, Zone AE) 3-96
Figure 3-94: Aerial of the Luminary Hotel with August 2008 FIRM flood zones effective at the time of its construction (Lee County, Zone AE) 3-97
Figure 3-95: Luminary Hotel in downtown Fort Myers along the Caloosahatchee River (Lee County, Zone AE) 3-98
Figure 3-96: Map of Chapel by the Sea and a nearby USGS HWM 3-100
Figure 3-97: Exterior water line marked (yellow arrow) at Chapel by the Sea 3-101
Figure 3-98: Overview of debris around Chapel by the Sea 3-102
Figure 3-99: Examples of observed damage at Chapel by the Sea 3-103
Figure 3-100: Damaged precast concrete floor panels at Chapel by the Sea 3-104
Figure 3-101: Location of Biomat USA Plasma Center and FIRM (Orange County, Zone AE) 3-105
Figure 3-102: Rear of shopping center where a 42-inch HWM was identified (Orange County, Zone AE) 3-106
Figure 3-103: HWMs on the exterior of public restroom in Vanderbilt Beach (Collier County, Zone AE, Seaward of CCCL) 3-107
Figure 3-104: Non-elevated restrooms on Bonita Beach at Little Hickory Island Beach Park (Lee County, Zone AE, Seaward of CCCL) 3-108
Figure 3-105: Public restroom facility in Sanibel Island at Lighthouse Beach Park (Lee County, Zone VE, Seaward of CCCL) 3-109
Figure 3-106: Elevated restrooms at the north end of Fort Myers Beach in the Bowditch Point Park (Lee County, Zone VE, Seaward of CCCL) 3-110
Figure 3-107: Destroyed elevated public restroom facility in Fort Myers Beach at Lynn Hall Memorial Park (Lee County, Zone VE, Seaward of CCCL) 3-111

Figure 3-108: Destroyed public restroom in Daytona Beach Shores (Volusia County, Zone VE, Seaward of CCCL) 3-112
Figure 3-109: Interior of destroyed public restroom in Daytona Beach Shores (Volusia County, Zone VE, Seaward of CCCL) 3-113
Figure 3-110: Manufactured home displaced from its foundation by flood loads (Lee County, Zone AE) 3-114
Figure 3-111: Manufactured home displaced from its foundation by flood loads (Lee County, Zone AE) 3-115
Figure 3-112: The 2008 FIRM in effect for the Old Bridge Village prior to Hurricane Ian (Lee County, Zone AE) 3-116
Figure 3-113: The November 2022 effective FIRM for the Old Bridge Village includes a LiMWA (Lee County, Zone AE & VE) 3-117
Figure 3-114: Typical manufactured home damage observed in Old Bridge Village (Lee County, Zone AE) 3-118
Figure 3-115: Common manufactured home interior finishing damage observed in Old Bridge Village (Lee County, Zone AE) 3-119
Figure 3-116: Manufactured home unreinforced pier (dry-stacked block) wedges displaced (red circle) during Hurricane Ian flooding (Lee County, Zone AE) 3-120
Figure 3-117: Damaged tie downs, unreinforced masonry piers, and skirting below a manufactured home in Old Bridge Village (Lee County, Zone AE) 3-121
Figure 3-118: 2019 Elevated manufactured home in the Old Bridge Village with no foundation damage and primary flood damage limited to crawlspace and storage unit (Lee County, Zone AE) 3-122
Figure 3-119: Map of the Adam Drive area (Lee County, Zone AE & VE) 3-123
Figure 3-120: Representative manufactured home along Adam Drive that performed well, elevated approximately 3 feet above ground (Lee County, Zone AE) 3-124
Figure 3-121: Representative manufactured home along Adam Drive that had interior flood damage, elevated approximately 1 foot above ground (Lee County, Zone AE) 3-124
Figure 3-122: Representative manufactured home along Adam Drive that had interior flood damage, elevated approximately 2 feet above ground (Lee County, Zone AE) 3-125
Figure 3-123: FIRM data from 2008 for Port Carlos Cove (Lee County, Zone VE & AE) 3-126
Figure 3-124: New 2022 FIRM for Port Carlos Cove that went into effect after Hurricane Ian (Lee County, Zone VE) 3-127
Figure 3-125: HWM near ceiling in Port Carlos Cove manufactured home (Lee County, Zone VE) 3-128
Figure 3-126: Representative interior damage in the office building for Port Carlos Cove (Lee County, Zone VE) 3-129
Figure 3-127: Prior to Hurricane Ian, this manufactured home was elevated on unreinforced hollow-core masonry block piers approximately 4 feet above grade (Lee County, Zone VE) 3-130
Figure 3-128: Lowest floor elevation differences, measured in multiple feet, were common in newer manufactured homes on Port Carlos Cove (Lee County, Zone AE) 3-131
Figure 3-129: FIRM data from 2008 for Gulf View Colony and the Red Coconut Recreational Vehicle Park (Lee County, Zone VE & AE) 3-132
Figure 3-130: Before Hurricane Ian imagery of the Gulf View Colony and the Red Coconut Recreational Vehicle Park (Lee County, Zone VE & AE) 3-133
Figure 3-131: Post-Hurricane Ian imagery of Gulf View Colony and the Red Coconut Recreational Vehicle Park (Lee County, Zone VE & AE) 3-134

Figure 3-132: 2012 FIRM for the Naples Land Yacht Harbor Community in Naples, FL (Collier County, Zone AE) 3-135
Figure 3-133: Representative elevated manufactured home in the Naples Land Yacht Harbor Community (Collier County, Zone AE) 3-136
Figure 3-134: Empty lot where a manufactured home was demolished in the Naples Land Yacht Harbor Community (Collier County, Zone AE) 3-136
Figure 3-135: Representative waterfront properties in Naples Land Yacht Harbor, many of which received 18 inches or more of floodwater inside except where they were sufficiently elevated (Collier County, Zone AE) 3-137
Figure 3-136: Representative damage included interior damage as well as ductwork and heating, ventilation, and air conditioning (HVAC) replacement under and near manufactured homes (Collier County, Zone AE) 3-137
Figure 3-137: Elevated manufactured home on the left, elevated 6 inches above BFE, had no interior damage but ductwork had to be replaced (Collier County, Zone AE) 3-138
Figure 3-138: Representative foundation for newer elevated manufactured home in the Naples Land Yacht Harbor Community (Collier County, Zone AE) 3-138
Figure 4-1: Recommended vinyl soffit installation (Figure 4-26 of FEMA P-2077 [2020c]) 4-3
Figure 4-2: House built in 2015 with roof covering and vinyl soffits damage (estimated wind speed [EWS] = 103 mph; design wind speed [DWS] = 159 mph) (Fort Myers Beach) 4-4
Figure 4-3: Post-FBC house (built in 2021) with vinyl soffit damage exposing the sprayed foam insulation in the attic (EWS = 109 mph; DWS = 161 mph) (Sanibel) 4-5
Figure 4-4: A vinyl soffit panel spanning approximately 24 inches that blew off the 2021 residence in Figure 4-3 (EWS = 109 mph; DWS = 161 mph) (Sanibel) 4-6
Figure 4-5: A house built in 2014 with significant damage to the vinyl siding on the west side (EWS = 114 mph; DWS = 160 mph) (St. James City) 4-7
Figure 4-6: A house under construction with fiber cement siding failure (EWS = 104 mph; DWS = 160 mph) (Fort Myers Beach) 4-8
Figure 4-7: A house built in 2003 with glazed opening damage (EWS = 114 mph; DWS = 160 mph) (St. James City) 4-9
Figure 4-8: A house built in 2016 with glazed opening damage (EWS = 114 mph; DWS = 161 mph) (St. James City) 4-9
Figure 4-9: A house built in 2021 with two- and three-panel sliding glass doors that experienced significant water intrusion (EWS = 130 mph; DWS = 151 mph) (Punta Gorda) 4-11
Figure 4-10: A house built in 2021 with a two-panel sliding glass door that experienced significant water intrusion due to wind-driven rain (the two red circles identify weepholes that enable water to exit) (EWS = 130 mph; DWS = 151 mph) (Punta Gorda) 4-12
Figure 4-11: Hip and ridge damage on four residences with different roof types: a tile roof (top left), asphalt shingle roof (top right), metal panel roof (bottom left), and cedar shake roof (bottom right) 4-13
Figure 4-12: A house with an asphalt shingle roof that was replaced in December 2020, with no damage (EWS = 128 mph; DWS = 155 mph) (Placida) 4-14
Figure 4-13: NOAA imagery of asphalt shingle damage on houses adjacent to the house shown in Figure 4-12 (EWS = 128 mph) (Placida) 4-15

Figure 4-14: A house built in 2021 with significant asphalt shingle damage on the northeast roof slope (EWS = 127 mph; DWS = 150 mph). The inset above shows an aerial image of the house post-Hurricane Ian. (Port Charlotte)............ 4-16
Figure 4-15: An asphalt shingle roof that was replaced in 2022 with minor damage near the ridge (EWS = 128 mph; DWS = 150 mph) (Port Charlotte)............ 4-17
Figure 4-16: A house built in 2015 with severe asphalt shingle damage (EWS = 103; DWS = 159) (Fort Myers Beach)............ 4-17
Figure 4-17: A house built in 1974 with a roof replacement in October 2019 with minor shake damage below the balcony (EWS = 123 mph; DWS = 162 mph) (Captiva)............ 4-18
Figure 4-18: A house built in 1974 with an older roof covering with significant shake damage; large areas of the roof were covered with a synthetic underlayment to prevent further water intrusion (EWS = 123 mph) (Captiva)............ 4-19
Figure 4-19: A house built in 1974 with a roof replacement in December 2021 with minor shake damage at hips (EWS = 123 mph; DWS = 162 mph) (Captiva)............ 4-20
Figure 4-20: A house built in 1974 with a tile replacement in July 2020 with no visible damage (EWS = 123 mph, DWS = 162 mph) (Captiva)............ 4-20
Figure 4-21: A house with a tile roof that was replaced in August 2021 with minor damage near the eave (EWS = 126 mph; DWS = 155 mph) (Placida)............ 4-21
Figure 4-22: Roof tile damage to houses built in 1991/1992 with their original roof covering (EWS: 126 mph) (Placida)............ 4-22
Figure 4-23: A house constructed in 1973 with a tile roof that was replaced in August 2022 with minor damage (EWS = 120 mph) (Pine Island)............ 4-23
Figure 4-24: Neighborhood built in 2020 and 2021 with tile roof coverings with minor and moderate damage (EWS = 126 mph; DWS = 153 mph) (Port Charlotte)............ 4-24
Figure 4-25: Typical hip cover damage on a metal panel roof (EWS: 115 mph; DWS: 161 mph) (St. James City)............ 4-25
Figure 4-26: A house built in 2015 with a through-fastened metal roof with no damage observed (EWS = 120 mph; DWS = 160 mph) (Placida)............ 4-25
Figure 4-27: A house with a standing seam metal panel roof that was replaced in 2018 with severe damage (EWS = 115 mph; DWS = 161 mph) (St. James City)............ 4-26
Figure 4-28: Metal panel roof cover damage on roofs that were recently replaced (EWS: 115 mph; DWS: 160 mph) (St. James City)............ 4-27
Figure 4-29: Limited amounts of interior contents by curbs in a Punta Gorda neighborhood (photo taken October 13, 2022) (EWS = 127 mph)............ 4-28
Figure 4-30: Roof underlayment requirements of the 5th Edition (2014) FBC............ 4-30
Figure 4-31: Cluster 1 for roof covering performance analysis; buildings built or reroofed since June 2015 shown with green stars and homes with additional images outlined in red (EWS = 127 mph) (Port Charlotte)............ 4-31
Figure 4-32: A house built post-2020 with asphalt shingle roof and photovoltaic panels; no damage observed (located in the Port Charlotte neighborhood in Figure 4-31) (EWS = 127 mph)............ 4-32
Figure 4-33: Houses with asphalt shingle roofs; top built in 1984 and reroofed in 2022 (no damage observed); middle built in 1984 (damaged observed on NOAA imagery); bottom built in 1990 (damage observed on NOAA imagery) (located in the Port Charlotte neighborhood in Figure 4-31) (EWS = 127 mph)............ 4-33
Figure 4-34: A house with asphalt shingle roof damage and tarp to help temporarily prevent water infiltration); built 1984 and reroofed in April 2022 (located in the Port Charlotte neighborhood in Figure 4-31) (EWS = 127 mph)............ 4-34

Figure 4-35: Cluster 2 for roof covering performance analysis; buildings built or reroofed since June 2015 shown with green stars (EWS = 128 mph) (Port Charlotte) 4-35
Figure 4-36: A house with metal roof; built in 1984 and reroofed in May 2022 (damage to a few metal panels) (EWS = 128 mph) (Port Charlotte) 4-36
Figure 4-37: A house with asphalt shingle roof; built 1998 and reroofed August 2020 (minor hip shingle damage) (EWS = 128 mph) (Port Charlotte) 4-37
Figure 4-38: A house built in 2001 with a tile roof (tile damage as indicated by black tarp on the roof) (EWS = 128 mph) (Port Charlotte) 4-38
Figure 4-39: Roof tile damage on newer and older roofs (EWS = 126 mph) (Placida) 4-40
Figure 4-40: Mechanically fastened tile roof in Placida that was replaced in August 2021 (EWS = 126 mph) 4-41
Figure 4-41: Roof tile damage to older tile roofs in Placida (EWS = 126 mph) 4-42
Figure 4-42: Roof tile damage to a roof in Placida that was replaced in September 2019 (EWS = 126 mph) 4-42
Figure 4-43: Roof tile damage (EWS = 126 mph; DWS = 153 mph) (Port Charlotte) 4-44
Figure 4-44: A house built in 1975 with no observable roof covering damage, a “storm-related roof replacement” permit was issued post-Hurricane Ian (EWS = 128 mph) (Port Charlotte) 4-45
Figure 4-45: A house built in 2002 with an asphalt shingle roof replacement in 2019, with minor hip shingle damage, a “storm-related” roof replacement permit was issued post-Hurricane Ian (EWS = 128 mph) (Port Charlotte) 4-46
Figure 4-46: A Pre-FBC two-family home (built in 1990) with severe structural damage from wind (EWS = 113 mph) (St. James City) 4-47
Figure 4-47: A house built in 2022 just before the storm with no visible damage (EWS = 113 mph; DWS = 161 mph) (St. James City) 4-48
Figure 4-48: A multi-family condominium built in 1979 with wind damage to the roof and second-story side walls missing (EWS = 130 mph) (Boca Grande) 4-48
Figure 4-49: A house built in 2022 that had no visible signs of damage (EWS = 130 mph; DWS = 150 mph) (Boca Grande) 4-49
Figure 4-50: Structural damage to pre-HUD manufactured homes (EWS = 129 mph) (Lee County) 4-51
Figure 4-51: Roof covering, wall covering, and fascia damage to post-HUD manufactured home (EWS = 126 mph) (Charlotte County) 4-52
Figure 4-52: Wind-borne debris damage to glazing and non-rated impact protective system (left); aluminum clamshell shutters remain in place on adjacent wall of same post-HUD manufactured home (right) (EWS = 126 mph) (Charlotte County) 4-53
Figure 4-53: Post-HUD manufactured home with roof and wall covering damage (EWS = 118 mph) (Lee County) 4-53
Figure 4-54: A 2019 manufactured home where the loss of the carport damaged the main unit where it was attached, as indicated by the red rectangle (EWS = 126 mph) (Charlotte County) 4-55
Figure 4-55: 1999 manufactured home; damage to main unit from loss of the front section of the attached carport, as indicated by the red rectangle (EWS = 129 mph) (Charlotte County) 4-56
Figure 4-56: Pre-storm image of a 2014 manufactured home that appeared to be undamaged by destroyed carport (top); red arrows indicate posts remaining from lost carport (bottom) (EWS = 118 mph) (Lee County) 4-57

Figure 4-57: A 2005 manufactured home with damaged carport; red square shows where independent support column prevented damage from spreading to the main unit (EWS = 129 mph) (Charlotte County) 4-58
Figure 4-58: Manufactured home with shifted, unstable dry-stack pier foundation; observations included a HWM approximately 6 inches above the top of the finished floor (Lee County) 4-59
Figure 4-59: Overturned manufactured home that appeared to have been delivered but not yet permanently installed prior to the storm (EWS = 129 mph) (Lee County) 4-60
Figure 5-1: ASCE 7-16 Risk Category IV wind speeds compared with Hurricane Ian windfield 5-4
Figure 5-2: Broken above-grade potable water lines (Lee County) 5-5
Figure 5-3: At-grade sewer lift station repaired after Hurricane Ian (Charlotte County) 5-7
Figure 5-4: Potable water truck and pump supplemented on-site stormwater for operating HVAC equipment and flushing toilets (Lee County) 5-9
Figure 5-5: Superficial wind damage at hospitals (Lee County) 5-10
Figure 5-6: Location of Lee Memorial Hospital (red map pin) in the Hurricane Ian windfield 5-11
Figure 5-7: Damage to elevator penthouse at Lee Memorial Hospital (Lee County) 5-12
Figure 5-8: Flood damage at Medical Plaza One (Lee County, Zone AE) 5-13
Figure 5-9: Effective FIRM for Medical Plaza One location at the time of Hurricane Ian's landfall 5-14
Figure 5-10: Detached nailing strip over a stairwell (left) and damaged mansard envelope system (right) (Southwest Florida) 5-15
Figure 5-11: Damaged wet fire protection standpipe (left) that resulted in significant water intrusion and damaged exhaust fan and roof cover (right) (Southwest Florida) 5-15
Figure 5-12: Effective FIRM at the Life Care Center of Orlando location at the time of Hurricane Ian's landfall 5-17
Figure 5-13: Effective FIRM at the Osceola Regional Medical Center Trauma Center location at the time of Hurricane Ian's landfall 5-19
Figure 5-14: Osceola Regional Medical Center Trauma Center parking lots that were flooded (Osceola County, Zone AE) 5-20
Figure 5-15: Access roads at Osceola Regional Medical Center Trauma Center that flooded, isolating the hospital for 2 hours (Osceola County, Zone AE) 5-21
Figure 5-16: Osceola Regional Medical Center Trauma Center parking garage that had approximately 21 inches of water at ground level during Hurricane Ian (Osceola County, Zone AE) 5-22
Figure 5-17: Two helipads at Osceola Regional Medical Center Trauma Center that were submerged and inoperable for at least 2 hours during Hurricane Ian (Osceola County, Zone AE) 5-23
Figure 5-18: Florida shelter deficit by region (left) and by county (right) (FDEM 2022, modified) 5-29
Figure 5-19: Babcock Ranch High School fieldhouse / hurricane safe room (Charlotte County) 5-31
Figure 5-20: Location of Babcock Ranch High School fieldhouse (red map pin) in the Hurricane Ian windfield 5-32
Figure 5-21: Babcock Ranch safe room enclosure for generator and backup well (Charlotte County) 5-33
Figure 5-22: Location of Turner Agri-Civil Center (red map pin) in the Hurricane Ian windfield 5-35
Figure 5-23: Exterior (left) and interior (right) photos of the Turner Center (DeSoto County) 5-36
Figure 5-24: Comparison of damage to the Turner Center in Hurricane Charley versus Hurricane Ian (DeSoto County) 5-37
Figure 5-25: Generator at the Turner Center that failed during Hurricane Ian (DeSoto County) 5-38

Figure 5-26: Florida Special Needs shelter deficit by region (left) and by county (right) (FDEM 2022, modified) 5-41
Figure 5-27: 2022 Evacuation zones and public shelters in Lee County 5-44
Figure 5-28: Effective FIRM at the Fort Myers Beach Fire Station #33 location at the time of Hurricane Ian's landfall 5-49
Figure 5-29: Fort Myers Beach Fire Station #33 apparatus bay (left) and commercial and residential area (right) (Lee County, Zone AE)....... 5-50
Figure 5-30: Floorplan of Fire Station #33 showing wet floodproofed area, dry floodproofed-area, and dry-floodproofed and elevated area....... 5-50
Figure 5-31: Equipment elevated on a platform (Lee County, Zone AE) 5-51
Figure 5-32: Effective FIRM at the Fort Myers Beach Fire Station #32 location at the time of Hurricane Ian's landfall 5-53
Figure 5-33: Fort Myers Beach Fire Station #32, view looking southeast (Lee County, Zone AE) ... 5-54
Figure 5-34: Floodproofing measures implemented in Fire Station #32....... 5-55
Figure 5-35: Stop logs/flood barriers for the Main Entrance (Lee County, Zone AE) 5-56
Figure 5-36: Flood barrier fastening device (Lee County, Zone AE) 5-56
Figure 5-37: Stop logs / flood barriers stored on site when not in use (Lee County, Zone AE)....... 5-57
Figure 5-38: Elevated electrical service and distribution equipment on the mezzanine above the apparatus bay (Lee County, Zone AE) 5-58
Figure 5-39: Elevated standby generator (behind wall) (Lee County, Zone AE)....... 5-59
Figure 5-40: Elevated HVAC condensing units (Lee County, Zone AE) 5-60
Figure 5-41: Electrical utility meter that is not elevated nor protected by dry floodproofing (Lee County, Zone AE) 5-61
Figure 5-42: HWM observed by the MAT (Lee County, Zone AE) 5-62
Figure 5-43: Front door glazing damaged by floodwater (Lee County, Zone AE)....... 5-63
Figure 5-44: City of Naples Fire Station #1 (Collier County, Zone AE)....... 5-65
Figure 5-45: Effective FIRM at the City of Naples Fire Station #1 location at the time of Hurricane Ian's landfall 5-66
Figure 5-46: 28-inch HWM at City of Naples Fire Station #1 (Collier County, Zone AE)....... 5-67
Figure 5-47: Doors to City of Naples ICC 500 EOC (Collier County, Zone AE) 5-68
Figure 5-48: Effective FIRM at the Volusia County Fire Station #12 location at the time of Hurricane Ian's landfall 5-70
Figure 5-49: Volusia County Fire Station #12 (Volusia County)....... 5-71
Figure 5-50: Volusia County Fire Station #12 with generator on right, elevated above Hurricane Ian floodwaters (Volusia County)....... 5-71
Figure 5-51: Effective FIRM at the Everglades City Fire Station #60 location at the time of Hurricane Ian's landfall 5-73
Figure 5-52: Everglades City Fire Station #60 (Collier County, Zone AE)....... 5-74
Figure 5-53: Everglades City Fire Station #60 with an elevated generator in the foreground (Collier County, Zone AE) 5-75
Figure 5-54: Everglades City Fire Station #60 with HWM (Collier County, Zone AE)....... 5-76
Figure 5-55: Fort Myers Beach Fire Station #33 (Lee County) 5-78
Figure 5-56: Location of Fort Myers Beach Fire Station #33 (red map pin) in Hurricane Ian windfield 5-79
Figure 5-57: Roof-mounted exhaust fan lost during Hurricane Ian (Lee County)....... 5-80
Figure 5-58: ATS damaged during Hurricane Ian (Lee County) 5-81

Figure 5-59: Fort Myers Beach Fire Station #32 (Lee County) 5-82
Figure 5-60: Location of Fort Myers Beach Fire Station #32 (red map pin) in Hurricane Ian windfield 5-83
Figure 5-61: Door from dining area to balcony that blew open during Hurricane Ian (Lee County). 5-84
Figure 5-62: Receiving slot (left) is significantly larger than latching mechanism (right) (Lee County) 5-85
Figure 5-63: Displaced and rippled roof membrane (Lee County) 5-85
Figure 5-64: Third-floor panelboard that experienced water entry during Hurricane Ian (Lee County) 5-86
Figure 5-65: Roof cap for communication cables that was dislodged during Hurricane Ian (Lee County) 5-87
Figure 5-66: Charlotte County Fire Station #1 (Charlotte County) 5-89
Figure 5-67: Location of Charlotte County Fire Station #1 (red map pin) in Hurricane Ian windfield 5-90
Figure 5-68: Damaged coping above the apparatus bays (Charlotte County) 5-91
Figure 5-69: Damaged coping above the apparatus bays (Charlotte County) 5-92
Figure 5-70: Damage to apparatus bay door (Charlotte County) 5-93
Figure 5-71: Charlotte County Fire Station #12 (Charlotte County) 5-95
Figure 5-72: Location of Charlotte County Fire Station #12 (red map pin) in Hurricane Ian windfield 5-96
Figure 5-73: Effective FIRM at the Naples Police Department location at the time of Hurricane Ian's landfall 5-98
Figure 5-74: Naples Police Department with the 1999 addition in the foreground and the older 1978 structure in the background to the right (Collier County, Zone AE) 5-99
Figure 5-75: Effective 2012 FIRM at the Everglades City School location at the time of Hurricane Ian's landfall 5-101
Figure 5-76: Everglades City School flood protection system (Collier County, Zone AE) 5-102
Figure 5-77: Interior perimeter drainage measures at Everglades City School (Collier County, Zone AE) 5-103
Figure 5-78: Hurricane Ian HWM along the west side of Everglades City School (Collier County, Zone AE) 5-104

Tables

Table 1-1: Ten Costliest Hurricanes in the U.S. since 1980 1-11
Table 1-2: Florida County Evacuations 1-12
Table 1-3: Inundation Levels along Hurricane Ian's Path in Florida 1-17
Table 1-4: Maximum Reported Rainfall 1-20
Table 1-5: Hurricane Ian vs Hurricane Charley 1-24
Table 2-1: Notable Florida-Specific Amendments in the FBCB and FBCR for Wind and Water Intrusion 2-26
Table 3-1. Overview of HMA house elevation projects in Volusia County, FL 3-3
Table 3-2: Comparison of Debris Loads Collected by Lee County 3-7
Table 3-3: Comparison of Typical Elevated Houses along the Florida Coast, 1970s vs 2010s 3-9
Table 3-4: Summary of Applicable Flood Zone and CCCL Requirements for the Houses Shown in Figure 3-56 3-56

Table 3-5: Summary Table of Field Observations for Houses #1 through #5 3-59
Table 3-6: Comparison of Hurricane Ian NFIP Claims across Representative Areas by Decade 3-63
Table 3-7: Comparison of Hurricane Ian NFIP Claims across Representative Areas by *Elevated* versus *Non-elevated Building* Type 3-64
Table 3-8: Flood Zone and BFE Information for Various Years for the Chapel by the Sea Presbyterian Church Site 3-99
Table 3-9: Summary of Hurricane Ian NFIP Building and Contents Claims for Manufactured Homes along Adam Drive 3-123
Table 4-1: Summary of Roof Covering Damage in a Cluster 1 (Figure 4-31); Port Charlotte (EWS = 127 mph) 4-34
Table 4-2: Summary of Roof Covering Damage in Cluster 2 (Figure 4-35); Port Charlotte (EWS = 128 mph) 4-38
Table 4-3: Summary of Roof Covering Damage Observed by the MAT in All Clusters Impacted by Hurricane Ian 4-43
Table 5-1: Risk Category Comparison 5-3
Table 5-2: Shelter Terminology Comparison 5-24
Table 5-3: Design Criteria and Support System Requirement Comparison between Shelter Types 5-25
Table 5-4: Summary of Data Collected from HESs 5-27
Table 5-5: Age Distribution as a Percentage of Total Population by Location 5-43
Table 6-1: Chapter Organization 6-1
Table 6-2: Summary of Conclusions and Recommendations 6-32

Appendices

Appendix A: References
Appendix B: Recovery Advisories
Appendix C: Hurricane Ian NFIP Claims Analysis Technical Advisory
Appendix D: Acknowledgements

Acronyms and Abbreviations

AAMA	American Architectural Manufacturers Association
ADCIRC	Advanced Circulation
AGL	above ground level
AHCA	Agency for Health Care Administration
AHJ	Authority Having Jurisdiction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ARA	Applied Research Associates, Inc.
ARC HESSS	American Red Cross *Standards for Hurricane Evacuation Shelter Selection*
ARMA	Asphalt Roofing Manufacturers Association
ASCE	American Society of Civil Engineers
ASTM	ASTM International
ATC	Applied Technology Council
ATS	automatic transfer switch
AWC	American Wood Council
BFE	base flood elevation
BOAF	Building Officials Association of Florida
BSDS	Building Science Disaster Support
C&C	components and cladding
C&D	construction and demolition
CAC	Community Assistance Contact
CAP-SSSE	Community Assistance Program State Support Services Element
CAV	Community Assistance Visit
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System

CCCL	Coastal Construction Control Line
CCU	Cape Coral Utilities
CERA	Coastal Emergency Risks Assessment
CFR	Code of Federal Regulations
CMU	concrete masonry unit
COVID-19	coronavirus disease 2019
CRS	Community Rating System
CSA	Canadian Standards Association
DFE	design flood elevation
DHS	Department of Homeland Security
DP	design pressure
DRRA	Disaster Recovery Reform Act
DWS	design wind speed
EHPA	Enhanced Hurricane Protection Area
EL	Elevation
EMAC	Emergency Management Assistance Compact
EOC	emergency operations center
ER	emergency room
ESF	Emergency Support Function
EV	electric vehicle
EWS	estimated wind speed
FBC	Florida Building Code
FBCA	Florida Building Code, Accessibility
FBCB	Florida Building Code, Building
FBCEB	Florida Building Code, Existing Building
FBCEC	Florida Building Code, Energy Conservation

FBCFG	Florida Building Code, Fuel Gas
FBCM	Florida Building Code, Mechanical
FBCP	Florida Building Code, Plumbing
FBCR	Florida Building Code, Residential
FDCA	Florida Department of Community Affairs
FDEM	Florida Division of Emergency Management
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
FFMA	Florida Floodplain Managers Association
FFRMS	Federal Flood Risk Management Standard
FGIO	Florida Geographic Information Office
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FlaWARN	Florida Water/Wastewater Agency Response Network
FPE	Flood Protection Elevation
GIS	geographic information system
HES	hurricane evacuation shelter
HMA	Hazard Mitigation Assistance
HQ	headquarters
HUD	U.S. Department of Housing and Urban Development
HVAC	heating, ventilation, and air conditioning
HVHZ	High-Velocity Hurricane Zone
HWM	high water mark
IBC	International Building Code
IBHS	Insurance Institute for Business and Home Safety
ICC	International Code Council

I-Codes®	International Codes®
IRC	International Residential Code
Joint LMS	Joint Local Mitigation Strategy
LiMWA	Limit of Moderate Wave Action
LP	liquid propane
MAT	Mitigation Assessment Team
mb	millibars
MCA	Metal Construction Association
MEP	mechanical, electrical, and plumbing
MHCSS	Manufactured Home Construction and Safety Standards
mph	miles per hour
MRI	mean recurrence interval
MWFRS	main wind force resisting system
NAVD 88	North American Vertical Datum of 1988
n.d.	no date
NDRF	National Disaster Recovery Framework
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NGVD 29	National Geodetic Vertical Datum of 1929
NIST	National Institute of Standards and Technology
NOA	Notice of Acceptance
NOAA	National Oceanic and Atmospheric Administration
NRCA	National Roofing Contractors Association
NSF	National Science Foundation
NSSA	National Storm Shelter Association
O&M	operations and maintenance

OFAs	other federal agencies
OFM	Office of Floodplain Management
OPA	Otherwise Protected Area
PG	Performance Grade
pre-MAT	pre-Mitigation Assessment Team
psf	pounds per square foot
psi	pounds per square inch
RPC	Regional Planning Council
RRCC	Regional Response Coordination Center
RSF	Recovery Support Function
RTF	Recovery Task Force
RV	recreational vehicle
SESP	Statewide Emergency Shelter Plan
SFHA	Special Flood Hazard Area
SLR	sea level rise
SLTT	state, local, tribal, and territorial
SME	subject matter expert
StEER Network	Structural Extreme Events Reconnaissance Network
TAC	Technical Advisory Committee
TAS	Testing Application Standard
USACE	U.S. Army Corps of Engineers
USFA	U.S. Fire Administration
USGS	U.S. Geological Survey
WBDR	wind-borne debris region
WFCM	Wood Frame Construction Manual
WDMA	Window and Door Manufacturers Association

1. Introduction

Hurricane Ian was the costliest hurricane in Florida's history and the third costliest in United States history, after accounting for inflation adjustments, with over $112 billion in damages according to the Hurricane Ian Tropical Cyclone report (NHC 2023). Hurricane Ian had 150-mile-per-hour (mph) sustained winds over water before making landfall and is tied with the 1919 Florida Keys Hurricane and Hurricane Charley in 2004 as the fourth strongest landfalling hurricane to hit Florida. Hurricane Michael in 2018, Hurricane Andrew in 1992, and the 1935 Labor Day Hurricane were stronger in comparison with 1-minute average maximum sustained wind speeds of 160 mph, 165 mph, and 185 mph, respectively (NCEI 2022).

Hurricane Ian Wind Speeds

The wind speeds referenced in this chapter, unless noted otherwise, are based on measurements taken by the National Oceanic Atmospheric Administration (NOAA) at higher elevations and over water.

In response to the disaster and a request for assistance, the President issued a major disaster declaration (DR-4673-FL) for the State of Florida on September 29, 2022. Part of the response involved deploying the Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA) Building Science Disaster Support (BSDS) Program's Mitigation Assessment Team (MAT) to assess the performance of buildings and the damage resulting from the hurricane. MATs are composed of national and regional experts in building science and other relevant disciplines who assess building performance after a disaster. These subject matter experts (SMEs) draw conclusions from observations and develop actionable recommendations for improving the resilience of new construction and performing repairs and retrofits of existing buildings and their associated utility systems. As part of the BSDS Program, the MAT also makes recommendations to various industries, other federal agencies (OFAs), and state, local, tribal, and territorial (SLTT) governments; provides guidance, training, outreach, and education to manufacturers, building owners and operators, planners, building code officials, designers, and contractors, among others; and helps determine knowledge, research, or operational gaps and needs for FEMA or impacted stakeholders to address or enhance their policies, operations, grant effectiveness, or other efforts to improve building and community resilience.

A pre-Mitigation Assessment Team (pre-MAT) consisting of a small team of SMEs was deployed to regions affected by Hurricane Ian from October 11–15, 2022. This team observed post-hurricane damage to structures and conducted a preliminary assessment of building performance across the affected areas. The pre-MAT team identified areas that sustained damage from Hurricane Ian and recommended more in-depth assessments on building performance and locations, as shown in Figure 1-1, to develop potential topics that would be further studied by the full MAT deployment. The blue "Ian PreMAT GPX Lines" represent areas visited by the pre-MAT team, whereas the dashed "Ian Storm Track" shows the travel path of Hurricane Ian.

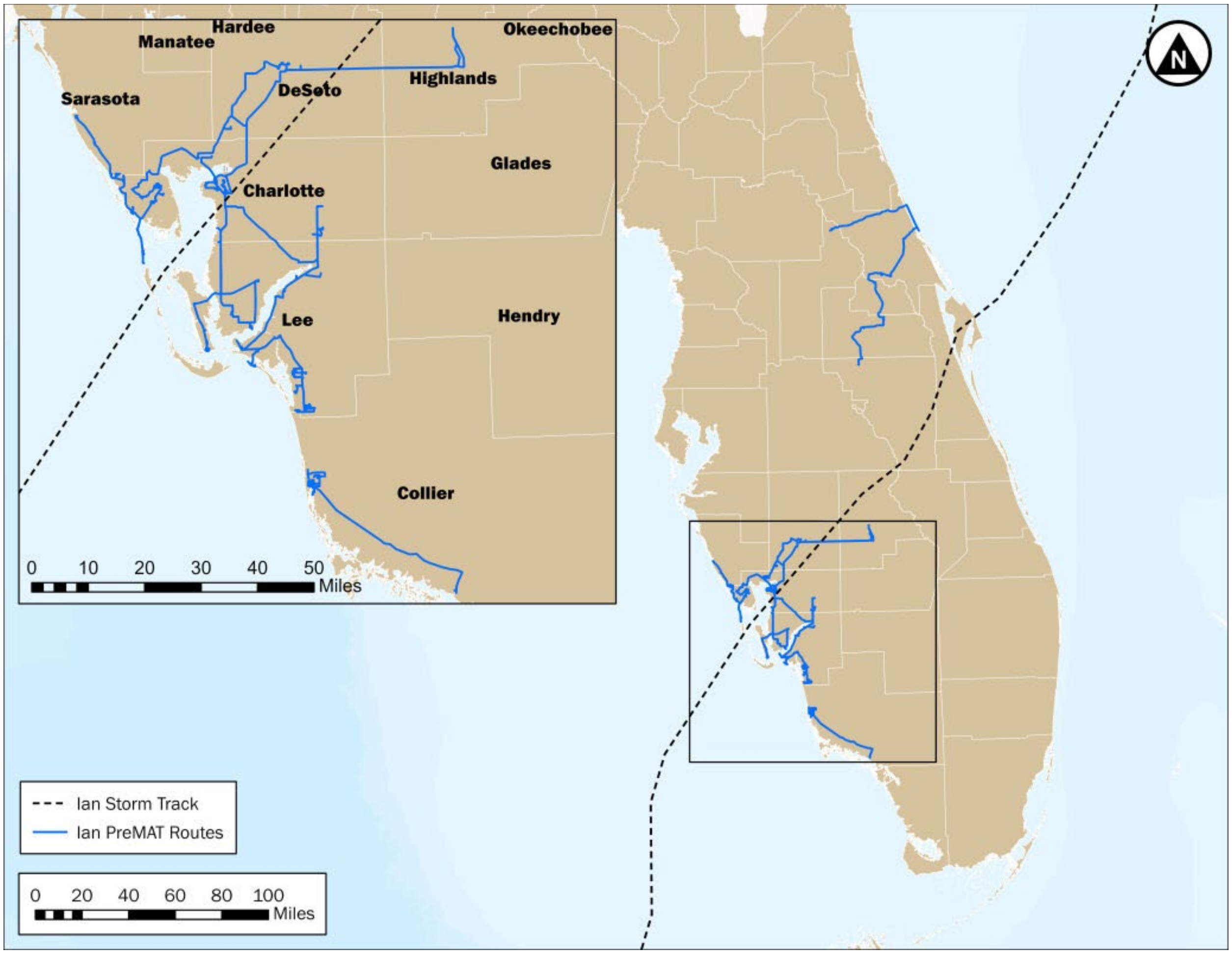

Figure 1-1: Pre-MAT areas visited

After successful outbriefs on pre-MAT activities, coordination among FEMA and state staff, and funding approval from the Federal Coordinating Officer at the Joint Field Office, as well as Joint Field Office, Region 4, and Headquarters (HQ) contract actions and award, a full MAT was deployed January 15–25, 2023, to further assess select building-related damage from Hurricane Ian. The MAT was split into four smaller teams based on individual focus areas: Coastal Flood, Flood, Wind, and Critical Facilities. These teams gathered detailed information on the performance of buildings, and their associated utility systems, within those focus areas. Areas visited by the MAT are shown in Figure 1-2.

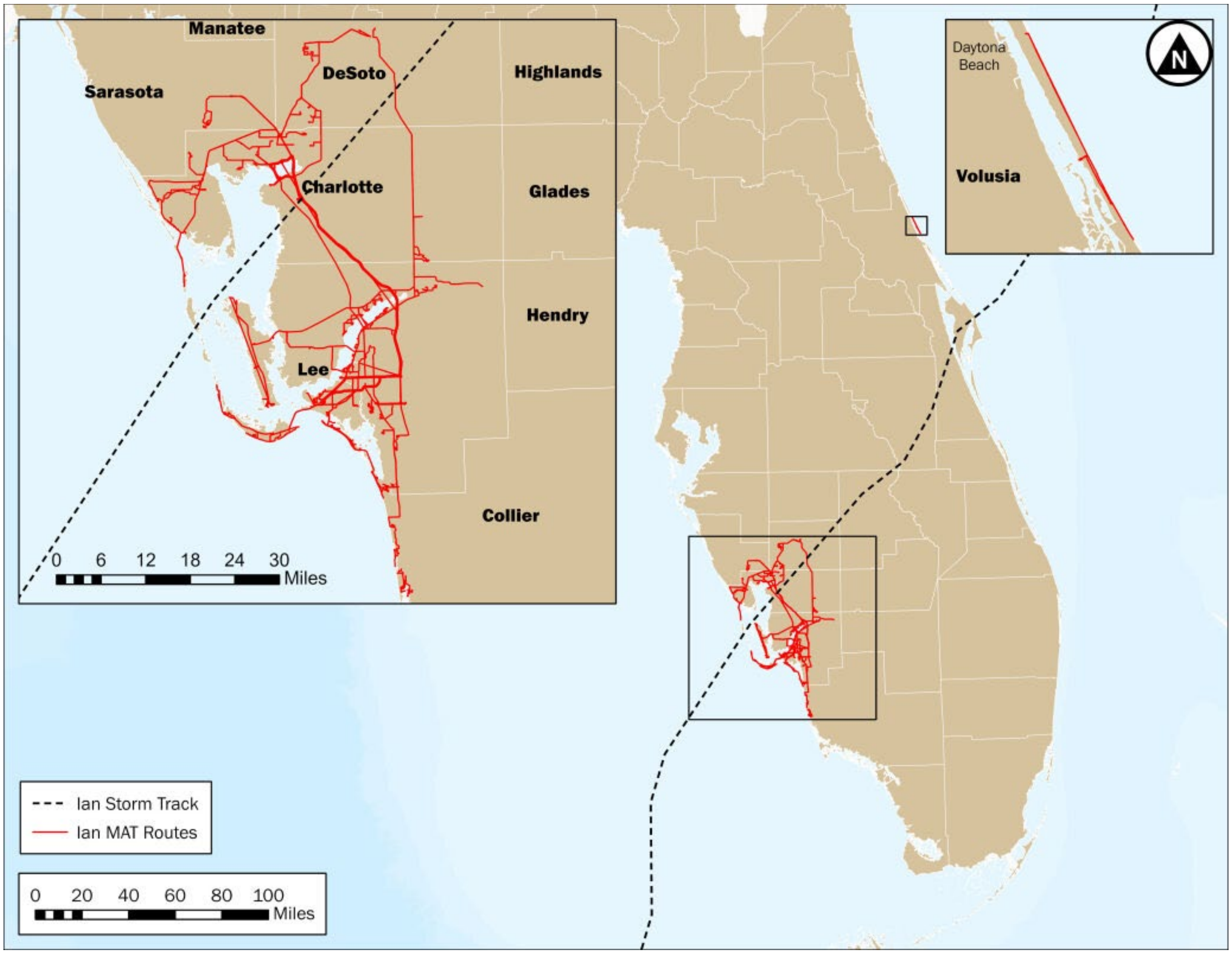

Figure 1-2: MAT area of focus / counties visited by the MAT

This report serves to provide detailed information on the MAT's observations during field assessments and the resulting conclusions and actionable recommendations based on those observations. The MAT focused on vulnerability and performance observations, and in some cases operational challenges, especially regarding the following:

- Coastal construction in storm surge areas
- Residential and non-residential structures
- Critical facilities
- Hurricane evacuation shelters (HESs) and storm shelters

In addition to observing overall storm surge flood damage in the affected coastal counties, the MAT also assessed flood impacts in the context of the following:

- Comparison of *elevated* versus *non-elevated buildings*
- Comparison of structures constructed to older versus newer building codes
- Performance of manufactured homes and their anchorage
- Erosion control structures such as seawalls

- General building performance and flood characteristics in Zone V, Coastal A Zones, and Zone A as well as nearby shaded and unshaded Zone X areas
- General building codes, building code enforcement, and other related efforts that help improve building performance and community resilience
- Select FEMA and other grant project performance
- Disaster Recovery Reform Act (DRRA) 1206 support and implementation effectiveness[1]

The MAT also assessed wind-related performance for both residential and non-residential structures. For residential structures, the MAT assessed:

- Performance of manufactured homes and their anchorage
- Structural systems / main wind force resisting systems (MWFRSs)
- Building envelope components and cladding (C&C), such as roof coverings, soffits, exterior wall coverings, windows, and doors
- Roof underlayment performance

For non-residential structures, the MAT assessed:

- Wind retrofit and new construction performance at critical facilities that had been designed to improve building performance during high-wind and flood events

For both residential and non-residential structures, the MAT assessed:

- Building performance based on age of the building and the building codes that were used to design and construct them
- General building codes and building code enforcement

The MAT further assessed the operational performance and the impact the loss of utility service, most notably the loss of potable water, had on hospitals and HESs.

Based on the above scope of observations and assessments, the MAT report provides conclusions and actionable recommendations that are intended not only to help guide recovery efforts for Florida, but also to improve resilience to hurricane-prone communities throughout the region and nation. It offers strategic recommendations to help provide or improve:

- Codes and standards for wind, flood, or other hazard-resistant provisions

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[1] The Disaster Recovery Reform Act of 2018 (DRRA), amended Sections 402 and 406 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), and authorized FEMA to “provide assistance to state and local governments for building code and floodplain administration and enforcement, including inspections for substantial damage compliance” and “base and overtime wages for extra hires to facilitate the implementation and enforcement of adopted building codes for a period of not more than 180 days after the major disaster is declared.” FEMA Policy FP 204-079-01 enacted through FEMA’s Public Assistance Program implements Section 1206 of DRRA by leveraging the amendments to Section 402 and Section 406. While the provisions of this policy apply only to the PA Program, assistance under Section 1206 of DRRA may be available under other FEMA programs, such as FEMA’s Federal Insurance and Mitigation Administration’s Substantial Damage Data Collection Contracts.

- Guidance to designers and contractors for more resilient buildings and their associated utility systems
- Robust building code and floodplain management enforcement
- Training and outreach to a multitude of organizations and skillsets
- Response, recovery, mitigation, and preparedness activities across the full spectrum of emergency management relating to community, building, and associated utility system resilience
- Shelter and safe room planning and operations locally, regionally, or potentially on a national scale
- Knowledge gaps related to needed research
- FEMA guidance policies, grant implementation, recovery operations, or other efforts as appropriate
- Guidance to OFAs, SLTTs, and/or a multitude of skillsets and organizations at all levels

1.1. Organization of Report

This MAT report is divided into six chapters and includes four appendices. The chapters are organized as follows:

- Chapter 1 provides overall context for Hurricane Ian and describes its impact on Florida. It also details the MAT composition, its deployment, mission, and the locations visited after Hurricane Ian, as well as FEMA's role providing BSDS in response and recovery activities after the event.
- Chapter 2 discusses the Florida building codes, including key wind provisions, floodplain management, the Florida evacuation shelter program, Florida's Coastal Construction Control Line (CCCL), the National Flood Insurance Program (NFIP) and its implementation in Florida, regulatory requirements for manufactured homes, and Section 1206 of DRRA.
- Chapter 3 describes MAT observations related to the performance of residential and non-residential buildings as well as other structures exposed to flooding conditions.
- Chapter 4 describes MAT observations related to wind, building envelopes, and manufactured homes.
- Chapter 5 describes MAT observations related to the performance, both building and operational, of critical facilities.
- Chapter 6 presents the MAT's conclusions and actionable recommendations.

In addition, the appendices are as follows:

- Appendix A: References
- Appendix B: Recovery Advisories
- Appendix C: Case Studies
- Appendix D: Acknowledgements

1.2. BSDS Program

The BSDS Program assembles and deploys SMEs to evaluate the performance of buildings, other structures, and associated community lifelines after extreme natural hazard events. The BSDS

Directive (FEMA Directive #206-22-0002) issued on July 21, 2022, is for internal FEMA use and applies to all FEMA components, programs, entities, missions, FEMA regions, and field offices providing support to BSDS activities. Hurricane Ian was the first declared disaster FEMA implemented under this Directive. The Directive supersedes a memo dated September 15, 1997, titled, “Eligibility of Assistance to Building and Land-Use Departments following a Disaster.” The 2022 directive summarizes agency-wide, agreed-upon, high-level required actions, roles, and responsibilities of 18 key stakeholders needed to support BSDS Program activities. It also presents agency principles for:

- Supporting data-driven decision making
- Advancing building codes, standards, and best practices
- Strengthening nationwide capability for superior building performance
- Driving public action
- Reducing disaster spending

In disaster readiness, the BSDS Program monitors significant events to determine whether a MAT should be deployed or BSDS support efforts are warranted. In addition to pre-MAT and MAT deployments, BSDS activities may include performance of building performance assessments, virtual assessments, problem-focused studies, or loss avoidance studies. BSDS Program products can include MAT reports, problem-focused study reports, recovery advisories, fact sheets, case studies, or other deliverables. The BSDS Program may also provide technical assistance and SME support to FEMA Disaster Operations and SLTT partners.

1.2.1. IMPORTANCE OF BSDS PROGRAM EFFORTS

The BSDS Program efforts, often through MATs, provide a feedback loop from disaster events to determine successes and failures of buildings, along with their associated utility systems, in order to improve building and community resilience. FEMA has unique roles, responsibilities, and authorities compared to OFAs and organizations. As such, BSDS Program efforts are a force multiplier in improving risk-informed decision making and positively impacting building and community resiliency, by developing guidance or other deliverables and providing education, training, outreach, or strategic recommendations for various FEMA programs, SLTT governments, businesses, non-profits, researchers, individuals, or other stakeholders. Furthermore, MATs have for decades been instrumental in providing a strong technical basis for wind, flood, and seismic codes and standards change proposals, successfully helping to update or uphold the hazard-resistant provisions of numerous model, state, and local codes, while also promoting best practices, resulting in more resilient buildings and communities. BSDS Program activities lead to improved knowledge of the performance of buildings, other structures, and associated community lifelines; help integrate codes and standards across FEMA; support community and capacity building for superior building performance; and help drive public action on improving hazard-resistant building code provisions and enforcement.

1.2.2. REGIONAL RESPONSE COORDINATION CENTER BUILDING SCIENCE LIAISON

The FEMA Region 4 Building Science Lead was pro-active and requested to be deployed to the Regional Response Coordination Center (RRCC) on September 29, 2022, and within 2 hours, was granted deployment by the RRCC Chief. Although Region 4 deployed a Building Science Liaison to the RRCC for the 2011 tornadoes as well as Hurricane Michael in 2018, this was the first time a Building Science Liaison was deployed in accordance with the recently signed FEMA BSDS Directive. The RRCC Building Science Liaison coordinates and collaborates internally and externally to FEMA as needed to gather appropriate building and associated infrastructure-related damage and disaster data for a potential MAT effort. The RRCC Building Science Liaison also helps the MAT Lead develop contract, funding, and planning documents to effectively implement a BSDS mission, if triggered.

The RRCC Building Science Liaison coordinated with the various RRCC Emergency Support Functions (ESFs) to help better understand building and utility system damage and their impacts to the survivors and operations in the area. This collaboration included collecting and assessing information from various sources, including, but not limited to:

- U.S. Army Corps of Engineers (USACE) mission assignments (e.g., blue roofs, generators, damage assessments) and other important information from ESF 3 – Public Works and Engineering
- Health and Human Services (HHS) status of medical facilities from ESF 8 – Public Health and Medical Services
- Operations information for mass care at shelters from ESF 6 – Mass Care, Emergency Assistance, Temporary Housing, and Human Services
- Data from search and rescue activities and information from buildings and locations the search and rescue teams visited from ESF 9 – Search and Rescue
- Security concerns from ESF 13 – Public Safety and Security
- Information on cell tower or other communication damage and outages of interest from ESF 2 – Communications
- Details of downed bridges and road and airport closures from ESF 1 – Transportation
- Businesses operations data and challenges from ESF 14 – Cross Sector Business and Infrastructure
- The amount of and severity of injuries and fatalities
- The extent, locations, and trends of power outages; and other related information from ESF 12 – Energy
- Monitoring information and news from ESF 15 – External Affairs
- Monitoring information on potential disaster base camp setup locations and timelines
- A multitude of information outputs from ESF 5 – Information and Planning
- Coordination with the FEMA Incident Management Assistance Team as needed
- Reports and information coming from the state emergency operations center (EOC)
- Results from RRCC Remote Sensing Cell analysis of numerous but select buildings, structures, and locations of interest
- Information from WebEOC and state and local reports

The Building Science Liaison also coordinated and collaborated with FEMA HQ Building Sciences, BSDS disaster readiness and disaster support operations and activities, the National Response Coordination Center, regional and RRCC leadership, and FEMA field liaison officers, among others.

All of the above information was critical in helping to better understand the overall circumstances and gain situational awareness of the width, breadth, depth, type, and severity of building and utility system damage and fatalities in order to help with improved planning, coordinating, collaborating, and developing of contract documents, an overall strategy, rough cost estimate, statement of objectives, and level of effort needed for carrying out an effective and efficient BSDS Program effort for Hurricane Ian.

1.3. BSDS Program's Mitigation Assessment Team

A MAT conducts building performance assessments after unique or nationally significant, Presidentially declared disasters to better understand their impacts and effects on the built environment. A MAT is generally deployed when FEMA believes the findings and recommendations derived from field observations will advance the understanding of damages to help improve design, construction, manufacturing, code enforcement, code and standard revisions, research, planning, mitigation, or any other key components for strengthening building, community, or lifeline resilience. Furthermore, FEMA can develop guidance, training, and outreach or improve policies, assistance, and program effectiveness to enhance hazard resilience of the built environment in the affected state or region, which can also be used by other states and stakeholders when appropriate. FEMA bases its decision to deploy a MAT on information such as:

- Request/approval of BDSD
- Magnitude of the event
- Type and severity of damage in the affected areas
- Pre-event site conditions in the impacted areas, such as the residential construction types, non-residential and critical facility stock, and utility systems
- Information collected during a pre-MAT evaluation
- Strategic lessons that can be learned and applied, potentially on a regional and national level, related to improving building performance, improving/advancing building codes and standard industry practices or guidance, code enforcement, research needs, closing knowledge gaps, or other topics
- Opportunities to validate the effectiveness of FEMA grant mitigation projects and FEMA guidance on best practices
- Potential, during recovery, to:
    - Help in planning, design, and construction of buildings and their associated infrastructure
    - Encourage code enforcement
    - Strengthen community resilience
    - Enhance capabilities or training for various skillsets or organizations

The MAT studies the adequacy of current building codes, standards, and floodplain management regulations, local construction requirements, building practices, and building materials in light of the building performance observed after a disaster. Lessons learned from the MAT's observations are communicated through recovery advisories, fact sheets, or other deliverables and a comprehensive MAT report is developed for the disaster. All MAT products are made available to communities and the public at large to aid recovery efforts and enhance disaster resilience of communities, buildings, and their associated utility systems for both existing buildings and new construction. Conclusions and recommendations from MAT reports are often the basis for FEMA's building code and standards change proposals at code and standards hearings. Such code change proposals help improve design and construction standards at the national, model code level and are often incorporated or implemented by SLTT governments to help them mitigate damage from hazard events through improved building and community resilience.

1.4. Hurricane Ian MAT

The Ian MAT was composed of 34 SMEs drawn from the following:

- FEMA HQ and Regional office architects, engineers, and specialists
- Florida Division of Emergency Management (FDEM) floodplain management and engineering specialists
- Construction and building code industry specialists
- Design professionals and technical consultants

MAT members included specialists from different areas of interest: architects; structural, civil, coastal, and electrical engineers; emergency managers; surveyors; and floodplain managers. The specialists are experts in a variety of pertinent topics, including wind damage–resistant buildings, floodplain management, building codes, construction materials, MEP (mechanical, electrical, and plumbing) systems, critical facilities, housing, and emergency management across its full spectrum of response, recovery, mitigation, and preparedness efforts from a building science perspective. The members of the MAT are listed in the front matter of this report.

1.5. Hurricane Ian: The Event

Below is a summary of key information provided by the National Hurricane Center (NHC), which is part of NOAA. The NHC's mission is to save lives, mitigate property loss, and improve economic efficiency by issuing the best watches, warnings, forecasts, and analyses of hazardous tropical weather and by increasing understanding of these hazards.

The origins of Hurricane Ian were first monitored by the NOAA on September 14–15, 2022, as a tropical wave off the west coast of Africa. On September 23, 2022, the weather system became organized and was classified as a tropical depression. Approximately 18 hours later, the system had strengthened into a tropical storm, south of Jamaica. Early on September 26, 2022, Hurricane Ian strengthened into a hurricane as it traveled north across the Caribbean Sea, heading toward Cuba. Hurricane Ian developed into a strong Category 3 storm by the time it made landfall in Cuba on September 27, 2022, and continued to strengthen after emerging over the Gulf of Mexico. At peak intensity, Hurricane Ian briefly reached Category 5 hurricane strength on the Saffir-Simpson scale with sustained winds of 140 knots (161 mph) over open water at 7 AM local time on September 28, 2022, just before making landfall in southwest Florida. After reaching the Category 5 rating, Hurricane Ian slightly weakened and made landfall as a Category 4 hurricane on the barrier island of Cayo Costa, FL, at 2:05 PM Eastern Daylight Time (EDT), with a sustained wind speed over open water of 130 knots (150 mph). At 4:35 PM EDT, Hurricane Ian again made landfall, near Punta Gorda, with an estimated intensity of 125 knots (144 mph) as it continued northeast across the Florida Peninsula as a tropical storm and emerged over the Atlantic Ocean, near Cape Canaveral, FL. Hurricane Ian, fueled by the warm Gulf Stream waters, re-intensified into a Category 1 hurricane on September 30, 2022, and made landfall near Georgetown, SC, with sustained wind speeds of 70 knots (80 mph). Hurricane Ian then dissipated into a post-tropical cyclone as it slowly traversed up the coast (NHC, 2023). Figure 1-3 shows the hurricane tracks with 6-hour intervals (NHC 2023).

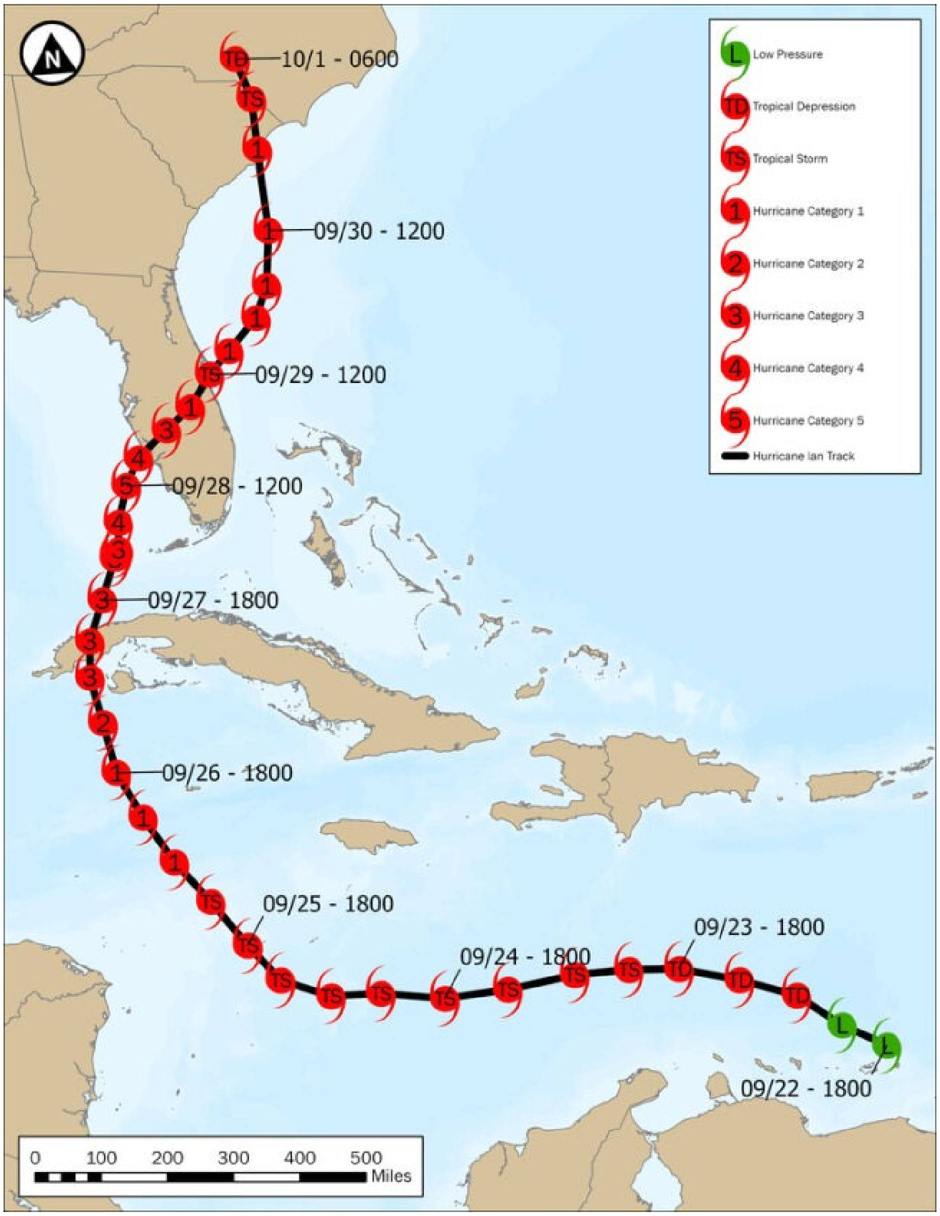


Figure 1-3: Hurricane Ian tracks

Hurricane Ian is the sixth Category 4 or 5 hurricane to make landfall in the United States over the last 6 years (NCEI 2022). After inflation adjustments, Hurricane Ian is also the third costliest U.S. weather disaster since 1980, behind Hurricanes Katrina and Harvey and the costliest hurricane to ever impact Florida (NHC 2023). Hurricane Ian is also the fifth strongest hurricane to hit the U.S. since 1963 based on the NOAA-estimated wind speed over open water (NCEI 2022). Table 1-1 shows the ten costliest hurricanes in the U.S. since 1980.

Table 1-1: Ten Costliest Hurricanes in the U.S. since 1980

Event	Begin Date	End Date	CPI-Adjusted Cost (in Billions)(a)
Hurricane Katrina	8/25/2005	8/30/2005	$193.8
Hurricane Harvey	8/25/2017	8/31/2017	$153.8
Hurricane Ian	9/28/2022	9/30/2022	$115.2
Hurricane Maria	9/19/2017	9/21/2017	$110.7(b)
Hurricane Sandy	10/30/2012	10/31/2012	$85.2
Hurricane Ida	8/29/2021	9/1/2021	$81.7
Hurricane Irma	9/6/2017	9/12/2017	$61.5
Hurricane Andrew	8/23/1992	8/27/1992	$58.3
Hurricane Ike	9/12/2008	9/14/2008	$41.7
Hurricane Ivan	9/12/2004	9/21/2004	$32.8

Source: NCEI 2022
(a) CPI = 2023 Consumer Price Index Adjustment
(b) This sum is predominantly costs from the U.S. Virgin Islands and Puerto Rico

The Significance of Hurricane Ian

- Hurricane Ian was the second major hurricane of the 2022 North Atlantic hurricane season and the first to make landfall in the contiguous United States.
- Hurricane Ian made landfall in Cayo Costa, FL, as a Category 4 hurricane with sustained wind speeds over open water of 150 mph.
- The large size of the storm and weather conditions led forecasts for Hurricane Ian to make landfall north of the actual landfall location on Florida's west coast.
- Hurricane Ian ultimately made landfall in a region extremely vulnerable to storm surge, which contributed to extensive and devastating impacts.
- In Fort Myers Beach, Hurricane Ian destroyed an estimated 900 structures and damaged an additional 2,200. In Lee County, at least 52,514 structures were impacted, with 5,369 completely destroyed and 14,245 experiencing significant damage. In Collier County alone, more than 3,500 buildings sustained major damage.
- The hurricane caused more than $112 billion in damages as of April 2023.

Source: NHC 2023

1.6. Hurricane Ian: The Impact

Hurricane Ian was responsible for 156 deaths in the United States; 150 in Florida, 5 in North Carolina, and 1 in Virginia. Of the total deaths, 41 were attributed to Hurricane Ian's storm surge, which reached upwards of 15 feet at Fort Myers Beach (NHC 2023). The storm surge was most severe in Lee County, where 36 people lost their lives (NHC 2023). Table 1-2 shows evacuation areas and the times the evacuation orders were issued for representative counties along the west coast of Florida where Hurricane Ian made landfall. Both storm surge and inland flooding directly caused dozens of deaths attributed to drowning. Storm surge alone was the cause of 41 deaths and freshwater flooding led to 12 fatalities (NHC 2023).

Table 1-2: Florida County Evacuations

County (Source)	Evacuation Zone [(a)]	Issued	Effective Time and Date (where available)
Charlotte (@CharlotteCoFL)	Evacuation Zone A Red Barrier Islands and manufactured homes	9/26 @ 3:56PM	

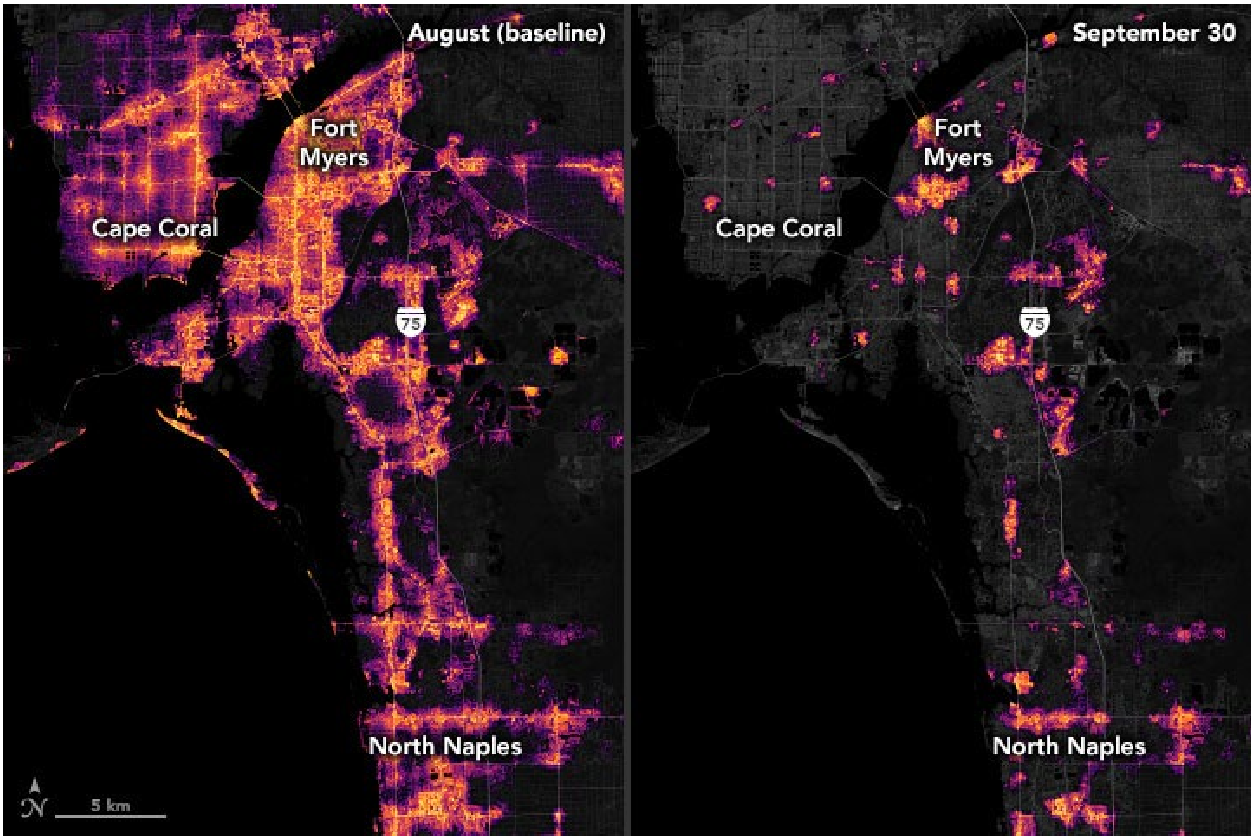
County (Source)	Evacuation Zone [(a)]	Issued	Effective Time and Date (where available)
Collier (@CollierGov)	Evacuation Zone A, immediate coastal areas, west and south of Highway 41, low-lying floodprone areas, and manufactured homes	9/27 @ 4:48PM	
Hillsborough (@HillsboroughFL)	Evacuation Zone A, manufactured homes, low-lying areas prone to flooding; Zone B is voluntary	9/26 @ 1:40PM	Effective 2PM 9/26
Lee (@LeeCountyFLBOCC and *Hurricane Ian After-Action Report* [Lee County 2023])	Evacuation Zone A and low-lying parts of Zone B Evacuation of all of Zone A and B Added portions of Zone C	9/27 @ 6:55AM	9/27 @ 7:00 AM 9/27 @ 8:45AM 9/27 @ 1:45PM
Manatee (@ManateeGov)	Evacuation Zone A and voluntary Zone B	9/26 @ 9:16AM	Effective 8AM 9/27
Pinellas (@PinellasGov)	Evacuation Zone A and all manufactured homes Evacuation Zone B, C	9/26 @ 11:10AM	Effective 6PM 9/26 Effective 7AM 9/27

County (Source)	Evacuation Zone (a)	Issued	Effective Time and Date (where available)
Sarasota (@SRQCountyGov)	Evacuation Level A, Barrier Islands, manufactured homes	9/26 @ 7:20PM	Effective 12PM 9/27
	Added Evacuation of Zone B	9/27 @ 8:21AM	Effective 10AM 9/28

Source: County Government Social Media Feeds, as noted, and Lee County 2023
(a) Evacuation Zones are locally identified by the corresponding county and not related to flood zones. Evacuations were mandatory unless noted as voluntary.

Between September 28 and October 1, 2022, roughly 4.45 million customers lost power in the United States due to Hurricane Ian, with Florida experiencing the largest loss of power with approximately 3.28 million customers total (NHC 2023). As Hurricane Ian passed through the southeast, around 579,000 customers in North Carolina and roughly 378,000 in South Carolina experienced power outages. In Virginia, an estimated 211,000 customers were affected. Hurricane Ian caused the entire island of Cuba to lose power for a few days (NHC 2023). Figure 1-4 shows typical power outage satellite imagery of a portion of Florida and what it looked like as a result of Hurricane Ian.

The number of power outages that occurred as a result of Hurricane Ian was much higher than Category 5 Hurricane Michael, which struck near Mexico Beach on October 10, 2018. Hurricane Michael struck a much less densely populated area on the Florida panhandle and left 1.7 million customers across six states without power (EIA 2018).



Source: NASA 2022

Figure 1-4: Power outage satellite imagery (left: August 2022, right: September 30, 2022)

1.6.1. COASTAL STORM SURGE FLOODING

A storm surge occurs when the force of cyclonic winds around a storm propels water toward the shore. Although the low pressure associated with powerful storms has a limited effect on surge, there is a significant impact of wind-driven water movement toward the coastline (NHC n.d.). The Florida Peninsula where Hurricane Ian made landfall is vulnerable to storm surge due to the shape of the coast and the shallow shelf waters, which make the area more prone to the effects of storm surge.

This vulnerability to storm surge resulted in catastrophic impacts along the southwest coast of Florida near Fort Myers, as well as in rivers and bays, such as the Caloosahatchee River, Estero Bay, the Imperial River, and Naples Bay. Peak storm tide inundation depths of 10 to 15 feet above ground level (AGL) were recorded in Fort Myers Beach. As Hurricane Ian moved across the state, significant impacts were experienced along the northeast coast of Florida and along the South Carolina coast where Hurricane Ian made a final landfall (NHC 2023).

In addition to the estimated peak storm tide inundation levels of 15 feet AGL in Fort Myers Beach, the levels reached a maximum of 3 feet in the Florida Keys and up to 13 feet on Sanibel Island. Storm surge also caused significant structural damage on Sanibel Island (NHC 2023). Table 1-3 lists various inundation levels across Florida.

Storm Surge Terminology

Storm Surge: The abnormal rise of water generated by a storm, over and above the predicted astronomical tide, expressed in terms of height above normal tide levels.

Storm Tide High Water Mark: A mark, represented by a seed line, discoloration, sediment, or debris that indicates the maximum rise of the water above the ground surface, that is surveyed and correlated to a North American Vertical Datum of 1988 (NAVD 88) elevation. Note that storm surge high water marks (HWMs) do not always represent the stillwater elevation for an event and can include wave effects.

Storm Tide Stillwater Elevation: The surface of the floodwater referenced to a vertical datum, including tides and storm surge, excluding all wave effects.

Storm Tide Inundation Depth: Depth of water above the ground surface caused by storm surge.

Wave Runup Elevation: The elevation of the rush of water that extends inland when waves come ashore. It is calculated as the maximum vertical extent above the stillwater level after interfacing with the shoreline or structure.

Sources: NOAA n.d. and FEMA 2011

Storm surge often causes severe flood damage to residential, commercial, public buildings, critical facilities, and infrastructure and is often considered the deadliest hazard. When storm surge is combined with powerful waves, it has the potential to inflict widespread devastation. Coastal areas bear the brunt of severe beach erosion and damage to coastal highways and bridges. The relentless pounding wave and storm surge forces pose a threat to people, property, equipment, vehicles, and structures and their associated utility systems. As surging waters advance inland, they have the potential to impact and interact with runoff from rivers and lakes, exacerbating the overall flood levels.

Storm surge levels reached 9 to 13 feet AGL in the eastern portion of Sanibel Island causing portions of the Sanibel Causeway to be scoured and heavily damaged. In Pine Island, Cape Coral, and other communities along the mouth of the Caloosahatchee River, maximum inundation levels reached 6 to 9 feet AGL. Maximum inundation levels reached 3 to 5 feet AGL at the northeast coast of the Florida/Georgia border and after moving up along the coast to South and North Carolina, the storm surge levels ranged between 2 to 6 feet AGL. Figure 1-5 shows the U.S. Geological Survey (USGS) HWMs from Hurricane Ian measured and reported after the storm (NHC 2023).

The USGS HWMs were subsequently compared to the effective Lee County Flood Insurance Study (FIS) data dated November 2022. The FIS provides stillwater elevations (ft NAVD 88) based on storms of particular frequencies, including the 100-year storm, for each coastal transect. Representative HWM locations were compared to the coastal transect locations in the FIS and the observed HWM elevations (ft NAVD 88) were compared to the FIS stillwater elevations to estimate the return period of Hurricane Ian at various locations (Figure 1-6). Hurricane Ian exceeded 100-year flood elevations (or base flood elevations [BFEs]) in many areas of coastal Lee County, especially throughout the barrier islands. While there was widespread flooding to inland portions of Lee County and other parts of Florida, most of those HWMs did not exceed the 100-year flood elevations (or BFEs) for those areas.

Table 1-3: Inundation Levels along Hurricane Ian's Path in Florida

Location	Inundation Level (feet AGL)
Fort Myers Beach and Estero Island	10 to 15
Eastern Sanibel Island	9 to 13
Pine Island	6 to 9
Caloosahatchee River	5 to 8
Estero, Bonita Beach, Bonita Springs, and North Naples	8 to 12
Naples	6 to 9
Marco Island through Everglades City	4 to 6
Florida Keys	1 to 3

Source: NHC 2023
AGL: above ground level

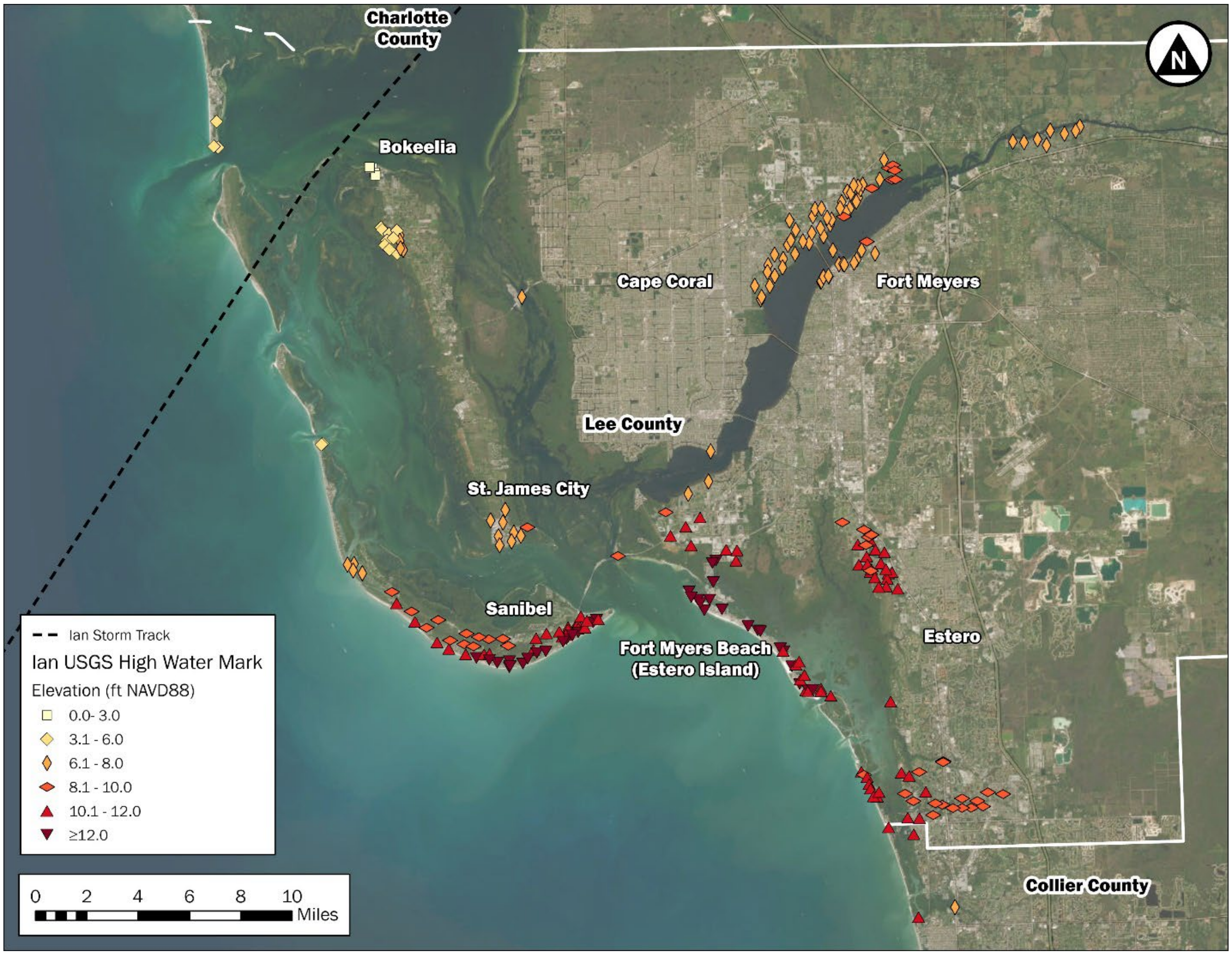


Figure 1-5: USGS HWMs

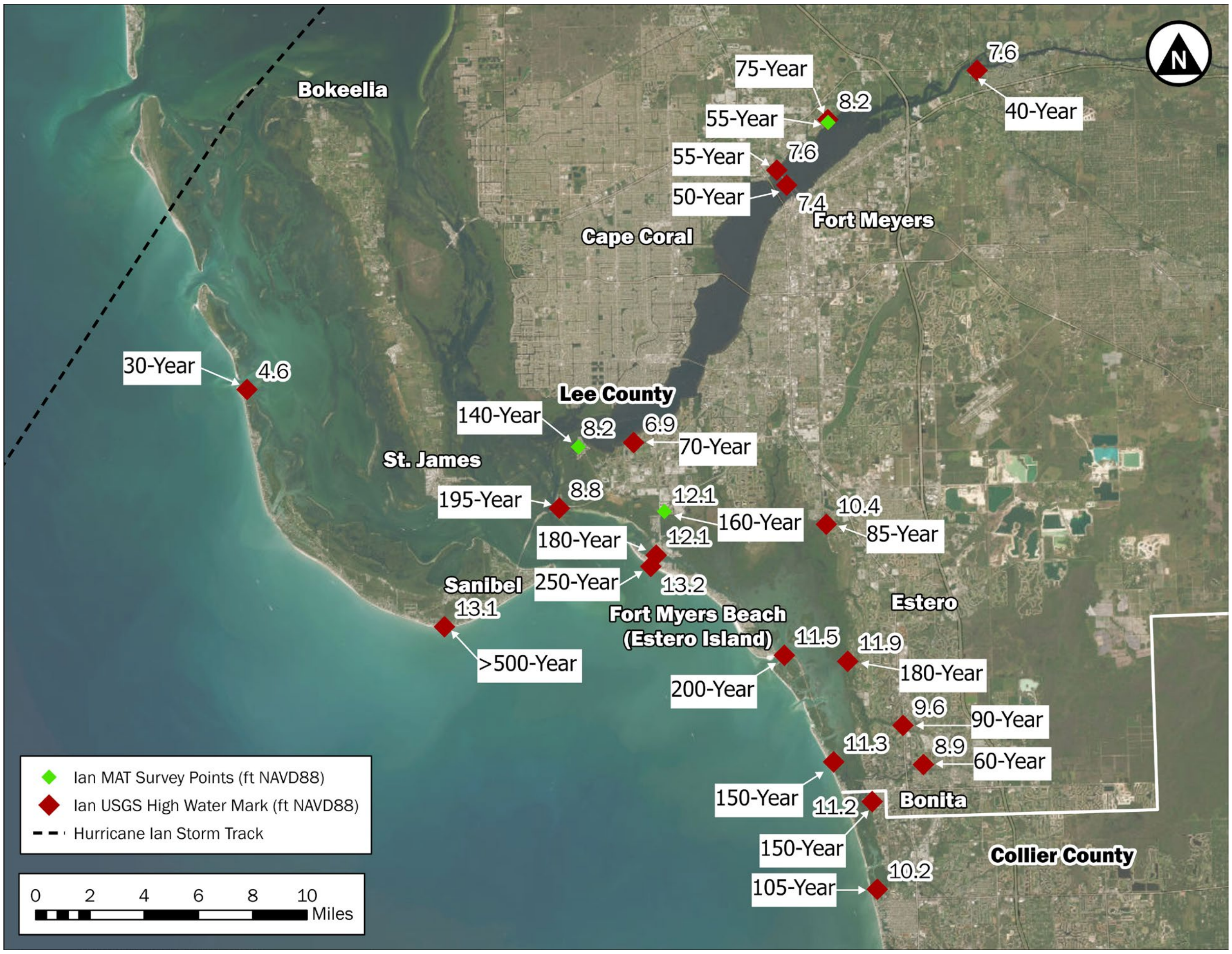


Figure 1-6: Estimated return period for Hurricane Ian HWMs

1.6.2. RAINFALL AND FLOODING

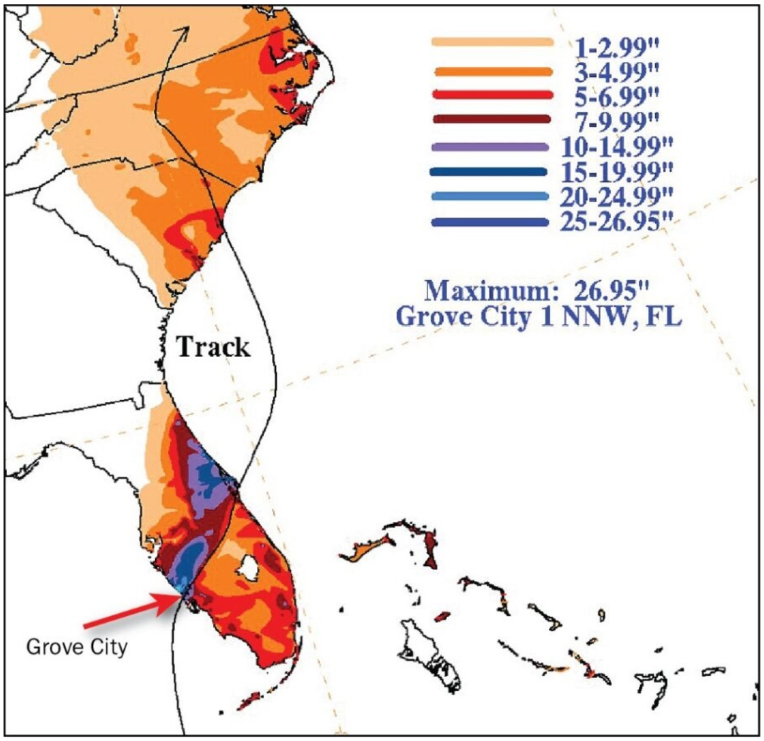
Hurricane Ian generated overwhelming rainfall that led to freshwater flooding in Florida, with storm totals exceeding the 100- to 200-year events at 24-, 48-, 72-, and 96-hour intervals at many locations throughout the path of the hurricane. Martin and St. Lucie Counties, South of Hurricane Ian's center, witnessed comparatively lower rainfall but still experienced flooded roads in certain areas. As Hurricane Ian moved up the coast, rainfall totals from the storm reached a maximum of 10.75 inches over 2 days in Charleston, SC (over a 50-year, 48-hour event), with lower rainfall totals observed toward western South Carolina. Table 1-4 shows NOAA NHC's maximum reported rainfall:

Table 1-4: Maximum Reported Rainfall

Location	Duration	Average Recurrence Interval (years)	Precipitation Estimate (inches)	Ian Precipitation (inches)
Grove City	96-Hour	1000	23	26.95
Orlando International Airport	48-Hour	100	12.7	13.2
Orlando International Airport	24-Hour	200	12.2	12.6
Daytona Beach	72-Hour	200	18.6	21.49

Source: NOAA, NHC

Significant flooding occurred in Florida counties north of the track of Hurricane Ian's center in Charlotte, Sarasota, Hardee, DeSoto, Polk, and Manatee counties when the Peace, Myakka, and Alafia Rivers and Horse Creek all peaked at record levels. Event rainfall totals in central and eastern Florida were 10 to 20 inches across the 4-day storm period, causing significant flooding along the St. Johns River, Lake George, Crest Lake, the Little Wekiva River, and Dunns and Shingle Creeks, affecting Seminole, Orange, Lake, Putnam, and Osceola Counties (NHC 2023). Figure 1-7 illustrates the distribution of the total precipitation across the area impacted by Hurricane Ian. The precipitation caused by Hurricane Ian produced flooding that extended beyond several days in various regions (NHC 2023).



Source: David Roth of the NOAA Weather Prediction Center, used with permission

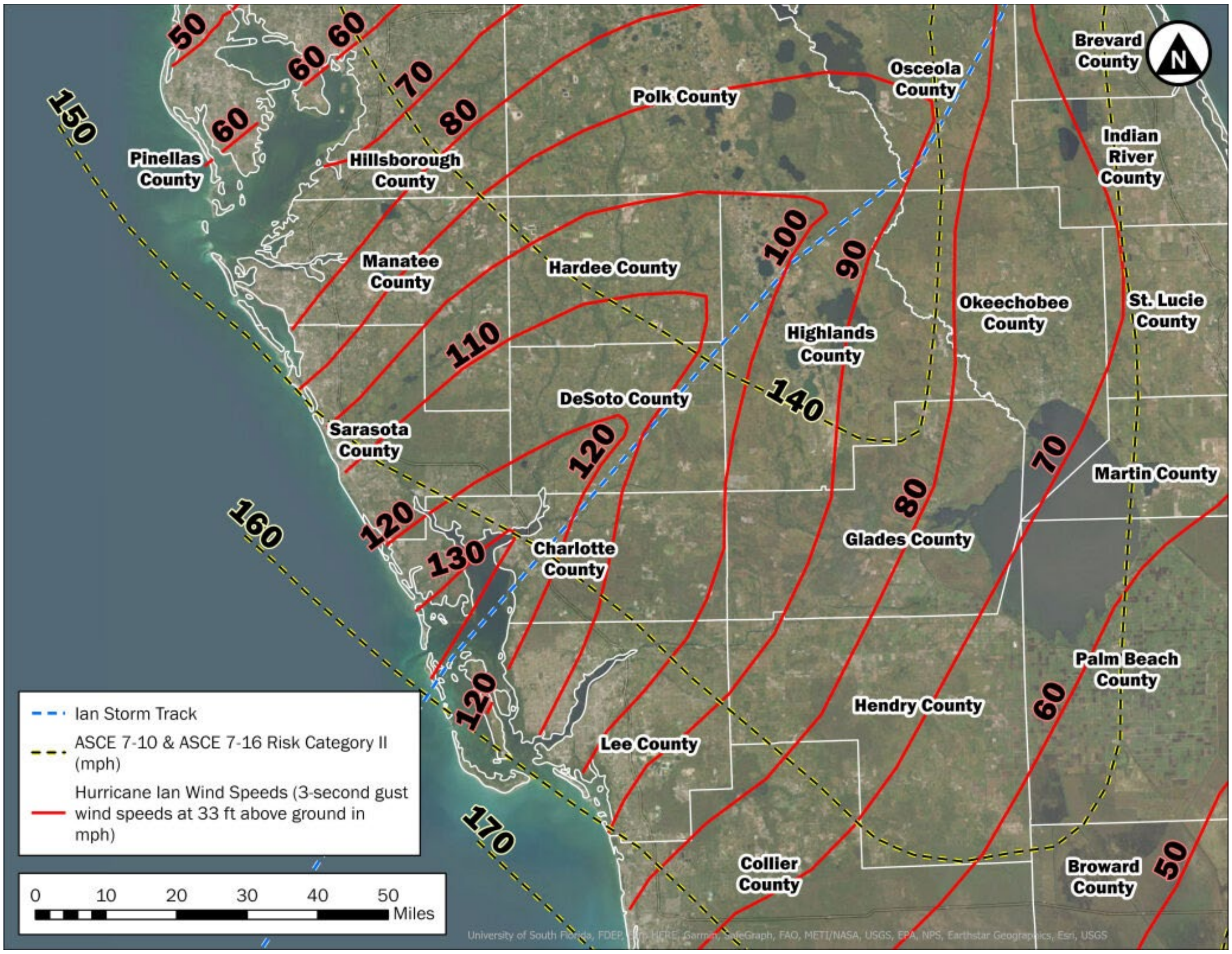
Figure 1-7: Rainfall Totals for Hurricane Ian

1.6.3. WIND

Hurricane Ian reached Category 5 status with a peak of 161 mph sustained winds over open water before making landfall in Cayo Costa, FL, as a Category 4 storm with sustained winds of 150 mph over open water (NHC 2023). The eye of Hurricane Ian is estimated to have been about 23 miles in diameter. The initial wind speed when Hurricane Ian made landfall is considered the fifth strongest on record (over open water) in the U.S. and fourth strongest in Florida (NCEI 2022). These severe wind speeds over open water slowed by the time they made landfall but still led to considerable damage to structures in Hurricane Ian's path of travel. Hurricane Ian's wind speeds were well below current design level wind speeds for new buildings, as shown in Figure 1-8.

Figure 1-8 represents an estimate of the surface-level windfield for Hurricane Ian in Florida developed by the National Institute of Standards and Technology (NIST) as part of a rapid response mission assignment from FEMA. NIST generates the windfield using instrumentation deployed pre-storm and wind measurements collected from airports and weather stations. Figure 1-8 overlays NIST's windfield with the design wind speeds from the 2016 Edition of American Society of Civil Engineers (ASCE) Standard 7, *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-16), for Risk Category II buildings. Both sets of wind speed contours represent an elevation of 33 feet AGL and are adjusted to reflect Exposure Category C to allow for direct comparison. These 3-second gust wind speeds are not the same as the wind speeds reported by the NHC using the Saffir-Simpson Hurricane Wind Scale. The wind speeds reported by the NHC are 1-minute sustained winds taken at varying elevations, over open water, and are intended to estimate the intensity of the hurricane using the Saffir-Simpson Hurricane Wind Scale and provide warnings to the public.

The MAT found that the estimated wind speed map (Figure 1-8) was consistent with the damages observed in the field. For example, most building damages and other wind speed estimating damage indicators, such as trees, immediately along the coast were consistent with 120–130 mph 3-second gusts.



Source: With permission from ASCE, NIST

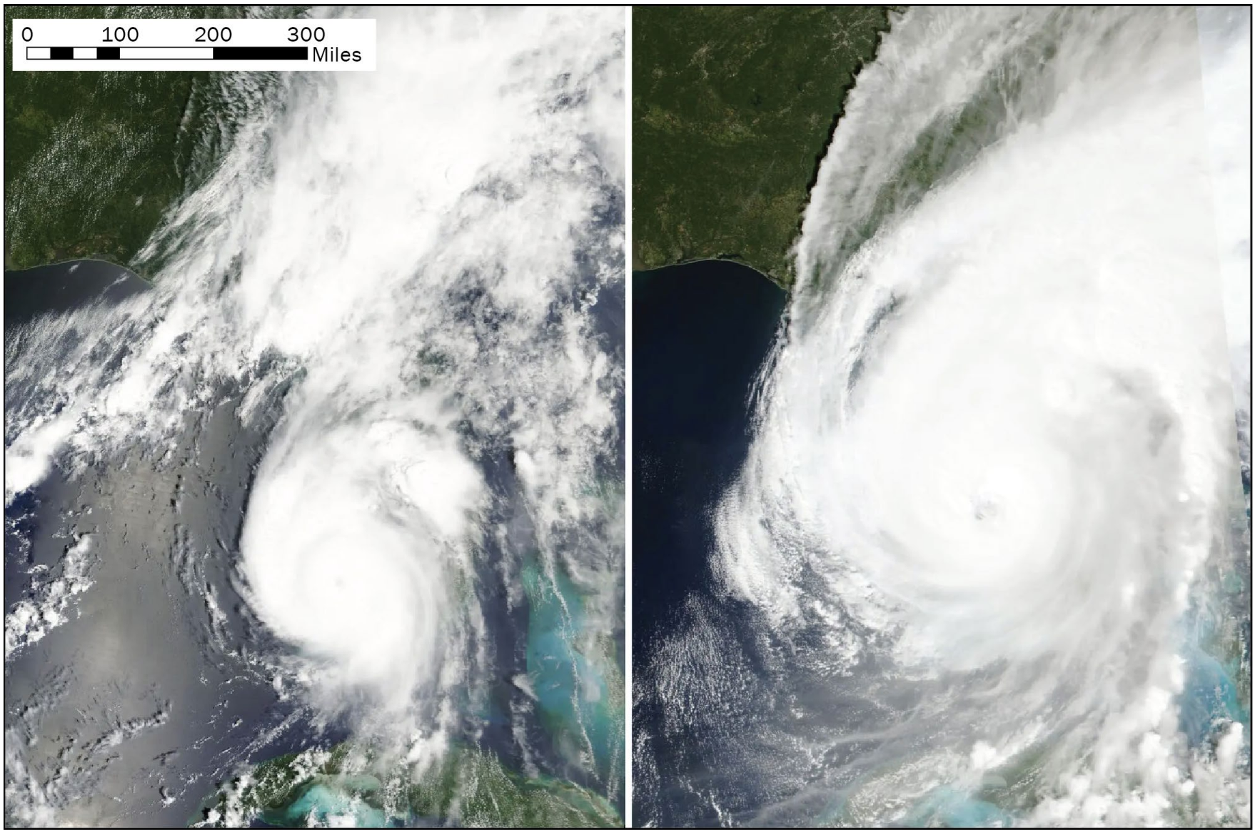
Figure 1-8: Hurricane Ian wind speeds vs design wind speeds

1.6.4. HURRICANE IAN VERSUS HURRICANE CHARLEY

Hurricane Ian and Hurricane Charley followed a similar path but resulted in significantly different types of predominant damage. According to NOAA,

- Hurricanes Ian and Charley had the same estimated wind speeds over open ocean at landfall; however, Hurricane Charley's strongest winds extended much further inland and Hurricane Charley was a design-level wind event in some areas, whereas Hurricane Ian was far below a design-level wind event in all areas.
- Hurricane Ian met or exceeded the design flood event in many locations.
- When comparing the spatial extent of the hurricanes, Hurricane Charley was about half the size of Hurricane Ian Figure 1-9).
- Hurricane Charley also traveled about twice the forward speed of Hurricane Ian as they approached and crossed Florida.

- The larger size of Hurricane Ian and the slower forward motion played a significant role in producing both twice the amount of rainfall and higher storm surge elevations as compared to Hurricane Charley.



Source: NCEI

Figure 1-9: Hurricane Charley (left) vs Hurricane Ian (right)

Figure 1-10 illustrates the paths of Hurricane Ian and Hurricane Charley. Though the paths are similar, the hurricanes had different impacts and characteristics as shown in Table 1-5. Hurricane Charley caused an estimated $25 billion in damages (adjusted to 2022 dollars for inflation) compared to Hurricane Ian's approximately $112 billion in estimated damages (NHC 2023). Hurricane Charley also caused 35 deaths while Hurricane Ian is estimated to have caused 152 deaths in the United States (NHC 2023).

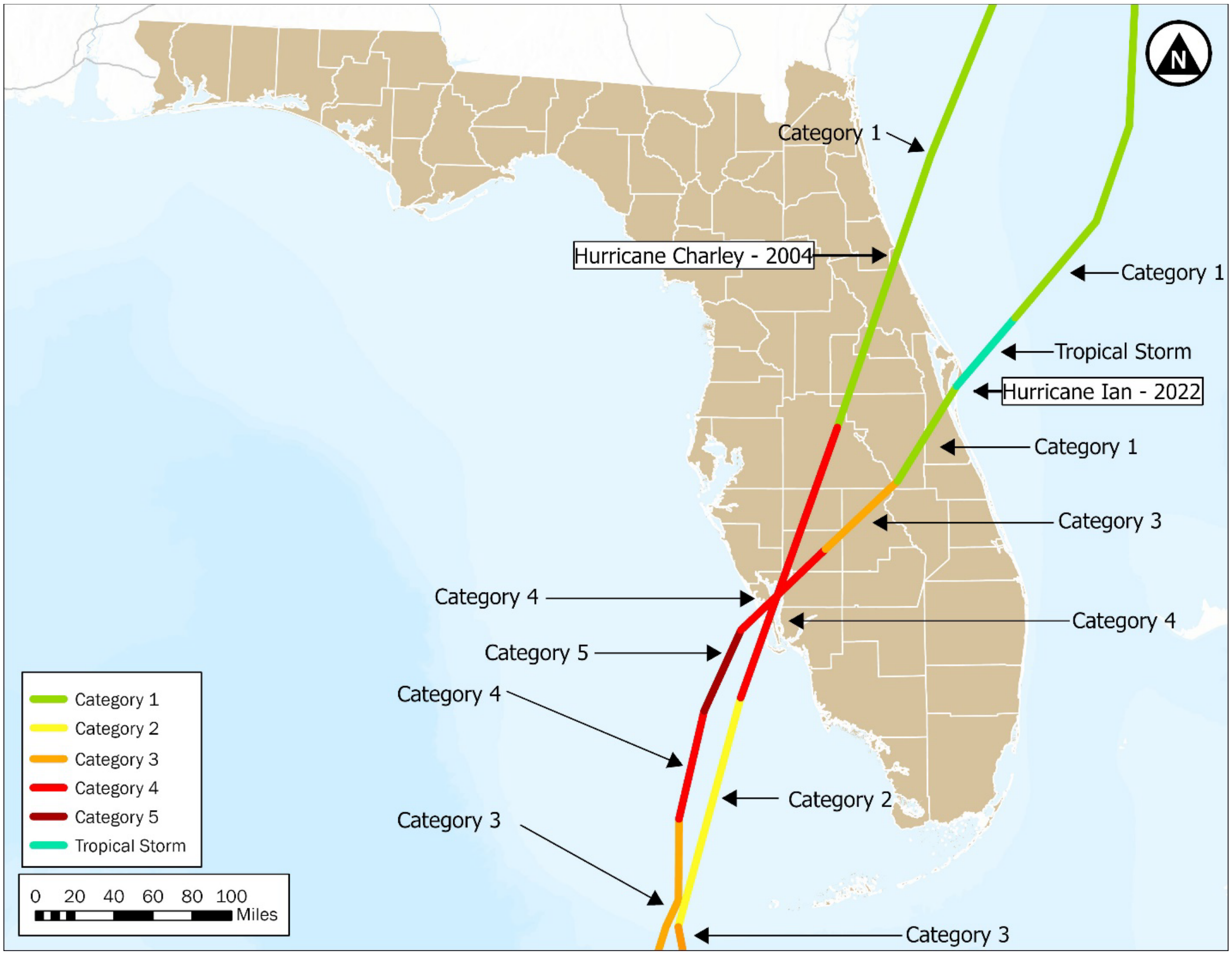


Figure 1-10: Hurricane Ian vs Charley landfall and path comparisons

Table 1-5: Hurricane Ian vs Hurricane Charley

Features	Hurricane Charley (2004)	Hurricane Ian (2022)
Central Pressure at landfall	941 mb	940 mb
Size at landfall, width of eye	14 miles	~26 miles
Forward speed at landfall	25 mph	9 mph
Population in Florida	17,842,038	21,781,128
Estimated $ in economic losses(a)	$25 billion	$112 billion
Estimated NFIP claims	$50 million	$3–5 billion
Fatalities	35	152
HWM comparison	8 feet (AGL)	13.8 feet (AGL)

Sources: NHC 2023; NHC 2004; U.S. Census Bureau 2022
(a) CPI-Adjusted, January 2023)
AGL = above ground level; CPI = Consumer Price Index; HWM = high water mark; mb = millibars; mph = miles per hour; NFIP = National Flood Insurance Program

2. Building Codes, Standards, and Regulations

This chapter presents an overview of Florida's building codes, the wind and flood provisions in those codes, and floodplain management in Florida. FEMA, the State of Florida, and others have documented how buildings are better able to resist damage from high winds and flooding when designed and constructed in compliance with building codes and standards that contain requirements to address those hazards. As with other post-disaster MAT reports, observations after Hurricane Ian reinforce the value of the wind and flood provisions of the Florida Building Code (FBC) and the importance of trained design plan reviewers, inspectors, and contractors. Observations by the MAT also underscore the critical importance of builders paying close attention to details during construction.

Section 2.1 describes state statute, the FBC, the process used by the Florida Building Commission to revise the FBC and consider changes from the International Codes® (I-Codes®); how local jurisdictions can amend the FBC; and options communities have for building department administration.

Section 2.2 highlights FDEM's support of communities that participate in the NFIP and summarizes the history of flood provisions in the FBC. Florida-specific amendments to the flood provisions of the I-Codes are described. This section also lists the most common local amendments to the flood provisions in the FBC that are adopted by many Florida communities to incorporate higher and more restrictive standards.

Section 2.3 summarizes the wind requirements in the FBC, including Florida-specific amendments for wind and water intrusion. The section also discusses wind, structural, and testing requirements for a special zone called the "High-Velocity Hurricane Zone" or HVHZ.

Section 2.4 discusses state emergency shelter operations in Florida. Section 2.4 provides an overview of the structural design provisions of the Public Shelter Design Criteria—also referred to as Enhanced Hurricane Protection Area (EHPA) provisions—as well as information about meeting these requirements through retrofit of existing spaces.

Section 2.5 provides an overview of manufactured homes, including for anchorage requirements.

Section 2.6 discusses FEMA's DRRA 1206 Policy and its implementation in Florida following Hurricane Ian.

2.1. Building Codes in Florida and the Florida Building Commission

The FBC is part of the Florida Administrative Code adopted through rulemaking as governed by Chapter 120 of the Florida Statutes. The adoption of the FBC by the Florida Building Commission as a rule is mandated by the Florida Legislature (the code is not adopted statutorily). Local jurisdictions are required to enforce the FBC, but do not need to adopt it locally.

When Hurricane Ian made landfall in the State of Florida, the 7th Edition (2020) FBC was in effect. The 7th Edition (2020) FBC went into effect on December 31, 2020. The term “Florida Building Code” refers to all of the codes administered by the Florida Building Commission, which include the:

- Florida Building Code, Building (FBCB)
- Florida Building Code, Residential (FBCR)
- Florida Building Code, Existing Building (FBCEB)
- Florida Building Code, Mechanical (FBCM)
- Florida Building Code, Plumbing (FBCP)
- Florida Building Code, Energy Conservation (FBCEC)
- Florida Building Code, Accessibility (FBCA)
- Florida Building Code, Fuel Gas (FBCFG)
- Florida Building Code, Test Protocols for High-Velocity Hurricane Zones (HVHZ)

The 7th Edition (2020) FBC is based on the 6th Edition (2017) FBC and includes many of the changes that were approved for the 2018 Edition of the applicable I-Codes published by the International Code Council (ICC) as well as additional Florida-specific amendments approved through Florida’s code development process.

Scope of the Florida Building Code

For new applicable construction types, the FBCB applies to all buildings and structures except detached one- and two-family dwellings and townhouses not more than three stories above grade plane, which are within the scope of the FBCR. One- and two-family dwellings and townhouses outside the scope of the FBCR are required to comply with the FBCB. The FBCEB applies to the repair, alteration, change of occupancy, addition to, and relocation of existing buildings, including historic structures.

The anticipated effective date for the 8th Edition (2023) FBC is December 31, 2023. Some of the key wind- and administrative-related changes in the 8th Edition (2023) FBC include the following:

- Update of wind provisions to the American Society of Civil Engineers (ASCE) Standard, Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7-22)
- Expansion of the location of the wind-borne debris region (WBDR) in some areas where the basic wind speed is 130 mph and greater and less than 140 mph
- Expansion of the underlayment requirements (sealed roof deck) adopted in the 7th Edition (2020) FBC for most of the state to apply in the HVHZ
- Requirement for roof underlayment for tile roofs to meet the applicable roof design wind pressure
- Addition of new installation requirements for vinyl siding that specifically require the use of a manufacturer-approved starter strip at the first course of siding and utility trim to secure the top of the siding where it must be cut under windows and at the top of walls
- Addition of soffit attachment and fascia covering attachments to the FBCB and strengthening of them in the FBCR
- Clarification that when affidavits are submitted as part of the permit application or to document inspections of the work, the building official shall review and inspect those requirements

For additional updates, visit the Florida Building Commission webpage at https://floridabuilding.org/c/default.aspx.

2.1.1. FLORIDA BUILDING COMMISSION

The FBC is maintained and updated by the Florida Building Commission with administrative support and technical assistance from the Florida Department of Business and Professional Regulation. The Commission comprises a stakeholder group that strives for consensus decisions on changes and updates to the FBC. Although the FBC is required to be updated every 3 years, the Commission may revise the code annually to incorporate declaratory statements (interpretations), clarifications, and standard updates.

The Florida Building Commission has a standing agreement with the University of Florida to execute an initial triage assessment of residential property damage resulting from any Category 3, 4, or 5 hurricane making landfall in Florida. If authorized by the program manager, the University of Florida performs a formal survey and damage assessment of buildings damaged and produces a final report to present to the Florida Building Commission for its consideration and approval. The University of Florida coordinates its investigations and survey with several organizations, including FEMA contractors, and the Structural Extreme Events Reconnaissance Network (StEER Network), www.steer.network.

In 2022, University of Florida's Professor David O. Prevatt led the post-Hurricane Ian building performance study, presented findings to the Florida Building Commission at three of its meetings, and produced the final report documenting the study and its findings and recommendations (Prevatt, Roueche, and Gurley 2023).

Code Development Process

Because of revisions to Section 553.73 of the Florida Statutes in 2017, the code development process for updating the FBC changed. With this change, the Florida Building Commission was required to use the previous effective edition of the FBC as the base code or starting point. Therefore, the base code for the 7th Edition (2020) FBC was required to be the 6th Edition (2017) FBC.

Before the Florida Building Commission reviews proposed code changes, it is first reviewed by Technical Advisory Committees (TACs), which make recommendations to the Commission on whether to approve specific code changes. The first phase of the development of the 7th Edition (2020) FBC required the Commission and TACs to review the 2018 I-Codes to examine changes from the 2015 I-Codes and determine whether to incorporate those changes into the 7th Edition (2020) FBC. During the second phase, the TACs and Commission reviewed proposals submitted by the public to determine whether to incorporate those changes into the 7th Edition (2020) FBC.

To achieve consensus, TAC recommendations for approval of a code change require support from two-thirds of the TAC members present at the meeting. In contrast, to approve a code change, the Florida Building Commission requires support from three-fourths of its members present at the meeting; 50% plus one of the members are required for a quorum for TAC and Commission meetings.

Once the code development process is completed, the rulemaking process begins, and the updated FBC becomes effective at a predetermined date.

As part of the 2017 statutory changes, the Florida Building Commission must "adopt any updates to such codes or any other code necessary to maintain eligibility for federal funding and discounts from the National Flood Insurance Program, the Federal Emergency Management Agency, and the United States Department of Housing and Urban Development." Any amendments or modifications made to the FBC will be carried forward to the next edition of the FBC unless they are subsequently revised.

Also noteworthy, the statute prohibits any weakening of the wind resistance or water intrusion requirements in the FBC, including those contained in referenced standards. This statutory requirement has existed since the mid-2000s.

Local Amendments

Local jurisdictions in Florida are permitted to amend the FBC provided such local amendments do not weaken the code. Local amendments must be submitted to the Florida Building Commission, which makes them available online. As part of the triennial code development process, the Commission reviews local amendments for consideration and inclusion in the FBC. However, the Commission does not have the authority to approve or disapprove local amendments.

Local amendments, except for those related to flood, expire with the effective date of each new edition of the codes, which means communities must re-adopt local amendments every 3 years. There are several other limitations on local technical amendments, but they can be challenged. As a result, there are very few local technical amendments of the code except for those related to flood, which, by statute, do not expire (refer to Section 2.2.3). The most common local technical amendments relate to the wind provisions of the code and clarify the specific location of the wind speed contours.

Building Department Administration

Florida counties and municipalities are required to have a Building Official to administer and enforce the FBC. Most communities establish building departments and have Building Officials on staff, along with support personnel, to perform all building department functions, including reviewing plans, issuing permits, citing unpermitted construction and violations, and performing construction inspections. The Florida statute provides municipalities the ability to enter into written interlocal agreements with another community to perform these functions. Communities may also have contracts with private-sector providers to perform all or some of the Building Official responsibilities and the building department functions.

Several communities visited by the MAT use private-sector providers for some or all building department functions. Because the FBC includes requirements for buildings in flood hazard areas, interlocal agreements and contracts do not need to explicitly identify responsibilities related to enforcement of the flood provisions in the FBC. However, agreements and contracts for building department functions typically do not explicitly include the responsibilities of the Floodplain Administrator that are spelled out in local floodplain management regulations. The State of Florida Office of Floodplain Management (OFM) has model regulations that are written explicitly to rely on the FBC for buildings and structures in Special Flood Hazard Areas (SFHAs). Gaps in administration may occur when agreements and contracts are silent with respect to floodplain management functions outside of the FBC requirements.

Florida Division of Emergency Management, Bureau of Mitigation, Office of Floodplain Management Guidance for Interlocal Agreements

FDEM offers a model interlocal agreement for floodplain management that spells out the duties of the community and the contracting entity, whether another community or a private provider. The model agreements, and a summary of community responsibilities for participation in the NFIP, can be accessed at www.floridadisaster.org/dem/mitigation/floodplain/community-resources/.

Hurricane Research Advisory Committee (HRAC)

The Florida Building Commission formed the HRAC in January 2005, following the damaging 2004 hurricane season, by appointing a small group of Commissioners along with other stakeholder representatives. The HRAC, which reports to the Florida Building Commission, identifies ongoing research to mitigate hurricane damage in the state and knowledge gaps where additional research on focused issues could be conducted. The HRAC provides reviews, comments, and recommendations and advises the Commission on research funding and research initiatives. The research is intended to help recommend changes to the FBC to increase hurricane resilience in Florida. The HRAC is an advisory board to the Florida Building Commission, which is the decision maker. More information on the HRAC can be found on its webpage.

2.2. Floodplain Management in Florida

Communities that participate in the NFIP agree to adopt and enforce floodplain management regulations that meet or exceed the minimum requirements of the NFIP (Title 44 of the Code of Federal Regulations [CFR] Parts 59 and 60). FDEM's OFM is designated by the Governor as the NFIP State Coordinating Agency. In this capacity, the OFM serves as a liaison between Florida's 467 NFIP communities and FEMA, helping communities implement sound land use development in floodplain areas to promote public health and safety, minimize loss of life, and reduce economic losses caused by flooding. Communities achieve those objectives by enforcing local floodplain management ordinances and the flood provisions of the FBC.

Supported by FEMA Community Assistance Program State Support Services Element (CAP-SSSE) funding, the OFM conducts Community Assistance Visits (CAVs) and Community Assistance Contact (CAC) interviews, provides one-on-one assistance for ordinance development and amendments, offers general technical assistance to Florida communities, supports FEMA's Risk Mapping, Assessment, and Planning process, and provides training for local officials. The training is conducted primarily through an agreement with the Florida Floodplain Managers Association (FFMA).

The OFM also supports communities that participate in the NFIP Community Rating System (CRS), a program that recognizes communities that undertake activities that exceed the minimum NFIP requirements in order to reduce flood risk by providing premium discounts on NFIP flood insurance policies. As of April 2023, 245 of the 467 Florida NFIP communities participate in the CRS program

(FEMA 2023a; Verisk Analytics, Inc. 2023). The CRS activities most commonly undertaken by Florida NFIP communities include:

- 91.4% of the Florida communities in the CRS have adopted freeboard of at least 1 foot
- 99.6% of the Florida communities in the CRS have adopted a building code based on the I-Codes
- 53.5% of the Florida communities in the CRS have adopted foundation protection requirements (e.g., engineered foundations not constructed on fill; constructed on compacted fill, protected from erosion and scour, with compensating storage volume provided; or constructed on compacted fill, protected from erosion and scour, without compensating storage volume provided)
- 91.8% of the Florida communities in the CRS have adopted local drainage protection requirements
- 14.7% of the Florida communities in the CRS have adopted enclosure limits

In May 2018, the OFM released the *Florida Post-Disaster Toolkit for Floodplain Administrators* (see textbox below). The toolkit describes six key actions, including planning ahead to communicate, assessing post-disaster needs, documenting HWMs, making Substantial Improvement / Substantial Damage determinations, understanding the NFIP claims and Increased Cost of Compliance coverage, and identifying post-disaster and mitigation funding assistance.

Post-Disaster Toolkit for Floodplain Managers

The toolkit is available online at https://www.floridadisaster.org/dem/mitigation/floodplain/community-resources/.

To facilitate insurance company access to Elevation Certificates, in the 2016 legislative session, the Governor signed a bill amending Section 472.0366 of the Florida Statutes to require a surveyor and mapper to submit a copy of Elevation Certificates used to demonstrate the elevation of buildings and property to FDEM beginning on January 1, 2017, using the form developed by FEMA. Section 472.0366 of the Florida Statutes was subsequently amended to require a digital copy of Elevation Certificates be provided to FDEM beginning January 1, 2023. Communities report that having access to Elevation Certificates for existing buildings is beneficial when owners elect to have certificates prepared as part of obtaining flood insurance policies.

Elevation Certificates

The web applications for submitting Elevation Certificates and accessing submitted documents are available at www.floridadisaster.org/elevation-certificates/.

2.2.1. HISTORY OF FLOOD PROVISIONS IN THE FLORIDA BUILDING CODE

The flood provisions in the FBC are based on the flood provisions in the I-Codes, which in turn are related to the floodplain management regulations of the NFIP. Since 1998, FEMA has participated in the code development process for the I-Codes. Every 3 years, the family of I-Codes is modified through a formal, public consensus process. Prior to the 2010 FBC, there were no flood provisions in the FBC. Since the 2010 FBC, the flood provisions in the I--Codes have been retained in the FBC as the Florida Building Commission undertakes the code development process every 3 years.

FEMA considers the flood provisions in the latest published editions of the I-Codes to meet or exceed the minimum NFIP requirements for buildings and structures in flood hazard areas.

Florida Building Code and the NFIP

The OFM has compiled excerpts of the flood provisions of the 7th Edition (2020) FBC into a resource that is available at www.floridadisaster.org/dem/mitigation/floodplain/community-resources (FDEM 2020). OFM refers users to FEMA's *Highlights of ASCE 24-14 Flood Resistant Design and Construction* (2015a) online at www.fema.gov/building-code-resources.

Many Florida communities, through local floodplain management regulations, have adopted and enforced provisions that exceed the NFIP minimum requirements for buildings. However, as dictated by the Florida Statutes, only the FBC governs the design and construction of buildings. Thus, to address the potential for conflict and challenge to locally adopted higher standards, the OFM developed a companion model ordinance written to rely on the FBC for design and construction of buildings in SFHAs. The model ordinance includes administrative provisions, duties and responsibilities of the Floodplain Administrator, provisions for determining BFEs and floodways when not specified on Flood Insurance Rate Maps (FIRMs), records retention, and other provisions, including requirements for development other than buildings within the scope of the FBC. Together, the FBC and the model ordinance meet or exceed the NFIP requirements (Figure 2-1).

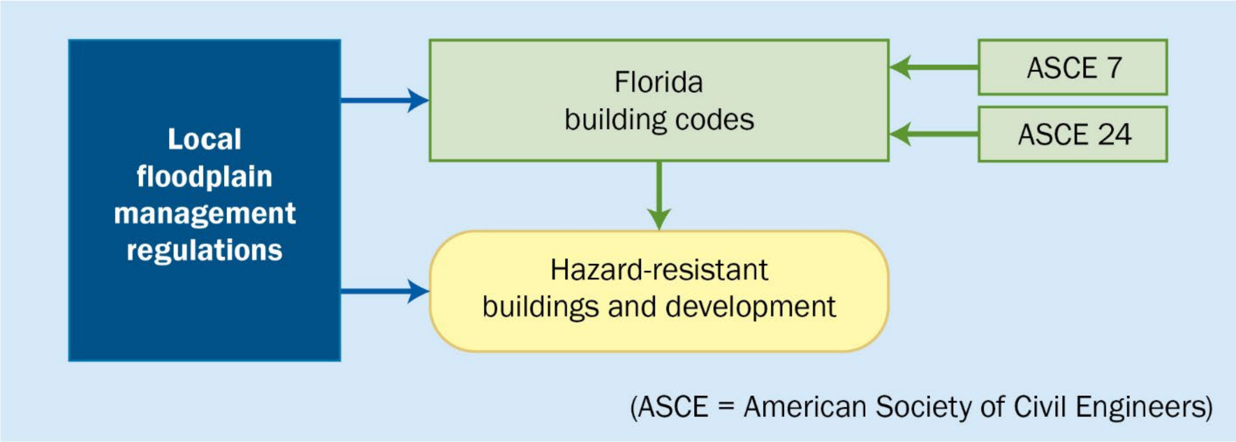
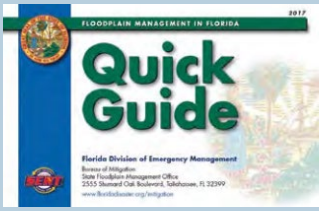


Figure 2-1: FBC and local regulations meet or exceed the NFIP requirements

The FBC-coordinated model ordinance is intended to be administered by the community Floodplain Administrator and Building Official.

Florida Quick Guide

The OFM produced an illustrated overview of floodplain management for non-technical local staff and a refresher for Floodplain Administrators and Building Officials. The guide is useful for informing elected officials, appointed citizen boards, and the public.


2017
FLOODPLAIN MANAGEMENT IN FLORIDA
Quick Guide
Florida Division of Emergency Management
Bureau of Mitigation
State Floodplain Management Office
2555 Shumard Oak Boulevard, Tallahassee, FL 32399
www.floridadisaster.org/mitigation

The Quick Guide is available online at
https://www.floridadisaster.org/dem/mitigation/floodplain/community-resources/.

2.2.2. FLOOD PROVISIONS IN THE FLORIDA BUILDING CODE

International Building Code (IBC) Chapter 1, Administration, forms the basis for Chapter 1 of the FBC, which is used to administer all volumes in the FBC family of codes. For each triennial code development cycle, the Florida Building Commission makes numerous amendments to tailor the IBC according to statutory requirements and state-specific needs. A summary of the most significant changes from the 6th Edition (2017) FBC to the 7th Edition (2020) FBC, which was in effect when Hurricane Ian made landfall, are available online at https://www.floridadisaster.org/dem/mitigation/floodplain/community-resources/. The 7th Edition (2020) FBC contains the following Chapter 1 provisions specific to buildings and structures in flood hazard areas:

- Section 102.7, Relocation of manufactured buildings – Requires that relocated manufactured buildings (those built to the FBC) comply with flood hazard area requirements (e.g., if moved into or within flood hazard areas). Manufactured homes are built to the U.S. Department of Housing and Urban Development (HUD) standards. Section R322.1.9 Manufactured homes of the FBCR defers to the state agency and local floodplain management ordinance for installation of manufactured homes.

- Section 105.14, Permit issued on basis of an affidavit, and Section 107.6.1, [Submittal Documents] Building permits issued on the basis of an affidavit – Restrict the Building Official's authority to issue permits based on affidavits by stating it does not extend to flood load and flood resistance requirements. This limitation is necessary because of the NFIP requirement that communities review development for compliance.
- Section 107.2.6, Site plan – Requires site plans to show flood hazard areas, floodways, and design flood elevations (DFEs).
- Section 107.3.5, Minimum plan review criteria for buildings – Specifies examination of documents, including minimum plan review criteria for "Building" and "Residential." Both of these review criteria include flood hazard area requirements, lowest floor elevations, enclosures, and flood damage-resistant materials. Plan review criteria for MEP and fuel gas include DFEs.
- Section 110.3, Required inspections – Replaces the I-Code section for inspections. It requires two inspections specific to flood hazard areas: a foundation inspection and a final inspection. As part of the foundation inspection, an elevation certification must be submitted upon placement of the lowest floor and prior to further vertical construction. As part of the final inspection, final certification of the lowest floor elevation must be submitted.
- Section 111.2, [Certificate of Occupancy] Certificate issued – Requires that certificates of occupancy for buildings in flood hazard areas include a statement that documentation of the as-built lowest floor elevation has been provided and is retained in the community's records.
- Section 117, Variances in Flood Hazard Areas – Refers to local floodplain management ordinances for procedures when requests for variances to the flood provisions (Section 1612 or R322) are requested. This section does not apply to Section 3109, Coastal Construction Control Line.

Through the triennial code development process, the Florida Building Commission considers Florida-specific amendments, including several sections in FBCB Chapter 4, Special Detailed Requirements Based on Occupancy and Use, that outline requirements for specific occupancies. Provisions in those sections are considered "agency amendments" and are carried forward from edition to edition. Specific to flood hazard areas, agency amendments include:

- Section 449, Hospitals, and Section 450, Nursing Homes – Require, for new construction of hospitals and nursing homes, elevation or dry floodproofing to the BFE plus 2 feet or "the height of hurricane Category 3 (Saffir-Simpson scale) surge inundation elevation," whichever is higher. The sections require Substantial Improvements to existing hospital and nursing home facilities in SFHAs or within a Category 3 surge inundation zone to be designed and constructed in compliance with Section 1612, Flood Loads. The sections also specify that all additions, patient support areas, including food service, and patient support utilities for the additions shall be at or above the elevation of the existing building if the existing building was built in compliance with applicable flood hazard areas requirements, unless otherwise required by Section 1612. For additions to facilities that pre-date the adoption of the code sections or local flood-resistant requirements, the elevation requirements for new facilities must be met, or dry floodproofing may be designed and constructed in accordance with Section 1612.

- Section 453, State Requirements for Educational Facilities – Requires educational facilities in flood hazard areas to comply with ASCE 24, Flood Resistant Design and Construction. Requires initial and subsequent installation of “public educational relocatable units” to comply with floodplain standards, including setting the “finished floor” 12 inches above the BFE and anchoring the units to resist “buoyant forces.”

- Table 1612.1, Cross References Defining Flood-Resistant Provisions of the Florida Building Code – Provides a cross-referenced list of all flood-resistant provisions of the FBC.

- Section 1612.3, Establishment of Flood Hazard Areas, and FBCR Table R301.2(1), Climatic and Geographic Design Criteria – Specify the establishment of flood hazard areas, which is accomplished by local floodplain management ordinances that adopt flood hazard maps and supporting data.

- Section 1612.4.1, Modification of ASCE 24 – Modifies ASCE 24 Table 6-1, Minimum Elevation of Floodproofing – Flood Hazard Areas Other Than Coastal High Hazard Areas, Coastal A Zones, and High Risk Flood Hazard Areas, and Section 6.2.1, Dry Floodproofing Limitations, to permit dry floodproofing of non-residential buildings located in Coastal A Zones provided “wave loads and the potential for erosion and local scour are accounted for in the design.” The FBC references ASCE 24 for specific requirements for buildings and related components in flood hazard areas.

- Section 1612.4.2, Modification of ASCE 24 – Modifies ASCE 24, Section 9.6 Pools by providing an exception for elevation requirements for equipment associated with pools, spas, and water features.

- Section 3109, Structures Seaward of a Coastal Construction Control Line – Contains requirements applicable to most structures located seaward of the CCCL, a line established by Florida Statute. In the 6th Edition (2017) FBCB, this section was completely revised to bring the CCCL requirements more in line with the Section 1612 requirements for Coastal High Hazard Areas (Zone V), while retaining certain requirements of statute and declaration statements (interpretations) issued by the Florida Building Commission. At many locations around Florida’s coast, the “100-year storm elevation” used in the CCCL requirements is higher than the BFE shown on FIRMs.

2.2.3. LOCAL AMENDMENTS TO THE FLOOD PROVISIONS OF THE FBC

A statutory provision was added in 2010 specifically for local amendments to the FBC flood provisions. Under three circumstances, these amendments do not expire every 3 years as other local amendments do (refer to Section 2.1.2): (1) if they are locally adopted before July 1, 2010; (2) if the higher standard is freeboard; and (3) if the higher standard is adopted for the purpose of participating in the NFIP CRS.

Florida's NFIP communities adopt FBC-coordinated floodplain management regulations. The OFM maintains a database of the most common locally adopted higher standards. As of June 8, 2023, the most common higher standards that affect the design and construction of buildings in flood hazard areas include:

- Additional elevation (freeboard). Freeboard specifies how high lowest floors and dry floodproofing must be above the minimum required elevation. More than 60 communities have adopted freeboard of 2, 3, or 4 feet above the BFE, 15 have adopted 1.5 feet above the BFE, and many have adopted a minimum elevation above the crown of the road (typically 12 to 18 inches). The 7th Edition FBC, requires a minimum elevation of the BFE plus 1 foot of freeboard. Lee County (unincorporated) began requiring 1 foot of freeboard on December 31, 2017, the effective date of the 7th Edition FBC.

  In addition to the 1-foot freeboard requirement, Lee County (unincorporated), with the passing of Ordinance No. 15-09 on May 19, 2015, adopted a requirement that new buildings not located in the SFHA must have the lowest floor elevation constructed at least 12 inches above the crown of the nearest local street unless the building official allows otherwise. The lowest floor requirement for buildings not in the SFHA became effective upon the filing of the ordinance with the Office of the Secretary of the Florida Department of State. The lowest floor elevation requirement for buildings not in the SFHA was not applied to those development order applications that were determined to be complete prior to the effective date.

  The Village of Estero, FL, in Section 7-206 of its Land Development Code, has surface water management requirements that new residential and commercials structures elevate the first floor to the BFE plus 1 foot or the 100-year, 3-day design stage elevation plus 1 foot, whichever is greater. In addition, the village also requires that new buildings not located in the SFHA have the lowest floor elevation at least 12 inches above the crown of the nearest local street unless the building official allows otherwise.

- Enclosure limits (prohibition, size limits, access, no partitions). More than 120 communities have adopted some form of enclosure limits. A small number prohibit walls (other than insect screening or lattice). Some communities limit the size to less than 299 square feet (primarily in Zone V), while many others limit the size and number of doors and do not allow partitions (except crawlspace if required for fire safety). Fort Myers, in Chapter 102, Article III of its Land Development Code, has limitations on enclosure areas that limit the installation of partitions to those for stairwells, ramps, and elevators and those required by the fire code.

- Cumulative Substantial Improvement. More than 125 communities have adopted requirements to accumulate costs of improvements and repairs over specific periods of time. The most common period of time is 5 years, followed by 10 years, 2 years, and the life of structures. Shorter periods are typically selected when the objective is to discourage deliberate phasing of improvements that, if taken together, would trigger the Substantial Improvement requirement to bring structures into compliance with the flood provisions.

  Lee County (unincorporated), with the passing of Ordinance No. 15-09 on May 19, 2015, adopted requirements to accumulate the costs over a 5-year period. The requirements became effective upon the filing of the ordinance with the Office of the Secretary of the Florida Department of State. The cumulative provision was not applied to those development order applications that were determined to be complete prior to the effective date of the ordinance.

  Bonita Springs, with passing of Ordinance 18-13 on August 6, 2018, adopted requirements to accumulate costs over a 5-year period. The requirement became effective 30 days after the passing of the ordinance.

  The Village of Estero, FL, in Section 7-3 of its Land Development Code, adopted requirements to accumulate costs over a 5-year period.

  Fort Myers, in Chapter 102, Article 2 of its Land Development Code, adopted requirements to accumulate costs over a 12-month period.

- Lower Substantial Improvement / Substantial Damage thresholds. Fifteen communities have adopted Substantial Improvement / Substantial Damage thresholds lower than 50%, ranging from 30% to 49%. Lower Substantial Improvement and Substantial Damage thresholds, which are more stringent than NFIP requirements, have the effect of requiring more structures to come into compliance if the owners want to improve them or if they are damaged.

- Repetitive flood loss. More than 50 communities modified the definition of “Substantial Damage” to include repetitive flood damage, such that the term includes “flood-related damage sustained by a structure on two separate occasions during a 10-year period for which the cost of repairs at the time of each such flood event, on average, equals or exceeds 25% of the market value of the structure before the damage occurred.” Thus, buildings that are determined to be Substantially Damaged by repetitive flooding must be brought into compliance with the flood requirements of the FBC. Owners of those buildings, if covered by NFIP flood insurance policies, may qualify for Increased Cost of Compliance claims that pay up to $30,000 toward the cost of bringing the buildings into compliance.

  Lee County (unincorporated), with the passing of Ordinance No. 15-09 on May 19, 2015, modified the definition of “Substantial Damage” to include repetitive flood damage. The modified definition became effective upon the filing of the ordinance with the Office of the Secretary of the Florida Department of State. The modified definition was not applied to those development order applications that were determined to be complete prior to the effective date of the ordinance.

Bonita Springs, with the passing of Ordinance No. 18-13 on August 6, 2018, modified the definition of "Substantial Damage" to include repetitive flood damage. The modified definition became effective 30 days after the passing of the ordinance.

The Town of Fort Myers Beach, in Article II, Division 3 and in Article IV of its Land Development Code, included repetitive flood damage in the definition of "Substantial Damage."

- Critical facilities. More than 50 communities have adopted some form of regulation pertaining to critical facilities. A common amendment is to define critical facilities to include Flood Design Class 3 and 4 structures (see ASCE 24-14 for the Flood Design Class descriptions). Many have adopted higher elevation requirements, which may now be superseded by the Flood Design Class 4 requirement that specifies lowest floors and dry floodproofing be at or above the BFE plus 2 feet or the 500-year flood elevation (elevation of the 0.2-percent-annual-chance flood), whichever is higher. A number of communities do not permit critical facilities in all or part of the SFHA or have adopted language requiring alternative locations to be considered.

  Lee County (unincorporated), with the passing of Ordinance No. 15-09 on May 19, 2015, requires critical facilities to be located outside of the SFHA where feasible and if located within the SFHA to be elevated to the higher of the BFE plus 2 feet of the 0.2-percent-chance flood elevation. The requirement became effective upon the filing of the ordinance with the Office of the Secretary of the Florida Department of State. The requirement was not applied to those development order applications that were determined to be complete prior to the effective date of the ordinance.

  Bonita Springs, in Section 24-114 of the Bonita Springs City Code, adopted requirements that require critical facilities to be located outside of the SFHA where feasible and if located within the SFHA to be elevated to the higher of the BFE plus 2 feet of the 0.2-percent-chance flood elevation.

  The Village of Estero, FL, in Section 7-3 of its Land Development Code, requires critical facilities to be located outside of the SFHA where feasible and if located within the SFHA to be elevated to the higher of the BFE plus 2 feet of the 0.2-percent-chance flood elevation.

  Fort Myers, in Section 110-82 of its Land Development Code, requires critical facilities to be located outside of the SFHA where feasible and if located within the SFHA to be elevated to the higher of the BFE plus 2 feet of the 0.2-percent-chance flood elevation.

- Manufactured home parks. Nearly 200 communities have adopted one or more of the following common amendments that govern the installation of manufactured homes:
  - Not permitting new installations in floodways or Zone V, except in existing manufactured home parks and subdivisions.
  - Prohibiting manufactured homes in the SFHA.

  - Eliminating the 36-inch elevation option in existing manufactured home parks and subdivisions, which typically results in higher elevation requirements for manufactured homes consistent with the FIS and FIRM BFE, when triggered for the given location. This is a new Class 8 prerequisite for all participating and new CRS communities that was effective January 2021.

  - Charlotte County, unincorporated, in Section 3-2-288 of its Land Development Code, requires manufactured homes to be elevated to the required elevation and does not allow the 36-inch replacement option.

  - City of Cape Coral, with the passing of Ordinance 38-21 on June 2, 2021, eliminated the 36-inch elevation option in existing manufactured home parks. The ordinance became effective immediately after its adoption.

2.2.4. OTHER LOCAL REQUIREMENTS

In addition to the building codes and floodplain management regulations, jurisdictions often have plans, programs, and additional regulations that serve to reduce the vulnerability to damage from natural disasters.

Charlotte County, Florida, in its 2020 Local Mitigation Strategy, includes a mitigation goal that focuses on protecting and acquiring unique natural habitats and ecological systems and restoring degraded natural systems to a functional condition to maximize mitigation values. Charlotte County citizens voted to tax themselves for the purchase of environmentally sensitive land via the Conservation Charlotte program on November 7, 2006 (Charlotte County 2023). The funds generated by the bonding of the tax go toward the purchase of environmentally sensitive lands that are held in preservation for public use. Additionally, the Charlotte County Code provides design standards for the coastal areas and regulates the operation of motor vehicles on shorelines, dune structures, shoreline stabilizations structures, and dune restoration and stabilization projects.

Lee County, and its political subdivisions of Bonita Springs, Cape Coral, Estero, Fort Myers, Fort Myers Beach, Sanibel, and Florida Gulf Coast University have a *Joint Local Mitigation Strategy* (Joint LMS) (Lee County Emergency Management 2022). The purpose of the Joint LMS is to establish a multi-jurisdictional mitigation framework for minimizing risks to life and the built and natural environments caused by natural hazards.

In addition to the Joint LMS, in response to the damage caused by Hurricane Ian, the Lee Board of County Commissioners formed the Recovery Task Force (RTF) based on the FEMA National Disaster Recovery Framework (NDRF) (Resilient Lee 2023). The RTF consists of representatives from Lee County Government, City Leaders, Law Enforcement, Fire, Lee County Schools, the Legislative Delegation, and Constitutional Office. The RTF has four objectives:

- Objective 1: Survey the needs (immediate, short term, and long term) of Lee County.
- Objective 2: Engage key partners to address community needs.

- Objective 3: Develop solutions that are viable, feasible, desirable, and actionable to meet the needs identified.
- Objective 4: Maximize available funding resources and recommend policies to implement the solutions.

The Land Development Code for unincorporated areas of Lee County provides requirements for vegetative buffers abutting natural waterways and regulates activities on the beach and dune areas, including the prohibition of non-authorized vehicular traffic. The Land Development Code also provides regulations that supplement and enhance the state environmental protection enforcement mechanisms with the intent to discourage the illegal alteration of mangrove trees.

Bonita Springs, in the Conservation/Coastal Management Element of its Comprehensive Plan, has a policy supporting the preservation of environmentally sensitive areas in the coastal planning area by land acquisition. In addition, the Bonita Springs Land Development Code also has regulations that supplement and enhance the state environmental protection enforcement mechanisms with the intent to discourage the illegal alteration of mangrove trees.

Cape Coral, in its Comprehensive Plan, states that the city will develop and maintain priorities for the acquisition of lands for preservation of vulnerable coastal ecological communities and acquire this land as either part of its land banking program or through other feasible methods.

The Village of Estero adopted a Comprehensive Plan in 2018 that establishes goals, objectives, and policies that focus on preserving, protecting, and integrating natural features within the community. These include collaborating with public agencies and private developers to preserve and maintain interconnected natural areas and adopt development and redevelopment strategies to reduce the risk of flooding, storm surge, and impacts of sea level rise (SLR).

Fort Myers Beach, in the Coastal Management Element of its Comprehensive Plan, addresses natural disaster planning concerns such as affected population, evacuation times, and sheltering; floodplain management and building back after a natural disaster; and beach erosion and other shoreline protection measures.

Fort Myers, in the Conservation and Coastal Management section of its Comprehensive Plan, adopted a goal to maintain, increase, and manage natural and coastal resources to preserve their quality and the ability to protect human life in areas subject to destruction by natural disasters.

The Comprehensive Land Use Plan of the City of Sanibel, adopted in 1976 and last revised in 1997, is known as *Sanibel Plan*. *Sanibel Plan* provides a plan for the orderly development to reduce the potential threat to life, beaches, and structures from hurricanes and to provide safe and efficient infrastructure and future needs for public services. Development regulations in the *Sanibel Plan* were incorporated into the Sanibel Land Development Code. A damage reduction measure from the *Sanibel Plan* is to maintain as much dense vegetation as possible and require revegetation as a means of reducing wave heights and wind velocity. The vegetation requirements can be found in Chapter 122 of the Sanibel Code of Ordinances, Subpart B – Land Development Code.

2.2.5. COASTAL CONSTRUCTION REQUIREMENTS

An important consideration in floodplain management regulation is siting requirements for development relative to the floodprone areas. Structures located closer to the source of flooding are often more exposed to wave impacts such as wave runup, scour, short-term and long-term erosion, debris impact, and storm surge and, thus, increase their lifetime residual risk to flood damage. Local, state, and federal requirements exist to help limit development in vulnerable areas.

FEMA guidance, described in FEMA P-55, *Coastal Construction Manual* (2011; see text box), clearly states that developers, designers, and other interested stakeholders need to evaluate and better understand hazards, risks, and vulnerabilities of structures within the coastal zone.

FEMA Guidance for Siting Structures

FEMA guidance and recommendations for siting structures within a parcel are presented in Chapter 4 of FEMA P-55, *Coastal Construction Manual*.

Other federal regulatory programs, such as the Coastal Barrier Resource Act (CBRA), are set to preserve coastal areas, open land, and vulnerable shorelines by limiting federal investment and discouraging development. The CBRA of 1982 and subsequent amendments established the John H. Chafee Coastal Barrier Resources System (CBRS), which consists of mostly undeveloped coastal barriers. The CBRS includes a category of coastal barriers known as Otherwise Protected Areas (OPAs). OPAs are undeveloped coastal areas that were established under federal, state, or local law, primarily as refuge areas for wildlife, sanctuaries, passive recreational uses, and natural resource conservation purposes. FEMA guidance also provides insight on development of raw land, notably that developers should not rely on engineering solutions to correct poor planning decisions.

Additional information about CBRA regulations and areas included is available at https://www.fws.gov/program/coastal-barrier-resources-act. Any building within a CBRS area that is constructed or Substantially Improved after October 1, 1983, or the date of designation for areas added to the system in 1991, is not eligible for federal flood insurance or other federal financial assistance. The same restriction applies to Substantially Damaged buildings in a CBRS area that are repaired or renovated after those dates. However, all buildings within the CBRS must still comply with the NFIP siting, design, and construction requirements in their communities.

Coastal Barrier Resources Act

The CBRA and subsequent amendments designated relatively undeveloped coastal barriers along the Atlantic, Gulf of Mexico, Great Lakes, U.S. Virgin Islands, and Puerto Rico coasts as part of the John H. Chafee CBRS.

2.2.6. COASTAL CONSTRUCTION CONTROL LINE

From a state perspective, one of the measures to regulate structures and activities in the coastal zone along the shoreline is the State of Florida’s CCCL Program. The CCCL Program is a component of the Florida Beach and Shore Preservation Act (Part I of Chapter 161, Florida Statutes). The purpose of the Florida Beach and Shore Preservation Act is to preserve and protect Florida's beach and dune system while ensuring reasonable use of private property. The CCCL marks the landward limit of areas where special siting and design considerations are necessary to protect the beach-dune system, proposed and existing structures, and adjacent properties, as well as to preserve public beach access. It is not a setback line but rather defines the landward limit of the Florida Department of Environmental Protection's (FDEP's) jurisdiction. The CCCL is established by metes and bounds descriptions in Chapter 62B-26, Florida Administrative Code. The CCCLs for the affected counties have the following effective dates:

- Charlotte – January 29, 1985
- Collier – June 29, 1989
- Lee – 1985 and updated May 30, 1991
- Volusia – 1991

Structures located seaward of the CCCL are expected to sustain greater impacts from winds and storm surge during severe storms than those located landward of the CCCL. The FDEP maintains an interactive geographic information system (GIS) called Map Direct (https://floridadep.gov/rcp/coastal-construction-control-line/content/locate-coastal-construction-control-line-cccl) that can be used to determine whether a property is located seaward of the CCCL.

New construction, including additions, remodeling, and repairs to existing structures require a CCCL permit from the FDEP unless they are exempt by the rule or law. The permit review is to ensure that structures are designed and built to withstand the winds and storm surge expected during severe storms.

In addition to the FDEP CCCL permit, Section 3109 of the FBC includes the CCCL requirements for certain buildings. The CCCL requirements in FBC Section 3109 apply to the design and construction of habitable structures that extend seaward of the CCCL, either in whole or in part. Those structures that are also located in whole or in part in the SFHA are subject to the flood requirements in FBC Section 1612. Section 3109 of the FBC describes the applicability of the FBC requirements; the need for an FDEP permit; design and construction requirements, including allowable foundations; elevation standards; walls and enclosures below the flood elevation; and documentation requirements.

Coastal Construction Control Line Requirements

Part I of Chapter 161, Florida Statutes provides the purpose of the Florida Beach and Shore Preservation Act. The CCCL Program is one of three interrelated parts of the Statewide Beach Management Program.

Chapter 62B-33 of the Florida Administrative Code provides the design and siting requirements for structures seaward of the CCCL.

Chapter 62B-33.024 requires builders to use a 30-year erosion projection for siting structures and establishes prohibitions and limitations on excavation and fill. It also describes turtle protection requirements, including lighting, and allowable dune restoration activities. The rule provides guidance for developing the shoreline change rates for natural beaches; beaches where coastal armoring is present; beaches adjacent to or in the vicinity of inlets without jetty structures; and beaches with established beach nourishment or restoration projects.

The CCCL can be located using tools from the FDEP website at https://floridadep.gov/rcp/coastal-construction-control-line/content/locate-coastal-construction-control-line-cccl.

2.3. Key Wind Provisions of the Florida Building Code

The design of buildings for wind loads in the State of Florida is governed primarily by the FBCB, FBCR, and FBCEB. The 7th Edition (2020) FBCB, FBCR, and FBCEB reference the 2016 Edition of ASCE Standard 7, *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-16). However, the FBCB, FBCR, and FBCEB also contain numerous Florida-specific, wind-related amendments that exceed the minimum criteria in the 2018 I-Codes.

The FBC also contains separate wind, structural, and testing requirements for Miami-Dade and Broward Counties, which are defined as the HVHZ. The HVHZ was created for the inaugural version of the FBC (2001) as a way to maintain certain wind- and structural design-related provisions from the South Florida Building Code. The wind criteria applicable in the HVHZ have historically been more stringent than the criteria applied in the rest of the state. However, recent updates for areas outside the HVHZ have minimized the differences.

There are exceptions specified in the FBC that allow for the use of certain prescriptive high-wind design standards. Although these prescriptive standards are primarily for one- and two-family dwellings, ICC 600, *Standard for Residential Construction in High-Wind Regions* (ICC 2014), is also permitted for applicable Group R2 buildings (apartments, hotels, dormitories, etc.). The prescriptive standards allowed for the FBC for high-wind design include:

- *Wood-Frame Construction Manual (WFCM) for One- and Two-Family Dwellings* (AWC 2018)
- *Standard for Residential Construction in High-Wind Regions* (ICC 600) (ICC 2014) – for concrete and concrete masonry walls only

- *Standard for Cold-Formed Steel Framing—Prescriptive Method for One- and Two-Family Dwellings* (American Iron and Steel Institute [AISI] S230) (AISI 2019)

2.3.1. WIND LOADS AND WIND DESIGN IN THE FBC

Section 2.3.1 provides information on the current design wind speeds in the FBC, as well as the WBDR. A history of wind-related changes in the FBC is also provided for reference.

The 7th Edition (2020) FBCB and FBCR contain Florida-specific design wind speed maps that are generally consistent with ASCE 7-16. The wind speed maps for Risk Category II, III, and IV buildings (FBCB) are shown in Figure 2-2, Figure 2-3, and Figure 2-4 and the wind speed map in the FBCR, including the WBDR, is shown in Figure 2-5. For more information on the WBDR, see Section 2.3.2. Although the 7th Edition (2020) FBCB and FBCR reference ASCE 7-16 for wind design, they do not include the Risk Category II basic wind speed map nor the Risk Category IV basic wind speed map from ASCE 7-16. The Risk Category II basic wind speed map in ASCE 7-16 includes reduced wind speeds in the "big bend" area[2] of Florida. Consequently, the FBCB and FBCR maintained the ASCE 7-10 Risk Category II basic wind speed map, which equals or exceeds the Risk Category II basic wind speeds in ASCE 7-16. ASCE 7-22 reversed these reductions in the big bend area of Florida, and the Risk Category II basic wind speed map in ASCE 7-22 is consistent with the 7th Edition (2020) FBCB and FBCR in the big bend area. Additionally, a processing error of storm data, which had underestimated basic wind speeds in the panhandle area of Florida, was discovered in the mapped basic wind speeds for Risk Category IV buildings. Consequently, the 7th Edition (2020) FBCB includes an updated Risk Category IV map that corrects the error in ASCE 7-16. This error has also been corrected in ASCE 7-22.

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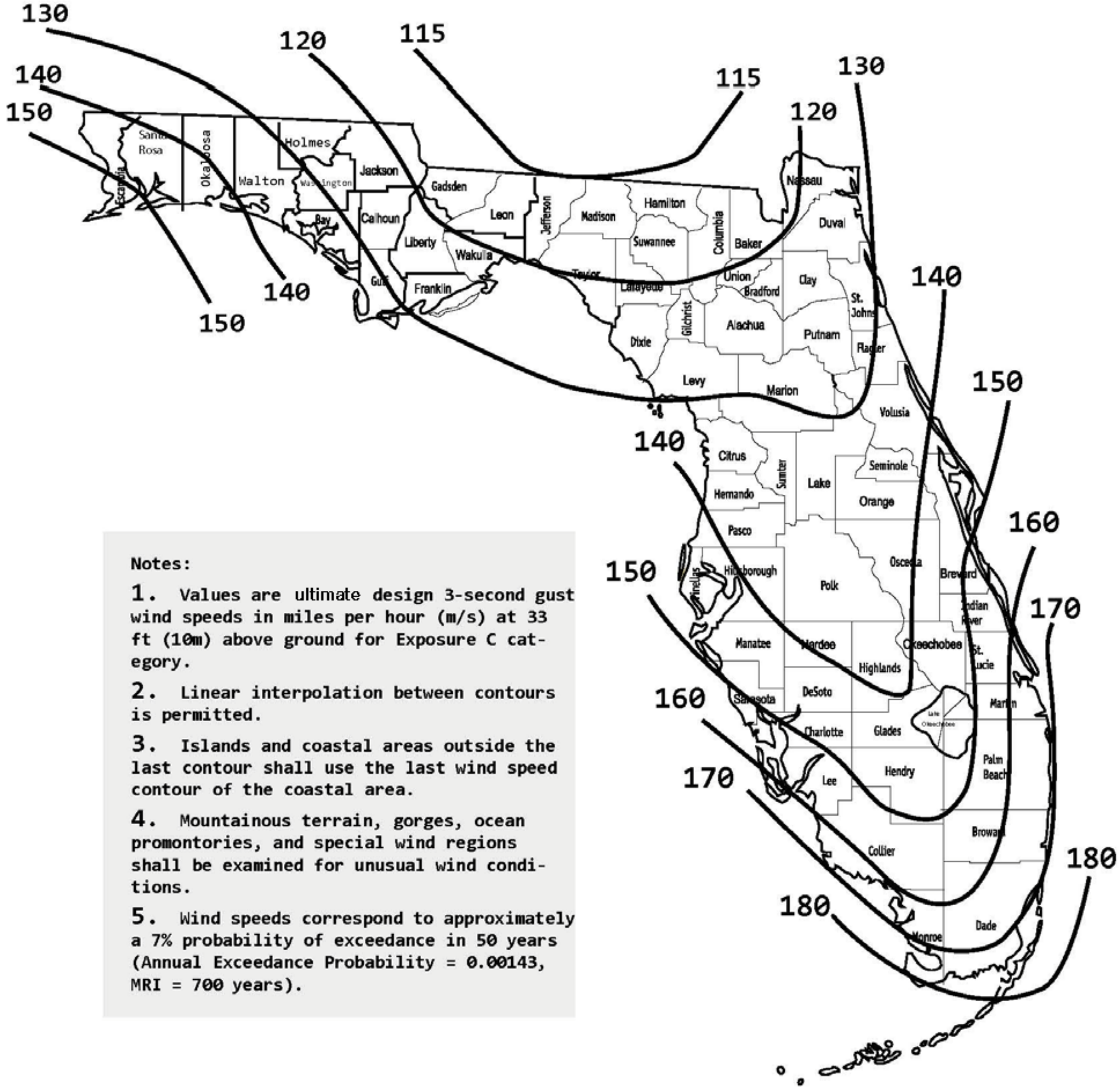
[2] The "big bend" is an informal area along the western gulf coast of Florida having an approximate geographic area that includes Dixie, Jefferson, Levy and Taylor counties.

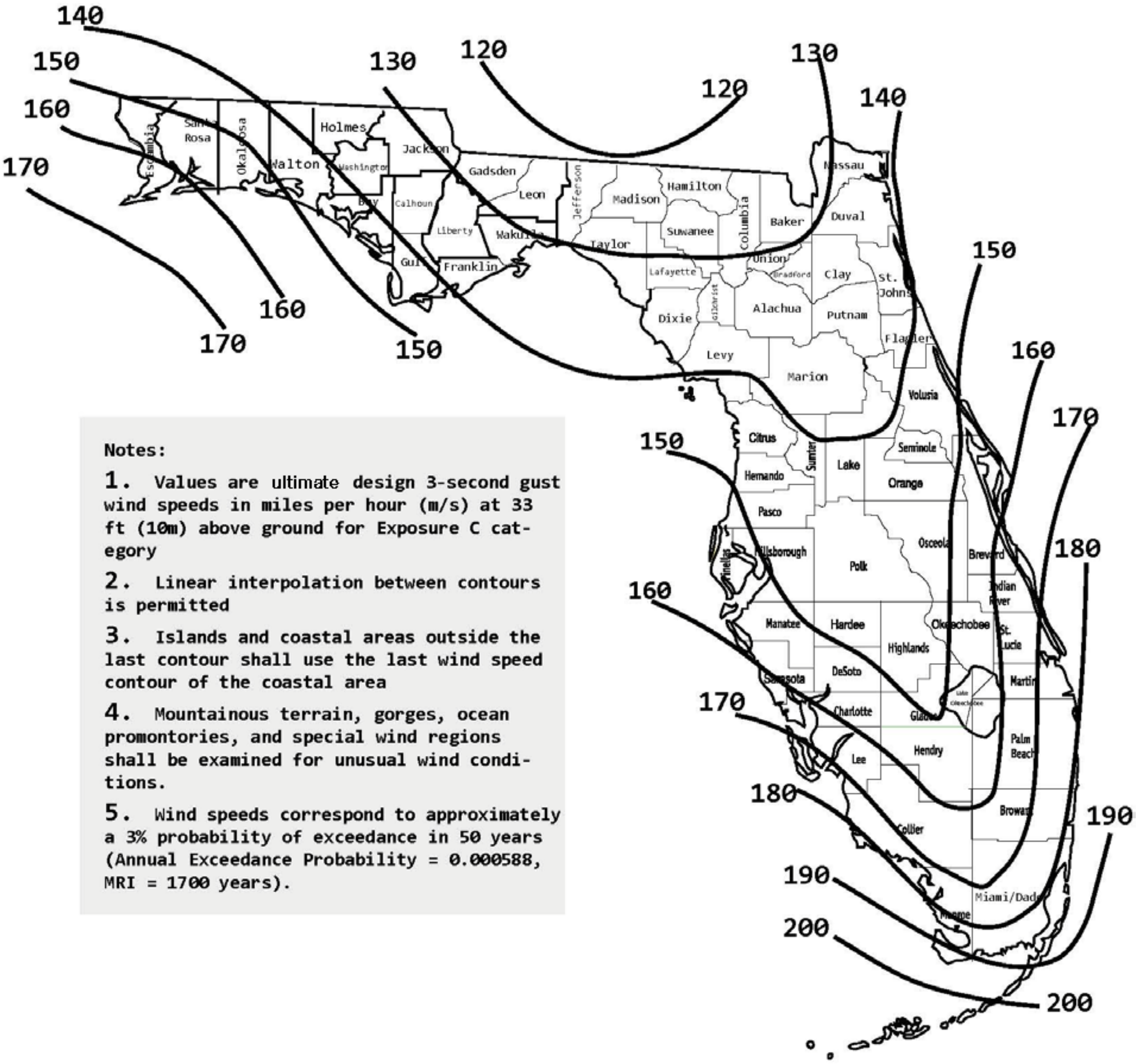


Notes:

1. Values are ultimate design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 years).

Source: 7th Edition (2020) FBCB, image used with permission from ICC

Figure 2-2: Wind speed map for Risk Category II buildings and other structures

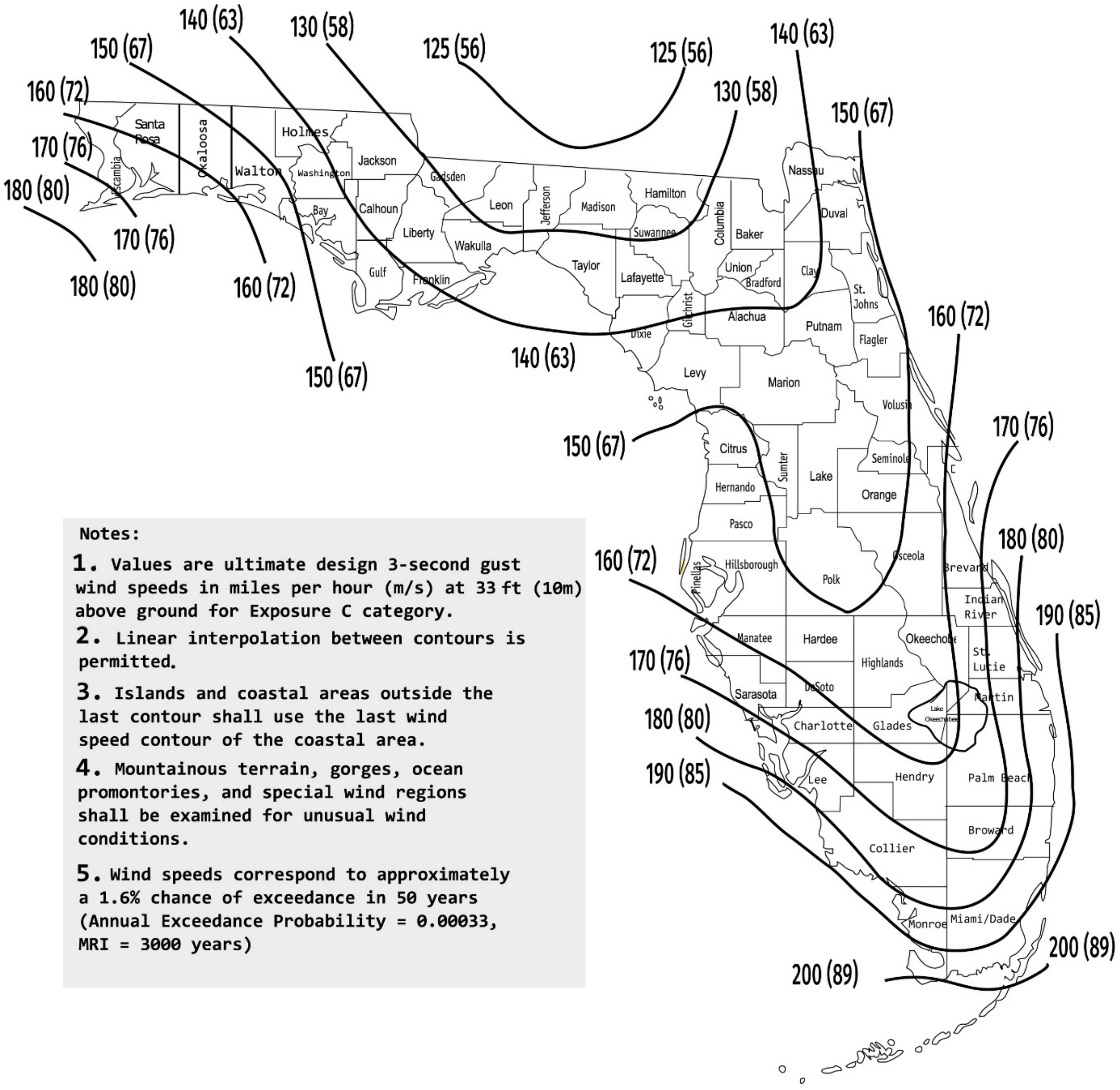


Notes:

1. Values are ultimate design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category
2. Linear interpolation between contours is permitted
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 3% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000588, MRI = 1700 years).

Source: 7th Edition (2020) FBCB, image used with permission from ICC

Figure 2-3: Wind speed map for Risk Category III buildings and other structures

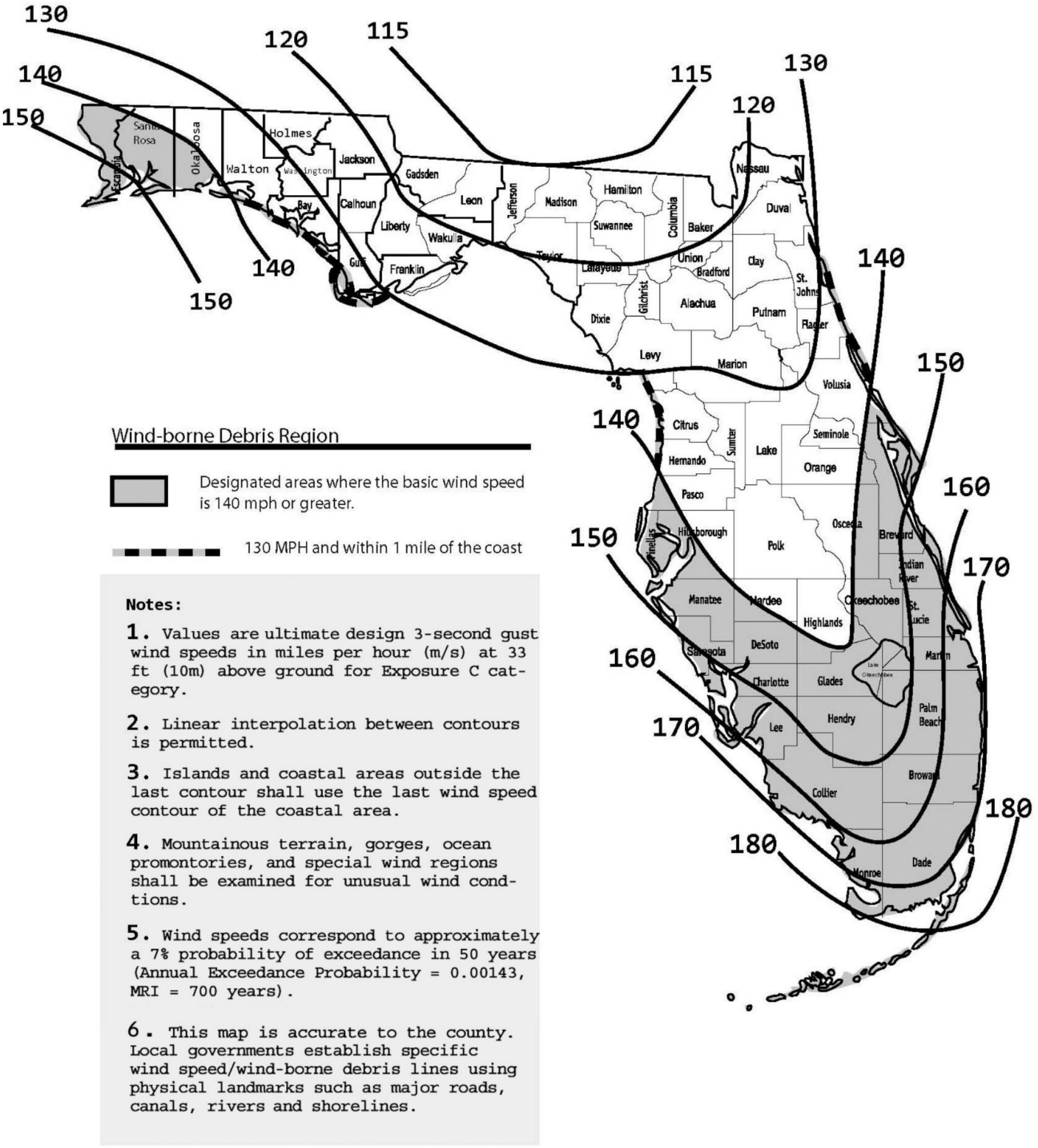


Notes:

1. Values are ultimate design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 1.6% chance of exceedance in 50 years (Annual Exceedance Probability = 0.00033, MRI = 3000 years)

Source: 7th Edition (2020) FBCB, image used with permission from ICC

Figure 2-4: Wind speed map for Risk Category IV buildings and other structures



Wind-borne Debris Region

▨ Designated areas where the basic wind speed is 140 mph or greater.

▬ ▬ ▬ 130 MPH and within 1 mile of the coast

Notes:

1. Values are ultimate design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 years).
6. This map is accurate to the county. Local governments establish specific wind speed/wind-borne debris lines using physical landmarks such as major roads, canals, rivers and shorelines.

Source: 7th Edition (2020) FBCR, image used with permission from ICC

Figure 2-5: Wind speed map and WBDR for FBCR buildings

2.3.2. WIND-BORNE DEBRIS REGION

In the WBDR, glazed openings in most buildings are required to be impact resistant or protected with an impact-resistant covering that meets one of the tests prescribed by the FBCB and FBCR. Most of the areas where Hurricane Ian made landfall are located within the WBDR and have been in this region since the 2001 FBC. A key change to the protection of glazed openings was made in the 2007 Supplement to the 2004 FBC. Prior to the 2007 Supplement, in lieu of protecting glazed openings, the FBCB and FBCR essentially permitted buildings to be designed as partially enclosed in accordance with ASCE 7. As a result of the Insurance Reform Act, the 2007 Supplement to the 2004 FBC eliminated the option to design a building as partially enclosed in lieu of protecting glazed openings from impact from wind-borne debris. Since 2007, all buildings built in Florida that are located in the WBDR are required to have glazed openings that are impact resistant or protected with an impact-resistant covering meeting the tests prescribed by the FBCB and FBCR. This exception did not apply to the HVHZ. In the HVHZ, the entire building envelope has been required to be impact resistant, including glazed openings, since the adoption of the 1994 South Florida Building Code in Miami-Dade and Broward Counties.

Definition: FBC Wind-Borne Debris Regions

Areas within *hurricane-prone regions* located in accordance with one of the following:

- Within 1 mile (1.61 km) of the coastal mean high water line where the ultimate design wind speed, V_{ult}, is 130 mph (58 m/s) or greater.
- In areas where the ultimate design wind speed, V_{ult}, is 140 mph (63.6 m/s) or greater; or Hawaii.

Source: Chapter 2 of the FBCR

Figure 2-4 shows the wind speed map from the 7th Edition (2020) FBCR with the WBDR shaded.

2.3.3. FLORIDA-SPECIFIC AMENDMENTS FOR WIND AND WATER INTRUSION

As previously stated, the FBC contains numerous Florida-specific amendments related to wind and water intrusion, including the requirements in the HVHZ that exceed the minimum requirements in the 2018 I-Codes. Table 2-1 lists some notable Florida-specific amendments in the 7th edition (2020) FBC related to wind and water intrusion mitigation.

Table 2-1: Notable Florida-Specific Amendments in the FBCB and FBCR for Wind and Water Intrusion

Code	Non-High-Velocity Hurricane Zone	High-Velocity Hurricane Zone
7th Edition (2020) FBC – Building	▪ Specifically requires soffits to be designed for wall C&C loads ▪ Limits the span of wood structural panels used for opening protection to 44 inches ▪ Requires roof covering underlayment to comply with the "sealed roof deck" provisions of the Insurance Institute for Business and Home Safety (IBHS) Fortified program; applies statewide except in the HVHZ ▪ Requires labeling on garage doors, impact-resistant coverings, and windows to include the design wind pressure rating ▪ Prohibits the use of the prescriptive provisions for conventional wood-frame construction in the 2018 IBC ▪ Reroofing – For buildings built prior to the FBC, requires all buildings with wood roof decks to be renailed when a roof covering is removed and replaced; underlayment must comply with the "sealed roof deck" provisions of the IBHS Fortified program; and roof-to-wall connections must be added in some cases ▪ Requires in-progress inspections for exterior wall coverings and soffits	▪ Requires all buildings to be designed for wind loads; prescriptive high-wind standards are not permitted ▪ Requires a single wind speed to be used for each county ○ Miami-Dade County - Risk Category II = 175 mph - Risk Category III = 186 mph - Risk Category IV = 195 mph ○ Broward County - Risk Category II = 170 mph - Risk Category III = 180 mph - Risk Category IV = 185 mph ▪ Requires the entire building envelope to be impact resistant (some deemed-to-comply assemblies are provided) ▪ Requires all areas to be designed for Exposure Category C unless Exposure Category D applies ▪ Requires the use of plywood sheathing; oriented strand board is not permitted ▪ Requires the use of ring shank nails to attach wood roof decks

Code	Non-High-Velocity Hurricane Zone	High-Velocity Hurricane Zone
7th Edition (2020) FBC – Residential	▪ Establishes the entire state as requiring wind design ○ Prescriptive high-wind standards are permitted ○ Prescriptive construction provisions in the 2018 IRC are not permitted ▪ Revises exposure category definitions to be consistent with ASCE 7 ▪ Specifically requires soffits to be designed for wall C&C loads; new section in the FBCR addresses soffits and requires vinyl soffit panels to be fastened at both ends of the soffit panel ▪ Limits the span of wood structural panels used for opening protection to 44 inches ▪ Requires roof covering underlayment to comply with the “sealed roof deck” provisions of the IBHS Fortified program; applies statewide except in the HVHZ ▪ Applies enhanced roofing underlayment provisions to high-wind areas throughout the entire state ▪ Requires labeling on garage doors, impact-resistant coverings, and windows to include the design wind pressure rating ▪ Removes references to the use of staples for wall covering attachment methods ▪ Specifically requires most roof coverings to have an uplift resistance in the Product Approval that is equal to or greater than the design uplift pressure with margin of safety of 2 to 1 ▪ Reroofing – For buildings built prior to the FBC, requires all buildings with wood roof decks to be renailed when a roof covering is removed and replaced; underlayment must comply with the “sealed roof deck” provisions of the IBHS Fortified program; and roof-to-wall connections must be added in some cases	▪ Refers to the HVHZ provisions in the FBCB

ASCE = American Society of Civil Engineers; FBCB = Florida Building Code, Building; FBCR = Florida Building Code, Residential; HVHZ = High-Velocity Hurricane Zone; IBHS = Insurance Institute for Business and Home Safety; IRC = International Residential Code; mph = miles per hour

2.3.4. REROOFING AND THE 25% RULE IN THE FBC

For repairs to damaged buildings, the FBC generally permits damaged elements to be restored to their pre-damaged condition as long as unsafe or dangerous conditions do not exist. However, for roof covering repair, the FBC has included an additional trigger called the “25% Roof Replacement Rule.” The 25% rule has been around in various forms and areas of Florida for many years. It has applied to construction in South Florida as far back as the 1957 South Florida Building Code. This rule limits how much of an existing roof can be repaired within a specific period of time before requiring the entire roof covering to be replaced to comply with the latest code. In the 7th Edition (2020) FBCB, FBCR, and FBCEB, the 25% rule reads as follows:

> Not more than 25% of the total roof area or roof section of any existing building or structure shall be repaired, replaced or recovered in any 12-month period unless the entire existing roofing system or roof section is replaced to conform to the requirements of this code.

Therefore, if more than 25% of the total roof area or roof section must be repaired, replaced, or recovered in any 12-month period, the remainder of the roof or roof section must be replaced to conform to the requirements of the code. Roof section is defined as a separation or division of a roof area by existing joints, parapet walls, flashing (excluding valleys), difference of elevation (excluding hips and ridges), roof type, or legal description, not including the roof area required for a proper tie-off with an existing system. The Florida Building Commission did issue a couple of Declaratory Statements (interpretations) establishing that proper tie-ins with the existing roof do not count toward the 25% threshold. The purpose, benefits, and costs associated with the 25% rule have been debated during the FBC development process for many years.

In May of 2022, the Florida Legislature effectively eliminated the 25% rule for buildings built to the 2007 FBC (effective date March 1, 2009) and later editions. Supplement 2 to the 7th Edition (2020) FBC adds the following exception to the 25% rule in order to comply with the legislation and went into effect May 27, 2022:

> **Exception:** If an existing roofing system or roof section was built, repaired, or replaced in compliance with the requirements of the 2007 Florida Building Code, or any subsequent editions of the Florida Building Code, and 25 percent or more of such roofing system or roof section is being repaired, replaced, or recovered, only the repaired, replaced, or recovered portion is required to be constructed in accordance with the Florida Building Code in effect, as applicable. Pursuant to s. 553.844(5), Florida Statutes, a local government may not adopt by ordinance an administrative or technical amendment to this exception.

The impact of this legislation regarding Hurricane Ian is that buildings built after March 1, 2009, that suffered roof covering damage from Hurricane Ian can be repaired even if the damaged roof area exceeds 25% of the total roof area or roof section. For buildings built prior to March 1, 2009, the 25% rule would still apply.

2.4. Florida Evacuation Shelter Program

In response to the sheltering challenges posed by Hurricane Andrew (1992), Florida's governor commissioned an evaluation of the state's evacuation and shelter operations. The commission's report, the *Lewis Commission Report* (Florida Governor's Disaster Planning and Response Review Committee 1993) identified a lack of "adequate and appropriate public shelter space," which led the state legislature to mandate elimination of the hurricane shelter capacity deficit in every region of the state. Subsequently, Florida's Department of Education was charged with developing standards for public shelter design criteria in "consultation with boards, county emergency management offices, and the Division of Emergency Management (DEM)." The resulting Public Shelter Design Criteria were adopted in 1997 and included "structural enhancements, potable water and sanitary requirements, provisions for standby emergency power, and other considerations that improve survivability and shelter management operations."

2.4.1. ENHANCED HURRICANE PROTECTION AREAS IN THE FLORIDA BUILDING CODE

The structural design provisions of the Public Shelter Design Criteria—also referred to as EHPA provisions—have evolved with the FBC. The 1st edition FBC (2001) included the following provision as cited in Section 6.5 of FEMA 488, *Hurricane Charley in Florida MAT Report* (2005):

> (d) Structural Standard for Wind Loads. At a minimum, EHPAs shall be designed for wind loads in accordance with ASCE 7-98, "Minimum Design Loads for Buildings and Other Structures, Category III (Essential Buildings)." Openings shall withstand the impact of windborne debris missiles in accordance with the impact and cyclic loading criteria per SBC/SSTD 12-99. Based on a research document, "Emergency Shelter Design Criteria for Education Facilities," 1993, by the University of Florida for the DOE, it is highly recommended by the Department that the shelter be designed using the map wind speed plus (40) mph, with an importance factor of 1.0.

FEMA reported on EHPA performance following its Hurricane Charley assessment (FEMA 488). FEMA reported on one significant EHPA structural failure (FEMA 488, Section 6.5.1.1), and recommended that 1) the EHPA design wind speed of the 2001 FBC basic wind speed plus 40 mph should be a requirement, not a best practice; and 2) minimum debris impact protection should be per ASTM E1996 Test Missile E for a 9-pound 2x4 (nominal) missile traveling at 50 mph (instead of 34 mph for all other buildings in the WBDR) (Section 8.2). Note that FEMA 488 preceded the first edition of ICC / National Storm Shelter Association (NSSA) *Standard for the Design and Construction of Storm Shelters* (ICC 500), which was published in 2008.

The 2nd, 3rd, 4th, and 5th editions of the FBC maintained essentially the same EHPA wind requirements as the 1st edition (ASTM E1996 and E1886 were added as impact testing alternatives in the 5th edition). Significantly, the 6th edition FBC (2017) included the first reference to ICC 500 for EHPA design. Specifically, Section 453.25.4 (Structural standards for wind loads) now provides: "**At a minimum, EHPA shall be designed for hurricane wind loads in accordance with ICC 500.**" The 7th edition FBC (2020) includes the same language.

Significant changes to EHPA requirements from the 6th edition FBC (2017) to the 7th edition FBC (2020) include the following:

1. Section 453.25.1.1: The minimum period of protection provided by EHPAs was increased from 8 to 24 hours.
2. Section 453.25.3.2: The minimum space capacity (aka usable floor area) of 60 square feet per occupant was added for Special Needs EHPAs. Previous editions only specified minimum usable floor area of 20 square feet per occupant and did not distinguish between General Population Shelters and Special Needs Shelters.
3. Section 453.25.6.3 from the 6th edition FBC was removed. It required that EHPAs be inspected and recertified for compliance with the code's structural requirements every 5 years by a Florida-registered Professional Engineer skilled in structural design. If any inspected structural system was determined to be damaged or replaced, then recertification was required prior to the beginning of the next hurricane season.

EHPA or Storm Shelter?

EHPA requirements described in this section are found in Section 453.25 of the 7th edition FBC (2020) and apply specifically to public shelters in educational facilities. Section 423 of the 7th edition FBC (2020) applies to all other storm shelters constructed "for the purpose of providing safe refuge from storms that produce high winds, such as tornadoes and hurricanes." Whereas, Section 453.25 only references ICC 500 for wind loads, Section 423 requires the design and construction of storm shelters to comply with all requirements in ICC 500.

2.4.2. STATE EMERGENCY SHELTER PLAN OPTIONS: EHPA OR RETROFIT

In compliance with state statutes, the FDEM prepares and submits the Statewide Emergency Shelter Plan (SESP) to the Governor and Cabinet for approval every other year. The plan provides detailed information on the current inventory of HES spaces along with current and projected shelter capacity deficits (or surpluses) for every Florida county. The plan also includes supplemental guidance on implementation of the state's sheltering criteria. The plan's shelter-tracking data and implementation guidance are intended to inform planning decisions by local officials that will ultimately serve to safely eliminate the state's shelter capacity deficit.

According to Section 2.2 of the 2022 SESP, unless specifically exempted by the school board with written concurrence from the state, all new educational facilities (including new buildings on existing campuses) in areas identified with shelter capacity deficits are required to meet the EHPA code provisions so that the facilities can be used during storms as directed by local authorities. However, local authorities can avoid having to meet the EHPA provisions for new school buildings by satisfying the estimated shelter capacity demands by identifying available shelter space in existing buildings. Qualifying existing buildings for state-recognized shelter space requires assessing selected buildings or building areas using the American Red Cross *Standards for Hurricane Evacuation Shelter Selection Standards* (ARC HESSS, formerly ARC 4496; 2002) – Prescriptive Summary Table (FDEM 2014). Based on the survey findings, the assessor assigns a qualitative ranking—preferred, less preferred/marginal, or further investigation/mitigation required—to 15 HES criteria categories. Mitigation of any shelter vulnerability may improve the ranking of buildings under consideration. For example, unprotected glazed openings (Category 10 – Fenestration/Window Protection) can be mitigated by retrofitting the opening with hurricane shutters, shields, or impact-resistant glazing to change the Category 10 ranking from "further investigation/mitigation required" to "preferred." Like in the 1st through 5th editions FBC, code recommendations on applying higher wind speeds for design of EHPAs, ARC HESSS guidance on the HES selection process is written in non-mandatory language and, therefore, highly subject to interpretation.

Wind Retrofitting and Vulnerability Assessment Resources

Hurricane Michael in Florida Recovery Advisory 1, *Successfully Retrofitting Buildings for Wind Resistance* (2019c), was developed based on the Hurricane Michael MAT's observations of critical facilities performance (including HESs) and provides guidance on how to comprehensively assess building vulnerabilities to hurricane high winds. FEMA P-2062, *Guidelines for Wind Vulnerability Assessments of Existing Critical Facilities* (2019b) also provides comprehensive guidance on performing vulnerability assessments for critical facilities.

FDEM's 2021 *Shelter Retrofit Report* (FDEM 2021a) outlines its shelter capacity deficit reduction strategy and includes county-specific information gathered on retrofit projects and/or EHPA construction from Fiscal Year 2020 to Fiscal Year 2021. The report recommends 262 retrofit projects over fiscal years 2021–2022 but does not indicate how many retrofit projects were submitted for approval or how many EHPAs were under construction during the same period. Despite significant progress in reducing shelter capacity deficits across the state, Lee, Collier, Charlotte, and Desoto Counties (those impacted by Hurricane Ian) still report deficits in shelter capacity. According to information provided in Appendix B of the report, none of the shelter space compiled for the four counties contained EHPA shelter space and no retrofit projects were under contract as of the time of that report.

2.5. Manufactured Home Requirements (HUD)

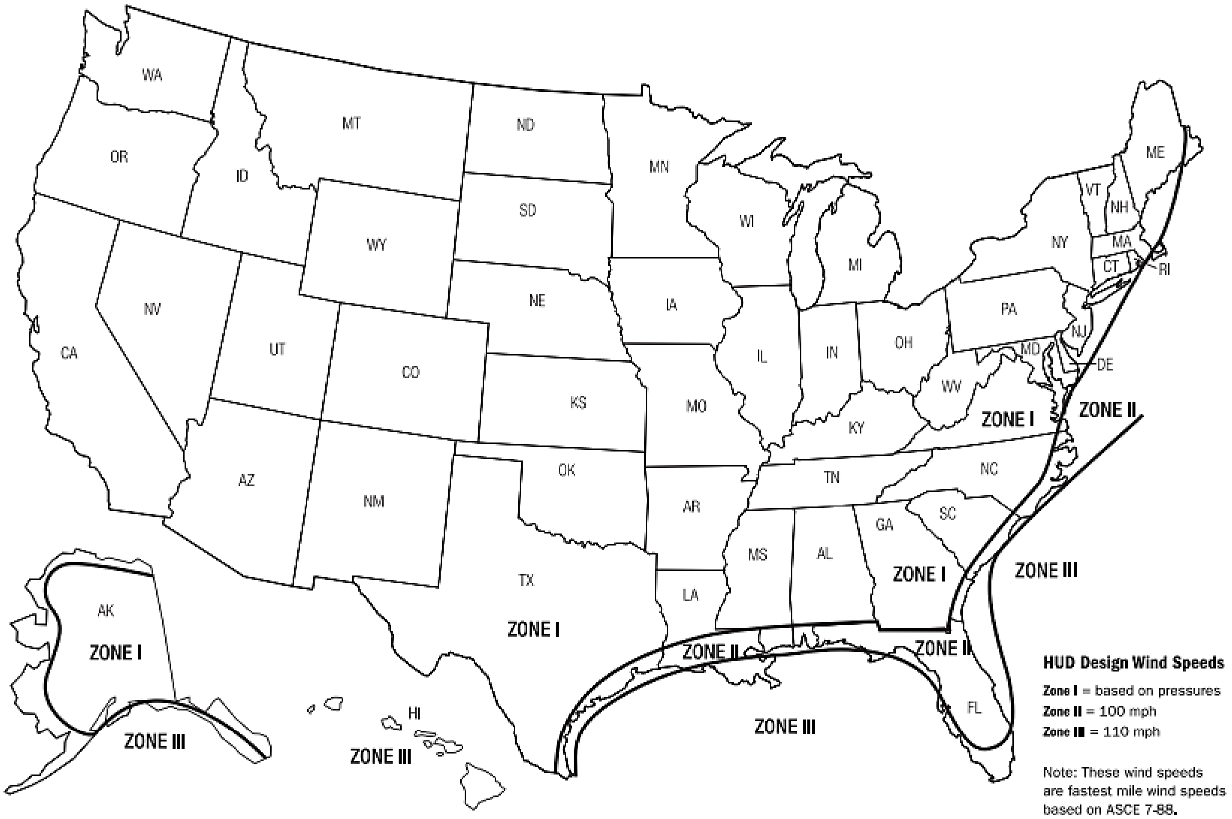
The Manufactured Home Construction and Safety Standards (MHCSS), 24 CFR Part 3280, developed by HUD, cover the design and construction of manufactured homes. The Florida Department of Highway Safety and Motor Vehicles has jurisdiction over the certification and installation of manufactured homes. Requirements for installation, setup, tie-downs, and anchoring foundations, with specific provisions related to wind loads, are contained in Chapter 15C of the Florida Administrative Code. As per Florida Statute 320.8285, each local jurisdiction in Florida is responsible for permitting, on-site inspection, and certificate of occupancy to ensure installation compliance with Chapter 15C of the Florida Administrative Code and local floodplain management ordinances. The design criteria in the standards require only diagonal (or frame) ties to be secured to the main frame members (usually two steel I-beams under each section). For manufactured homes designed to be installed in Wind Zone II and III areas, the standards require that the manufactured homes be provided with vertical wall ties at each frame tie location or that anchorage be designed by a Registered Professional Engineer or Architect in the State of Florida. Statutes contained in the

Department of Highway Safety and Motor Vehicles Division of Motor Vehicles Chapter 15C-1 also require longitudinal ties to resist a manufactured home's movement along the length of the manufactured home. Figure 2-6 provides the HUD wind zone map, and Figure 2-7 illustrates typical ground anchor supports for each HUD wind zone.

HUD Wind Code

Hurricane Andrew destroyed numerous manufactured homes in 1992. In response to this damage, the MHCSS were strengthened on July 13, 1994. The strengthened standards apply to manufactured homes placed in higher wind speed areas. These 1994 revisions, which remain in effect today, established three types of manufactured homes: HUD Zone I, HUD Zone II, and HUD Zone III homes. HUD Zone I manufactured homes are designed to the original 1976 HUD standards, whereas HUD Zones II and III manufactured homes are comparable to one- and two-family dwellings designed using wind loads in ASCE 7-88.

In Florida, new manufactured homes must be HUD Zone II or Zone III and must meet those requirements accordingly. There is no HUD Zone I location in Florida.



Source: FEMA P-85

Figure 2-6: Basic wind speed map for manufactured homes

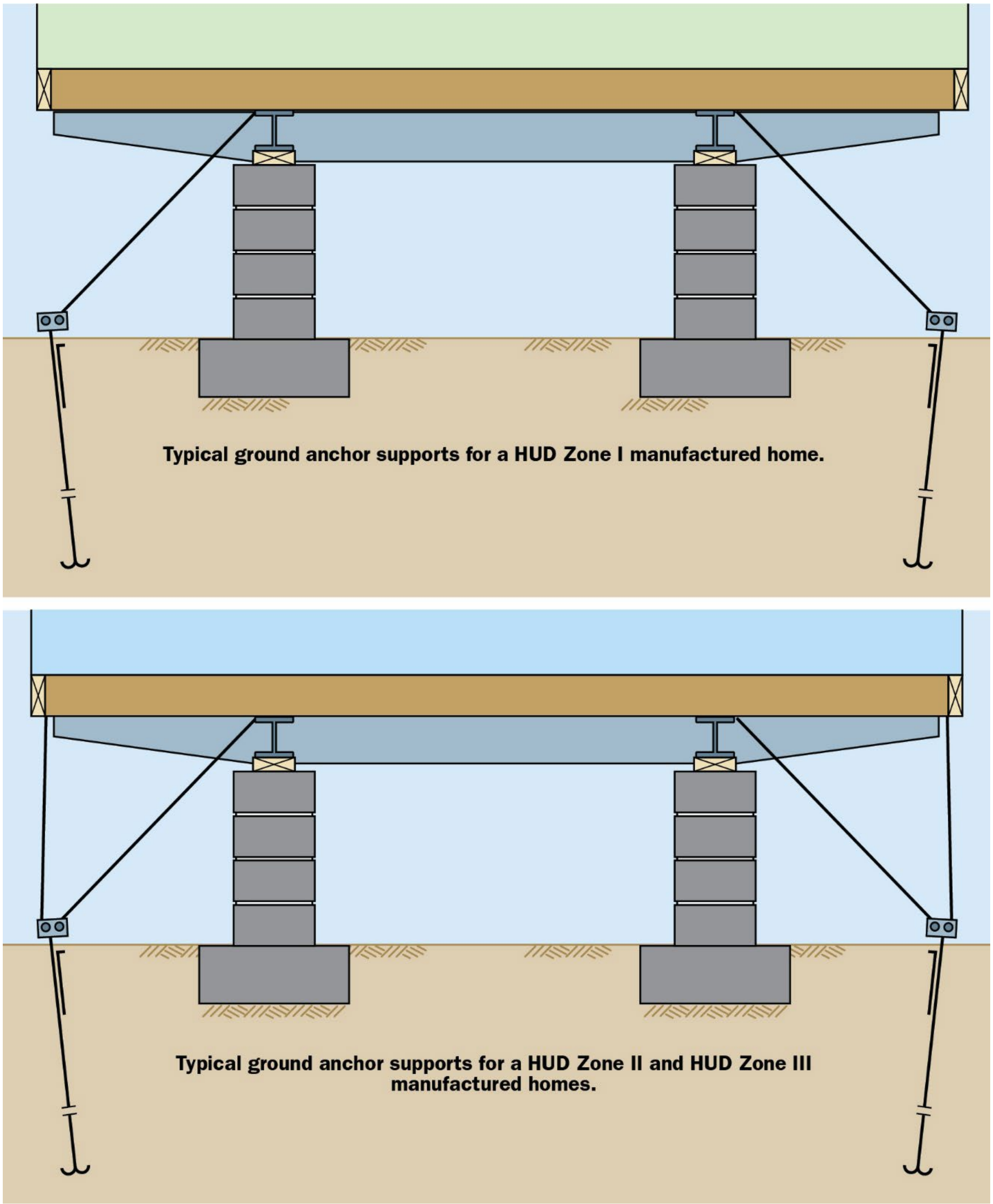


Figure 2-7: Typical ground anchor supports for HUD Zone I manufactured homes (top) and HUD Zone II and Zone III manufactured homes (bottom)

With respect to floodprone areas, FBCR Section 322.1.9 stipulates that installation is subject to the provisions of the local floodplain management ordinance. Furthermore, the FBCR Section R322.1.8

requires the use of flood-resistant materials (as defined by FEMA's NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* [FEMA 2008]) for flooring and interior and exterior walls and wall coverings below the elevation required in Section R322.2 or R322.3.

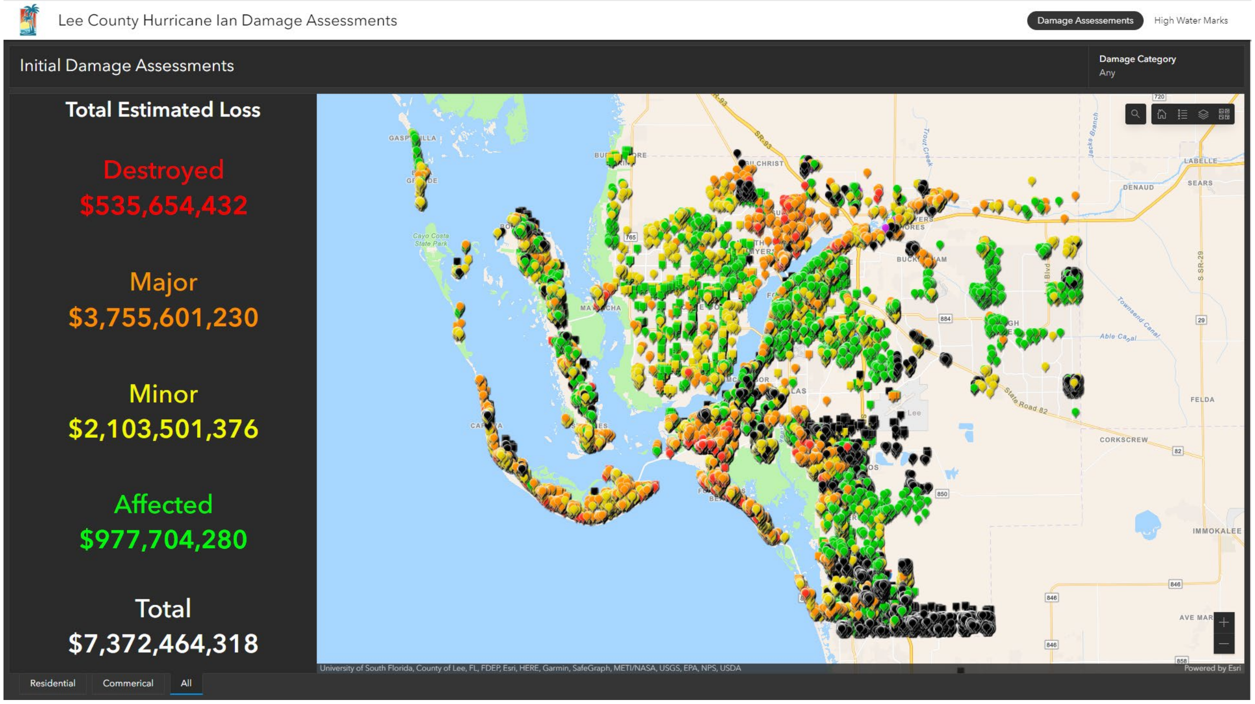
Florida regulations also refer to and incorporate by reference the almost 40-year-old first edition of FEMA P-85, *Manufactured Home Installation in Floodprone Areas* (1985). The second edition of FEMA P-85 was released in November 2009 and included over two decades of improved research and advances made to reflect the requirements of the most current codes and standards at that time and to provide a best practices approach in reducing damage from natural hazards. The 2009 edition includes some pre-engineered foundation specifications that minimize the need for site-specific engineered solutions for many locations.

2.6. Disaster Recovery Reform Act 1206 Policy

DRRA 1206 authorizes FEMA to provide communities approved for Public Assistance, under Section 406 of the Stafford Act, with reimbursement for costs incurred for work done to administer and enforce their legally adopted building codes and floodplain management ordinances. As of August 2023, only five Public Assistance grant requests had been submitted under the Hurricane Ian Disaster Declaration (FEMA-4673-DR), one from FDEM, one from Hardee County (Unincorporated Hardee County), and three from Lee County (City of Cape Coral, City of Sanibel, and Town of Fort Myers Beach). Between Lee and Collier Counties, there are at least 12 eligible jurisdictions and across the state there are another 26 counties eligible for 1206 along with the jurisdictions within those counties. Considering the FEMA DRRA 1206 Policy was released in November 2020 and retroactive to August 2017, along with the widespread Hurricane Ian damage across Florida and the amount of training and outreach related to DRRA 1206 executed by ICC, FEMA, FDEM, FFMA, and others, the low number of grant requests was unexpected. Based on MAT interviews with a limited number of building departments, they do not feel adequately staffed and resourced to serve their communities immediately following a catastrophic disaster and DRRA 1206 provisions are not widely known or understood.

3. Flood-Related Observations

Hurricane Ian caused flood damage across the state with intense flood loads on waterfront properties along the southwest coast, extensive building inundation from storm surge and rainfall across the southwest coast and throughout central Florida. Furthermore, widespread scour and erosion occurred along the southwest coastline as well as specific parts of the east coastline. The MAT studied and applied a variety of information to support planning and performing building performance assessments caused by flooding. The information included damage assessments and HWMs collected by Lee County, coastal videography from the FDEP's Office of Resilience and Coastal Protection, aerial imagery collected by NOAA, HWMs collected by USGS, and 360-degree street level imagery, aerial imagery, and HWMs collected by the National Science Foundation's (NSF's) StEER Network. Figure 3-1, Figure 3-2, and Figure 3-3 provide examples of each of these invaluable information sources.



Lee County Hurricane Ian Damage Assessments

Initial Damage Assessments

Damage Category
Any

Total Estimated Loss

Destroyed
$535,654,432

Major
$3,755,601,230

Minor
$2,103,501,376

Affected
$977,704,280

Total
$7,372,464,318

Source: Lee County, image used with permission

Figure 3-1: Lee County's Hurricane Ian Initial Damage Assessment Dashboard

Source: FDEP

Figure 3-2: Example FDEP Office of Resilience and Coastal Protection videography

Source: NSF StEER

Figure 3-3: Example NSF StEER streetview imagery (Lee County, Zone VE)

While conducting field observations, the MAT primarily focused on flood impacts to newer buildings designed and constructed to the FBC. With widespread flood damage there were numerous opportunities to evaluate building performance. Using parcel data, building permit records, Elevation Certificates, and other relevant data, the MAT planned daily routes throughout the floodplain that presented opportunities to compare building performance across different eras of construction. Note, the MAT predominantly documented building performance within the SFHA because that is where most flood-resistant design and construction requirements are enforced. In addition, the MAT sought opportunities to evaluate buildings that had been retrofitted to reduce future flood damage. For example, the MAT visited six single-family house elevation projects funded through a FEMA Hazard Mitigation Assistance (HMA) grant program. All six houses are located in Volusia County in Zone AE. Table 3-1 outlines the details of these elevation projects and Figure 3-4 and Figure 3-5 show an elevation in-progress. The in-progress elevation images show temporary dry-stacked piers and cribbing to aid in the elevation process and steel reinforcement (i.e., rebar) that has been fitted for a concrete grade beam and new integral reinforced permanent concrete piers. Concrete will be poured around the steel reinforcement to create the grade beam and piers. Per the approved scope of work, the project shall be designed and constructed in compliance with the FBC, ASCE 24-14, NFIP standards codified in 44 CFR Part 60, local floodplain ordinances, and any other applicable local regulations. The community is elevating the structures in place to a minimum required height of 1½ feet above the BFE or the highest known flood level, whichever is higher, plus 3 feet to account for SLR. Many of the final finished floor elevations exceed the minimum required elevation of BFE plus 1½ feet plus 3 feet for SLR. The reason for the added elevation is not known; the highest known flood level may have exceeded the BFE or the owner may have selected a higher elevation for functionality (e.g., parking or storage) or insurance reduction purposes. These projects were awarded before the effective date of the current Federal Flood Risk Management Standard (FFRMS) policy; however, they will meet the FFRMS requirements.

Table 3-1. Overview of HMA house elevation projects in Volusia County, FL

House ID	Year Built	Existing Lowest Floor Elevation per Elevation Certificate	BFE at time of Grant Funding	Minimum Required Design Elevation: BFE + 1½ Feet + 3 Feet of SLR	Final Finished Floor Elevation
House 1	1960	4.50	6	10.5	14.8
House 2	1959	4.36	6	10.5	12.4
House 3	1962	4.60	6	10.5	12.7
House 4	1972	4.70	6	10.5	12.8
House 5	1959	4.30	6	10.5	12.4
House 6	1958	4.53	6	10.5	In-process

All elevations given in feet NAVD 88.
BFE = base flood elevation, NAVD 88 = North American Vertical Datum of 1988, SLR = sea level rise

Figure 3-4: House in the process of being elevated (Volusia County, Zone AE)

Figure 3-5: View of house elevation foundation preparation and support cribbing

The MAT also spent some limited time on newer and unique challenges presented by Hurricane Ian. For example, the MAT observed building damage caused by an electric vehicle (EV) battery fire. Figure 3-6 depicts a house that caught fire from a neighboring house fire started by an EV battery fire. Various accounts of EV battery fires were noted during the MAT. The U.S. Fire Administration

(USFA) explains that EV batteries exposed to salt water are especially susceptible to short-circuiting because of the salt residue and can cause the battery to overheat, resulting in fires (USFA 2022).

Figure 3-6: House destroyed by fire spread from an EV fire in a neighboring house (Lee County, Zone AE and VE)

Upon completion of the field assessments, the MAT collaborated with various entities to supplement flood-related building performance observations. For example, Lee County Solid Waste Department provided the location and type of debris load collected throughout unincorporated Lee County. The debris load data reinforced two common field observations: Hurricane Ian building damage was predominantly flood related, and newer construction had less damage than older construction. Lee County collected over 60,000 loads of construction and demolition debris, 87% of those loads came from the SFHA. In comparison 57% of the vegetative debris loads were from the SFHA (see Table 3-2). The MAT was able to geospatially reference approximately one-third of the construction and demolition debris loads with a developed parcel, Figure 3-7 provides a summary of the year built for those parcels with associated construction and demolition debris loads that could be joined geospatially.

Table 3-2: Comparison of Debris Loads Collected by Lee County

Area	Number of Vegetative Debris Loads	Percent of Vegetative Debris Loads	Number of Construction and Demolition Debris Loads	Percent of Construction and Demolition Debris Loads
Special Flood Hazard Area	55,188	57%	63,947	87%
Area of Minimal Flood Hazard	41,718	43%	9,196	13%
All	**96,906**		**73,143**	

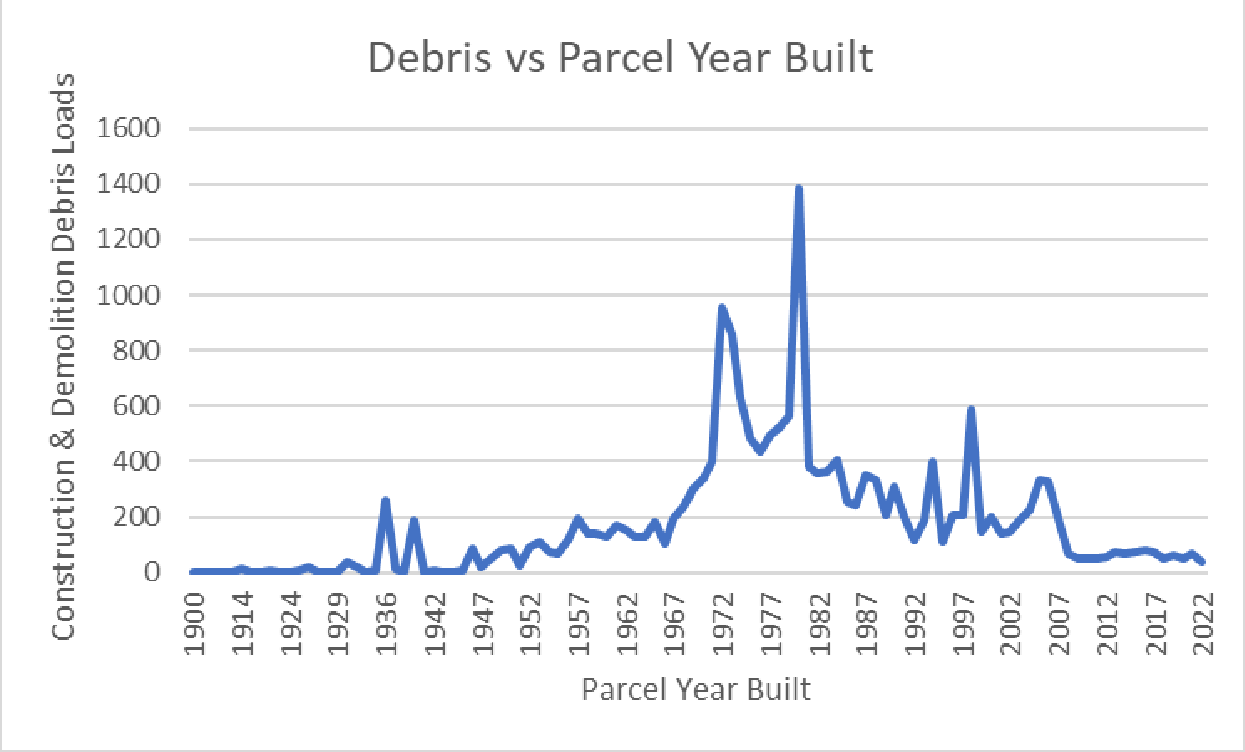


Figure 3-7: Graph of quantity of construction and demolition debris loads from developed parcels versus year built

In addition to Lee County, the NSF StEER and ASCE shared information related to building performance, including damage assessments, and the FDEM provided a summary of HWMs collected by various organization. Also, the FEMA Flood Insurance Directorate provided flood insurance claims information on specific areas and buildings visited to help better quantify the actual damage incurred.

The observations in this chapter focus on the performance of buildings relative to coastal and riverine flooding and are not intended to address damage associated with wind loading. This chapter summarizes observations of building performance under a variety of flood conditions, including:

- Comparison of coastal construction practices over the life of the NFIP (1970s versus 2010s)
- Performance of breakaway walls as well as decks and porches
- Scour, erosion, and flood-borne debris
- Vegetation impacts to the built environment
- Performance of manufactured homes along with single and multi-family buildings and commercial buildings

Overall, building elevation and foundation type were primary indicators of building performance versus flood damage in the areas visited by the MAT; this observation has been frequently documented in previous FEMA MAT reports as well as by other research groups. The damage observed by the MAT after Hurricane Ian demonstrates that stricter enforcement of building codes and implementation of floodplain management practices that go beyond the minimum requirements is needed to help achieve greater long-term resilience, as recommended in numerous MAT reports.

3.1. Comparison of Coastal Construction in the 1970s and 2010s

The design and construction of residential structures along the Florida coast has drastically changed since the initiation of the NFIP in 1968 due to NFIP-compatible floodplain management regulations, flood provisions in the FBC and referenced standards, and CCCL design and construction requirements. Where small wood-frame or masonry beach bungalows once stood, there are now multistory concrete structures.

The NFIP makes flood insurance available in those states and communities that agree to adopt and enforce floodplain management ordinances to reduce future flood risk. Participation in the NFIP is voluntary and is contingent on community compliance with NFIP floodplain management regulations, whether through building codes, standalone flood ordinances, or a combination thereof. The NFIP minimum requirements apply to areas designated as SFHAs by FEMA and adopted by the local communities into their building codes and ordinances. FEMA FIRMs and FISs are used in the regulation of the minimum NFIP requirements and serve as the basis for many provisions in building codes and standards. Constructing a building to the minimum NFIP requirements—or constructing a building outside of the SFHA—does not guarantee the building will avoid damage from flooding. While many of the changes in design and construction were driven by the building codes that were adopted and implemented, there are also differences in construction techniques and materials, structural complexity, and the average square footage of a typical single-family house. These larger square footage homes result in a larger footprint structure on the lot, and the breakaway wall foundations create the potential for intact walls to act as obstructions. See Sections 3.2 and 3.4.3 for additional discussion of intact breakaway walls.

Figure 3-8 shows a typical 1970s beach cottage next to a typical 2010s multilevel structure. The impacts of construction techniques and material changes had a significant effect on building performance during Hurricane Ian. Table 3-3 describes these changes, and Figure 3-9, Figure 3-10, and Figure 3-11 illustrate some of them.

Left image shows typical 1970’s construction of a single elevated level on timber piles. The right image shows typical 2010’s construction of a multilevel structure using CMU block.

Source: Lee County Property Appraiser, used with permission

Figure 3-8: Two houses, one constructed in the 1970s (left) and one constructed in the 2010s (right)

Table 3-3: Comparison of Typical Elevated Houses along the Florida Coast, 1970s vs 2010s

Building Characteristic	Typical 1970s Construction	Typical 2010s Construction
Building Code	Various legacy codes; pre-FBC(a)	2010 and later FBC
Structural system	Wood frame	Concrete frame
Typical Wall Construction	Wood	CMU
Typical Foundation	Wood pile	Concrete pile/column
Number of stories	1	2–3
Average Size (square feet)	1,600	3,200

(a) Prior to the FBC, communities had the option of adopting one of four recognized building codes. See FEMA publication, Building Codes Save: A Nationwide Study, Losses Avoided as a Result of Adopting Hazard-Resistant Building Codes (2020a), for more information on the history of building codes.
CMU = concrete masonry unit

Figure 3-9 shows an area in Fort Myers Beach. All of the numbered structures shown in the figure are within Zone VE and are all fully or partially seaward of the CCCL. The structure labeled #1 is along the shoreline and was under construction during the MAT’s assessment of building performance during Hurricane Ian. The ground floor of the structure has concrete columns with concrete masonry unit (CMU) breakaway walls and flood openings in the walls. The structure on the inland side of the street, labeled #3, was built in 1951, with modifications in 1981. The older structure is wood construction and is raised on a pile foundation. While the older structure survived the coastal flood, the newer, larger, sturdier, oceanside structure #1 could have partially sheltered the older structure against wave attack by disrupting the wave propagation and reducing the wave heights reaching structure #3. Structure #4 (1956) was destroyed in Hurricane Ian. This light-framed house was built similar to Structure #3 but was not as sheltered. The front row home (#2), which was seaward of Structure #4, was built on an open pile foundation with wood slats for privacy that broke away, allowing for passage of surge and waves without obstruction. Other factors that could have contributed to the different performance of structures #3 and #4 are not known.

Source: Reprinted with the permission of EagleView. Copyright © 2021 EagleView. All rights reserved (top)

Figure 3-9: New concrete construction on coast (#1) could have provided shelter against waves to older, vulnerable structure (#3) on Fort Myers Beach (Lee County, Zone VE)

The evolution towards concrete and CMU construction along the coast was also observed in Sanibel Island (Figure 3-10) and Bonita Beach (Figure 3-11). The structure on Sanibel Island was under construction during Hurricane Ian. Vegetative debris lines were visible against the ceiling panels inside the lowest level, indicating that the storm surge completely inundated the lowest level of the structure. The structures on Bonita Beach, Figure 3-11, indicate a similar trend toward newer construction methods consisting of concrete and CMU. Sections 3.2 and 3.4.3 discuss the performance of breakaway walls as well as potential impacts of walls that survived acting as obstructions. In Bonita Beach, there were visible, ongoing, extensive repairs to breakaway walls perpendicular to the direction of wave action and flood flow, but it was obvious that the foundation had minimal structural damage outside of the loss of breakaway walls. Additional analysis is needed relative to the performance of the lack of walls breaking away parallel to the flood flow as to whether they influenced damage to adjacent structures.

Figure 3-10: Large CMU structure on Sanibel Island (Lee County, Zone VE, Seaward of CCCL)

Figure 3-11: Large CMU structures on Bonita Beach (Lee County, Zone VE, Seaward of CCCL)

3.2. Performance of Breakaway Walls

Hurricane Ian highlighted how breakaway walls function under flood loads. The MAT observed many breakaway walls parallel to the flood flow that remained intact. As in the changing building practices highlighted in Section 3.1, many of these breakaway walls were CMU construction.

Figure 3-12 shows that CMU breakaway walls perpendicular to the flood flow failed (note that the front of the building is a garage door opening that acts as a breakaway wall), but the walls parallel to the flow did not break away. Construction of the structure began in 2022, and it was still under construction during the pre-MAT visit.

Figure 3-12: CMU breakaway wall in Fort Myers Beach (Lee County, Zone VE, Seaward of CCCL)

Figure 3-13 represents a section of shoreline in Fort Myers Beach that indicates differences in the performance of breakaway walls based on construction techniques. All images shown in Figure 3-13 are post-Hurricane Ian. Specifically, in this example, masonry breakaway walls constructed with flood openings and windows installed and parallel to the flow of water exhibited increased survival when compared to wood breakaway walls constructed without flood openings. Structure A is a 2018 CMU construction with flood openings and windows installed in the masonry breakaway walls. Structure A's masonry breakaway walls parallel to the flow remained intact while the windows in the walls failed. Structure B was built in 1990 and includes an addition built in 2020. The 1990 portion of Structure B had wood-frame breakaway walls while the 2020 portion had masonry breakaway walls. The 1990 portion likely did not contain flood openings in the walls while the 2020 portion did have flood openings. All the wood-framed breakaway walls in the 1990 portion broke away during Hurricane Ian and the only remaining ground-level wall structure was two portions of a masonry knee wall. Why two sections of the knee wall survived is unknown. Within the 2020 portion, some masonry breakaway walls installed parallel to the flow with flood openings remained intact.

Source: FDEP

Figure 3-13: Comparison of nearby breakaway walls in Fort Myers Beach (Lee County, Zone VE, Seaward of the CCCL)

A structure (shown in Figure 3-14 and Figure 3-15) along the Gulf of Mexico coast on Sanibel Island built in 1987 with breakaway walls that partially failed was visited by the MAT. The enclosure was constructed with wood-framed breakaway walls finished with wall sheathing coated in lath and plaster (stucco). The structure is seaward of the CCCL. According to the Elevation Certificate, the top of the enclosure floor is 7.3 feet NAVD 88 and the bottom of the lowest horizontal structural member of the elevated floor is 12.0 feet NAVD 88. StEER recorded an HWM (surge only) of 15.4 feet NAVD 88 at the neighboring house. As shown in Figure 3-14, one of the Gulf front shore-parallel breakaway walls did not completely breakaway; the bottom 2x4 plate separated from the bottom permanent 2x4 nailer plate, but the top 2x4 plate did not separate from the top permanent 2x4 nailer plate. The wall appears to be properly framed to enable separation and failed in a typical manner in which the bottom plate disconnected and the wall swung from the top. The exterior finish of stucco and netting was continuous across a support column, which can prevent proper breakaway performance, but did not hinder performance in this instance. Figure 3-15 depicts shore-perpendicular breakaway walls for which the wood-framing remained in place. These breakaway walls also appear to be properly framed to enable separation, but the exterior finish of stucco and netting appears continuous across support columns. The shore-perpendicular breakaway wall wood framing remained in-place. This may have been a result of the interior and exterior finishes breaking away below the design load and, therefore, reducing the overall load on the wood frame. No structural damage was observed as a result of the partial failure of the breakaway walls.

Figure 3-14: Partial failure of shore-parallel breakaway wall on Sanibel Island (Lee County, Zone VE, Seaward of CCCL)

Figure 3-15: Partial failure of shore-perpendicular breakaway wall on Sanibel Island (Lee County, Zone VE, Seaward of CCCL)

Many breakaway walls in buildings along Bonita Beach performed as intended, breaking away as a result of the flood loads. There was evidence of multiple ongoing repairs of CMU breakaway walls in buildings throughout Bonita Beach (Figure 3-16). These breakaway walls often enclosed spaces that were being used for other than the allowable uses (building access, vehicle parking, or storage). See the Section 3 introduction regarding the large amounts of debris observed in the floodplain, which the presence of non-flood damage–resistant materials below the BFE contributed to.

Figure 3-16: Staging of repairs to CMU breakaway walls in Bonita Beach (Lee County, Zone VE, Seaward of CCCL)

In general, the MAT observed breakaway walls perpendicular to the flood flow working. In Bonita Beach, some of the perpendicular walls were part of a pool system and did not fail. The design load for these walls is not known. Whether the design storm occurred along this section of coast is also unknown. Performance of breakaway walls parallel to the flood flow was not consistent. With the failure of the breakaway walls perpendicular to the flood flow, the surviving parallel walls may have been subject to equal flood loads on the exterior and what was the interior side leading to their survival. Section 3.4 provides additional discussion of the survival of parallel walls and the potential influence on scour. Free-of-obstruction requirements do not consider the orientation of the enclosure with respect to flood flow but rather that the space below the lowest floor in Zone VE is to be constructed with non-supporting breakaway walls. Therefore, the performance of walls parallel to the flood flow should not be that different than those perpendicular to the flood flow.

3.3. Performance of Decks and Porches

In coastal areas where wave action and hydrodynamic effects are present, the MAT observed varying degrees of performance of exterior attached structures such as decks and porches. Some exterior attached structures survived Hurricane Ian while others failed. Upon failure, some separated without damaging the main structure and others exhibited evidence that the separation may have damaged the main structure. Various codes, regulations, and standards require that exterior attached structures either be designed to meet the same design requirements as the main structure itself or be structurally independent from the main structure. These codes, regulations, and standards are in place to help ensure an exterior attached structure does not cause damage to the main structure. If an exterior attached structure is structurally connected to the main structure and is not designed to the same requirements, the exterior attached structure may fail before the main structure and can cause envelope and structural damage to the main structure. More information can be found in FEMA P-499, *Home Builder's Guide to Coastal Construction* (2010), Technical Fact Sheet No. 8.2, *Decks, Pools, and Accessory Structures* and NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas in Accordance with the National Flood Insurance Program* (2020b). The field observations are consistent with current requirements and recommendations and support the continuation of these requirements and recommendations.

In some instances, the failure of attached structures resulted in significant damage to the main structure. Figure 3-17 depicts a beachfront residence in Zone VE, seaward of the CCCL, in Bonita Springs, that experienced the loss of an elevated porch. The porch was likely anchored to the main structure, as indicated by the remaining anchors, which are depicted at the bottom right in Figure 3-17. The residence's main structure also exhibited structural damage as observed through a visual assessment of the corner column and the presence of temporary support (lally) columns. The separation of the elevated porch may have contributed to the corner column damage. Signs of possible pre-existing corrosion of reinforcing steel within the concrete framing, were also observed on the damaged corner column.

Bottom right: Post-event photo from January 2023. Top left: Corner column damage. Bottom left: Remaining anchors in the main structure.

Figure 3-17: Single-family house (built in 1982) in Bonita Springs with porch damage and structural damage to column (Lee County, Zone VE, Seaward of the CCCL)

The Coastal Flood Team also observed porches that failed in a way that effectively rendered them a breakaway system, avoiding damage to the main structure. For the house pictured in Figure 3-18, a ledger board was fastened to the main structure, and the exterior floor joists were attached to the ledger with hangers. Upon separation, failure was experienced at the connections between the joists and joist hangers and the hangers to the ledger board, but the ledger board remained attached to the main structure. This likely reduced damage to the main structure as compared to framing approaches that would have incorporated the porch framing into the joist system of the main structure, which could have racked the main structure (i.e., twisted the structural components out of plumb) during the loss of the porch structure.

An intact breakaway wall, which likely resulted in wave deflection that damaged the siding on the elevated portion of the house.

Figure 3-18: Structure (built in 2022) in Fort Myers Beach with damaged porch that cleanly separated from the main structure (Lee County, Zone VE, Seaward of the CCCL)

Some decks and porches withstood the coastal hazards without significant structural damage. These exterior attached structures appeared to be designed and constructed to the same standards as the main structure. The homes shown in Figure 3-19 had few remaining obstructions below their lowest floor post-hurricane, whereas Figure 3-17 and Figure 3-18 both depict buildings with obstructions below their lowest floors, which demonstrates that intact breakaway walls may divert waves upward (i.e., wave deflection and run-up), resulting in damage to exterior attached structures and wall finishes above the breakaway wall (Figure 3-17 and Figure 3-18). See Section 3.2 for further discussion of intact breakaway walls.

Figure 3-19: Single-family houses built in 2000 (left) and 1994 (right) in Fort Myers Beach with intact decks and porches (Lee County, Zone VE, Seaward of the CCCL)

3.4. Scour and Erosion

The MAT observed widespread scour and dune erosion in Lee County (Fort Myers Beach, Sanibel Island, Bonita Beach, Matlacha) and dune erosion in Volusia County (Wilbur-by-the-Sea/Port Orange). Erosion is the loss of soil over a large area whereas scour is localized loss of soil due to interaction of flow and building components or disturbed soils. Scour is often considered in three categories: scour around foundation elements, scour due to obstructions such as walls, and preferential scour. Scour around foundation elements and walls relate to scour due to the presence of building elements. Preferential scour is caused by preferential scour pathways. Preferential scour pathways are a form of scour in which the scour location and extent are influenced by the relative compaction of soils in an area. Preferential scour pathways occur where soils have been disturbed and are looser than their neighboring soils and enable a greater rate of scour that may induce further scour by channeling the flow.

3.4.1. FORT MYERS BEACH

Scour was visible on the ocean side of several of the large condominium complexes in Fort Myers Beach. Flow paths were visible in the sand. In many of these situations, there was evidence of frangible concrete slabs breaking up, as they are intended to do, as a result of the loss of sand supporting them (Figure 3-20).

Figure 3-20: Frangible concrete slabs breaking up as intended due to the erosion of sand supporting them on Fort Myers Beach (Lee County, Zone AE, Seaward of CCCL)

3.4.2. SANIBEL ISLAND

Multiple areas of coastal scour were visible on Sanibel Island immediately after Hurricane Ian struck. Because scour is known to negatively impact building performance when the building has not been designed for scour or the scour exceeds the design assumption, the MAT was interested in evaluating building performance in these locations. The NOAA post-disaster imagery and the Florida Geographic Information Office (FGIO)-collected data sets that were very helpful in determining the best areas to visit. Figure 3-21 is a scour channel on Sanibel Island that was captured by an FGIO helicopter on October 2, 2022; the MAT visited the channel on January 17, 2023 (Figure 3-22). The large scour channels that occurred along a great length of Sanibel Island could have adversely impacted structural foundations had those foundations not been adequately designed to withstand scour. The scour channel shown in Figure 3-21 was still present during the MAT visit, and the MAT observed visible scour around the outer foundation piles. The scour channel closely aligned with a preferential scour pathway visible in the pre-storm imagery of a dune walkover and connected to the corner of a large, vegetated, water retention area behind the houses on either side of the scour channel (Figure 3-23). There was no visible damage to the building piles, and the piles had not shifted. An air conditioning unit elevated on a platform was lost as a result of scour undermining the platform (Figure 3-24).

Source: FDEP

Figure 3-21: Scour channel depiction, captured October 2, 2022

Figure 3-22: Scour channel and debris near deep pile foundation (Lee County, Zone VE, Seaward of CCCL)

The yellow dotted line on the left image indicates the approximate location of the scour channel for reference.

Figure 3-23: Imagery of the scour channel location before (left) and after (right) Hurricane Ian

Figure 3-24: Scour resulting in the collapse of a platform supporting an air conditioning unit

3.4.3. BONITA BEACH

In Bonita Beach, a scour channel was visible near a large CMU residential structure that was built in 2008. The adjacent property was a wood pile–supported structure built in 1984 (Figure 3-25). The scour channel coincided with disturbed ground as an old septic tank and drain field and newer sewer lines were visible. This scour channel may have resulted from a combination of channeled flow due to the large adjacent structure and the preferential scour pathway through previously disturbed soils (Figure 3-26).

Source: FDEP

Figure 3-25: Scour beside and under houses in Bonita Beach (Lee County, Zone VE, Seaward of CCCL)

Source: Reprinted with the permission of EagleView. Copyright © 2022 EagleView. All rights reserved. (top images)

Figure 3-26: Photos before and after Hurricane Ian depicting significant scour on Bonita Beach (Lee County, Zone VE, Seaward of CCCL)

3.4.4. MATLACHA

Preferential scour pathways, which can result in excessive localized scour, were also observed on Matlacha. Figure 3-27 depicts a house with scour along multiple sides of the house. The maximum observable scour depth was between 4 and 5 feet. The scour appeared to occur in areas where the ground had been disturbed for the installation of irrigation lines. Also notable is that the maximum scour occurs at the corners of the house, which is expected because of the velocity and flow change at the corners.

Figure 3-27: Scour surrounding a house and undermining the foundation in Matlacha (Lee County, Zone AE)

Whether the scour resulted in damage to the structure itself is unknown. However, the foundation appears to be a shallow foundation consisting of a slab on grade and, at a minimum, backfilling would be required to restore support of the building foundation. As shown in Figure 3-28, the building is located along the Matlacha Pass and is miles from the Gulf coast. Additionally, the building was in a FEMA mapped Zone A when constructed (1995); it is now in a Coastal A Zone as mapped on a revised FEMA FIRM (effective 2022). This example illustrates that the potential for scour and the consideration of designing with deep foundations should be taken into account when certain circumstances are present, such as being located on a waterway with the potential for high-velocity flow and flooding during storms.

Per FEMA P-55, *Coastal Construction Manual* (2011), equation 8.12, scour along a building wall is expected to be 0.15 times the horizontal length along the side of the building exposed to flow with a limit of a maximum of 10 feet of scour. The house in Figure 3-27 is approximately 75 feet long with a 27-foot-long wall abutting the deepest scour area. For the house pictured in Figure 3-27, the expected maximum scour is 10 feet for the 75-foot-long back wall and 4 feet for the 27-foot-long abutting side wall. Although the wall scour calculation in FEMA P-55 provides a reasonable design baseline for coastal sites, the FEMA P-55 wall scour calculation should not be directly compared with scour documented in this subsection. This is because the flow direction during Hurricane Ian is not known, and the location of the house depicted in Figure 3-27 does not represent a typical coastal location as it is bordered by Matlacha Pass and not a large body of saltwater (e.g., gulf or ocean). This simple example helps provide better context as to the tremendous damage that can occur from scour if shallow foundation systems are used in Coastal A and V Zones that are subject to high-velocity flow. For these reasons, the IBC, IRC, and ASCE 24 require structures to be designed with foundation systems that accommodate local scour in Coastal A Zones and V Zones. See *FEMA Quick Reference Guide: Comparison of Select NFIP and 2018 I-Code Requirements for Special Flood Hazard Areas* (2018c).

Figure 3-28: Map depicting the location of the house shown in Matlacha in Figure 3-27

3.4.5. WILBUR-BY-THE-SEA/PORT ORANGE

The MAT visited an area in Volusia County that was impacted by Hurricane Ian on September 28, 2022, and by Hurricane Nicole on November 10, 2022. The impact of the two storms—43 days apart—resulted in a significant amount of failed or damaged seawall sections and areas with large, severe dune erosion. In Wilbur-by-the-Sea, a stretch of three homes lost their fronting coastal protection structures during Hurricane Ian, and there was further erosion during Hurricane Nicole that resulted in damage to several of the structures (Figure 3-29). The failed coastal protection structures are shown in the second image in Figure 3-29; they are in front of the three middle houses and resemble a line of debris partially covered in sand. All the homes shown in Figure 3-29 were constructed before NFIP requirements came into existence. This stretch of shoreline is currently in a Zone VE on the 2017 effective FEMA FIRM, and the area of interest is seaward of the CCCL shown in Figure 3-30.

Source: Civil Air Patrol (middle and bottom)

Year built shown over each house in center image.

Figure 3-29: Dune erosion, bulkhead failures, and impacts on multiple structures in Wilbur-by-the-Sea (Volusia County, Zone VE/Unshaded Zone X)

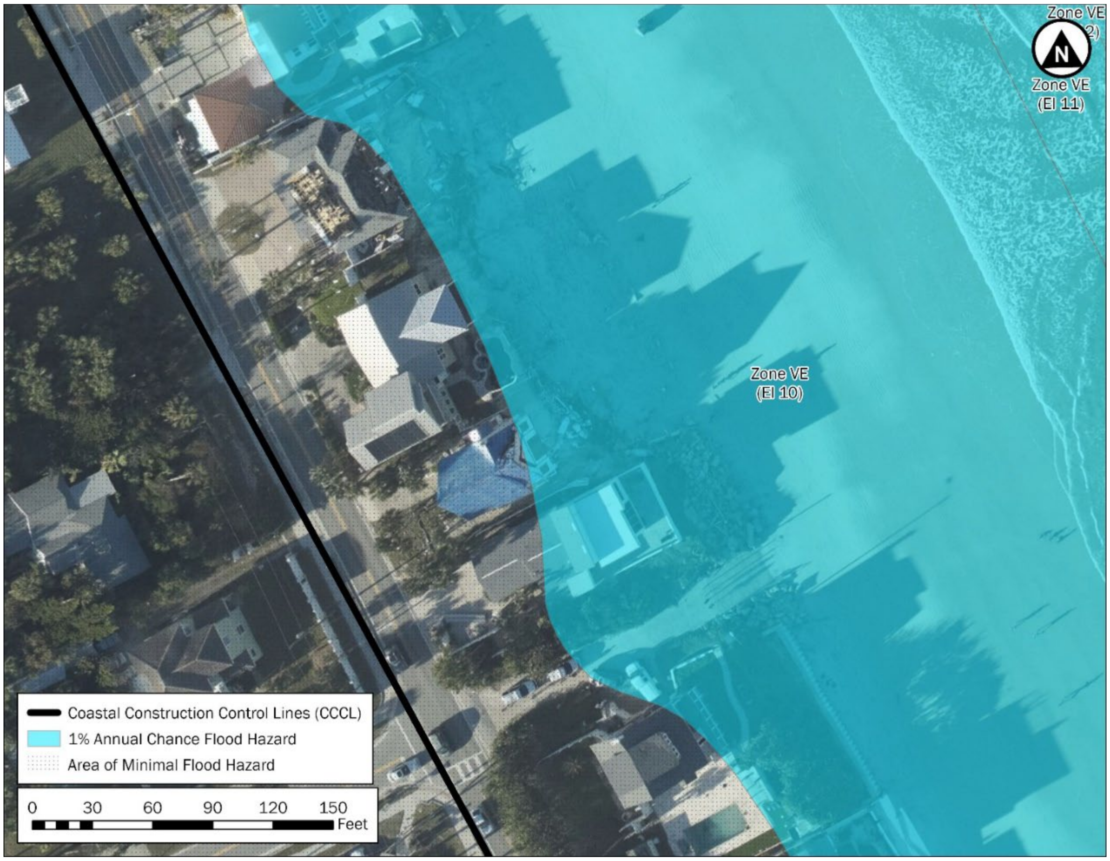


Figure 3-30: Map depicting the SFHA for the area shown in Figure 3-29

Figure 3-31: Dune erosion in Wilbur-by-the-Sea resulting in exposed foundation micropiles

The house depicted in Figure 3-31 is the third house from the left shown in Figure 3-29 and Figure 3-30 with a non-rectangular pool. The site of this house experienced erosion from both Hurricane Ian and Hurricane Nicole, which resulted in failure of the porch floor and exposure of the micropiles that support the porch foundation and pool. The pool and porch structure, both added in 2014, were structurally supported by a deep foundation system consisting of micropiles. Deep foundations are required by current building codes for such elements in a coastal high hazard area where soils are subject to scour or erosion. The neighboring houses to each side in Figure 3-31 were built more seaward in 1904 and 1963 before deep foundation elements were required. Neither of the neighboring houses had deep foundation elements visible and both lost portions of their structure.

The house in Figure 3-31 is located between two coastal transects on the FIRM. Each of these bordering transects (northern and southern) has a transect profile in the FIS for the 0.2-percent-annual-chance wave envelope, which shows the eroded dune profile for the 0.2-percent-annual-chance event. The eroded dune profile shown for both transects in Figure 3-32 depicts retreating dune erosion. Retreating dune erosion means the dune is expected to erode but will not result in a complete loss of the dune. The eroded profiles for both bordering transects depict the limit of erosion to be at the peak of the primary frontal dune (Figure 3-32). Based on publicly available elevation data (a site survey was not performed), the house in Figure 3-31 is situated such that the pool and porch are seaward of the dune peak and the main house is landward of the dune peak. Based on the observed erosion and the eroded profiles in Figure 3-32, the combined erosion from Hurricane Ian and Hurricane Nicole resulted in dune erosion similar to the erosion predicted for a 0.2-percent-annual-chance (500-year) event.

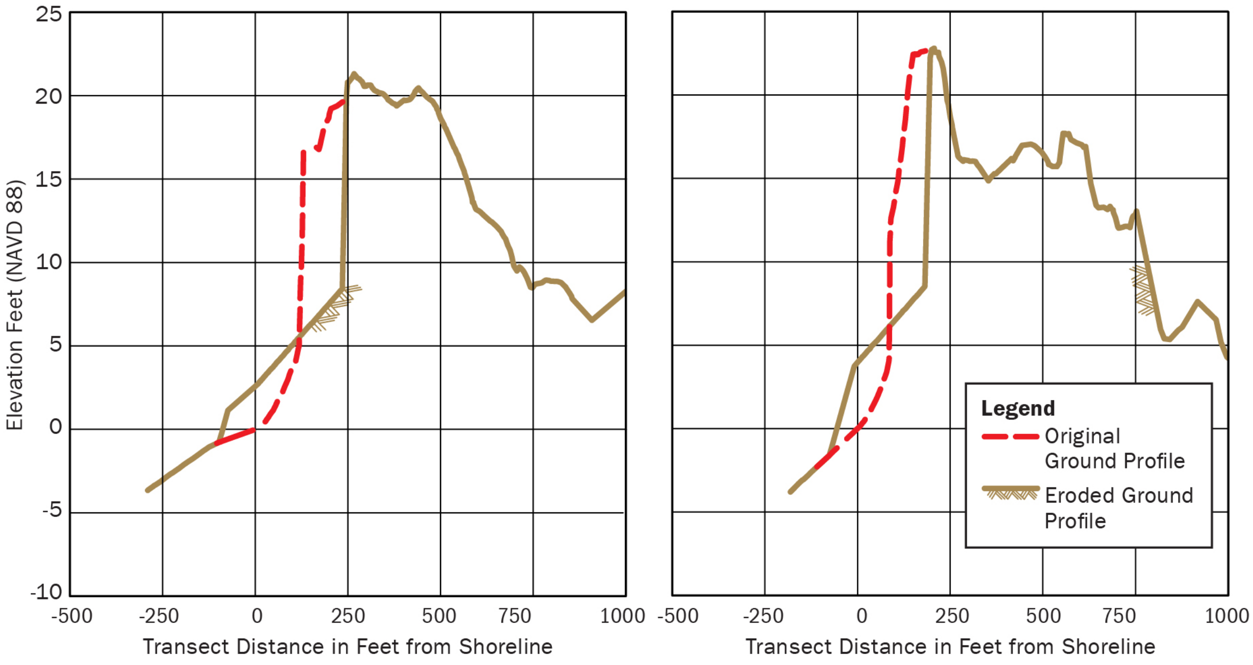


Figure 3-32: 0.2-percent-annual-chance eroded profiles for the northern (left) and southern (right) transects on either side of Figure 3-31

The structure in Figure 3-33 with a fronting vertical concrete seawall and return is in Port Orange and was built in an area classified as Zone X at the time of design and construction that remains Zone X under the currently adopted flood hazard map. This condominium complex abuts a nature area, and the coastal protection structure includes an end return. Adjustable lally columns were brought in as emergency measures to support the undermined corners of the residential structure. The residential structure was built in 1984 and is located seaward of the CCCL.

The condominium structure was behind a coastal protection structure, and erosion occurred by flow bypassing the end of the protective structure's return. This "red tagged" condo required multiple lally columns to provide support and stability until repairs could be accomplished.

Figure 3-33: Significant erosion occurred around and under the foundation of a condominium structure (Volusia County, Zone VE/Unshaded Zone X)

In summary, scour across the areas visited by the MAT predominantly consisted of preferential scour pathways and scour around foundation elements, including piles and grade beams. While scour caused by above-grade obstructions such as shore-perpendicular walls was not as widespread in the field observations, it was observed in both the FDEP videography and NOAA imagery. See Figure 3-13 for an example; building A in the top FDEP image (beach-side view) depicts a large scour channel beside the house; whereas, the scour channel had been filled by the time the inset photo (streetside view) of building A was taken by the MAT. Additionally, the MAT noted many areas where seawalls/retaining walls resulted in many feet of scour. However, that scour is not documented herein as it did not impact building performance. In general, much of the scour that occurred was not observable during the MAT's visit because recovery efforts had already begun and sand had been redistributed as an early recovery measure. Although erosion occurred on both the southwest and east coastlines of Florida, the impacts of erosion were most notable on the east coastline. Some of the largest impacts occurred in the Wilbur-by-the-Sea area and resulted in undermined foundations and collapsed houses.

3.5. Coastal Armoring

Aside from the observations made by the MAT, FDEP summarized the major and minor damage to coastal armoring structures in the counties impacted by Hurricanes Ian and Nicole in its own report (FDEP 2022). FDEP defines major damage to a coastal armoring structure as damage that requires reconstruction. Hurricane Ian caused 4,756 lineal feet of major damage to coastal armoring in Lee County and 6,330 lineal feet of major damage to coastal armoring in Volusia County. Hurricane Nicole caused an additional 13,262 lineal feet of major damage to coastal armoring in Volusia County.

3.5.1. COASTAL ARMORING PERFORMANCE

The MAT observed multiple failed coastal protection structures. Coastal protection structures are intended to resist wave action and prevent loss of sand/soil. Seawalls are a type of coastal protection structure that are either cantilevered or anchored and employ a tie-back system to assist with resisting overturning moments (Figure 3-34). Tie-back bars are used in bulkheads or retaining walls to provide additional support and stability to the structure. However, these bars can corrode over time due to exposure to the elements and other environmental factors, which can weaken the structure and potentially lead to failure (Figure 3-35). Figure 3-36 is an example where corroded tie-back bars were replaced; however, the soil around the tie-backs was removed due to the recent disturbance to replace the bars.

Figure 3-34: Failed coastal protection wall rotating seaward (Volusia County, Zone VE)

Figure 3-35: Corroded tie-back system of a coastal protection structure (Volusia County, Zone VE)

Figure 3-36: Example of exposed, newly installed, tie-back rods in Matlacha Isles (Lee County, Zone VE)

The MAT also observed various repairs on the coastal protection structures. The replacement of corroded steel tie-backs with sleeve-protected tie-backs was observed in Matlacha Isles along multiple coastal structures (Figure 3-37). In Volusia County, a seawall had tie-backs installed as an emergency repair to regain the structural capacity that was lost due to existing corroded tie-backs as shown in Figure 3-38.

Figure 3-37: New seawall under construction after Hurricane Ian on Matlacha Isle (Lee County, Zone VE)

Figure 3-38: Emergency repairs to account for corroded tie-backs (Lee County, Zone VE)

3.5.2. TEMPORARY EROSION CONTROL MEASURES

In areas with damaged coastal protection structures, several temporary measures were deployed to provide a temporary level of protection to long lengths of shoreline. FDEP supplied and approved placement of a water-filled tube system that acts as a barrier to reduce further erosion (Figure 3-39). The tubes were arranged in a pyramid and then temporarily anchored into the beach. These systems had to be removed at the start of turtle nesting season (beginning of May 2023). Additional temporary erosion control measures included textile bag cubes that were filled with sediment (Figure 3-40 and Figure 3-41) and vertical vinyl sheet walls employed to retain sediment until a permanent structure could be constructed (Figure 3-42).

Figure 3-39: Temporary erosion control installed along Daytona Beach Shores to help counteract further coastal erosion in an area where seawalls were destroyed (Volusia County)

Figure 3-40: Large sediment-filled bags used to counteract further coastal erosion along an area of Daytona Beach Shores where seawalls were destroyed (Volusia County)

Figure 3-41: Sediment-filled bags used to counteract further coastal erosion in an area of Port Orange where seawalls were destroyed (Volusia County)

Figure 3-42: Vertical vinyl sheet wall piles installed along Daytona Beach to replace destroyed seawalls (Volusia County)

3.6. Corrosion and Deterioration of Building Components

Throughout the MAT field work, the team observed numerous instances of corrosion on critical building component connectors and fasteners that enable load transfer to the foundation, and on connectors for exterior mechanical equipment. The corroded connectors and fasteners included but were not limited to nails attaching various connector types, hurricane ties, and straps. In some instances, the corroded connectors withstood the forces exerted by Hurricane Ian, but in other instances, the corroded connectors failed. The presence of corrosion likely contributed to component failure, which can lead to overall building failure as a result of disruption in the load path. Instances of material deterioration on non-metallic items such as wood were also noted.

The team also observed successful preventative maintenance as well as the use of corrosion-resistant materials. Figure 3-43, Figure 3-44, and Figure 3-45 show examples of observed corrosion, degradation, and preventive maintenance. Material degradation is common in coastal environments because of constant exposure to the sun, wind, salt air, and saltwater, all of which create a harsh environment known to corrode various metals and to quicken the deterioration of other materials. Proper material selection and diligent maintenance of coatings and components can aid in the prevention of corrosion and other deterioration. Without proper maintenance, significant vulnerabilities to the structure may occur.

The examples depict rusted straps or ties that failed and helped enable the structure above to separate from the lowest horizontal structural member of the lowest floor.

Figure 3-43: Two locations on Fort Myers Beach with examples of rusted straps or ties

Figure 3-44: Deteriorated wood supports in Bonita Springs that failed during Hurricane Ian

While proper maintenance was performed, the connectors shown are not ideal for support elements that may be subjected to flood loads, see Hurricane Sandy Recovery Advisory 1, *Improvising Connections in Elevated Coastal Residential Buildings* (2013c) for more information.

Figure 3-45: Example of new hurricane ties installed near old, rusted ties on Sanibel Island

3.7. Flood-Borne Debris

The MAT observed varying types of flood-borne debris (items that were transported to another location by floodwater) that caused or had the potential to cause damage to structures. Floodwaters with high velocities and large flood depths have the greatest potential to transport debris.

The flood-borne debris observed by the MAT included, but was not limited to, trees, structures, or portions of structures (including breakaway wall components), automobiles, and boats. Many buildings washed off their foundations and came to rest near or against other buildings as shown in Figure 3-46 in this section and Figure 3-57 in Section 3.9. Figure 3-47 depicts a porch that failed, likely as a result of debris impact or debris damming from a neighboring house, pieces of a roof are visible. Trees and driftwood were a common debris source as shown in Figure 3-48 and Figure 3-49. Figure 3-48 shows a structure that is supported by temporary structural supports due to a missing column. The column was destroyed during Hurricane Ian. The remaining columns had scarring, which was likely caused by contact with debris and the trees that collected between the house and the neighboring house. Some examples of automobiles transported by the floodwater are shown in Figure 3-50. In Fort Myers Beach, an approximately 100-foot-long houseboat was transported roughly 800 feet, mostly over land, and appears to have damaged structures that were in its path (Figure 3-51). Section 3.8 and Figure 3-54 discuss other displaced boats in the same vicinity as the houseboat.

Source: FDEP (top)

Figure 3-46: Overview of various displaced buildings on Fort Myers Beach

The porch likely failed due to debris impact and damming during Hurricane Ian. The debris had been cleaned up between this house and the neighboring house when photo was taken.

Figure 3-47: House with a failed porch and debris piled against the house in Fort Myers Beach (Lee County, Zone VE)

Source: FDEP (inset)

Top right inset was captured by FDEP contracted videography on October 2, 2022. Bottom photo was taken during the MAT in January 2023 after debris had been cleaned up and the temporary support was installed. The temporary support is a single lally column. It is inboard of the corner and is inside of the red circle in the bottom image.

Figure 3-48: House with missing column and temporary support structure in Sanibel (Lee County, Zone VE, Seaward of CCCL)

Source: FDEP (inset)

Figure 3-49: Driftwood lying between the piles of a foundation without a structure in Sanibel (Lee County, Zone VE, Seaward of CCCL)

Source: NSF StEER (right)

The left photo shows an automobile that was transported by approximately 22-inch-deep (or less) floodwater and damaged a garage door. The right photo shows two automobiles that were transported by floodwater on Fort Myers Beach.

Figure 3-50: Examples of automobiles transported by flood waters

Source: NSF StEER (bottom inset)

Figure 3-51: Before and after images of a houseboat that was transported by floodwater

3.8. Comparison of Building Performance and Vegetation Density

The MAT observed greater building survival in areas of higher vegetation density when compared to building survival in areas of lower vegetation density. The buildings in areas of higher vegetation density exhibited less evidence of wave damage and flood-borne debris. Figure 3-52 through Figure 3-54 show examples of where vegetation may have aided in reducing damage to structures from coastal flood effects such as wave action, flood velocity, and flood-borne debris. House A in Figure 3-52, which is approximately 550 feet from the Gulf of Mexico, may have benefited from the fronting and surrounding vegetation. After Hurricane Ian, House A had undamaged lattice remaining at ground level on the front of the house. The surviving lattice was notable because light construction materials, such as lattice, are expected and were often observed to be destroyed when a structure was close to the Gulf of Mexico. The two waterfront houses (House B and House C in Figure 3-52) in front of House A exhibited signs of damage from coastal flood effects such as wave action and flood velocity. Houses B and C likely provided sheltering effects (e.g., wave height reduction) for House A and the survival of House A's lattice may be attributable to both the presence of vegetation and the fronting structures.

Before Hurricane Ian

After Hurricane Ian

Source: Lee County Property Appraiser, used with permission (top right)

The second-row house (House A) had dense fronting vegetation before Hurricane Ian and had lattice that survived Hurricane Ian. The first-row houses (Houses B and C) experienced much greater damage than House A. House A's lesser damage is likely attributable to a combination of vegetation and first row structures.

Figure 3-52: Comparison of house performance on Sanibel (Zone VE/AE)

The vegetation density is greater on Sanibel Island compared to Fort Myers Beach. Over 50% of the island of Sanibel consists of conservation land (FDEP 2017). Sanibel Island regulates the pruning and removal of vegetation and has specific requirements for vegetation buffers along property lines on Sanibel Island; refer to Section 38 and Section 122 of the Sanibel Code of Ordinances for more information. Many of these regulations were originally outlined in the *Sanibel Plan*, adopted in 1976 (City of Sanibel 1976).

Figure 3-53 shows two areas in Fort Myers Beach with varying levels of building performance and flood-borne debris spread. Area A is a mixed development area that is classified as a recreational vehicle (RV) park but also has structures such as mobile homes (built before June 15, 1976) and manufactured homes (built after June 15, 1976). Area B consists of a mix of mobile homes and manufactured homes and is surrounded by wide, dense vegetation (mangroves). In general, the homes in Area A (build dates are grouped and only list 1969 and 1994) appear to be older and smaller than those in Area B (listed build dates range from 1966 to 2019). Figure 3-54 provides enlarged views of the two areas and shows that the homes in Area B performed better than those in Area A and that the mangroves surrounding Area B reduced the spread of flood-borne debris. Given the differences in age and type of construction between the two areas, the building performance between the two areas cannot be compared in relation to the vegetation alone. However, the flood-borne debris spread between the two areas provides for a good comparison.

After Hurricane Ian, the residential portions of Area A and Area B had approximately eight and six displaced boats without trailers, respectively (based on aerial imagery) (Figure 3-54). Area A had more displaced boats and larger boats than Area B. Based on virtual measurements, the eight boats in Area A included one 100-foot-long boat, four 38- to 46-foot-long boats, and three 20- to 23-foot-long boats. In Area B, all six boats were approximately 16- to 22- foot-long boats. Based on the size of the boats in Area B and Area B’s number of house docks, the boats in Area B may have been transported by floodwater from the docks behind the houses. An additional five displaced boats in Area B were on boat trailers. The boats on trailers are noted separately because they were landward of the vegetation before Hurricane Ian made landfall. The vegetated portion of Area B had more than 30 boats caught in the vegetation, they ranged in size from approximately 18 to 60 feet long. The surrounding vegetation aided in preventing these boats from traveling further inland into the residential portion of Area B as flood-borne debris.

Figure 3-53: Two areas in Fort Myers Beach; Area B is surrounded by dense vegetation (Zone VE)

Source: NSF StEER (boat insets)

The post-Hurricane Ian images show markers where displaced boats have been identified in the residential portions of the two areas. Representative boats are shown in inset images. The third boat inset picture shown in Area A is also discussed in Section 3.7 and Figure 3-51 Markers are not included for boats in the vegetated portions of Area B because of the large number of boats.

Figure 3-54: Enlarged views of pre- and post- Hurricane Ian imagery for the areas shown in Figure 3-53

3.9. Comparison of Elevated and Non-Elevated Single-Family Houses

The MAT visited numerous neighborhoods in which there were side-by-side examples of older, newer, and newly constructed residences that met or exceeded NFIP requirements (Figure 3-55). Visiting such neighborhoods provided the MAT with opportunities to evaluate the effectiveness of elevating houses to mitigate flood damage. Building elevation was generally a universal indicator of performance: many older existing buildings built before communities joined the NFIP, and began regulating SFHA development, were inundated by 2 to 8 feet of water. Meanwhile, newer, elevated residential buildings performed substantially better; some buildings had no inundation or far less inundation.

The MATs found several sites that enabled a comparison of newer versus older single-family houses. At this site, the 1990 and 2006 houses had less than 2 feet of flooding, with the 1990 house having floodwater in the lowest floor and the 2006 house having floodwater in its enclosure below the lowest floor; whereas, the 1973 house had approximately 7 feet of flooding in the lowest floor.

Figure 3-55: Example of side-by-side construction that the MAT compared (Lee County, Zone AE)

Along the coast, elevation was a critical indicator of building performance, especially when the lowest horizontal structural member of the lowest floor was constructed higher than the elevation of Hurricane Ian's maximum wave crest. Figure 3-56 shows a map of an area with seven elevated single-family houses in a Fort Myers Beach neighborhood that were constructed between 1958 and 2006. As denoted in Figure 3-56, house ID numbers are shown in circles for each structure. This area is Zone VE and AE based on the November 2022 FIRM (Date: November 17, 2022, Panel #: 12071C0554G) and is seaward of the CCCL. The Zone AE on the November 2022 FIRM is seaward of the newly delineated Limit of Moderate Wave Action (LiMWA) and is therefore a Coastal A Zone.[3]

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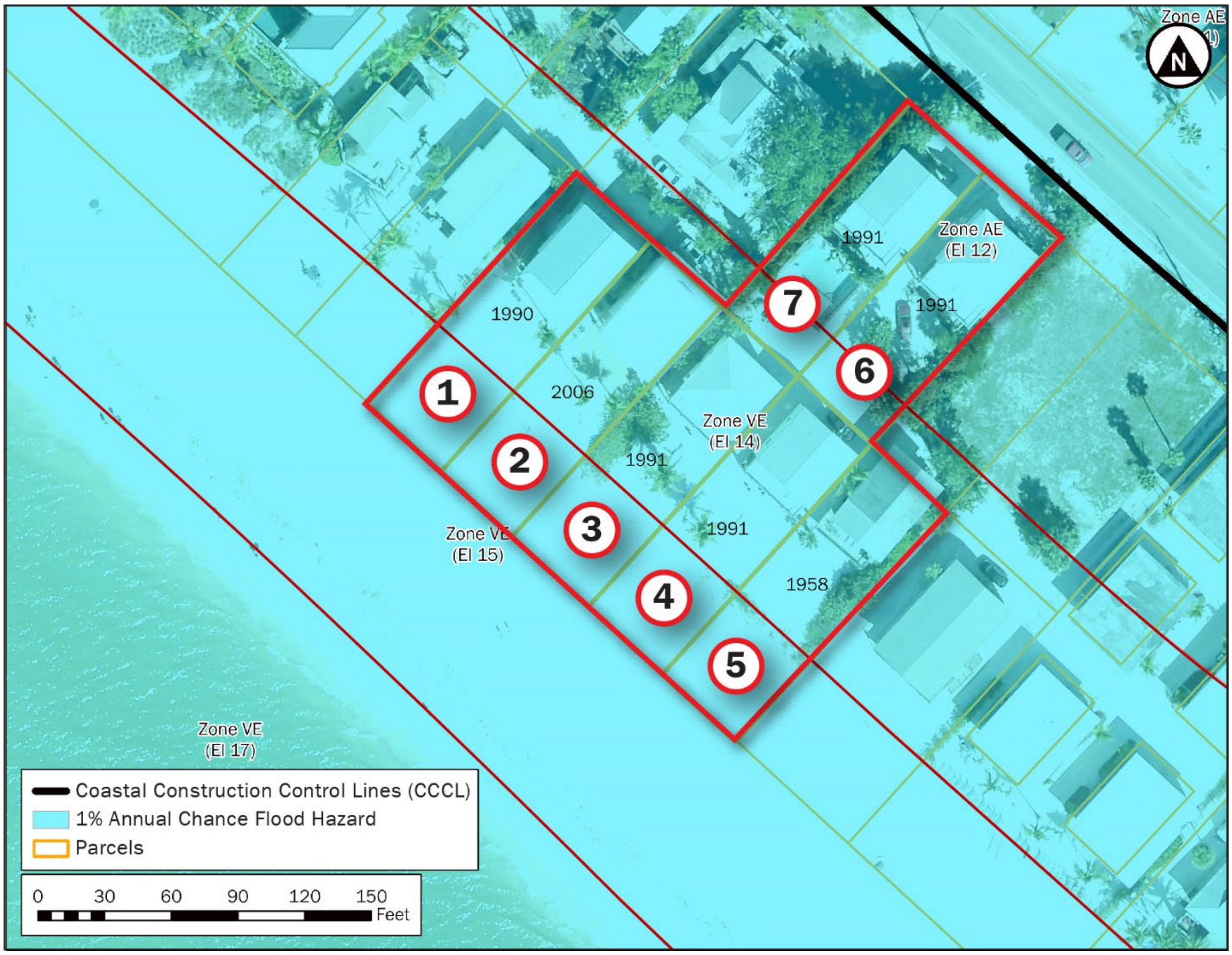
[3] For enforcement purposes, the Coastal A Zone is defined in ASCE 24 and the FBC. In general, Coastal A Zones represent areas of moderate wave action with wave heights between 1.5 and 3.0 feet and may include other areas designated by the jurisdiction. The LiMWA delineates the landward limit of waves heights of 1.5 feet and greater.

See Table 3-4 for further details on flood zones, BFEs, and CCCL 100-Year Storm Elevation requirements in this area. Note: Given the age of the structures, none were required to incorporate freeboard (added elevation above the BFE). Conditions during Hurricane Ian included inundation from surge with evidence of velocity and waves. StEER recorded an HWM, including surge and waves, of 17.6 feet NAVD 88 at house #3. No other nearby waterfront HWMs are available. Another HWM that is approximately 1,000 feet inland (and is expected to include reduced wave heights or no wave height) was recorded at 12.4 feet NAVD 88.



Numbered circles represent the house ID number for reference in discussions in this section. This map depicts the FIRM's BFEs, effective on August 28, 2008, which were still effective at the time of Hurricane Ian's landfall. Note: All of these homes are older than 2008; see Table 3-4 for more information.

Figure 3-56: Map of an area with different eras of construction for seven elevated single-family houses (Lee County, Zone VE/AE, seaward of the CCCL)

Table 3-4: Summary of Applicable Flood Zone and CCCL Requirements for the Houses Shown in Figure 3-56

House ID Number	Year Built(a)	Date of Effective FIRM for Year Built	Effective Flood Zone for Year Built	Effective BFE for Year Built (feet, NAVD 88)(b) [NGVD 29]	CCCL 100-Year Storm Elevation (feet, NAVD 88) [NGVD 29]	2022 Effective FIRM Flood Zone and BFE (feet, NAVD 88)
1	1990	9/19/1984	VE	15.8(c) [17]	No Requirement(d)	VE, 15
2	2006	9/19/1984	VE	15.8(c) [17]	19.8(b) [21.0]	VE, 15
3	1991	9/19/1984	VE	15.8(c) [17]	No Requirement(d)	VE, 15
4	1991	9/19/1984	VE	15.8(c) [17]	No Requirement(d)	VE, 15
5	1958	Existing Building	Existing Building	Existing Building	No Requirement(d)	VE, 15
6	1991	9/19/1984	VE	14.8(c) [16]	No Requirement(d)	AE, Coastal, 12
7	1991	9/19/1984	VE	14.8(c) [16]	No Requirement(d)	AE, Coastal, 12

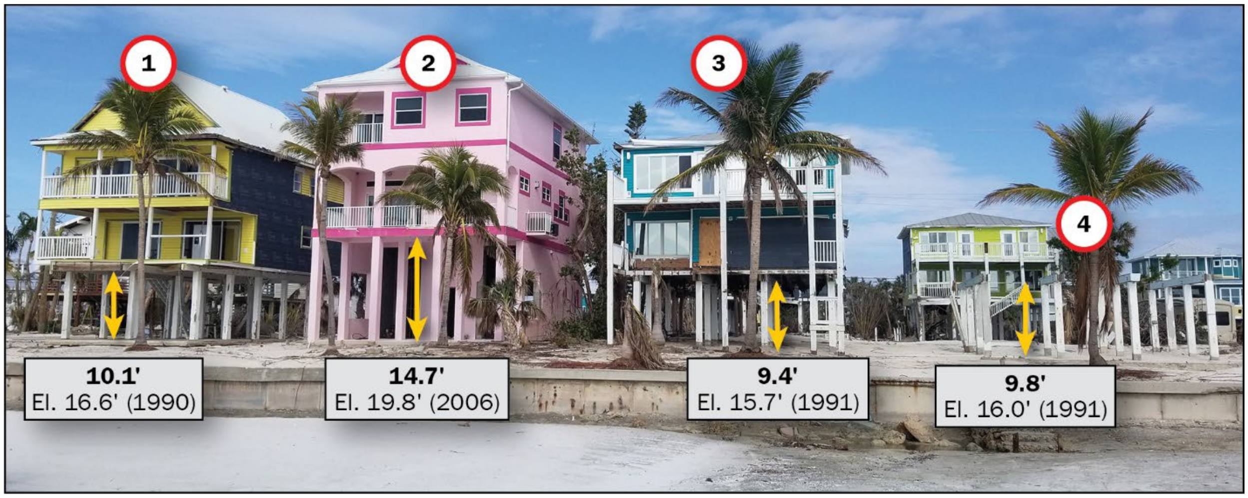
(a) Based on available data. Represents the earliest of the reported years.
(b) If a building crosses two flood elevations, the higher of the two is shown.
(c) Conversion from National Geodetic Vertical Datum of 1929 (NGVD 29) to North American Vertical Datum of 1988 (NAVD 88) performed with NOAA's online Vertical Datum Transformation tool (NOAA 2023).
(d) Lee County's reestablished CCCL location, which places these houses seaward of the CCCL, became effective on May 30, 1991. Building permits for these houses were acquired before May 30, 1991. Thus, the house designs were not required to include accommodation for the CCCL requirements.
BFE = base flood elevation, FIRM = Flood Insurance Rate Map, NAVD 88 = North American Vertical Datum of 1988, NGVD 29 = National Geodetic Vertical Datum of 1929

The MAT further studied the area shown in Figure 3-56 in the field given the varying building elevations and performance of the side-by-side structures. The houses were elevated on pilings or columns with a mix of concrete and wood construction. Some of the houses had small enclosures below the lowest floor for building access; only one of the seven houses, house #3, had a large, enclosed space below the lowest floor. Two of the seven structures were separated from their foundations during Hurricane Ian; both were beachfront properties (Figure 3-57). Field measurements of the lowest horizontal structural member supporting the lowest floor for the three remaining beachfront properties (#1 to 3) and the foundation of #4 were recorded; measurements were not taken for houses #5 to #7. The measurements were taken from the concrete slab or grade directly below the structure to the lowest horizontal structural member supporting the lowest floor of each house (Figure 3-58).

Source: Reprinted with the permission of EagleView. Copyright © 2022 EagleView. All rights reserved (top) and FDEP (bottom)

House #4 was moved from its foundation during Hurricane Ian; its post-storm location is indicated by the dotted line box. House #5, built in 1958 and having a lower elevation, was destroyed.

Figure 3-57: Seven elevated single-family houses in Lee County, built to different elevations



Bolded measurements are to the lowest horizontal structural member supporting the lowest floor from either the top of the concrete slab or grade level at the time of measurement post–Hurricane Ian and are given in feet. Approximate elevations, shown as "EL. #'," are given in feet NAVD 88. The year built for each structure is shown in parentheses for reference.

Figure 3-58: Field measurements of the four waterfront structures

Detailed field observations were recorded for the waterfront properties, houses #1 to #4. Of the houses shown in Figure 3-58, house #2 (2006) has the highest elevated lowest horizontal structural member supporting the lowest floor (14.7 feet field measured from slab) while house #3 (1991) has the lowest elevated horizontal structural member supporting the lowest floor (9.4 feet field measured from grade). See Table 3-5 for a summary of the approximate elevation of the lowest horizontal structural member of the lowest floor as well as observations for houses #1 to #5. Figure 3-59 shows examples of damage observed for each structure. A comparison of damage to these houses indicated significant differences based on the height of the building above grade. Structures with higher elevations above grade experienced less damage than those at lower elevations above grade. However, the varying performance of houses #3 and #4, which have similar elevations above grade, demonstrates that other factors also contributed to building performance. The contributing factors that lead to the failure of house #4 or the survival of house #3 are unknown. House #2 exhibited the least amount of damage and was elevated 3 to 4 feet higher than houses #1, #3, and #4. House #2 was required to comply with the CCCL 100-Year Storm Elevation requirements, which exceed the BFE by 4 feet. The other houses were not required to comply with CCCL 100-Year Storm Elevation requirements and were only required to be elevated to the BFE. The CCCL elevation requirements likely minimized the damage sustained by house #2.

Table 3-5: Summary Table of Field Observations for Houses #1 through #5

House ID Number (year built)	Approximate Elevation of Bottom of Lowest Horizontal Structural Member of the Lowest Floor (feet, NAVD 88)	Summary of Observations
1 (1990)	16.6(a)	Damage included a missing exterior set of stairs, failed façade trim boards, missing railings, and almost complete removal of the underside floor joist covering. Although the team could not evaluate the interior of the building, water likely entered the lowest floor of the structure and caused additional damage.
2 (2006)	19.8(b)	This house included an enclosure with breakaway walls and flood openings. Minimal damage was observed for this house, and floodwater likely did not enter the lowest floor. The breakaway walls appeared to perform as expected with the exception of some façade failure, which was likely due to improper separation from the breakaway wall components.
3 (1991)	15.7(a)	Damage included a failed deck that further damaged the main structure, a door and windows were boarded and likely concealed damage to these elements, damaged underside floor joist covering, missing siding, and submerged electrical boxes. Although the team could not evaluate the interior of the building, water likely entered the lowest floor of the structure and caused additional damage given the boarding in place to temporarily close the home envelope.
4 (1991)	16.0(a)	Complete loss. Main structure separated from the lowest horizontal structural members supporting the lowest floor.
5 (1958)	Unknown; lower than houses #1–#4 based on Figure 3-57	Complete loss.

(a) Derived from field measurements and field ground elevation survey.
(b) Based on permit data.

Figure 3-59: Examples of damage observed for each of the three remaining waterfront structures

3.9.1. COMPARISON OF HURRICANE IAN NFIP INSURANCE CLAIMS IN REPRESENTATIVE AREAS

Based on historical NFIP claims data (without any adjustments made for inflation), the average claim from 1980 through 2022 was $41,399, nationally. In Florida, the average NFIP claim was $43,312 over that same period. Prior to 2022 (1980–2021), the average NFIP claim in Florida was $30,438. The average NFIP claim in Florida in 2022 was $109,239; 16% of the historical claims in Florida and 41% of the historical payments in Florida from 1980 through 2022 came in 2022. Nevertheless, Hurricane Ian flood damage in Florida was unprecedented. Based on field observations of the numerous side-by-side examples of older, newer, and newly constructed residences, the MAT explored opportunities to evaluate the effectiveness of flood design and construction practices relative to mitigation of flood damage.

With over 37,000 Hurricane Ian NFIP claims throughout Florida, and over 22,000 claims in Lee County alone, the MAT used NFIP policy claims data to support the comparison of damage to *elevated* and *non-elevated buildings*. Representative areas were selected based on a high percentage of NFIP policies in force and a large age-of-construction distribution, whenever possible. The estimated annual exceedance probability based on the nearest HWM and the effective FIS was also used to select representative areas, with priority given to areas where Hurricane Ian flood depths were at or near design requirements. Figure 3-60 depicts the locations of the representative areas selected and Figure 3-61 indicates the estimated annual exceedance probability nearest to the coastal representative areas selected. Figure 3-61 includes estimated maximum water heights from the Coastal Emergency Risks Assessment (CERA), which is an interactive web mapper that delivers storm surge and wave guidance based on the Advanced Circulation (ADCIRC) computer model to calculate the storm surge corresponding to the latest official hurricane forecast track. CERA assists emergency managers, weather forecasters, and GIS specialists with real-time results from the ADCIRC storm surge model to evaluate the impacts of a tropical event or to see the tide, wind-wave, and surge conditions on a daily basis.

Elevated Building

For insurance purposes, an *elevated building* is a non-basement building that has its lowest elevated floor raised above ground level by foundation walls, shear walls, posts, piers, pilings, or columns (per 44 CFR 59.1).

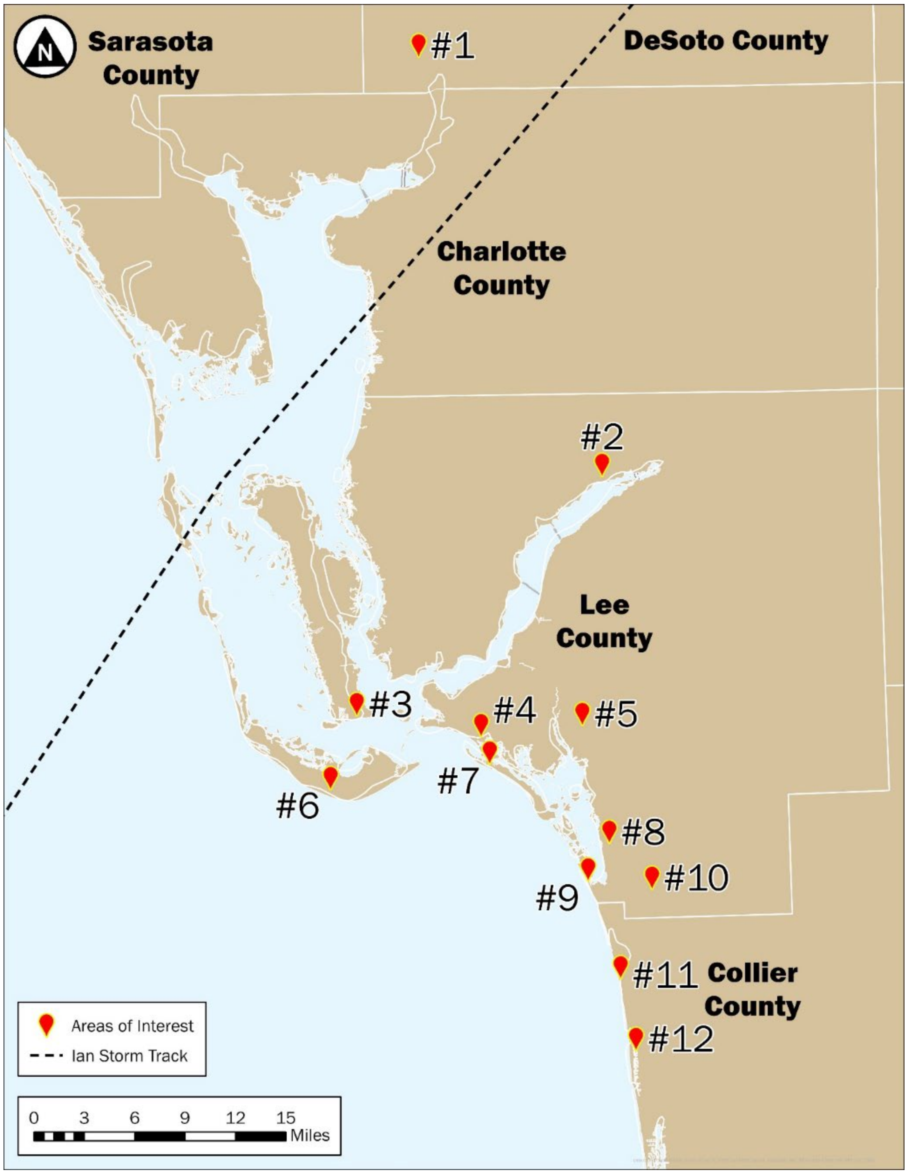


Figure 3-60: Locations of the representative areas

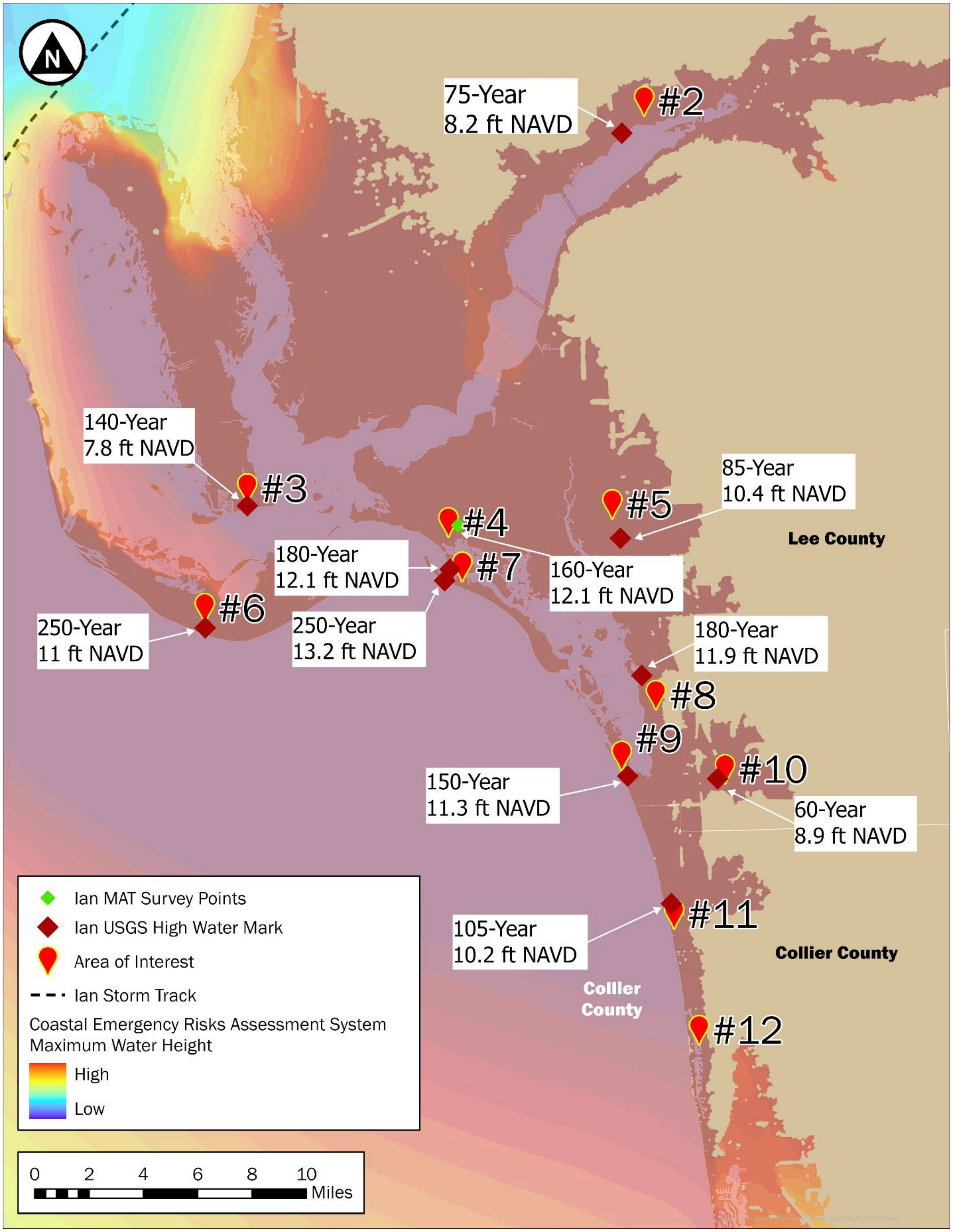


Figure 3-61: Estimated annual exceedance probability for Areas of Interest 2 through 12

Based on field observations, structural damage in these areas typically depended on whether or not the building experienced wave action or high-velocity flood loads. Debris-impact loads were also a contributing factor to structural damage. For the most part, unless buildings were subject to hydrodynamic loads or experienced scour and erosion damage to foundations, buildings did not typically have structural damage. Nevertheless, extensive damage was observed to non-structural building components and non-flood damage–resistant materials that were exposed to flooding. While *elevated buildings* were more flood-damage resilient than *non-elevated buildings*, finished enclosures with various elements that did not appear to comply with flood-damage-resistant material requirements, and had functions beyond the only allowable uses of parking, building access, and storage below the lowest floor, were prevalent. These common issues reduced building and community resilience by generating avoidable flood damage, creating debris that also caused the closing and blocking of countless roads, requiring cleanup and repairs, and unnecessarily tied up limited resources.

To reinforce field observations related to flood damage of single-family residential buildings, the MAT collected NFIP policy claims data along with county parcel data. The policy data from the FEMA Flood Insurance Directorate included claims status, *elevated* versus *non-elevated building* type, pre- versus post-FIRM construction, primary residence, claims payment, and building and contents coverage limits. Parcel data attributes included the year built and size of the house in square feet. To help recommend improvements for flood-resistant design and construction requirements, building and contents claims were analyzed to supplement observations made in the field. Table 3-6 through Table 3-7 summarize NFIP claims in the representative areas. Table 3-6 compares average total, building, and contents claim by decade. The summary shows a decrease by decade, indicating newer construction had less insured flood damage claims. Table 3-7 compares average total, building, and contents claims by *elevated* vs *non-elevated building* type. The average *non-elevated building* claims were considerably higher as expected. Note, not every insurance policy analyzed had contents coverage, so the combined averages will not equal the total average claim.

Table 3-6: Comparison of Hurricane Ian NFIP Claims across Representative Areas by Decade

Decade Built	Quantity	Average Total Claim	Average Building Claim	Average Contents Claim
Pre-1980	426	$191,378	$164,891	$38,265
1980s	344	$117,074	$100,584	$22,781
1990s	173	$73,857	$62,496	$13,017
2000s	205	$73,898	$61,791	$13,562
Post-2010	122	$54,894	$48,091	$9,651
All	**1,270**	**$123,168**	**$105,662**	**$23,053**

Table 3-7: Comparison of Hurricane Ian NFIP Claims across Representative Areas by *Elevated* versus *Non-elevated Building* Type

Type	Quantity	Average Total Claim	Average Building Claim	Average Contents Claim
Elevated	413	$50,287	$46,033	$5,077
Non-elevated	857	$158,291	$134,398	$33,133
All	1,270	$123,168	$105,662	$23,053

The *elevated* versus *non-elevated building* attribute is likely the largest indicator of building performance within the insurance policy and claims data. This is consistent with field observations and expected because standard NFIP policy building and contents coverage is relatively limited below the lowest floor of an *elevated building*. With the amount of enclosure damage observed, it is important to keep in mind that NFIP coverage below the lowest floor of an *elevated building* is limited and does not cover finishes, as only one example. Therefore, damage to enclosures is probably not fully represented in these statistics and damage in *elevated buildings* is likely higher.

Age of construction is also an indicator of building performance. The average post-2010 building claim ($48,091) is more than a third less than the average pre-1980 building claim ($164,891) and more than 50% less than the overall average building claim ($105,662). These averages are consistent with field observations. Figure 3-62 illustrates the average building claim across all buildings as well as *elevated versus non-elevated building* by decade. On average, the damages in newer buildings are consistently lower.

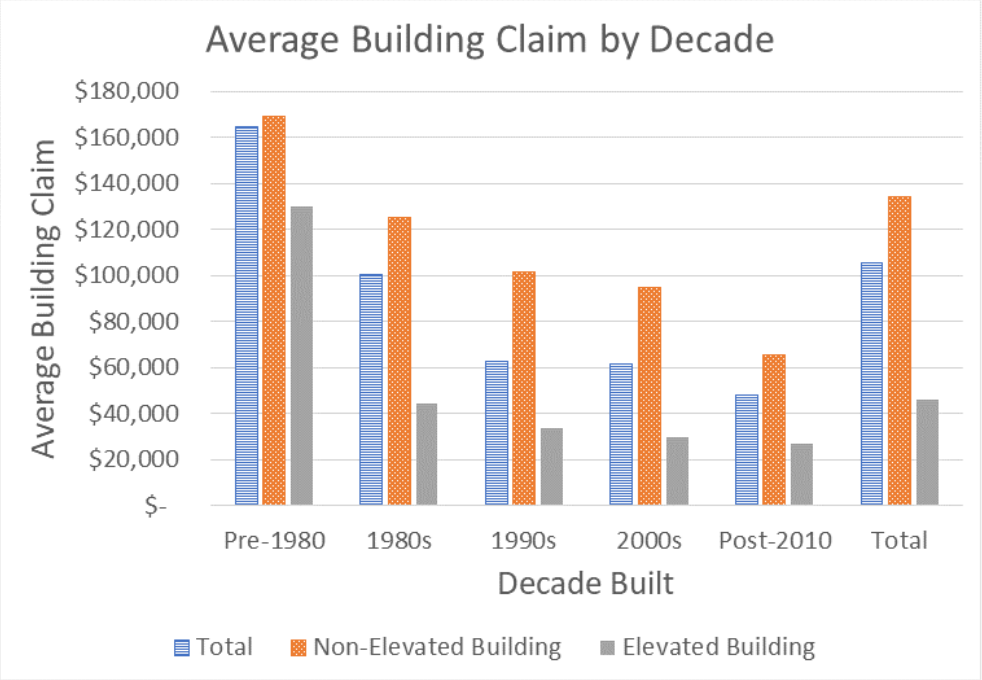


Figure 3-62: Average building claim in *elevated* versus *non-elevated buildings* by decade

Comparing across decades can be challenging because the average size of the buildings varied by area as well as by decade; newer construction was observed to be considerably larger and the claims are consistent with that observation. However, the overall results were consistent with field observations related to flood damage. Building performance, elevation, and foundation type matter and newer construction is a likely indicator of improved building performance. One indicator that is helpful in comparing across the building age of construction and other attributes is the average building claim per square foot. Figure 3-63 shows the average building claim per square foot in *non-elevated buildings* versus depth of flooding. The results of this graph is consistent with observations in the field, which indicates the claims data is a reasonable supplement to field observations and likely representative of the buildings throughout the areas studied.

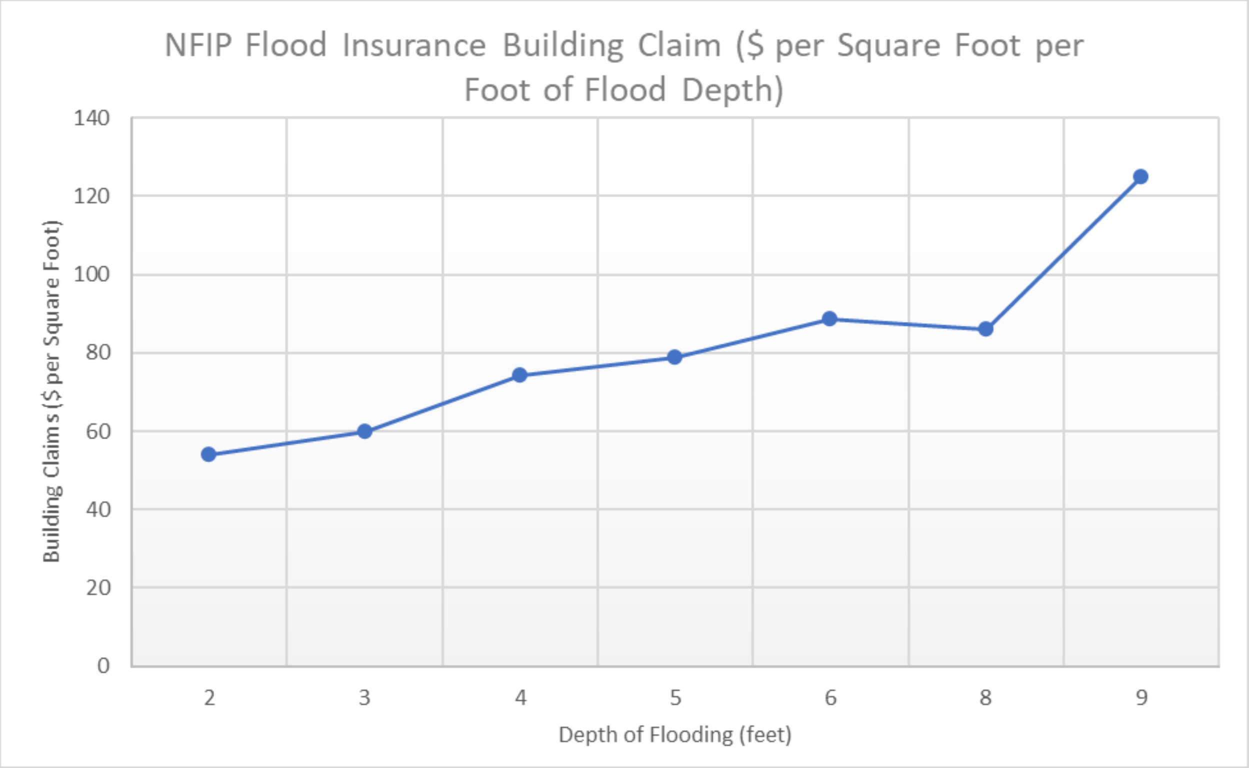


Figure 3-63: Average building flood insurance claim per square foot in *non-elevated buildings* versus depth of flooding

A few key observations from field notes as well as flood insurance policy and Hurricane Ian claims data include (see also supporting Tables in Appendix C):

- **Elevation and foundation type matter** – The *elevated* versus *non-elevated building* attribute is likely the largest indicator of building performance within the flood insurance policy and claims data. This is consistent with field observations and expected because standard NFIP policy building and contents coverage is relatively limited below the lowest floor of an *elevated* building.
    - *Elevated buildings* constructed above ground level by foundation walls, shear walls, posts, piers, pilings, or columns are generally more likely to have a lowest floor that exceeds the minimum NFIP and building code elevation requirements. Based on discussions with homeowners in the field, most indicated they extended their foundation beyond the minimum requirement to allow for an enclosure as well as provide some additional flood risk reduction. The higher the lowest floor is elevated on a proper foundation with flood damage–resistant materials below it, the less likely there will be flood damage.
    - *Elevated buildings* without structural damage were generally repaired and habitable faster as areas below the lowest floor can typically be repaired while the house is occupied; they are generally simpler to retrofit as well. However, securing the damaged enclosures below the lowest floor and separating areas normally used for parking, storage, and access was a common challenge.

  - The far majority of the policies, 94% (132 out of 140), with a maximum building claim ($250,000), were *non-elevated buildings*.

  - In newer (post-2000) construction, 52 policies have building claims between $125,000 to $250,000 (50% to 99% of the maximum building claim allowed); of these, only four (or less than 8%) are *elevated buildings*. Ten of the 52 are post 2010; none of them are *elevated buildings*. These data support field observations that indicate a clear difference in building performance of *elevated buildings* (constructed above ground level by foundation walls, shear walls, posts, piers, pilings, or columns). Note, there are 148 *elevated* and 159 *non-elevated* post-2000 buildings, with insurance claims. The average building claim per square foot is $11.53 in *elevated buildings* versus $29.15 in *non-elevated buildings*.

  - The lowest 10% of building claims are $6,400 or less; of these 127 claims, 78 claims, or approximately 60%, are from *elevated buildings*.

  - The average building claim per square foot is 2.7 times greater in *non-elevated buildings* ($72.42 per square foot versus $26.46 per square foot).

  - Based on limitations in the standard NFIP flood insurance policy, *elevated buildings* significantly reduce exposure to the National Flood Insurance Fund.

- **Newer construction had considerably less flood damage, but there is room for improvement** – The average post-2010 building flood insurance claim ($48,091) is more than three times less than the average pre-1980 building claim ($164,891) and greater than 50% less than the overall average building claim ($105,662). While the claims indicate improved performance, there was extensive damage to non-structural building components and non-flood damage–resistant materials that were exposed to flooding (likely not reflected in the claims data because coverage below an *elevated building* is limited). Although *elevated buildings* were more flood-damage resilient than *non-elevated buildings*, finished enclosures that had various elements that did not appear to comply with flood damage–resistant material requirements and had functions beyond the allowable uses of parking, building access, and storage below the lowest floor, were prevalent. These common issues reduced building and community resilience by generating avoidable flood damage and creating extensive debris that resulted in closing and blocking roads, requiring repairs, and unnecessarily tying up limited resources.

- **Trends in *elevated* vs *non-elevated buildings*** – Although the *elevated* versus *non-elevated building* attribute was likely the largest indicator of building performance, newer buildings are less likely to be *elevated buildings*. In most areas where the claims were analyzed, new *elevated* and *non-elevated buildings* are allowed and the MAT commonly observed newer houses built on fill or stem wall foundations, all of which appeared to be built to the required elevation. The flood insurance policy and claims data reinforced this trend as the ratio of *elevated* to *non-elevated buildings* was greatest in the 1990s. Post-2010 construction is more likely to be a *non-elevated building* type than elevated on foundation walls, shear walls, posts, piers, pilings, or columns.

Several factors could be contributing to this trend, including availability of materials, planning and zoning requirements, construction time, construction cost, and/or homeowner preference.

- **Increasing average house size** – The increasing average building size has far outpaced the NFIP maximum flood insurance coverage cap, which also has not been adjusted since 1994. The average building size by Areas of Interest ranged from 1,285 to 3,112 square feet. Across all 1,270 NFIP policies, the average was 2,133 square feet, the average pre-1980 insured house was 1,799 square feet, and the average post-2010 insured house was 2,977 square feet. Based on field observations, the increased size in waterfront properties was significant and especially noticeable.

- **Proximity to hurricane track** – While the high water/depth of flooding and building characteristics (age of construction, foundation type, building size, etc.) are key indicators of damage, proximity to the hurricane track is not as evident an indicator. Unlike wind damage where proximity to the track was a key indicator of damage; based on field observations, age of construction, building type and size, extent of surge and depth of flooding, and other parameters were more critical indicators of flood damage and building performance. Given the significant size and strength of Hurricane Ian, there was widespread and significant flooding along the coast and up the river and extensive canal systems.

- **Pre-FIRM construction and Substantial Damage** – Although numerous pre-FIRM buildings were flooded, how many were sufficiently damaged to trigger Substantial Damage is unclear. Based on the insurance policy data for pre- versus post-FIRM construction, the average pre-FIRM ($148,708) building claim was more than twice the post-FIRM construction average ($63,020). In addition, 70% of the policies (99 out of 140) with a maximum building claim ($250,000) were pre-FIRM construction. Based on the claims data, 3% to 15% of the buildings across these Areas of Interest will likely be deemed Substantially Damaged, triggering NFIP and building code compliance requirements.

See Appendix C for more detailed information about each Area of Interest, including maps of each area with year built and more breakdowns of the flood insurance claims.

3.10. Performance of Commercial and Multi-Family Buildings

Similar to single-family houses, the MAT visited several areas that provided opportunities to evaluate the effectiveness of flood-resistant design and construction practices in commercial and multi-family buildings. Once again, building elevation was a universal and effective indicator of performance. Older buildings built before communities regulated floodplain development were often inundated during Hurricane Ian, while newer buildings elevated above ground or on fill performed much better, in some cases with no inundation. Finished (non-compliant) enclosures below *elevated buildings* without flood damage–resistant materials below the lowest floor often had reduced flood resilience effectiveness because they did not have the required wet floodproofing measures implemented, which resulted in increased flood damage. Although occupancy beyond allowable uses of parking, storage, and access was not as prevalent as in single-family construction, it still occurred. The MAT observed only a few actively implemented dry floodproofing measures (e.g., flood shields), which inhibited the MAT from evaluating the overall effectiveness of dry floodproofing measures. There were numerous cases in which designed dry floodproofing systems were never employed by the owner/operator, resulting in flood damage and adverse business impacts. In some cases, performance varied based on whether the dry floodproofing measures were passive or active. For example, two mixed-use buildings across the street from one another in downtown Naples (Figure 3-64), both built in the late 2010s, one with active and the other with passive measures, varied in performance during Hurricane Ian.

Figure 3-64: Downtown Naples (Collier County, Zone AE)

The building on the left in Figure 3-64 was built in 2018 on foundation walls and had fill of approximately 2 to 3 feet above grade to reach the DFE, requiring pedestrian access via stairs from street level. This building also included one level of below-grade parking. The building on the right in Figure 3-64 was built in 2019 and had a combination of wet and dry floodproofing measures that were intended to prevent floodwater from entering the commercial areas and to intentionally allow floodwater to enter and exit automatically in enclosures providing residential building access. The designs of the two buildings were intentionally different because the latter building owners considered direct pedestrian access (unimpeded by stairs) to store front commercial spaces important on corner lots in a high-density urban area.

The building on the left did not experience any flood damage, while the building on the right, for which the owners ineffectively deployed its designed dry floodproofing measures, had about 3 to 6 inches of flooding. This caused the retail spaces to be closed for about 7 days, according to one business owner, while repairs were made and business operations were restored. The floodproofing measures for the building on the right were ineffective because the wet and dry floodproofing measures conflicted with one another (areas intended to be fully dry floodproofed had flood openings). The building on the left was sufficiently elevated above Hurricane Ian flood levels, including an elevated ramp enabling access into a below-grade parking garage, which helped keep the entire building flood resistant without requiring human intervention. Figure 3-65 through Figure 3-67 provide representative pictures of the two buildings.

Figure 3-65: Anchors for active dry floodproofing measures on building in downtown Naples (Collier County, Zone AE)

Figure 3-66: Building elevated on fill and foundation walls in downtown Naples (Collier County, Zone AE)

Figure 3-67: Below-grade parking with elevated ramp access in the building elevated on fill and foundation walls (Collier County, Zone AE)

3.10.1. DRY FLOODPROOFED BUILDINGS

Across the October 2022 preliminary assessments and especially during the field work in January 2023, the MAT visited over a dozen buildings throughout Naples and Collier County that were designed to be dry floodproofed (Figure 3-68 through Figure 3-72). The MAT visited office buildings, restaurants, retail/storefronts, a post office, bank, coffee shop, and other non-residential buildings in areas that experienced flooding during Hurricane Ian (primarily in the vicinity of downtown Naples). Although the MAT was hoping to document lessons learned related to the performance of dry floodproofing measures, the most common observations from field assessments were that the dry floodproofing measures were often not deployed as designed. Figure 3-70 through Figure 3-72 illustrate barriers that were not deployed as designed for Hurricane Ian. Several of these buildings experienced flooding of 6 inches to 3 feet because the dry floodproofing measures (e.g., flood shields) were not deployed. This resulted in extensive flood inundation damage as well as weeks or months of business disruption while repairs were completed. Numerous businesses were still not in operation during the time of the MAT assessments, fully 4 months after landfall, and many were still weeks or months away from reopening because of repairs. Some of these businesses went out of business permanently, which could have been the result of not implementing available floodproofing measures in preparation for Hurricane Ian and sustaining significant flood damage.

Figure 3-68: Dry floodproofed office building; note anchors on each side of door frame to support opening barriers (Collier County, Zone AE)

Figure 3-69: Dry floodproofed retail building; note anchors on each side of the window frame to support opening barriers (Collier County, Zone AE)

Figure 3-70: Office building where dry floodproofing measures were not deployed; note HWM (arrow) and posts for dry floodproofing measures (circled) (Collier County, Zone AE)

These opening barriers did not appear to have been moved from this onsite storage location for several months/years.

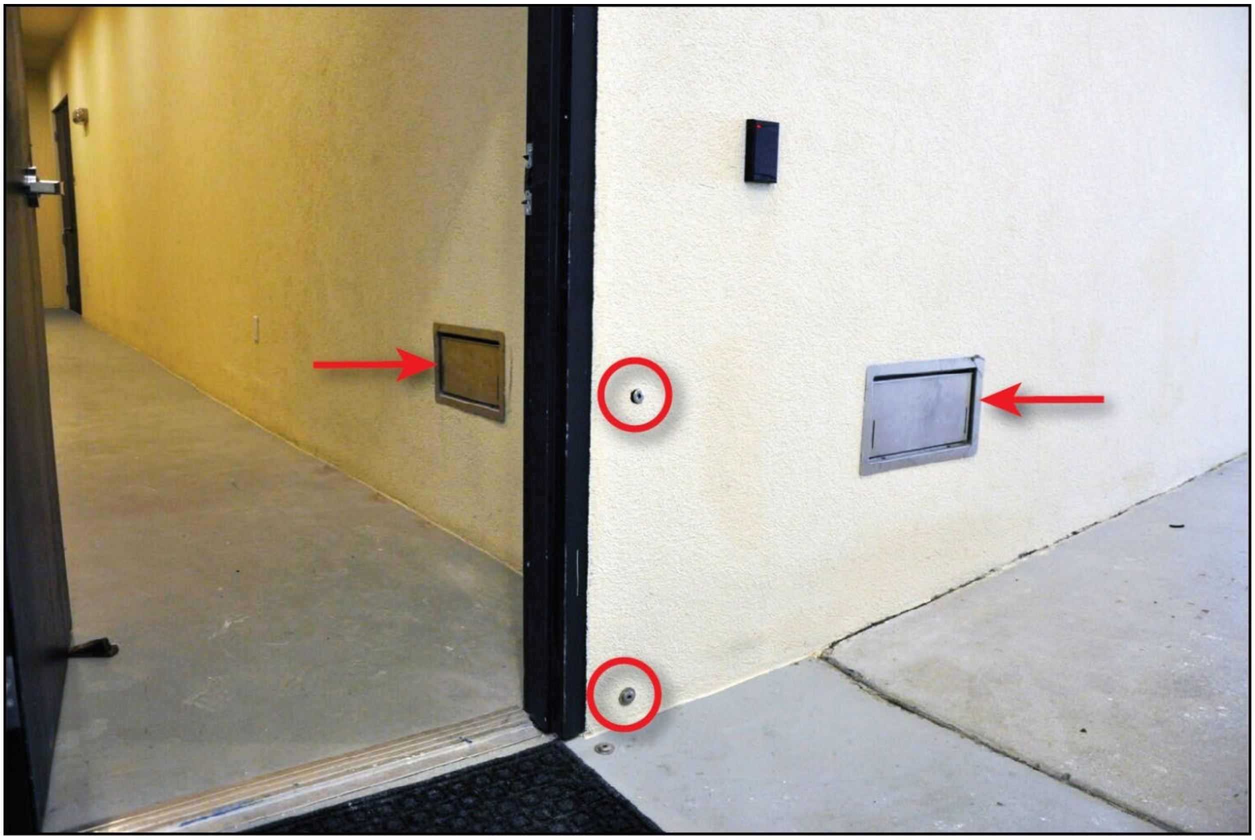
Figure 3-71: Opening barriers for an office building that were not deployed (Collier County, Zone AE)

These opening barriers did not appear to have been moved from this onsite storage location for several months/years. The seals on these barriers were worn and corroded as well.

Figure 3-72: Opening barriers for a post office facility that were not deployed (Collier County, Zone AE)

One relatively unique building that the MAT visited is a mixed-use building that was designed for a combination of dry and wet floodproofing measures (Figure 3-73). The plans indicated dry floodproofing of the retail non-residential space and wet floodproofing of the lobby; however, the construction/implementation was inconsistent with the design drawings, including one area that had flood openings immediately adjacent to connections for temporary barriers (Figure 3-74). While the dry floodproofing measures were installed along the storefronts just prior to Hurricane Ian, similar dry floodproofing measures were not installed at the rear entrances, resulting in 3 to 6 inches of flooding of the retail space. According to one of the store owners, the store and several other retail spaces were closed for at least a week to repair and restore business operations.

Figure 3-73: Mixed-use building with wet floodproofing measures (arrow) in residential access area and dry floodproofing measures (circle) in retail space/non-residential area (Collier County, Zone AE)



Red arrows indicate wet floodproofing measures and circles illustrate anchors for dry floodproofing measures for an enclosed area within a mixed-use building.

Figure 3-74: Inconsistent and counterproductive floodproofing measures in a mixed-use building (Collier County, Zone AE)

The Fort Myers Beach Town Hall was one of the few buildings observed by the MAT that had dry floodproofing measures implemented. Based on street view imagery taken in October, the entrance along the south facing wall (along Estero Boulevard and parallel to the coast) was destroyed by the storm surge. The flood loads returned the south-facing wall and entrance to its pre-2015 retrofit conditions (Figure 3-75 and Figure 3-76). Although this site was in Zone AE 13 based on the 2008 effective FIRM and remains in Zone AE 11 based on the November 2022 effective FIRM, the LiMWA is immediately along the southern limit of the parcel (Figure 3-77). An HWM of 11.4 feet NAVD 88 was collected by the USGS at the church adjacent to the Town Hall building. Based on observations made by the MAT in mid-January, the building implemented active dry floodproofing measures (Figure 3-78); however, it was unclear to what height or whether all the barriers were installed. The storm surge appeared to force its way in through the south wall/entrance then force its way back out through other openings (from the back side of the flood barriers). These site conditions and flood loads on the dry floodproofing measures reinforce flood-resistant design and construction requirements that prohibit dry floodproofing in Coastal High Hazard Areas. Figure 3-79 shows the barriers along the north wall main entrance having been blown out and Figure 3-80 shows an employee entrance door having been blown out.

Source: (Top Left and Right) Lee County Property Appraiser, used with permission

Figure 3-75: Fort Myers Beach Town Hall south-facing wall 2015 through present (Lee County, Zone AE)

Figure 3-76: Fort Myers Beach Town Hall south-facing wall following Hurricane Ian (Lee County, Zone AE)

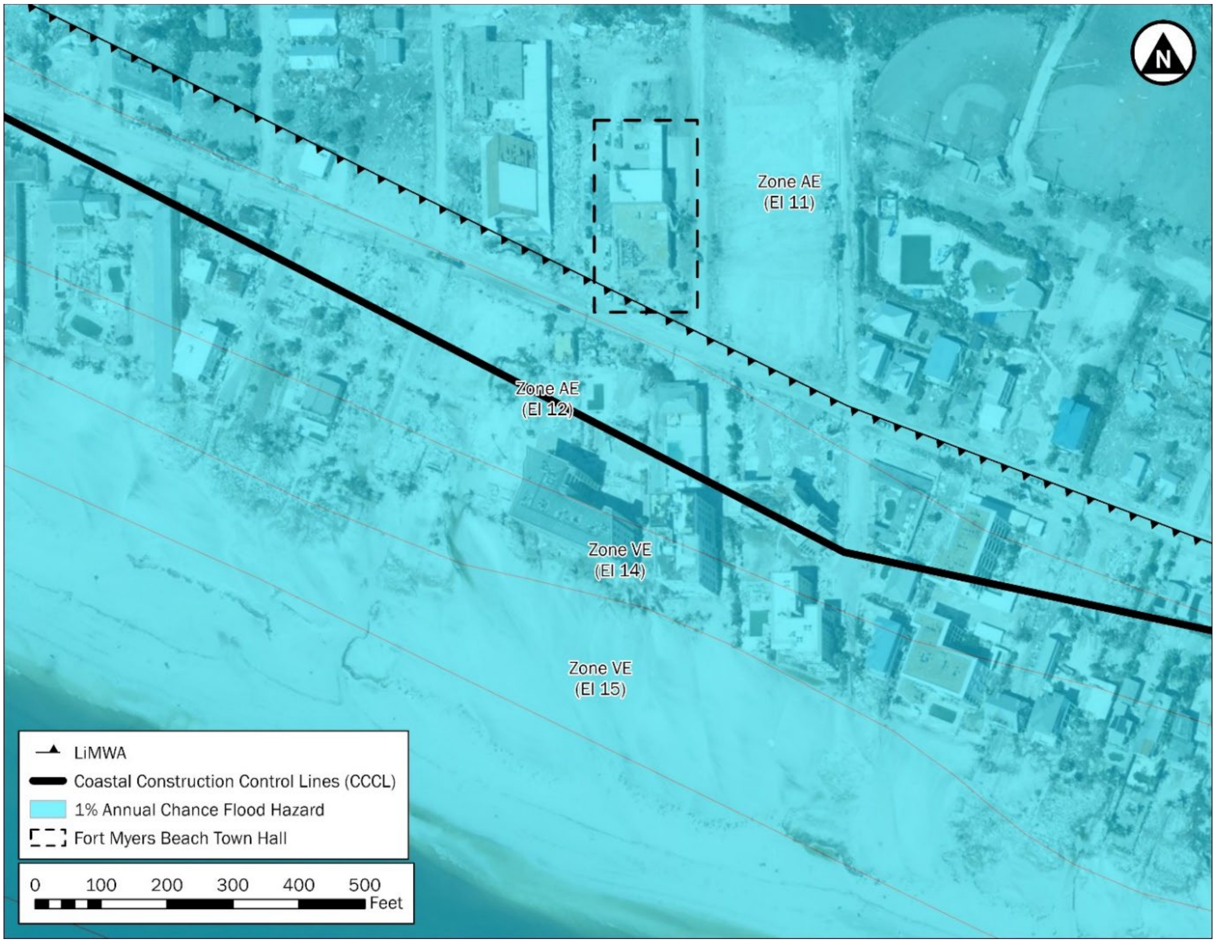
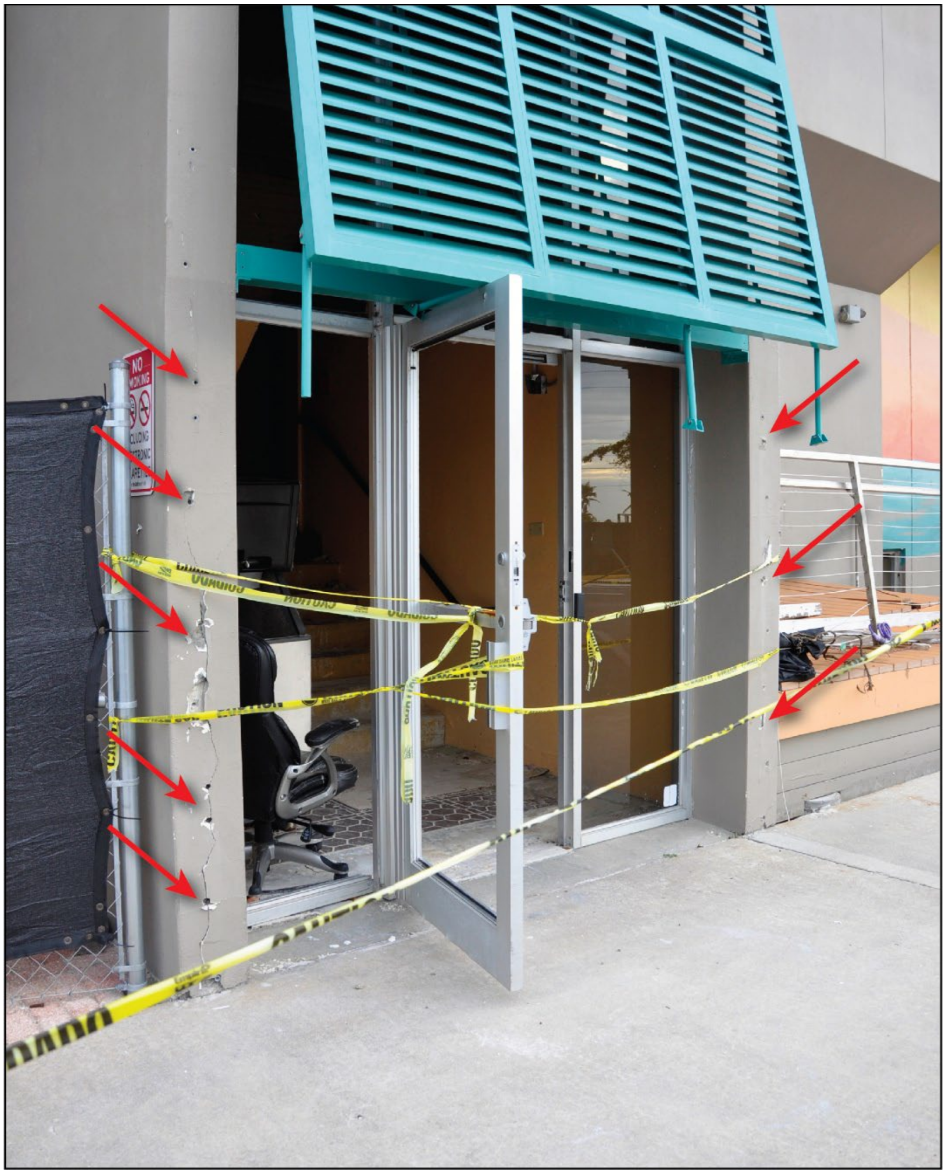


Figure 3-77: November 2022 effective FIRM for Fort Myers Beach Town Hall (Lee County, Zone AE)

Figure 3-78: Dry floodproofing measures implemented (barriers circled) at Fort Myers Beach Town Hall (Lee County, Zone AE)



Red arrows indicate the locations of several anchors, which had minimal structural embedment, along the north-facing wall. The barriers along this entrance were pulled away from the wall as surge entered from the south side and forced its way through and back out of the building through the north side.

Figure 3-79: Dry floodproofing measures along north-facing wall at Fort Myers Beach Town Hall were blown out (Lee County, Zone AE)

Figure 3-80: Employee entrance door blown out by flood loads at Fort Myers Beach Town Hall (Lee County, Zone AE)

3.10.2. MULTI-FAMILY APARTMENTS AND MIXED-USE BUILDINGS IN NAPLES

In addition to visiting buildings that were designed to be dry floodproofed, the MAT visited about a dozen multi-family buildings in Naples. These buildings were located in Zone AE (various DFEs), were typically at least two to three stories high, and were mostly residential but in some cases, mixed-use. The older apartments were constructed at grade, and the newer ones typically had the lowest floor elevated above ground with parking and building access enclosures. The older buildings experienced between 6 inches and 3 feet of flooding, causing extensive flood damage and forcing lowest floor occupants to be displaced for weeks or months.

The MAT visited an older condo complex built at grade 4 months after landfall; the lowest floor remained unoccupied and extensive repairs were still being completed. In contrast, newer buildings elevated above ground had minor flood damage that was limited primarily to contents and non-flood damage–resistant materials, elevators, and other interior finishings. Figure 3-81 through Figure 3-85 are representative multi-family residential buildings visited by the MAT.

Figure 3-81: Mixed-use building with retail space and parking at grade, with residential apartments above (Collier County, Zone AE)

The building on the left had several feet of flooding and was still undergoing repairs 4 months after Hurricane Ian made landfall; there was no reported damage to the building on the far right, other than having limited access during the hurricane as the roads were flooded.

Figure 3-82: Older condominium complex to the left, newer building on the far right (Collier County, Zone AE)

Based on a field interview with the tenant, the building was surrounded by floodwater several feet up the parking ramp, but the floodwater did not enter the garage enclosure. The building did not sustain flood damage.

Figure 3-83: The rear of an elevated on fill, mixed-use building with parking (Collier County, Zone AE)

No flood damage was observed or reported to this building.

Figure 3-84: Newer multi-family building with parking enclosure below DFE and residential apartments above (Collier County, Zone AE)

Damage in this elevated above-ground building was limited to non-flood damage–resistant materials in enclosures used for storage and access as well as damage to the elevator system.

Figure 3-85: Multi-family building with parking and storage enclosures below the DFE along with elevated residential condominiums (Collier County, Zone AE)

3.10.3. FORT MYERS BEACH LIBRARY

Fort Myers Beach Library

Date of Construction: 1994/2013
Conformance Category: Legal non-conforming
Effective BFE:* 13 feet, NAVD 88 [Date: August 27, 2008, Panel #: 12071C0554F]
*During Hurricane Ian

The Fort Myers Beach Library opened in 1955. The flood zone history of the library's location is as follows:

- Zone AE 12 NGVD 29 (approximately EL11 NAVD 88) based on the September 1984 Effective/November 1992 Revised FIRM
- Zone AE 13 NAVD 88 based on the August 2008 FIRM (FEMA, 2008) effective FIRM prior to Hurricane Ian's landfall
- Zone AE 11 NAVD 88 based on the November 2022 FIRM, which is currently in effect

Figure 3-86 provides a map illustrating the library's location and the effective FIRM prior to Hurricane Ian.

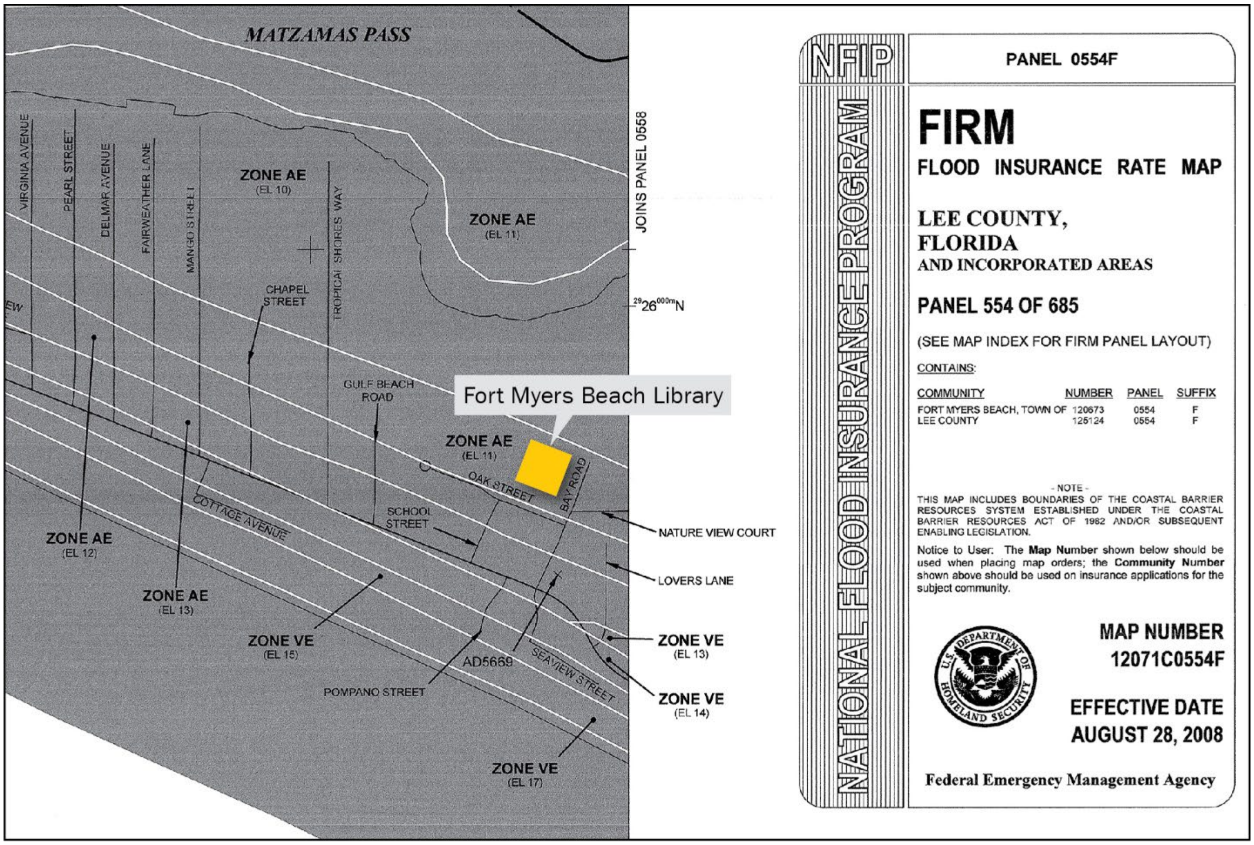
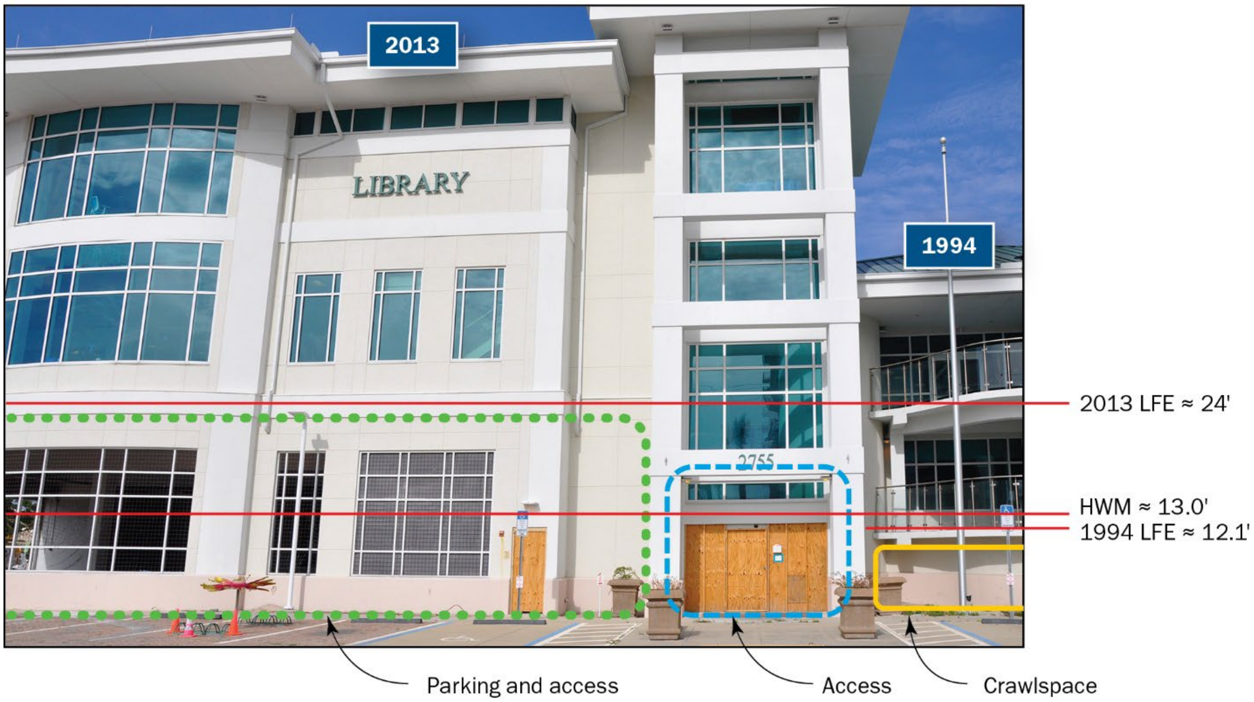


Figure 3-86: FIRM for the Fort Myers Beach Library (Lee County, Zone AE)

In 1994, a new two-story elevated addition (an approximately 15,300-square-foot building) was constructed over part of the original structure. The main entrance into the new library was located at the top of the exterior stairway, which is the lowest floor (12.15 feet NAVD 88). Interior HWMs approximately 12 inches above the lowest floor (approximately 13 feet NAVD 88) were observed during the MAT site visit.

In 2013, an elevated addition with approximately 18,900 square feet was constructed adjacent to the 1994 structure. The lowest floor of the 2013 portion is at 24.15 feet NAVD 88. The main entry of the 1994 structure was altered to connect the 1994 portion of the library to the 2013 addition. The existing entry door was removed and re-located from the lowest floor elevation of 12.15 feet NAVD 88 to grade level at approximately 5 feet NAVD 88. The alteration created additional interior space that serves as an atrium between the 1994 and 2013 buildings. This atrium area was damaged by floodwater, and the MAT was unable to determine what flood damage prevention measures were incorporated into the new atrium (likely intended to be wet floodproofed). Figure 3-87 illustrates the 1994 and 2013 portions of the Fort Myers Beach Library.



The access is to interior space that serves as an atrium between the 1994 and 2013 buildings.

Figure 3-87: Fort Myers Beach Library (Lee County, Zone AE)

During Hurricane Ian, water entered the 1994 building and reached approximately 8 feet in the atrium and 1 foot above the lowest floor (12.15 feet NAVD 88). Based on library building plans, site survey elevations, and HWMs in the general vicinity of the library, the MAT estimated the following:

- Grade adjacent to the atrium is approximately 5 feet NAVD 88
- Lowest floor of the 1994 building is 12.15 feet NAVD 88
- East exterior equipment deck is 14.44 feet NAVD 88
- Hurricane Ian HWMs in this area range from 12.70 to 13.80 feet NAVD 88

Site conditions observed during the MAT did not indicate that all doors and windows below the BFE were protected against flooding. One egress opening in the 1994 portion of the building appeared to have some form of a panel track to facilitate dry floodproofing measures, but there is no indication that a panel was installed, as evidenced by an interior HWM observed during the MAT site visit. Figure 3-88 and Figure 3-89 show a representative HWM and interior damage. It is unclear whether the dry floodproofing measures to the 1994 portion of the library were original and retained or incorporated with the 2013 addition.

Figure 3-88: HWM observed at the Fort Myers Beach Library lowest floor of the 1994 building (Lee County, Zone AE)

The multiple feet of drywall removal and the wood sheathing in the background are representative of interior flood damage at the lowest floor and enclosure below the lowest floor.

Figure 3-89: Representative interior flood damage within the 1994 portion of the Library (Lee County, Zone AE)

3.10.4. JERRY'S FOOD CENTER IN SANIBEL ISLAND

Jerry's Food Center

Date of Construction: 1983

Conformance Category: Legal non-conforming

Effective BFE:* 9 feet, NAVD 88 [Date: August 27, 2008, Panel #: 12071C0533F]

*During Hurricane Ian

Jerry's Food Center, a community shopping center built in 1983, was in Zone A 10 (EL 12) NGVD 29 or 9 NAVD 88 based on the 1979 FIRM and in Zone AE 9 NAVD 88 based on the August 2008 FIRM (FEMA, 2008). The main building is elevated on columns, allowing an area underneath for parking (Figure 3-90).

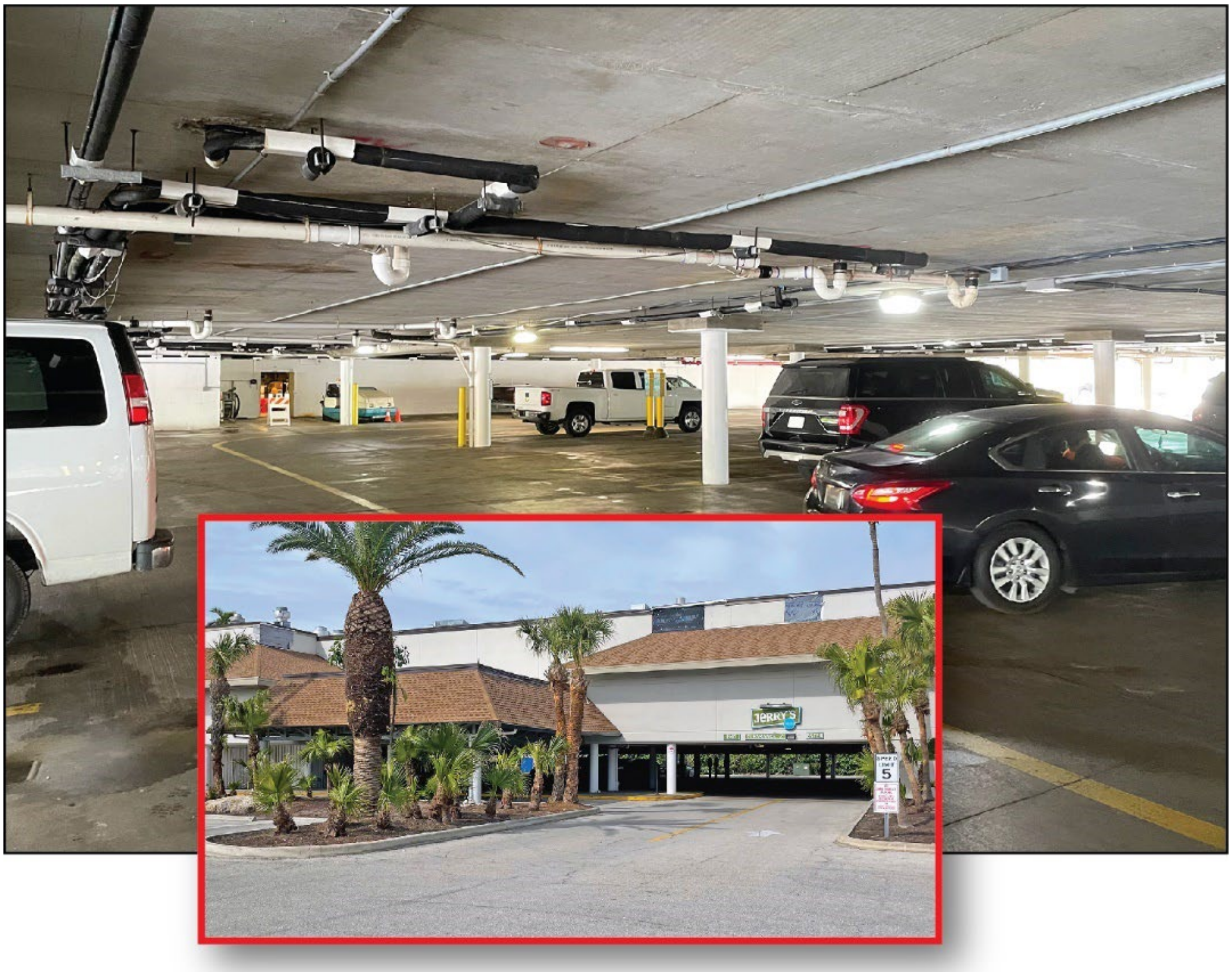


Figure 3-90: Jerry's Food Center underground parking on Sanibel Island (Lee County, Zone AE)

USGS HWMs measured in this area ranged from 10.10 to 11.00 feet NAVD 88 (Figure 3-91).

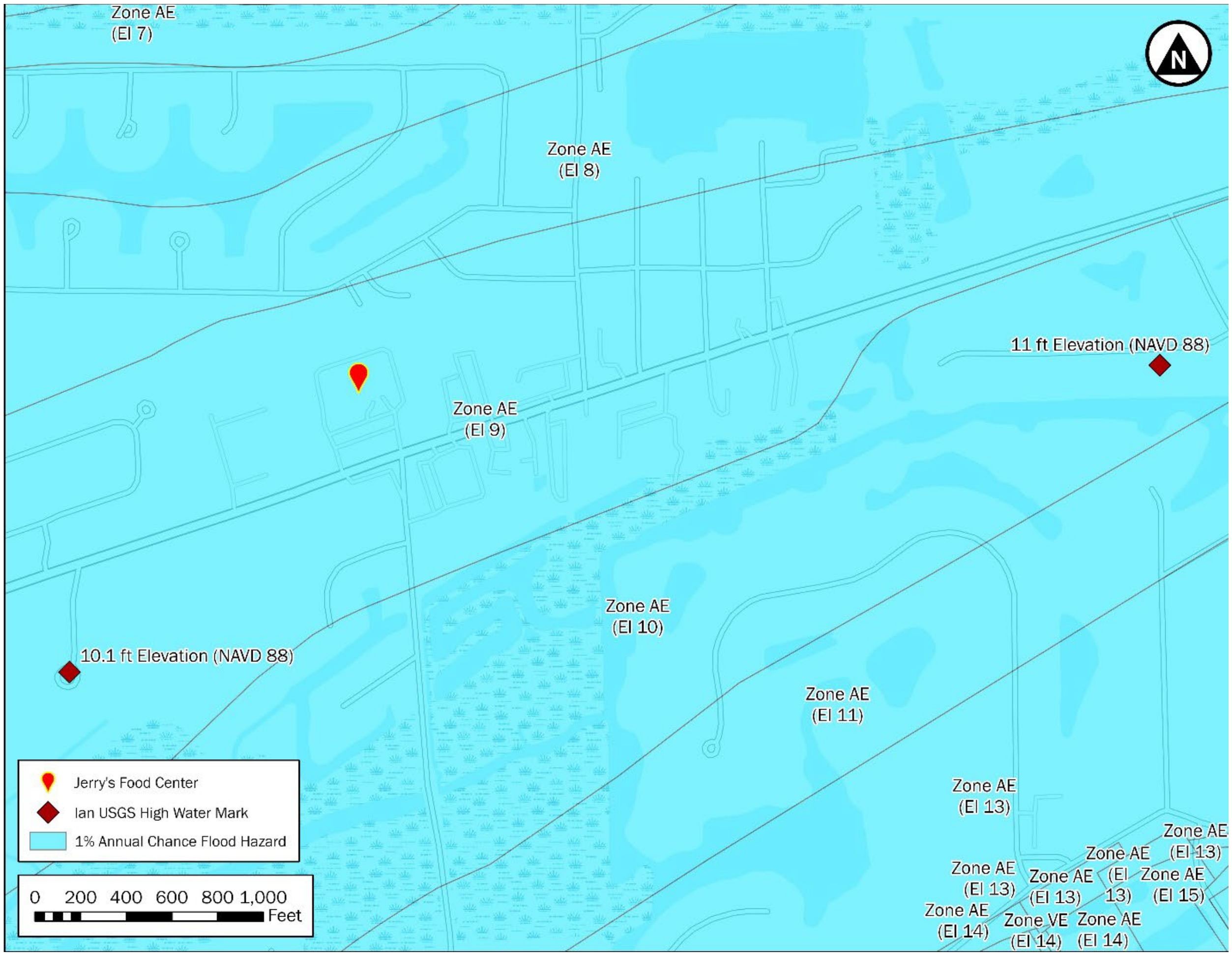


Figure 3-91: A red pin designates the location of Jerry's Food Center along with nearby diamond shaped USGS HWMs (Lee County, Zone AE)

The backup generator, along with the building, were elevated approximately 7 feet above grade. Floodwater inundated this site with approximately 5 to 6 feet of storm surge above grade. The elevated interior portion of the store did not experience any flood inundation damage, and the elevated generator continued to operate until the fuel was depleted (the tank's capacity was approximately 2,200 gallons). There were no indications or reports of structural damage from flood and/or wind loads during Hurricane Ian. Although wind damage to the building envelope enabled wind-driven rain to enter the building, requiring repairs to interior finishing and the replacement of content/equipment, the store reopened approximately 3 weeks after Hurricane Ian made landfall. Based on a field interview, the generator ran for several days, but once the fuel was depleted, it took days for fuel to be resupplied and most of the store's refrigerated inventory was lost. At-grade MEP equipment rooms adjacent to the open parking area were constructed of poured concrete walls equipped with watertight doors. These enclosures and doors performed as designed and prevented floodwater from entering the electrical equipment rooms. The elevator and exterior conveyor belt underneath the lowest floor were not enclosed and were inundated by floodwater. At the time the MAT visited the site, the damage had not been repaired. Other enclosures at grade used primarily as storage rooms were not designed with watertight doors and flooded. The mechanical and electrical rooms had minimal damage; however, none of these were formally certified to be dry floodproofed. The other enclosures did not appear to be deliberately wet floodproofed either. Figure 3-92 and Figure 3-93 provide representative pictures of these spaces. Jerry's Food Center had a reopening ceremony on Friday October 28, 2022.

Figure 3-92: Vaulted doors prevented floodwater from entering the equipment rooms (Lee County, Zone AE)

Figure 3-93: Ground level storage room was not floodproofed and sustained flood damage (Lee County, Zone AE)

3.10.5. LUMINARY HOTEL IN FORT MYERS

Luminary Hotel

Date of Construction: 2020

Conformance Category: New construction

Effective BFE:* 7 feet NAVD 88 [Date: August 27, 2008, Panel #: 12071C0288G]

*During Hurricane Ian

The Luminary Hotel in downtown Fort Myers along the Caloosahatchee River was built in 2020. Based on the August 2008 FIRM, the effective FIRM prior to Hurricane Ian's landfall, the hotel was located in Zone AE 7 NAVD 88. Based on the November 2022 FIRM, which is currently in effect, the hotel is now in Zone VE 11/AE 10 NAVD 88. Figure 3-94 illustrates the hotel's downtown location and the effective FIRM zones around it prior to Hurricane Ian's landfall.

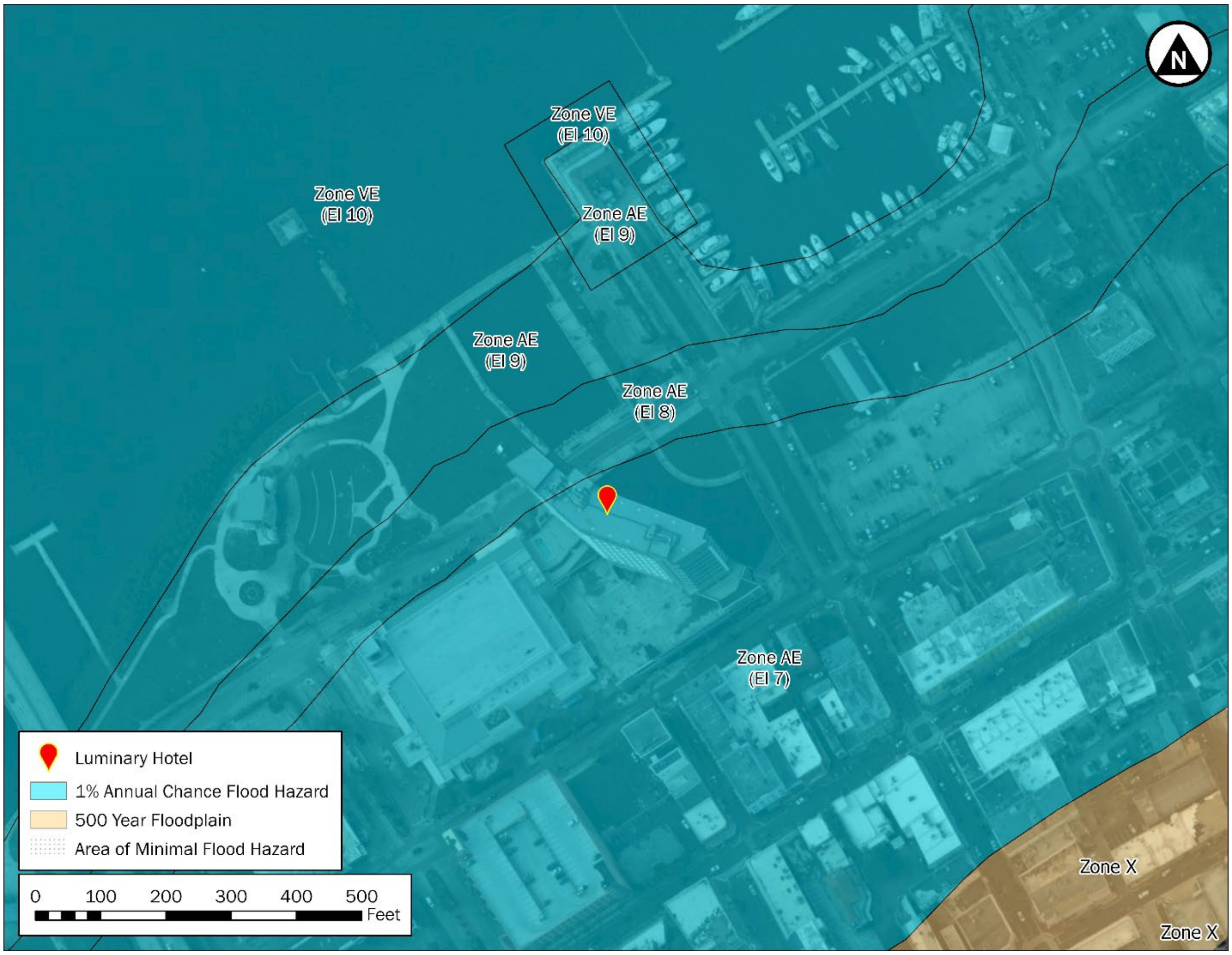


Figure 3-94: Aerial of the Luminary Hotel with August 2008 FIRM flood zones effective at the time of its construction (Lee County, Zone AE)

Based on the DFE at the time of construction, the 12-story hotel (Figure 3-95) was estimated to be elevated to at least 8 feet NAVD 88; HWMs collected by the USGS following Hurricane Ian in downtown Fort Myers near the hotel were 7.6 feet NAVD 88.

Figure 3-95: Luminary Hotel in downtown Fort Myers along the Caloosahatchee River (Lee County, Zone AE)

Within hours of sustaining 100+ mph winds and storm surge from Hurricane Ian, the Luminary Hotel was functioning on its emergency generator. The building experienced minor wind building envelope damage, and no floodwater entered the lowest floor of the building. In fact, the hotel served as one of the primary facilities to house first responders and emergency response personnel for weeks immediately following the hurricane.

3.10.6. CHAPEL BY THE SEA PRESBYTERIAN CHURCH IN FORT MYERS BEACH

Chapel by the Sea Presbyterian Church

Date of Construction: 1984/1985

Conformance Category: Existing building

Effective BFE:* 12/13 feet, NAVD 88 [Date: August 27, 2008, Panel #: 12071C0554F]

*During Hurricane Ian

During the MAT field work, the team visited the Chapel by the Sea Presbyterian Church in Fort Myers Beach. The existing church was built in 1984/1985. The first available FIRM for Fort Myers Beach became effective in September 1984. Based on the build date of the church and the date of the first effective FIRM, the church was not likely required to be built in accordance with the FIRM. See Table 3-8 for an overview of flood zone and BFE information for various years at this site. As shown in Table 3-8, the structure is currently included in the newly delineated Coastal A Zone. The FBC and ASCE 24 require structures in Coastal A Zones to be built in accordance with most Zone V standards. See Section 2.2.2 for more information on flood provisions in the FBC.

Table 3-8: Flood Zone and BFE Information for Various Years for the Chapel by the Sea Presbyterian Church Site

Year of FIRM	Significance of Year of FIRM	Flood Zone	BFE (feet, NAVD 88)
1984	First effective FIRM for the site; likely not in effect or required for design and permitting of the structure	AE	10.8(a)
2008	Effective FIRM during Hurricane Ian	AE	12.13
2022	Current effective FIRM	AE/Coastal A Zone	11

(a) BFE on FIRM is 12 feet NGVD 29 and was converted to an NAVD 88 elevation for consistency.
BFE = base flood elevation, FIRM = Flood Insurance Rate Map

A recorded USGS HWM approximately 1,440 feet (480 yards) from the Chapel by the Sea Presbyterian Church is at an elevation of 12.7 feet NAVD 88. Figure 3-96 shows the building and USGS HWM location. Church members marked an exterior water line on the church as shown in Figure 3-97. Based on the mark's alignment with the door handle, the HWM is approximately 3 feet above the floor at this location.

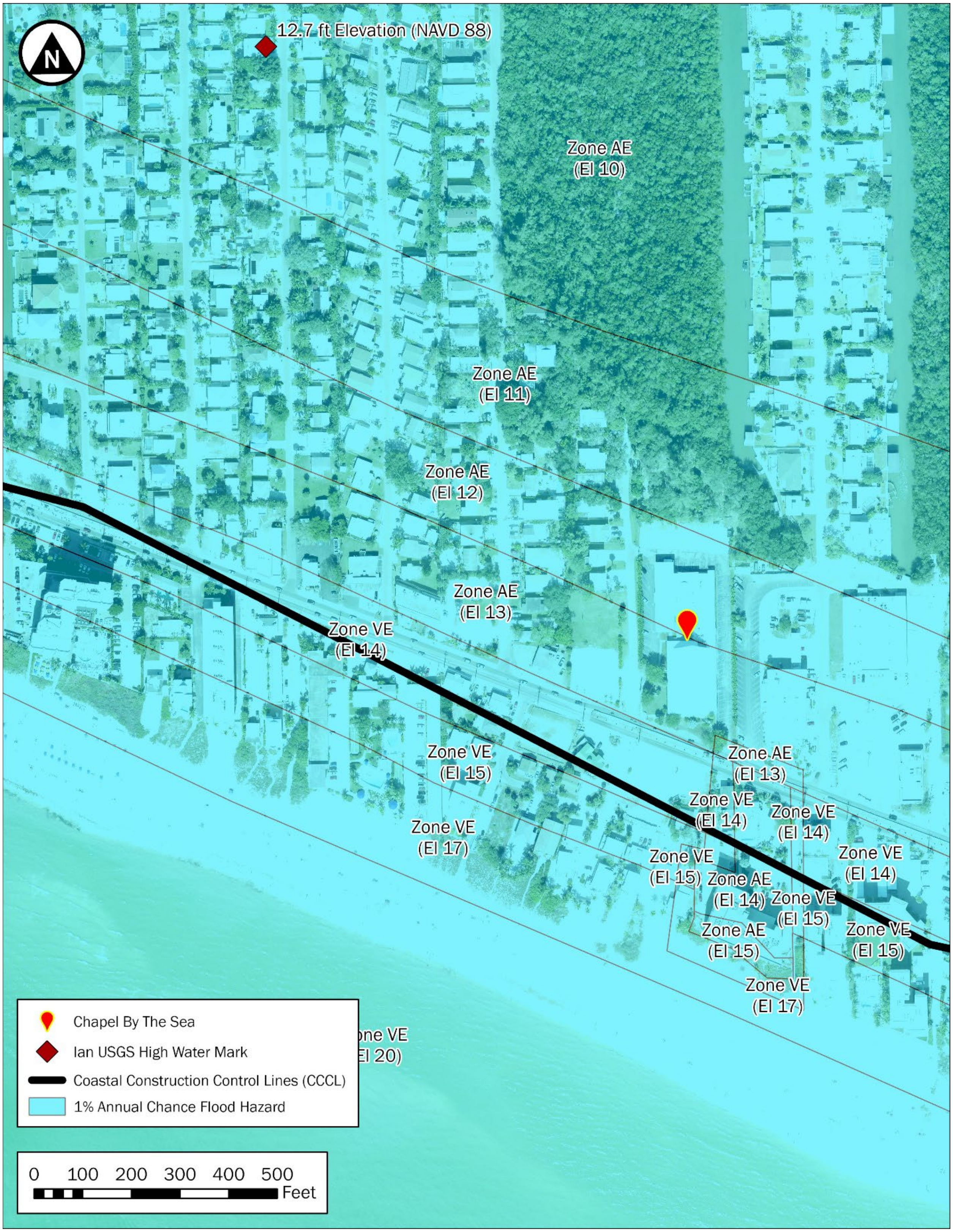


Figure 3-96: Map of Chapel by the Sea and a nearby USGS HWM

Right image depicts extensive damage to Chapel by the Sea caused by Hurricane Ian flood conditions and the location of an exterior water line marked by church members. Left image shows the exterior waterline mark.

Figure 3-97: Exterior water line marked (yellow arrow) at Chapel by the Sea

An inspection of the Chapel by the Sea's foundation in 2010 noted that structural support elements had deteriorated due to salt air and saltwater exposure. After the inspection, the foundation was structurally repaired and included the addition of waterproof paint. The foundation was re-inspected 1 month before Hurricane Ian, and the repairs were deemed successful and structurally sound. During Hurricane Ian, floodwater moved through and around the building, causing extensive damage and depositing widespread piles of debris around the church. Figure 3-98 shows the extent of debris in the area. The building also experienced wind damage, which led to additional water intrusion.

Source: NSF StEER (top and bottom right)

The left image provides an aerial overview of the area surrounding Chapel by the Sea. The top right image depicts various debris, including part of a house that was displaced during Hurricane Ian. The bottom right image shows a view from the west side of Chapel by the Sea. NOAA's aerial imagery shown here was collected 1 to 5 days after Hurricane Ian made landfall, and the StEER 360 imagery was collected 2 weeks after Hurricane Ian's landfall.

Figure 3-98: Overview of debris around Chapel by the Sea

The structure was deemed structurally safe to enter following Hurricane Ian, but because of the extent of damage, no portions of the building were in stable condition. The MAT visited the site in January 2023, 114 days after Hurricane Ian made landfall in Fort Myers Beach. Damage to the building and contents included loss of new audio-video equipment; widespread façade and interior finishes damage; toppling of kitchen equipment such as large industrial refrigerators; and the widespread loss of contents, such as three grand pianos that were swept away in the floodwater. Extensive mold growth was observed during the visit. Figure 3-99 depicts examples of exterior and interior damage at Chapel by the Sea.

Figure 3-99: Examples of observed damage at Chapel by the Sea

Chapel by the Sea experienced extreme damage to the floors of the sanctuary as shown in Figure 3-100. The flooring system in the sanctuary was constructed from precast concrete panels that spanned structural supports and were held in place by gravity. Based on the post-Hurricane Ian damage observations, some of the panels were subject to uplift forces during flooding and were broken as a result of their displacement. Similar damage to precast concrete floor panels was observed at a mid-rise condominium building on Fort Myers Beach.

The NFIP regulations are decades old and do not define, nor recognize Coastal A Zones. Numerous FEMA MATs over the decades have consistently documented the extensive surge damage that can occur to structures in Coastal A Zones, similar to Zone V surge damage. This structure was built long before Coastal A Zones even existed in ASCE 24 and the building codes. The damage to Chapel by the Sea is yet another example of the importance of designing structures in a Coastal A Zone to Zone V standards.

Figure 3-100: Damaged precast concrete floor panels at Chapel by the Sea

3.10.7. BIOMAT USA PLASMA CENTER IN KISSIMMEE

Commercial/Storefront Building

Date of Construction: 1959

Conformance Category: Existing building

Effective BFE:* 65 feet, NAVD 88 [Date: June 18, 2013, Panel #: 12097C0067G]

*During Hurricane Ian

During field work in October 2022, the pre-MAT visited a 90,000-square-foot shopping center built in 1959. The property includes a variety of businesses that serve the neighboring community and is approximately 15 miles south of downtown Orlando, located within Kissimmee in an Zone AE with a BFE of 65 (Figure 3-101). The shopping center included Biomat USA Plasma Center, a 16,000-square-foot facility for plasma donations. Based on interviews with employees, an estimated 12 to 16 inches of floodwater from high-intensity rainfall entered the building interior during Hurricane Ian. An exterior HWM of 42 inches was identified along the property closest to the drainage canal (Figure 3-102). Patients were forced to coordinate alternative plasma services for 90 days before the plasma center reopened on January 25, 2023.

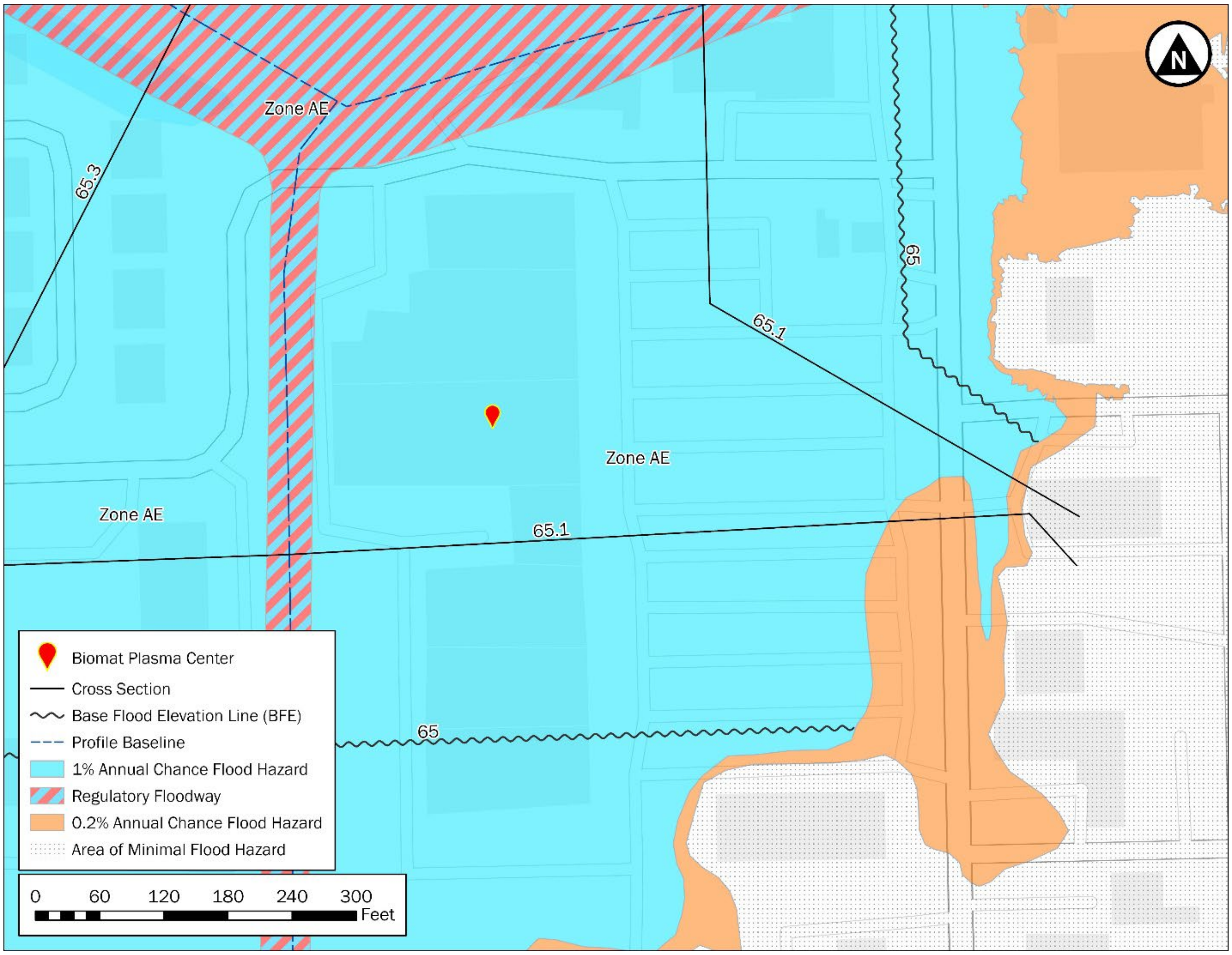


Figure 3-101: Location of Biomat USA Plasma Center and FIRM (Orange County, Zone AE)

Figure 3-102: Rear of shopping center where a 42-inch HWM was identified (Orange County, Zone AE)

3.10.8. PUBLIC RESTROOMS

Public restroom facilities were visited during both the pre-MAT and MAT. The facilities were both *elevated* and *non-elevated buildings* and had varying performance.

- A restroom in Vanderbilt Beach may have been protected from direct wave attack by adjacent mangroves. The 1994 existing building was dry floodproofed, but the closures were not installed prior to Hurricane Ian (Figure 3-103). USGS surveyed HWMs at an elevation of 11.4 feet NAVD 88. The facility lost power, but there was neither internal nor external structural damage.

- Restrooms in Bonita Beach were two 1996 existing non-elevated CMU structures with flood openings (Figure 3-104). At the time of the pre-MAT, the doors to each of the restrooms were damaged or torn off, and there was visible damage to the plumbing fixtures inside each room. The facilities had both been demolished by the time the MAT visited in January 2023.

- A restroom in Sanibel Island at Lighthouse Point Park was gated off and could not be assessed (Figure 3-105). The facility is slab-on-grade, and the external structure of the building appeared to be intact with visible wind damage to the roof.

- The public restrooms on Fort Myers Beach were *elevated buildings* with varied performance. The 1993 facility in Bowditch Point Park (Figure 3-106) comprised several structures connected by a walkway. The facilities did not show any damage to internal or external components. The 1991 facility at Lynn Hall Memorial Park was subject to direct wave attack and suffered damage to the CMU walls of the structure (Figure 3-107). The foundations appeared to be intact.

- A restroom in Daytona Beach Shores was a slab-on-grade structure that was heavily impacted by scour around the foundation, resulting in the destruction of the facility (Figure 3-108 and Figure 3-109).

The flood depth was approximately 5 feet; although the facility was designed to be dry floodproofed, the measures were not implemented.

Figure 3-103: HWMs on the exterior of public restroom in Vanderbilt Beach (Collier County, Zone AE, Seaward of CCCL)

While the buildings were functional, there was both flood damage (doors and finishings) and wind damage (roof); this picture was taken in October, and the facilities were already demolished when the MAT visited in January.

Figure 3-104: Non-elevated restrooms on Bonita Beach at Little Hickory Island Beach Park (Lee County, Zone AE, Seaward of CCCL)

Although the MAT was unable to access it, the building appeared structurally intact from a perimeter assessment of it. Based on adjacent water marks, the building likely had 12 feet or more of flooding; the louvered walls likely contributed to its performance as surge waters likely entered the building relatively freely.

Figure 3-105: Public restroom facility in Sanibel Island at Lighthouse Beach Park (Lee County, Zone VE, Seaward of CCCL)

With the exception of privacy panels and crawlspace damage, the facilities seemed largely intact.

Figure 3-106: Elevated restrooms at the north end of Fort Myers Beach in the Bowditch Point Park (Lee County, Zone VE, Seaward of CCCL)

The building likely had 8 feet or more of flooding over the lowest floor, which contributed to extensive structural damage.

Figure 3-107: Destroyed elevated public restroom facility in Fort Myers Beach at Lynn Hall Memorial Park (Lee County, Zone VE, Seaward of CCCL)

Figure 3-108: Destroyed public restroom in Daytona Beach Shores (Volusia County, Zone VE, Seaward of CCCL)

Figure 3-109: Interior of destroyed public restroom in Daytona Beach Shores (Volusia County, Zone VE, Seaward of CCCL)

3.11. Performance of Manufactured Homes

The MAT visited numerous manufactured home neighborhoods impacted by Hurricane Ian, including ones in North Fort Myers, San Carlos Island, Fort Myers Beach, and Naples. Common flood damage to manufactured homes included damage to interior finishes and contents, foundation and/or skirting damage, and damage to exterior mechanical equipment, including ductwork. Note, most manufactured homes were impacted by both wind and flood damage. Most foundation failures were associated with piers that were dry-stacked. For the most part, reinforced foundations performed well; minor foundation damage was limited to non-structural components such as skirting.

The MAT visited multiple sites where manufactured homes were retrofitted with tie downs under the Florida Hurricane Loss Mitigation Program; generally, the tie down retrofits, predominantly intended for wind damage reduction, were effective. In some extreme cases, manufactured homes were displaced from their foundations. In most cases where this was observed, the manufactured homes were not sufficiently elevated and/or had an insufficient load path and foundation to resist the flood loads (Figure 3-110 and Figure 3-111). The primary differentiator in the flood-resistance performance of manufactured homes was whether the bottom of the steel frame was elevated above the Hurricane Ian flood levels, which in many areas visited, was relatively close to the DFE for Flood Design Class 2 buildings. Some newer manufactured homes for lots in existing manufactured home parks were permitted to be 36 inches in height above grade, likely via a limited exception under the NFIP. These manufactured homes sustained extensive damage compared to those elevated to the DFE.

Figure 3-110: Manufactured home displaced from its foundation by flood loads (Lee County, Zone AE)

Figure 3-111: Manufactured home displaced from its foundation by flood loads (Lee County, Zone AE)

3.11.1. NORTH FORT MYERS – OLD BRIDGE VILLAGE

The Old Bridge Village in North Fort Myers is a 55+ retirement community, started in 1971, along the Caloosahatchee River consisting of approximately 525 manufactured homes. This community started long before the first FIRM became effective. Prior to Hurricane Ian, the 2008 FIRM was in effect for the community, which showed it being located in Zones AE 7 through AE 9 (NAVD 88) with the land immediately adjacent to the river in Zone VE 10. The 2022 FIRM, which became effective after Hurricane Ian, reflects the community now being in Zones AE 9 through AE 11 (NAVD 88), with the flood zones closest to the Caloosahatchee River in Zones VE 11 through VE 13 (NAVD 88), and a portion of the Zone AE in the community is within the LiMWA. Figure 3-112 depicts 2008 FIRM data, along with year-built information for buildings in the vicinity of the Old Bridge Village area based on county parcel data. Figure 3-113 depicts the 2022 FIRM, which indicates a portion of the Zone AE is within the LiMWA (or Coastal A Zone).

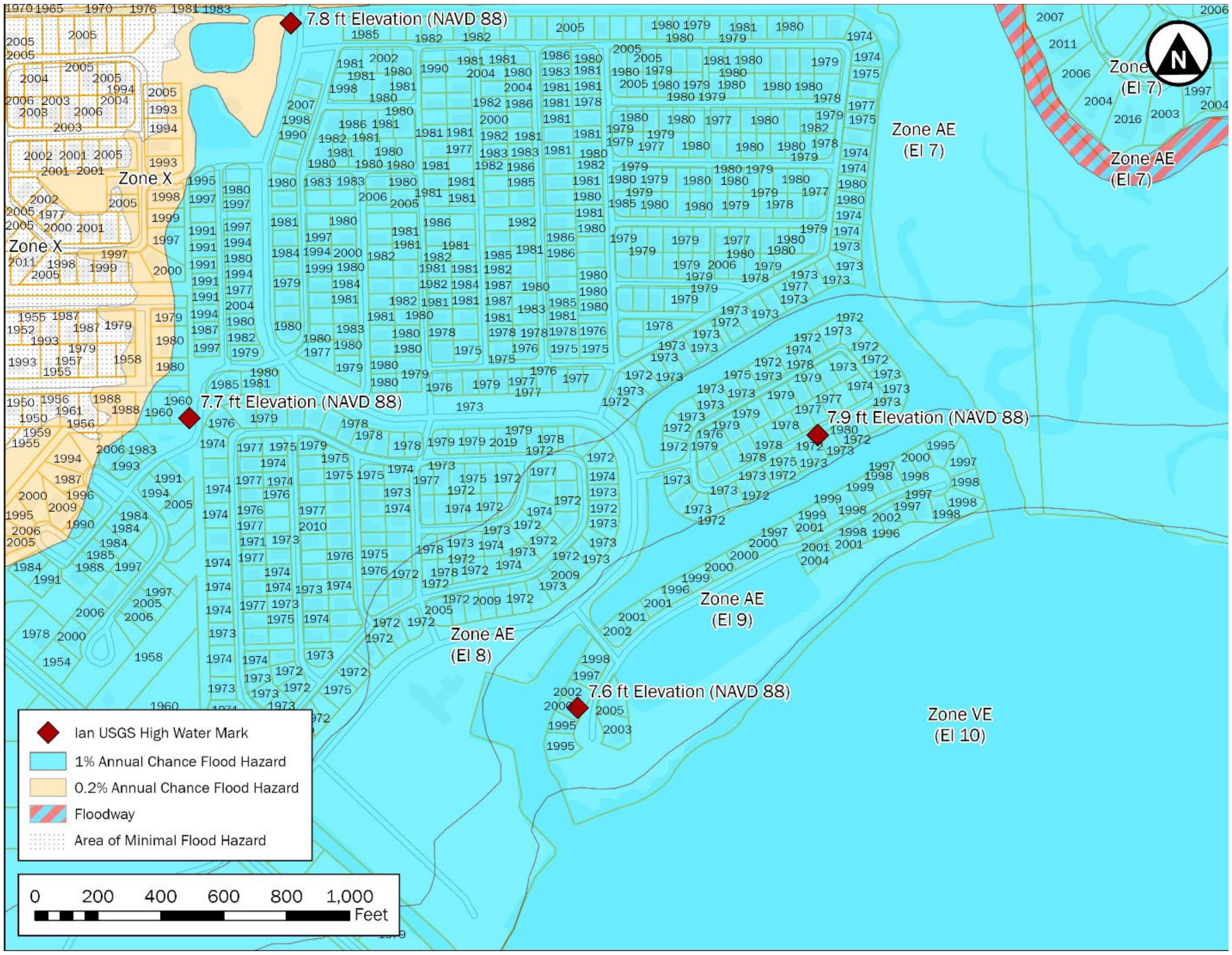


Figure 3-112: The 2008 FIRM in effect for the Old Bridge Village prior to Hurricane Ian (Lee County, Zone AE)

Figure 3-113: The November 2022 effective FIRM for the Old Bridge Village includes a LiMWA (Lee County, Zone AE & VE)

Following Hurricane Ian, the USGS recorded an HWM of 7.8 feet NAVD88 (approximately 2.7 feet above grade) via a seed line inside a guard shack at Old Bridge Village at the end of New Post Road. Three additional HWMs were collected by the USGS across the community, ranging from 7.7 to 8.2 feet NAVD 88 (approximately 1 to 4 feet above grade). The 1994 effective FIRM depicts Old Bridge

Village in Zone AE with a BFE of 8 NGVD 29 (approximately 7 NAVD 88). As a result, several of the newest manufactured homes (mid-1990s through mid-2000s, so pre-2008 FIRM) were installed at about 6 to 12 inches below the Hurricane Ian HWM. The MAT visited a manufactured home installed in 2000 that had approximately 4 inches of floodwater above the lowest floor during Hurricane Ian, and its unreinforced pier (dry-stacked block) wedges were displaced by the flooding. Other common damage observed throughout the community included flood damage to exterior accessory structures, interior finishings, exterior mechanical equipment (predominantly unelevated), ductwork below the lowest floor, and vinyl and brick skirting. A limited number of manufactured homes were observed with minimal flood damage; they were typically elevated higher, on reinforced piers, and had tie-downs. Homeowners interviewed along the road closest to the river where the most extreme damage was observed estimated their flood damage at approximately $100,000. Figure 3-114 through Figure 3-118 show representative examples of manufactured homes in Old Bridge Village.

Figure 3-114: Typical manufactured home damage observed in Old Bridge Village (Lee County, Zone AE)

Figure 3-115: Common manufactured home interior finishing damage observed in Old Bridge Village (Lee County, Zone AE)

Figure 3-116: Manufactured home unreinforced pier (dry-stacked block) wedges displaced (red circle) during Hurricane Ian flooding (Lee County, Zone AE)

Figure 3-117: Damaged tie downs, unreinforced masonry piers, and skirting below a manufactured home in Old Bridge Village (Lee County, Zone AE)

Figure 3-118: 2019 Elevated manufactured home in the Old Bridge Village with no foundation damage and primary flood damage limited to crawlspace and storage unit (Lee County, Zone AE)

NFIP claims were analyzed for approximately 40 manufactured homes in the vicinity of Adam Drive within Old Bridge Village. This area represents the newest development within the community, with manufactured homes installed in the mid-1990s through mid-2000s as well as properties that are closest to the Caloosahatchee River (Figure 3-119). Most manufactured homes were a single unit and elevated between 1 and 3 feet above the ground. Figure 3-120 through Figure 3-122 show representative manufactured homes along Adam Drive. All three of these manufactured homes had flood damage; as expected, the manufactured home elevated 3 feet above ground had the least/minimal interior flood damage. The manufactured homes along Adam Drive elevated 1 to 2 feet above ground were inundated with extensive interior damage. All manufactured homes along Adam Drive had damage below the lowest floor. Almost half (18) of the properties had an active flood insurance policy during Hurricane Ian. The average total NFIP claim is $112,832, with approximately $90,000 of that payment for building damage and the remainder for contents. Two of the 18 policies did not have contents coverage and both the building and contents claim for five of the 18 reached the maximum coverage for the policy. Table 3-9 provides a summary of the NFIP building and contents claims for 18 of the manufactured homes along Adam Drive. The average claims are consistent with estimates provided by homeowners during field observations in January 2023.

Figure 3-119: Map of the Adam Drive area (Lee County, Zone AE & VE)

Table 3-9: Summary of Hurricane Ian NFIP Building and Contents Claims for Manufactured Homes along Adam Drive

Coverage Type	Quantity	Average Claim	Average Coverage	Quantity of Claims Reaching Maximum Coverage
Building	18	$89,483	$120,806	5
Contents	16	$26,268	$46,031	5
Total (Building & Contents Combined)	**$112,832**		**$161,722**	**3**

Figure 3-120: Representative manufactured home along Adam Drive that performed well, elevated approximately 3 feet above ground (Lee County, Zone AE)

Figure 3-121: Representative manufactured home along Adam Drive that had interior flood damage, elevated approximately 1 foot above ground (Lee County, Zone AE)

Figure 3-122: Representative manufactured home along Adam Drive that had interior flood damage, elevated approximately 2 feet above ground (Lee County, Zone AE)

3.11.2. SAN CARLOS ISLAND – PORT CARLOS COVE

Port Carlos Cove on San Carlos Island in Fort Myers Beach is a 55+ retirement community along Hurricane Bay consisting of 155 manufactured homes ranging in age of construction from 1966 to the present.

The effective FIRM prior to Hurricane Ian showed the community located in Zone AE 9 with the land immediately adjacent to the bay in Zone VE 12. The new 2022 FIRM reflects that the community is entirely in Zone VE 12. Figure 3-123 and Figure 3-124 show the effective FIRMs for Port Carlos Cove prior to and after Hurricane Ian.

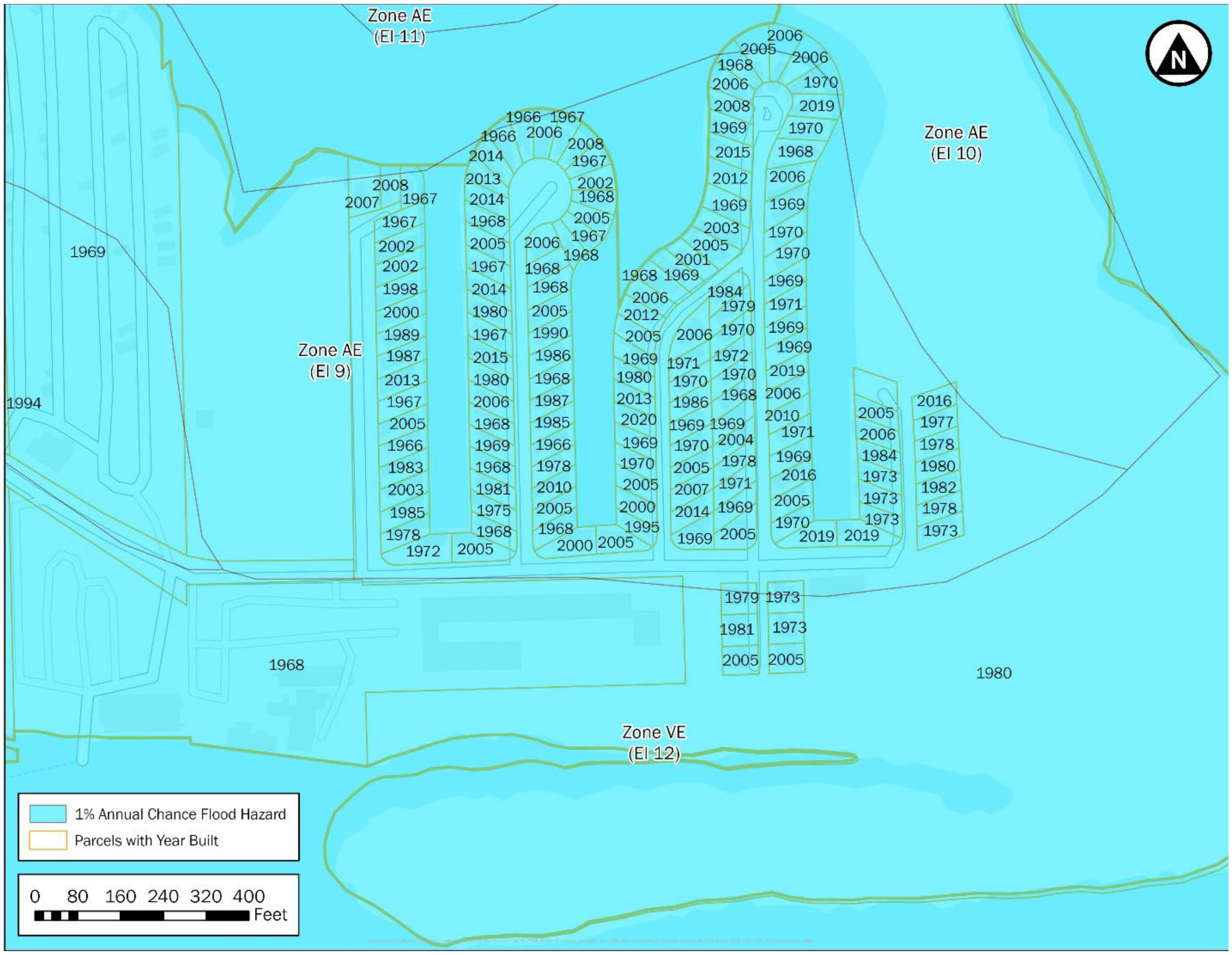


Figure 3-123: FIRM data from 2008 for Port Carlos Cove (Lee County, Zone VE & AE)

Figure 3-124: New 2022 FIRM for Port Carlos Cove that went into effect after Hurricane Ian (Lee County, Zone VE)

During Hurricane Ian, most manufactured homes in Port Carlos Cove were heavily inundated with multiple feet of water as HWMs indicated floodwater exceeded the San Carlos Island seawall cap by more than 10 feet. Most of the manufactured homes in this area were installed prior to the 2008 FIRM, which was effective prior to Hurricane Ian; several manufactured homes were installed prior to any floodplain management requirements existing in the area. Although there is a mixture of lowest floor elevations throughout the cove, HWMs in this area were estimated at 12.8 feet NAVD 88. Flooding caused extensive damage throughout the community as flood depths exceeded the elevation requirements (old and new construction were damaged throughout). Common damage types included extensive flood damage to interior finishings as floodwater was above the lowest floor in every unit, displacement of houses from foundations, foundation damage, and exterior mechanical equipment damage, including ductwork. Displaced manufactured homes were predominantly in the southern portion of the community (closest to Spanish Main Street), which likely experienced the greatest velocity and wave action during Hurricane Ian. Several of the manufactured homes in the area were being demolished and replaced at the time the MAT visited; however, some homeowners reset their manufactured homes on a foundation and were restoring their homes. In some cases, manufactured homes were occupied and power was restored within 90 days. Figure 3-125 through Figure 3-128 illustrate representative elevation and damage across manufactured homes in Port Carlos Cove.

Figure 3-125: HWM near ceiling in Port Carlos Cove manufactured home (Lee County, Zone VE)

Figure 3-126: Representative interior damage in the office building for Port Carlos Cove (Lee County, Zone VE)

This manufactured home was in the area that likely experienced the greatest flood velocity based on field observations and analysis of aerial imagery. The flood loads destroyed the pier foundation and the manufactured home was displaced from its foundation.

Figure 3-127: Prior to Hurricane Ian, this manufactured home was elevated on unreinforced hollow-core masonry block piers approximately 4 feet above grade (Lee County, Zone VE)

Although newer manufactured homes were typically elevated at least 2 to 3 feet above older adjacent ones, every manufactured home in this area was inundated because of the surge heights.

Figure 3-128: Lowest floor elevation differences, measured in multiple feet, were common in newer manufactured homes on Port Carlos Cove (Lee County, Zone AE)

3.11.3. FORT MYERS BEACH – GULF VIEW COLONY

Gulf View Colony, an all-ages manufactured home community, and the Red Coconut Recreational Vehicle Park are adjacent parcels along Estero Boulevard in Fort Myers Beach. The RV park is immediately adjacent to the beach and extends across both sides of Estero Boulevard, while the manufactured home community is on the north side of Estero Boulevard with pedestrian beach access. The properties are located in Zone VE (13-17) and AE (11-13). Figure 3-129 shows the 2008 FIRM of the area.

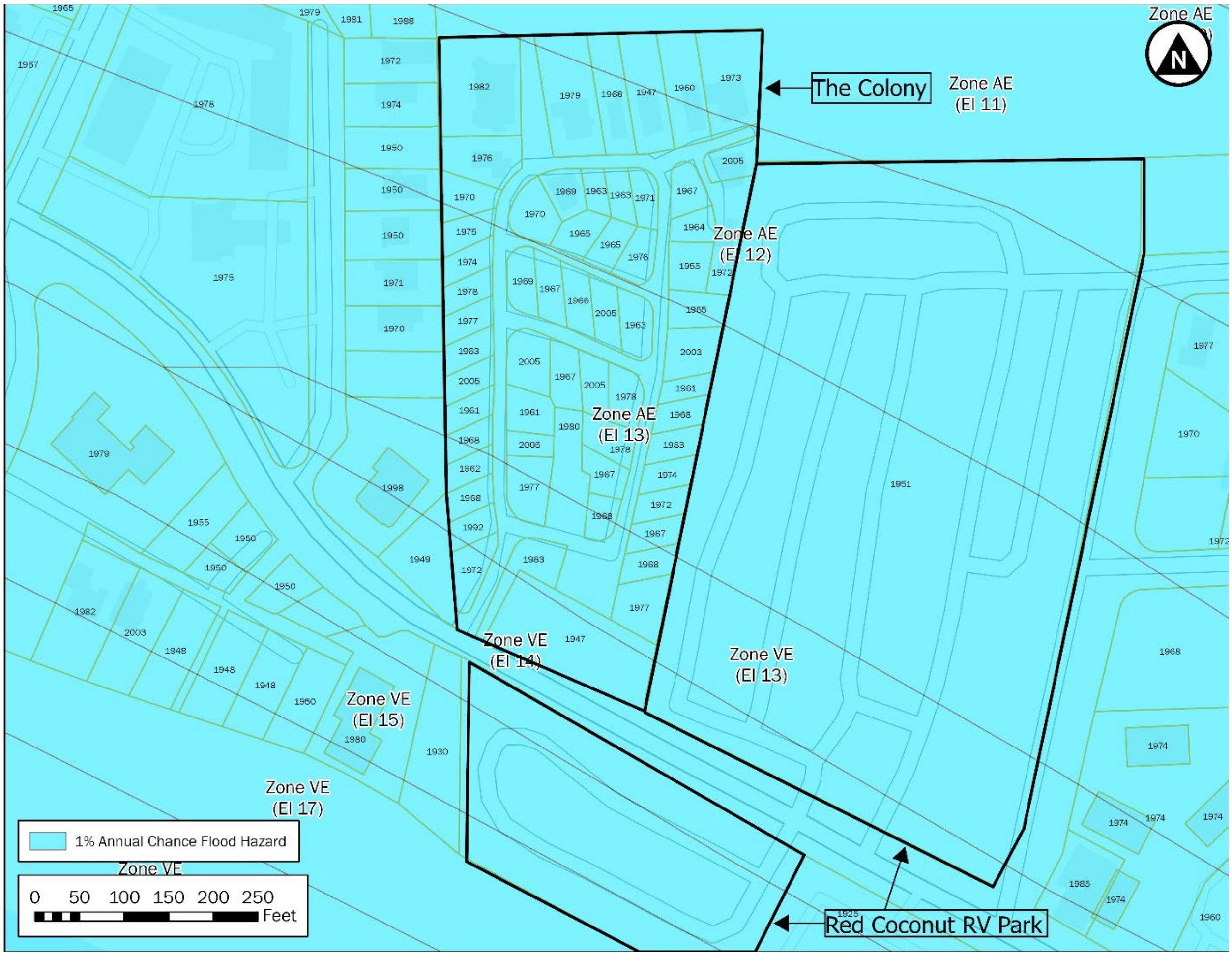


Figure 3-129: FIRM data from 2008 for Gulf View Colony and the Red Coconut Recreational Vehicle Park (Lee County, Zone VE & AE)

Of approximately 50 manufactured homes in the Gulf View Colony, the first was built in 1947 based on Lee County parcel data, and the latest house was constructed in 2005. Similarly, the RV park was established in 1951. Both the manufactured home community and the RV park were destroyed during the hurricane as evident in the before and after Hurricane Ian imagery (Figure 3-130 and Figure 3-131). This area experienced some of the most destructive Hurricane Ian damage to manufactured homes observed by the MAT.

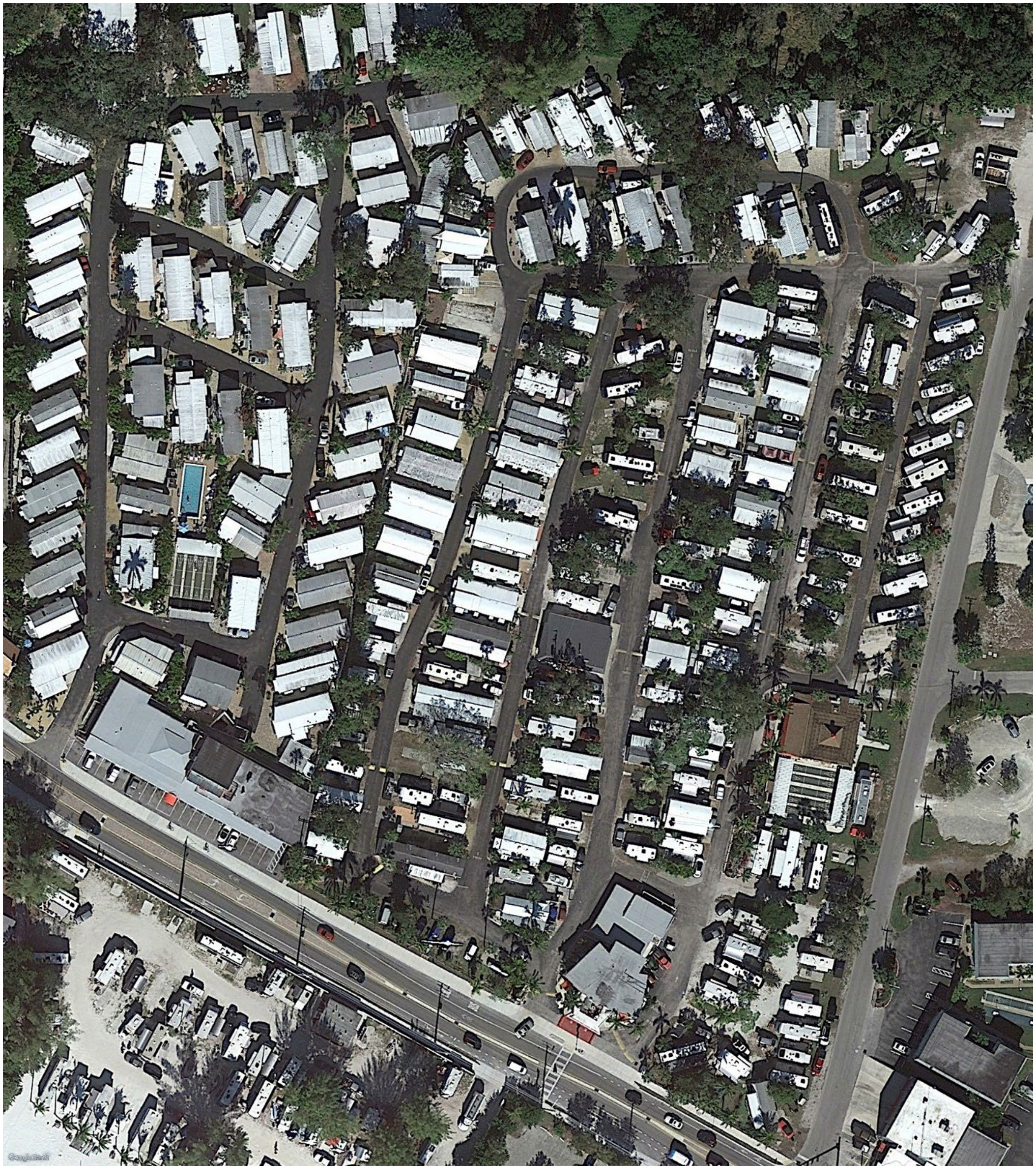
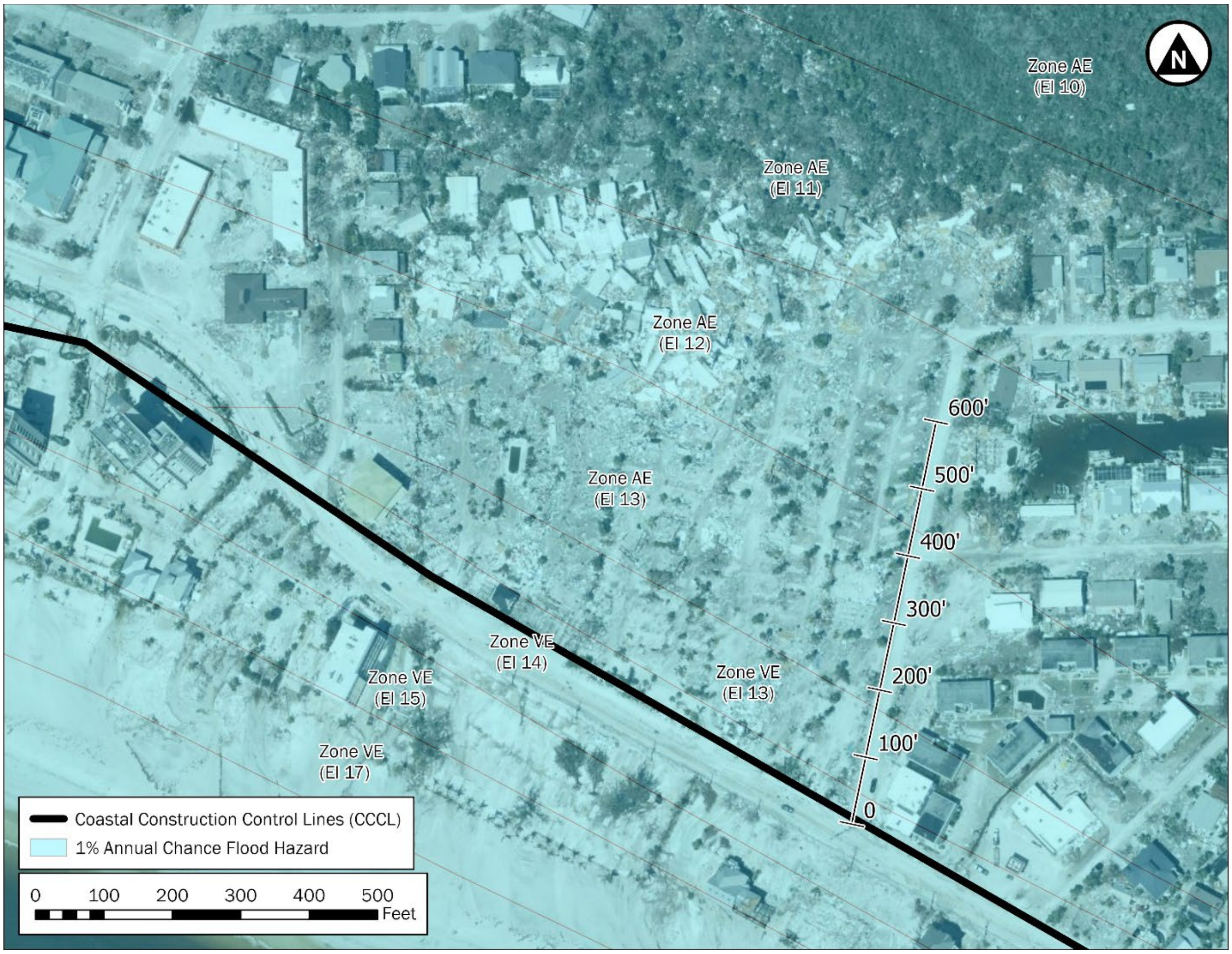


Figure 3-130: Before Hurricane Ian imagery of the Gulf View Colony and the Red Coconut Recreational Vehicle Park (Lee County, Zone VE & AE)



The manufactured homes were displaced between 100 and 1,000 feet landward.

Figure 3-131: Post-Hurricane Ian imagery of Gulf View Colony and the Red Coconut Recreational Vehicle Park (Lee County, Zone VE & AE)

3.11.4. NAPLES – LAND YACHT HARBOR

The Naples Land Yacht Harbor is a senior adult waterfront community with approximately 350 manufactured homes. Homes were built in the community starting in 1963, and the current age of construction varies from less than 1 year to 50 years. The community is in Zone AE 7 and 8 NAVD 88 based on the effective 2012 FIRM as shown in Figure 3-132. The entire community is within the SFHA, and it has a number of canals that lead to Naples Bay. There were no readily available surveyed HWMs near this community to compare Hurricane Ian inundation levels with the 2012 BFE. Over the past 50 years, as new manufactured homes were installed, or older ones replaced, the local floodplain management ordinance required new or replacement manufactured homes be elevated above the BFE. Although the MAT was unable to identify the requirements in a specific ordinance, the newer homes were clearly 3 feet or more higher than the original/older adjacent manufactured homes. Newer elevated manufactured homes were evident when driving through the community (Figure 3-133).

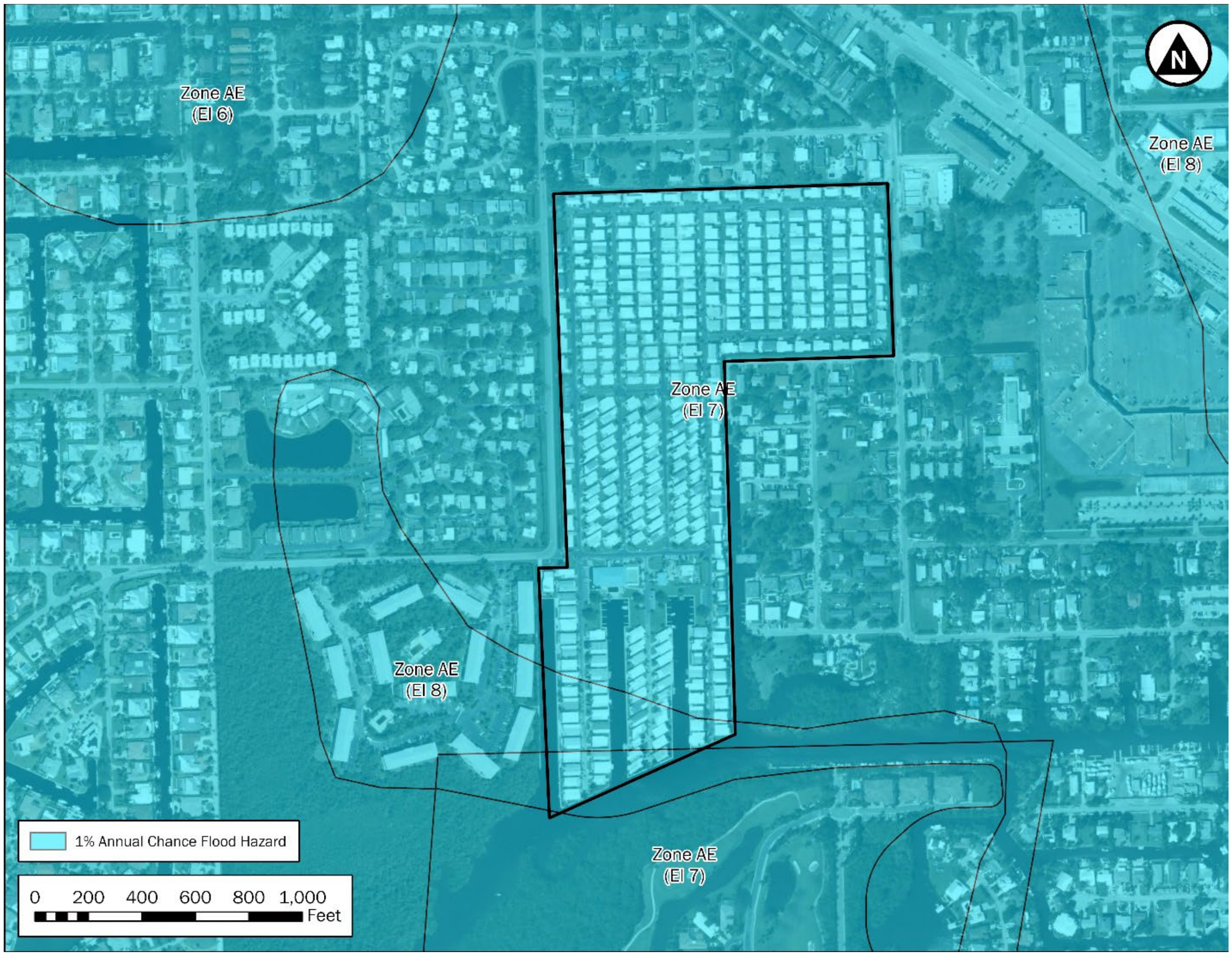
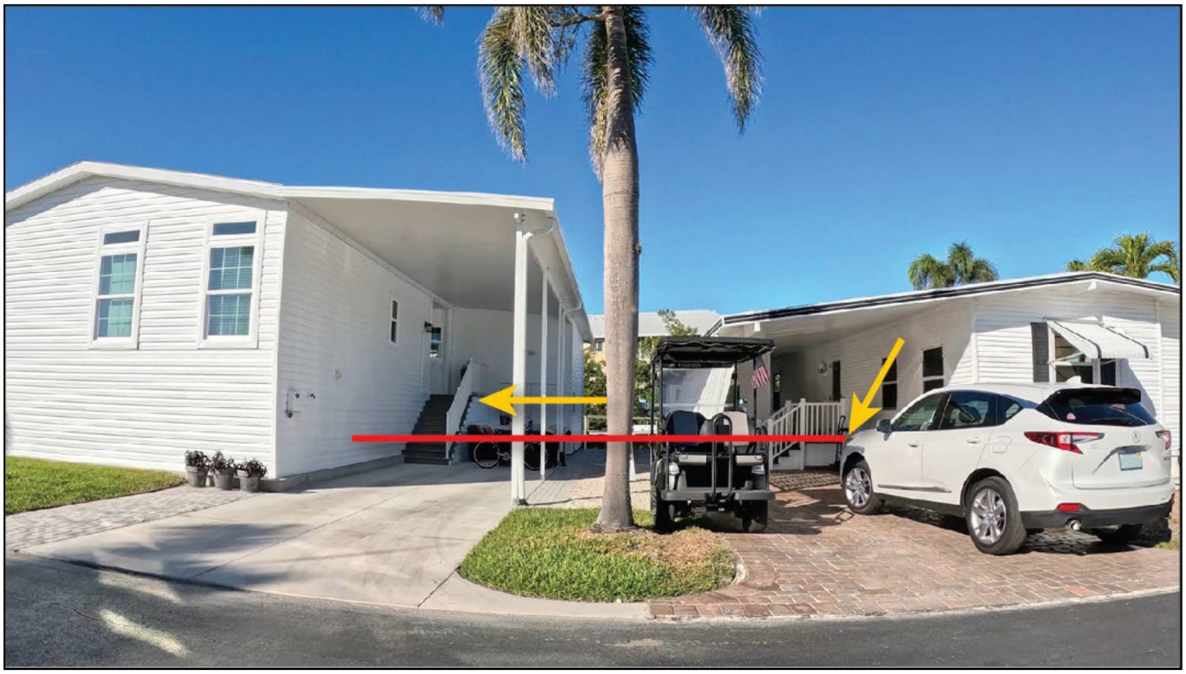


Figure 3-132: 2012 FIRM for the Naples Land Yacht Harbor Community in Naples, FL (Collier County, Zone AE)

When the MAT visited the community following Hurricane Ian, owners of older manufactured homes (those built prior to the 2012 FIRM or before any floodplain management requirements existed in the area) reported 1 to 2 feet of flooding on the lowest floor. In newer manufactured homes, owners reported damage to ductwork and insulation below the lowest floor. And in the newest manufactured homes, owners reported limited to no damage as their units were elevated above the flooding (damage was limited to contents in at-grade storage units adjacent to carports). Figure 3-133 through Figure 3-138 show representative examples of manufactured homes in the Naples Land Yacht Harbor community.



The manufactured home on the left is representative of one of the newest in the community and had no flood damage. The manufactured home on the right had crawlspace/ductwork damage along with some interior damage. The arrows reflect lowest floor and the red line is the approximate flood depth. The lowest floor elevation difference between these two properties was approximately 3 feet.

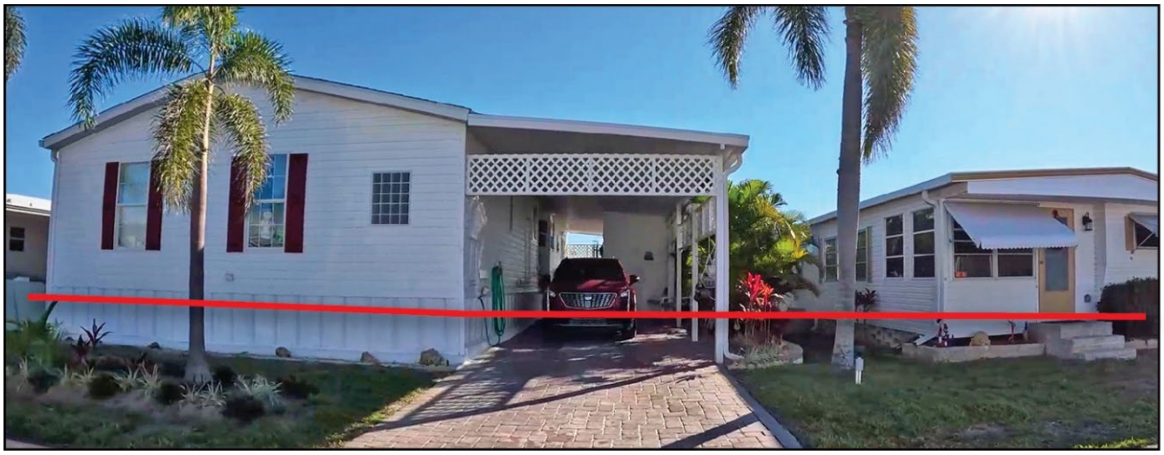
Figure 3-133: Representative elevated manufactured home in the Naples Land Yacht Harbor Community (Collier County, Zone AE)

Figure 3-134: Empty lot where a manufactured home was demolished in the Naples Land Yacht Harbor Community (Collier County, Zone AE)

Figure 3-135: Representative waterfront properties in Naples Land Yacht Harbor, many of which received 18 inches or more of floodwater inside except where they were sufficiently elevated (Collier County, Zone AE)

The yellow arrow highlights masonry skirt and crawlspace damage and the red line is the approximate flood depth.

Figure 3-136: Representative damage included interior damage as well as ductwork and heating, ventilation, and air conditioning (HVAC) replacement under and near manufactured homes (Collier County, Zone AE)



The red line is the approximate flood depth of the home on the left; the older manufactured home on the right had interior flood damage.

Figure 3-137: Elevated manufactured home on the left, elevated 6 inches above BFE, had no interior damage but ductwork had to be replaced (Collier County, Zone AE)

Figure 3-138: Representative foundation for newer elevated manufactured home in the Naples Land Yacht Harbor Community (Collier County, Zone AE)

4. Wind-Related Observations

This chapter describes the MAT wind-related observations of the performance of building envelope and structural systems of newer residential buildings. The performance of recent roof replacements on older residential buildings was also analyzed. Buildings that were built after March 2012 (effective date of the 2010 FBC) and roof replacements that were done after June 2015 (effective date of the 5th Edition [2014] FBC) were given priority for observation. This chapter also describes the wind-related performance of manufactured homes that were observed by the MAT. Section 4.2 discusses observations on the performance of roof coverings, including relatively recent roof replacements, soffits, exterior wall coverings, windows, doors, and other elements of the building envelope. Section 4.3 discusses observations on the performance of structural systems, and Section 4.4 discusses observations on the performance of manufactured homes, which include comparisons of the performance of pre-HUD versus post-HUD manufactured homes, damage to manufactured home appurtenances, and anchoring of manufactured homes.

In general, structural damage to Pre-FBC buildings due to wind was isolated in the areas visited by the MAT. The MAT did not observe structural damage of the MWFRSs due to wind for any Post-FBC buildings in the areas visited. However, failures of building envelope components were observed to some degree at all sites visited. Roof covering failure was the most common building envelope damage observed by the MAT. However, the degree of damage to each structure varied significantly.

4.1. Estimated Wind Speeds/Design Wind Speeds

NIST, working with Applied Research Associates, Inc. (ARA), developed an estimate of the surface-level windfield (estimated wind speeds) for Hurricane Ian in Florida, in support of a Mission Assignment from FEMA. Design wind speeds referenced within this chapter (also referred to as basic wind speeds) are the Risk Category II 3-second gust wind speeds as specified in the 7th Edition (2020) FBC, which was in effect when Hurricane Ian made landfall. The design wind speeds were obtained using the Hazards by Location website (ATC Hazards by Location (atcouncil.org) developed by the Applied Technology Council (ATC). ASCE 7-16 is referenced in the 7th Edition (2020) FBC. (The 8th Edition [2023] FBC, tentatively scheduled to go into effect on December 31, 2023, will reference ASCE 7-22). The estimated wind speeds and design wind speeds referenced in this chapter are 3-second gust wind speeds at a height of 33 feet for Exposure Category C.

Hurricane Ian's estimated wind speeds did not exceed the design (basic) wind speeds required by the 7th Edition (2020) FBC. When considering wind speed only, estimated wind speeds in Hurricane Ian also did not exceed the design wind speeds specified in any edition of the FBC since its inception (2001 FBC). The 7th Edition (2020) FBC applies to new construction and alterations, repairs, and reroofs permitted on or after December 31, 2020. Refer to Chapter 1 for additional discussion on Hurricane Ian and wind speeds.

Each photograph in this chapter showing an observed building or area includes the estimated wind speed during Hurricane Ian in the caption for the location shown. The year built, when included in the caption, offers some context with respect to the wind provisions in the FBC that were in effect when the building was permitted for construction. The wind-specific requirements in the various editions of the FBC and the year built provide a good baseline from which to evaluate and compare damage observed to relevant code requirements. Design wind speeds are, therefore, provided for comparison when the photographs in this chapter feature buildings constructed after March 2002 (effective date of the 2001 FBC, first edition) and roof replacements after June 2015 (effective date of the 5th Edition [2014] FBC). For buildings built prior to the 2001 FBC, the design wind speed could have varied from jurisdiction to jurisdiction depending on the adopted building code.

Although wind speeds are used to compare event conditions and design requirements, other factors can also impact wind pressures and damage to buildings (e.g., site location, internal pressures, the penetration of glazed openings by wind-borne debris). Nevertheless, comparisons of estimated wind speeds to design wind speeds provides a useful and convenient basis for comparing event conditions with design requirements.

4.2. Building Envelope

The MAT observed building envelope damage on both older and newer construction. The building envelope components the MAT focused on include exterior windows and doors, exterior wall coverings, soffits, and roof coverings on Post-FBC buildings. Buildings built after March 2012 (effective date of the 2010 FBC) were given priority. The team also performed a data analysis of the performance of roof coverings that were installed after June 2015 (effective date of the 5th Edition [2014] FBC). The MAT primarily targeted single-family dwellings, although the team also evaluated the performance of some multi-family buildings (apartments and condominiums). The objective of the building envelope observations was to determine how the design and installation requirements specified for building envelope components in the FBC performed in Hurricane Ian. Another key focus was levels of water intrusion through windows, doors, roofs, and soffits. The most frequent envelope damage observed by the MAT were to roof coverings and soffits. Homeowners consistently reported water intrusion through soffits and sliding glass doors for many sites visited by the MAT.

4.2.1. EXTERIOR SOFFITS

The MAT observed not only widespread damage to soffits, but also repeated reports of water intrusion through both damaged and undamaged soffits. The performance of soffit assemblies was poor across all areas visited by the MAT. Vinyl soffit panels were the most common soffit materials observed on Post-FBC houses. Wood structural panel soffits were common on Pre-FBC houses.

Soffit Installation

Building code requirements for soffits have been strengthened in recent FBC editions based largely on observations from the Hurricane Irma and Hurricane Michael MATs. The 7th Edition (2020) FBC improved soffit installation requirements by specifically requiring that soffit panels be fastened at the fascia and at the adjacent wall to the framing or a nailing strip. Where the span of vinyl soffit panels exceeds 12 inches, an intermediate nailing strip is required to be installed so that the span between soffit panel fasteners does not exceed 12 inches. Chapter 1 of the FBC was also updated to require in-progress inspections of soffits. Figure 4-1 depicts a representative vinyl soffit installation detail that the FBC now requires. Although the FBC has required soffits to resist wind loads since the 2007 edition, a common practice for vinyl soffits has been to “float” one or both ends of the soffit panel in channels that are attached near the fascia and/or the wall. This method of installing vinyl soffit may be the most convenient, but it offers little resistance to wind loads.

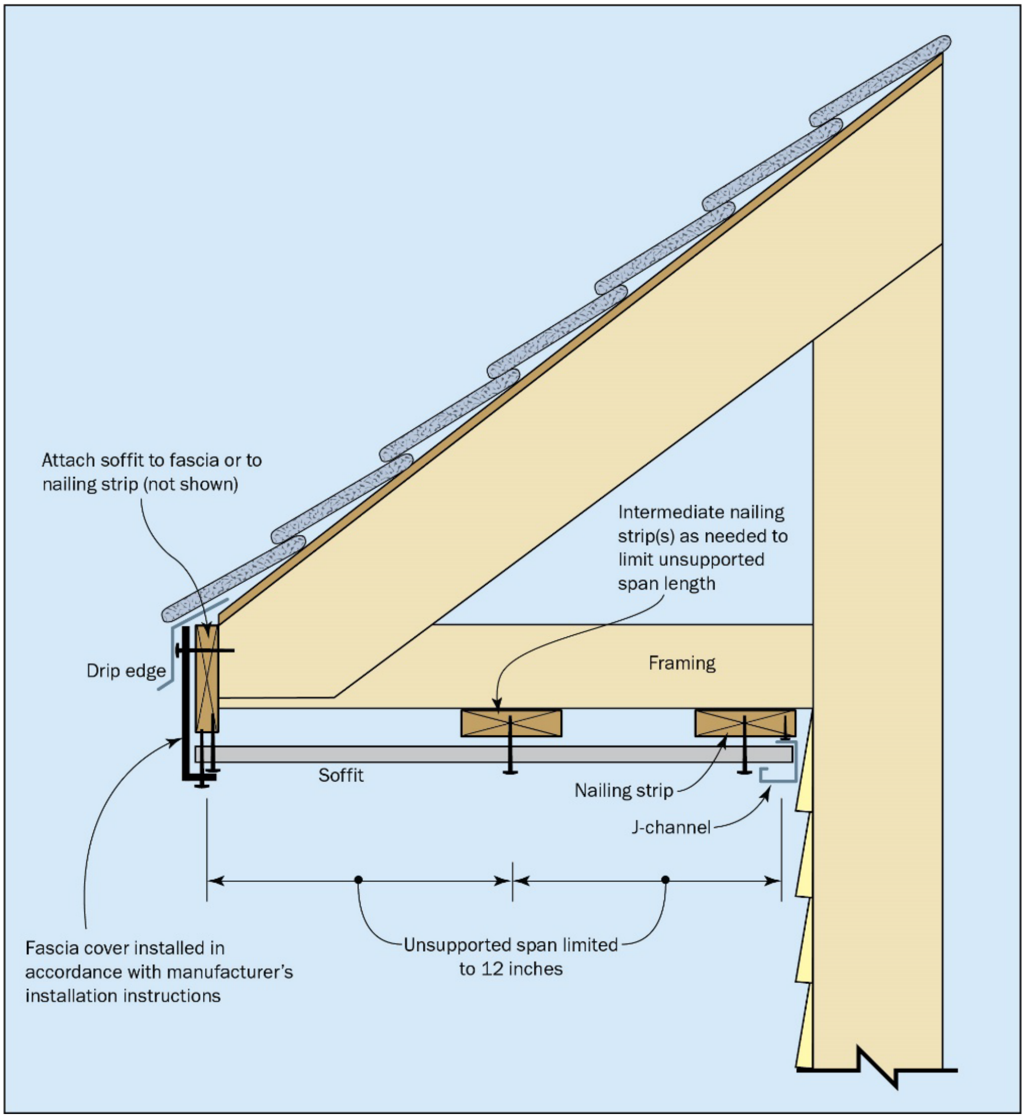


Figure 4-1: Recommended vinyl soffit installation (Figure 4-26 of FEMA P-2077 [2020c])

The waterfront house in Figure 4-2 is located on Fort Myers Beach, FL. The house was built in 2015 and suffered significant roof covering loss on the northwest side of the roof. Vinyl soffit panels failed along the eaves on both sides of the house. Although the soffit panels were fastened at the fascia (as evidenced by rust stains from fasteners on the soffit panel), the soffit panel was floated in the channel and not fastened at the exterior wall. The photograph shows the lack of a nailing strip at the wall. The soffit panel was floated in the channel that was attached to the roof framing. This house was built prior to the implementation of the improved soffit installation criteria in the 7th Edition

(2020) FBC. The homeowner indicated that this house experienced significant water intrusion primarily through the failed soffit panels.

Figure 4-2: House built in 2015 with roof covering and vinyl soffits damage (estimated wind speed [EWS] = 103 mph; design wind speed [DWS] = 159 mph) (Fort Myers Beach)

The house on Sanibel Island in Figure 4-3 was built to the 7th Edition (2020) FBC. The MAT observed significant damage to its vinyl soffit panels on the west, south, and east sides. The MAT noted two problems with this installation. The span of the soffit panel was approximately 24 inches as shown in Figure 4-4. The FBC requires an intermediate nailing strip for vinyl soffit panels that exceed 12 inches. As shown in Figure 4-3, the MAT did not find evidence that an intermediate nailing strip was installed. Although the soffit panel was fastened at the fascia and to a nailing strip at the exterior wall, an up-close inspection revealed the soffit was attached with staples that were fastened tightly against the nailing strip. The Vinyl Siding Institute's Vinyl Siding Installation Manual (includes installation guidelines for vinyl soffit as well) specifically recommends that fasteners not be driven tightly against vinyl products to allow for expansion and contraction. The manual recommends a clearance of approximately 1/32 inch between the fastener head and the vinyl. The MAT could not determine whether the staple fastener used was permitted in its Product Approval because the product was not labeled.

Notably, the house did not have any significant water intrusion according to the homeowner. Minor water intrusion through some of the windows was noted, but none through the soffit. Spray foam insulation was used in the attic area to create an unvented attic. Using spray foam insulation effectively separated the attic area from the soffit, which likely limited wind-driven rain from entering the attic area.

Figure 4-3: Post-FBC house (built in 2021) with vinyl soffit damage exposing the sprayed foam insulation in the attic (EWS = 109 mph; DWS = 161 mph) (Sanibel)

Figure 4-4: A vinyl soffit panel spanning approximately 24 inches that blew off the 2021 residence in Figure 4-3 (EWS = 109 mph; DWS = 161 mph) (Sanibel)

4.2.2. EXTERIOR WALL COVERINGS

The most common exterior wall covering on Post-FBC houses observed by the MAT was stucco. Stucco wall coverings performed well overall with infrequent minor damage noted, likely from wind-borne debris. Fiber cement and vinyl siding wall coverings were also observed on Post-FBC houses in the areas impacted by Hurricane Ian with isolated damage noted. For all sites visited, the observations of wall covering damage were much less than the observations of damage to roof coverings.

Figure 4-5 is a house in St. James City that is representative of the isolated vinyl siding damage observed. The house was built in 2014 and sustained significant vinyl siding damage on its west side. It appeared that an appropriate starter strip was used for the first course. However, utility trim was not used under the windows or the top of the wall to secure the top edge of the siding. If the top edge of the siding was not secured under the windows or at the top of the wall with utility trim, the siding would have been vulnerable at those locations.

The next edition of the FBC (8th Edition [2023]) has been revised to specifically require the first course of vinyl siding to be secured using a starter strip approved by the manufacturer and for the top course of siding to be secured with utility trim under windows and at the top of walls.

Figure 4-5: A house built in 2014 with significant damage to the vinyl siding on the west side (EWS = 114 mph; DWS = 160 mph) (St. James City)

Figure 4-6 shows a house that was under construction at the time of the site visit. The building envelope on the upper floors appeared to have been completed when Hurricane Ian made landfall. The fiber cement siding on the upper floors failed due to a combination of fastener withdrawal and shear "punch-through" failure around the fastener heads as can be seen in the inset.

Figure 4-6: A house under construction with fiber cement siding failure (EWS = 104 mph; DWS = 160 mph) (Fort Myers Beach)

4.2.3. WINDOWS AND DOORS

The MAT observed scattered instances of glazing failures that were likely due to wind-borne debris. The waterfront house in Figure 4-7 is located in St. James City, FL, and was built in 2003. One window had been broken, and based on the glass breakage pattern, the breakage was likely the result of wind-borne debris. Many of the glazed openings on this level of the house have louvered type shutters with stand-offs. This glazed opening appeared also to be protected with a similar type of shutter that detached from the building (one of the stand-offs is still attached). The MAT could not determine whether these shutters meet the ASTM International (ASTM) test standards ASTM E1886 and ASTM E1996 or the Testing Application Standard (TAS) 201, 202, and 203 test protocols (HVHZ) as required by the FBC. At the time this house was built, impact protection for glazed openings was not required by the FBC (2001 FBC).

Figure 4-7: A house built in 2003 with glazed opening damage (EWS = 114 mph; DWS = 160 mph) (St. James City)

The house in Figure 4-8 is also located in St. James City, FL, and was built in 2016. The 5th Edition (2014) FBC was in effect when this house was built and required impact protection for glazed openings in this area. Three of the four glazed openings appeared to have been impacted by wind-borne debris. These glazed openings were likely impact resistant, though that cannot be determined with certainty without a closer inspection. While the outboard panes are clearly damaged, the inboard panes appeared to remain in place.

Figure 4-8: A house built in 2016 with glazed opening damage (EWS = 114 mph; DWS = 161 mph) (St. James City)

The MAT received numerous homeowner reports of water intrusion at windows and doors, particularly through sliding glass doors, at nearly all sites visited. Interior finishes and contents can be severely damaged by water intrusion through and around windows and doors. The house in Figure 4-9 was built in 2021 and is located in Punta Gorda, FL. The homeowner reported significant water intrusion due to wind-driven rain at both sliding glass doors in the rear of the house. This house was not impacted by storm surge. The three-panel sliding glass door was protected by an overhang. The ratio of the length of the overhang to its height above the door sill (overhang ratio) exceeded 1.0. For doors installed where the overhang ratio is equal to or greater than 1.0, the FBC does not require testing for water intrusion resistance (Section R609.3, Exception 2 of the 7th Edition [2020] FBCR). However, the code is not as clear for the adjacent two-panel sliding glass door in the perpendicular wall regarding water intrusion testing and protection by an overhang. Additionally, a nearby two-panel sliding glass door also in the rear of the same house, (Figure 4-10) was not protected by an overhang meeting the overhang ratio specified in the FBC to exempt water penetration resistance testing. Therefore, this door would have been required to be tested for water penetration resistance at 15% of its positive design pressure (DP) rating. According to the homeowner, significant water intrusion from wind-driven rain occurred around all these doors. Weepholes (see the two red circles in Figure 4-10) for draining water are visible in the photograph. The presence of weepholes indicates this door is a “contain and drain” product in that it allows water penetration to occur but contains the water in an integral sill pan and allows the water to drain to the exterior. The integral sill pan should include a sill riser (sill dam) on the interior side of the door to meet the water penetration resistance testing required by the FBC. The height of the sill riser depends on the required DP rating of the product. This door clearly lacked a sill riser as the back side of the track is flush with the interior tracks. It is not clear whether the door was installed without the sill riser or the homeowner removed the sill riser at some point. Without a sill riser, this door had little resistance to water intrusion from wind-driven rain. See Hurricane Ian in Florida Recovery Advisory 3, *Reducing Water Intrusion Through Windows and Doors* (2023d) for illustrations of typical sliding door integral sill pans and sill risers and for more information on the FBC exception for water intrusion testing for doors installed beneath overhangs.

Figure 4-9: A house built in 2021 with two- and three-panel sliding glass doors that experienced significant water intrusion (EWS = 130 mph; DWS = 151 mph) (Punta Gorda)

Figure 4-10: A house built in 2021 with a two-panel sliding glass door that experienced significant water intrusion due to wind-driven rain (the two red circles identify weepholes that enable water to exit) (EWS = 130 mph; DWS = 151 mph) (Punta Gorda)

4.2.4. ROOF COVERINGS

This section highlights the performance of roof coverings and underlayment methods on Post-FBC houses observed by the MAT in addition to the performance of recent roof replacements on older houses. Common Roof Coverings provides a general description of the performance of the common roof covering types in the areas where Hurricane Ian's estimated wind speeds were the highest. Data Analysis of the Performance of Newer Roof Coverings provides an analysis of damage frequency of roof coverings installed in accordance with the 5th Edition (2014) FBC and later editions compared to those installed prior to the 5th Edition (2014) FBC.

Common Roof Coverings

Asphalt shingles and metal panels were, by far, the most common types of roof coverings encountered in the areas assessed by the MAT. Roof tile was observed in many areas but was generally dispersed amongst asphalt shingles and metal panels. The MAT did assess a small subset of wood roofs (cedar shakes and shingles) in Captiva, FL, but they were not found in most of the areas examined.

Although roof covering damage was widespread at all sites visited by the MAT, the degree of roof covering damage varied across the sites. The most common damage observed by the MAT for all roof coverings was displacement of hip and ridge roof coverings.

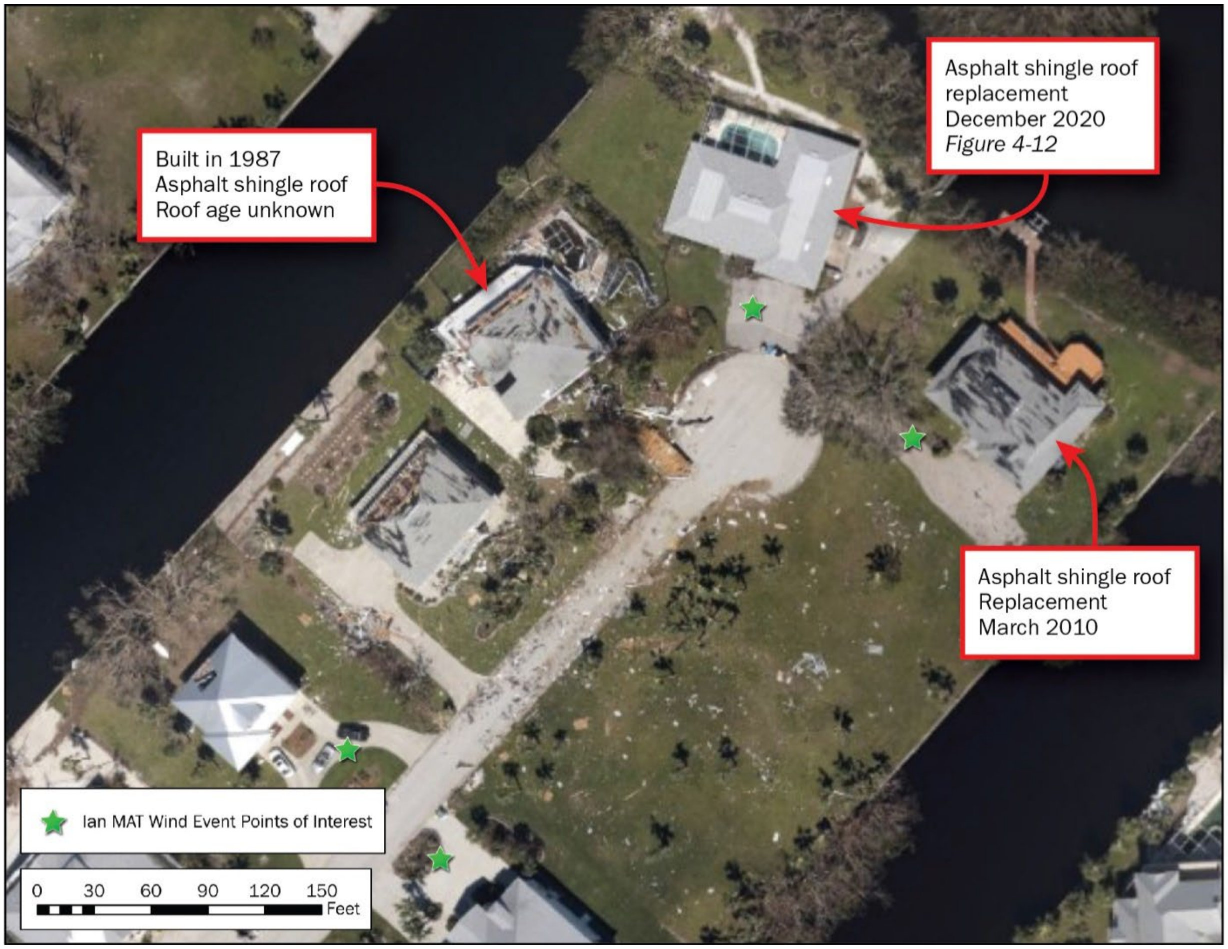
Figure 4-11 shows typical examples of hip and ridge failures observed. The estimated wind speeds from Hurricane Ian were far less than design-level wind speeds for this area.

Figure 4-11: Hip and ridge damage on four residences with different roof types: a tile roof (top left), asphalt shingle roof (top right), metal panel roof (bottom left), and cedar shake roof (bottom right)

Asphalt Shingle Roof Coverings

The MAT observed widespread damage to asphalt shingle roofs on both newer and older construction for all sites visited. However, the degree of damage varied considerably. Generally, newer asphalt shingle roofs significantly outperformed older asphalt shingle roof coverings (see Data Analysis of the Performance of Newer Roof Coverings). Figure 4-12 shows a house with an asphalt shingle roof in Placida, FL. Permit data extracted using a desktop analysis indicated an asphalt shingle roof replacement was performed in December 2020. As observed at the site visit and corroborated by the homeowner, the roof covering did not sustain any damage. However, the homeowner did report interior water damage due to water intrusion through the soffits. Figure 4-13 shows considerable asphalt shingle damage to older roof coverings on adjacent houses. The houses on this street with metal panel roofs did not have any damage that could be observed by the MAT during the site visits or from NOAA imagery.

Figure 4-12: A house with an asphalt shingle roof that was replaced in December 2020, with no damage (EWS = 128 mph; DWS = 155 mph) (Placida)



Aerial Source: NOAA

Figure 4-13: NOAA imagery of asphalt shingle damage on houses adjacent to the house shown in Figure 4-12 (EWS = 128 mph) (Placida)

The house in Figure 4-14 was built in 2021. NOAA imagery indicates fairly significant asphalt shingle roof covering loss on the northeast roof slope (back of house). The homeowner indicated that while approximately 50% of the asphalt shingles on the back roof slope failed, the house did not experience any water intrusion through the roof or soffit. A self-adhered underlayment (sealed roof deck) was installed under the asphalt shingles and spray foam insulation was used in the attic area. The homeowner indicated that many houses on this street sustained significant water intrusion damage through soffits.

Aerial Source: NOAA (top)

Figure 4-14: A house built in 2021 with significant asphalt shingle damage on the northeast roof slope (EWS = 127 mph; DWS = 150 mph). The inset above shows an aerial image of the house post-Hurricane Ian. (Port Charlotte)

Figure 4-15 shows a house in Port Charlotte, FL, that had an asphalt shingle roof replacement in April 2022. NOAA imagery indicated minor damage near the ridge. A blue tarp was used to cover the damaged area to temporarily prevent water intrusion damage.

Figure 4-15: An asphalt shingle roof that was replaced in 2022 with minor damage near the ridge (EWS = 128 mph; DWS = 150 mph) (Port Charlotte)

The house in Figure 4-16 was built in 2015 and suffered severe asphalt shingle roof covering damage on the northwest slope, but the underlayment stayed in place. The homeowner indicated the house experienced significant water intrusion damage, but it was mostly through the soffits. The darker colored underlayment on the right side of the picture is likely a newer/different underlayment material that was installed as part of some previous repair work.

Figure 4-16: A house built in 2015 with severe asphalt shingle damage (EWS = 103; DWS = 159) (Fort Myers Beach)

Cedar Shake and Shingle Roof Coverings

The MAT assessed a small grouping of cedar shake and shingle roofs in a neighborhood in Captiva, FL. Permit data indicated that many of these roof coverings had recently been replaced. Although most of the wood roofs in this neighborhood appeared to be wood shakes, distinguishing shakes from shingles on aged wood roof coverings can be difficult. Additionally, many of the roof replacements included concrete tile formed to simulate cedar shakes and synthetic shakes. The newer roof coverings (including tile and synthetic shakes) clearly outperformed the older roof coverings. The most common damage observed on the newer roof coverings was damage at hips and ridges. The roof on the house in Figure 4-17 was replaced with wood shakes in 2019. The roof performed well and the house shows virtually no damage except for minor displacement of wood shakes in front of the balcony. Figure 4-18 is a house built in 1974 with an older roof covering (available permit data did not indicate a roof replacement in the last 15 years). A synthetic underlayment had been attached to cover most of the west slope of the roof to protect the interior of the house from water intrusion. NOAA imagery indicates significant damage to the wood shakes near and extending from the ridge. The picture also shows displaced wood shakes in areas of the roof not covered by the synthetic underlayment. According to the homeowner, the house suffered significant interior water damage as a result. Figure 4-19 shows a house that had a roof replacement in December 2021. The roof sustained minor damage at the hips. Figure 4-20 shows a house that had the roof replaced with concrete tile in July 2020 with no visible roof covering damage.

Figure 4-17: A house built in 1974 with a roof replacement in October 2019 with minor shake damage below the balcony (EWS = 123 mph; DWS = 162 mph) (Captiva)

Figure 4-18: A house built in 1974 with an older roof covering with significant shake damage; large areas of the roof were covered with a synthetic underlayment to prevent further water intrusion (EWS = 123 mph) (Captiva)

Figure 4-19: A house built in 1974 with a roof replacement in December 2021 with minor shake damage at hips (EWS = 123 mph; DWS = 162 mph) (Captiva)

Figure 4-20: A house built in 1974 with a tile replacement in July 2020 with no visible damage (EWS = 123 mph, DWS = 162 mph) (Captiva)

Tile Roof Coverings

Although the MAT visited a few neighborhoods where the roof coverings were exclusively tile, tile roofs were generally dispersed among more common asphalt shingle and metal panel roofs. Damage to tile roofs observed by the MAT generally occurred at edges—eaves, rakes, ridges, and hips. Similar to the other roof coverings assessed, newer roof tile experienced less damage overall than older tile roof coverings.

The tile roof on the house in Figure 4-21 was replaced in August 2021 and sustained minor damage near the eave. Two adjacent homes built in 1991/1992 with likely the original tile roof coverings are shown in Figure 4-22. These two roofs sustained significantly more damage than the tile roof that was replaced in August 2021.

Figure 4-21: A house with a tile roof that was replaced in August 2021 with minor damage near the eave (EWS = 126 mph; DWS = 155 mph) (Placida)

Figure 4-22: Roof tile damage to houses built in 1991/1992 with their original roof covering (EWS: 126 mph) (Placida)

Figure 4-23 is a house built in 1973 in Pine Island, FL, that had a tile replacement in August 2022. Imagery indicates minor tile damage near the ridge in the area covered by the blue tarp.

Figure 4-23: A house constructed in 1973 with a tile roof that was replaced in August 2022 with minor damage (EWS = 120 mph) (Pine Island)

Figure 4-24 shows a neighborhood in Port Charlotte that was built in 2020 and 2021. Many of the tile roofs sustained minor to moderate damage, particularly at discontinuities, such as eaves, rakes, and hips and ridges. Tile in this neighborhood was adhered with a foam adhesive.

Figure 4-24: Neighborhood built in 2020 and 2021 with tile roof coverings with minor and moderate damage (EWS = 126 mph; DWS = 153 mph) (Port Charlotte)

Metal Panel Roof Coverings

Metal roof panels, along with asphalt shingles, were the most common roof coverings observed at the sites visited by the MAT. Through-fastened metal roof panels were the most common metal roof panels observed. Standing seam metal roofs were also observed but not nearly as frequently as through-fastened metal roofs. The most common damage to metal roof panels observed were to hip and ridge covers. Figure 4-25 depicts typical hip cover damage to metal panel roofs observed by the MAT. Figure 4-26 shows a house in Placida, FL, built in 2015 with a through-fastened metal panel roof that performed well. An interview with the homeowner confirmed there was no damage to the roof covering.

Figure 4-25: Typical hip cover damage on a metal panel roof (EWS: 115 mph; DWS: 161 mph) (St. James City)

Figure 4-26: A house built in 2015 with a through-fastened metal roof with no damage observed (EWS = 120 mph; DWS = 160 mph) (Placida)

Figure 4-27 shows a standing seam metal roof replacement that was performed in 2018 in St. James City, FL. The MAT was unable to determine why this roof replacement performed poorly.

Figure 4-27: A house with a standing seam metal panel roof that was replaced in 2018 with severe damage (EWS = 115 mph; DWS = 161 mph) (St. James City)

Newer houses (built to 2010 FBC and later) with original metal panel roofs appeared to outperform older houses with recent metal roof panel replacements. An example of this is shown in Figure 4-28. Based on NOAA imagery and site visits, the house built in 2020 had no visible damage to the metal panel roof covering. Other homes recently built on this street similarly showed no indication of visible damage. The houses where the roofs were replaced in 2019, 2020, and 2021 all sustained some damage to the metal panel roof coverings as indicated on the NOAA imagery and confirmed by site visits.

Aerial Source: NOAA

Figure 4-28: Metal panel roof cover damage on roofs that were recently replaced (EWS: 115 mph; DWS: 160 mph) (St. James City)

Data Analysis of the Performance of Newer Roof Coverings

In addition to evaluating the overall performance of new construction in the path of Hurricane Ian, the MAT performed a data analysis of the performance of newer roof coverings on older buildings as well as new buildings. Given the availability of online permit data, the MAT used a desktop analysis to identify specific locations where roofs had recently been replaced. With the parcel data, reroofing permit data, and NOAA post-Hurricane Ian storm imagery (https://storms.ngs.noaa.gov/storms/ian/index.html#9/26.9488/-81.9626), the MAT targeted locations within the impacted area where there were clusters of new construction, recent reroofs, and older roofs. The clusters included buildings on the same street or adjacent streets. The wind speeds the buildings were exposed to and the exposure categories were similar within each cluster. The goal was to evaluate the performance of newer roof coverings compared to older roof coverings and determine, to the extent possible, the level of water intrusion that occurred through failed or damaged roof coverings. As previously indicated, based on initial damage surveys and other reports, there was less evidence of water intrusion damage from wind-driven rain than was observed in previous storms. However, as previously stated, Hurricane Ian was a far less than a design level wind speed event.

As has been the case in previous storms, roof covering damage is often covered by a tarp or other water-resistant material soon after the storm to temporarily prevent water intrusion through the roof. For many of the observations in the chapter, the MAT assumed that if part or all of the roof was covered with a tarp or other material to temporarily prevent water intrusion, the roof covering was damaged to some degree.

A key piece of evidence pointing to water intrusion damage is the presence of interior content debris piles near curbs. For the sites visited, the MAT observed fewer interior content debris piles by curbs overall than in recent major storms. The buildings in Figure 4-29, located in a neighborhood in Punta Gorda, FL, clearly suffered roof covering damage, as evidenced by the presence of tarps and other water-resistant materials placed on the roofs. However, as shown in the figure, there were limited amounts of interior contents by the curbs, indicating limited water intrusion damage to the interior of these buildings. This picture was taken by the pre-MAT approximately 2 weeks after Hurricane Ian impacted the area. The estimated maximum peak wind gust from Hurricane Ian in this area was 127 mph.

Figure 4-29: Limited amounts of interior contents by curbs in a Punta Gorda neighborhood (photo taken October 13, 2022) (EWS = 127 mph)

Key FBC Roofing Definitions

The following FBC definitions help to inform the discussion of roof repairs in this section and throughout the chapter:

- **Reroofing:** The process of recovering or replacing an existing roof covering. See "Roof recover."
- **Roof Recover:** The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering.
- **Roof Replacement:** The process of removing the existing roof covering, repairing any damaged substrate, and installing a new roof covering.

The MAT surmised that in addition to Hurricane Ian wind speeds being far less than design level, the lower levels of water intrusion damage might be attributed to the improved roof underlayment installations that have been required in Florida since the 5th Edition (2014) FBC, which went into effect in June of 2015. Requirements for underlayment were strengthened significantly after the 2010 FBC. The 2010 FBC permitted underlayment to comply with ASTM D226 Type I or ASTM D4869 Type I or II and only required fastening at the laps at 36 inches on center. For roof slopes of 4:12 and greater, the 5th Edition (2014) FBC required the use of underlayment complying with ASTM D226 Type II or ASTM D4869 Type IV (thicker than ASTM D226 Type I and ASTM D4869 Type I or II) and required it to be fastened at 6 inches on center at laps and two staggered rows at 12 inches on center between the laps. Figure 4-30 depicts the required underlayment method in the 5th Edition (2014) FBC for roof slopes 4:12 and greater. Roof replacements permitted after the effective date of the 5th Edition (2014) FBC on buildings with roof slopes 4:12 and greater would have had to comply with these strengthened underlayment requirements. Buildings with this underlayment method would have better resistance to water intrusion though the roof if the primary roof covering is lost or damaged compared to roof coverings installed prior to the 5th Edition (2014) FBC. In the 7th Edition (2020) FBC, roof underlayment requirements were further strengthened and are consistent with the Insurance Institute for Business and Home Safety (IBHS) Fortified™ Roof requirements for a Sealed Roof Deck for roof slopes 2:12 and greater.

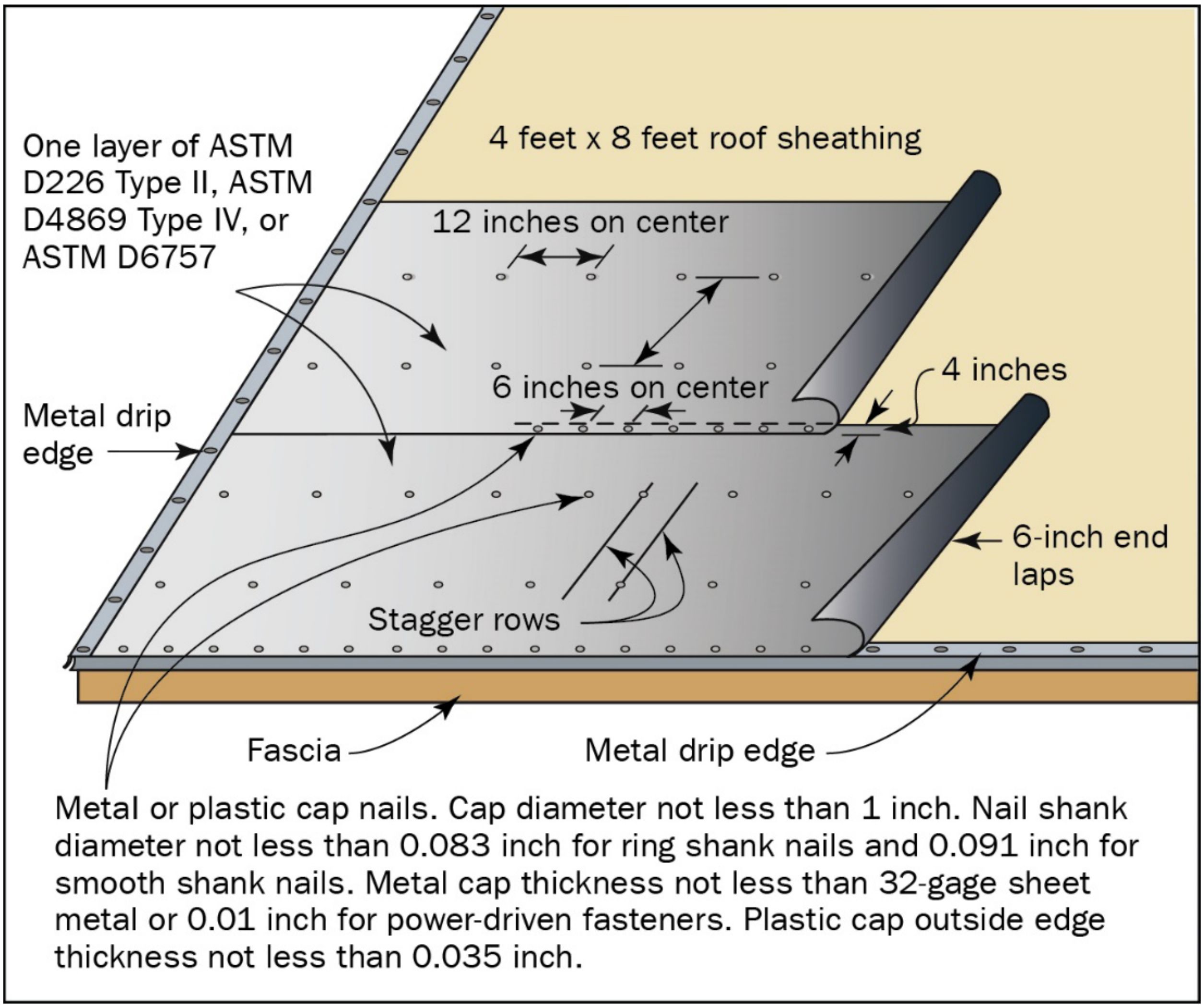


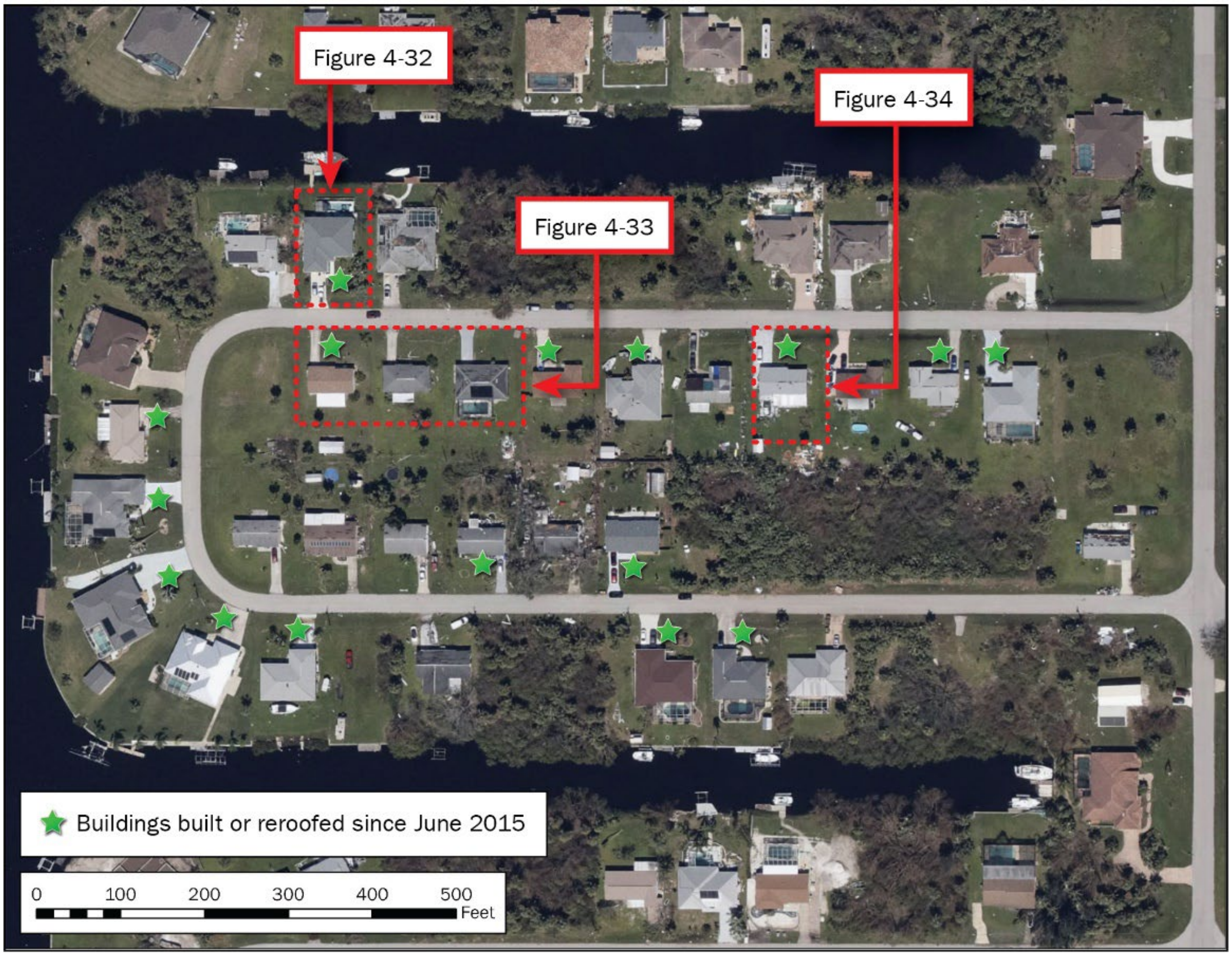
Figure 4-30: Roof underlayment requirements of the 5th Edition (2014) FBC

Using the desktop analysis, the MAT identified buildings in the target clusters that had been reroofed or built since June 2015. These data, combined with site visits and discussions with homeowners, provided data sets to analyze the performance of newer roof coverings compared to older ones and provide some insights into the levels of water intrusion that occurred through damaged roofs. In the following sections, example data are shown for some of the targeted clusters and a summary table is provided for all of the data collected for all clusters analyzed.

Cluster 1 Port Charlotte

One example of a target cluster (Cluster 1) is shown in Figure 4-31. This area included a mixture of new construction, recent reroofs, and older roofs. The green stars indicate buildings that were built after June 2015 or had been reroofed since June 2015. The maximum estimated wind speed in this area during Hurricane Ian was 127 mph. The design wind speed for new construction is 151 mph. Figure 4-32 shows a house with a post-2020 asphalt shingle roof and no visible damage. Figure 4-33 and Figure 4-34 depict representative observations by the MAT in this area. The houses in

Figure 4-33 and Figure 4-34 were covered with blue tarps and/or synthetic underlayments to temporarily prevent water intrusion. NOAA imagery clearly indicates damage to these asphalt shingle roofs.



Aerial Source: NOAA

Figure 4-31: Cluster 1 for roof covering performance analysis; buildings built or reroofed since June 2015 shown with green stars and homes with additional images outlined in red (EWS = 127 mph) (Port Charlotte)

The MAT used NOAA imagery and site visits to determine whether roofs had suffered damage. Most damaged roofs were covered with tarps and other water-resistant materials to prevent water infiltration after the storm. This precluded specific determinations of the cause of damage. Additionally, many roofs had already been recovered/repaired at the time the MAT observations took place. The following discussion covers the damage observations the MAT could discern from the available data.

Figure 4-32: A house built post-2020 with asphalt shingle roof and photovoltaic panels; no damage observed (located in the Port Charlotte neighborhood in Figure 4-31) (EWS = 127 mph)

Figure 4-33: Houses with asphalt shingle roofs; top built in 1984 and reroofed in 2022 (no damage observed); middle built in 1984 (damaged observed on NOAA imagery); bottom built in 1990 (damage observed on NOAA imagery) (located in the Port Charlotte neighborhood in Figure 4-31) (EWS = 127 mph)

Figure 4-34: A house with asphalt shingle roof damage and tarp to help temporarily prevent water infiltration); built 1984 and reroofed in April 2022 (located in the Port Charlotte neighborhood in Figure 4-31) (EWS = 127 mph)

Table 4-1 provides a summary of the data collected in Cluster 1 (see Figure 4-31).

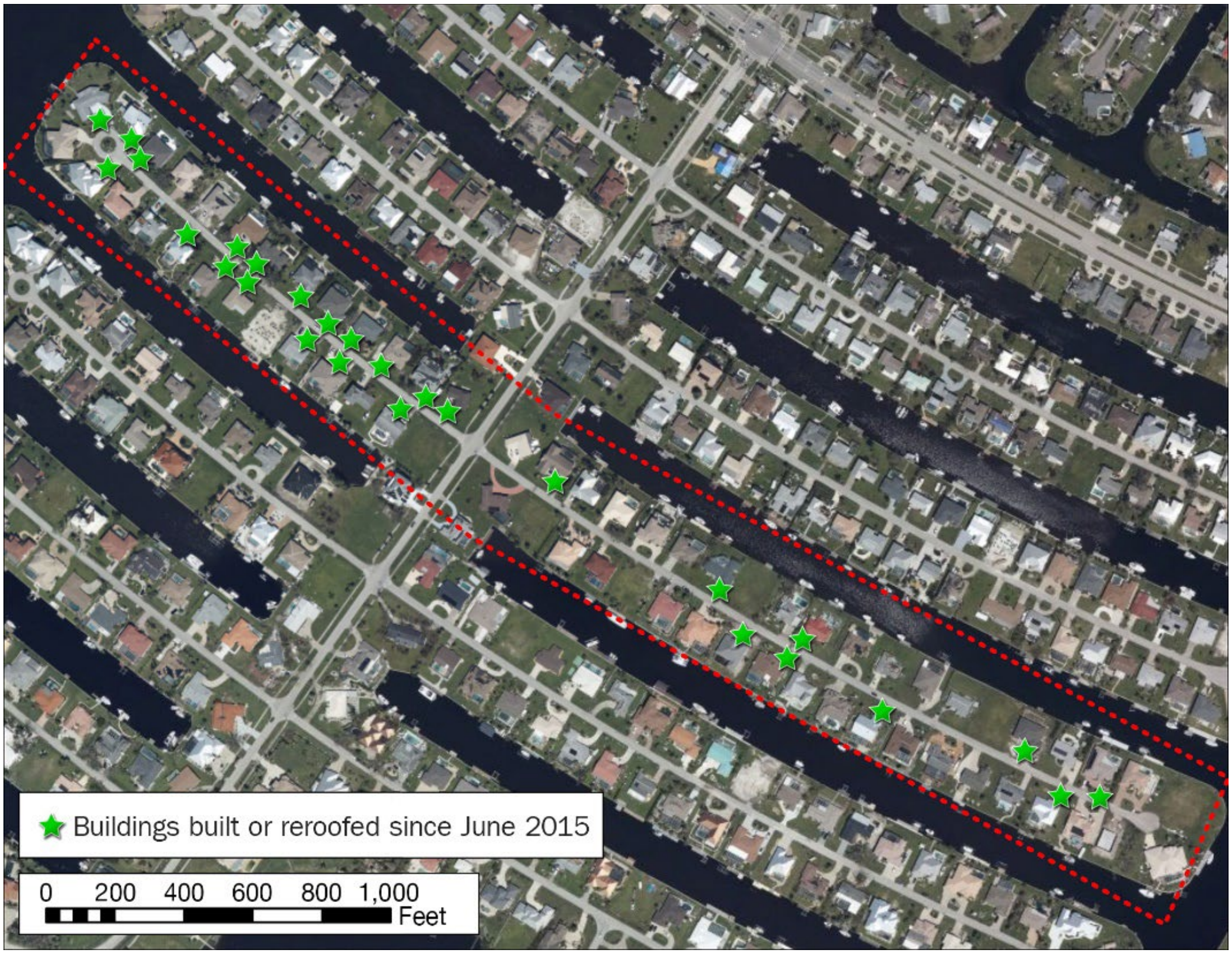
Table 4-1: Summary of Roof Covering Damage in a Cluster 1 (Figure 4-31); Port Charlotte (EWS = 127 mph)

	Asphalt Shingle Roofs with Visible Damage	Asphalt Shingle Roofs without Visible Damage	Metal Panel Roofs with Visible Damage	Metal Panel Roofs without Visible Damage	Tile Roofs with Visible Damage	Tile Roofs without Visible Damage
Roofs Installed After June 2015	2	13	0	1	0	0
Roofs Installed Prior to 2015	17	0	0	1	0	0

For the cluster shown in Figure 4-31 (Cluster 1), 34 buildings were evaluated. Sixteen of these buildings had roofs that were installed after June 2015. Two of the 16 buildings visited had visible roof covering damage. Seventeen of the 18 buildings with roof coverings installed prior to 2015 had visible roof covering damage. Neither of the two metal panel roof coverings observed in this cluster suffered damage.

Cluster 2 Port Charlotte

Figure 4-35 shows Cluster 2 with a mixture of new construction, recent reroofs, and older roofs. The maximum estimated wind speed in this area during Hurricane Ian was 128 mph. The design wind speed is 150 mph. Figure 4-36, Figure 4-37, and Figure 4-38 show representative damage observed by the MAT in this area.



Aerial Source: NOAA

Figure 4-35: Cluster 2 for roof covering performance analysis; buildings built or reroofed since June 2015 shown with green stars (EWS = 128 mph) (Port Charlotte)

Figure 4-36: A house with metal roof; built in 1984 and reroofed in May 2022 (damage to a few metal panels) (EWS = 128 mph) (Port Charlotte)

Figure 4-37: A house with asphalt shingle roof; built 1998 and reroofed August 2020 (minor hip shingle damage) (EWS = 128 mph) (Port Charlotte)

Figure 4-38: A house built in 2001 with a tile roof (tile damage as indicated by black tarp on the roof) (EWS = 128 mph) (Port Charlotte)

Table 4-2 provides a summary of the data collected in this cluster.

Table 4-2: Summary of Roof Covering Damage in Cluster 2 (Figure 4-35); Port Charlotte (EWS = 128 mph)

	Asphalt Shingle Roofs with Visible Damage	Asphalt Shingle-Roofs without Visible Damage	Metal Panel Roofs with Visible Damage	Metal Panel Roofs without Visible Damage	Tile Roofs with Visible Damage	Tile Roofs without Visible Damage
Roofs Installed after June 2015	7	11	1	5	0	0
Roofs Installed prior to 2015	12	7	1	4	2	5

For Cluster 2, 55 buildings were evaluated. Twenty-four of these buildings had roofs that were installed after June 2015. Eight of the 24 buildings had visible roof covering damage (33%). Fifteen of the 21 buildings with roof coverings installed prior to 2015 had visible roof covering damage (71%).

Cluster 3 Placida

At another targeted cluster (Cluster 3), the MAT noted that many of the tile roofs on the buildings in Figure 4-39 in Placida, FL, had suffered damage and many had recently been replaced (tile roof replacement). Bare roof sheathing is visible on several buildings in the NOAA imagery. The maximum estimated wind speed for this area during Hurricane Ian was 126 mph. The design wind speed for this area is 156 mph. Tile was replaced on 11 of the 18 buildings in this area since 2019 and before Hurricane Ian made landfall (indicated by green stars). According to homeowners, most of the older roofs and the roofs that had been recently replaced were mechanically fastened. The MAT was able to confirm during the site visits that some of the newer roofs were mechanically fastened (see Figure 4-40). The newer roof coverings clearly suffered less damage overall than the older roof coverings. Figure 4-41 shows some of the worst damage observed on some of the older roof coverings (the tile roof in the far-left side of the picture was reroofed after Hurricane Ian). However, while less extensive than for the older roof coverings, many of the newer roof coverings also suffered some damage (see Figure 4-42 and Figure 4-43). Because many new roofs were installed and the wind speeds were far less than the design wind speeds, more roofing damage was observed than was anticipated.

Of the 11 houses that had been reroofed since June 2015, four had visible roof covering damage. Of the seven houses with roof coverings installed prior to June 2015, five had visible roof covering damage.

Aerial Source: NOAA

Figure 4-39: Roof tile damage on newer and older roofs (EWS = 126 mph) (Placida)

Figure 4-40: Mechanically fastened tile roof in Placida that was replaced in August 2021 (EWS = 126 mph)

Figure 4-41: Roof tile damage to older tile roofs in Placida (EWS = 126 mph)

Figure 4-42: Roof tile damage to a roof in Placida that was replaced in September 2019 (EWS = 126 mph)

Summary of All Clusters

Table 4-3 summarizes the roof covering performance for all targeted clusters visited by the MAT. Damage percentages for asphalt shingle and metal panel roofs are also indicated in the table.

Table 4-3: Summary of Roof Covering Damage Observed by the MAT in All Clusters Impacted by Hurricane Ian

	Asphalt Shingle Roofs with Visible Damage	Asphalt Shingle Roofs without Visible Damage	Metal Panel Roofs with Visible Damage	Metal Panel Roofs without Visible Damage	Tile Roofs with Visible Damage	Tile Roofs without Visible Damage
Roofs Installed after June 2015	11 (28%)	28 (72%)	6 (18%)	27 (82%)	5	7
Roofs Installed prior to June 2015	63 (90%)	7 (10%)	9 (21%)	34 (79%)	8	7

As previously stated, the MAT observed widespread roof covering damage throughout the sites visited. The predominant types of roof coverings observed in the impacted area were asphalt shingles and metal panels. Although roof covering damage was widespread, based on the desktop analysis using NOAA imagery and site visits, roof covering damage did not appear as extensive on each building as has been observed in recent major storms, such as Hurricane Irma and Hurricane Michael. However, considering the required design wind speeds for new roof coverings in the areas impacted by Hurricane Ian compared to the estimated wind speeds in Hurricane Ian, there was more wind damage to roof coverings observed than anticipated.

While the data and observations show newer roof coverings generally performed better than older roof coverings, several relevant points should also be considered in this analysis. Changes to both material and installation requirements have been improved in recent FBC code development cycles that have led to and will lead to better wind uplift performance. Additionally, through innovation and market forces, some manufacturers have made improvements to their products in this regard in ways that may not be readily apparent using current testing methods. Lastly, these observations do not take into account likely significant differences in the quality of installation methods.

The most prevalent type of damage observed after Hurricane Ian, was damage to hips and ridges, which was observed on both newer and older roofs. Figure 4-43 shows typical hip and ridge damage to roof tile in a neighborhood built in 2020 and 2021. The maximum estimated wind speed in this area was 126 mph. The design wind speed is 153 mph. This type of damage was observed for all roof covering types. The lack of evidence of significant water intrusion due to roof covering damage was supported by numerous discussions with homeowners. While some homeowners indicated their homes had experienced water intrusion through the roof, the majority stated that water intrusion was more typically through soffits and sliding glass doors.

Discussions with homeowners and a desktop analysis performed after the site visits also revealed that many roof coverings were being replaced on roofs with minor to no discernable damage. Although the MAT visited the house with the tile roof in Figure 4-44, the MAT could not identify any damage to the roof on the NOAA imagery or from the site visit. However, a permit was pulled in March 2023 for a tile replacement for “storm-related repair/replacement.” Another example of this is the house shown in Figure 4-45, which was built in 2002 and replaced with asphalt shingles in February 2019. Using NOAA imagery and observations during the site visit, the MAT only saw minor hip shingle damage. However, a permit was issued in November 2022 for a complete asphalt shingle roof replacement.

Figure 4-43: Roof tile damage (EWS = 126 mph; DWS = 153 mph) (Port Charlotte)

Source: NOAA (top)

Figure 4-44: A house built in 1975 with no observable roof covering damage, a "storm-related roof replacement" permit was issued post-Hurricane Ian (EWS = 128 mph) (Port Charlotte)

Figure 4-45: A house built in 2002 with an asphalt shingle roof replacement in 2019, with minor hip shingle damage, a "storm-related" roof replacement permit was issued post-Hurricane Ian (EWS = 128 mph) (Port Charlotte)

4.3. Structural Systems

The MAT did not observe wind-related structural damage to any Post-FBC houses. However, the MAT did observe some houses constructed prior to the 2001 FBC (Pre-FBC) that experienced considerable structural damage. Of all sites visited by the MAT, the most extensive structural damage to Pre-FBC buildings was observed in the southern areas of Pine Island and scattered areas near Boca Grande.

Figure 4-46 shows a two-family house built in 1990 in St. James City with significant structural damage from the storm. Figure 4-47 shows a house located about half a mile from the house in Figure 4-46; the house was built in 2022 and the MAT did not identify any damage to the house. The homeowner indicated the only damage sustained was to the screened enclosure at the back of the house.

Figure 4-48 shows a multi-family condominium built in 1979 in Boca Grande. The second-story side walls and roof are missing, leaving the wood framing and interior exposed. Figure 4-49 is the house across the street from the condominium (Figure 4-48); built in 2022, the house showed no signs of damage. The discrepancy in performance between the houses in Figure 4-46 and Figure 4-47, and between the condominium in Figure 4-48 and the house in Figure 4-49 highlights the improved performance of buildings built to modern building codes. These observations are similar to those observed by the MAT in other recent hurricanes.

As previously indicated, buildings built to building codes prior to the 2001 FBC, such as those shown in Figure 4-46 and Figure 4-48, are not provided with design wind speed in this report. Most building codes adopted locally in Florida prior to the 2001 FBC did not specify a wind speed limitation on using conventional construction methods. Thus, the MAT cannot determine with any degree of certainty whether these houses were designed to a specific wind speed (or wind design methodology) or built using conventional construction methods. With the implementation of the 2001 FBC, as well as the 2000 IRC and IBC, the use of conventional construction methods was limited based on wind speed. Where conventional construction was limited, design by a registered design professional or the use of one of the prescriptive “high wind” standards (American Wood Council’s [AWC’s] *Wood Frame Construction Manual* [WFCM], ICC 600, SSTD 10, etc.) was required. Conversely, buildings built to the 2001 FBC and later editions, like the houses depicted in Figure 4-47 and Figure 4-49, are provided with design wind speeds.

Figure 4-46: A Pre-FBC two-family home (built in 1990) with severe structural damage from wind (EWS = 113 mph) (St. James City)

Figure 4-47: A house built in 2022 just before the storm with no visible damage (EWS = 113 mph; DWS = 161 mph) (St. James City)

Figure 4-48: A multi-family condominium built in 1979 with wind damage to the roof and second-story side walls missing (EWS = 130 mph) (Boca Grande)

Figure 4-49: A house built in 2022 that had no visible signs of damage (EWS = 130 mph; DWS = 150 mph) (Boca Grande)

4.4. Manufactured Homes

The MAT observed manufactured homes in Lee and Charlotte counties. Manufactured homes are included on property appraisal websites maintained by counties and municipalities, but the date listed is the date that manufactured homes were installed in the referenced locations and not necessarily the date they were constructed in the factory. However, since HUD-required identification plates were rarely available and manufactured homes are seldomly relocated in Florida, the Hurricane Ian MAT Report uses the county parcel data as a proxy for the year built, unless the county's information was obviously and significantly different than the apparent age of the observed manufactured home, given the following information on HUD construction codes.

4.4.1. POST-HUD CONSTRUCTION PERFORMANCE VERSUS OLDER MANUFACTURED HOMES

Prior to 1975, there were no mandatory federal regulations or standards governing the design and construction of manufactured homes. Since 1976, HUD's MHCSS, or "HUD codes," have regulated the design and construction of factory-built manufactured homes. As described in Section 2.5 of this report, HUD codes were strengthened in 1994 to provide greater resistance to high winds but have not changed significantly since then. Hurricane Ian MAT observations included in this report only distinguish between manufactured homes constructed before or after July 13, 1994. Therefore, manufactured homes constructed after July 13, 1994, will be referred to as "post-HUD" units in this report, while those constructed before July 13, 1994, will be referred to as "older" units (i.e., "pre-HUD" or "early-HUD").

Wind Speed Measurement

Wind speeds provided in the 1994 HUD codes are based on ASCE 7-88, which uses fastest mile wind speeds that were determined by recording the time required for 1 mile of wind to pass through a designated measuring point. ASCE 7-95 and subsequent editions of ASCE 7 use 3-second gust wind speeds that are measured using an averaging time of 3 seconds. The change in ASCE 7 was needed for consistency with updated instrumentation and measurement protocols at the National Weather Service. This MAT report uses Table C26.5-7 in the ASCE 7-16 Commentary to convert fastest-mile wind speeds to equivalent 3-second gust strength design-level wind speeds.

In accordance with the post-HUD wind design requirements, both Lee and Charlotte Counties are within Wind Zone III, where the design wind speed is 110 mph (fastest mile wind speed, based on ASCE 7-88). The HUD Wind Zone III fastest mile design wind speed of 110 mph converts to approximately 125 mph for 3-second gust basic wind speeds (see above textbox for conversion reference source). When the HUD Wind Zone III 125 mph 3-second gust basic wind speed is further converted from allowable stress design wind speeds to strength design basic wind speeds for Risk Category II buildings and structures (as introduced in ASCE 7-10), the equivalent 3-second gust basic wind speed for HUD Wind Zone III is approximately 160 mph (reference 2021 IBC Section 1609.3.1 for conversion), which is very close to the basic wind speeds required for buildings scoped by the current edition of the FBCR in the same areas visited by the MAT. However, the similarity is misleading with respect to the resulting wind loads that govern design because of the many changes to other wind load parameters between ASCE 7-88 and ASCE 7-16. Examples of key changes in ASCE 7 since the 1988 edition and in the 7th Edition (2020) FBCR for site-built homes that are not considered in HUD manufactured homes include:

- Higher component cladding loads for roof elements, including the roof covering, roof decking thickness, and roof decking attachment

- Increased roof sheathing attachment methods
- Improved testing of windows and doors for wind loads and water infiltration
- Impact protection of glazed openings from wind-borne debris
- Improved soffit installation and details
- Sealed roof decks for roofs (secondary water barrier)
- New design wind speed maps based on 30 plus years of new data and improvements to the hurricane models

Aside from damage incurred from attached appurtenances as described in Section 4.4.2, structural damage to post-HUD manufactured homes was uncommon in Lee and Charlotte Counties. Conversely, many older manufactured homes were destroyed, as shown in Figure 4-50.

Figure 4-50: Structural damage to pre-HUD manufactured homes (EWS = 129 mph) (Lee County)

Although Hurricane Ian structural wind damage to post-HUD manufactured homes was limited, envelope damage was widespread. In particular, observed roof covering and wall covering damage was widespread; glazed opening damage was also observed. Like site-built residential buildings, the envelope breaches enabled wind-driven rain to penetrate the damaged manufactured homes, resulting in costly repairs or need for replacement.

Figure 4-51 illustrates typical envelope damage to a post-1994 manufactured home in Charlotte County, including damage to the roof covering (asphalt shingle roof replacement is underway), vinyl siding, and fascia. The manufactured home also suffered wind-borne debris damage, as shown in Figure 4-52, where it appears the aluminum clamshell shutters (not rated to protect glazing in the WBDR[4]) failed or were not properly deployed. The image at right in Figure 4-52 shows shutters still in place along the adjacent wall. The Manufacturer's Data Plate was attached to the unit and indicated a model year of 2012 and Wind Zone III construction.

Figure 4-51: Roof covering, wall covering, and fascia damage to post-HUD manufactured home (EWS = 126 mph) (Charlotte County)

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[4] See Section 2.3.2 for definition of WBDR in Florida.

Figure 4-52: Wind-borne debris damage to glazing and non-rated impact protective system (left); aluminum clamshell shutters remain in place on adjacent wall of same post-HUD manufactured home (right) (EWS = 126 mph) (Charlotte County)

Figure 4-53 is another representative case of envelope damage to a post-1994 manufactured home. In this case, a tarp was placed over the damaged roof covering to help protect it from further damage. Siding was also blown off from the end wall and just below the fascia on the adjacent exterior wall. According to Lee County parcel data, the damaged manufactured home was installed (and assumed constructed) in 2005.

Figure 4-53: Post-HUD manufactured home with roof and wall covering damage (EWS = 118 mph) (Lee County)

4.4.2. APPURTENANCE DAMAGE TO POST-HUD MANUFACTURED HOMES

Carports, decks, porches, and awnings are often attached after the manufactured home has been installed. Chapter 15C of the Florida Administrative Code requires that additions "shall be free-standing and self-supporting with only the flashing attached to the main unit unless the added unit has been designed to be married to the existing unit (15C-2.0081)."

As observed in the Hurricane Irma MAT Report (FEMA 2018d: Section 4.3.2), the Hurricane Charley MAT report (FEMA 2005: Section 7.4), and in FEMA Recovery Advisories 4 and 5 for the 2007 tornado outbreak in central Florida, *Understanding and Improving Performance of Older Manufactured Homes During High-Wind Events* (2007c) and *Understanding and Improving Performance of New Manufactured Homes During High-Wind Events* (2007b), respectively, wind damage to manufactured homes is frequently initiated when improperly attached appurtenances are blown off or damaged. Specifically, when carports and covered porches—which are particularly vulnerable to wind loads—break away from the manufactured home, they leave openings at failed connections in the remaining roof and/or wall that enable rain to enter the manufactured home envelope. The openings left by noncompliant appurtenance attachments can also initiate additional damage to adjacent roof and wall systems.

The following examples of post-HUD manufactured home damage initiated by improperly attached appurtenances were observed during the Hurricane Ian MAT deployment. Figure 4-54 shows a 2019 manufactured home in Charlotte County that lost the attached carport during Hurricane Ian, which created an opening along the entire length of the unit. A 1999 manufactured home located in Charlotte County and shown in Figure 4-55 lost the front portion of the attached carport, opening the envelope to wind-driven rain and potentially initiating or exacerbating the roof damage observed over the main unit. Note that neither carport was supported by posts along the exterior wall; instead, the appurtenances were attached along the top of the exterior wall.

Figure 4-54: A 2019 manufactured home where the loss of the carport damaged the main unit where it was attached, as indicated by the red rectangle (EWS = 126 mph) (Charlotte County)

Figure 4-55: 1999 manufactured home; damage to main unit from loss of the front section of the attached carport, as indicated by the red rectangle (EWS = 129 mph) (Charlotte County)

The MAT also observed manufactured homes where appurtenances were destroyed, but because they were supported independently by columns along the main unit, their failure didn't cause further or significant damage to the main unit. Figure 4-56 shows a 2014 manufactured home located in Lee County that lost the patio roof structure and screened porch but was left intact. The 2005 manufactured home located in Charlotte County, shown in Figure 4-57 lost the front portion of the double carport to high winds but did not suffer additional damage because, in accordance with Section 15C-2.0081 of the Florida Administrative Code, it was not structurally attached to the main unit.

Source: Lee County Property Appraiser, used with permission (top)

Figure 4-56: Pre-storm image of a 2014 manufactured home that appeared to be undamaged by destroyed carport (top); red arrows indicate posts remaining from lost carport (bottom) (EWS = 118 mph) (Lee County)

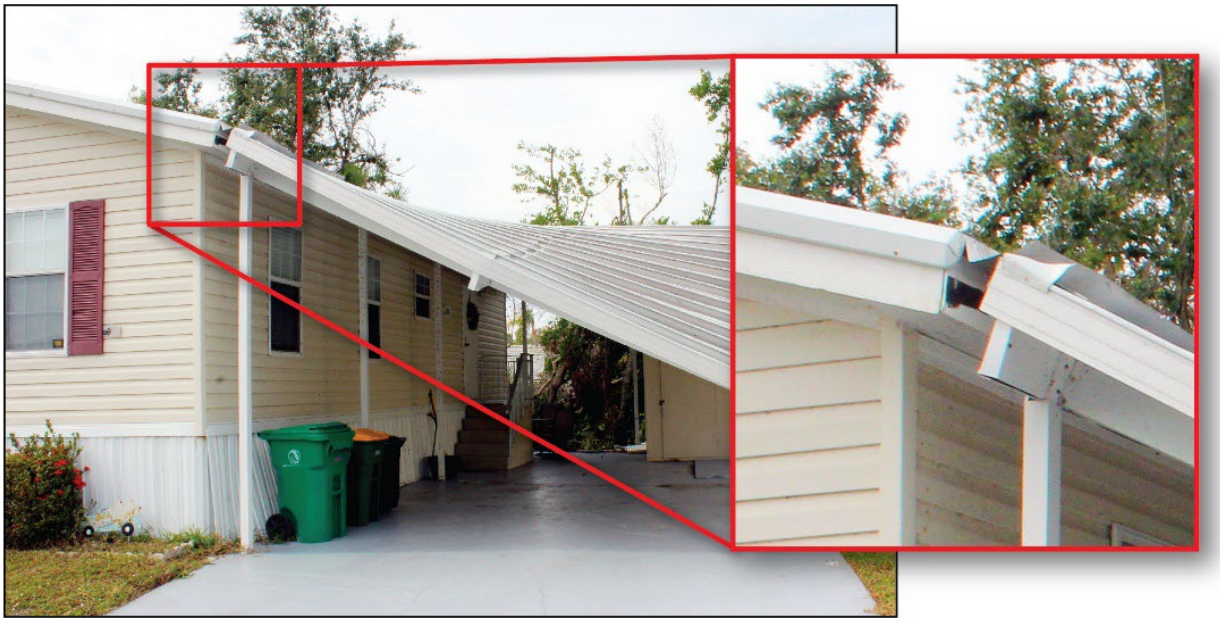

Figure 4-57: A 2005 manufactured home with damaged carport; red square shows where independent support column prevented damage from spreading to the main unit (EWS = 129 mph) (Charlotte County)

4.4.3. ANCHORING

When observing wind-related performance of manufactured homes post-Hurricane Ian, the MAT looked for evidence of anchorage failures. Among the anchoring failures observed were a manufactured home in Lee County that appeared to have been lifted and set back down again due to buoyant forces from floodwater inundation (see Figure 4-58). Several manufactured homes appeared to have been delivered prior to the storm but were not yet permanently installed (see the example in Figure 4-59), The MAT observed no apparent wind-related anchoring failures of installed post-HUD code manufactured homes.

Figure 4-58: Manufactured home with shifted, unstable dry-stack pier foundation; observations included a HWM approximately 6 inches above the top of the finished floor (Lee County)

Figure 4-59 shows an overturned manufactured home and running gear assembly (chassis subsystem consisting of suspension springs, drawbar, axles, bearings, wheels, hubs, tires, and brakes with their related hardware)[5] that appeared to have been temporarily anchored and awaiting permanent installation prior to the onset of the storm. The MAT concluded that the temporary anchors failed when subjected to Hurricane Ian's high winds. The rectangle with inset on the right side of the figure shows an intact 48-inch-long helical anchor that withdrew from the surrounding soil; the two circles show the remaining metal straps from anchors that failed in tension, and the rectangle with inset on the left side of the figure shows an anchor that remained in place. Although Section 15C-2.011 of the Florida Administrative Code requires the manufactured home dealer to disclose whether the running gear assembly is included in the sale of the unit, the MAT found no requirements for pre-installation anchorage in either the Florida Administrative Code or the HUD codes.

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[5] Definition of "running gear assembly" as provided in Section 15C-2.011 of the Florida Administrative Code

Figure 4-59: Overturned manufactured home that appeared to have been delivered but not yet permanently installed prior to the storm (EWS = 129 mph) (Lee County)

5. Critical Facility–Related Observations

Hurricane Ian significantly affected many critical facilities, with impacts varying from non-structural, to structural damage, to interruption of operations, such as loss of potable water supply. Hurricane Ian highlighted the challenges faced by HESs in terms of shortages of the correct types of structures available, the complications of sheltering for long durations, and the difficulties in operating a shelter without potable water supply. This chapter describes the MAT's observations of the performance and operational challenges that critical facilities faced during and immediately following Hurricane Ian. Hospitals, fire rescue facilities, and HESs are critical to disaster response and recovery operations. Interruptions of service may prevent, delay, or impede rescue or other operations from effectively or efficiently occurring. These interruptions also hinder critical healthcare facilities from operating as intended and reduce needed help and support to the impacted population, including the most vulnerable and displaced people.

Section 5.1 discusses the performance of utilities in Lee County. Section 5.2 discusses the building performance and operational performance of health care facilities. Section 5.3 discusses the building performance and operational performance of HESs and the relationship of their performance to Florida's shelter deficit and shelter program overall. Section 5.4, Section 5.5, and Section 5.6 discuss the flood and wind performance of fire stations, police stations, and schools. The facilities described within this chapter were specifically selected from a much larger group of damaged critical facilities, because they were either representative of various performance and/or operational issues and trends or offered an opportunity to identify best practices for resiliency.

Estimated Wind Speeds

NIST and ARA developed a windfield map showing estimated surface-level winds for Hurricane Ian in Florida (estimated wind speeds). The map, completed in support of a rapid response Mission Assignment from FEMA, depicts estimated 3-second gust wind speeds for Exposure Category C at a height of 33 feet (10 meters) above ground.

Basic (Design) Wind Speeds

For structures visited by the MAT and discussed herein, basic wind speeds (for this MAT report, the basic wind speeds associated with a building's design criteria are referred to as "design wind speeds") are provided for comparison to Hurricane Ian estimated wind speeds when buildings were constructed after March 2002 (effective date of the 1st edition of the FBC [2001]). To determine basic wind speeds when building design criteria were not available, the MAT referenced the FBC version at time of construction. The 2001 FBC references ASCE 7-98; the 2004 FBC references ASCE 7-02; and the 2007 FBC references ASCE 7-05. The 7th edition (2020) FBC, which was in effect when Hurricane Ian made landfall, references ASCE 7-16. For buildings built prior to the 2001 FBC, the basic wind speed is not stated as the basic wind speed could have varied from jurisdiction to jurisdiction depending on the locally adopted building code.

The ASCE 7 wind provisions changed significantly in ASCE 7-10 when new ultimate basic wind speed maps were provided for Risk Category I, Risk Category II, and combined Risk Category III/Risk Category IV. ASCE 7-16 closely followed the wind provisions of ASCE 7-10, though an individual Risk Category IV ultimate basic wind speed maps were added in ASCE 7-16. The wind provision changes in ASCE 7-10 made wind speed comparisons between ASCE 7-05 (nominal) and ASCE 7-10 (ultimate) much less clear.

In this MAT report, ***comparable*** ASCE 7-16 wind speeds are provided for ASCE 7-98, ASCE 7-02, and ASCE 7-05 wind speeds for the essential and critical facilities visited by the MAT. The *comparable* ASCE 7-16 wind speeds are based on the Chapter 2 load factors contained in ASCE 7-05 and ASCE 7-16 and the importance factors contained in Chapter 6 of ASCE 7-05. For Risk Category III and IV structures, a factor of 1.356 is applied to the ASCE 7-05 basic wind speed to obtain the *comparable* ASCE 7-16 basic wind speed. The 1.356 factor is the product of the square root of the 1.15 Risk Category III and IV importance factor in ASCE 7-05 and the square root of the 1.6 wind load factor from ASCE 7-05 (this wind load factor is 1.0 in ASCE 7-16). The term *comparable* is used because the result only considers importance and wind load factors and does not consider the new ASCE 7-16 ultimate basic wind speed maps. These comparison factors also apply to ASCE 7-98 and ASCE 7-02.

Unless otherwise indicated, the basic/design wind speeds were obtained from the Basic Wind Speed maps from the respective edition of the ASCE 7. The basic/design wind speeds referenced in this chapter are 3-second gust wind speeds at a height of 33 feet for Exposure Category C unless otherwise indicated.

All of the critical facilities visited experienced wind loads that were well below ASCE 7-16 wind speeds for Risk Category IV (essential facilities) structures.

Figure 5-1 shows the location of critical facilities visited by the MAT and highlighted in this chapter along with a comparison of the design wind speed for Risk Category IV structures and the Hurricane Ian windfield. Table 5-1 describes the nature of occupancy for each Risk Category for reference.

Water surface elevations varied from 50-year to 200-year recurrence intervals for critical facilities that were subjected to flooding.

Critical Facilities versus Essential Facilities

Critical facilities are defined by FEMA as buildings that are essential for the delivery of vital services or protection of a community. Critical facilities include emergency operation centers, healthcare facilities, police and fire stations, schools, and power stations. These facilities support critical community lifelines that enable the continuous operation of critical business and government functions and are essential to human health and safety or economic security.

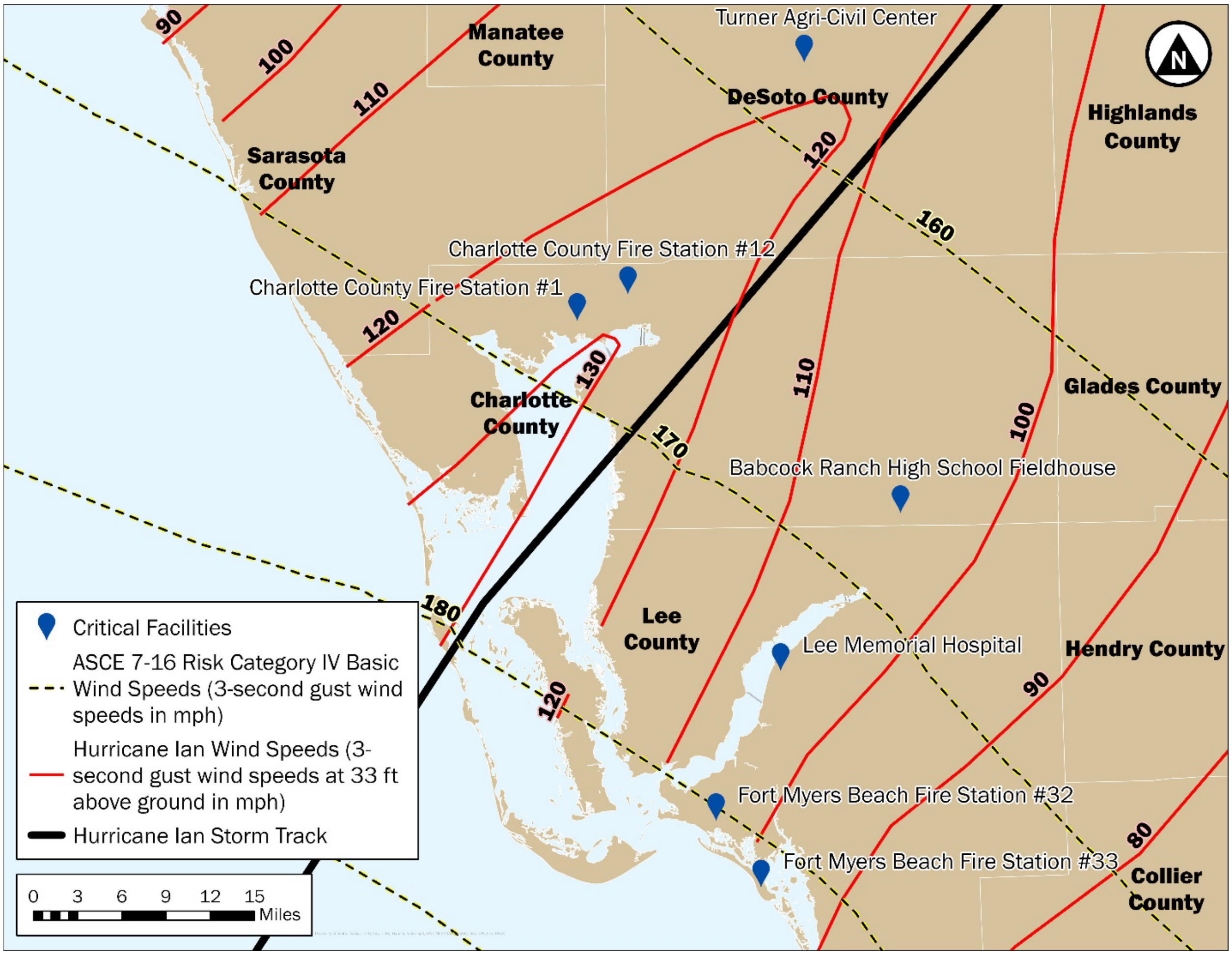
Essential facilities are defined by ASCE 7-22, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE, 2022) and the forthcoming 2023 FBCB and 2024 IBC as "buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, tornado, snow, or earthquakes." Essential facilities are also designated as Risk Category IV structures.

For this MAT report, critical facilities and essential facilities are synonymous.

Table 5-1: Risk Category Comparison

Risk Category	Nature of Occupancy
I	Buildings and other structures that represent a low hazard to human life in the event of a failure. Most commonly attributed to agricultural facilities.
II	Buildings and other structures except those listed in Risk Categories I, III, and IV. Most commonly attributed to residential structures and non-residential structures with a low occupant load and non-emergency functions.
III	Buildings and other structures that represent a substantial hazard to human life in the event of a failure. Most commonly attributed to educational facilities and medical offices without emergency services. See Table 1604.5 of the 2021 IBC for additional information and details.
IV	Buildings and other structures designated as essential facilities. Most commonly attributed to hospitals with emergency services; fire, rescue, and police stations; and hurricane evacuation shelters. See Table 1604.5 of the 2021 IBC for additional information and details.

Source: Table 1604.5 from the 2021 IBC, used with permission



Source: With permission from ASCE, NIST

The blue map pins reflect critical facilities whose wind performance is covered in this chapter. ASCE 7-16 wind speeds are shown to demonstrate the expected design wind speed for a new Risk Category IV building at the facility location.

Figure 5-1: ASCE 7-16 Risk Category IV wind speeds compared with Hurricane Ian windfield

5.1. Utilities

The high winds from Hurricane Ian resulted in the regional loss of electrical service. In Florida, 3.28 million customers statewide, including approximately 85% of the connections in Lee County and Charlotte County, lost power. For most critical facilities visited by the MAT, the loss of electrical service did not result in a loss of operations, as standby generators were able to provide electricity to bridge the gap until electrical service could be restored. For example, the MAT visited a water treatment facility that successfully operated on power supplied by generators for two weeks after Hurricane Ian, until power service was restored. However, there were reports of generator failures that hindered some critical facilities from operating or performing their missions as intended. Ultimately, the loss of potable water service to some critical facilities significantly interrupted their operations and resulted in the evacuation of three Lee County hospitals, in particular. Although critical facilities typically prepare in advance for power outages, they may not adequately prepare for prolonged interruption of potable water service.

In addition to the observations and information that follows, refer to Hurricane Ian in Florida, Recovery Advisory 2, *Reducing "Loss of Utility" Impacts in Critical Facilities* (FEMA 2023c).

5.1.1. LOSS OF POTABLE WATER

The loss of potable water service was most widespread in Lee County, where almost all utility providers reported a complete loss of potable water service. This near county-wide outage resulted in the most serious impacts to the operations of critical facilities. While critical facilities in Charlotte and DeSoto Counties did experience potable water outages, the outages were more isolated and had location-specific issues. The primary cause of the loss of potable water in Lee County was the breaking of thousands of small-diameter pipes in residential areas. Service lines in residential areas were commonly broken through two scenarios. In the first scenario, trees planted over or near residential service lines, which run from the water main in the street to the house, were uprooted. In the process of uprooting, the service lines were pulled up by the tree's root ball and broken. In the second scenario, above-grade meters, backflow preventor valves, and service lines were broken by either flood or wind-borne debris (Figure 5-2).

Source: Cape Coral Utilities (Image used with permissions)

Broken above-grade service lines (1) and water meters with backflow preventor valves (2)

Figure 5-2: Broken above-grade potable water lines (Lee County)

These thousands of pipe breaks resulted in a loss of system pressure throughout Lee County. In Cape Coral, pressure dropped from a normal operating level of approximately 80 pounds per square inch (psi) to 5 psi. Because of the drop in system pressure, many hospitals and other critical facilities in Lee County began to report the loss of potable water.

For hospitals and other critical facilities, the loss of potable water affected more than just the supply of water for drinking. The loss of potable water also meant water was not available for sanitary requirements, such as hand washing and toilet flushing, and water-cooled chillers required to control interior temperature and humidity levels. More importantly, the loss of potable water meant that wet fire suppression systems, which are required by code to be operational to allow buildings to be occupied, unless a fire watch is staffed, could not operate. To remain occupied, critical facilities needed to staff fire watches, as required by the local authority having jurisdiction (AHJ); overcome difficult sanitary conditions; and provide water to HVAC systems. Ultimately, the delay in restoring the potable water supply resulted in the evacuation of three hospitals in Lee County as ordered by Florida's Agency for Health Care Administration (AHCA).

As a result of the slow movement and the large size of Hurricane Ian, utility crews were unable to begin recovery efforts until late in the evening on September 28 or until daylight on September 29, 2022. Utility crews were dispatched to close isolation valves from the primary water mains to service lines that provide service to residential areas where leaks were suspected. The efforts to close the isolation valves were hampered by storm debris cluttering streets and valve operators.

For Cape Coral Utilities (CCU), the priority was isolating the water main that supplies water to Cape Coral Hospital in order to restore water service at the necessary water pressure, enabling the wet fire suppression system to regain function. Prior to Hurricane Ian, CCU did not have an established plan identifying which valves would need to be closed to isolate the water main to Cape Coral Hospital and other critical facilities. To restore water supply to Cape Coral Hospital, hundreds of valves along the 8.5-mile-long water main between the water treatment plant and the hospital needed to be closed. Once those valves were closed, CCU was able to increase the water pressure to the necessary level for operation of the hospital's wet fire suppression system before the evacuation deadline.

Once water distribution was restored to Cape Coral Hospital and other critical facilities, CCU worked to restore potable water to the remainder of the service area. Repair crews worked section by section to further isolate individual houses where service lines were broken until all leaks within the designated area were stopped. Once leaks in a section of pipeline was isolated, the section could be pressurized to operational levels and brought online. This effort was repeated countless times until the entire water distribution system was able to maintain system pressure and pass water quality and sanitary tests to ensure safe water consumption. CCU was able to restore full operational capacity to its potable water distribution system on October 8, 2022, when the boil water notice was rescinded, roughly 10 days after landfall. The remaining areas within Lee County, including Fort Myers, had the boil water notice rescinded on October 13, 2022.

5.1.2. LOSS OF SEWAGE SERVICE

Loss of sewage service was often tied to loss of power or to locations where floodwater inundated lift stations (Figure 5-3). For lift stations that lost power and were not equipped with standby generators, the wells could not be emptied, resulting in backups within their area of service. In areas where floodwater inundated lift stations, at-grade electrical equipment failed and the wet wells were filled with floodwater, surcharging the sewer system in the area.

The generator (circled) for the lift station has been elevated to help reduce flood vulnerability and improve resilience for future events.

Figure 5-3: At-grade sewer lift station repaired after Hurricane Ian (Charlotte County)

CCU supplies potable water, wastewater, and irrigation water to portions of Lee County. Although wastewater treatment capacity was not interrupted, Hurricane Ian did interrupt portions of the wastewater collection system, namely those portions that have lift stations that are not equipped with standby generators. Of the roughly 320 lift stations in CCU’s system, only 22 stations (6.9%) had on-site generators; the other lift stations had provisions for power to be supplied by portable generators.

FlaWARN: Florida Water/Wastewater Agency Response Network

Commencing in 2005, FlaWARN is a formalized system for water/wastewater utilities to provide mutual aid during natural disasters and other emergency situations. FlaWARN was modeled after California Water/Wastewater Response Network. FlaWARN is made up of water and wastewater utilities across Florida, assisted by regulatory, technical, and law enforcement agencies. In addition to 125 member utilities, FlaWARN collaborates with the FDEP, the University of Florida Training, Research and Education for Environmental Occupations Center, the Florida Rural Water Association, the State Emergency Response Team, the Florida Section of American Water Works Association, the Florida Water & Pollution Control Operations Association, the Florida Water Environment Association, and the Southeast Desalting Association.

After Hurricane Ian, potable water service in some areas was restored before utility power. This resulted in numerous sanitary sewer overflows that occurred when the wet wells of sewer lift stations filled with sewage but could not be pumped. CCU and Lee County requested assistance from FlaWARN to bring numerous portable generators to lift stations to pump down the wet well levels before backflows could occur. Utility crews needed to move portable generators from lift station to lift station to keep sewage levels down, as there were more lift stations than available generators. With portable generators being brought in from various utilities within the state, some portable generators were found to be unusable because of incompatible wiring of the prewired generator connections.

5.2. Health Care

The building performance and operational performance of health care facilities in the path of Hurricane Ian varied significantly. Health care facilities sustained minor wind damage to building envelopes or were inundated by floodwater. Hurricane Ian’s impact to health care facilities in Florida revealed that facilities do not need to sustain flood or wind damage to lose the ability to operate. Some hospitals became temporarily surrounded by floodwater, while others were forced to halt operations and were required to evacuate as a result of a prolonged potable water outage.

5.2.1. LOSS OF POTABLE WATER/NEED TO EVACUATE

The loss of potable water service primarily impacted hospitals in Lee County. The loss of potable water service meant the necessary water pressure for wet fire suppression system operations was unavailable. The loss of the fire suppression system required hospitals to staff fire watches. Reports provided from water utilities to the Lee County Emergency Operation Center and Florida’s AHCA indicated a timeline for the restoration of potable water service. Hospitals were given until 4PM on Friday, September 30, 2022, to either establish a potable water supply or evacuate. This section will focus on the operational challenges caused by loss of potable water encountered by the acute care and specialty hospitals operated by Lee Health.

Within Lee County, Lee Health operates four acute care hospitals, two specialty hospitals, three skilled nursing facilities, and approximately 100 medical offices, such as outpatient clinics and doctors’ offices. Hospitals were able to overcome the loss of electrical utility power with robust standby power systems consisting of diesel generators with a minimum of 7 days of fuel to supply power. However, hospitals did not plan for the extended loss of potable water. The loss of potable water had immediate impacts on wet fire suppression systems, water-cooled HVAC equipment, and sanitary needs.

Building engineers and managers used a variety of approaches to minimize the impact the potable water outage had on the operations of the hospitals. Bucket brigades initially took water from on-site stormwater detention ponds and later from water trucks, to manually recharge toilets to enable flushing. Without water for cooling systems, the temperature and humidity indoors rose rapidly, resulting in high heat-index temperatures that added stress and risk to patients. To supplement the water supply needed for chillers and cooling towers used in the HVAC systems, hoses with pumps were run to stormwater ponds or existing groundwater wells. When stormwater was used, chemicals were added to the water to prevent the growth of algae and bacteria inside the cooling system. In addition to water from stormwater ponds, once roads were passible, water was pumped from potable water trucks to supplement water supply and to help increase water pressure (Figure 5-4).

Source: Lee Health (Image used with permissions)

Figure 5-4: Potable water truck and pump supplemented on-site stormwater for operating HVAC equipment and flushing toilets (Lee County)

One of the challenges with using potable water trucks was the time it took to refill the trucks once emptied. After Hurricane Ian, the closest utility filling water trucks was in Bonita Springs. Normally, the drive to Bonita Springs would take approximately 30 minutes, one way. With road closures and traffic congestion on the roads that were still open following the storm, a one-way trip took each truck 3 to 4 hours.

The emergency measures described above helped many of Lee Health's hospitals and medical facilities to remain operational during and immediately following Hurricane Ian. Nevertheless, because of the prolonged potable water service outage, Health Park Medical Center, Gulf Coast Medical Center, and Golisano Children's Hospital began patient evacuations at 4PM on Friday, September 30, 2022.

5.2.2. BUILDING PERFORMANCE

During Hurricane Ian, the wind performance of hospitals and other Risk Category IV structures was not actually "wind tested" as the wind design criteria of newer buildings are far greater than what they were subjected to by Hurricane Ian wind speeds. This means even if the building "performed well," it was expected to, because it was designed to much higher wind speeds. However, if and when wind damage did occur, it raises questions as to why. Most of the wind damage to critical facilities observed by the MAT and reported to the MAT by others, was envelope damage and minor wind-driven rain intrusion (Figure 5-5). However, there were isolated incidents of more severe wind damage to hospitals in Lee and Charlotte Counties that impacted operations.

Source: Lee Health (Images used with permissions)

Figure 5-5: Superficial wind damage at hospitals (Lee County)

Lee Memorial Hospital

Lee Memorial Hospital (Figure 5-6) is a 368-bed facility built in 1968. The approximately 366,000-square-foot hospital is located in a Zone X on the FIRM, which was effective August 8, 2008 and was in effect at the time Hurricane Ian made landfall. This hospital did not experience flooding during Hurricane Ian.

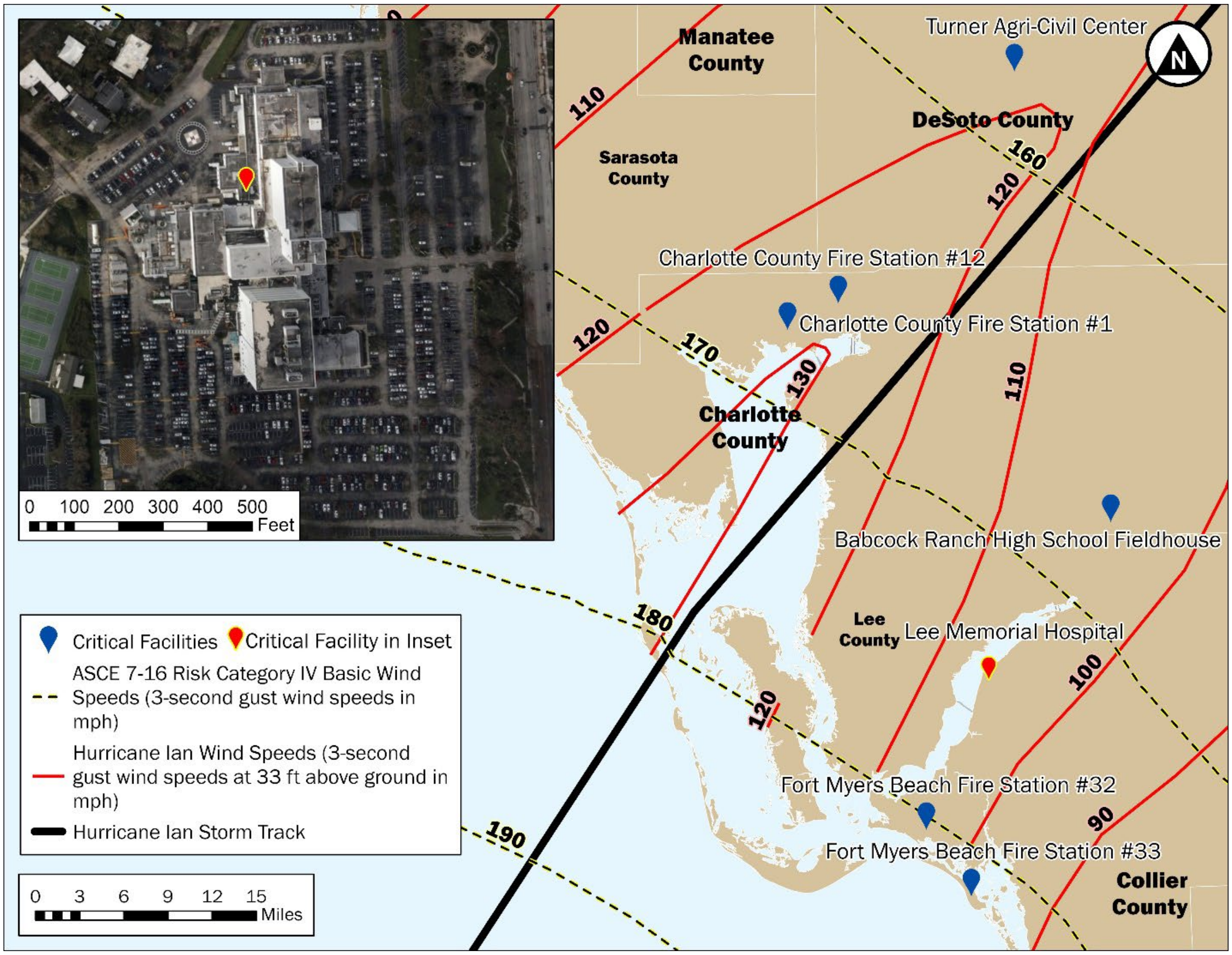
Lee Memorial Hospital

Date of Construction = 1968

Estimated Wind Speed = 105 mph (3-second gust)

Design Wind Speed = unknown

ASCE 7-16 Basic Wind Speed (Risk Category IV) = 174 mph (3-second gust)



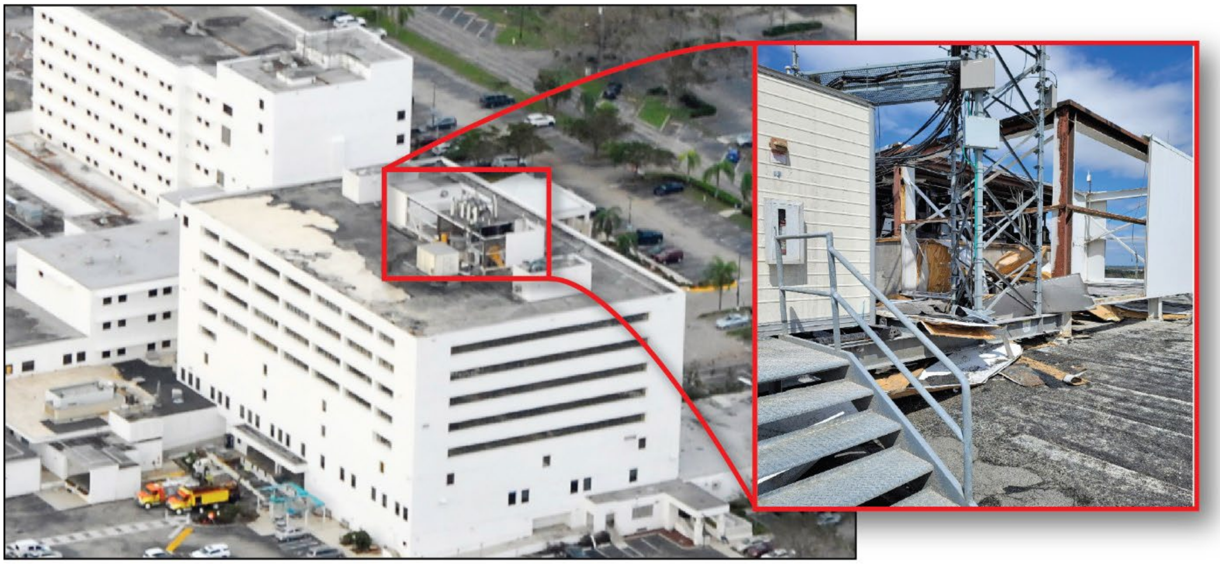
Source: NIST

Figure 5-6: Location of Lee Memorial Hospital (red map pin) in the Hurricane Ian windfield

During Hurricane Ian, sections of the roof cover and the rooftop elevator penthouse of Lee Memorial Hospital were damaged (Figure 5-7). The damage to the roof cover was not unexpected, as the cover was 20 years old and was scheduled to be replaced. The damage to the penthouse resulted in damage to three of the hospital’s four elevators.

Building Performance and Operational Performance:

- Roof cover, rooftop elevator penthouse, and three elevators were damaged.
- Hospital operations prioritized the usage of the non-damaged elevator for critical activities, such as moving patients between floors, until repairs were completed.



Source: Civil Air Patrol, left and Lee Health, right (Image used with permissions)

Figure 5-7: Damage to elevator penthouse at Lee Memorial Hospital (Lee County)

Lee Heath Facilities

Lee Health owns and operates more than 100 facilities that were impacted by Hurricane Ian. These facilities, which were constructed from the 1960s to 2022, were subject to high winds and wind-driven rain, and at isolated locations, to flooding. After Hurricane Ian, Lee Health estimated the damages to its facilities as totaling approximately $15 million with most of the cost associated with repairing the damaged elevators at Lee Memorial Hospital and the flood damage to Medical Plaza One (Figure 5-8). Flooding at Medical Plaza One, located in a Zone AE 10 (Figure 5-9), was approximately 6 inches above the lowest floor.

Medica Plaza One

Date of Construction = 1993

Flood Zone and BFE per FIRM effective at time of construction = Zone A10 (9 NGVD 29) / Zone A10 (8 NAVD 88) (FIRM effective September 17, 1984)

Flood Zone and BFE per FIRM effective at the time of Hurricane Ian = Zone AE 9 (NAVD 88) (FIRM effective September 25, 2009)

Measured Water Surface Depth = 6 inches above the lowest floor

Source: Lee Health (Images used with permissions)

The water level at Medical Plaza One was estimated to be roughly 6 inches above the lowest floor.

Figure 5-8: Flood damage at Medical Plaza One (Lee County, Zone AE)

Figure 5-9: Effective FIRM for Medical Plaza One location at the time of Hurricane Ian's landfall

Southwest Florida Hospital

During Hurricane Ian, roof and rooftop equipment failures caused building damage that resulted in a loss of operational capacity for a southwest Florida hospital, whose operators requested to remain anonymous in this report. While available data prevented the MAT from accurately determining the failure progression, post-event aerial imagery suggests that the roof membrane, installed in 2021, detached at two locations on the roof. One location was over a stairwell at the east end of the main hospital tower. The second location was along the mansard that runs along the south side of that tower (Figure 5-10). Both locations are in portions of the roof where suction pressures are at their greatest. When the roof membrane detached from these areas, the roof membrane inflated. The inflated roof membrane displaced five rooftop exhaust fans, which breached the building envelope and allowed water to enter the building. One of the displaced exhaust fans struck a pressurized wet fire protection standpipe that extended above the roof line (Figure 5-11). The impact from the exhaust fan caused a valve to break, which allowed more water to enter the breached envelope.

Southwest Florida Hospital

Estimated Wind Speed = 128 mph (3-second gust)

Design Wind Speed = unknown

ASCE 7-16 Basic Wind Speed (Risk Category IV) = 168 mph (3-second gust)

Source: Civil Air Patrol

Figure 5-10: Detached nailing strip over a stairwell (left) and damaged mansard envelope system (right) (Southwest Florida)

Eventually water from the wet fire protection standpipe and rainwater flowed down through the fourth and third Intensive Care Unit floors and to the patient care rooms on the second and first floors. The water entering the hospital forced hospital staff to relocate patients to dry areas on the lowest floor, in wings of the hospital that were separate from the water infiltration. After Hurricane Ian passed, 161 patients had to be evacuated, as a result of the damage, to other hospitals in Florida on the morning of September 29, 2022. After all patients were evacuated, the hospital closed for repairs.

Source: Southwest Florida Hospital (Images used with permissions)

Figure 5-11: Damaged wet fire protection standpipe (left) that resulted in significant water intrusion and damaged exhaust fan and roof cover (right) (Southwest Florida)

The health care group operating this southwest Florida hospital operates dozens of hospitals in Florida. In anticipation of Hurricane Ian, the group pre-staged 40,000 square feet of modified bitumen roofing, roofing components, and other building materials at a local warehouse to accelerate storm damage repair. Three days after Hurricane Ian made landfall, the roof damage was repaired, within 7 days the emergency room (ER) reopened, and within 100 days the hospital was fully operational.

Building Performance and Operational Performance:

- Roof membrane, rooftop equipment, and fire suppression system were damaged.
- Operations were temporarily suspended, but the ER reopened in 7 days, and the hospital was fully operational in 100 days.

Life Care Center of Orlando

Built in approximately 2000, the Life Care Center of Orlando is a 100,000-square-foot, three-story assisted living facility. The 132-room facility is near the Little Econlockhatchee River and located in a Zone X on the current FIRM, which was effective September 25, 2009, on the fringe of the floodplain (Figure 5-12).

Life Care Center of Orlando

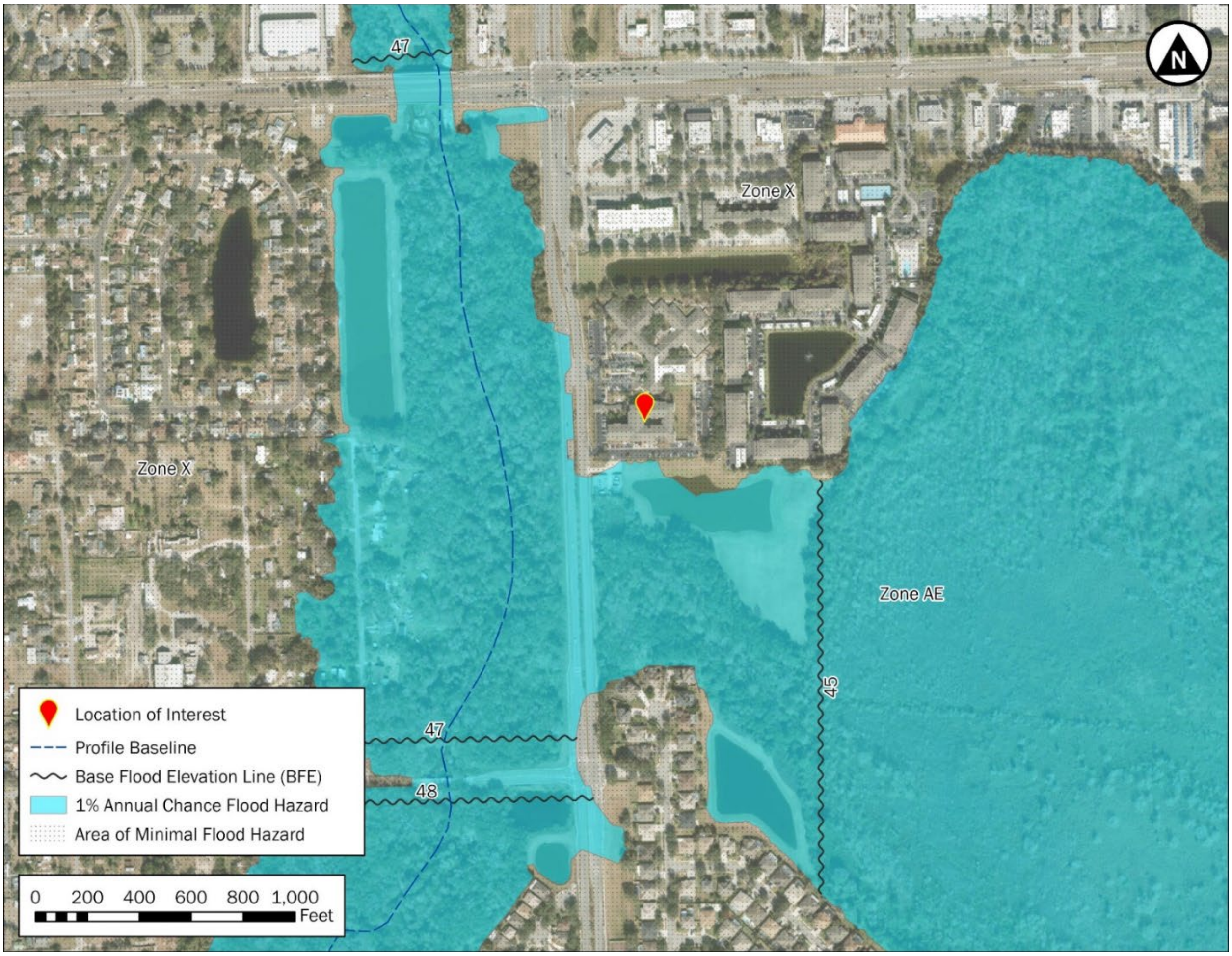
Date of Construction = 2000

Flood Zone and BFE per FIRM effective at time of construction = Zone C, no shading (FIRM effective December 6, 2000)

Flood Zone and BFE per FIRM effective at time of Hurricane Ian = Zone X (FIRM effective September 25, 2009)

Measured Water Surface Depth = 18 inches

During Hurricane Ian, the building sustained approximately 18 inches of flooding, which forced the facility to evacuate the 122 rooms that were occupied at the time. Through coordination with county and state emergency management, and with assistance from the National Guard, the tenants were successfully relocated. Life Care Center of Orlando staff interviewed by the MAT attributed planning and annual/routine exercises prior to Hurricane Ian to the successful evacuation. Excessive rainfall along with inoperable lift (pump) stations caused by power outages, resulted in flooding that caused extensive damage to the ground floor. The facility manager initially estimated in October of 2022 that it would be 10 to 12 months before the facility returned to full operations. As of August 2023, the Life Care Center of Orlando remains closed as a result of ongoing flood damage renovations.



The location of the Life Care Center of Orlando is in Zone X but is on the fringe of the floodplain.

Figure 5-12: Effective FIRM at the Life Care Center of Orlando location at the time of Hurricane Ian's landfall

Building Performance and Operational Performance:

- Rainfall and inoperable lift stations led to extensive flood damage to lowest floor.
- Flooding forced evacuation of patients.

The Osceola Regional Medical Center Trauma Center

The Osceola Regional Medical Center Trauma Center in Kissimmee, FL, is a 404-bed full-service hospital established in 1996. As of March 2023, the hospital is one of 33 trauma centers throughout Florida (one of four in the Orlando area). As a Level II trauma center, the hospital features state-of-the-art medical technology and professionals capable of highly specialized treatment for the most critical injuries. The approximately 500,000-square-foot hospital is located in Zone AE 65 on the FIRM effective at the time of Hurricane Ian's landfall (April 21, 2017) and has three primary towers, which were built in 1996, 2004, and 2017. Although the hospital has just two electric utility feeds, it has sufficient backup power to service the entire hospital, especially the emergency functions.

Osceola Regional Medical Center Trauma Center

Date of Construction = 1996

Flood Zone and BFE per FIRM effective at time of construction = ZONE AH 64 (NGVD 29) / AH 63 (NAVD 88) (FIRM effective July 2, 1981)

Flood Zone and BFE per FIRM effective at time of Hurricane Ian = Zone AE 65 (NAVD 88) (FIRM effective April 21, 2017)

Measured Water Surface Depth = Not applicable

During Hurricane Ian, the hospital campus was flooded, which caused minor flooding of some portions of the hospital (parking garage, helipad, access roads); however, floodwater did not enter the hospital buildings. Water damage to the hospital interior was primarily caused by wind-driven rain and was relatively minor. During the hurricane, 79 staff vehicles were flooded in the parking deck and parking lots as well. Although the flooding of the campus resulted in its isolation, the campus did not have to be evacuated. However, accessing the buildings became more and more challenging, and this significantly impacted the hospital's ability to service the general public. Two hospital helipads were under water and the hospital was temporarily inaccessible by vehicle, resulting in it being isolated and closed to incoming patients for approximately 2 hours. Facility managers established a new ER access for ambulances at a higher point on the hospital campus, enabling the hospital to open to incoming patients again. Although the hospital was temporarily isolated by floodwater and lost electrical utility power, four generators provided sufficient backup power to service the critical functions for the hospital, including the trauma center and its critical operations. Although the hospital did have to limit the use of five rooms because of water intrusion from wind-driven rain and relocate patients within the hospital, it did not evacuate any patients. With the exception of the 2-hour window in which the new access routes were determined, the hospital remained fully operational (Figure 5-13 through Figure 5-17).

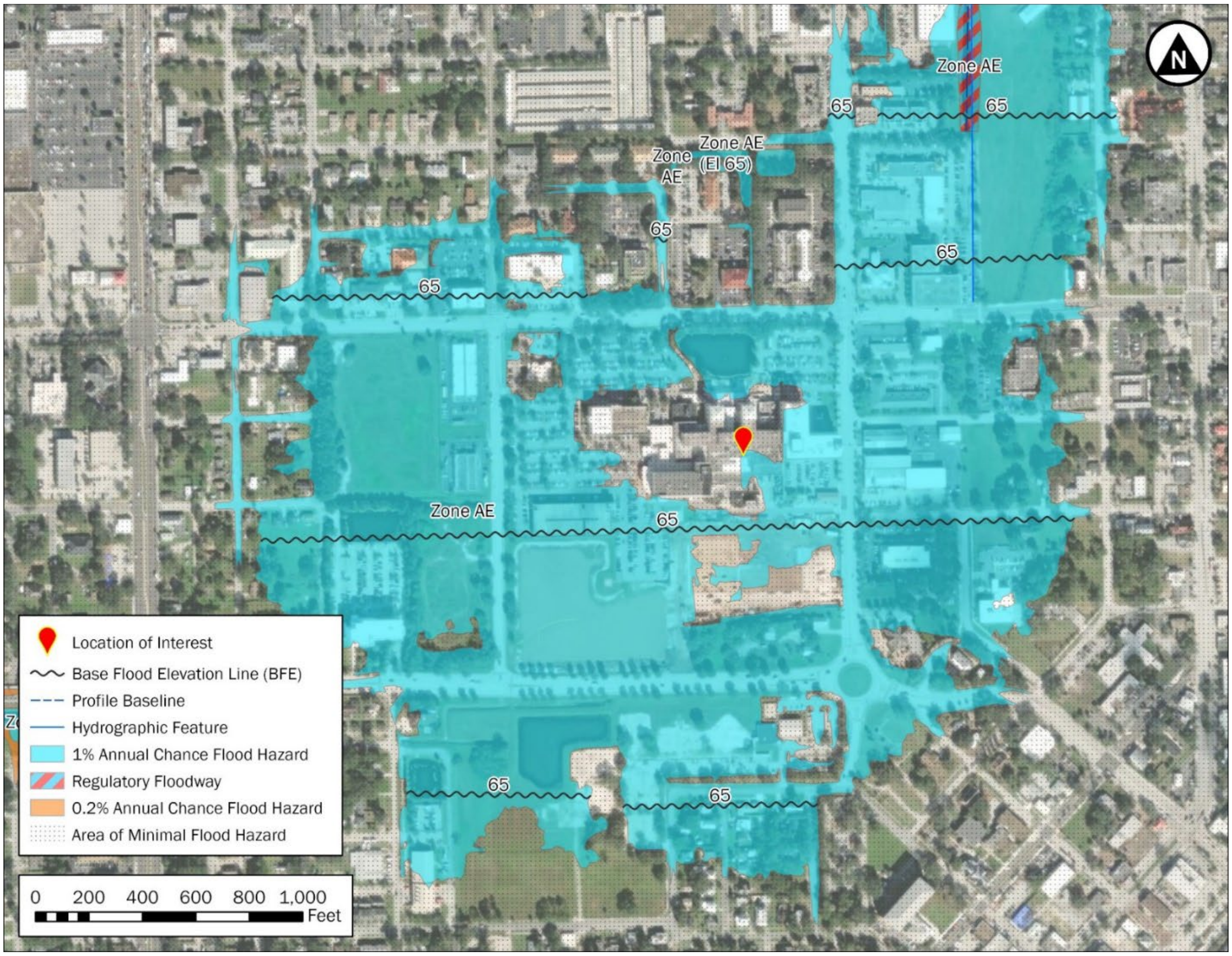


Figure 5-13: Effective FIRM at the Osceola Regional Medical Center Trauma Center location at the time of Hurricane Ian's landfall

Figure 5-14: Osceola Regional Medical Center Trauma Center parking lots that were flooded (Osceola County, Zone AE)

Figure 5-15: Access roads at Osceola Regional Medical Center Trauma Center that flooded, isolating the hospital for 2 hours (Osceola County, Zone AE)

Figure 5-16: Osceola Regional Medical Center Trauma Center parking garage that had approximately 21 inches of water at ground level during Hurricane Ian (Osceola County, Zone AE)

Figure 5-17: Two helipads at Osceola Regional Medical Center Trauma Center that were submerged and inoperable for at least 2 hours during Hurricane Ian (Osceola County, Zone AE)

Building Performance and Operational Performance:

- Floodwater did not enter the facility but flooded the campus and left the facility isolated.
- Patients were relocated within the hospital but evacuations were not needed.

5.3. Hurricane Evacuation Shelters

In response to past hurricane damage and their awareness of shelter space deficits, Florida developed the SESP, which identifies HESs. The SESP is updated every other year to guide local emergency planning and "to provide advisory assistance to school districts contemplating construction of educational facilities and the need to provide public shelter space within those facilities" (FDEM 2022). Although the SESP defines shelters that meet minimum safety performance criteria, several types of shelters offer varying degrees of protection. Table 5-2 presents the terminology for different shelter types.

Florida State Emergency Shelter Plan

Refer to Section 2.4 for more information on Florida's long-established SESP, including the criteria for designating new and existing building areas as HESs. Florida's criteria for HESs differ from FEMA criteria for FEMA P-361 community safe rooms (for hurricanes and tornadoes) and the ICC 500 standard for storm shelters (for hurricanes and tornadoes).

Table 5-2: Shelter Terminology Comparison

Shelter Terminology	Description
FEMA P-361 Safe Rooms	A hardened structure specifically designed to meet FEMA criteria and provide life-safety protection in extreme wind events, including tornadoes and/or hurricanes. To be considered a safe room, the structure must be designed and constructed to the guidelines specified in FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms* (2021a). Safe rooms constructed with FEMA grant funds are required to adhere to the FEMA Recommended Criteria described at the beginning of FEMA P-361 Part B chapters as well as the corresponding ICC 500 requirements (FEMA 2021a).
ICC 500 Storm Shelters	A building, structure, or portion(s) thereof, constructed in accordance with Standard ICC 500, *Standard for the Design and Construction of Storm Shelters*, and designated for use during a severe windstorm event such as a hurricane and/or tornado (FEMA 2021a).
Enhanced Hurricane Protection Area (EHPA) Shelters	A new educational facility, or portion thereof, designed, constructed, inspected, and maintained in accordance with the Public Shelter Design Criteria, section 453.25, *Florida Building Code – Building* (FDEM 2022).
Florida Hurricane Evacuation Shelters (HESs), or Evacuation Shelters	A safe congregate care facility that provides services and is used for populations displaced by an emergency or disaster incident. An evacuation shelter may be located either inside (risk shelter) or outside (host shelter) of the disaster impact area and is typically operational for a period not to exceed 72 hours. Typically, these capacities are determined based on 20 square feet per person (FDEM 2022).
Risk Shelter	Facilities designated as risk shelters may be located within the hazard risk zone (i.e., lie in the forecast path and associated error cone of an approaching hurricane or severe storm). Construction of these facilities meets established minimum safety requirements considered for least-risk decision-making for the community (FDEM 2022).

Shelter Terminology	Description
Host Shelter	A facility that is safe and provides services and is located outside of a hazard risk zone (FDEM 2022).

NOTE: In comparison, only ICC 500-compliant storm shelters and FEMA-compliant safe rooms are designed to provide life-safety protection during tornadoes and hurricanes. The storm type—tornado, hurricane, or combined—chosen for the individual facility dictates storm-specific design criteria. For example, hurricane storm shelters and safe rooms must be designed for longer-duration occupancy than tornado shelters and must be sited and elevated to mitigate hurricane-specific flood hazards. Although many Florida HES non-structural criteria (e.g., flood hazard siting/minimum lowest floor elevation, minimum occupant space, sanitation) may equal those of ICC 500 and FEMA, structural criteria for existing evacuation shelters are lower and vary significantly from shelter to shelter. Even with the improved structural criteria for EHPAs under the 6th Edition (2017) FBC as described in Section 2.4.1, FEMA safe rooms and ICC 500 storm shelters still require substantially higher criteria for opening protection than Florida HESs and EHPAs. A comparison of design criteria and support system requirements is presented in Table 5-3.

Table 5-3: Design Criteria and Support System Requirement Comparison between Shelter Types

Component		Shelter Type		
		FEMA P-361 Safe Room and ICC 500 Storm Shelter	**Enhanced Hurricane Protection Area (EHPA) Shelter**	**Florida Hurricane Evacuation Shelter (HES), or Evacuation Shelter**
Design Criteria	Wind Speed	Hurricane wind speed maps in accordance with ICC 500 (2020) Figures 304.2(1), 304.2(2), and 304.2(3) (FEMA P-361 [2021] Section B3.2.5.1)	Hurricane wind speed maps in accordance with ICC 500 (2020) Figures 304.2(1), 304.2(2), and 304.2(3) (7th Edition [2020] FBC Section 453.25.4)	Florida Building Code for Risk/Occupancy Category II. At a minimum, buildings must meet ASCE 7-98 or American National Standards Institute (ANSI) A58 structural design criteria per ARC HESSS V.1.0 2018.06.23.
	Wind-Borne Debris	Wind-borne debris protection for all portions of the safe room envelope and critical systems following test missile criteria per ICC 500 (2020) Section 305.1.2 (FEMA P-361 [2021] Section B3.2.6.2).	Wind-borne debris protection for building envelope, louvers, vents, and standby power protection (7th Edition [2020] FBC Sections 453.25.4.3 and 453.25.5)	No requirements

Component		**Shelter Type**		
		FEMA P-361 Safe Room and ICC 500 Storm Shelter	**Enhanced Hurricane Protection Area (EHPA) Shelter**	**Florida Hurricane Evacuation Shelter (HES), or Evacuation Shelter**
Support System Requirements	Emergency Power Systems	Sufficient backup power for emergency lighting and ventilation for the entire period of occupancy per ICC 500 (2020) Sections 701.2 and 703.7 (FEMA P-361 [2021] Section B7.2.6)	Sufficient backup power for emergency lighting, exit signs, fire protection, and minimum ventilation for health/safety purposes (7th Edition [2020] FBC Section 453.25.5)	No requirements
	Potable Water	1 gallon drinking water plus 1.5 gallons water for waste per occupant per ICC 500 (2020) Sections 703.4 and 703.3.4.1 (FEMA P-361 [2021] Sections B7.2.2 and B7.2.3)	Stored water is required for sanitation though no recommended capacity is provided (7th Edition [2020] FBC Section 453.25.3.3.1)	No requirements
	Sanitation	1 water closet per 50 occupants and 1 lavatory per 100 occupants per ICC 500 (2020) Table 703.3 (FEMA P-361 [2021] Section B7.2.2)	One per 40 occupants (7th Edition [2020] FBC Section 453.25.3.3)	No requirements

The MAT looked at the building performance and operational performance of shelters in Charlotte, Lee, and DeSoto Counties. The MAT did not identify any EHPA shelters based on the 2022 SESP in these counties, although numerous HESs were occupied during the event. The MAT visited five HESs that were open during Hurricane Ian (two in Lee County and one in DeSoto County are highlighted in Table 5-4) and met with EOCs and building operators to discuss several other facilities. The MAT also visited the Babcock Ranch High School fieldhouse, which had signage indicating it is a safe room.[6]

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[6] The MAT did not conduct an independent check to verify compliance with all components of FEMA P-361 and ICC 500.

The Babcock Ranch High School fieldhouse was occupied during Hurricane Ian. Table 5-4 provides a summary of the data collected from HESs.

Table 5-4: Summary of Data Collected from HESs

Shelter Name/ County	Visited During MAT	Shelter Building	Shelter Type	Building Performance and Operational Performance Summary
Turner Agri-Civil Center (Arcadia) – DeSoto County	Yes	Event center	Public HES	▪ Failure of roll-up door, causing people to feel unsafe; shelter residents moved to another location within the facility away from the door. ▪ Water intrusion through wall. ▪ Loss of utility power and backup generator failed soon after startup. ▪ Loss of potable water, causing loss of sewage function.
Hertz Arena – Lee County(b)	No	Event center	Public HES(a)	▪ No structural damage; minor roof leaks(b) and water intrusion through doors. ▪ No loss of utility power. ▪ Loss of potable water causing loss of sewage function.
Estero Recreation Center – Lee County	Yes	Community center	Public HES(a)	▪ No structural damage; only minor water intrusion through doors. ▪ Loss of utility power resulting in no HVAC; standby generator only powered limited wall outlets. ▪ Loss of potable water causing loss of sewage function.
Kingsway Elementary School - Charlotte County	No	School	Public HES(a)	▪ Water entry through northeast corner stairway roof caused water intrusion on several floors. ▪ Despite water intrusion, shelter was not evacuated during Hurricane Ian, but shelter residents were relocated to another facility after the event.
Harold Ave Recreation Center - Charlotte County(b)	No	Community center	Public HES(b)	▪ Minor roof damage; occupants thought the roof was going to blow off during the event. ▪ Despite roof damage, evacuation was not needed for shelter.

Shelter Name/ County	Visited During MAT	Shelter Building	Shelter Type	Building Performance and Operational Performance Summary
Babcock Ranch – Charlotte County	Yes	High school fieldhouse	Public HES/safe room(c)	- No structural damage. - No loss of potable water or utility power.

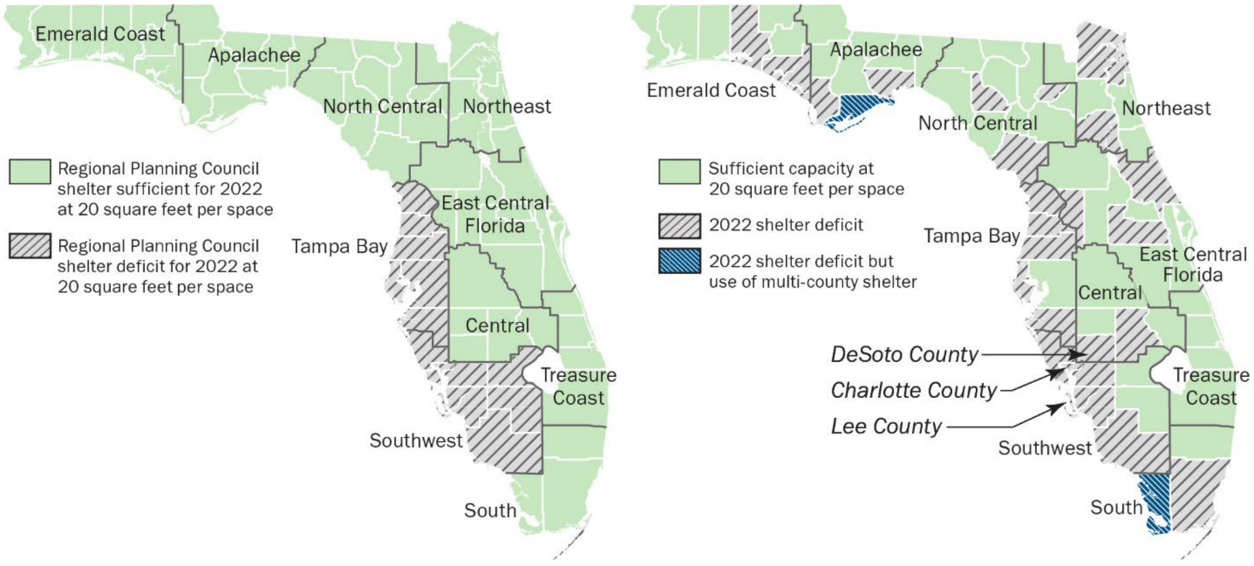
(a) Facility is not on the list of HESs in Appendix A of the 2022 SESP. Building does not or has not been evaluated to meet ARC-4496, Standards for Hurricane Evacuation Shelter Selection (ARC 2002) (now ARC HESSS V.1.0, Hurricane Evacuation Shelter Selection Standards [ARC 2018]) minimum HES criteria. This may be because the facility is located within an A, B, or C hurricane evacuation zone (see Hurricane Evacuation Zones textbox in Section 5.3.1).
(b) Hertz Arena and Harold Avenue Recreation Center are currently undergoing roof retrofits that were not completed prior to Hurricane Ian.
(c) Building was not fully operational as an evacuation shelter during Hurricane Ian because the generator to be protected from wind-borne debris was not yet installed. Designation of the fieldhouse as a safe room is based on signage. The MAT did not conduct an independent check to verify compliance with all components of FEMA P-361 and ICC 500.

Section 5.3.1 addresses shelter building performance and operational performance as it relates to the shelter deficit in Florida. This section covers selecting the correct type of shelter, Special Needs shelters, and observations related to the shelter deficit.

Section 5.3.2 discusses shelter operations' challenges, which include loss of potable water, longer period of occupancy, security, coordination of resources, and psychological aspects.

5.3.1. BUILDING PERFORMANCE AND THE SHELTER DEFICIT

As discussed in Section 2.4, Florida has been actively addressing the shelter deficit since Hurricane Andrew in 1992. According to the 2022 SESP, Florida was no longer in a shelter deficit when aggregating shelter space statewide. However, deficits remain when analyzed from a regional and county level (Figure 5-18). The MAT visited Lee, Charlotte, and DeSoto Counties, which are classified by the SESP as falling within the Central Florida Region and the Southwest Florida Region. The Southwest Florida Region, Lee County, Charlotte County, and DeSoto County are classified as deficient for shelter space; Southwest Florida has the largest shelter deficit in Florida, according to the 2022 SESP. This means for events where the maximum expected number of residents seek shelter space, these counties must either use local facilities that do not meet the ARC HESSS V.1.0 (previously ARC-4496) minimum hurricane safety criteria or transport residents to host shelters outside of the area.



Source: SESP (FDEM 2022)

Lee and Charlotte Counties are in the Southwest Florida Region and DeSoto County is in the Central Florida Region. Figures do not include Public Health Emergency provisions for social distancing. Figures have been updated to reflect August 2022 audit data provided by FDEM.[7]

Figure 5-18: Florida shelter deficit by region (left) and by county (right) (FDEM 2022, modified)

Shelter space was not an issue during Hurricane Ian, as counties reported less than expected shelter attendance. Shelter managers noted that people were less likely to evacuate because they expected Hurricane Ian impacts would be minor based on recent experience with Hurricane Irma, which residents reported was less impactful than expected. Nevertheless, the area still faced numerous challenges with shelter facilities.

Insufficient Shelters of the Correct Type

Selection of "safe shelter space" as defined by FDEM, originates from ARC-4496 *Standards for Hurricane Evacuation Shelter Selection*, which is currently referred to as ARC HESSS V.1.0. The same criteria were defined by *Florida's Hurricane Shelter Selection Guidelines Review* in 2001 (FDCA/DEM 2001). However, the ARC HESSS V.1.0 is the minimum standard for evaluating the sufficiency of a facility as a shelter. As shown in Table 5-2, there are several types and levels of protection of shelters, including shelters designed to the highest standards (safe rooms) that far exceed the minimum requirements of other criteria, such as ARC HESSS V.1.0. Consistent with this point, shelters designed to higher performance standards had better building performance and operational performance during Hurricane Ian compared to those designed to minimal standards.

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[7] Since the publication of the 2022 SESP, FDEM has developed a fair and uniform formula for determining shelter space demand, which will allow for more accurate reporting of shelter space demand. Shelter space status of Regional Planning Council (RPC) regions and counties will be updated in the 2024 SESP to reflect this change.

This section demonstrates this observation with two shelter case studies: Babcock Ranch Hurricane Safe Room and Turner Agri-Civil Center.

Minimum Shelter Selection Criteria

The ARC HESSS V1.0 (previously ARC-4496) recommends avoiding the following building types when selecting shelter space:

- Buildings with long roof spans
- Unreinforced masonry buildings
- Pre-engineered buildings built before the mid-1980s
- Buildings that will be exposed to the full force of hurricane winds
- Buildings with flat roofs or roofs built with lightweight materials

Babcock Ranch Hurricane Safe Room

The Babcock Ranch High School fieldhouse is a cafeteria, gymnasium, and fitness center for the joint local- and state-funded regional storm shelter for Southwest and Southeast Florida (Figure 5-19 and Figure 5-20). The approximately 43,000-square-foot facility can shelter about 1,300 occupants. Newly constructed when Hurricane Ian hit, the facility opened at the start of the 2022–2023 school year. The safe room[8] was not fully operational during Hurricane Ian as the on-site generator, meeting the requirements of Section 701.2 of ICC 500 (2020), had not been installed yet. Nevertheless, during Hurricane Ian, the facility had no reported damage and no adverse operational issues.

Babcock Ranch Hurricane Safe Room

Date of Construction = 2022

Estimated Wind Speed = 106 mph (3-second gust)

Design wind speed (based on wall plaque) = 180 mph (3-second gust) (FEMA P-361)

ASCE 7-16 Basic Wind Speed (Risk Category IV) = 167 mph (3-second gust)

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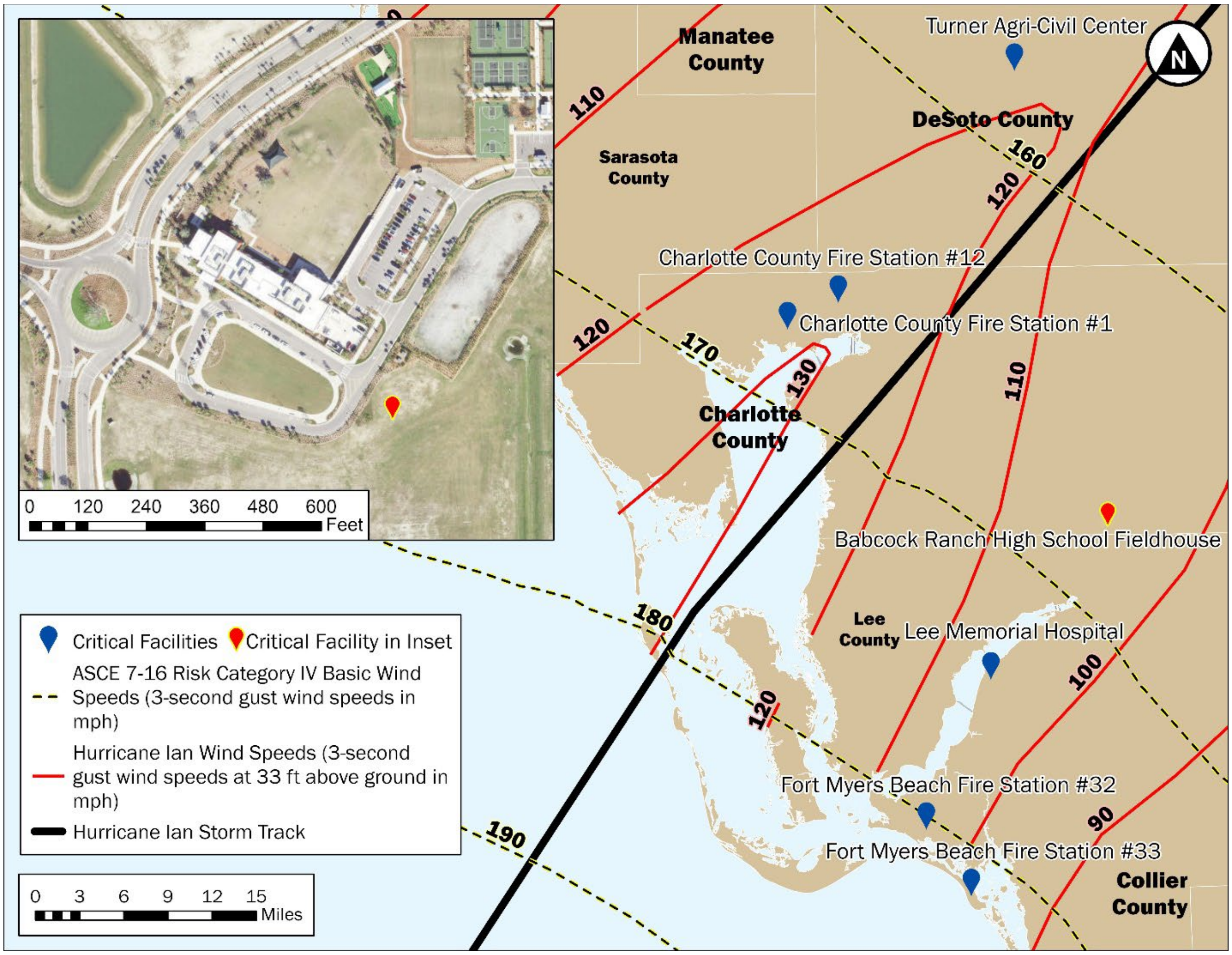
[8] Designation of the fieldhouse as a safe room is based on signage. The MAT did not conduct an independent check to verify compliance with all components of FEMA P-361 and ICC 500.

Source: Babcock Ranch (main photo) (Image used with permissions)

The structure has 12-inch-thick concrete tilt-up walls and steel roof trusses with a hollow-core concrete deck. Signage at the entry door labels the safe room's design wind speed and missile impact resistance (in compliance with FEMA P-361 [2021] Section B5.2.8). According to the door frame label, the assembly is rated for a design pressure of +/-284 pounds per square foot (psf) and an impact of 15-pound 2x4 at 100 mph per ICC 500-2014 and FEMA P-361 (2015b). This impact rating exceeds the design requirements for hurricane community safe rooms of a 9-pound 2x4 at 90 mph for vertical missiles (ICC 500-2014 Section 305.1.2 and FEMA P-361 (2015b) Section B3.2.5.2). Doors are listed and labeled (in compliance with FEMA P-361 [2021] Section B1.2.9).

Figure 5-19: Babcock Ranch High School fieldhouse / hurricane safe room (Charlotte County)



Source: NIST

Note that the aerial view was taken prior to the construction of the high school and fieldhouse.

Figure 5-20: Location of Babcock Ranch High School fieldhouse (red map pin) in the Hurricane Ian windfield

Although the Babcock Ranch community did not experience a loss of electricity or potable water during Hurricane Ian, the fieldhouse was equipped with a generator[9] and backup groundwater well. The safe room's single permanent, standby generator can power all systems for 72 hours. The groundwater well system provides sanitary water as required by Section 703.3.4.1 of ICC 500 (2020).

Both the permanent, standby generator and backup groundwater well are located in an enclosure (Figure 5-21) protected by impact-rated walls on four sides to protect against horizontal missiles. For

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[9] As previously noted, the permanent standby generator had not been installed when Hurricane Ian made landfall, though the safe room was equipped with a temporary generator.

vertical missiles, a system composed of chain-link mesh, supported by steel beams is attached to the walls. The chain-link system appears to work by dissipating energy through extensive deflection of the material. At the generator enclosure, vertical missiles can potentially enter through the opening for the access ladder to the rooftop HVAC enclosure. Given this opening, the enclosure system does not appear to meet ICC 500 requirements, nor FEMA P-361 criteria, for wind load or impact rating. Other non-compliance issues with this enclosure system could not be confirmed by the MAT.

Enclosure walls are impact-rated but the chain-link mesh cover above does not appear to meet ICC 500 requirements for wind load or impact rating.

Figure 5-21: Babcock Ranch safe room enclosure for generator and backup well (Charlotte County)

Turner Agri-Civil Center, Arcadia

The Turner Center (Figure 5-22 and Figure 5-23) sheltered approximately 350 people during Hurricane Ian. Constructed in 2002, this pre-engineered metal building with masonry infill walls and roof spans of approximately 200 feet suffered major structural damage during Hurricane Charley, as discussed in FEMA 488, *Mitigation Assessment Team Report: Hurricane Charley in Florida Observations, Recommendations, and Technical Guidance* (2005), and faced multiple structural and operational challenges during Hurricane Ian. Although the facility is on the list of HESs in Appendix A of the 2022 SESP, ARC HESSS V1.0 recommends avoiding this type of facility when selecting shelter space.

Turner Agri-Civil Center

Date of Construction = 2002 (original construction), 2008 (reconstruction post-Hurricane Charley)

Estimated Wind Speed = 119 mph (3-second gust)

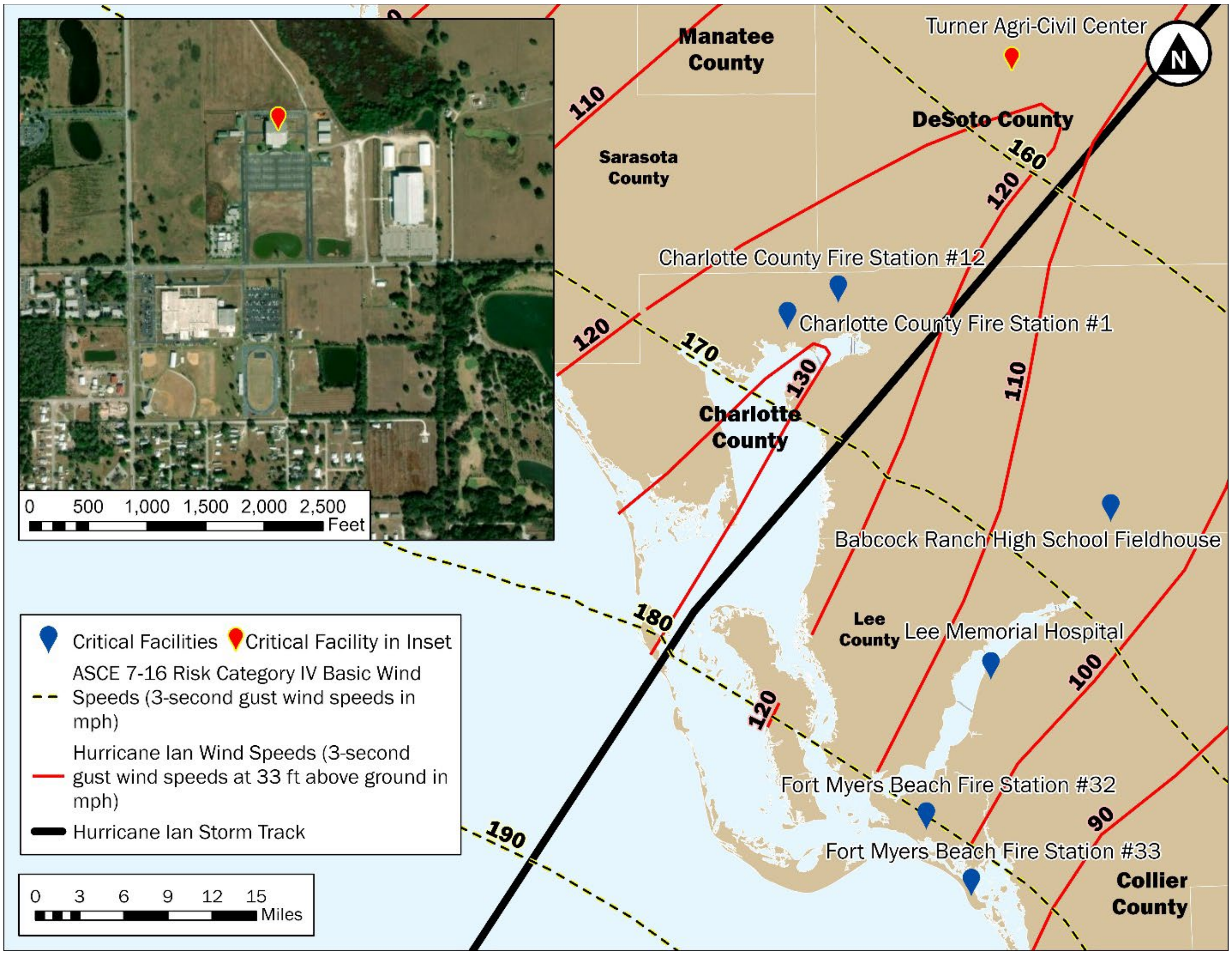
Design Wind Speed for original construction (per FEMA 488) = 140 mph (3-second gust) (ASCE 7-98) (140 mph ASCE 7-98 basic wind speed is comparable to an ASCE 7-16 Risk Category II(a) basic wind speed of 177 mph [3-second gust] (b))

Design Wind Speed for reconstruction (based on code requirements at time of reconstruction) = 109 mph (3-second gust) (2007 FBC/ASCE 7-05) (109 mph ASCE 7-05 basic wind speed is comparable to an ASCE 7-16 Risk Category II(a) basic wind speed of 138 mph [3-second gust] (b))

ASCE 7-16 Basic Wind Speed (Risk Category IV) = 158 mph (3-second gust)

(a) **Per FEMA 488, the facility was designed with an importance factor of 1.0, which is comparable to ASCE 7-16 Risk Category II.**

(b) **A factor of 1.265 is applied to the ASCE 7-98 and ASCE 7-05 basic wind speed to obtain the comparable ASCE 7-16 basic wind speed. The 1.256 factor is the product of the square root of the 1.0 Risk Category II importance factor in ASCE 7-98/ASCE 7-05 and the square root of the 1.6 wind load factor from ASCE 7-98/ASCE 7-05 (this wind load factor is 1.0 in ASCE 7-16).**



Source: NIST

Figure 5-22: Location of Turner Agri-Civil Center (red map pin) in the Hurricane Ian windfield

The Turner Center is a pre-engineered metal building constructed of long span trusses. ARC HESSS V1.0 recommends against using these types of buildings as shelters.

Figure 5-23: Exterior (left) and interior (right) photos of the Turner Center (DeSoto County)

The Hurricane Charley MAT report indicates that the facility was designed per ASCE 7-98 to 140 mph wind speeds with an importance factor of 1.0[10] and met EHPA minimum requirements. However, the Florida Department of Community Affairs (FDCA) had not evaluated compliance with EHPA design requirements at the time of the Hurricane Charley MAT report. During Hurricane Charley, the east gable end wall partially collapsed, potentially due to faulty roof clips; as a result, shelter occupants were evacuated to a nearby high school. During Hurricane Ian, occupants reported hearing a rattling sound and seeing a large deflection of the door and significant water intrusion coming from a large roll-up door on the same wall that failed during Hurricane Charley (Figure 5-24). Although the shelter was not evacuated, occupants moved away from the door; some sheltered in interior hallways and stairwells, concerned that a door failure was imminent. There was also water intrusion in the northeast and northwest corners of the structure; the cause of this water intrusion is still under investigation. The Hurricane Charley MAT report states the area experienced 3-second wind gusts of between 110 and 120 mph, which may have been locally higher due to terrain effects. During Hurricane Ian, the estimated wind speed at the shelter location was approximately 119 mph.

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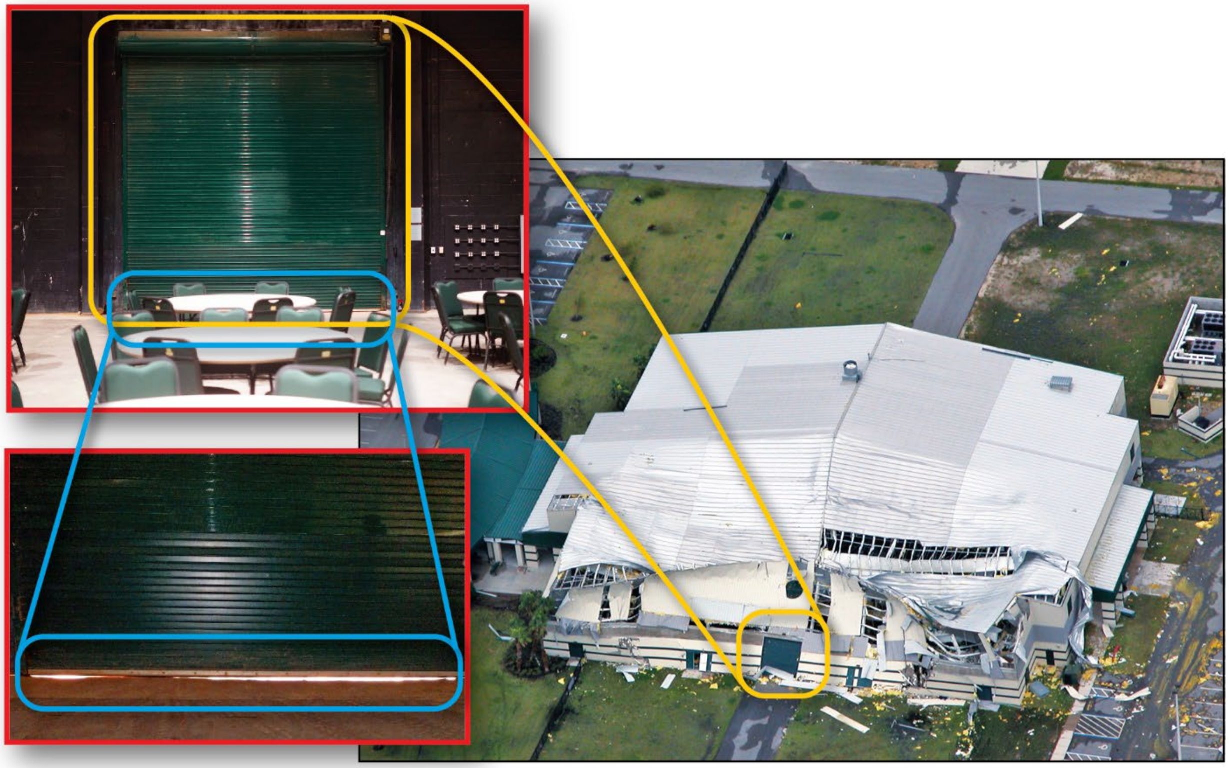
[10] As stated in Section 2.4.1, EHPAs must be designed as Category III structures at a minimum. ASCE 7-98 requires hurricane shelters to be designed as Risk Category IV structures. Per ASCE 7-98, both Risk Category III and Risk Category IV structures require a 1.15 wind importance factor, which suggests that the Turner Center was not designed to meet EHPA design requirements or that incorrect criteria were used in its design.



Source: FEMA 488 (main photo)

The Turner Center experienced partial collapse to a gable end wall during Hurricane Charley in 2004 (right aerial view). During Hurricane Ian, a large roll-up door (inset on left) on the same gable end wall rattled and deflected, enabling water to enter and causing shelter occupants to feel unsafe. In the bottom inset, the blue circle shows the gap at the bottom of the door caused by the door deflecting.

Figure 5-24: Comparison of damage to the Turner Center in Hurricane Charley versus Hurricane Ian (DeSoto County)

The shelter faced a number of operational challenges in addition to the structural performance issues. The shelter lost both municipal power and potable water during Hurricane Ian. Although the shelter has an emergency generator (Figure 5-25), the generator failed 30 minutes after utility power was lost, leaving shelter residents without power for 2 to 3 days. Staff did not know why the generator failed and did not know whether it was routinely maintained[11] and tested. The MAT observed that the generator was manufactured in April 2002. The date it was installed could not be determined. When Hurricane Ian made landfall, the generator may have been in service for over 20 years.

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[11] Immediately prior to Hurricane Ian, the Turner Center experienced a transition in staff, which contributed to the knowledge gap about maintenance activities.

Shelter occupants also faced issues flushing toilets due to the loss of potable water. A potable water service outage occurred the evening of September 28 and lasted into September 29. Around noon on September 29, a potable water truck arrived on site to enable a bucket brigade, which used 5-gallon buckets, to manually recharge and flush toilets. Operations at the Turner Center were further complicated by inland flooding of the Peace River and Joshua Creek, which closed the major roadways that were used to provide supplies to the shelter.

Figure 5-25: Generator at the Turner Center that failed during Hurricane Ian (DeSoto County)

Generator Failure Observations

Another facility that the MAT visited experienced generator failure; though the effects of the failure were much less widespread and of much shorter duration than those felt at the Turner Center. The facility visited had two generators, one identified as Standby and the other as Emergency. Although insufficient information was available to confirm, the MAT suspects that the Emergency generator supplies emergency and legally required standby systems and the generator identified as Standby supplies optional standby systems.

During Hurricane Ian, the fan belt for one of the generators failed, which caused the generator to overheat and forced it to shut down. Whether the failed fan belt was for the Standby generator or the Emergency generator is unknown, but the MAT did confirm that the Emergency and Standby generators are not interconnected and if either generator fails when normal power is lost, all of the equipment supplied by the failed generator will not be able to operate.

After the fan belt was replaced, the generator was restarted, and power was restored to the equipment supplied by the generator. The equipment supplied by the other generator never lost power and remained operational for the entire utility power outage.

Shelter Operations in Florida

The HESs discussed throughout this chapter demonstrate how several different shelters visited or investigated by the MAT are operated and maintained.

Babcock Ranch High School fieldhouse: The high school and fieldhouse at Babcock Ranch is privately owned. The owners received grant funding from local entities and the State of Florida for the construction of the safe room. Because of the use of state funding for this facility, any county in Florida can activate and operate the shelter in an emergency.

Hertz Arena: The Hertz Arena is privately owned. Lee County emergency managers lease the facility during an emergency and are responsible for shelter operations. The owners of Hertz Arena received grant funding for hurricane strengthening activities. Under the lease stipulations, the county provides regular generator maintenance and annual shelter training at the facility, while the building owner is responsible for overall routine maintenance of the facility (not including the generator).

Estero Recreation Center: Similar to Hertz Arena, Lee County emergency managers are in charge of shelter operations during an emergency. The recreation center is owned by Lee County and maintained by the county’s parks and recreation division.

Turner Center: DeSoto County owns and maintains the facility. However, during Hurricane Ian, the shelter was operated by the American Red Cross.

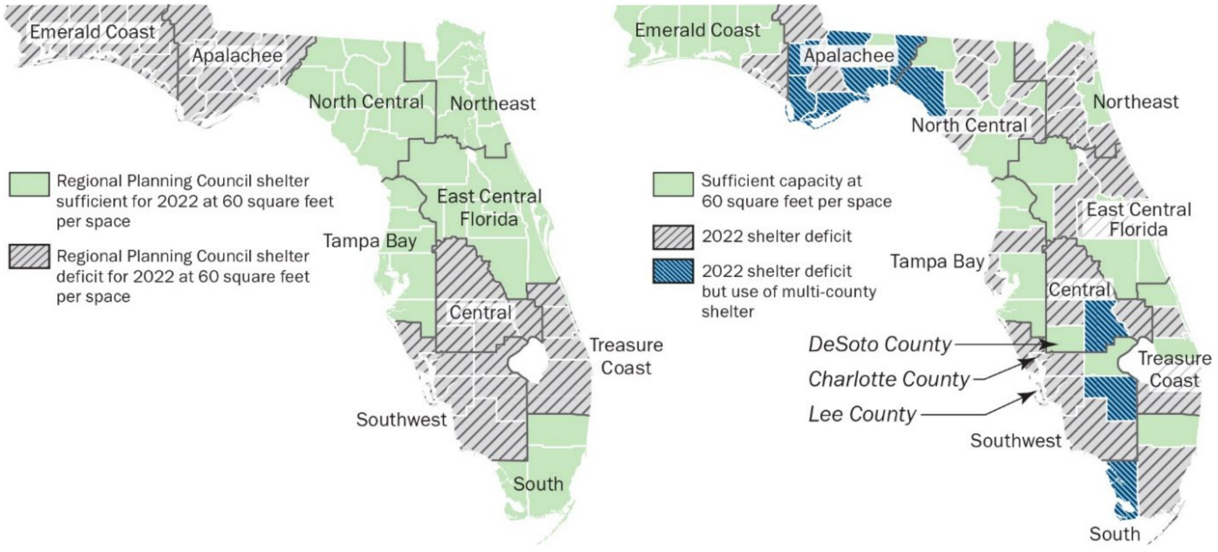
Special Needs Shelters

The SESP has provided separate reporting on Special Needs shelters since 2006. Despite continued efforts in reducing the Special Needs shelter usable area deficits since reporting began, Florida continues to have a deficit of Special Needs shelters (Figure 5-26). Meanwhile the vulnerable population continues to grow. Since 2000, around the time SESP was first introduced, the percentage of Florida's population that is 65 years and older has increased from 17.6% to 21.1%. However, the percentage of the population 65 years and older in Charlotte and Lee Counties is significantly higher than for the state (40.5% in Charlotte County and 29.1% in Lee County). Numerous communities and organizations reported to the MAT about challenges they faced during Hurricane Ian because of the shortage of Special Needs shelters.

Special Needs Shelters

Special Needs shelters should meet the same hurricane safety criteria as a General Population shelter. However, Special Needs shelters must, at a minimum, have standby power supporting air-conditioning and have shelter space of 60 square feet per person (in lieu of the 20 square feet per person for standard shelters and 40 square feet per person for bedridden occupants per ICC 500 and FEMA P-361 [2021a]). The larger usable area considers caregivers and medical equipment supporting the occupant with special needs.

Per the SESP, a person with special needs is "someone who during periods of evacuation or emergency, requires sheltering assistance due to physical impairment, mental impairment, cognitive impairment, or sensory disabilities" (FDEM 2022).



Source: SESP (FDEM 2022)

Lee and Charlotte Counties are in the Central Florida Region and DeSoto County is in the Southwest Florida Region. Figures have been updated to reflect August 2022 audit data provided by FDEM.[12]

Figure 5-26: Florida Special Needs shelter deficit by region (left) and by county (right) (FDEM 2022, modified)

Lee County has a registry with approximately 2,000 residents with special needs whom the county contacts prior to an emergency. Buses are available to transport these residents to shelters. Despite these planning efforts, Lee Health reported numerous evacuees with special needs were sent to and sheltered in hospitals prior to Hurricane Ian. This is contrary to the hospital's hurricane planning efforts. In the lead-up to a hurricane—including Hurricane Ian—hospitals often "de-risk," a term used to describe their efforts to reduce the number of patients at a hospital. Additionally, because of staffing shortages and higher patient counts caused by the coronavirus disease 2019 (COVID-19) pandemic, the hospitals stated they did not have the support staff to take on additional patients, nor perform functions as Special Needs shelters. Accommodating the evacuees with special needs placed an extra burden on the hospitals and staff.

Several seniors with special needs were reportedly dropped off at Estero Recreation Center, a general population shelter, according to shelter staff. Residents preferred sheltering close to home and were evacuating to the nearest shelter instead of the shelter that best suited their needs. Although visiting nurses were able to meet the needs of these occupants, managing the influx of nurses added to the chaos of the situation. The Estero Recreation Center shelter was not equipped with the type of generator required in a Special Needs shelter, that is, a generator sized to

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[12] Since the publication of the 2022 SESP, FDEM has developed a fair and uniform formula for determining shelter space demand, which will allow for more accurate reporting of shelter space demand. Shelter space status of Regional Planning Council regions and counties will be updated in the 2024 SESP to reflect this change.

accommodate medical equipment and the HVAC system. In DeSoto County, shelter staff reported that caregivers dropped off residents with special needs and then left, placing additional burden on the shelter staff. Hurricane Ian highlighted a lack of strategic planning by state and local governments and shelter and medical care facilities. All need to do better in planning for and addressing the requirements and operational challenges associated with Special Needs shelters.

Other Options for Shelters

The MAT did not identify any EHPA shelters based on the 2022 SESP in the three counties visited by the MAT (Lee County, Charlotte County, and DeSoto County). This may be explained by the Florida statutes regulating the designation of EHPAs in the FBC. The FDEM shelter deficit reduction plan assumed AHJs would focus on the construction of new schools to reduce the shelter deficit in agreement with the Florida statute providing authority and requirements through the FBC.

FBC Exemptions for EHPAs

Five factors are considered when FDEM or the local emergency management agency is making an EHPA exemption decision for a new educational facility. An exemption may be granted if the:

1) Location of the proposed site is within an identified Category 1, 2, or 3 (or A, B, or C) hurricane evacuation zone (see Hurricane Evacuation Zones textbox on next page).
2) Location is subject to hurricane-related rainfall or storm surge flooding or isolation.
3) Location is on a coastal barrier island.
4) Location is within the evacuation zone of facilities that manufacture, use, or store certain types and quantities of hazardous materials.
5) Location is within an area having a low evacuation demand.

(FDEM 2022)

However, Florida statute requires, through the FBC, that only new educational facilities under certain conditions meet EHPA provisions, and this does not apply to facilities that are being altered or repaired. Lee and Charlotte Counties in particular have older populations, compared with the rest of Florida. Table 5-5 shows that both counties have a higher percentage of residents 65 years and older (significantly higher for Charlotte County) and a lower percentage of residents of school age (18 years of age and younger). Since the 2000 census (approximately the time when the EHPA requirements were first adopted by the FBC), the older population in these counties has only increased, and this trend is expected to continue into the foreseeable future. Construction of new educational facilities will likely be less of a priority for these counties, as the demand will be decreasing. In a declared emergency, if additional area for sheltering is required by emergency management officials, public facilities must, by Florida statute, be activated as emergency shelters. However, consideration of public shelter performance criteria in public facility design criteria is only recommended, not required.

Table 5-5: Age Distribution as a Percentage of Total Population by Location

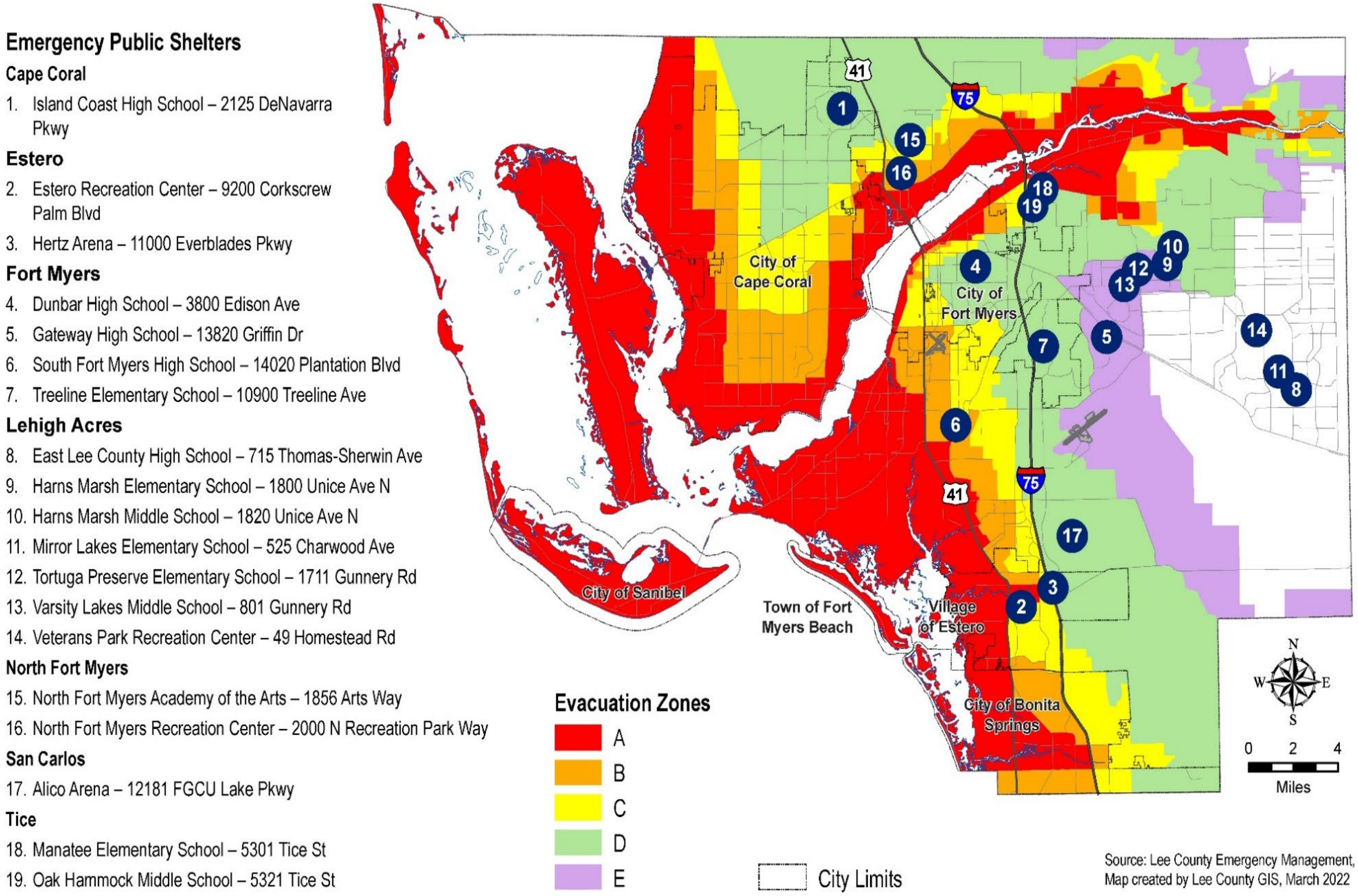
Location	65 Years of Age and Older		18 Years of Age and Younger	
	2000	2021	2000	2021
United States	12.4%	16.8%	26.0%	22.2%
Florida	17.6%	21.1%	25.3%	19.7%
DeSoto County	19.0%	22.6%	25.9%	18.5%
Lee County	25.4%	29.1%	21.5%	17.3%
Charlotte County	34.7%	40.5%	17.2%	11.8%

Source: www.census.gov

In addition to limiting EHPA designations to new educational facilities, the FBC does not require educational facilities located in Category A, B, and C hurricane evacuation zones to meet EHPA requirements. This is a challenge particularly noted by Lee County, as a significant portion of the county is located in Category A, B, and C hurricane evacuation zones. In Lee County (Figure 5-27), shelters are clustered inland, with the majority of them in Lehigh Acres, which is quite a distance from the population centers of Cape Coral and Fort Myers. This is counter to the needs of the population, which tend to shelter near their homes, according to shelter facility operators and emergency management personnel. Charlotte County has the same issue. Charlotte County does not have any American Red Cross–certified shelters, as the American Red Cross does not permit sheltering within Category A, B, or C hurricane evacuation zones (ARC 2018).

Hurricane Evacuation Zones

Hurricane evacuation zones are areas officials may order evacuations of prior to a hurricane. These zones do not directly correspond to hurricane categories but are instead defined by hurricane surge. Hurricane evacuation zones are classified as Category A, B, C, D, and E. Zones A and B are expected to flood first from storm surge. These areas are typically the most vulnerable and likely to evacuate first. Zone C areas flood depending on the track and intensity of the storm. Zone E is likely to evacuate last. Structures may be vulnerable to flooding even when they are not located in an evacuation zone. Note that evacuation zone designations are entirely different than NFIP flood zone designations.



Source: Lee County Emergency Management (Image used with permissions)

Figure 5-27: 2022 Evacuation zones and public shelters in Lee County

There is one other building code exemption that may restrict the construction of new facilities as EHPA structures. EHPA requirements may be waived if the new facility will be in a region where a shelter deficit does not exist. As noted in Figure 5-18 at the beginning of this section, numerous counties have a shelter deficit but are located in a region without a shelter deficit. This means educational facilities built in counties without ample shelter space may not be required to incorporate EHPA requirements into their facility given their regional shelter status. Given these potential EHPA exemptions, Lee, Charlotte, and DeSoto counties in particular, among maybe others having deficits, will most likely need to add shelter space by retrofitting existing buildings instead of relying on the construction of new EHPA buildings.

While shelter capacity should be assessed at the state, regional, and local government/community levels, each assessment will be for slightly different planning and execution purposes. Residents typically seek shelter close to their home and resist traveling great distances to evacuate. This can be more prevalent in lower-income areas where residents typically lack the disposable income to travel greater distances and stay in hotels. However, while residents prefer evacuating to a shelter closer to their homes, community planners need to weigh the practicality of that tendency to limit travel, with factors such as flooding or storm surge, wind speeds, existing building vulnerabilities, available funding for building retrofits, shelter logistics, maintenance and operations, and the availability of safe shelter space.

5.3.2. OPERATIONAL CHALLENGES

The slow movement of Hurricane Ian, long periods of shelter occupancy by hurricane evacuees, and shelters without access to potable water in many locations resulted in numerous operational challenges for shelter management staff.

Loss of Potable Water

The loss of potable water in Lee County significantly impacted shelters, as previously discussed. Although all shelters observed by the MAT had a backup supply of drinking water, such as water bottles, loss of potable water greatly impacted the sanitary sewer function in all shelters in Lee County, except for a privately owned shelter, which had portable restrooms from the start of the event. In shelters where potable water was lost, shelter occupants used trash bags or red bagged excrement during the storm. Immediately following the hurricane but before the arrival of portable restrooms and eventual resumption of potable water service, buckets were used to refill toilets. The buckets were filled from either water trucks or stormwater ponds. Generally, shelters reported losing potable water supply on Wednesday after landfall and gaining access to water trucks to fill buckets on Thursday; portable restrooms were delivered on Friday.

Longer Period of Occupancy

FEMA P-361 and ICC 500 provide for a minimum period of hurricane shelter occupancy of 24 hours. In the aftermath of Hurricanes Irma and Maria, FEMA reimbursed hurricane safe room costs for the necessary components to provide a minimum period of occupancy of 72 hours in Puerto Rico and the U.S. Virgin Islands. For recent events, including Hurricane Ian, shelters were occupied and operational for much longer than the 24-hour minimum period of hurricane shelter occupancy required by ICC 500. Shelter management reported people began evacuating to the shelters about a day or two before landfall. People were required to stay in the shelters after the hurricane passed for several days because of safety concerns, such as debris, downed power lines, and life safety operations. Some communities implemented curfews that kept people in shelters after Hurricane Ian had passed. The shelters could provide basic utilities, such as power and water, that the surrounding areas did not have.

Following Hurricane Ian, shelter functionality design assumptions were tested under longer periods of occupancy, especially the long operational duration required of the generators. At the Turner Center and the Estero Recreation Center, high heat and humidity were major concerns once the facilities lost power. For longer periods of occupancy, functioning cooling systems are extremely important. The time of year when hurricanes typically hit and the location where hurricanes make landfall can affect the risk of heat stroke among shelter occupants. At both the Turner Center and the Estero Recreation Center, standby generators provided power to few electrical loads, mostly lighting and some convenience outlets. Mechanical systems that provide ventilation and control interior temperatures and humidity levels were not supplied by standby power systems. Shelter managers at one shelter noted that occupants were searching for more outlets connected to emergency generators, as occupants now have a greater reliance on technology for communication and entertainment. However, the drawback to expanding emergency generator capacity is that more capacity is then needed for fuel storage, and a redundant generator would potentially be needed to allow for servicing.

Besides generator capacity, shelter managers often reported they had to consider whether to provide showers to address sanitary needs. Even when they had shower facilities, the shelters the MAT visited did not allow them to be used by the general population (shelter occupants that are not shelter staff), based on previous negative experiences and past misuse. Shelters that had a potable water outage during the hurricane would have been unable to make use of shower facilities anyway.

Security

Security concerns were an issue in several county shelters visited by the MAT. The shelter at the Turner Center was operated by the American Red Cross, whose policy it is to not turn away anyone seeking shelter. During the hurricane, Turner Center occupants were not disruptive, but after the hurricane, some occupants were troublesome. At Hertz Arena, as the weeks wore on, some shelter occupants began to exhibit behavior that posed a risk to themselves as well as other occupants. Staff reported the use of illegal drugs and alcohol on the premises, and one person overdosed on site. With large numbers of people in confined areas for long periods of time, verbal and sometimes physical altercations occurred. At the Hertz Arena, law enforcement was present at the shelter for only the first 3 weeks after the event. During Hurricane Irma, the National Guard was in charge of security for the duration of its use as a shelter, which limited altercations. In contrast, for the Estero Recreation Center shelter, which was run by Lee County, three deputies and a sergeant were on the premises at all times during its operation as a shelter and no major security concerns were reported.

However, shelter managers needed to coordinate additional space so that law enforcement could have an area separated from the general population.

Coordination of Resources

Operation of a shelter is a large logistical undertaking that requires coordination of resources to be successful. Shelters visited by the MAT were typically operated by either the American Red Cross or the county. Although these entities provide yearly training in shelter operations, that training may not cover operation of a particular building. Shelter staff were overwhelmed by having to learn on the spot how to coordinate food distribution or other unforeseen challenges, such as the loss of potable water. An overwhelming number of traveling nurses showed up unexpectedly and became more of a logistical challenge than an asset. Hertz Arena staff reported being overwhelmed after the hurricane by the number of portable restrooms being delivered and by donations from the public, which they then had the added responsibility to sort through, store, and distribute.

In contrast, the MAT was aware of two private shelters that are good examples of operational best practices. Staff are trained yearly in how to run the shelters. Plans are in place for different scenarios, and lessons learned are collected after every event and changes implemented.

Psychological Aspects

From surviving an extreme weather event to suddenly living with hundreds or even thousands of strangers in cramped spaces, to wondering what the community will look like once the storm passes, sheltering can be a harrowing experience. The Charlotte County website states that the County’s shelters are the “last resort” option for those who cannot evacuate. According to *Florida’s Hurricane Shelter Selection Guidelines Review* (FDCA/DEM 2001), Florida’s definition of a successful shelter is a structure capable of providing sleeping and feeding accommodations that may be damaged but is “survivable.” However, the MAT observed shelter operations that also incorporated practices that addressed the psychological aspects of sheltering.

In many cases, people occupy shelters before, during, and after hurricanes for extended periods of time. Thinking about the functionality of the shelter space in terms of the length of time the shelter will be occupied is important. The MAT was aware of a private shelter that used circulation corridors to allow people easy access to restrooms, food and water, and other supplies. This reduced the stress of being in the shelter by allowing occupants to walk laps around the circulation corridors for exercise and to socialize with other occupants. Staff also found access to Wi-Fi connections and cell phone chargers important, as occupants could then be connected with the outside world and reach family and friends during and immediately after the event. As a result, extra outlets for charging stations are connected to the emergency generator.

5.4. Fire Stations

Fire stations are often sited in areas of high vulnerability due to their emergency response function, where minimizing response time is a critical consideration in the location of fire stations. Fire stations that were visited by the pre-MAT and MAT had either received FEMA funding for mitigation or reconstruction after Hurricane Charley or were located in areas that exposed them to storm surge and flooding from Hurricane Ian. The wind and flood performance of each fire station was dependent on the age of construction, design criteria, and location in relationship to the path of Hurricane Ian. In general, newer facilities with more resilient design criteria, tended to perform better than older facilities.

The pre-Mat and MAT visited in excess of 15 fire stations; the wind and/or flood performance of seven fire stations are discussed herein:

- In Lee County: Fort Myers Beach Fire Stations #33 and #32
- In Charlotte County: Charlotte County Fire Stations #1 and #12
- In Collier County: Fire Station Everglades City #60 and City of Naples Fire Station #1
- In Volusia County: Volusia County Fire Station #12

5.4.1. FLOOD PERFORMANCE

Five fire stations visited during pre-MAT or MAT were exposed to floodwaters during Hurricane Ian and their building performance varied. At three of the fire stations, flood elevations either exceeded the BFE (Fort Myers Beach fire stations #33 and #32) or extended beyond the SFHA (Volusia County Fire Station #12). Of those three, flood damages were nearly avoided by incorporating additional freeboard into the DFE (Fort Myers Beach fire station #33) or minimized by using flood resistant materials below the DFE and by elevating equipment above the DFE (Fort Myers Beach fire station #32). The third station (Volusia County Fire Station #12) was extensively damaged due to flooding and was taken out of service. While there was very limited to no indication of structural damage at the fire stations visited, flooding required non-flood-damage resistant materials to be removed and fire department personnel typically relocated to a temporary facility while repairs were completed. In some cases, the temporary facilities were located elsewhere, which extended average response times.

Fort Myers Beach Fire Station #33

Fort Myers Beach Fire Station #33 is located approximately 1.4 miles northwest of the midspan of the Big Carlos Pass Bridge. When Hurricane Ian made landfall, the effective FIRM placed the fire station in Zone AE with a BFE of 13 feet NAVD 88 (Figure 5-28). When the facility was constructed in 2007, the effective FIRM placed it in Zone AE with a BFE of 12 feet NGVD 29 (11 feet NAVD 88). The LiMWA was not delineated on the effective map at the time of construction or on the effective FIRM at the time of Hurricane Ian’s landfall.

Fort Myers Beach Fire Station #33

Date of Construction = 2007

Flood Zone and BFE per FIRM effective at time of construction = Zone AE 12 (NGVD 29) / Zone AE 11 (NAVD 88) (FIRM effective July 20, 1998)

Flood Zone and BFE per FIRM effective at the time of Hurricane Ian = Zone AE 13 (NAVD 88) (FIRM effective August 28, 2008)

Measured Water Surface Elevation = 12.6 feet (NAVD 88)

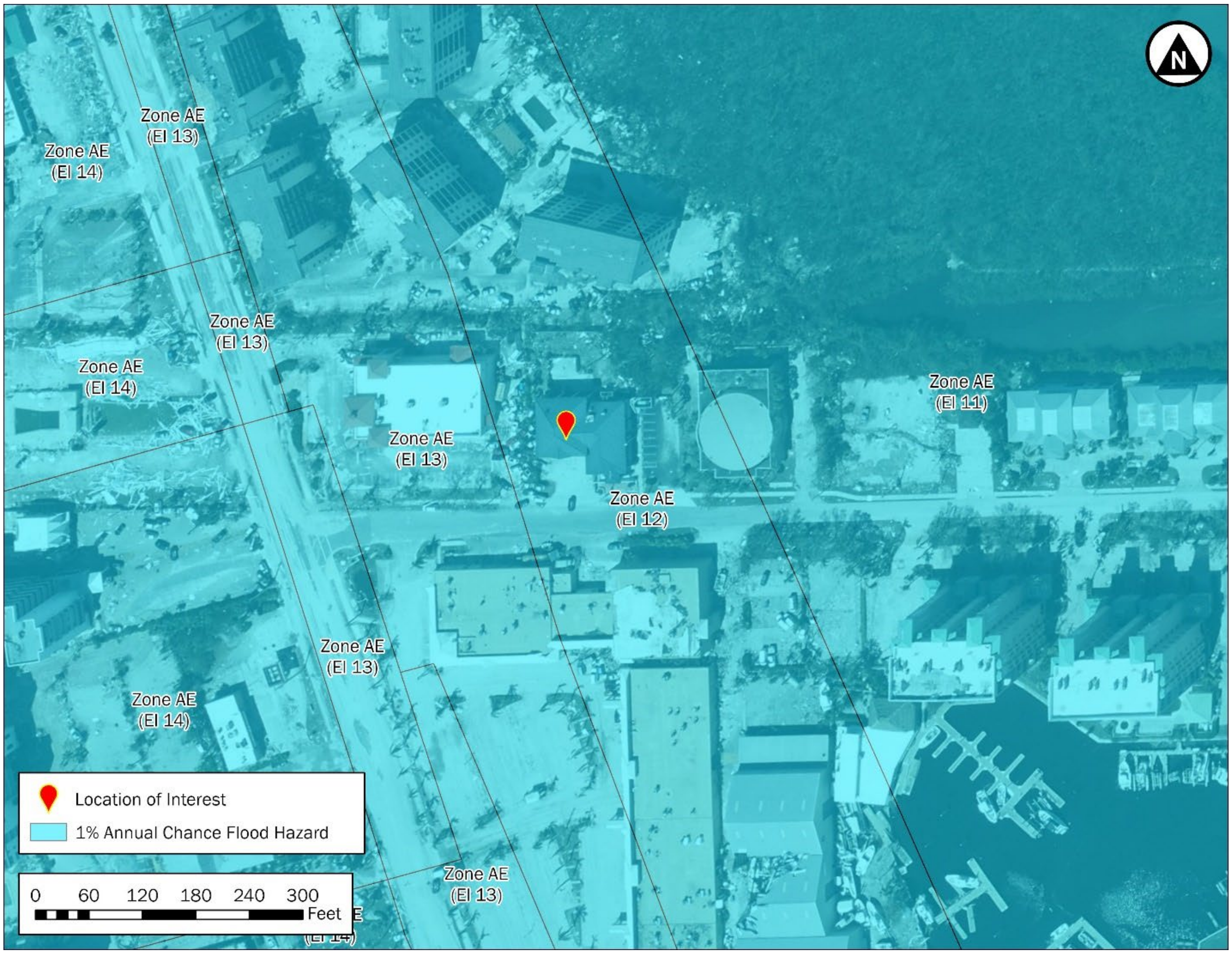


Figure 5-28: Effective FIRM at the Fort Myers Beach Fire Station #33 location at the time of Hurricane Ian's landfall

The two-level fire station, constructed in 2007, totals approximately 7,500 square feet (Figure 5-29). The apparatus bay, located on the west side of the building, is constructed near grade at an elevation of 7.6 feet NAVD 88. The floor on the east side of the building, which contains staff living spaces (kitchen, breakroom, dayroom, bathrooms, and bunk rooms), is at an elevation of 11.0 feet NAVD 88.

Figure 5-29: Fort Myers Beach Fire Station #33 apparatus bay (left) and commercial and residential area (right) (Lee County, Zone AE)

The apparatus bay is wet floodproofed and equipped with flood vents that allow for the automatic entry and exit of floodwater. The utility rooms, which are to the east of the apparatus bay and are also constructed at an elevation of 7.6 feet NAVD 88, are dry floodproofed. Common areas, such as the kitchen, rest rooms, and dining and bunk rooms, are elevated and dry floodproofed (Figure 5-30).

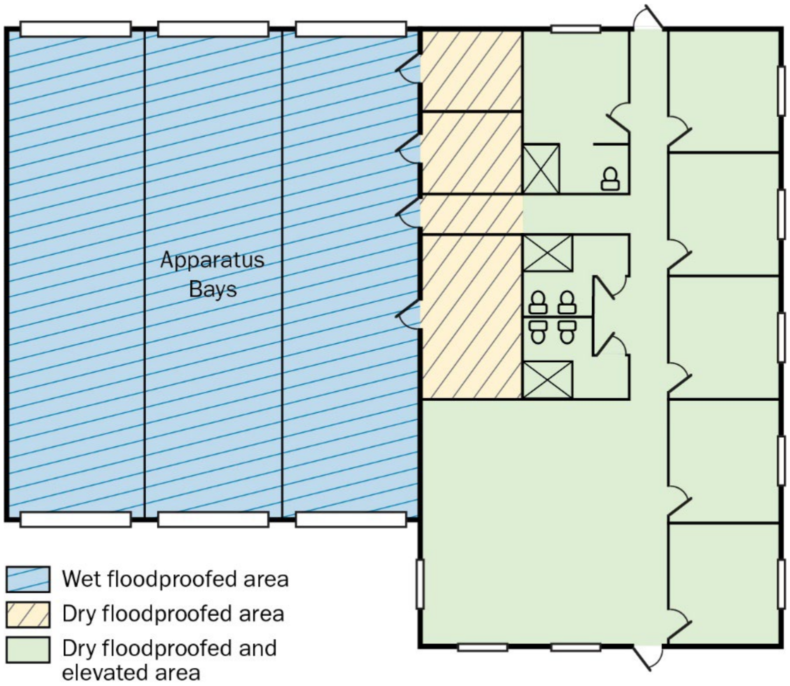


Figure 5-30: Floorplan of Fire Station #33 showing wet floodproofed area, dry floodproofed-area, and dry-floodproofed and elevated area

The Flood Protection Elevation (FPE) for the dry-floodproofed areas is 15 feet NGVD 29 (13.8 feet NAVD 88) or BFE+3. Dry floodproofing measures include the solid grouting of masonry walls, the application of a polymer cement waterproofing, and the installation of gasketed aluminum stop logs for all doors that access the dry-floodproofed areas.

application of a polymer cement waterproofing, and the installation of gasketed aluminum stop logs for all doors that access the dry-floodproofed areas.

Mechanical and electrical equipment are elevated and equipment below the BFE is minimized. Elevated equipment includes the electrical service and distribution equipment, the standby generator that supplies the entire facility,[13] the automatic transfer switch (ATS) that controls the generator and utility power, and the air conditioning equipment (Figure 5-31).

Figure 5-31: Equipment elevated on a platform (Lee County, Zone AE)

During Hurricane Ian, flood depths in the apparatus bay reached 60 inches or 12.59 feet NAVD 88 or 1.21 feet below the FPE. Based on the FIS in effect when Hurricane Ian made landfall, the flood elevation correlates to a flood event with approximately a 200-year recurrence interval. Floodproofing measures performed as anticipated during Hurricane Ian. The dry floodproofing prevented floodwater from entering protected areas.

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[13] The liquid propane (LP) tank that supplies the standby generator was not elevated.

One of the six overhead doors in the apparatus bay was damaged during Hurricane Ian, rendering the door inoperable and requiring its replacement. Fire station staff believe damage resulted from a dumpster that was dislodged during the event.

During Hurricane Ian, the anchorage straps securing the unelevated liquid propane (LP) tank broke. The tank was dislodged, and its fuel lines severed.

Building Performance and Operational Performance:

- Stillwater elevations during Hurricane Ian correlate to approximately a 200-year recurrence interval.
- The FPE of BFE +3 was not exceeded during Hurricane Ian and dry and wet floodproofing performed as anticipated.
- An apparatus bay door was damaged, likely by flood-borne debris. Damage rendered the door inoperable.
- An LP tank, which was placed below the BFE, was dislodged by floodwater. The dislodged tank temporarily rendered the facility's standby generator inoperable.
- No known impacts to operations after station was reoccupied following Hurricane Ian.

Fort Myers Beach Fire Station #32

Fort Myers Beach Fire Station #32 is located approximately 1.08 miles north of the midspan of the Hurricane Pass Bridge that connects San Carlos Island to the mainland. When Hurricane Ian made landfall, the effective FIRM placed the fire station in Zone AE with a BFE of 11 feet NAVD 88. When the facility was constructed, the effective FIRM placed it in Zone A12 with a BFE of 11 feet NGVD 29 (10 NAVD 88). The LiMWA was not delineated on the effective FIRM at the time of construction or on the effective map when Hurricane Ian made landfall (Figure 5-32).

Fort Myers Beach Fire Station #32

Date of Construction = 2007

Flood Zone and BFE per FIRM effective at time of construction Zone A12 with a BFE of 11 feet (NGVD 29) / 10 feet (NAVD 88) (effective November 4, 1992)

Flood Zone and BFE per FIRM effective at the time of Hurricane Ian = Zone AE 11 (NAVD 88) (FIRM effective August 28, 2008)

Measured Water Surface Elevation = 12.1 feet (NAVD 88)

Figure 5-32: Effective FIRM at the Fort Myers Beach Fire Station #32 location at the time of Hurricane Ian's landfall

The fire station is a three-story building (Figure 5-33). The lowest floor, constructed at an elevation of 5.8 feet (NAVD 88), contains the apparatus bay to the right (southwest) side of the building, and the main entrance, lobby, gear room, and decontamination/laundry room to the left (northeast) side of the building. The left side also contains two staircases and a single-cab elevator. The second floor contains staff living space, which includes bunkrooms, a kitchen and dining room, men's and women's bathrooms, and an exercise room. The third floor contains offices, mechanical and electrical rooms, a training room, and restrooms. There are two flat roofs, one above the third floor and the second at the third-floor level.

Figure 5-33: Fort Myers Beach Fire Station #32, view looking southeast (Lee County, Zone AE)

The building was designed in 2006 and constructed in 2007. Dry and wet floodproofing were included in the design. The apparatus bay is wet floodproofed and equipped with nine automatic flood vents that allow for the automatic entry and exit of floodwater. The remaining portions of the first floor are dry floodproofed (Figure 5-34).

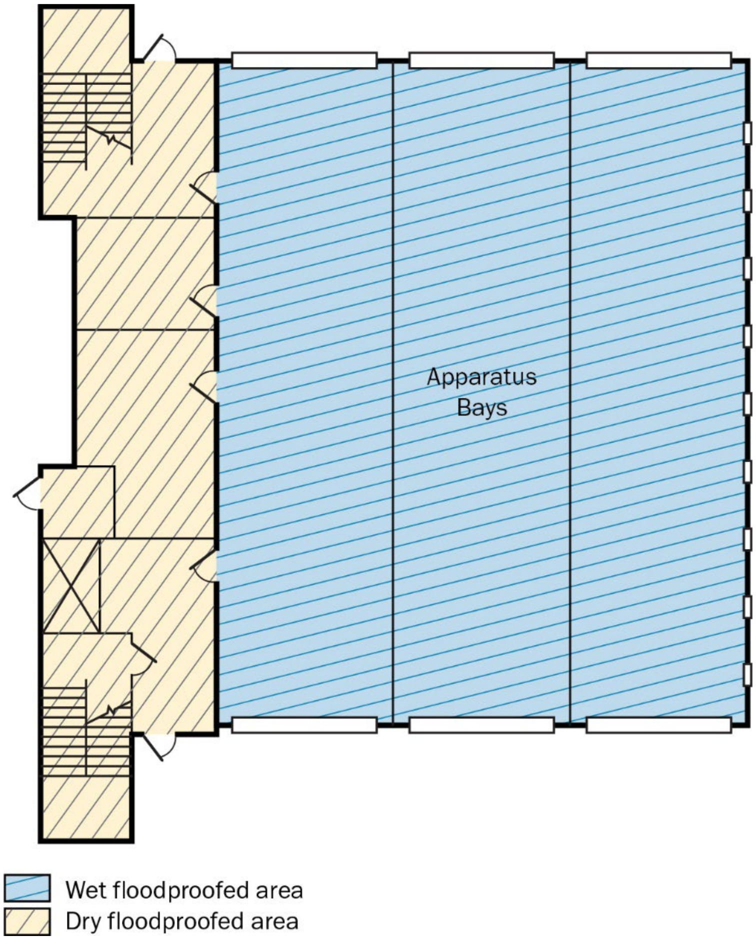


Figure 5-34: Floodproofing measures implemented in Fire Station #32

The FPE for the dry-floodproofed areas is 12 feet NGVD 29 (10.8 feet NAVD 88) or BFE+1. Dry floodproofing measures include the solid grouting of all first-floor walls, the application of a polymer cement waterproofing, and the installation of gasketed aluminum flood barriers for all doors that access the dry-floodproofed areas. Figure 5-35 shows the receiving components for the stop logs. Those components include devices to hold the logs in place and compress their gaskets (Figure 5-36). The stop logs are stored on site (Figure 5-37).

Figure 5-35: Stop logs/flood barriers for the Main Entrance (Lee County, Zone AE)

Figure 5-36: Flood barrier fastening device (Lee County, Zone AE)

Figure 5-37: Stop logs / flood barriers stored on site when not in use (Lee County, Zone AE)

Mechanical and primary components of the electrical service and distribution system are elevated. Secondary components of the electrical system, such as branch circuit wiring, convenience outlets, and switches, are elevated or located in dry-floodproofed areas. Some secondary electrical components in the apparatus bay are located below the BFE but they have been elevated as much as practical. Elevated primary components of the electrical service and distribution system include the electrical service equipment and the ATS, which are mounted on the mezzanine above the apparatus bay (Figure 5-38) and the standby generator, which is elevated on a platform behind the building (Figure 5-39). The service and distribution equipment, the ATS, and the standby generator are elevated to approximately 15 feet NGVD 29 or BFE+4. HVAC condensing units, which are located on the lower roof (Figure 5-40), are elevated well above the BFE. The elevator equipment, located near the main entrance, is below the BFE but located in a dry-floodproofed area.

Figure 5-38: Elevated electrical service and distribution equipment on the mezzanine above the apparatus bay (Lee County, Zone AE)

Figure 5-39: Elevated standby generator (behind wall) (Lee County, Zone AE)

Figure 5-40: Elevated HVAC condensing units (Lee County, Zone AE)

The electrical utility meter, which is mounted on the northeast side of the building near the elevator shaft, is not elevated and not protected by dry floodproofing (Figure 5-41).

Figure 5-41: Electrical utility meter that is not elevated nor protected by dry floodproofing (Lee County, Zone AE)

During Hurricane Ian, floodwater within the apparatus bay reached an elevation of 13.32 NGVD 29 (12.14 feet NAVD 88), which exceeded the FPE by 1.32 feet (Figure 5-42).

The flood elevations correlate to a flood event with approximately a 150-year recurrence interval.

Figure 5-42: HWM observed by the MAT (Lee County, Zone AE)

Floodwater overtopped the flood barriers and completely inundated the dry-floodproofed areas. Staff reported that equipment in the hydraulic elevator pit was extensively damaged and required replacement. Submerged electrical equipment and submerged materials that were not flood damage–resistant had to be removed. Glazing in the storefront-style front entrance door, which is located behind flood barriers, was broken (Figure 5-43). Damage likely resulted from the rate at which floodwater filled the dry-floodproofed areas and from the overall air tightness of the door, which prevented flood levels on either side of the door to equalize.

Figure 5-43: Front door glazing damaged by floodwater (Lee County, Zone AE)

Damaged or submerged electrical equipment was generally limited to branch circuit wiring and devices, and damage to submerged materials that were not flood damage–resistant was limited to gypsum drywall in the elevator lobby. Materials in wet-floodproofed areas and most materials in dry-floodproofed areas were flood damage–resistant and did not require replacement. Primary electrical equipment (e.g., electrical service equipment, ATS, feeders and panels) was elevated above the flood levels and was not damaged by flooding.

Building Performance and Operational Performance:

- Stillwater elevations during Hurricane Ian correlate to a flood event with an approximate 150-year recurrence interval.
- During Hurricane Ian, floodwater exceeded the FPE of BFE +1 by 1.32 feet. Flood barriers were overtopped and the dry-floodproofed areas were inundated.
- Critical equipment that relied on dry floodproofing for protection was damaged.
- Critical equipment that was elevated above the flood elevation and did not rely on dry floodproofing was not damaged.
- Minor operational impacts, fire station reoccupied following Hurricane Ian, elevators were out of service and equipment in storage areas needed to be replaced.

City of Naples Fire Station #1

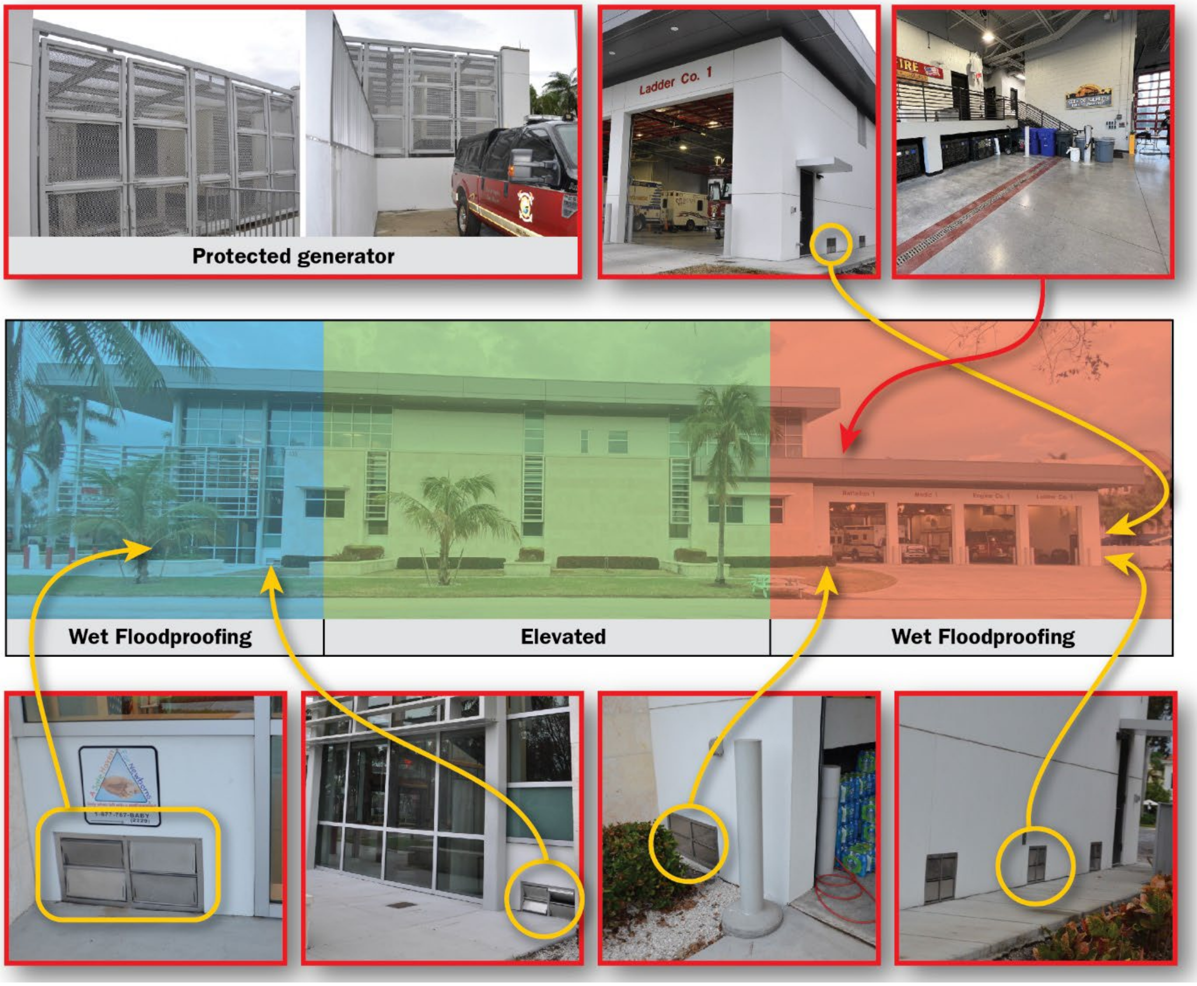
This 22,000-square-foot fire station, which was constructed in 2019, is located in Zone AE 8 (NAVD 88). The building was designed as a Risk Category IV building, and equipped to withstand Category 5 Hurricane wind speeds, as well as a Flood Design Class 4 structure according to ASCE 24-14. This fire station houses several essential operations for the City of Naples, including its EOC. The interior doors separating the EOC from the main portion of the building are ICC 500–rated doors, and the generator has a screened enclosure to protect it from wind-borne debris. While components of the EOC construction included design considerations and components of an ICC 500 storm shelter, the MAT could not independently verify full compliance with ICC 500 standards. The main lobby on the western end of the building and the garage to the east are both at-grade and wet floodproofed and are designed to allow for the automatic entry and exit of floodwater. The main lobby and garage are equipped with flood openings that appear to have performed as designed, as this area had been inundated with floodwater. During the pre-MAT field work in October 2022, a HWM of 28 inches above the garage slab was identified in the fire bay parking area. The center/main portion of the building has an elevated lowest floor that is 5 feet above the garage floor level. According to reports by fire station personnel during the site visit, the primary damage was to equipment in the garage (including fire trucks). In addition, the fire department reported in a follow-up that the elevator on the lobby side of the facility had experienced damage (Figure 5-44 through Figure 5-47).

City of Naples Fire Station #1

Date of Construction = 2019

Flood Zone and BFE per FIRM effective at time of construction and Hurricane Ian = Zone AE 8 (NAVD 88) (FIRM effective May 16, 2012)

Measured Water Surface Depth = 28 inches



Wet floodproofed lobby and bay on each side of an elevated fire station approximately 5 feet above the garage floor level.

Figure 5-44: City of Naples Fire Station #1 (Collier County, Zone AE)

Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Esri Community Maps Contributors, University of South Florida, County of Collier, FDEP, © OpenStreetMap, Microsoft, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, State of Florida, Maxar, Microsoft

Figure 5-45: Effective FIRM at the City of Naples Fire Station #1 location at the time of Hurricane Ian's landfall

Figure 5-46: 28-inch HWM at City of Naples Fire Station #1 (Collier County, Zone AE)

Figure 5-47: Doors to City of Naples ICC 500 EOC (Collier County, Zone AE)

Building Performance and Operational Performance:

- There were no indications of building performance failures beyond the flood damaged elevator.
- The wet floodproofed portions of the structure appeared to perform as designed.
- No known impacts to operations after station was reoccupied following Hurricane Ian.

Volusia County Fire Station #12

Fire Station #12, originally built in 1975, is located at the intersection of State Routes 415 and 421 in Volusia County, less than 500 feet from a regulatory floodway. Figure 5-48 shows the FIRM effective at the time of Hurricane Ian. This property is currently outside the SFHA. Since 2000, the station has had several wind retrofits completed as well as an elevated generator installed. During Hurricane Ian, the fire station was inundated by floodwater, and based on exterior measurements taken by the pre-MAT, the estimated flood depths within the fire station were 36 inches. A HWM was found near the generator, which was sufficiently elevated to avoid floodwater damage. As a result of the flood damage to the facility, the fire station was closed and taken out of service until repairs could be made. According to a Volusia County summary report in early February 2023, the repairs and remodeling associated with Hurricane Ian damage had just begun and were estimated to take 8 weeks to complete. According to County officials, approximately $120,000 was spent to repair damage from flooding. Interior drywall and finishes were removed and replaced. As of June 16, 2023, most of the work was complete (Figure 5-49 and Figure 5-50).

Volusia County Fire Station #12

Date of Construction = 1975

Flood Zone and BFE per FIRM effective at time of construction = Zone D (undetermined, but possible, flood hazard) (FIRM effective July 1, 1974)

Flood Zone and BFE per FIRM effective at the time of Hurricane Ian = Zone X (FIRM effective February 19, 2014)

Measured Water Surface Depth = 36 inches

Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Esri Community Maps Contributors, FDEP, © OpenStreetMap, Microsoft, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, State of Florida, Maxar, Microsoft

Figure 5-48: Effective FIRM at the Volusia County Fire Station #12 location at the time of Hurricane Ian's landfall

Figure 5-49: Volusia County Fire Station #12 (Volusia County)

Figure 5-50: Volusia County Fire Station #12 with generator on right, elevated above Hurricane Ian floodwaters (Volusia County)

Building Performance and Operational Performance:

- Estimated flood depths within the fire station were 36 inches despite the fire station's location outside the SFHA.
- As a result of the flood damage to the facility, the fire station was closed and taken out of service until repairs were made. Repairs to flood damage were still being performed in June 2023.

Everglades City Fire Station #60

City Fire Station #60 is operated by Greater Naples Fire Rescue. The 5,000-square-foot steel structure was built in the early 1970s. It is located in Zone AE with a BFE of 9 feet NAVD 88 on the current effective 2012 FIRM. At the estimated time of construction, the 1972 FIRM identified this as Zone A. The pre-MAT team measured a HWM 34 inches above the lowest floor in the fire station bays. The elevated generator is above this HWM and did not appear to be damaged by floodwater (Figure 5-51 through Figure 5-54). Based on a May 2023 site inspection by FEMA Public Assistance, all interior finishings were removed and the building was in the process of being repaired.

Everglades City Fire Station #60

Date of Construction = Early 1970s

Flood Zone per FIRM effective at time of construction = Zone A (FIRM effective October 6, 1972)

Flood Zone and BFE per FIRM effective at the time of Hurricane Ian = Zone AE 9 (NAVD 88) (FIRM effective May 16, 2012)

Measured Water Surface Depth = 34 inches

State of Florida, Maxar, Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Esri Community Maps Contributors, University of South Florida, County of Collier, FDEP, © OpenStreetMap, Microsoft, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA

Figure 5-51: Effective FIRM at the Everglades City Fire Station #60 location at the time of Hurricane Ian's landfall

Figure 5-52: Everglades City Fire Station #60 (Collier County, Zone AE)

Figure 5-53: Everglades City Fire Station #60 with an elevated generator in the foreground (Collier County, Zone AE)

Figure 5-54: Everglades City Fire Station #60 with HWM (Collier County, Zone AE)

Building Performance and Operational Performance:

- Although there was no indication of structural damage to the fire station, approximately 3 feet of flooding required most interior finishings to be removed.
- After the station flooded, the fire department personnel operated from a motorhome parked adjacent to the fire station while repairs were already underway.
- The elevated generator is above the HWM and did not appear to be damaged by floodwater.

5.4.2. WIND PERFORMANCE

Most of the fire stations visited by the MAT were exposed to estimated wind speeds less than, and in some cases significantly less than ASCE 7-16 wind speeds. Most experienced little or limited wind damage during Hurricane Ian, with the predominant damage being roof damage. Generally, the damage did not affect the operation of the fire stations.

Fort Myers Beach Fire Station #33

Fort Myers Beach Fire Station #33 (Figure 5-55) is approximately 25 miles southeast of Hurricane Ian's path. Based on the NIST-estimated surface-level windfield for Hurricane Ian, the station experienced approximately a 98 mph wind speed during Hurricane Ian (Figure 5-56).

Design drawings for Fire Station #33 specified a 130 mph (3-second gust), Exposure C design wind speed with an importance factor of 1.15 per ASCE 7-98, and the building is in a WBDR. The design drawing for roof trusses stated they were designed as C&C for exterior zone locations. Copies of numerous Notices of Acceptance (NOAs) were available. The NOAs were not reviewed in depth by the MAT, but the NOAs generally state that the components were tested for wind pressures and small and large missile impact.

Fort Myers Beach Fire Station #33

Date of Construction = 2007

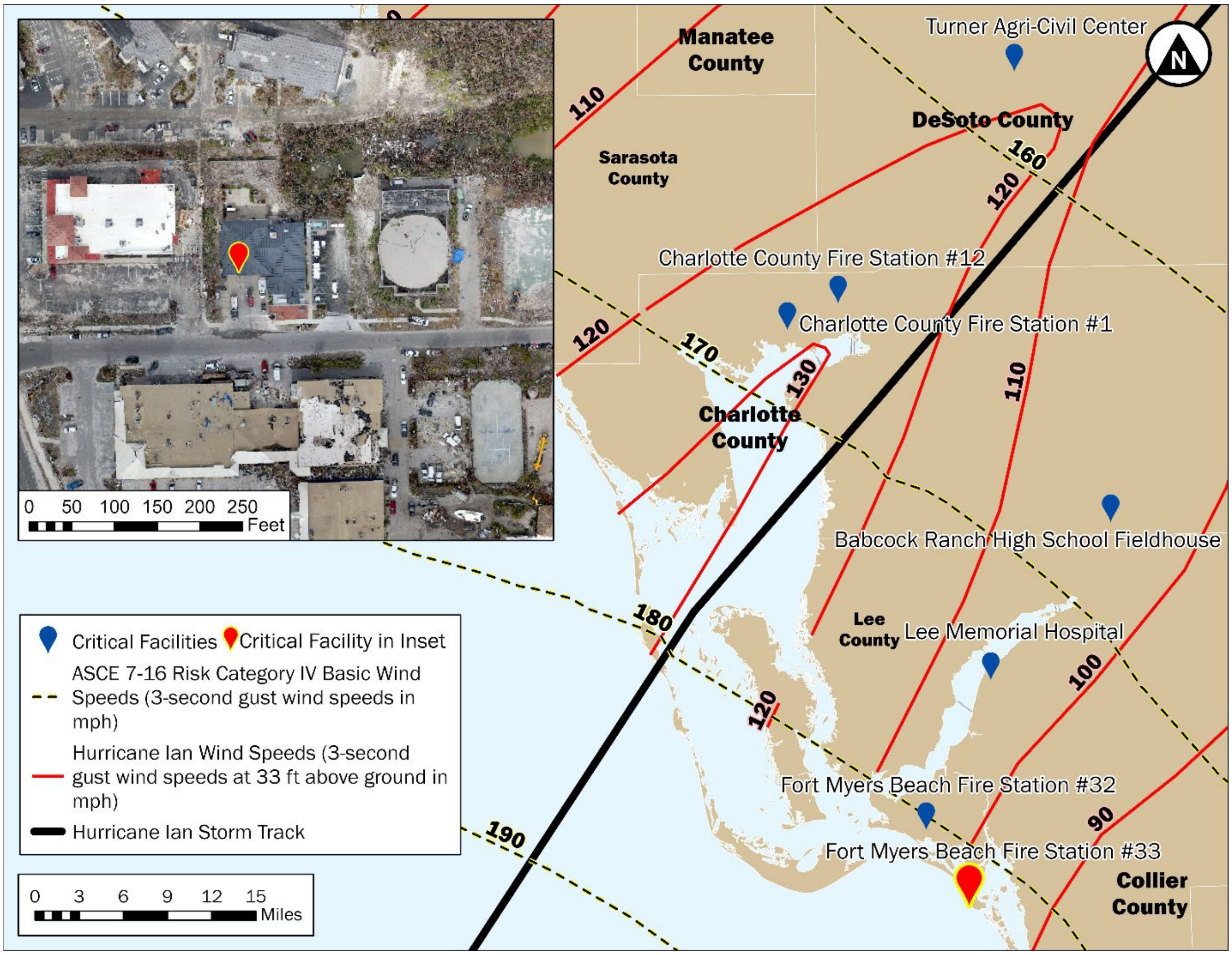
Estimated Wind Speed = 98 mph (3-second gust)

Design Wind Speed (stated on drawings) = 130 mph (3-second gust) (ASCE 7-98) (130 mph ASCE 7-98 basic wind speed is comparable to an ASCE 7-16 Risk Category III(a) basic wind speed of 176 mph [3-second gust])

ASCE 7-16 Basic Wind Speed (Risk Category IV) = 182 mph (3-second gust)

(a) Per design drawings, the facility was designed as a Category III structure.

Figure 5-55: Fort Myers Beach Fire Station #33 (Lee County)



Source: NIST

Figure 5-56: Location of Fort Myers Beach Fire Station #33 (red map pin) in Hurricane Ian windfield

During the MAT site visit, post-event cleanup and repairs were nearly complete and no glazing or building envelope damage was observed. One of the six overhead doors in the apparatus bay was damaged and inoperable, but the damage was believed to have resulted from flood-borne debris impact, not wind.

Fire station staff reported that a roof-mounted exhaust fan blew off during Hurricane Ian (Figure 5-57). They also reported some limited roofing damage on one of the roof's exposures, likely the south or southwest, but no wind damage was evident during the site visit. Staff stated that there was no interior damage from water entry.

Figure 5-57: Roof-mounted exhaust fan lost during Hurricane Ian (Lee County)

Staff also reported that the ATS for the standby generator was damaged when the wind loads forced its enclosure door to open and allowed wind-driven rain to enter (Figure 5-58). During the MAT site visit, the enclosure door was closed and latched, and no physical damage was evident to the door or its latching mechanism. The interior of the enclosure could not be observed. The ATS was not operational and could only be operated manually.

Figure 5-58: ATS damaged during Hurricane Ian (Lee County)

Building Performance and Operational Performance

- The estimated wind speed during Hurricane Ian correlates to approximately an 18-year recurrence interval.
- The metal roof sustained limited damage and a roof-mounted exhaust fan was blown off.
- The ATS for the standby generator was damaged when winds forced the enclosure door to open and allowed wind-driven rain to enter.

Fort Myers Beach Fire Station #32

Fort Myers Beach Fire Station #32 (Figure 5-59) is approximately 20 miles southeast of Hurricane Ian’s path. Based on the NIST-estimated surface-level windfield for Hurricane Ian, the station experienced approximately a 104 mph wind speed during Hurricane Ian (Figure 5-60).

Design drawings for Fire Station #32 specified a 150 mph (3-second gust), Exposure B design wind speed with an importance factor of 1.15 per ASCE 7-02 (2004 FBC). This is higher than the ASCE 7-02 basic wind speed for the area, which is 130 mph. The building was designed as enclosed (protected openings) with an internal pressure coefficient of +/- 0.18. Copies of numerous NOAs were available. The NOAs were not reviewed in depth by the MAT, but the NOAs generally state that the components were tested for wind pressures and some had been tested for small and large missile impact.

The roofs are surfaced with single-ply membranes.

Fort Myers Beach Fire Station #32

Date of Construction = 2007

Estimated Wind Speed = 104 mph (3-second gust)

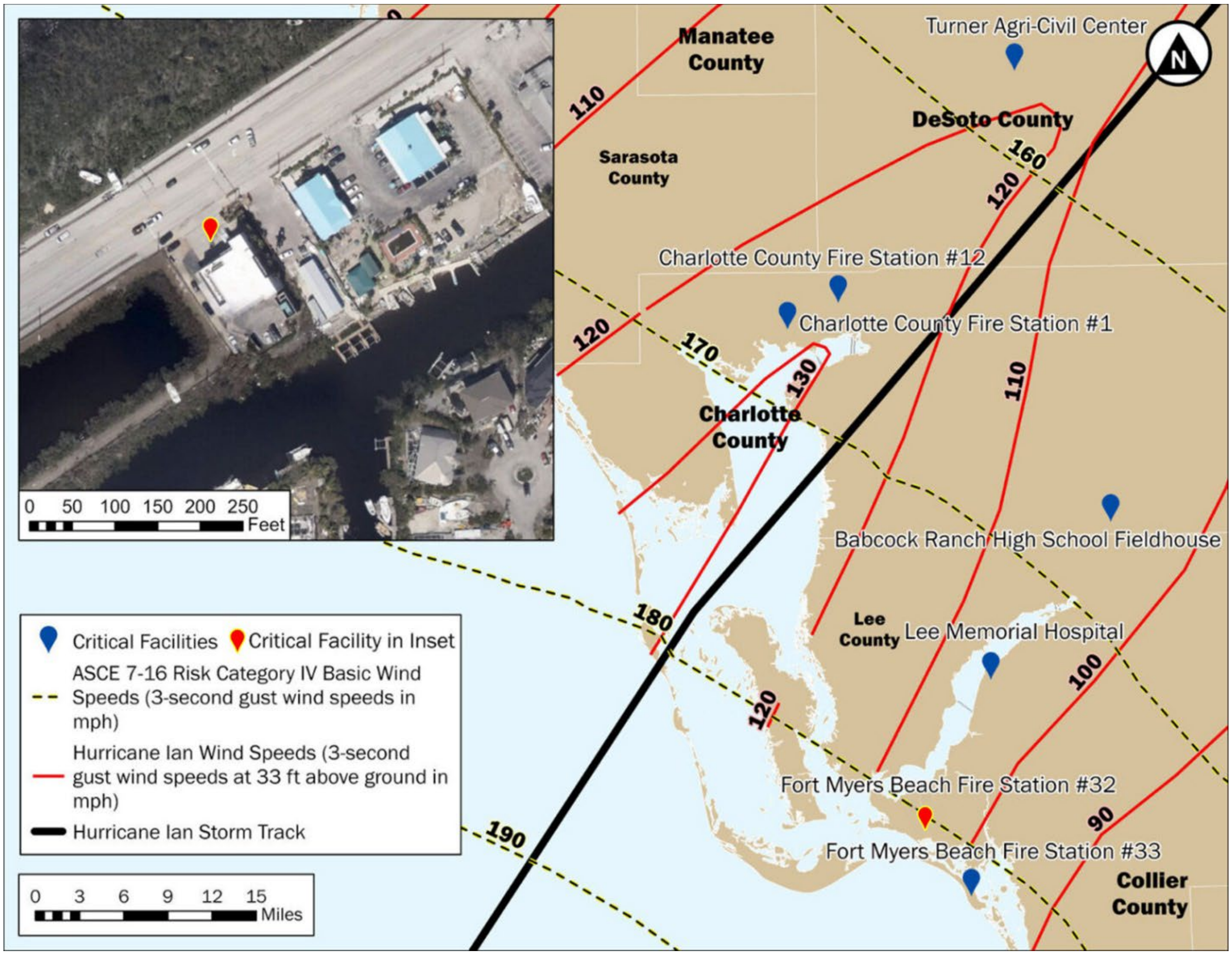
Design Wind Speed (stated on drawings) = 150 mph (3-second gust) (ASCE 7-02) (150 mph ASCE 7-02 basic wind speed is comparable to an ASCE 7-16 Risk Category IV(a) basic wind speed of 204 mph [3-second gust])

ASCE 7-02 Basic Wind Speed = 130 mph (3-second gust) (130 mph ASCE 7-02 basic wind speed is comparable to an ASCE 7-16 Risk Category IV(a) basic wind speed of 176 mph [3-second gust])

ASCE 7-16 Basic Wind Speed (Risk Category IV) = 181 mph (3-second gust)

(a) Per design drawings, the facility was designed as a Category IV structure.

Figure 5-59: Fort Myers Beach Fire Station #32 (Lee County)



Source: NIST

Figure 5-60: Location of Fort Myers Beach Fire Station #32 (red map pin) in Hurricane Ian windfield

During Hurricane Ian, fire station staff reported that two exterior doors blew open. Both doors lead out onto the balcony on the right side of the building. One door accessed the balcony from the dining room (Figure 5-61); the second accessed the balcony from the corridor to the rear of the building. Both doors have three-point latches (head, threshold, and latch).

Figure 5-61: Door from dining area to balcony that blew open during Hurricane Ian (Lee County)

The cause of the doors opening during Hurricane Ian could not be determined. The documentation provided suggests that the doors are rated for positive and negative pressures of +70 and -80 psf respectively, which exceed the C&C corner zone pressures specified on the structural drawings. The relatively low wind speeds experienced during Hurricane Ian suggest that the doors may have been left unlatched inadvertently. The MAT did observe that the receiving slots in the head and threshold were significantly larger than the diameters of the corresponding latching mechanisms (Figure 5-62). This could allow the door panel to move excessively within the door frame and could contribute to a potential latch failure.

Figure 5-62: Receiving slot (left) is significantly larger than latching mechanism (right) (Lee County)

The roofs are surfaced with unballasted single-ply membranes. The membranes are not fully adhered, and within the field of the roof, no evidence of mechanical fastening was observed.

The MAT observed several vertically displaced and rippled sections of the roof membrane (Figure 5-63). Stains on the roof membrane suggest that some of the rippled sections may have existed before Hurricane Ian.

Figure 5-63: Displaced and rippled roof membrane (Lee County)

Fire station staff reported that during Hurricane Ian, water flowed into a branch circuit panelboard located on the third floor (Figure 5-64). Subsequent investigation determined that a roof cap for a roof penetration for communication cables (Figure 5-65) dislodged during Hurricane Ian and allowed water to enter the building. The water then flowed down a grounding cable that ran toward the panelboard. By the time the MAT visited the site, the cap had been repaired.

Figure 5-64: Third-floor panelboard that experienced water entry during Hurricane Ian (Lee County)

Figure 5-65: Roof cap for communication cables that was dislodged during Hurricane Ian (Lee County)

Building Performance and Operational Performance

- The estimated wind speed during Hurricane Ian correlates to approximately a 25-year recurrence interval.
- Two exterior doors blew open. The cause could not be determined, but a latch failure may have occurred or the doors may have been inadvertently left unlatched.
- A roof cap for a communication cable penetration was blown off, which enabled water to enter the building.

Charlotte County Fire Station #1

Charlotte County Fire Station #1 (Figure 5-66), located along South Tamiami Trail in Port Charlotte, is approximately 10 miles northwest of Hurricane Ian's track. Based on the NIST-estimated surface-level windfield for Hurricane Ian, the station experienced approximately 127 mph wind speeds during Hurricane Ian (Figure 5-67). The ASCE 7-16 basic wind speed for Risk Category IV structures is 168 mph.

During Hurricane Charley, Charlotte County Fire Station #1 (circa 1980) lost its mineral surface built-up roof covering and several cement fiber roof-deck panels, its apparatus bay doors failed, and several windows and doors were damaged. After Hurricane Charley, Charlotte County Fire Station #1 was demolished and rebuilt. The facility was dedicated in February 2006, approximately 18 months after Hurricane Charley hit the area.

Charlotte County Fire Station #1

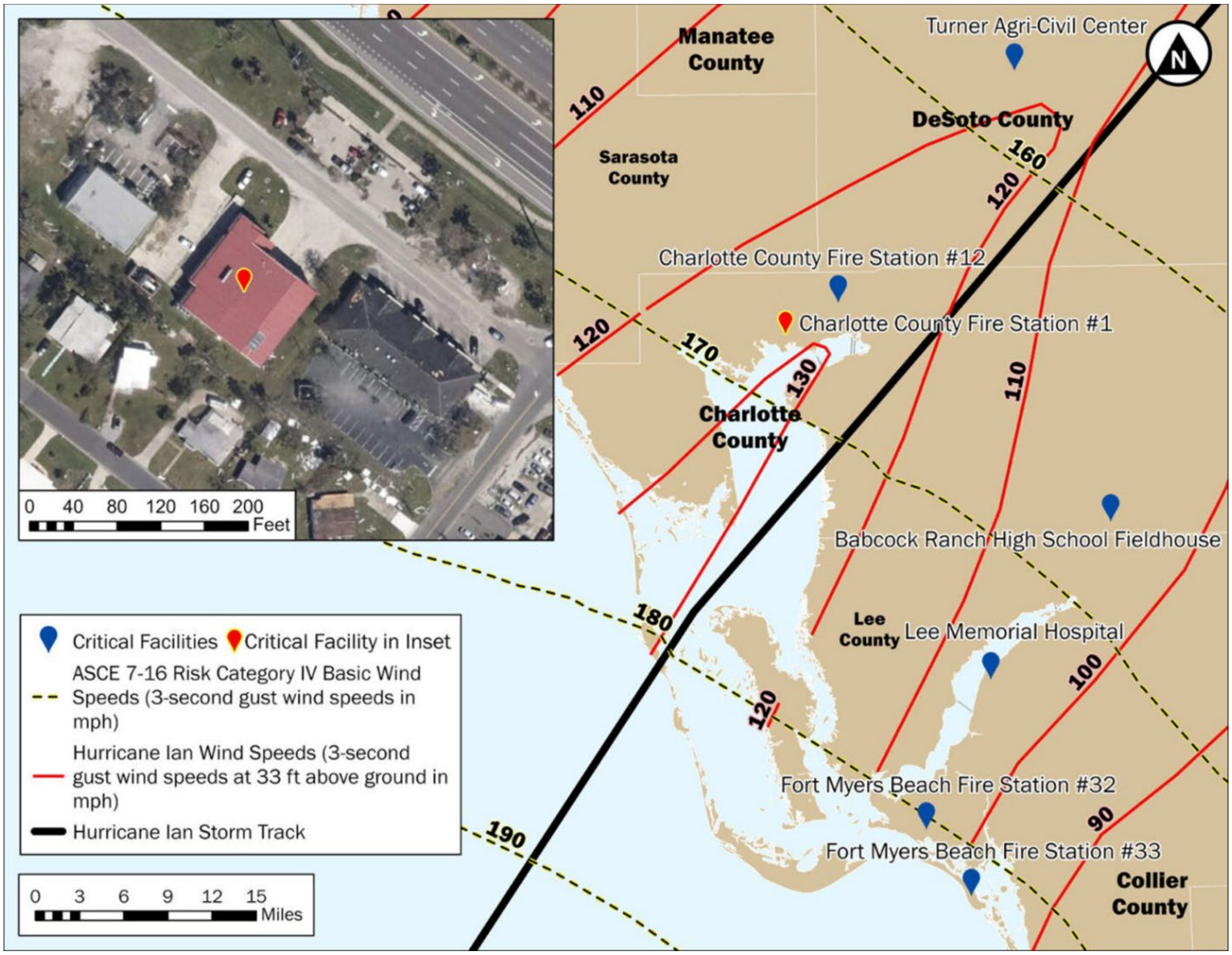
Date of Construction = 2006

Estimated Wind Speed = 127 mph (3-second gust)

Design Wind Speed (based on code requirements in effect at time of reconstruction) = 122 mph (3-second gust) (2004 FBC/ASCE 7-02) (122 mph ASCE 7-02 basic wind speed is comparable to an ASCE 7-16 Risk Category IV basic wind speed of 166 mph [3-second gust])

ASCE 7-16 Basic Wind Speed (Risk Category IV) = 168 mph (3-second gust)

Figure 5-66: Charlotte County Fire Station #1 (Charlotte County)



Source: NIST

Figure 5-67: Location of Charlotte County Fire Station #1 (red map pin) in Hurricane Ian windfield

Fire station staff were evacuated to Kingsway Elementary School prior to Hurricane Ian's landfall and returned when conditions permitted. After returning, staff reported that the station experienced minimal water entry from wind-driven rain. The station lost utility power. Its standby generator initially failed to start but was quickly repaired by county staff and remained functional until utility power was restored approximately 1 week later.

The facility lost metal coping in approximately six areas along the parapet over the apparatus bay and over the gable ends of the portion of the building adjacent to the apparatus bay. Figure 5-68 and Figure 5-69 show typical coping damage observed. The building's location in relation to Hurricane Ian's track suggest that coping failures occurred on the windward side of the building.

Figure 5-68: Damaged coping above the apparatus bays (Charlotte County)

Figure 5-69: Damaged coping above the apparatus bays (Charlotte County)

Portions of the apparatus bay doors were damaged. The damage appeared to have resulted from wind-borne debris impact. The doors are equipped with debris curtains. Whether the curtains were in place during the storm is unknown (Figure 5-70).

Figure 5-70: Damage to apparatus bay door (Charlotte County)

Building Performance and Operational Performance:

- The 127 mph (3-second gust) estimated wind speed during Hurricane Ian correlates to approximately a 155-year recurrence interval and is less than the design wind speed of 166 mph (3-second gust). The 166 mph (3-second gust) design wind speed is the comparable ASCE 7-16 Risk Category IV basic wind speed.
- The building experienced metal coping damage on the windward side of the building. An apparatus bay door was slightly damaged. Damage appeared to result from wind-borne debris impact.
- The building experienced minimal water entry from wind-driven rain.
- Fire station staff were evacuated prior to Hurricane Ian but returned after conditions permitted.
- The station lost utility power but functioned on standby power from an on-site generator until utility power was restored.

Charlotte County Fire Station #12

Charlotte County Fire Station #12 (Figure 5-71) located along Luther Road in Punta Gorda, is approximately 4 miles northwest of Hurricane Ian's track. Based on the NIST-estimated surface-level windfield for Hurricane Ian, the station experienced approximately 128 mph wind speeds during Hurricane Ian (Figure 5-72). The ASCE 7-16 basic wind speed for Risk Category IV structures is 166 mph.

Charlotte County Fire Station #12 is a reinforced masonry structure with a wood-framed roof structure surfaced with metal roofing. During Hurricane Charley, Charlotte County Fire Station #12 (circa 1998), lost sections of metal panel roofing, wood roof decking. and portions of its wood-framed roof structure. Sections of the masonry walls were also damaged. After Hurricane Charley, Charlotte County Fire Station #12 was repaired.

Charlotte County Fire Station #12

Date of Construction = 1998 (original), 2005 approximately (reconstruction post-Hurricane Charley)

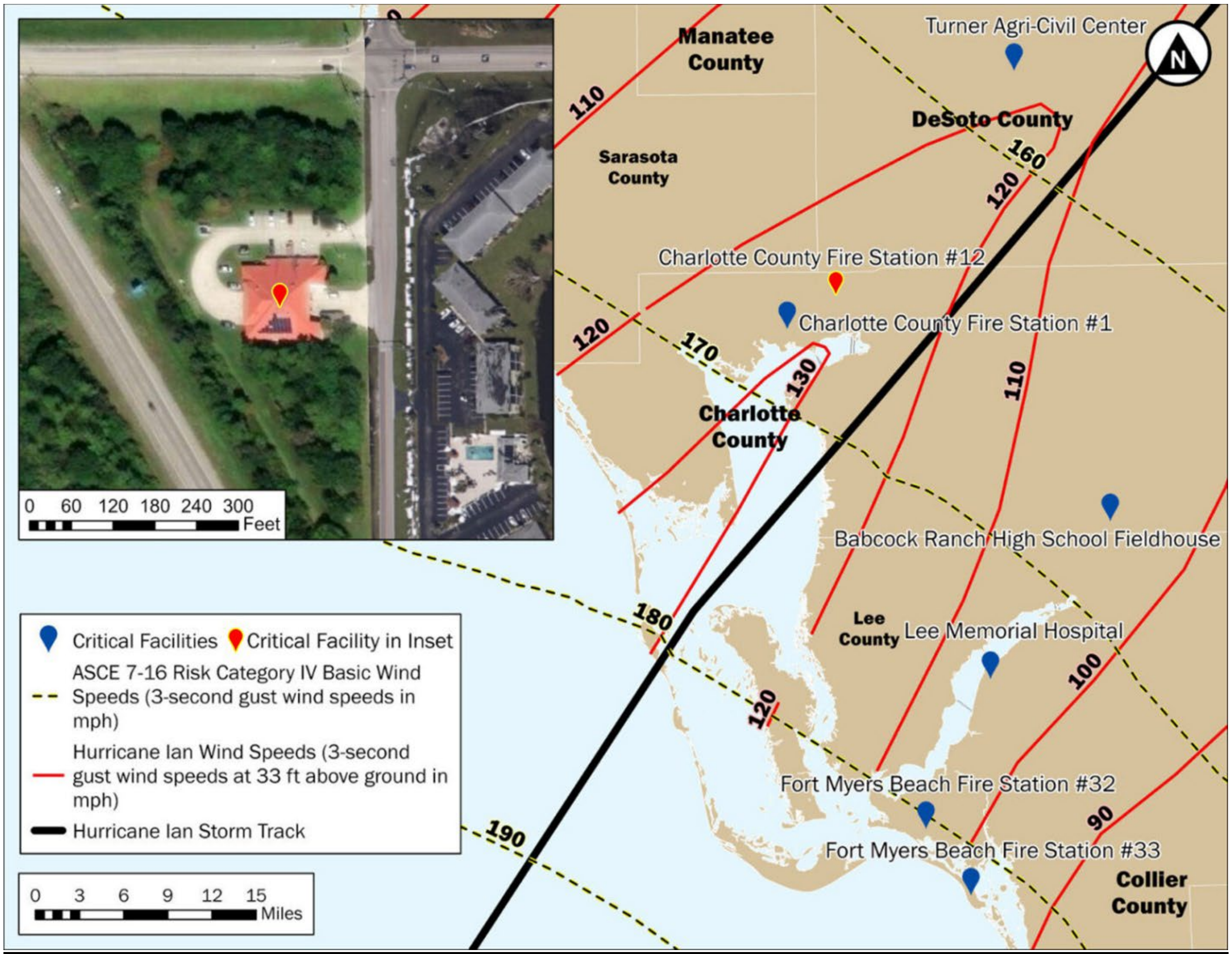
Estimated Wind Speed = 128 mph (3-second gust)

Design Wind Speed (for original construction) = unknown

Design Wind Speed for reconstruction (based on code requirements in effect at time of reconstruction) = 120 mph (3-second gust) (2004 FBC/ASCE 7-02) (120 mph ASCE 7-02 basic wind speed is comparable to an ASCE 7-16 Risk Category IV basic wind speed of 163 mph [3-second gust])

ASCE 7-16 Basic Wind Speed (Risk Category IV) = 166 mph (3-second gust)

Figure 5-71: Charlotte County Fire Station #12 (Charlotte County)



Source: NIST

Figure 5-72: Location of Charlotte County Fire Station #12 (red map pin) in Hurricane Ian windfield

Fire station staff reported that the station was not damaged during Hurricane Ian and experienced no water entry.

Building Performance and Operational Performance:

- The 128 mph (3-second gust) estimated wind speed during Hurricane Ian correlates to approximately a 176–year recurrence interval and is less than the design wind speed of 163 mph (3-second gust). The 163 mph (3-second gust) design wind speed is the comparable ASCE 7-16 Risk Category IV basic wind speed.
- No reported damage occurred during Hurricane Ian.
- No operational loss resulted from Hurricane Ian.

5.5. Police Stations

During the pre-MAT, the team visited one police station in Naples. While other law enforcement facilities were likely impacted by Hurricane Ian, this is the one the team was able to coordinate access to.

5.5.1. NAPLES POLICE DEPARTMENT

The original 18,000-square-foot office building for the Naples Police Department was built in 1978, based on Collier County parcel data. In 1999, 12,000 square feet were added to the building. The Police Headquarters building is located in Zone AE 8 (Figure 5-73). During Hurricane Ian, the original 1978 portion of the building experienced approximately 7 inches of flooding, forcing staff to relocate. The flooding caused damage to flooring, interior finishes, and contents; more importantly, it had a significant impact on the police department's operations during a major hurricane as most law enforcement staff were forced to relocate away from their common areas, impacting command and control as well as situational awareness. The City of Naples Utility Operations Building and Fleet Management Facility across the street from the Police Headquarters (Figure 5-74), shown in the aerial imagery with the FIRM, were also impacted by Hurricane Ian, with the fleet bays and offices receiving floodwater. Although the utility building was surrounded by water, it did not flood.

Naples Police Department

Date of Construction = 1978 with 1999 addition

Flood Zone and BFE per FIRM effective at time of construction = Zone AE 7 (NGVD 29) / Zone AE 6 (NAVD 88) (FIRM effective February 13, 1976)

Flood Zone and BFE per FIRM effective at the time of Hurricane Ian = Zone AE 8 (NAVD 88) (FIRM effective May 16, 2012)

Measured Water Surface Depth = 7 inches inside original portion of the building

Figure 5-73: Effective FIRM at the Naples Police Department location at the time of Hurricane Ian's landfall

Figure 5-74: Naples Police Department with the 1999 addition in the foreground and the older 1978 structure in the background to the right (Collier County, Zone AE)

Building Performance and Operational Performance:

- Interior flooding caused damage to flooring, interior finishes, and contents.
- Damage forced staff to relocate away from their common areas, which affected command and control, impacting the police department's operations during and after Hurricane Ian.

5.6. Schools

In addition to schools that were used as HESs, the pre-MAT visited the Everglades City School to observe the flood mitigation measures that performed successfully during Hurricane Ian.

5.6.1. EVERGLADES CITY SCHOOL

The Everglades City School, which was built in 1995, consists of several buildings on a single campus located in Zone AE 9. Figure 5-75 shows the effective FIRM at the school at the time of Hurricane Ian's landfall. It is the only public school in the Everglades for grades pre-Kindergarten through 12. In 2017, during Hurricane Irma, the campus experienced widespread flooding, including up to 3 feet of water in several campus buildings. As a result, the Collier County School Board sought to minimize flood impacts to the school through mitigation measures to improve drainage, perform grading and erosion control, and erect flood gates. Under the FEMA Public Assistance Program, hazard mitigation measures were incorporated into the repair work following Hurricane Irma, specifically a floodwall around the campus. The flood mitigation measures followed the minimum elevation requirements in ASCE 24 for a Flood Design Class 3 building (BFE+1 foot), and the overall design addressed utilities (including backflow prevention valves) and pumping capacity for rain accumulating behind the floodwall (including emergency power for the pump), and incorporated a passive approach, reducing the need for human intervention. Four pedestrian gates and one vehicular gate are part of the overall system, protected with passive opening barriers; however, the barriers were manually deployed by school staff in preparation for Hurricane Ian (Figure 5-76 and Figure 5-77).

Everglades City School

Date of Construction = 1995

Flood Zone and BFE per FIRM effective at time of construction = Zone AE 10 (NGVD 29) / Zone AE 9 (NAVD 88) (FIRM effective June 3, 1986)

Flood Zone and BFE per FIRM effective at the time of Hurricane Ian = Zone AE 9 (NAVD 88) (FIRM effective May 16, 2012)

Measured Water Depth = 69 inches

Though much of Everglades City was inundated by floodwater during Hurricane Ian, the Everglades City School did not experience any flood damage. Based on HWMs measured on the floodwall as well as security camera footage during Hurricane Ian, the floodwall system avoided the kind of damage that was experienced during Hurricane Irma (at least) as Hurricane Ian surge levels reached within a foot of the top of the floodwall (Figure 5-78). When the pre-MAT visited the school (Wednesday, October 12, 2022), the school campus was in full operation, and the administrative staff and faculty at the school could not have been happier with the performance of the mitigation measures implemented following Hurricane Irma.

Figure 5-75: Effective 2012 FIRM at the Everglades City School location at the time of Hurricane Ian's landfall

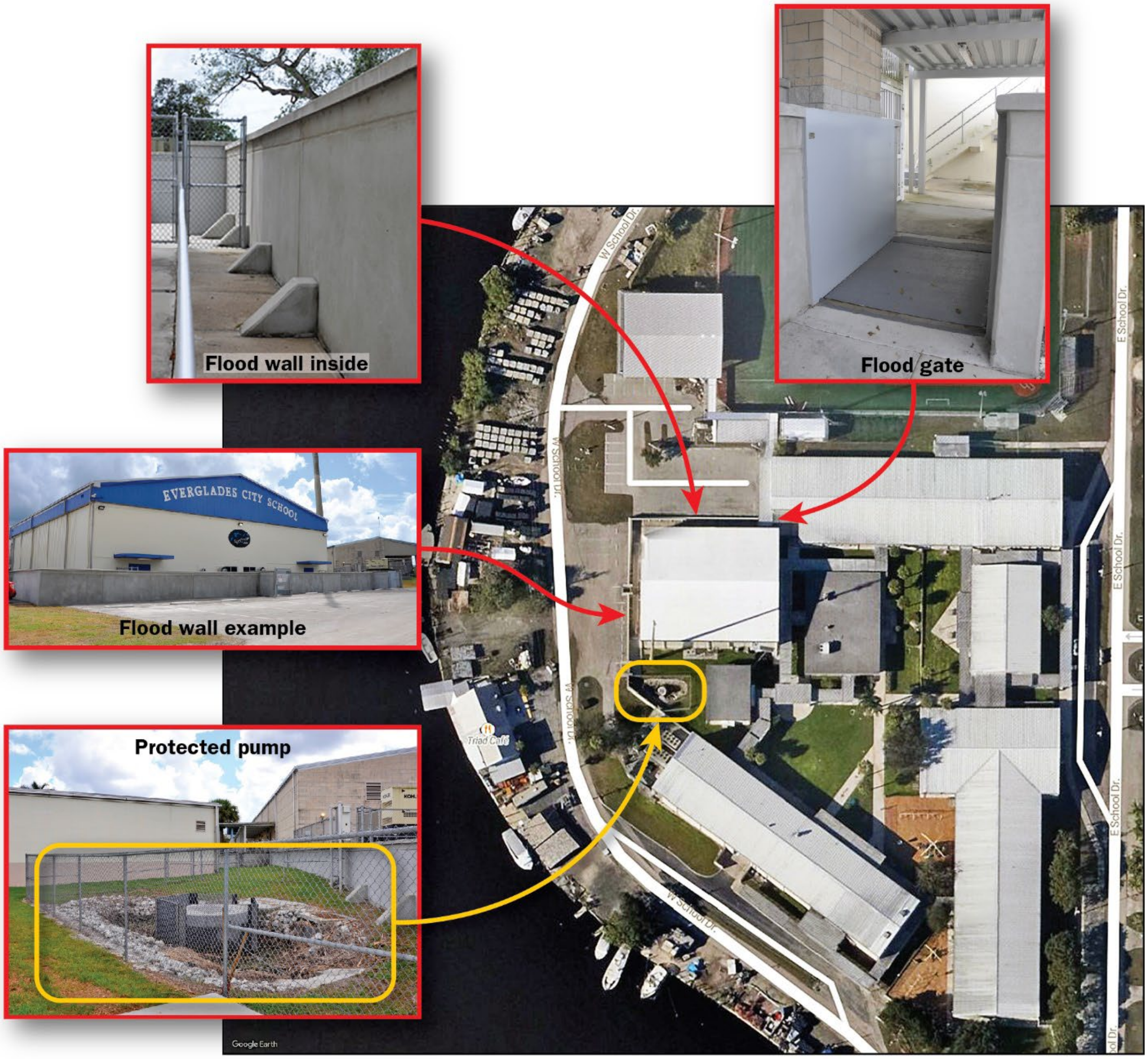


Figure 5-76: Everglades City School flood protection system (Collier County, Zone AE)

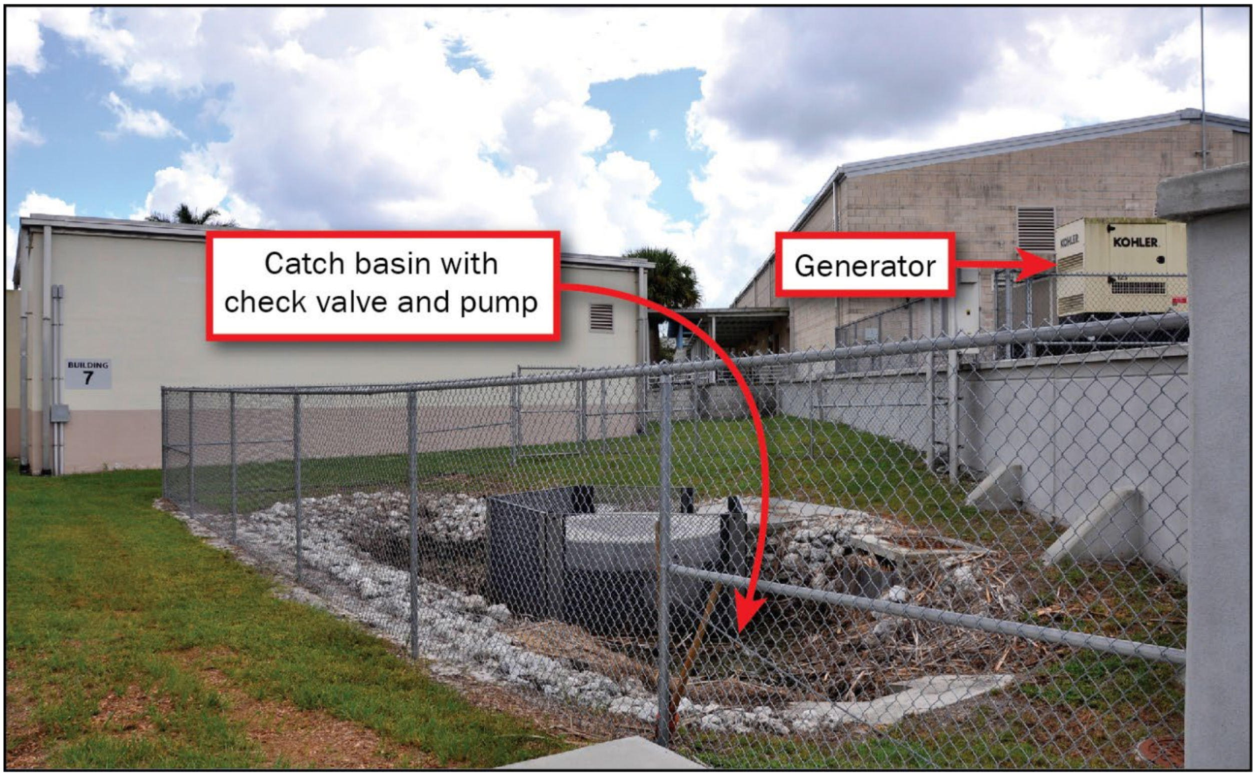


Figure 5-77: Interior perimeter drainage measures at Everglades City School (Collier County, Zone AE)

Figure 5-78: Hurricane Ian HWM along the west side of Everglades City School (Collier County, Zone AE)

Building Performance and Operational Performance:

- The recently installed floodwall system was a success and prevented the kind of damage that was experienced during Hurricane Irma.
- When the pre-MAT visited the school (Wednesday, October 12, 2022), the school campus was in full operation.

6. Conclusions and Recommendations

The conclusions and recommendations presented in this report are based on the MAT's observations in the areas studied; evaluation of relevant codes, standards, and regulations; and meetings with local officials, facility representatives, designers, and contractors.

The recommendations are intended to assist FEMA, the State of Florida, communities, designers, contractors, building officials, facility managers, floodplain administrators, regulators, emergency managers, building owners, academia, select industries and associations, local officials, various agencies and organizations, and individuals in the reconstruction process. The recommendations will also help FEMA coordinate and collaborate with agencies and organizations to help assess hazard-resistant provisions of building codes and standards and improve planning, outreach, training, design, and construction to ultimately minimize future injuries, reduce damage, and enhance community resilience not only in Florida, but elsewhere as applicable.

The organization of Chapter 6 is shown in Table 6-1.

Table 6-1: Chapter Organization

Section	Description
6.1	Overview of the conclusions and recommendations based on the MAT's observations
6.2	Flood-related conclusions and recommendations correlated to building codes, standards, regulations, and floodplain management
6.3	Wind-related conclusions and recommendations correlated to building codes and standards
6.4	Manufactured homes-related conclusions and recommendations
6.5	Flood-related building performance conclusions and recommendations
6.6	Wind-related building performance conclusions and recommendations
6.7	Critical facility and sheltering-related conclusions and recommendations
6.8	Crosswalk matrix, in tabular format, of the MAT's observations (with section number), conclusions and recommendations, and the pertinent action office / Recovery Support Function (RSF)

6.1. Overview of Conclusions and Recommendations

The conclusions in the sections that follow are drawn from the MAT observations discussed in previous chapters. Each conclusion sets up a list of specific recommendations. The recommendations are presented as guidance to the many stakeholders listed in the introduction to this chapter and those who are involved with the design, construction, and maintenance of the built environment in the state, as well as other regions impacted by hurricanes. The entities involved in the reconstruction and mitigation efforts should consider these recommendations in conjunction with their existing priorities and resources when determining how they can or will be implemented.

Applying Residential Building Recommendations to Non-Residential Buildings

Different components of and themes from the recommendations presented for residential buildings can be adapted and applied to non-residential buildings, and vice versa. The MAT recommends a registered design professional be consulted for specific applications. Questions can also be directed to the FEMA Building Science Helpline at FEMABuildingsciencehelp@fema.dhs.gov as to whether specific recommendations can be applied to other building types than described herein.

6.2. Floodplain Management and Flood-Related Building Codes, Standards, and Regulations Conclusions and Recommendations

Conclusion FL-1

Coastal buildings experienced damage to siding and exterior attached structures likely due to wave runup on the building. Buildings that had shore-parallel surviving walls below the flood elevation exhibited increased damage to exterior attached structures and siding. Vertical elements below the flood elevation enable waves to reflect upwards, which results in uplift forces from the reflected waves being applied to elevated structures and C&C.

> Recommendation FL-1. **ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, should be revised to provide additional guidance on the impacts of wave runup on coastal buildings.** The standard should be revised to specifically address wave runup impacts to exterior attached structures (e.g., decks and porches) to determine the overall risk that wave runup poses to coastal structures and how to quantify the risk. The guidance should build on the guidance included in ASCE 7-22, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures,* Supplement 2, and should include methods to estimate wave runup height and recommended uplift load calculations that can be performed with readily available data without requiring the designer to generate new empirical data. In the context of this recommendation, “walls” are meant to signify any vertical element that results in substantial wave runup and may include wide foundation elements not typically considered as a wall.
>
> This change will aid in generating more resilient designs, which in turn in will result in less direct building damage and indirect building damage from failed building material debris. The suggested requirement would be applicable for: (1) buildings that are allowed to have shore-parallel walls, either due to their location relative to a flood zone or where permitted by ASCE 24, or where described in FEMA NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas in Accordance with the National Flood*

Insurance Program (2020b); (2) breakaway walls before the design load is achieved and the walls break away; (3) implementing design to account for future flood conditions where the design flood exceeds the minimum elevation requirement.

Conclusion FL-2

Back-to-back storms resulted in extensive dune erosion and building damage. The observed erosion from the combined effects of Hurricanes Ian and Nicole on the east coast of Florida was comparable to the erosion from an individual storm having a 500-year mean recurrence interval (MRI) .

Recommendation FL-2a. **SLTT governments, AHJs, and applicable agencies should consider implementing design and construction regulations that require evaluation of dune erosion for a minimum of a 500-year MRI storm.** Consider implementing various changes to regulations, such as: (a) requiring the use of deep foundations that extend below the extent of the predicted erosion and (b) prohibiting new construction in areas where dune erosion is expected for the 500-year MRI storm. The additional regulations may be useful to account for instances of successive storms when there is insufficient time between storms for the beach and dune system to recover. Such requirements would also account for observed trends of increasing probability of long-term erosion based on future conditions.

Recommendation FL-2b. **FEMA should consider researching and updating existing guidance related to using a 1,100-square-foot cross-section for primary frontal dune reservoir removal to include a 500-year MRI storm reservoir cross-section recommendation.** FEMA P-55, *Coastal Construction Manual* (FEMA, 2011) currently recommends designers use a 1,100-square-foot reservoir cross-section as the minimum dune cross-section for determining whether dune removal occurs for the 100-year storm; this exceeds the NFIP criteria outlined in 44 CFR § 65.11, which requires using a 540-square-foot dune reservoir. FEMA P-55 guidance should be updated to include a value beyond the 1,100 square feet (approximated from Hallermeir and Rhodes study [1988]) for a 500-year MRI storm. At a minimum, the MAT recommends that FEMA P-55 require a dune reservoir for a 500-year MRI storm that is 2,050 square feet, which is double the value (1,028 square feet) calculated by Equation 1 in the Hallermeir and Rhodes study (1988) to align with the 100-year guidance presented in FEMA P-55. As part of the process of updating this guidance, FEMA should consider conducting additional studies on this topic.

Conclusion FL-3

Extensive corrosion of erosion control structure tie-back bars was commonly observed and was a major contributing factor to seawall failure. Tie-back bars used in bulkheads or seawalls provide anchorage and stability to the erosion control structure. These bars corrode over time from exposure to the harsh coastal environment, which weakens the structure and potentially leads to failure.

Recommendation FL-3. **SLTT governments, AHJs, and applicable agencies should develop and implement guidance and requirements for adequate inspections, maintenance, and repairs to coastal armoring structures.** The frequency of the inspections, to be conducted by property owners, should be based on the type, Risk Category, and age of the structure. FDEP has existing guidance on how to build coastal erosion control structures. ASCE's *Underwater Investigations: Standard Practice Manual* (ASCE, 2001) recommends that seawalls be inspected every 5 to 6 years. Agencies overseeing coastal erosion control structures should add to this existing guidance to address the level of inspection and timing of inspections to ensure protection of upland development. Potential resources could include a checklist property owners can use on a routine basis for existing infrastructure, and agencies can consider the inspections as a requirement for new infrastructure moving forward.

Conclusion FL-4

Non-flood damage–resistant materials used in enclosures below the BFE (non-compliant with the NFIP and flood-resistant design and construction building code requirements) in *elevated buildings* was widespread, with resultant largescale damage. Unless properly enforced, current building code and floodplain management requirements/practices reduce exposure to the insurance program (standard NFIP policy is relatively limited below the lowest floor of an *elevated building*) versus reducing damage.

Recommendation FL-4a. **FDEM should consider developing or modifying existing training on the flood provisions in the FBC and local floodplain management ordinances with an emphasis on enforcement to reduce damage from the use of non-compliant materials in enclosures below the BFE.** Building code officials and local floodplain administrators must enforce, and design professionals and builders must comply with, the requirement to use flood damage–resistant materials below an *elevated building's* DFE, as per the AHJ agreement to be part of the NFIP. At a minimum, wet floodproofed enclosures should be clearly delineated on plans and finished or marked in a certain manner to clearly differentiate them from finished interior spaces that are not required or intended to be flood resistant.

Recommendation FL-4b. **Local communities (AHJs) should require a non-conversion agreement when permitting enclosed areas below the BFE.** These agreements document the building owner's understanding that the allowed use of enclosures is limited to parking, building access, and storage; conversion to other uses is prohibited; and modifying enclosed areas beyond these limited uses will render a building non-compliant with minimum requirements of the NFIP. In addition, non-conversion agreements should incorporate routine (every 3 to 5 years) inspection requirements to verify compliance.

Recommendation FL-4c. **FEMA should continue ongoing efforts to develop a consensus standard for flood damage–resistant materials and also consider revising NFIP floodplain management regulations to reduce damage within and to enclosures.** Based on the amount of debris piles from enclosures in *elevated buildings* where the HWM did not exceed the lowest floor, there was widespread damage to enclosures. The standard should outline performance requirements for materials used in solid foundation walls and floor systems, which are allowed in Zone A below the BFE.

Conclusion FL-5

Designed dry floodproofing measures that were subjected to Hurricane Ian flooding failed in numerous buildings observed in the SFHA when owners did not deploy them. The MAT observed numerous instances of building owners failing to deploy dry floodproofing systems designed for their buildings, which subsequently did not provide any protection. These buildings often suffered extensive damage and loss of business. Some had months of downtime while others went out of business.

> Recommendation FL-5a. **FEMA should consider adding flood insurance policy language that dry floodproofing measures must be deployed in accordance with the operations and maintenance (O&M) plan before a claim can be filed.** Based on numerous observations where dry floodproofing measures were not deployed, requirements should be developed to ensure that proposed measures are actually implemented or claims will be denied.
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> Recommendation FL-5b. **Local floodplain administrators, design professionals, and building owners should follow the guidance in Hurricane Harvey in Texas, Recovery Advisory 1, *Dry Floodproofing: Planning and Design Considerations* (2018b) and Hurricane Irma in Florida, Recovery Advisory 1, *Dry Floodproofing: Operational Considerations* (2018a) related to dry floodproofing.** The Recovery Advisories provide information to instill a culture of preparedness and can assist with developing an effective Emergency Operations Plan. The guidance also encourages the use of passive measures in implementing dry floodproofing and recommends limiting the occupancy/use of dry floodproofing areas to parking, storage, access, and limited ancillary uses. No critical functions or MEP should be within dry floodproofed areas unless there is no other alternative and further protection is provided. At a minimum, dry floodproofed areas should be clearly delineated on design plans and finished or marked to clearly differentiate them from other finished interior spaces that are not required or intended to be dry or wet floodproofed.
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> Recommendation FL-5c. **FEMA should collaborate with the Flood Mitigation Industry Association and the Association of State Floodplain Managers and consider establishing a training and certification program for design professionals, contractors, and inspectors implementing and certifying dry floodproofed areas.** FEMA should consider a certification program similar to the IBHS FORTIFIED Program used for making buildings more wind resistant. The program should include a requirement for dry floodproofing measures to be routinely installed (at least every 1–3 years) in accordance with the O&M plan.
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> Recommendation FL-5d. **FEMA, ASCE, and the Florida Building Commission should consider requiring passive measures in new construction of Risk Category IV facilities where dry floodproofing is proposed.** Based on numerous observations where dry floodproofing measures were not deployed and the criticality of Risk Category IV facilities, consideration should be given for requiring passive, or at least permanently installed active, measures in essential facilities.

Conclusion FL-6

Based on the analytics of representative NFIP claims data as well as observations in the field, most Substantially Damaged or destroyed buildings were existing or legal non-conforming construction. Approximately 65% of the NFIP claims analyzed that reached maximum building claim ($250,000) were existing construction.

> Recommendation FL-6. **FEMA should consider alternative approaches to Substantial Improvement / Substantial Damage, such as expedited post-flood acquisitions, elevations, or relocations to amenable property owners.** FEMA should consider incorporating requirements to expedite compliance of existing as well as legal non-conforming buildings. Based on the analytics of representative NFIP claims data, as well as observations in the field, most buildings will not likely reach the Substantial Damage threshold unless they had structural or foundation damage. Current Substantial Damage and Substantial Improvements requirements are insufficient to significantly reduce long-term damage and insurance claim payout trends for older construction in flood zones, which are well known to be vulnerable to flood damage.

Conclusion FL-7

Most of the flood damage observed outside of areas that experienced hydrodynamic loads, was to building materials. Building material damage can be costly. It can also make buildings unhabitable for lengthy periods of time without proper remediation.

> Recommendation FL-7a. **FEMA should encourage the use of flood damage–resistant materials up to 4 feet above the BFE and consider requiring flood damage–resistant materials for at least 2 feet above the BFE.** Many newer *non-elevated buildings* were extensively damaged from 1 foot or less of floodwater above the lowest floor, as indicated by observed HWMs. The use of flood damage–resistant materials will provide additional resilience beyond elevation so that if flooding reaches or exceeds the lowest floor, flood damage, including “wicking,” will be kept to a minimum. Over time, use of these materials will also have significant positive impacts across a community’s building inventory and will help to improve its overall resilience.

> Recommendation FL-7b. **FEMA should consider requiring the use of flood damage–resistant materials as part of a flood insurance building claim payment.** When implementing repairs through an NFIP policy claim, the use of flood damage–resistant materials should be required, with only limited potential exceptions, regardless of whether Substantial Damage was triggered or not.

> Recommendation FL-7c. **FEMA, FDEM, and the FBC should consider developing practical criteria for when *elevated buildings* should be required for new construction within the regulated floodplain.** The difference in performance of *non-elevated* versus *elevated buildings* in varying conditions was visible in the field and strongly supported by flood insurance claims data. Practical criteria should be developed and supported by the AHJs for

when construction in a regulated floodplain is required to have its lowest elevated floor raised above ground level by walls, posts, piers, pilings, or columns.

Conclusion FL-8

The state and communities did not receive (or did not receive in a timely manner) data on buildings that appeared to have incurred Substantial Damage. When buildings appeared to have incurred Substantial Damage, the state and communities either did not receive requested data submitted by NFIP claims adjusters or did not receive the information in a timely manner.

Recommendation FL-8. **FEMA should develop an effective and timely means to deliver the Adjuster Preliminary Damage Assessment data.** The state and communities had little to no visibility of estimated building claims. The lack of effective transmission of information continues to be a missed opportunity for assisting communities in identifying buildings that were likely Substantially Damaged. If Personal Identifiable Information or other legal limitations are hindering delivery of these data, FEMA should at least provide a report delineating the percentage of properties along a street, within a zip code, or associated with other geographical criteria, so that communities can prioritize their Substantial Damage assessments.

Conclusion FL-9

Numerous AHJs were overwhelmed with the widespread and extensive damage from Hurricane Ian and were not staffed or prepared for the building permit workload required to repair or replace buildings and residences. With the passing of Section 1206 of the DRRA, policies and procedures were established to help state and local governments seek financial assistance for building code and floodplain management enforcement.

Recommendation FL-9a. **FEMA should continue providing guidance and increase technical assistance opportunities and training to SLTT governments related to building code and floodplain management administration and enforcement authorized under Section 1206 of DRRA.** FEMA should provide SLTT governments, AHJ building departments, and floodplain managers with DRRA 1206 awareness and training. Very few subapplicants used FEMA funding for the multitude of eligible building code and floodplain management administration and enforcement activities available for up to 180 days after Hurricane Ian was declared. DRRA 1206 funding is meant to help address well-known gaps and shortfalls in typical building departments that are not staffed to handle the significant number of permit applications and tremendous increase in workload for building code and floodplain management administration and enforcement activities that are typically required after a major disaster impacts a jurisdiction.

Recommendation FL-9b. **FDEM should continue to encourage pre-event planning of post-disaster needs and inform appropriate parties about assessing resources through statewide mutual aid agreements and the Emergency Management Assistance Compact (EMAC).** FDEM should continue collaborating with the Building Officials Association of Florida (BOAF), FFMA, and other organizations to help establish mutual aid agreements for building code and floodplain administration. Many building code departments and floodplain managers are not familiar with EMAC, which has been ratified by the U.S. Congress (PL 104-321) and is law in all 50 states, the District of Columbia, Puerto Rico, Guam, the U.S. Virgin Islands, and the Northern Mariana Islands. EMAC Members can share resources from all disciplines, protect personnel who deploy, and be reimbursed for mission-related costs. EMAC Requests would be made through FDEM, but would require awareness and training in EMAC processes, procedures and being prepared in order to effectively use it.

Recommendation FL-9c. **FEMA should work with SLTTs in helping their building code departments, and other pertinent departments, include various building code-related injects into exercises in order to improve their preparedness, response, recovery, and mitigation operations in a post-disaster environment.** Exercises are intended to help validate plans, policies, procedures, and capabilities as well as identify resource requirements, capability gaps, areas for improvement, and potential best practices. FEMA should develop guidance and resources related to post disaster building code and floodplain management enforcement to support SLTTs with validating the preparedness of their building code department and other departments. FEMA should continue to develop materials for SLTTs through its Substantial Damage Administrative Procedures (SDAP) Program. The SDAP Program materials are intended to reduce the administrative and resource burden for FEMA and SLTTs associated with executing Substantial Damage estimates by planning and producing workshops for communities. This is accomplished by providing templated materials and enabling multiple communities to participate in workshops. FEMA should continue encouraging SLTTs to seek HMA grants for adopting or enhancing existing building codes to incorporate more current requirements or higher standards as well as developing workforce capabilities relating to building codes through technical assistance.

Recommendation FL-9d. **FEMA, in partnership with NIST, NSF, NOAA, and OFAs, should provide guidance to help SLTTs with implementing policies and procedures related to collecting damage assessment data.** Following Hurricane Ian, several organizations collected critical damage assessment information, including federal search and rescue teams; the NSF-funded StEER team, which collected over 650 miles of post-Hurricane Ian, street-level panoramic imagery; the FDEP, which collected helicopter videography of the beach and dune system of over 180 miles along the Gulf of Mexico; and Lee County, which performed thousands of damage assessments. The information collected was invaluable in providing situational awareness related to the extent and magnitude of damage as well as documenting building performance to help make recommendations towards design and construction practices. For example, the data can support research and investigations on the impacts of Hurricane Ian on buildings and infrastructure, especially from wind and related hazards, including storm surge, wind-driven rain penetration, and wind damage. The building damage assessment dashboard established by Lee County should be considered across the state as a pre-event tool that can be established to support building departments immediately following an event like Hurricane Ian. FEMA should consider working with Lee

County to capture any lessons learned from the process as the damage assessment dashboard would be an effective tool to include in preparedness exercises and training. It would be highly beneficial to SLTTs to have access to street-level panoramic imagery and helicopter videography following an event like Hurricane Ian to support various response, recovery, mitigation, and preparedness efforts.

6.3. Wind-Related Building Codes, Standards, and Regulations Conclusions and Recommendations

Conclusion FL-10

Hip and ridge roof coverings for many residential buildings appeared to have inadequate resistance to wind loads. Failure of hip and ridge roof coverings on asphalt shingle and metal panel roof coverings was widespread and the most common roof covering failure observed by the MAT. While some asphalt shingle manufacturers test hip and ridge shingles to a modified version of ASTM D3161, the IBC, IRC, and FBC do not specifically require testing of hip and ridge asphalt shingles or metal panel roof coverings.

Recommendation FL-10a. **FEMA should consider submitting code change proposals or supporting code change proposals from other stakeholders—such as IBHS, Asphalt Roofing Manufacturers Association (ARMA), National Roofing Contractors Association (NRCA), and other aligned groups to the IBC, IRC, and the FBC—to require testing of hip and ridge roof coverings for asphalt shingle roof coverings.** The IBC, IRC, and the FBC require asphalt shingles to be tested for wind loads in accordance with ASTM D7158 or ASTM D3161. Underwriters Laboratories (UL) 2375, *Outline of Investigation for Hip and Ridge Shingles* (2016), provides a methodology to use a modified version of ASTM D3161 to test hip and ridge shingles for wind resistance. As an alternative to testing, a prescriptive solution that includes the use of an appropriate adhesive should be developed and included in the IBC, IRC, and FBC.

Recommendation FL-10b. **FEMA should consider submitting code change proposals or supporting code change proposals from other stakeholders—such as IBHS, Metal Construction Association (MCA), NRCA, and other aligned groups to the IBC, IRC, and the FBC—to require testing of hip and ridge roof coverings for metal panel roof coverings.** The ANSI/MCA FTS-1, *Test Method for Wind Load Resistance of Flashings Used with Metal Roof Systems* (2019), specifies wind load resistance testing of hip covers on metal panel roof systems in addition to other edge/flashing metal.

Recommendation FL-10c. **FEMA should consider submitting code change proposals or supporting code change proposals from other stakeholders—such as IBHS, ARMA, NRCA, and other aligned groups to the IBC, IRC, and the FBC—to require a minimum of 6 inches overlap of the roof underlayment to hip and ridges that do not have ventilation components.** Wrapping underlayment over hips and ridges that don't have ventilation components will improve the roof's resistance to water intrusion in the event the hip and ridge coverings are damaged or blown off.

Conclusion FL-11

The failure of soffits and ventilated soffits often contributed to water intrusion into attic areas and exterior walls. Water intrusion through soffits was consistently reported by homeowners across the impacted areas visited by the MAT. This occurred even though the wind speeds for Hurricane Ian were well below design level wind speeds in ASCE 7 and the FBC.

Recommendation FL-11. **The Florida Building Commission should revise the FBCR to require ventilated soffits to be tested for water intrusion resistance in accordance with FBC Test Protocol TAS 100(A) throughout the state, as is required in the HVHZ.** Soffit installation requirements in the 7th Edition of the FBCR (2020) have been strengthened; however, water intrusion can occur through ventilated soffit panels. This can be mitigated by requiring all ventilated soffit panels to be tested in accordance with TAS 100(A).

Conclusion FL-12

The inability of sliding doors to adequately resist wind-driven rain often contributed to water intrusion at many sites. Water intrusion through sliding doors was consistently reported by homeowners across the impacted areas visited by the MAT. Water intrusion through sliding doors occurred in new and relatively new sliding door installations.

Recommendation FL-12a. **The Florida Building Commission should collaborate with the window industry (Window and Door Manufacturers Association [WDMA], Fenestration and Glazing Industry Alliance, and key manufacturers) and other stakeholders to modify or delete the exceptions to water intrusion testing in the FBC.** The FBC exempts doors from water intrusion testing required by American Architectural Manufacturers Association (AAMA)/WDMA/Canadian Standards Association (CSA) 101/I.S.2/A440, and TAS 202 for doors installed in certain conditions. While these installations may provide sufficient protection in areas outside hurricane-prone regions, it will not protect doors from the wind-driven horizontal rain that commonly occurs during hurricanes. The entire State of Florida is within a hurricane-prone region.

Recommendation FL-12b. **The window industry should revise AAMA/WDMA/CSA 101/I.S.2/A440 to require window and door Performance Grade (PG) ratings to be equal to the positive DP wind pressure rating.** The water penetration resistance of windows and doors tested to AAMA/WDMA/CSA 101/I.S.2/A440 is not directly tied to the positive design wind pressure rating. The PG rating in AAMA/WDMA/CSA 101/I.S.2/A440 is the indicator of a product's resistance to water penetration. Additionally, AAMA/WDMA/CSA 101/I.S.2/A440 does not require correlation of a window and door product's design wind pressure rating and water penetration resistance (windows and doors with higher design wind pressure ratings are likely to primarily be used in hurricane-prone regions where exposure to wind-driven rain will be severe). Correlating product's design wind pressure rating with the water penetration resistance would align AAMA/WDMA/CSA 101/I.S.2/A440 with FBC Test Protocol TAS 202, which specifically requires windows and doors to be tested for water penetration resistance at 15% of the positive design wind pressure rating.

6.4. Manufactured Homes-Related Conclusions and Recommendations

Conclusion FL-13

Florida's installation requirements for manufactured homes references the 1985 edition of FEMA 85, *Protecting Manufactured Homes from Flood and Other Hazards,* that is 24 years older than its 2009 revision. Florida's installation requirements for manufactured homes follows the 1985 edition of FEMA 85; the currently referenced edition lacks important research, clarity and guidance and is 24 years older than the current edition of FEMA P-85, published in 2009. The revision includes updated installation guidance to improve resilience to both flood and wind conditions and includes some pre-engineered foundation specifications that minimize the need for site-specific engineered solutions for many locations.

> Recommendation FL-13. **The Florida Department of Highway Safety and Motor Vehicles should reference the most recent edition of FEMA P-85 (2009) in the Florida Administrative Code Chapter 15C.** In accordance with Chapter 120 "Administrative Procedure Act," the Florida Department of Highway Safety and Motor Vehicles should update Florida Administrative Code Chapter 15C to align with Florida Statute 320.8285. The revised FEMA P-85 (2009) has 24 years of additional lessons learned from performance observations, research on anchoring in saturated soils and other information, which will benefit manufactured homeowners, installers and interested stakeholders with improved manufactured homes and community resilience.
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> The state should also consider incorporating additional wind- and flood-resistant construction provisions, with particular emphasis on anchoring, and develop a training unit for manufactured home installers that includes specific focus on requirements for wind resistance and installation in SFHAs. This training should be designed to satisfy continuing education requirements for manufactured home installers.

Conclusion FL-14

Post-1994 manufactured homes suffered widespread envelope failures, including to roof and wall coverings; glazed opening damage was also observed. Like site-built residential buildings, the envelope breaches enabled wind-driven rain to penetrate the damaged manufactured homes, resulting in costly repairs or need for replacement. Current building codes require higher wind pressures on C&C than the HUD code, HUD MHCSS (24 CFR 3280), which is based on ASCE 7-88. Furthermore, protection of glazed openings in the WBDR was not required in ASCE 7-88, so glazing in post-HUD manufactured housing remains vulnerable to wind-borne debris.

> Recommendation FL-14. **HUD should update its HUD MHCSS 24 CFR 3280 wind requirements for consistency with ASCE 7-22.** To improve performance of manufactured housing, wind provisions in the HUD code should be updated for consistency with ASCE 7-22 for all HUD-designated wind zones. In particular, improvements to C&C and glazed opening requirements in WBDRs would address much of the post-1994 manufactured home wind damage observed during the Hurricane Ian MAT. HUD MHCSS 24 CFR 3280 wind requirements are more than 30 years behind the state of practice, including several revisions to ASCE 7 since 1988.

Conclusion FL-15

The primary differentiator in the flood-resistance performance of manufactured homes was whether the bottom of the steel frame was elevated above the Hurricane Ian flood level. Hurricane Ian flood levels, in many areas visited by the MAT, were relatively close to or exceeded the DFE for Flood Design Class 2 buildings.

> Recommendation FL-15. **AHJs in Florida should incorporate the most recent edition of FEMA P-85, *Protecting Manufactured Homes from Flood and Other Hazards* (2009) and FEMA P-348, *Protecting Building Utility Systems From Flood Damage* (2017), into its floodplain ordinances and integrate associated best practices.** Manufactured homes should be elevated so the bottom of the frame is at or above the DFE. Utilities and mechanical equipment need to be protected. If ductwork must be installed below the DFE, it should be minimized as much as possible. Placing the bottom of the steel frame at or above the DFE, as recommended, enhances protection of utility and mechanical equipment.

Conclusion FL-16

FEMA P-85, *Protecting Manufactured Homes from Flood and Other Hazards*, was published in 2009 and is becoming increasingly out of date. Many lessons learned from previous FEMA MAT efforts, as well as other entities over the last 14 years are not adequately captured in the most current version of FEMA P-85 (2009).

> Recommendation FL-16. **FEMA should lead the update of FEMA P-85 to incorporate lessons learned since the 2009 edition.** FEMA should incorporate lessons learned from numerous MAT efforts, as well as the research IBHS has performed on manufactured homes since 2009, to update FEMA P-85. Updates could focus on best practices for wind- and flood-resistant construction, as well as advocate for the installation of standalone safe rooms for residents of manufactured homes. FEMA should include HUD, IBHS, and other manufactured home organizations as reviewers to gather their input during the update process.

Conclusion FL-17

Failures of improper appurtenance attachments to post-1994 manufactured homes significantly increased vulnerability to wind and rain damage. Despite the Florida Administrative Code requirement 15C-2.0081 for standalone manufactured home appurtenances, MAT observations indicate that appurtenances (such as carports and screened porches) continue to be improperly attached to manufactured homes and initiate envelope failures during high wind events.

> Recommendation FL-17a. **Local AHJs and manufactured home communities should enforce the Florida Administrative Code requirement 15C-2.0081 for standalone manufactured home appurtenances.** Based on MAT observations, enforcement of appurtenance attachment requirements appears to be lacking. Enforcement of the existing requirement will improve manufactured housing performance in high wind events.

> Recommendation FL-17b. **HUD and the Manufactured Housing Institute should develop training to be provided to AHJs and manufactured home communities in Florida to help them understand and implement Florida Administrative Code requirement 15C-2.0081 for standalone manufactured home appurtenances.** Training should also serve to advance discussions on who should be tasked with enforcement of manufactured home requirements in the Florida Administrative Code since they fall outside the scope of the Florida Building Commission.

Conclusion FL-18

Newly delivered manufactured homes without permanent anchorage endangered surrounding manufactured homes when overturned by Hurricane Ian's winds. The overturned manufactured homes observed by the MAT were not inhabited or permanently anchored. Any manufactured home that overturns could potentially impact adjacent manufactured homes, especially in Florida's densely sited manufactured home communities.

> Recommendation FL-18. **Manufactured home dealers should not deliver manufactured homes unless permanent installation is scheduled to occur at the time of delivery.** The State of Florida should consider amending the Florida Administrative Code to improve coordination and limit the duration a manufactured home is unanchored to help protect manufactured home communities, nearby buildings, and surrounding infrastructure from potential damage inflicted by newly delivered manufactured homes without permanent anchorage. The potential for damage in Florida is highest during hurricane season.

Conclusion FL-19

Utility components below manufactured homes suffered flood damage. Manufactured homes observed, consistently had heating and cooling systems at grade below the lowest floor, leaving them vulnerable to flood damage.

> Recommendation FL-19. **Local communities should encourage manufactured homeowners to elevate mechanical equipment in existing manufactured homes and ensure that the equipment is properly elevated in new manufactured homes.** Components of heating and air-conditioning systems installed within manufactured homes are generally located above the floor. Components located below the floor are vulnerable to flood damage. In particular,

exterior heating and air conditioning compressors can be elevated by placing them on platforms elevated to at least the BFE.

6.5. Flood-Related Building Performance Conclusions and Recommendations

Conclusion FL-20

Surviving front-row structures may have had both beneficial and detrimental impacts to surrounding structures. Based on MAT observations, surviving front-row structures may have provided varying levels of shielding (protection) to the inland structures on the backside of the surviving structure. The level of protection may be inversely linked to the openness of the surviving building's foundation. However, the surviving structures were also observed to be potentially linked to excessive neighboring scour.

Recommendation FL-20a. **NIST, along with OFAs, should further evaluate the extent to which surviving front-row structures provide shielding and the relationship of the amount of shielding to the openness of the front-row structure below the BFE.** The MAT observed instances where buildings behind structures with surviving walls below the BFE performed better than neighboring structures of similar construction that did not have similar fronting protection. Based on observations, as well as existing research, the fronting structures influence wave heights, flow, wave direction, likely debris impacts, and flood velocity. Survival of these buildings may aid in reducing NFIP claims and increasing coastal storm resilience. However, free-of-obstruction requirements often prevent the construction of buildings that provide shielding. Based on the findings of this recommendation coupled with Recommendation FL-20b, FEMA should consider any necessary changes to free-of-obstruction requirements. Existing studies, such as ATC 149, *Coastal Inundation in Developed Regions: Experimental Results and Implications for Engineering Practice* (ATC n.d.), should be leveraged.

Recommendation FL-20b. **Industry groups, interested stakeholders, and/or academia should study whether and how surviving front-row structures with surviving walls below the BFE impact neighboring structures.** The MAT observed numerous instances where large scour holes were adjacent to surviving front-row structures with surviving walls below the BFE. In some instances, the scour extended to the neighboring house's foundation. Research could include whether and to what extent channelized flow between buildings increases flow velocity and scour. Industry groups and interested parties (e.g., FEMA Building Science Branch, DHS Science and Technology Directorate, NIST's Disaster and Failure Studies Program, NSF, NOAA Sea Grant, IBHS, ASCE, and FBC), as well as academia, should consider collaborating to determine whether these surviving structures with surviving walls result in negative impacts to neighboring structures by altering flow characteristics. The blockage allowance in FBC Section 3109.3.2.2 and FEMA's free-of-obstruction requirements should be evaluated.

Conclusion FL-21

Shore-perpendicular CMU breakaway walls sustained less damage when compared to shore-perpendicular wood-framed breakaway walls. CMU breakaway walls perpendicular to the shoreline in low-rise buildings exhibited increased survival over wood-framed breakaway walls.

> Recommendation FL-21. **FEMA should collaborate with OFAs, academia, and building science industry partners to study what may have caused the increased survival rates for the shore-perpendicular CMU breakaway walls.** There are numerous possible explanations for the increased survival of the CMU breakaway walls. The study should explore possible reasons for the observed difference, including, but not limited to, the walls experienced less than their design conditions, the presence of flood openings, the walls were designed above the allowable design load, or possibly that the wood-framed breakaway walls were designed to minimum standards; whereas, the CMU breakaway walls were designed to higher allowable standards (prescriptive vs. simplified vs. performance-based design methods). The study should include considerations relative to wave attack direction and whether shore-perpendicular walls were designed with the same load assumptions as shore-parallel walls.
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> Based on the study findings, FEMA should consider any necessary changes or additions to the guidance associated with breakaway walls. For example, additional guidance may be required for load assumptions for breakaway walls based on their orientation to the shore and likelihood of direct wave attack. The results of the analysis should be incorporated into future minimum NFIP design and construction requirements.

Conclusion FL-22

Numerous preferential scour pathways were observed that resulted in excessive localized scour and building damage. Preferential scour pathways are a form of scour where the scour location and extent are influenced by the relative compaction of soils in an area and are created by various features and actions. Actions and features observed by the MAT that may have induced preferential scour include disturbing the compacted ground, such as in areas where irrigation or plumbing/electrical/cable/sewer lines had been installed and the presence of dune walkovers.

> Recommendation FL-22. **FEMA should develop guidance for communities, utilities, and homeowners regarding preferential scour pathways to provide measures that can be implemented to reduce the scour experienced in these types of areas during high flow-velocity events.** The guidance should include best practices to address unconsolidated soils resulting from earth disturbance work and improved methods of earth disturbance work demonstrated to result in minimal scour potential after an event.

Conclusion FL-23

Material degradation of various exterior building materials was commonly observed throughout the coastal areas visited by the MAT. The MAT observed numerous instances of degradation, such as metal connector corrosion or wood decay, for materials that are intended to transfer loads, such as connections to wood piles that support buildings. Such degradation can lead to reduced building performance or failure.

> Recommendation FL-23. **FEMA should consider developing an inspection and maintenance checklist for NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (2008), and NFIP Technical Bulletin 8, *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas* (2019a).** Technical Bulletins 2 and 8 provide invaluable information on the selection, inspection, and maintenance of materials in coastal and floodprone areas. Despite this available literature, homeowner inspection and maintenance appears to be severely lacking based on MAT observations of degraded materials. Checklists that homeowners can use on a routine basis to evaluate their exterior building materials may simplify the process and encourage more home and building owners to implement routine inspection and maintenance, thereby resulting in more resilient buildings. The checklists should be succinct and straightforward and provide cross-references to sections of existing Technical Bulletins when more detailed information is required.

Conclusion FL-24

Pre-cast concrete floor panels held in place by gravity were highly susceptible to damage from uplift loads where flood elevations exceeded the elevation of the floor panel. The MAT observed various instances where pre-cast concrete floor panels were lifted out of place due to uplift forces resulting in displaced and broken floor panels.

> Recommendation FL-24. **FEMA should consider providing guidance and best practices for the use of pre-cast concrete floor panels held in place by gravity.** The guidance and best practices should state that designers should not use pre-cast concrete floor panels held in place by gravity on the lowest floor of a structure in an SFHA or a shaded Zone X. While the use of pre-cast floor panels held in place by gravity would not meet performance requirements if the floor is below the BFE, due to their buoyant nature, this recommendation is meant to discourage use even if the lowest floor is above the BFE or DFE. Implementing this recommendation will result in building floors that are more resilient against flood elevations that exceed the BFE or DFE and will also help structures resist the impacts of future conditions such as SLR. Guidance could also include recommendations for retrofits to older buildings that have pre-cast concrete floor panels on the lowest floor. The retrofit recommendations would be most pertinent for structures with floors below the current BFE or DFE. This guidance can be incorporated into FEMA Building Science publications as well as FEMA NFIP Technical Bulletins.

Conclusion FL-25

Many observed buildings were developed in high-risk and hazardous areas without appropriately considering and adequately addressing the lifetime risks and vulnerabilities to the structure from a siting, design, construction, maintenance, and other important risk factors perspective, resulting in

poor building performance and significant damage or destruction. SLTTs and federal agencies can decrease future flood-related disasters by limiting development in highly vulnerable areas.

> Recommendation FL-25a. **The Mitigation Framework Leadership Group should consider coordinating with OFAs to limit funding for new building and development, including obtaining flood insurance, in very vulnerable areas where appropriate.** Developing in high-risk and hazardous areas requires community lifelines to be operated and maintained in vulnerable areas, as well as putting first responders and emergency managers at risk. Building owners, operators, design professionals, planners, emergency managers, and decision makers should consider lifetime risks and vulnerabilities of structures from the perspective of siting, design, construction, maintenance, and other risk factors in order to make more informed and prudent decisions for improved building and community resilience. Flood-resistant design and construction practices, along with flood insurance, help reduce and offset flood risk; however, they are not the best defense. The best method to reduce flood damage is to limit buildings in excessively vulnerable and at-risk locations. Consideration should be given to assisting with identifying vulnerable areas and incentivizing communities to limit development in those areas. Reducing federal funding to develop and the availability of federal flood insurance in these areas would help reduce future flood damage.
>
> Recommendation FL-25b. **FEMA, FDEM, and local communities should continue to encourage building owners in high flood-risk areas to have an active flood insurance policy.** Residential areas studied by the MAT had flood insurance take-up rates between 20% to 66%. Across the 12 residential areas studied, the percentage was 44% (note that in most cases, these areas were selected because they had the highest take-up rate for that source of flooding). Although flood insurance does not reduce a building's flood damage, it does transfer risk from the property owner to the insurer and provides funding to repair flood-damaged property without relying on federal disaster assistance that is very limited to only making a home "safe, sanitary and fit to occupy." As of October 1, 2021, the average FEMA disaster assistance grant (Individual Assistance) was $5,000 for a household, while the average NFIP insurance claim payout over the previous 5 years was $69,000.

Conclusion FL-26

Many insufficiently elevated or low-elevation buildings built to legacy or older building codes sustained significant flood damage. With the exception of Fort Myers Beach, Sanibel Island, and a few other coastal areas, HWMs in most areas where flood damage was observed did not exceed the DFE under the FBC; therefore, limited flood damage occurred above the lowest floor in most of the newer construction observed in regulatory flood zones.

> Recommendation FL-26. **Building owners, operators, design professionals, planners, and other interested stakeholders should follow Hurricane Ian in Florida, Recovery Advisory 1, *Designing for Flood Levels Above the Minimum Required Elevation After Hurricane Ian* (2023b) and consider exceeding ASCE 24, using best available data, and referencing future**

conditions whenever appropriate. Federally funded projects begun after Hurricane Ian should be required by FEMA, and OFAs, to meet or exceed the FFRMS as well as incorporate best available flood data. Only building to requirements that are based on historical flood hazard data without accounting for future conditions will result in unnecessary long-term vulnerabilities and continued challenges with building performance.

Conclusion FL-27

There was confusion over what steps a homeowner should take after their house was flooded. The MAT spoke with multiple homeowners who did not know the proper steps to take following the flooding of their houses during Hurricane Ian.

Recommendation FL-27. **FEMA should consider updating Hurricane Sandy Fact Sheet No. 1, *Cleaning Flooded Buildings* (2013a), and combining this information with, *The ABC's of Returning to Flooded Buildings* (FEMA n.d.).** The guidance will help building owners, operators, contractors, and volunteer assistance groups deal with the challenges of working in structures that were not fully cleaned and dried shortly after the flooding, provide a step-by-step guide for homeowners about what to do once their house is flooded, and offer information about what they can generally expect from an AHJ for the entire permitting process through to completion when significant damage occurs.

6.6. Wind-Related Building Performance Conclusions and Recommendations

Conclusion FL-28

Asphalt shingle roof coverings for many residential buildings appeared to have inadequate resistance to wind loads. The amount of damage varied widely at each site visited. Data analysis of roof covering performance in the discrete clusters assessed by the MAT found that 90% of the asphalt shingle roofs older than 7 years sustained visible damage. Given that Hurricane Ian wind speeds were far less than design-level wind speeds, this is significant.

Recommendation FL-28. **The Florida Building Commission should consider funding more research in collaboration with academia and industry groups, such as ARMA, NRCA, and IBHS, to determine why asphalt shingle damage, particularly on aged asphalt shingle roofs, is often observed to be widespread.** Such research should, at a minimum, include consideration of developing a new or revised test method for wind resistance of asphalt shingles to provide improved resistance to wind loads and study of potential installation, workmanship, and manufacturing issues; the effects of aging; potential effects related to transportation and delivery of the product to the site; and the lack of thorough "in-progress" inspections. A similar recommendation was made in both the Hurricane Irma and Hurricane Michael MAT reports.

Conclusion FL-29

Roof coverings that had minor damage that likely could be repaired were often being replaced. Through interviews with homeowners, interviews with contractors, and roof permit data, the MAT learned that many roof coverings that appeared to have minor damage (hip and ridge damage was commonly observed) were being replaced instead of repaired.

> Recommendation FL-29. **To better identify minor roof covering damage that could be repaired, the roofing industry (NRCA, ARMA, MCA, Roof Tile Institute, Florida Roofing and Sheet Metal Contractors Association), insurance industry, IBHS, and other stakeholders should develop guidelines, training programs, and informational tests for building owners and homeowners.** Complete roof replacements for roofs that have minor repairable damage is unnecessary and has negative long-term environmental impacts. Replacing roofs is particularly problematic when there is only minor damage to roof coverings that have been recently replaced. The repair of roof coverings with minor damage is significantly more cost-effective and less wasteful than a complete roof replacement. Furthermore, replacing roofs that only need minor repairs ties up expertise and resources that are already in limited supply after a disaster and results both in longer wait times for home and building owners that truly need roofs to be replaced and lengthier community recovery periods. While many factors, such as age, color, material availability, location of the damage on the roof, etc., will affect whether a particular roof is a candidate for repair versus replacement, key stakeholders should develop guidance, training, and information to help address this important issue.

Conclusion FL-30

The use of spray foam insulation in attics to create an unvented attic provided some benefit against water intrusion through soffits on some houses. The MAT observed evidence that spray foam insulation likely prevented water intrusion into some houses where soffit failure occurred.

> Recommendation FL-30. **The Florida Building Commission, in collaboration with academia and industry groups such as IBHS, should consider funding research to determine whether the use of spray foam insulation in the attic is effective in limiting water intrusion through ventilated or failed soffit panels as a secondary benefit.** For favorable climates, the use of spray foam insulation in the attic area may be effective in separating the attic space from the soffit area, thereby limiting the amount of wind-driven rain that can enter the attic space through ventilated or failed soffit panels.

Conclusion FL-31

Water intrusion through windows and doors can result in costly damage. Water intrusion through and around windows and doors due to pre-existing openings in the building envelope, wind-driven rain, and/or wind-created openings can result in costly damage to interior finishes and furnishings. While not specifically observed after Hurricane Ian, inadequate flashing can also enable water to enter the building around windows and doors, resulting in costly damage. Water intrusion damage through windows and doors was widespread after Hurricane Ian, even though the hurricane wind speeds were far below design-level wind speeds.

> Recommendation FL-31. **Building owners, operators, and managers; design professionals; building officials; contractors; and municipal building and planning officials should follow the guidance in Hurricane Ian in Florida, Recovery Advisory 3, *Reducing Water Intrusion Through Windows and Doors* (2023d).** Recovery Advisory 3 provides recommended techniques for consideration during rebuilding and mitigation activities to reduce water intrusion through windows and doors during extreme wind events.

Conclusion FL-32

Flight level wind speeds, reported without adequate context, led to confusion and the misperception that Hurricane Ian's wind speeds were among the strongest recorded hurricanes at ground level. Specifically, news outlets reported on landfall wind speed estimates of 156 mph measured at flight level rather than the ground level landfall wind speed estimates of over 130 mph that were experienced by the built environment. As a result, many people falsely believed they experienced a wind event of rare, historic intensity that will not be repeated in their lifetimes. Unfortunately, this misperception can be a significant disincentive and can result in communities, building owners and operators, homeowners, and various stakeholders not evacuating for weaker storms or not taking appropriate preparedness and mitigation actions, thinking their structures and communities "survived" or "weathered" a much greater wind event than they actually did.

> Recommendation FL-32. **FEMA, in partnership with OFAs (including NOAA and NIST), should consider providing guidance to help the general public better understand hurricane wind speed measurements, their limitations, and key differences, as well as how they can best use the information to improve their plaining and decision making.** Conferences and outreach coordination with groups like Federal Alliance for Safe Homes that focus on raising awareness should be leveraged to effectively reach the target audiences and interested stakeholders with the newly developed guidance.

6.7. Critical Facility– and Sheltering-Related Conclusions and Recommendations

Conclusion FL-33

Numerous critical and essential facilities lacked an adequate plan to maintain operations when subjected to multiple days of potable water supply loss. Most critical and essential facilities have established plans and equipment, such as standby generators, to overcome the loss of electrical service. However, many do not have a plan in place or the necessary infrastructure to overcome a loss in potable water service. The loss of potable water service at critical and essential facilities impacted operations of wet fire suppression systems, HVAC systems, and the ability to flush toilets. The inability to overcome the loss of potable water supply resulted in the cessation of operations at three hospitals, which in turn had widespread impacts to Lee and surrounding counties in Florida.

Recommendation FL-33a. **Critical and essential facility owners, operators, planners, emergency managers, and other impacted stakeholders should develop coordinated disaster operations plans and, if needed, construct the necessary infrastructure to adequately address potable water needs to fulfill their given missions.** In order to fulfill their given missions, even through disaster operations, the plans should be developed and properly coordinated with critical and essential facility owners, operators, and other impacted stakeholders. The plans should either be developed to address an appropriate pre-determined outage duration or for a duration required by a regulating authority or AHJ. For more information on overcoming a potable water outage, refer to FEMA's Hurricane Ian in Florida, Recovery Advisory 2, *Hurricane Ian in Florida Reducing "Loss of Utility" Impacts to Critical Facilities* (2023c).

Recommendation FL-33b. **FEMA should consider submitting a code change proposal or supporting a code change proposal from other stakeholders to the FBC for modifying Section 453.25.3.3.1 to align support system capacities for EHPAs with the drinking and sanitary water storage capacity per FEMA P-361*, Safe Rooms for Tornadoes and Hurricanes* (2021a), Sections B7.2.2 and B7.2.3 and ICC/NSSA *Standard for the Design and Construction of Storm Shelters* (ICC 500), Sections 703.4 and 703.3.4.** Currently, the FBC does not have requirements for critical support systems for EHPAs. Additionally, FDEM and local emergency management agencies should develop guidelines to ensure HESs have potable water and sanitary water storage capacity similar to the requirements of FEMA P-361 (Sections B7.2.2 and B7.2.3) and ICC 500 (Sections 703.4 and 703.3.4). Providing potable water and sanitary water storage will help EHPAs and HESs overcome challenging sanitary conditions in restrooms in the event that potable water service is interrupted.

Conclusion FL-34

Potable water utilities did not have pre-established plans for prioritizing potable water supply to critical and essential facilities, such as hospitals and HESs. Within Lee County, system-wide loss of water pressure resulted from extensive damage to the water distribution system. The lack of pre-established plans that prioritized potable water support to critical and essential facilities resulted in delays in re-establishing supply. The interruption of potable water supply contributed to difficult sanitary conditions in HESs and the evacuation of three Lee County hospitals.

Recommendation FL-34. **Potable water utilities should identify which potable water supply pipelines provide service to critical and essential facilities and develop a plan for how to either isolate these pipelines from the remaining portions of the distribution system for quicker repair or prioritize and provide water supply to these essential facilities.** Identifying potable water supply pipelines and the necessary valves that can be closed, and prioritizing the order to close valves can direct potable water supply to critical and essential facilities more quickly. A pre-established plan will assist in reducing the duration of service interruption in the event of a system-wide loss of pressure. Depending on the complexity of the system and severity of event, limiting the duration of the potable water supply outage may allow for the critical and essential facility to remain fully operational.

Conclusion FL-35

There is a general confusion regarding classifications of shelter types, and often shelter terminology is used interchangeably without regard to term definitions. In discussions with EOC personnel, the MAT found a knowledge gap related to shelter types, including safe rooms, storm shelters, HES, evacuation shelters, American Red Cross shelters, and EHPAs, to name only a few. This misperception of shelter terminology by the public creates an overconfidence in shelters designed to a less-stringent performance standard and disincentivizes the construction of safe rooms built to the highest standards.

> Recommendation FL-35. **FEMA should collaborate with key stakeholders and develop guidance on different shelter terminology.** FEMA should develop a fact sheet and/or other resources to help better define the different types of shelters (e.g., HES, safe room, storm shelter, evacuation shelter, American Red Cross Shelter) that currently exist and the level of protection expected by each type. FEMA should consider developing a guidance document followed by a potential code change proposal to include these definitions in Section 423.2 of the FBC.

Conclusion FL-36

At least one HES observed by the MAT demonstrated significant vulnerabilities to high-wind events. While this HES is listed in the 2022 SESP, it does not meet the minimum FDEM HES criteria as it is an uncertified pre-engineered metal building. There were both building performance and operational performance issues experienced at this facility.

> Recommendation FL-36a. **The State of Florida and FDEM should consider re-evaluating their policies, procedures, and requirements for assessing existing spaces for use as HESs.** The State of Florida and FDEM should consider requiring more robust and holistic vulnerability assessments for HESs that are designated through assessment and mitigation of existing spaces. Further, the HESs listed in the SESP should be reevaluated to confirm compliance with the intended sheltering standard; what standard each building meets should be identified and made publicly available. Facilities that are uncertified pre-engineered metal buildings should not be included in the SESP list. Furthermore, buildings meeting ARC HESSS V1.0 criteria (formerly ARC 4496) are intended for evacuation shelter operations, not for sheltering occupants from high winds (e.g., tornadoes, hurricanes) and associated windborne debris impacts or protecting corresponding utility systems.

> Recommendation FL-36b. **Any building identified as a shelter that will be occupied during a storm event should meet or exceed FEMA P-361 or ICC 500 standards in order to provide life-safety protection.** The criteria for safe rooms and storm shelters are provided in FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms* (2021a), and the ICC/NSSA *Standard for the Design and Construction of Storm Shelters* (ICC 500). The ARC HESSS V1.0 standard is less than the ideal criteria for evaluating HESs as the standard does not have certification for the building envelope,

including windows and doors. FEMA has several funding vehicles for safe rooms; information on FEMA safe room grants is available at www.fema.gov/safe-room-funding.

Recommendation FL-36c. **FEMA and FDEM should continue delivering training on FEMA P-361 safe room design, construction, and O&M.** FEMA and FDEM, in conjunction with FFMA and BOAF, should develop and provide webinars on safe room design and construction, including FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms* (2021a). This training should be directed to builders, developers, building officials, plan reviewers, building inspections, various planners, and building owners and operators.

Conclusion FL-37

The MAT did not identify any EHPAs in the Hurricane Ian impact areas visited (Charlotte, Lee, and Desoto Counties) based on the 2022 SESP. The state planning assumption that communities would use new school construction to reduce the shelter deficit was not accurate in the areas visited by the MAT. Lee and Charlotte Counties, in particular, have a much greater percentage of their population 65 years of age and older, while also having a much lower percentage of the population 18 years of age and younger (school age), compared to the rest of Florida. As such, new school construction in these counties is not likely in the foreseeable future. Lee, Charlotte, and DeSoto Counties continued to remain in a shelter deficit as of the 2022 SESP.

Recommendation FL-37a. **FEMA and FDEM should consider submitting a code change proposal to the FBC to expand EHPA construction requirements.** The EHPA design and construction requirements could be expanded to include alterations or repairs of existing educational facilities and new public facilities with assembly spaces. In addition, FDEM and/or local emergency management agencies should consider both region-level and county-level shelter demand versus capacity data when making EHPA exemption decisions.

Recommendation FL-37b. **State, regional, county, and local officials should consider applying for grants or investing in the construction of more FEMA P-361–compliant safe rooms and/or ICC 500 storm shelters.** Compliance with FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes* (2021a) and ICC/NSSA *Standard for the Design and Construction of Storm Shelters* (ICC 500) address vulnerabilities of HESs not designed to these standards. FEMA has several funding vehicles for safe rooms; information on FEMA safe room grants is available at www.fema.gov/safe-room-funding.

Conclusion FL-38

Enclosure elements of shelters/safe rooms observed by the MAT did not appear to be fully compliant. Observations of the enclosure for the critical support systems at shelters/safe rooms visited by the MAT did not appear to meet ICC 500/FEMA P-361 requirements for impact rating/protection.

> Recommendation FL-38. **FEMA should consider submitting a code change proposal to add language to Chapter 1 of ICC 500 to ensure the design information on protection of critical support systems outside of the protected envelope is captured with submittal documents and subsequent peer reviews.** FEMA should consider submitting a code change proposal to modify the ICC 500 standard by adding "protection of storm shelter critical support systems located outside the storm shelter envelope in accordance with ICC 500 Section 701.2" to the list of submittal document design information required in ICC 500 Section 106.2.1.

Conclusion FL-39

Sealed roof decks (secondary water barriers) are often effective in reducing damage from water infiltration. Sealed roof decks were often observed to be effective in reducing water intrusion damage to buildings.

> Recommendation FL-39. **IBHS and other research organizations should investigate the feasibility and benefits of providing a sealed roof deck on low-slope roofs.** There are no requirements for the inclusion of a sealed roof deck for low-slope roofs in the IBC and FBC. Current code requirements for sealed roof decks are for roofs with a slope of 2:12 or greater.

Conclusion FL-40

Gaps often existed in shelter O&M planning and coordination between building owners and operators responsible for day-to-day functions and shelter operators. Contacts for each shelter visited by the MAT described various operational challenges experienced as the facility transitioned to a shelter. For example, staff at the Hertz Arena reported challenges with food distribution, especially as the shelter operations transitioned to the American Red Cross. At the Estero Recreation Center, staff reported challenges faced by an overwhelming number of traveling nurses arriving on site. Lee County's After-Action Report includes continuing to develop strategies for coordinating shelter operations as a recommendation (Lee County 2023).

> Recommendation FL-40a. **Florida shelter (HES, EHPA, safe room, and storm shelter) operators should conduct a yearly on-site training at each shelter.** Training participants should include the main point of contact person/people operating the shelter and building owner representatives. The training should include a review of roles and responsibilities, area layout, and critical support systems. FEMA P-361 (Section A4.2.3, 2021 version) and ICC 500 (Section A105, 2020 version) should be referenced as guidance for developing a training plan.

> Recommendation FL-40b. **Florida shelter (HES, EHPA, safe room, and storm shelter) owners and operators should have their own O&M plan that is reviewed and updated on at least an annual basis.** FEMA P-361 (Chapter A4) and ICC 500 (Appendix A) should be referenced as guidance for developing an O&M plan, even when the facility is not a safe room or storm shelter. Conducting a yearly on-site training at the shelter should be included in the O&M plan.

Conclusion FL-41

A lack of planning for sheltering residents with special needs caused operational challenges for General Population shelters and local hospitals in Lee and other counties. Despite Lee County developing a registry of residents with special needs and arranging transportation, Lee Health reported evacuees being sent to the hospital instead of the designated Special Needs HESs. The hospital did not have adequate staffing or resources for these evacuees. Considering residents with special needs in hurricane planning is critically important given the residents' special needs during a major storm, the continued deficit of Special Needs shelter space, and the growing elderly population throughout counties in Florida.

> Recommendation FL-41a. **AHJs should assess or re-assess their Special Needs sheltering plans and address shortfalls with the county and state.** Local entities should engage the community through education and training programs to communicate who may evacuate to Special Needs shelters, what critical support systems are available at Special Needs shelters, and how their services differ and are not available at General Population shelters.
>
> Recommendation FL-41b. **AHJs should work with hospital stakeholders to identify residents required to shelter at a hospital well ahead of an emergency event.** Hospitals should ensure their hurricane plan includes sufficient capacity, support staff, and resources for the intended number of residents seeking shelter at the facility. In the lead-up to a hurricane, hospitals are typically "de-risking" facilities by reducing the number of patients at the hospital. Evacuating residents to hospitals is counter to this operation. Hospitals that have not pre-approved admittance of residents with special needs should not be used as a Special Needs shelter.

Conclusion FL-42

The low number of residents evacuating to shelters prior to Hurricane Ian should not be used as a justification for lowering expectations of shelter demand. Shelter managers noted a lower-than-expected turnout at shelters, possibly due to residents' experiences with Hurricane Irma, which saw a much higher turnout in shelters.

> Recommendation FL-42a. **FEMA, in partnership with OFAs, should continue evaluating human behavior related to evacuation decision making.** The FEMA National Hurricane Program, NOAA National Severe Storms Laboratory, NIST Disaster and Failure Studies Program, NSF Disaster Resilience Research Grant Program, and other federal programs should continue ongoing efforts to more accurately model human behavior related to evacuations. Federal agencies should disseminate data, resources, and technical assistance from those studies for use in SLTT-level hurricane evacuation planning and operations. In addition, federal agencies should collaborate on findings from individual agency research to ensure lessons learned are shared across the federal government. For example, federal agencies can collaborate on how much the confidence in shelter building performance contributes to evacuation decision making, including the confidence in FEMA P-361 safe rooms, ICC 500 storm shelters, or other various buildings currently being used as shelters.

Recommendation FL-42b. **FDEM and the Regional Planning Council (RPC) should consider performing behavioral studies researching how the severity of past hurricanes informs residents' decisions to seek shelter for upcoming events.** Behavioral studies should also consider studying how consistency in messaging, confidence in the forecast, credibility of who is delivering messages, and transparency of the shelter selection process impacts evacuation and shelter demand. FDEM and RPC are responsible for developing the Statewide Regional Evacuation Studies, which inform Florida's SESP of shelter demands for shelter capacity planning. Shelter capacity planning should incorporate the findings of the studies to help with identifying the number of shelters required for an upcoming event and staffing requirements.

Conclusion FL-43

Shelter occupancy duration for Hurricane Ian was often much longer than what is currently required in design standards and operational planning. A communities' actual needs and their response to a hurricane event dictates the duration of occupancy of HESs, storm shelters, and safe rooms. Event duration, curfews, security, hazardous debris, utility system outages, overall severity of community damage, and rescue efforts, among many other factors, may require evacuees to remain in shelters for longer than the 24-hour minimum duration of occupancy as required by FEMA P-361 and ICC 500.

Recommendation FL-43a. **FEMA should consider revising FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes* (2021a), and other related safe room guidance and grant requirements to consider longer occupancy duration timeframes.** Considerations should include, but not necessarily be limited to:

- Increasing fuel storage capacity and requiring an emergency generator "quick connect" to enable redundant capability to ensure the safe room can operate for an increased duration as needed.
- Connecting the cooling system to the emergency generator or creating an isolated cooling room through which occupants can circulate. When considering longer occupancy durations, providing functioning cooling systems becomes more important. When considering the time of year and the location where hurricanes make landfall, the risk of heat stroke among shelter occupants is a concern.
- Providing many more electrical receptacles for occupants. Occupants have a far greater reliance on technology for communication now, than in the past. Furthermore, these shelter receptacles should either be wired in advance, or be able to be connected to emergency generators with the capacity to provide power for a longer shelter occupancy duration than 24 hours.
- Stating the drinking and wastewater requirements of ICC 500 (Sections 703.3.4 and 703.4, 2020 version) in gallons of water per occupant per day considering an

occupancy duration of longer than 24 hours. ICC 500 dictates a required amount of drinking and wastewater in gallons per person that cannot be scaled for longer occupancy durations.

- Revising FEMA P-361 commentary to include the potential transition of safe rooms into recovery shelters.

Recommendation FL-43b. **FEMA should consider including guidance and/or commentary in FEMA P-361 on shower facilities.** If a shelter allows for the use of showers, shelter managers should consider the showers when planning for interruption of potable water service. This could either be by increasing potable water storage to account for the increased water usage or connecting the showers to a separate and distinct plumbing loop that only services the showers.

Conclusion FL-44

Prior to Hurricane Ian, shelter operators did not establish a secure area within the shelter for security personnel. Last minute, shelter operators needed to identify a location or create a cordoned off area within the shelter to house security personnel. Security personnel often carry equipment that could cause a safety concern around the general population if not properly secured.

Recommendation FL-44a. **In emergency and shelter planning and designs, shelter planners, operators, and design professionals should consider identifying or designing a location or creating a cordoned off area within the shelter to house security personnel.** For shelters with security personnel, whether law enforcement officers, national guard, or private security, planners, operators, and designers should consider having an area separated from the general population to house the security team. The designing, sizing, and developing of the floor plan of the safe room should consider this additional space. In interviews conducted by the MAT and shelters observed by the MAT, security incidents were reduced when security personnel were on the premises during the duration of shelter operations.

Recommendation FL-44b. **FEMA should consider revising FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes* (2021a) (Sections A4.6.1 and B5) to expand the guidance on safe rooms with security personnel.** As a best practice, safe rooms should include a room or cordoned off area to house security personnel. As such, the safe room usable area should be increased accordingly.

Conclusion FL-45

Minimizing the stress of long-term sheltering is currently not considered in shelter operational planning. Traditional operational planning considers shelters a “last-resort” option with a minimum of sleeping and feeding accommodations for those who cannot evacuate. Studies of long-term sheltering during high-stress events is not at the forefront of shelter planning.

Recommendation FL-45. **NIST should consider further research on psychological and physical challenges of shelter occupants associated with shelter operations.** Research could include the psychological effects (i.e., stress, trauma) of surviving an extreme weather event in a shelter with limited space with hundreds or thousands of strangers. Following this research, NIST should consider developing guidance and best practices for effectively addressing these challenges. This guidance and best practices may include, but not be limited to, incorporating circulation corridors in the shelter layout and including Wi-Fi and outlets for personal device charging on the backup power system.

Conclusion FL-46

Some standby power systems failed shortly after the loss of normal (utility) power. Some generator and standby power system failures likely resulted from a lack of maintenance or from the generators reaching or exceeding the end of their service life. Standby power system failures also resulted from wind-driven rain entering electrical equipment through failures in building envelopes or from wind pressures opening the doors of exterior electrical equipment enclosures. The water caused electrical faults that prevented standby power systems from operating when needed for critical and essential facilities.

Recommendation FL-46a. **Owners and operators of critical facilities should protect electrical equipment required for operations by maintaining the integrity of the components that enclose the equipment.** Owners and operators of critical and essential facilities should assess the ability of doors for exterior electrical enclosures housing critical equipment to remain closed during high-wind events. When enclosure doors are at risk of failing due to high-wind loads, latching mechanisms should be properly maintained or strengthened to address the expected wind loads for the location. As part of the plans to prepare for projected high-wind events, operators of critical and essential facilities should inspect exterior electrical enclosure doors to ensure they are properly maintained, closed, and latched.

Recommendation FL-46b. **Owners and operators of Risk Category III and IV facilities that must remain operational during prolonged power outages should routinely maintain and test all standby power systems and ancillary equipment.** Emergency managers and local officials that rely on those critical and essential facilities should support the replacement of standby power systems that have operated beyond their service life, are not able to meet the needed electrical load due to increased mission requirements or have otherwise become unreliable.

Conclusion FL-47

For facilities with two or more alternate power sources, the inability to supply emergency and standby power systems from all available alternate power sources, renders power to those critical systems vulnerable to single-point failures of the alternate power sources.

Recommendation FL-47a. **Owners and operators of existing Risk Category III and IV facilities that have more than one alternate power source that supplies emergency and standby**

systems should consider incorporating improvements to those systems that will enable critical equipment to be supplied from all available alternate power sources.

Recommendation FL-47b. **Designers of new Risk Category III and IV facilities should consider redundancy in alternate power sources for critical and essential facilities that must remain operational during extended periods of loss of normal (utility) power outages.** All emergency systems, legally required standby systems, and optional standby systems must meet the requirements contained in Chapter 7, *Special Conditions,* of the National Electrical Code (National Fire Protection Association [NFPA] 70).

Conclusion FL-48

Generators provided by FlaWARN and USACE had electrical connections that were incompatible with the pre-wired lift station connections. Sanitary sewer lift stations were pre-wired to facilitate the connection of portable generators. The presence of incompatible connections prevented the portable generators from supplying standby power to the lift stations and resulted in the delivered generators being unavailable for use until they were transported elsewhere.

Recommendation FL-48. **Utilities that rely on others to provide temporary generators should develop and maintain a database of key information on all lift stations and other facilities needing portable generators.** The database should include key information regarding the configuration of the pre-wired connections, the voltage and wiring configuration of the stations, the number and horsepower ratings of all motors within the facilities, and when available, their full load ratings and starting demands. When requesting temporary generators, the data should be provided to FlaWARN, the USACE, or other providers so they can properly resource the request the first time.

Conclusion FL-49

Many critical and essential facilities visited by the MAT were older buildings, where the majority of the building was constructed prior to modern building codes and does not meet the current requirements for Risk Category IV design and construction. These facilities sustained damage to building envelope components, primarily to roof components, that adversely impacted operations during and after Hurricane Ian. This damage occurred even though Hurricane Ian wind speeds were well below design-level wind speeds. Structures, especially Risk Category IV structures, built to older legacy codes (prior to the 2001 FBC) are potentially at risk of failure due to known vulnerabilities.

Recommendation FL-49. **SLTT governments and private facility owners and operators should perform a wind vulnerability assessment of their critical and essential facilities to determine whether they meet the current requirements for a Risk Category IV building.** If vulnerabilities are identified, the critical and essential facility stakeholder should consider either performing the retrofit, relocating to another building, or building a new building. For more information on vulnerability assessments and on retrofitting critical and essential facilities, refer to FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds* (2007a); FEMA P-2062, *Guidelines for Wind Vulnerability Assessments of Existing Critical*

Facilities (2019b); and FEMA's Hurricane Michael in Florida, Recovery Advisory 1, *Successfully Retrofitting Buildings for Wind Resistance* (2019c). FEMA has several funding vehicles for hurricane wind retrofits, including completion of wind vulnerability assessments; information on FEMA wind retrofit grants is available at www.fema.gov/grants/mitigation.

Conclusion FL-50

Roofs of critical and essential facilities showed signs of poor performance and were damaged even though wind speeds were well below design-level wind speeds. For some critical and essential facilities whose roofs were damaged during Hurricane Ian, estimated wind speeds were relatively low and correlate to a 20- to 25-year recurrence interval. While widespread roof failure did not occur, the affected roofs were only exposed to moderate wind speeds and their performance was less than desired or expected.

Recommendation FL-50. **Critical and essential facility owners and operators and other stakeholders of facilities that experienced high wind speeds during Hurricane Ian should consider roof inspections and follow-up mitigation, as needed, to strengthen roofing components.** For critical and essential facilities located in areas where the estimated wind speeds during Hurricane Ian exceeded 100 mph, owners, operators, and other stakeholders should consider having the roofs of their facilities inspected by qualified professionals familiar with wind effects on roof systems. Where post-Hurricane Ian inspections reveal that roofs were damaged during Hurricane Ian, mitigation should be incorporated into the repairs to strengthen the damaged areas to improve overall roof performance. Note that the 100 mph inspection threshold was not determined analytically but is considered reasonable and appropriate.

Conclusion FL-51

The success of floodproofing is improved when a multiprong and multidisciplinary approach is taken to mitigate flood risks. The MAT observed fire stations where wet floodproofing, dry floodproofing, elevation (of both the building and utilities), additional freeboard, and the use of flood-resistant materials below FPE were incorporated in the architectural, structural, mechanical, and electrical designs. Overall, this approach reduced building damage from flood events even when the FPE was exceeded.

Recommendation FL-51a. **Designers of critical and essential facilities with a high-flood risk should combine elevation, wet floodproofing, dry floodproofing, and the use of flood-resistant materials below the FPE to reduce potential damage.** The MAT observed that when a flood event did not exceed the FPE, the combination of flood mitigation methods worked as intended and prevented damage. With proper design considerations, when the FPE was exceeded, although there was damage, the extent of damage and, more importantly, the operational impacts to critical and essential facilities were significantly reduced.

Recommendation FL-51b. **Designers should increase the FPE to provide additional protection for higher than design-level events.** The inclusion of additional freeboard into the design prevented overtopping of dry floodproofing barriers. Refer to Hurricane Ian in Florida, Recovery Advisory 1, *Designing for Flood Levels Above the Minimum Required Elevation After Hurricane Ian* (2023b), for guidance on improving resiliency to future flood damage through elevation and other mitigation considerations.

Recommendation FL-51c. **A multidisciplinary approach should be taken to reduce flood risks.** Architects, structural engineers, mechanical engineers, electrical engineers, builders, and other stakeholders should follow guidance included in FEMA P-936, *Floodproofing Non-Residential Structures* (2013b) and FEMA P-348, *Protecting Building Utility Systems from Flood Damage* (2017), and should minimize wiring and equipment installed below the FPE**.**

Conclusion FL-52.

FEMA currently prohibits dry floodproofing of residential areas. The MAT observed fire stations with sleeping quarters in dry floodproofed areas.

Recommendation FL-52. **FEMA should clarify its position on dry floodproofing non-residential buildings that have sleeping quarters.** FEMA allows dry floodproofing in non-residential buildings and non-residential portions of mixed-used buildings; clarification is needed for non-residentials buildings with sleeping quarters.

Conclusion FL-53.

The mitigation measures taken at Everglades City School reduced extensive flood damage and were a tremendous success. A floodwall, along with five barriers at egress points and an internal drainage pumping system, built with FEMA Public Assistance funding following Hurricane Irma prevented flood damage and floodwaters from entering any of the buildings within the protected area during Hurricane Ian.

Recommendation FL-53. **FEMA should maintain a publication or webpage documenting design and construction details of successful mitigation projects funded through FEMA grant programs for FEMA staff and SLTTs to reference and learn from.** While FEMA has a Mitigation Portfolio, various Loss Avoidance Studies, and Best Practices, there is not a clear repository of references for mitigation success stories. The repository should include, for example, subapplication information, such as design and construction criteria, so that similar projects can be submitted for grant funding. FEMA should consider collaborating with Florida to highlight mitigation success stories captured by the Ian MAT and other sources on the recently published Florida Enhanced State Hazard Mitigation Plan all-online format.

6.8. Crosswalk/Matrix of Conclusions and Recommendations with MAT Observations

Table 6-2 is a matrix listing the conclusions and recommendations cross-referenced to the sections of the report that describe the supporting observations.

Each recommendation summary includes "key stakeholders" for implementing the specific recommendation. The provided "key stakeholders" are not intended to be all inclusive. While there are primary, secondary, and tertiary stakeholders for each of these recommendations, the recommendation table only provides the primary stakeholders as written in the summary recommendation statement. Many local organizations and stakeholders, although not listed for a given recommendation, are critical to championing and implementing the recommendation in their states and communities. Examples include FDEM, local officials (emergency managers, floodplain administrators, building code officials, the Association of State Floodplain Managers, Inc., chapters), and other professional groups.

Table 6-2: Summary of Conclusions and Recommendations

Observations	Conclusions	Recommendations
Chapter 3 (Section 3.3)	**FL-1.** Coastal buildings experienced damage to siding and exterior attached structures likely due to wave runup on the building.	FL-1. ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, should be revised to provide additional guidance on the impacts of wave runup on coastal buildings.
Chapter 3 (Section 3.4.5)	**FL-2.** Back-to-back storms resulted in extensive dune erosion and building damage.	FL-2a. SLTT governments, AHJs, and applicable agencies should consider implementing design and construction regulations that require evaluation of dune erosion for a minimum of a 500-year MRI storm. FL-2b. FEMA should consider researching and updating existing guidance related to using a 1,100-square-foot cross-section for primary frontal dune reservoir removal to include a 500-year MRI storm reservoir cross-section recommendation.
Chapter 3 (Section 3.5.1)	**FL-3.** Extensive corrosion of erosion control structure tie-back bars was commonly observed and was a major contributing factor to seawall failure.	FL-3. SLTT governments, AHJs, and applicable agencies should develop and implement guidance and requirements for adequate inspections, maintenance, and repairs to coastal armoring structures.

Observations	Conclusions	Recommendations
Chapter 3 (Section 3.9.1)	**FL-4.** Non-flood damage–resistant materials used in enclosures below the BFE (non-compliant with the NFIP and flood-resistant design and construction building code requirements) in *elevated buildings* was widespread, with resultant largescale damage.	FL-4a. FDEM should consider developing or modifying existing training on the flood provisions in the FBC and local floodplain management ordinances with an emphasis on enforcement to reduce damage from the use of non-compliant materials in enclosures below the BFE. FL-4b. Local communities (AHJs) should require a non-conversion agreement when permitting enclosed areas below the BFE. FL-4c. FEMA should continue ongoing efforts to develop a consensus standard for flood damage–resistant materials and also consider revising NFIP floodplain management regulations to reduce damage within and to enclosures.
Chapter 3 (Section 3.10.1)	**FL-5.** Designed dry floodproofing measures that were subjected to Hurricane Ian flooding failed in numerous buildings observed in the SFHA when owners did not deploy them.	FL-5a. FEMA should consider adding flood insurance policy language that dry floodproofing measures must be deployed in accordance with the operations and maintenance (O&M) plan before a claim can be filed. FL-5b. Local floodplain administrators, design professionals, and building owners should follow the guidance in Hurricane Harvey in Texas, Recovery Advisory 1, *Dry Floodproofing: Planning and Design Considerations* (2018b) and Hurricane Irma in Florida, Recovery Advisory 1, *Dry Floodproofing: Operational Considerations* (2018a) related to dry floodproofing. FL-5c. FEMA should collaborate with the Flood Mitigation Industry Association and the Association of State Floodplain Managers and consider establishing a training and certification program for design professionals, contractors, and inspectors implementing and certifying dry floodproofed areas. FL-5d. FEMA, ASCE, and the Florida Building Commission should consider requiring passive measures in new construction of Risk Category IV facilities where dry floodproofing is proposed.

Observations	Conclusions	Recommendations
Chapter 3 (Section 3.9.1) and Appendix C	**FL-6.** Based on the analytics of representative NFIP claims data as well as observations in the field, most Substantially Damaged or destroyed buildings were existing or legal non-conforming construction.	FL-6. FEMA should consider alternative approaches to Substantial Improvement / Substantial Damage, such as expedited post-flood acquisitions, elevations, or relocations to amenable property owners.
Chapter 3 (Section 3.9.1) and Appendix C	**FL-7.** Most of the flood damage observed outside of areas that experienced hydrodynamic loads, was to building materials.	FL-7a. FEMA should encourage the use of flood damage–resistant materials up to 4 feet above the BFE and consider requiring flood damage–resistant materials for at least 2 feet above the BFE. FL-7b. FEMA should consider requiring the use of flood damage–resistant materials as part of a flood insurance building claim payment. FL-7c. FEMA, FDEM, and the FBC should consider developing practical criteria for when *elevated buildings* should be required for new construction within the regulated floodplain.
General field observations	**FL-8.** The state and communities did not receive (or did not receive in a timely manner) data on buildings that appeared to have incurred Substantial Damage.	FL-8. FEMA should develop an effective and timely means to deliver the Adjuster Preliminary Damage Assessment data.

Observations	Conclusions	Recommendations
General field observations	**FL-9.** Numerous AHJs were overwhelmed with the widespread and extensive damage from Hurricane Ian and were not staffed or prepared for the building permit workload required to repair or replace buildings and residences.	FL-9a. FEMA should continue providing guidance and increase technical assistance opportunities and training to SLTT governments related to building code and floodplain management administration and enforcement authorized under Section 1206 of DRRA. FL-9b. FDEM should continue to encourage pre-event planning of post-disaster needs and inform appropriate parties about assessing resources through statewide mutual aid agreements and the Emergency Management Assistance Compact (EMAC). FL-9c. FEMA should work with SLTTs in helping their building code departments, and other pertinent departments, include various building code-related injects into exercises in order to improve their preparedness, response, recovery, and mitigation operations in a post-disaster environment. FL-9d. FEMA, in partnership with NIST, NSF, NOAA, and OFAs, should provide guidance to help SLTTs with implementing policies and procedures related to collecting damage assessment data.

Observations	Conclusions	Recommendations
Chapter 4 (Section 4.2.4)	**FL-10.** Hip and ridge roof coverings for many residential buildings appeared to have inadequate resistance to wind loads.	FL-10a. FEMA should consider submitting code change proposals or supporting code change proposals from other stakeholders—such as IBHS, Asphalt Roofing Manufacturers Association (ARMA), National Roofing Contractors Association (NRCA), and other aligned groups to the IBC, IRC, and the FBC—to require testing of hip and ridge roof coverings for asphalt shingle roof coverings. FL-10b. FEMA should consider submitting code change proposals or supporting code change proposals from other stakeholders—such as IBHS, Metal Construction Association (MCA), NRCA, and other aligned groups to the IBC, IRC, and the FBC—to require testing of hip and ridge roof coverings for metal panel roof coverings. FL-10c. FEMA should consider submitting code change proposals or supporting code change proposals from other stakeholders—such as IBHS, ARMA, NRCA, and other aligned groups to the IBC, IRC, and the FBC—to require a minimum of 6 inches overlap of the roof underlayment to hip and ridges that do not have ventilation components.
Chapter 4 (Section 4.2.1)	**FL-11.** The failure of soffits and ventilated soffits often contributed to water intrusion into attic areas and exterior walls.	FL-11. The Florida Building Commission should revise the FBCR to require ventilated soffits to be tested for water intrusion resistance in accordance with FBC Test Protocol TAS 100(A) throughout the state, as is required in the HVHZ.
Chapter 4 (Section 4.2.3)	**FL-12.** The inability of sliding doors to adequately resist wind-driven rain often contributed to water intrusion at many sites.	FL-12a. The Florida Building Commission should collaborate with the window industry (Window and Door Manufacturers Association [WDMA], Fenestration and Glazing Industry Alliance, and key manufacturers) and other stakeholders to modify or delete the exceptions to water intrusion testing in the FBC. FL-12b. The window industry should revise AAMA/WDMA/CSA 101/I.S.2/A440 to require window and door Performance Grade (PG) ratings to be equal to the positive DP wind pressure rating.

Observations	Conclusions	Recommendations
Chapter 2 (Section 2.5) Chapter 3 (Section 3.11) Chapter 4 (Section 4.4)	**FL-13.** Florida's installation requirements for manufactured homes references the 1985 edition of FEMA 85, *Protecting Manufactured Homes from Flood and Other Hazards,* that is 24 years older than its 2009 revision.	FL-13. The Florida Department of Highway Safety and Motor Vehicles should reference the most recent edition of FEMA P-85 (2009) in the Florida Administrative Code Chapter 15C.
Chapter 4 (Section 4.4.1)	**FL-14.** Post-1994 manufactured homes suffered widespread envelope failures, including to roof and wall coverings; glazed opening damage was also observed.	FL-14. HUD should update its HUD MHCSS 24 CFR 3280 wind requirements for consistency with ASCE 7-22.
Chapter 2 (Section 2.5) Chapter 3 (Section 3.11)	**FL-15.** The primary differentiator in the flood-resistance performance of manufactured homes was whether the bottom of the steel frame was elevated above the Hurricane Ian flood level.	FL-15. AHJs in Florida should incorporate the most recent edition of FEMA P-85, *Protecting Manufactured Homes from Flood and Other Hazards* (2009) and FEMA P-348, *Protecting Building Utility Systems From Flood Damage* (2017), into its floodplain ordinances and integrate associated best practices.
Chapter 2 (Section 2.5) Chapter 3 (Section 3.11) Chapter 4 (Section 4.4)	**FL-16.** FEMA P-85, *Protecting Manufactured Homes from Flood and Other Hazards*, was published in 2009 and is becoming increasingly out of date.	FL-16. FEMA should lead the update of FEMA P-85 to incorporate lessons learned since the 2009 edition.

Observations	Conclusions	Recommendations
Chapter 4 (Section 4.4.2)	**FL-17.** Failures of improper appurtenance attachments to post-1994 manufactured homes significantly increased vulnerability to wind and rain damage.	FL-17a. Local AHJs and manufactured home communities should enforce the Florida Administrative Code requirement 15C-2.0081 for standalone manufactured home appurtenances. FL-17b. HUD and the Manufactured Housing Institute should develop training to be provided to AHJs and manufactured home communities in Florida to help them understand and implement Florida Administrative Code requirement 15C-2.0081 for standalone manufactured home appurtenances.
Chapter 4 (Section 4.4.3)	**FL-18.** Newly delivered manufactured homes without permanent anchorage endangered surrounding manufactured homes when overturned by Hurricane Ian's winds.	FL-18. Manufactured home dealers should not deliver manufactured homes unless permanent installation is scheduled to occur at the time of delivery.
Chapter 3 (Section 3.11)	**FL-19.** Utility components below manufactured homes suffered flood damage	FL-19. Local communities should encourage manufactured homeowners to elevate mechanical equipment in existing manufactured homes and ensure that the equipment is properly elevated in new manufactured homes.
Chapter 3 (Section 3.1) Chapter 3 (Section 3.4.3)	**FL-20.** Surviving front-row structures may have had both beneficial and detrimental impacts to surrounding structures.	FL-20a. NIST, along with OFAs, should further evaluate the extent to which surviving front-row structures provide shielding and the relationship of the amount of shielding to the openness of the front-row structure below the BFE. FL-20b. Industry groups, interested stakeholders, and/or academia should study whether and how surviving front-row structures with surviving walls below the BFE impact neighboring structures.

Observations	Conclusions	Recommendations
Chapter 3 (Section 3.2)	**FL-21.** Shore-perpendicular CMU breakaway walls sustained less damage when compared to shore-perpendicular wood-framed breakaway walls.	FL-21. FEMA should collaborate with OFAs, academia, and building science industry partners to study what may have caused the increased survival rates for the shore-perpendicular CMU breakaway walls.
Chapter 3 (Section 3.4.2) Chapter 3 (Section 3.4.3) Chapter 3 (Section 3.4.4)	**FL-22.** Numerous preferential scour pathways were observed that resulted in excessive localized scour and building damage.	FL-22. FEMA should develop guidance for communities, utilities, and homeowners regarding preferential scour pathways to provide measures that can be implemented to reduce the scour experienced in these types of areas during high flow-velocity events.
Chapter 3 (Section 3.6)	**FL-23.** Material degradation of various exterior building materials was commonly observed throughout the coastal areas visited by the MAT.	FL-23. FEMA should consider developing an inspection and maintenance checklist for NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (2008), and NFIP Technical Bulletin 8, *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas* (2019a).
Chapter 3 (Section 3.10.6)	**FL-24.** Pre-cast concrete floor panels held in place by gravity were highly susceptible to damage from uplift loads where flood elevations exceeded the elevation of the floor panel.	FL-24. FEMA should consider providing guidance and best practices for the use of pre-cast concrete floor panels held in place by gravity.

Observations	Conclusions	Recommendations
Chapter 3 (Section 3.9) and Appendix C.	**FL-25.** Many observed buildings were developed in high-risk and hazardous areas without appropriately considering and adequately addressing the lifetime risks and vulnerabilities to the structure from a siting, design, construction, maintenance, and other important risk factors perspective, resulting in poor building performance and significant damage or destruction.	FL-25a. The Mitigation Framework Leadership Group should consider coordinating with OFAs to limit funding for new building and development, including obtaining flood insurance, in very vulnerable areas where appropriate FL-25b. FEMA, FDEM, and local communities should continue to encourage building owners in high flood-risk areas to have an active flood insurance policy.
Chapter 3 Overall and Appendix C	**FL-26.** Many insufficiently elevated or low-elevation buildings built to legacy or older building codes sustained significant flood damage.	FL-26. Building owners, operators, design professionals, planners, and other interested stakeholders should follow Hurricane Ian in Florida, Recovery Advisory 1, *Designing for Flood Levels Above the Minimum Required Elevation After Hurricane Ian* (2023b) and consider exceeding ASCE 24, using best available data, and referencing future conditions whenever appropriate.
General Field Operations, Chapter 3 Overall	**FL-27.** There was confusion over what steps a homeowner should take after their house was flooded.	FL-27. FEMA should consider updating Hurricane Sandy Fact Sheet No. 1, *Cleaning Flooded Buildings* (2013a), and combining this information with, *The ABC's of Returning to Flooded Buildings* (FEMA n.d.).
Chapter 4 (Section 4.2.4.)	**FL-28.** Asphalt shingle roof coverings for many residential buildings appeared to have inadequate resistance to wind loads.	FL-28. The Florida Building Commission should consider funding more research in collaboration with academia and industry groups, such as ARMA, NRCA, and IBHS, to determine why asphalt shingle damage, particularly on aged asphalt shingle roofs, is often observed to be widespread.

Observations	Conclusions	Recommendations
Chapter 4 (Section 4.2.4)	**FL-29.** Roof coverings that had minor damage that likely could be repaired were often being replaced.	FL-29. To better identify minor roof covering damage that could be repaired, the roofing industry (NRCA, ARMA, MCA, Roof Tile Institute, Florida Roofing and Sheet Metal Contractors Association), insurance industry, IBHS, and other stakeholders should develop guidelines, training programs, and informational tests for building owners and homeowners.
Chapter 4 (Section 4.2.1)	**FL-30.** The use of spray foam insulation in attics to create an unvented attic provided some benefit against water intrusion through soffits on some houses.	FL-30. The Florida Building Commission, in collaboration with academia and industry groups such as IBHS, should consider funding research to determine whether the use of spray foam insulation in the attic is effective in limiting water intrusion through ventilated or failed soffit panels as a secondary benefit.
Chapter 4 (Section 4.2.3)	**FL-31.** Water intrusion through windows and doors can result in costly damage.	FL-31. Building owners, operators, and managers; design professionals; building officials; contractors; and municipal building and planning officials should follow the guidance in Hurricane Ian in Florida, Recovery Advisory 3, *Reducing Water Intrusion Through Windows and Doors* (2023d).
General Field Observations, Chapter 1 (Section 1.6.3)	**FL-32.** Flight level wind speeds, reported without adequate context, led to confusion and the misperception that Hurricane Ian's wind speeds were among the strongest recorded hurricanes at ground level.	FL-32. FEMA, in partnership with OFAs (including NOAA and NIST), should consider providing guidance to help the general public better understand hurricane wind speed measurements, their limitations, and key differences, as well as how they can best use the information to improve their plaining and decision making.

Observations	Conclusions	Recommendations
Chapter 5 (Section 5.2.1) Chapter 5 (Section 5.3.2)	**FL-33.** Numerous critical and essential facilities lacked an adequate plan to maintain operations when subjected to multiple days of potable water supply loss.	FL-33a. Critical and essential facility owners, operators, planners, emergency managers, and other impacted stakeholders should develop coordinated disaster operations plans and, if needed, construct the necessary infrastructure to adequately address potable water needs to fulfill their given missions. FL-33b. FEMA should consider submitting a code change proposal or supporting a code change proposal from other stakeholders to the FBC for modifying Section 453.25.3.3.1 to align support system capacities for EHPAs with the drinking and sanitary water storage capacity per FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes* (2021a), Sections B7.2.2 and B7.2.3 and ICC/NSSA *Standard for the Design and Construction of Storm Shelters* (ICC 500), Sections 703.4 and 703.3.4.
Chapter 5 (Section 5.1.1)	**FL-34.** Potable water utilities did not have pre-established plans for prioritizing potable water supply to critical and essential facilities, such as hospitals and HESs.	FL-34. Potable water utilities should identify which potable water supply pipelines provide service to critical and essential facilities and develop a plan for how to either isolate these pipelines from the remaining portions of the distribution system for quicker repair or prioritize and provide water supply to these essential facilities
Chapter 5 (Section 5.3)	**FL-35.** There is a general confusion regarding classifications of shelter types, and often shelter terminology is used interchangeably without regard to term definitions.	FL-35. FEMA should collaborate with key stakeholders and develop guidance on different shelter terminology.

Observations	Conclusions	Recommendations
Chapter 5 (Section 5.3.1)	**FL-36.** At least one HES observed by the MAT demonstrated significant vulnerabilities to high-wind events.	FL-36a. The State of Florida and FDEM should consider re-evaluating their policies, procedures, and requirements for assessing existing spaces for use as HESs. FL-36b. Any building identified as a shelter that will be occupied during a storm event should meet or exceed FEMA P-361 or ICC 500 standards in order to provide life-safety protection. FL-36c. FEMA and FDEM should continue delivering training on FEMA P-361 safe room design, construction, and O&M.
Chapter 5 (Section 5.3)	**FL-37.** The MAT did not identify any EHPAs in the Hurricane Ian impact areas visited (Charlotte, Lee, and Desoto Counties) based on the 2022 SESP.	FL-37a. FEMA and FDEM should consider submitting a code change proposal to the FBC to expand EHPA construction requirements. FL-37b. State, regional, county, and local officials should consider applying for grants or investing in the construction of more FEMA P-361–compliant safe rooms and/or ICC 500 storm shelters.
Chapter 5 (Section 5.3)	**FL-38.** Enclosure elements of shelters/safe rooms observed by the MAT did not appear to be fully compliant.	FL-38. FEMA should consider submitting a code change proposal to add language to Chapter 1 of ICC 500 to ensure the design information on protection of critical support systems outside of the protected envelope is captured with submittal documents and subsequent peer reviews.
Chapter 5 (Section 5.4.2)	**FL-39.** Sealed roof decks (secondary water barriers) are often effective in reducing damage from water infiltration.	FL-39. IBHS and other research organizations should investigate the feasibility and benefits of providing a sealed roof deck on low-slope roofs.

Observations	Conclusions	Recommendations
Chapter 5 (Section 5.3.1)	**FL-40.** Gaps often existed in shelter O&M planning and coordination between building owners and operators responsible for day-to-day functions and shelter operators.	FL-40a. Florida shelter (HES, EHPA, safe room, and storm shelter) operators should conduct a yearly on-site training at each shelter. FL-40b. Florida shelter (HES, EHPA, safe room, and storm shelter) owners and operators should have their own O&M plan that is reviewed and updated on at least an annual basis.
Chapter 5 (Section 5.3.1)	**FL-41.** A lack of planning for sheltering residents with special needs caused operational challenges for General Population shelters and local hospitals in Lee and other counties.	FL-41a. AHJs should assess or re-assess their Special Needs sheltering plans and address shortfalls with the county and state. FL-41b. AHJs should work with hospital stakeholders to identify residents required to shelter at a hospital well ahead of an emergency event
Chapter 5 (Section 5.3.1)	**FL-42.** The low number of residents evacuating to shelters prior to Hurricane Ian should not be used as a justification for lowering expectations of shelter demand.	FL-42a. FEMA, in partnership with OFAs, should continue evaluating human behavior related to evacuation decision making. FL-42b. FDEM and the Regional Planning Council (RPC) should consider performing behavioral studies researching how the severity of past hurricanes informs residents' decisions to seek shelter for upcoming events.
Chapter 5 (Section 5.3.2)	**FL-43.** Shelter occupancy duration for Hurricane Ian was often much longer than what is currently required in design standards and operational planning.	FL-43a. FEMA should consider revising FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes* (2021a), and other related safe room guidance and grant requirements to consider longer occupancy duration timeframes. FL-43b. FEMA should consider including guidance and/or commentary in FEMA P-361 on shower facilities.

Observations	Conclusions	Recommendations
Chapter 5 (Section 5.3.2)	**FL-44.** Prior to Hurricane Ian, shelter operators did not establish a secure area within the shelter for security personnel.	FL-44a. In emergency and shelter planning and designs, shelter planners, operators, and design professionals should consider identifying or designing a location or creating a cordoned off area within the shelter to house security personnel. FL-44b. FEMA should consider revising FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes* (2021a) (Sections A4.6.1 and B5) to expand the guidance on safe rooms with security personnel.
Chapter 5 (Section 5.3.2)	**FL-45.** Minimizing the stress of long-term sheltering is currently not considered in shelter operational planning.	FL-45. NIST should consider further research on psychological and physical challenges of shelter occupants associated with shelter operations.
Chapter 5 (Section 5.3.1) Chapter 5 (Section 5.4.2)	**FL-46.** Some standby power systems failed shortly after the loss of normal (utility) power.	FL-46a. Owners and operators of critical facilities should protect electrical equipment required for operations by maintaining the integrity of the components that enclose the equipment. FL-46b. Owners and operators of Risk Category III and IV facilities that must remain operational during prolonged power outages should routinely maintain and test all standby power systems and ancillary equipment.
Chapter 5 (Section 5.3.1)	**FL-47.** For facilities with two or more alternate power sources, the inability to supply emergency and standby power systems from all available alternate power sources, renders power to those critical systems vulnerable to single-point failures of the alternate power sources.	FL-47a. Owners and operators of existing Risk Category III and IV facilities that have more than one alternate power source that supplies emergency and standby systems should consider incorporating improvements to those systems that will enable critical equipment to be supplied from all available alternate power sources. FL-47b. Designers of new Risk Category III and IV facilities should consider redundancy in alternate power sources for critical and essential facilities that must remain operational during extended periods of loss of normal (utility) power outages.

Observations	Conclusions	Recommendations
Chapter 5 (Section 5.1.2)	**FL-48.** Generators provided by FlaWARN and USACE had electrical connections that were incompatible with the pre-wired lift station connections.	FL-48. Utilities that rely on others to provide temporary generators should develop and maintain a database of key information on all lift stations and other facilities needing portable generators.
Chapter 5 (Section 5.2.2) Chapter 5 (Section 5.4.2)	**FL-49.** Many critical and essential facilities visited by the MAT were older buildings, where the majority of the building was constructed prior to modern building codes and does not meet the current requirements for Risk Category IV design and construction.	FL-49. SLTT governments and private facility owners and operators should perform a wind vulnerability assessment of their critical and essential facilities to determine whether they meet the current requirements for a Risk Category IV building.
Chapter 5 (Section 5.4.2)	**FL-50.** Roofs of critical and essential facilities showed signs of poor performance and were damaged even though wind speeds were well below design-level wind speeds.	FL-50. Critical and essential facility owners and operators and other stakeholders of facilities that experienced high wind speeds during Hurricane Ian should consider roof inspections and follow-up mitigation, as needed, to strengthen roofing components
Chapter 5 (Section 5.4.1) Chapter 5 (Section 5.6.1)	**FL-51.** The success of floodproofing is improved when a multiprong and multidisciplinary approach is taken to mitigate flood risks.	FL-51a. Designers of critical and essential facilities with a high-flood risk should combine elevation, wet floodproofing, dry floodproofing, and the use of flood-resistant materials below the FPE to reduce potential damage. FL-51b. Designers should increase the FPE to provide additional protection for higher than design-level events. FL-51c. A multidisciplinary approach should be taken to reduce flood risks.

Observations	Conclusions	Recommendations
Chapter 5 (Section 5.4.1)	**FL-52.** FEMA currently prohibits dry floodproofing of residential areas.	FL-52. FEMA should clarify its position on dry floodproofing non-residential buildings that have sleeping quarters.
Section 5.6.1	**FL-53.** The mitigation measures taken at Everglades City School reduced extensive flood damage and were a tremendous success.	FL-53. FEMA should maintain a publication or webpage documenting design and construction details of successful mitigation projects funded through FEMA grant programs for FEMA staff and SLTTs to reference and learn from.

Appendix A: References

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Appendix B: Recovery Advisories

Hurricane Ian Recovery Advisory 1: *Designing for Flood Levels Above the Minimum Required Elevation After Hurricane Ian*

Hurricane Ian Recovery Advisory 2: *Reducing "Loss of Utility" Impacts to Critical Facilities*

Hurricane Ian Recovery Advisory 3: *Reducing Water Intrusion Through Windows and Doors*

These advisories are also available online at https://www.fema.gov/emergency-managers/risk-management/building-science/disaster-support.

Designing for Flood Levels Above the Minimum Required Elevation After Hurricane Ian

Recovery Advisory 1

July 2023

FEMA

DR-4673-FL RA 1

Table of Contents

1. Purpose and Intended Audience 1

1.1. This Recovery Advisory Addresses 1

2. Building Damage When Flood Levels Exceed the Lowest Floor 3

3. Required Design Considerations 5

3.1. NFIP Requirements and Mapping Guidance 6

3.2. Building Codes and Floodplain Management Regulations 9

3.3. Building Height Restrictions 9

3.4. Importance of the Building to the Community 10

3.5. Federal Grant Requirements 10

4. How High Above the Minimum Required Elevation a Building Should be Elevated 10

4.1. Recommended Considerations 10

4.1.1. Age of the Effective Flood Analysis 10

4.1.2. Availability of Preliminary FIRMs 11

4.1.3. Building owner and operator tolerance for damage, displacement, and downtime 11

4.1.4. Essential Facilities 11

4.1.5. Future Conditions 11

4.1.6. Residual Risk 11

4.2. Future Conditions 12

4.2.1. Relative Sea Level Rise 12

4.2.2. Coastal Erosion 14

4.2.3. Increased Wave Height 16

4.2.4. Determining Flood Elevations Based on Future Conditions 17

4.2.5. Anticipating Future Flood Zones 20

4.3. Summary of Considerations for Selecting a Building's Elevation 20

5. Additional Design Considerations for Mitigating Flood Damage 21

5.1. Design Loads 21

5.2. Use Strong Connections 21
5.3. Use Flood Damage–Resistant Materials 22

6. References 23

Figures

Figure 1: Three neighboring buildings with varying degrees of elevation and damage on Fort Myers Beach, Florida, after Hurricane Ian. The right-most building has the lowest elevation of the three and the most damage to the lower levels, whereas the middle building has the highest elevation and minimal damage to the lower levels............2
Figure 2: Image (top) shows waterfront houses damaged by coastal flood effects such as waves and velocity in Bonita Springs, Florida. Image (bottom left) shows siding damage above the lowest floor and significant scour, image (bottom center) shows complete loss of a deck as well as damage to glass doors, image (bottom right) shows structural damage to a concrete column and complete loss of a porch. 4
Figure 3: Probability under current conditions of a flood exceeding the 10-year (10% annual chance), 50-year (2% annual chance), 100-year (1% annual chance), and 500-year (0.2% annual chance) flood level during a given period of time (assuming no sea level rise) 5
Figure 4: Sample FIRM showing Zone AE, the Limit of Moderate Wave Action (LiMWA), and Zone VE. BFEs for each zone are noted in parentheses below the Zone AE/VE text. The BFEs are site specific and vary by location. The Coastal Construction Control Line (CCCL) is overlayed onto the FIRM and shown for reference purposes only. The CCCL is discussed later in this Recovery Advisory........8
Figure 5: Relative Sea Level Trend, Naples, Florida. Credit: NOAA/National Ocean Service...............12
Figure 6: Erosion’s effects on ground elevation, shoreline retreat, and dune migration.....................14
Figure 7: Overview of design parameters for current and future flood conditions 17
Figure 8: Process for determining flood elevations based on future conditions (Units: feet).............19
Figure 9: Examples of recommended construction and elevation for anticipated future flood zones 20

1. Purpose and Intended Audience

This Recovery Advisory outlines observations from Hurricane Ian in Florida, DR-4673-FL, that provide insights regarding building improvement opportunities. These recommendations are applicable to buildings experiencing similar issues and need not be limited to the state or disaster in which they were observed.

Flooding in Florida from Hurricane Ian in 2022 extended far beyond mapped Special Flood Hazard Areas (SFHAs) and often exceeded base flood elevations (BFEs) depicted on the Flood Insurance Rate Maps (FIRMs), by several feet in some areas. Lessons learned from Hurricane Ian can help guide repair and reconstruction efforts in designing new or retrofitting existing buildings to improve resiliency to future flood damage. This Recovery Advisory discusses how Flood Insurance Studies (FISs), Flood Insurance Rate Maps (FIRMs), and base flood elevations (BFEs) are established and provides guidance on elevating buildings to minimize flood damage in cases where flood levels exceed the minimum required elevation (Figure 1). The State of Florida has adopted a regulatory flood elevation for construction, as such, this Recovery Advisory uses design flood elevation (DFE) to reference the minimum elevation requirement.

The intended audience for this Recovery Advisory is designers, local and emergency management planners, home and building owners, and operators. It may also be helpful to any stakeholders involved in selecting lowest floor elevations for new construction in areas either affected by Hurricane Ian or with similar hazards. To properly address the hazard as well as the necessary measures required to select a building elevation, portions of this Recovery Advisory include in-depth technical information. Readers are encouraged to review the entire document to gain an understanding of the general principles; consultation with a design professional may be needed for implementation. Note that this Recovery Advisory provides recommendations that are primarily applicable to buildings subject to damage from storm surge, waves, and/or erosion. Although buildings subject to riverine flood hazards should also consider designing above the DFE, the process by which those additional risks are quantified is beyond the scope of this Recovery Advisory.

1.1. This Recovery Advisory Addresses

- Building Damage When Flood Levels Exceed the Lowest Floor
- Required Design Considerations
- How High Above the Minimum Required Elevation a Building Should be Elevated
- Additional Design Considerations for Mitigating Flood Damage

Figure 1: Three neighboring buildings with varying degrees of elevation and damage on Fort Myers Beach, Florida, after Hurricane Ian. The right-most building has the lowest elevation of the three and the most damage to the lower levels, whereas the middle building has the highest elevation and minimal damage to the lower levels.

Terminology

Flood Insurance Rate Map (FIRM): Official map of a community on which FEMA has delineated the Special Flood Hazard Areas (SFHAs), the base flood elevations (BFEs) and the risk premium zones applicable to the community.

Flood Insurance Study (FIS): A compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community. When a flood study is completed for the National Flood Insurance Program (NFIP), the information and maps are assembled into an FIS. The FIS report contains detailed flood elevation data in flood profiles and data tables.

Special Flood Hazard Area (SFHA): An area having special flood, mudflow, or flood-related erosion hazards and shown on a Flood Hazard Boundary Map (FHBM) or a Flood Insurance Rate Map (FIRM) as Zone A, AO, A1–A30, AE, A99, AH, AR, AR/A, AR/AE, AR/AH, AR/AO, AR/A1–A30, V1–V30, VE or V.

Base Flood Elevation (BFE): The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year. The BFE is shown on the FIRM for zones AE, AH, A1–A30, AR, AR/A, AR/AE, AR/A1–A30, AR/AH, AR/AO, V1–V30 and VE.

Design Flood Elevation (DFE): Regulatory flood elevation adopted by a local community. If a community regulates to the minimum NFIP requirements, the DFE is identical to the BFE. Typically, the DFE is the BFE plus any freeboard adopted by the community. See the section

"How High Above the DFE a Building Should be Elevated" for additional information on the DFE and freeboard. Some communities adopt flood maps with elevations that exceed the BFEs and become their adopted DFEs.

Stillwater Elevation: The surface of the floodwater referenced to a vertical datum, including tides and storm surge, excluding all wave effects.

Stillwater Depth: The difference between the stillwater elevation and the ground elevation.

2. Building Damage When Flood Levels Exceed the Lowest Floor

When flood levels exceed the lowest floor elevation of a building, there can be a sudden onset of damage. The type of building damage varies based on the type of flooding experienced. When flooding occurs as inundation flooding (low velocity and without waves) in Zone A areas, the structure may be submerged and contents will get wet, but it often occurs without causing extensive structural damage. However, if the water from inundation flooding does not equalize on the inside and outside of the structure, the hydrostatic loads have the potential to cause structural damage if the building was not designed to withstand the hydrostatic loading.[1] In contrast, severe flood damage is likely in areas where waves and high velocities accompany flooding as moving water and breaking waves impart large structural loads on the building. In Zone V and Coastal A Zone areas, waves are capable of causing significant damage to some buildings (Figure 2) as a result of the energy of coastal waves striking and undermining buildings. As water depths increase, higher waves may be present resulting in higher breaking wave loads. The action of wave crests striking the elevated portion of a structure is known as "wave slam." Wave slam introduces lateral and vertical loads on the lower portions of the elevated structure. For example, for a residential structure and a 5-foot stillwater depth, when the wave crest extends above the bottom of the floor joist by 1 foot, 312 pounds per foot (lb/ft) is exerted by lateral wave slam. In comparison, wave crests extending above the bottom of the floor joist by 2 feet and 3 feet exert 624 lb/ft and 936 lb/ft, respectively, due to wave slam.[2]

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[1] Wet floodproofing techniques may be utilized as a retrofit measure to enable the hydrostatic loads to equalize on the inside and outside of a building. See NFIP Technical Bulletin 7, *Wet Floodproofing Requirements and Limitations* (FEMA 2022), for information on techniques and compliance requirements.

[2] Wave slam loads are based on equation 8.7 in FEMA P-55, *Coastal Construction Manual, Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas* (2011).

Figure 2: Image (top) shows waterfront houses damaged by coastal flood effects such as waves and velocity in Bonita Springs, Florida. Image (bottom left) shows siding damage above the lowest floor and significant scour, image (bottom center) shows complete loss of a deck as well as damage to glass doors, image (bottom right) shows structural damage to a concrete column and complete loss of a porch.

FIRMs depict the regulatory limits of flooding, flood elevations, and flood hazard zones for the 1% annual-chance (100-year) flood event. Buildings constructed to the elevations shown on a FIRM only safeguard to the base flood, as designated by the BFE. Some storms impacting coasts, rivers, or both result in flood levels that exceed the BFE. The dark blue line in Figure 3 shows the probability (y-axis) of a flood event that will result in floodwaters above the 100-year flood level during a given time period (x-axis). As shown on the figure, there is an 18% chance the 100-year flood level will be exceeded in a 20-year period, a 26% chance it will be exceeded in a 30-year period, and a 51% chance it will be exceeded in a 70-year period. Elevating above the BFE can significantly improve the building's and its associated utility system's resilience. Likewise, buildings sited just outside of the SFHA (beyond the 100-year flood hazard area), but especially those within the 500-year flood hazard area, can still have a significant chance of being flooded. For those within the 500-year flood hazard area (i.e., shaded Zone X) the probability of flooding occurrence for that structure is somewhere between the red (500-year) and blue (100-year) lines in Figure 3. Note that the figure does not represent a water surface elevation but rather the probability of exceedance of a given mean recurrence interval (MRI). While the probability of exceedance of the MRI does not change with sea level rise, erosion, and land use change, the water surface elevation associated with the MRI may change.

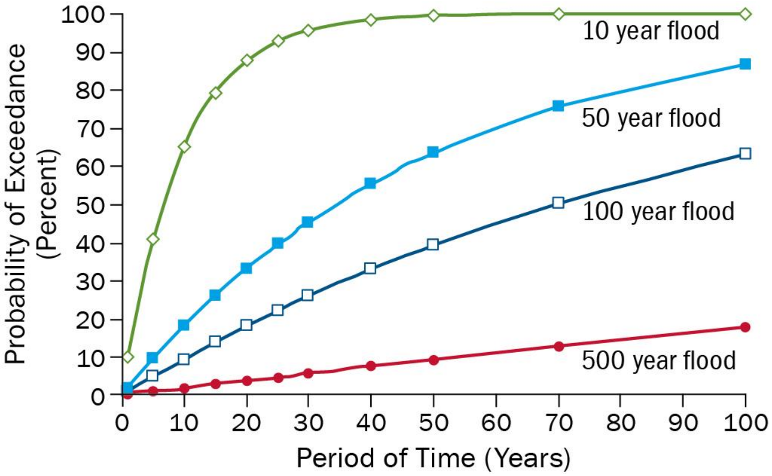

Figure 3: Probability under current conditions of a flood exceeding the 10-year (10% annual-chance), 50-year (2% annual-chance), 100-year (1% annual-chance), and 500-year (0.2% annual-chance) flood level during a given period of time (assuming no sea level rise)

3. Required Design Considerations

To meet the NFIP minimum requirements, new buildings, buildings with substantial damage[3,4] undergoing reconstruction, and buildings undergoing substantial improvement[5] must be elevated so that their lowest floor,[6] or the lowest horizontal structural member of the lowest floor (where required), is at or above the BFE. Some states and communities require elevation above the BFE; this is known as adding freeboard. Adding freeboard or regulating to a flood more severe than the base flood results in a higher minimum building elevation. This minimum building elevation is often referred to as the Design Flood Elevation (DFE). The amount of freeboard to be added depends on a number of factors. Building owners and designers should consult with building officials and floodplain managers regarding minimum elevation requirements.

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[3] Substantial damage is defined in 44 CFR § 59.1 as "damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50% of the market value of the structure before the damage occurred."

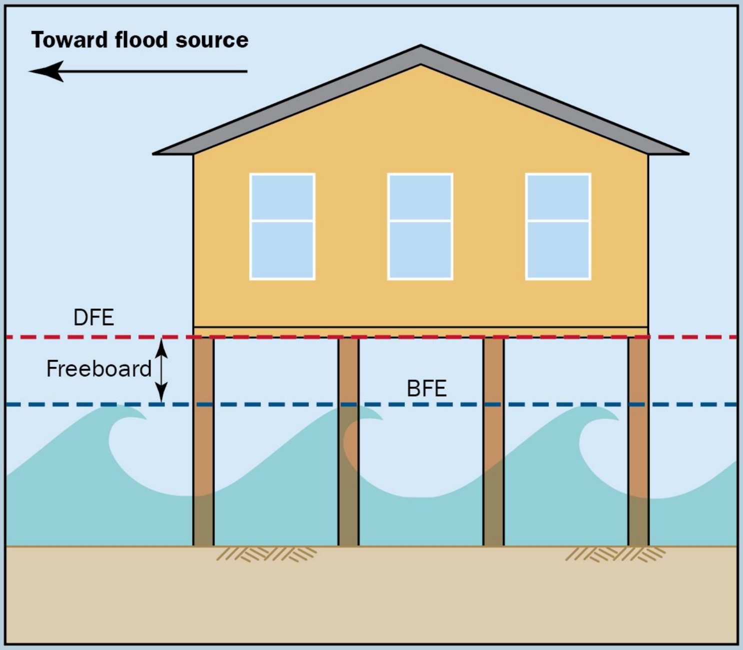
[4] Refer to FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010b) for more information.

[5] Substantial improvement is defined in 44 § CFR 59.1 as "any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50% of the market value of the structure before the "start of construction" of the improvement. This term includes structures which have incurred "substantial damage", regardless of the actual repair work performed."

[6] In Zone A, lowest floor means the top of the lowest floor; in Zone V (and Coastal A Zone per ASCE 24/ICC/FBC), lowest floor means the bottom of the lowest horizontal structural member of the lowest floor.

Terminology

Freeboard: A factor of safety usually expressed in feet above a flood level for the purposes of floodplain management. "Freeboard" tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed. (44 CFR § 59.1)



The freeboard graphic depicts the freeboard condition for Zone V (and Coastal A Zone per ASCE 24/ICC/FBC) where the elevation requirement is to the bottom of the lowest horizontal structural member of the lowest floor. In Zone A, the elevation requirement is to the top of the lowest floor.

3.1. NFIP Requirements and Mapping Guidance

FEMA issues FIRMs, which are then adopted by communities that regulate floodplain development. SFHAs (e.g., Zone VE, Zone AE) delineated on FIRMs reflect the nature of the flood conditions expected during the base flood. FIRMs also typically show a shaded Zone X, which denotes areas that are outside the SFHA but are subject to flooding with a 0.2% annual chance of occurrence (500-year flood). FIRMs show BFEs associated with a flood that has a 1% annual chance of occurrence (Figure 4). BFEs in coastal areas include wave effects and are higher than storm surge stillwater levels. Shaded Zone X elevations typically do not include wave effects.

FEMA FIRMs and FISs are used in the regulation of the minimum NFIP requirements. The NFIP is a program that makes flood insurance available in those states and communities that agree to adopt and enforce floodplain management ordinances to reduce future flood risk. Participation in the NFIP is voluntary and is contingent on community compliance with NFIP floodplain management regulations. The NFIP minimum requirements apply to areas designated as Special Flood Hazard

Areas (SFHAs) by FEMA. Constructing a building to the minimum NFIP requirements—or constructing a building outside of the SFHA—does not guarantee the building will not be damaged by flooding. In order to make informed decisions during repair and reconstruction, designers, local and emergency planners, building owners and operators, and other interested stakeholders should understand the following:

- FIRMs are based on modeling of the best available topographic, hydrologic, hydraulic, development, and climate conditions data available at the time the FIS was prepared. However, there are inherent uncertainties in the modeling and analysis of BFEs and flood hazard zones. Some FIRMs, particularly older FIRMs, may no longer accurately reflect the streamline or shoreline location, bathymetry, land characteristics, and actual risk during a base flood event.
- The BFE is the flood level with a 1% annual chance of exceedance in any given year. In coastal areas, the BFE includes the contribution of waves and is not representative of any individual storm but is derived from an analysis of many potential and historical storm responses.
- The Limit of Moderate Wave Action (LiMWA) indicates where wave heights are 1.5 feet. The 1.5-foot wave is designated on the FIRMs because waves up to this height are known to cause Zone V type damage to foundations and other light-framed structural elements. To reduce damage, FEMA encourages building to Zone V standards, such as constructing on deep open foundations, in the area between the Zone V boundary and the LiMWA, also known as the Coastal A Zone.
- Flood elevations can and do exceed the BFE and extend beyond the mapped boundaries of the SFHA. In some recent storms (Sandy [2012], Michael [2018], and Ian [2022]), flood levels exceeded the BFEs by several feet in numerous areas and flood inundation extended far beyond the SFHA shown on the FIRMs.

More information on coastal FIRMs, FISs, and BFEs is available in the following FEMA publications: Section 3.6 of FEMA P-55, *Coastal Construction Manual* (2011), and Fact Sheet No. 3 in FEMA P-499, *Home Builder's Guide to Coastal Construction* (2010a). Section 3.7.1 of FEMA P-55 also provides guidance on evaluating a FIRM to determine whether it still reasonably depicts base flood conditions.

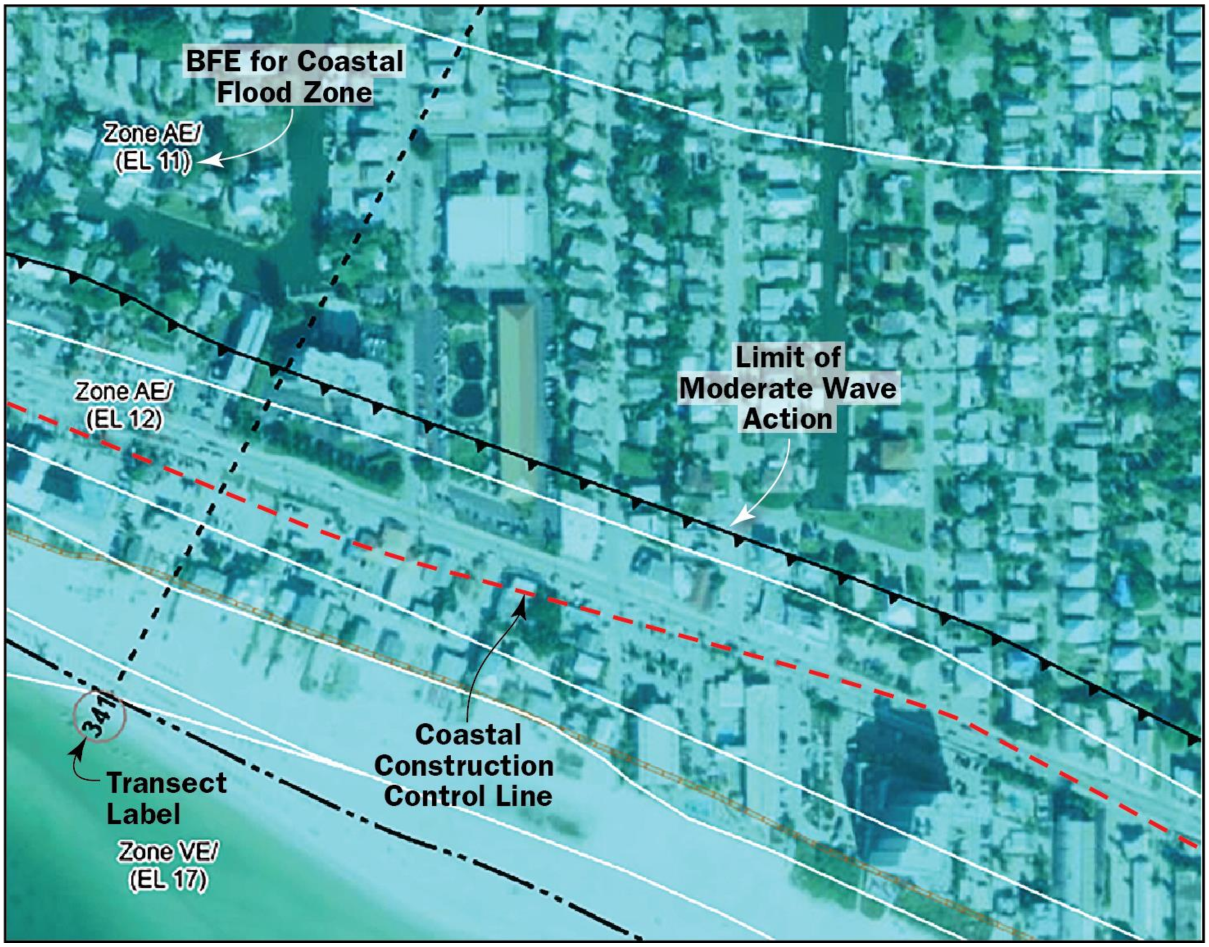


Figure 4: Sample FIRM showing Zone AE, the Limit of Moderate Wave Action (LiMWA), and Zone VE. BFEs for each zone are noted in parentheses below the Zone AE/VE text. The BFEs are site specific and vary by location. The Coastal Construction Control Line (CCCL) is overlayed onto the FIRM and shown for reference purposes only. The CCCL is discussed later in this Recovery Advisory.

The two Florida Gulf Coast counties primarily impacted by Hurricane Ian storm surge (Lee and Collier), were both in a map adoption process when the storm hit in September 2022. Lee County now has updated maps that went into effect in November 2022. Collier County has preliminary FIRMs that provide an understanding of current risks but are not the final regulatory products. These map updates include delineating the Limit of Moderate Wave Action (LiMWA), which is depicted as a solid black line with arrows pointing in the direction of the area with additional wave-associated risk (Figure 4). Residents and business owners living or working in the Coastal A Zone should be aware of the potential wave action risks along with floating debris, erosion, and scour that could cause significant damage to their property. Additional guidance on the importance of designing for the Coastal A Zone is available in Fact Sheet No. 1.3 in FEMA P-499, *Home Builder's Guide to Coastal Construction* (2010a).

3.2. Building Codes and Floodplain Management Regulations

The International Codes (I-Codes) generally serve as the basis for most state building codes.[7] Building codes may contain freeboard requirements or reference other documents with freeboard requirements. The International Building Code (IBC) requires buildings to be designed and constructed in accordance with the American Society of Civil Engineers' (ASCE) standard for *Flood Resistant Design and Construction* (ASCE 24) and the International Residential Code (IRC) implements many of the same requirements presented in ASCE 24. ASCE 24 defines elevation and protection height requirements based on the flood hazard zone and the importance of the building. The building's use and importance places it in a Flood Design Class per the ASCE 24-14 standard. ASCE 24 also contains requirements above the NFIP for items such as flood openings in Zone V breakaway walls and measuring the elevation in Coastal A Zones to the lowest horizontal structural member supporting the lowest floor. ASCE 24-14 requirements are summarized in the FEMA publication, *HIGHLIGHTS OF ASCE 24-14 Flood Resistant Design and Construction* (2015); the Flood Design Class requirements and categorizations are provided on pages 4 and 5. Buildings must be elevated as high as the freeboard requirement in the building code or reference standard or floodplain management regulations. For example, Florida adopted 1 foot of freeboard in its residential building code and several communities in Florida have adopted additional freeboard (above the 1-foot requirement) in their floodplain management regulations. Owners may choose to build even higher.

In Florida, there is a Coastal Construction Control Line (CCCL) program, see Figure 4. The CCCL establishes a jurisdiction for application of special siting and design criteria; it is not designed to limit development. The CCCL is meant to address activities that could cause beach erosion, destabilize dunes, damage upland properties, or interfere with public access. Development activities along Florida's sandy shorelines need to consider the CCCL and include any local standards that may be more stringent than the rest of the coastal building zone. The CCCL program is governed by Chapter 161.053 in the Florida Statues. In most instances, a permit from Florida's Department of Environmental Protection is required for construction and excavation activities seaward of the CCCL.

3.3. Building Height Restrictions

Some communities may limit (through zoning or building regulations or restrictive covenants) the number of building stories or may specify a maximum height above the ground that a building floor level or roof cannot exceed. Such height restrictions may limit the vertical height of a building and preclude the amount of freeboard that some owners may desire. Owners and designers should check with their communities to see if height restrictions exist and work with the communities to relax those restrictions to achieve improved flood damage resilience.

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[7] This was the case for the Florida Building Code (FBC) until the 7th edition (2020) FBC, which used the 6th Edition (2017) FBC as the base code and took into account the 2018 I-Codes. Further details on the development of the 7th edition (2020) FBC can accessed here under the Analysis of Changes to the 7th Edition (2020) Florida Building Code: floridabuilding.org/fbc/Links_to_Code_Resources.html

3.4. Importance of the Building to the Community

Certain buildings and facilities (e.g., police stations, fire stations, emergency operations centers, storm shelters, hospitals) are deemed critical or essential to a community and must remain partly or fully operational during and after severe flood events. In some cases, the community may determine that other buildings and facilities (such as schools, community centers, transportation, manufacturing facilities, and utilities) are either critical or essential to the community and should be capable of carrying out operations immediately after a severe storm or are a facility that poses a high risk to the public if damaged by flooding. To maintain needed functionality or to reduce risk to the public, essential or high-risk buildings and facilities should be elevated or protected to a higher elevation than most commercial and residential buildings. Building codes and ASCE 24 acknowledge this need and require additional freeboard and other higher requirements.

3.5. Federal Grant Requirements

Projects utilizing federal funding for elevating or reconstructing buildings may have additional elevation requirements associated with the Federal Flood Risk Management Standard (FFRMS). Specific federal grant requirements can be found in the grant’s Notice of Funding Opportunity (NOFO) or Notice of Funding Availability (NOFA), depending on the funding opportunity.

4. How High Above the Minimum Required Elevation a Building Should be Elevated

Before selecting an elevation, building owners and designers should decide whether the minimum required elevation mandated by a state or community is sufficient to protect a particular building or additional elevation is needed. FEMA recommends building owners and operators, designers, local and emergency management planners, and other interested stakeholders review available FIRMs and FISs, evaluate possible future conditions, and consider the building owner and operator’s risk tolerance when determining appropriate building elevations.

4.1. Recommended Considerations

The selection of an appropriate elevation must include consideration of locally adopted requirements, as well as other factors such as the importance of the building’s function to the community during and after a hazard event. This section discusses factors to consider in selecting a building elevation.

4.1.1. AGE OF THE EFFECTIVE FLOOD ANALYSIS

FISs and FIRMs are based on data collected for model creation at the time the FIS is prepared. BFEs and flood hazard zones shown on FIRMs are established during a study process that takes several years from project inception to completion. The topographic data and flood hazards often represent different years of that study timeline and may understate actual flood risk because of changes in the topography and development. In such cases, FEMA recommends elevating buildings above the BFE and extending flood-resistant construction practices outside the mapped SFHA. The associated FIS documentation for any referenced FIRM provides the date of the technical studies establishing the BFEs and flood hazard zones.

4.1.2. AVAILABILITY OF PRELIMINARY FIRMS

When FISs are completed, the FIRMs are first issued as "Preliminary" maps to enable the public to review and submit comments and appeals, if applicable. Once the comment period is over and appeals, if any, have been resolved, the final maps are issued. Preliminary FIRMs represent the best available data prior to final FIRMs being adopted and becoming effective. If preliminary BFEs are available and higher than effective BFEs, owners, operators, planners, designers, and communities should consider utilizing the preliminary BFEs for the design basis.

4.1.3. BUILDING OWNER AND OPERATOR TOLERANCE FOR DAMAGE, DISPLACEMENT, AND DOWNTIME

Many building owners or operators never want to go through the disruption and damage sustained during Hurricane Ian or a similar event again. To avoid such disruption, building operators need to be involved in building design decisions relating to flood risk reduction and should understand their risk tolerance in order to determine whether they can work with the building owner or need to make alternative decisions regarding their operations. Reducing the probability of similar disruption requires using higher design elevations that incorporate future conditions when repairing and rebuilding buildings and equipment or when constructing flood barriers (where permitted). Increased design elevations and other flood-resistant design and construction practices should be incorporated to the maximum extent feasible.

4.1.4. ESSENTIAL FACILITIES

FEMA recommends that all essential facilities[8] be elevated or protected to a minimum of the higher of the code-mandated elevation, the community-mandated elevation, or the 500-year flood elevation. Communities should also consider using an elevation exceeding the flood of record[9] as an additional criterion for the elevation/protection level for essential facilities.

4.1.5. FUTURE CONDITIONS

Building owners, designers, and communities should consider how future conditions (such as sea level rise, subsidence, shoreline erosion, and increased storm frequency/intensity) may influence flood characteristics over the life of the building when deciding how high to elevate a building. See subsection on future conditions.

4.1.6. RESIDUAL RISK

The U.S. Army Corps of Engineers defines residual risk as the flood risk that remains if a proposed flood damage reduction project is implemented as well as the consequence of capacity exceedance (USACE n.d.a). Understanding residual risk is critical for making risk tolerance decisions as well as

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[8] In addition to those facilities specifically defined by ASCE 24 as essential, communities may designate buildings such as schools and utilities as essential facilities.

[9] Refers to the highest recorded flood elevation for a given location.

for selecting an appropriate freeboard amount. Residual risk is discussed in NFIP Technical Bulletin 10, *Reasonably Safe from Flooding Requirement for Building on Filled Land* (FEMA 2023) and *Flood Risk Assessment and Reduction Community Guidebook* (Charlotte-Mecklenburg Storm Water Services 2021).

4.2. Future Conditions

Because FIRMs reflect conditions at the time of the FIS, owners, operators, planners, designers, and communities should consider how future conditions (such as sea level rise, subsidence, shoreline erosion, increased storm frequency/intensity, land use change, and levee settlement and failure) may influence flood characteristics over the life of a building when deciding how high to elevate the building or how high to specify flood protection elevations. Most buildings have a functional life span of many decades, so considering future conditions is important when designing new buildings or when performing significant renovations or retrofits of existing ones. This section focuses on how to account for future conditions of coastal flood hazards and presents methods to account for sea level rise and coastal erosion as well as the associated wave height increases.

4.2.1. RELATIVE SEA LEVEL RISE

Rising sea levels have been well documented at National Oceanic and Atmospheric Administration (NOAA) tide gages in Florida and throughout the coastal United States. Sea level rise rates vary by location. For example, the tide gage in Naples, Florida, which is the nearest Gulf of Mexico tide gage for Lee and Collier Counties, has recorded an average relative sea level rise of 3.2 millimeters/year (1.0 foot/century) since 1965. Figure 5 depicts the relative sea level records for Naples, Florida, between 1965 and 2022. If this rate of sea level rise continues, the frequency of coastal flooding will increase, today's base flood will be more likely to occur in the future, and future BFEs will increase above today's level. If the rate of sea level rise accelerates beyond the historical trend, as many scientists predict (NOAA 2021), sea levels could rise several feet in the next century, significantly increasing the risk of flooding to buildings inside and outside the SFHA in coastal communities.

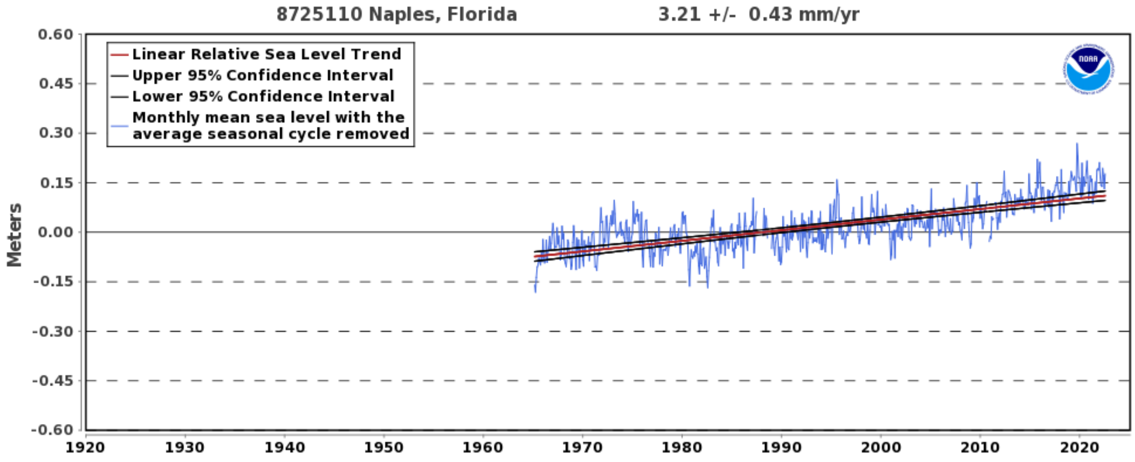

Figure 5: Relative Sea Level Trend, Naples, Florida. Credit: NOAA/National Ocean Service

At a minimum, FEMA recommends accounting for a continuation of the relative sea level rise rate equal to the historical rate. Detailed historical relative sea level data for U.S. coastal stations are available from NOAA's Center for Operational Oceanographic Products and Services Tides and Currents (tidesandcurrents.noaa.gov/sltrends/). However, owners, designers, and coastal communities should consider planning for relative sea level rise above the historical trend to further increase the resilience of buildings that may face higher future rates of sea level rise. Based on the 2022 NOAA relative sea level rise projection[10] for Naples, Florida, 2.9 feet of relative sea level rise is projected over the next 50 years (USACE. n.d.b). Whereas the historical sea level rise rate of 3.2 millimeters/year only results in a 0.5-foot relative sea level rise over 50 years (NOAA n.d.). Some states specify which future sea level rise projections should be used as a minimum. Alternatively, various public resources are available, such as the U.S. Army Corps of Engineers' (USACE's) Sea Level Tracker (climate.sec.usace.army.mil/slr_app/), to determine future relative sea level rise projections. USACE's Sea Level Tracker includes vertical land movement estimates, which account for local subsidence or uplift, so these factors do not need to be accounted for separately. Section 3.3.4 of FEMA P-55 provides additional discussion on sea level rise, subsidence, and uplift.

Resilient Florida Program – Sea Level Impact Projection (SLIP) Study Requirement

Florida requires corporate bodies of the state to perform a Sea Level Impact Projection (SLIP) Study if state funds are being utilized for a construction project within the coastal building zone.[11] These requirements are set forth in Section 161.551 of the Florida Statutes and details are provided in the Florida Administrative Code 62S-7.012, "SLIP Study Standards" (Florida Department of State 2010a). Per 62S-7.014, "Implementation of SLIP Study findings," the findings of a SLIP Study are required for informational and awareness purposes only and do not represent elevation requirements (Florida Department of State 2010b).

Although the SLIP Study requirement only impacts specific construction projects in Florida, it may also be utilized as guidance for recommended minimum requirements for non-state funded projects. Highlights of the criteria outlined in the "SLIP Study Standards," which are most applicable to this Recovery Advisory are listed below by their section designation:

(1) Show the amount of sea level rise expected over 50 years or the expected life of the structure, whichever is less. The amount of sea level rise expected must be calculated using the following criteria:

(1.a) The sea level rise scenarios used for analysis must, at a minimum, include the NOAA Intermediate-High sea level rise scenario from the NOAA Technical Report NOS Center for Operational Oceanographic Products and Services (NOS CO-OPS) 083, Global and Regional Sea Level Rise Scenarios for the United States (2017).

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[10] Projected based on NOAA et al. 2022 Scenario 1.5 (Intermediate-High) with a 0.83 non-exceedance probability.

[11] Per 2019 Florida Statute Title XI 161.54, Coastal building zone "means the land area from the seasonal high-water line landward to a line 1,500 feet landward from the coastal construction control line as established pursuant to s. 161.053, and, for those coastal areas fronting on the Gulf of Mexico, Atlantic Ocean, Florida Bay, or Straits of Florida and not included under s. 161.053, the land area seaward of the most landward velocity zone (V-zone) line as established by the Federal Emergency Management Agency and shown on flood insurance rate maps."

(1.d) *The contribution of land subsidence to relative local sea level rise must be included. NOAA calculates the land subsidence contribution for each local tide gauge and the subsidence is included in each of the NOAA sea level projections.*

The complete Rule for Section 62S-7.012 can be accessed here flrules.org/gateway/ruleno.asp?id=62S-7.012.

To facilitate the SLIP study requirements, Florida provides an online SLIP tool[12] that can be accessed here floridadep-slip.org/Map.aspx.

4.2.2. COASTAL EROSION

The two primary types of coastal erosion are erosion associated with shoreline retreat (from sea level rise and other chronic natural processes) and storm-induced erosion. This section provides an overview of the methods used for estimating these primary types of coastal erosion. Although storm-induced erosion that is not associated with dune loss or retreat may also pose a large risk to buildings during flood events, methods to account for this type of erosion are not presented herein because of the complexity of the erosion process.[13] This Recovery Advisory focuses on how erosion affects ground elevations (Figure 6) and, thus, results in increased flood depths. This Recovery Advisory does not provide detailed guidance on evaluating overland wave characteristics following dune loss.

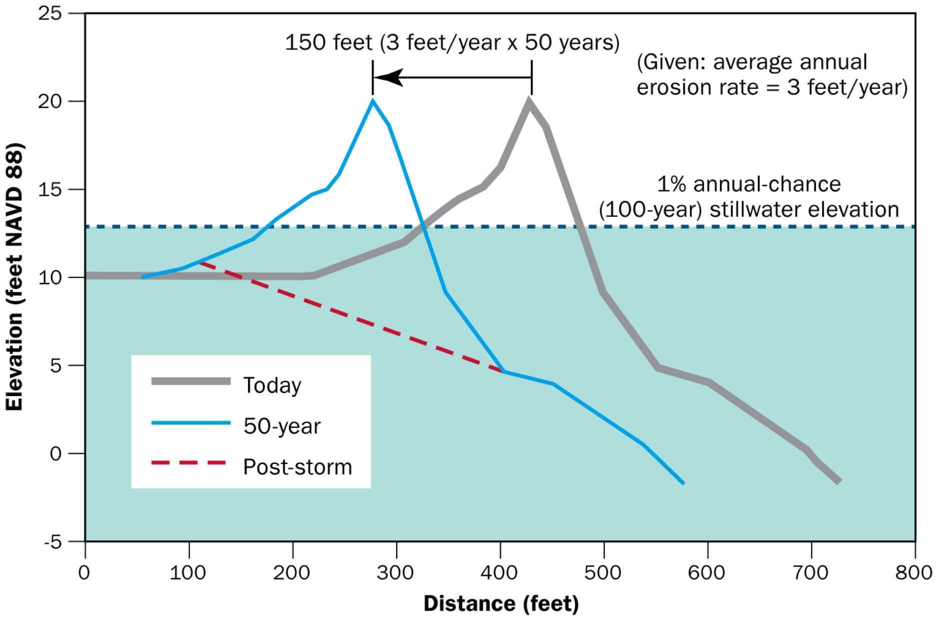

Figure 6: Erosion's effects on ground elevation, shoreline retreat, and dune migration

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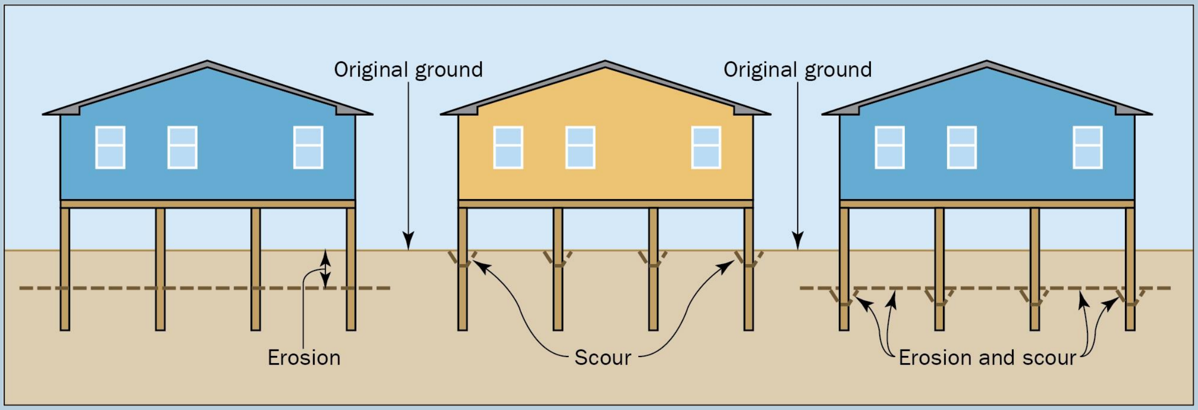
[12] Florida's SLIP tool currently uses sea level rise scenarios published in 2017. As projections are updated, it may be appropriate to use more recently published scenarios.

[13] Wide spread coastal erosion was observed during Hurricane Ike and is documented in Hurricane Ike Recovery Advisory: *Erosion, Scour, and Foundation Design* (FEMA 2009a). Designers may need to consider further increasing the foundation system's embedment depth to account for additional storm-induced erosion.

Scour and Erosion

Erosion is a lowering of the ground surface over a large area, usually brought on by a coastal storm or long-term shoreline recession. Erosion increases the unbraced length of vertical foundation elements and increases the stillwater depth at the building, allowing larger waves to reach the foundation.

Scour is a localized loss of soil immediately around an object or obstruction. Scour also increases the unbraced length of vertical foundation elements but does not act to increase the stillwater flood depth across which waves propagate. Thus, scour can be ignored for wave height and flood load calculation purposes. Walls, columns, pilings, pile caps, footings, slabs, and other objects found under a coastal building can contribute to localized scour.



Depending on the building location, soil characteristics, and flood conditions, a building may be subject to either coastal erosion or scour, or both. Refer to Section 8.5.11 of FEMA P-55 for additional information on scour. Refer to Chapter 10 of FEMA P-55 for guidance on designing foundations to withstand the effects of erosion and scour.

Methods for Estimating Shoreline Retreat Erosion

Erosion associated with shoreline retreat refers to the inland movement of the shoreline due to various processes, including sea level rise, subsidence (or conversely uplift), wave action, longshore drift (transport of beach sediment), and the interruption of longshore drift. Section 8.5.2 of FEMA P-55, outlines procedures to estimate future effects of coastal erosion. State Coastal Zone Management agencies should be consulted for applicable local erosion rates. Alternatively, various public resources, such as the U.S. Geological Survey's (USGS's) Coastal Change Hazards Portal (marine.usgs.gov/coastalchangehazardsportal/), can be used to determine historical erosion rates that may also be termed shoreline change rates.

Methods for Estimating Storm-Induced Dune Loss

Erosion associated with storm-induced dune loss refers to complete dune removal due to storm conditions. Evaluating potential of storm-induced dune loss is critical for structures built on or near a dune system as the loss of the dune may undermine the structure's foundation if the foundation was not designed to accommodate the dune erosion. Section 3.6.8 of FEMA P-55 outlines procedures to estimate storm-induced dune erosion.

An upcoming guidance document will include detailed processes for evaluating coastal erosion and provide information pertaining to the flood calculations required for ASCE standard for *Minimum Design Loads and Associated Criteria for Building and Other Structures* (ASCE 7-22), Supplement 2. The anticipated publication date is late 2023.

4.2.3. INCREASED WAVE HEIGHT

This section introduces general wave theories as well as methods for calculating wave heights. The methods herein can be utilized to determine potential wave height increases when the stillwater depth is increased. Stillwater depth may increase above the mapped 100-year stillwater depth as a result of sea level rise or factors such as selecting a 500-year stillwater elevation.

Overland wave propagation is limited by numerous factors, including water depth and obstructions. Depth-limited waves occur when the wave height exceeds the wave height that can be supported by the local water depth and the wave breaks. Depth-limited waves are common at the shoreline before obstructions. Overland waves, which travel inland from the shoreline, experience wave height reductions as the grade rises and as waves interact with obstructions. Thus, as local flood depths increase due to relative sea level rise and erosion, wave heights may increase as the water depths will support higher waves.

Breaking wave heights (H_b) for depth-limited waves may be calculated by multiplying the local stillwater depth by the wave height coefficient. The wave height coefficient may be taken as 0.78. Because the breaking wave height represents the highest wave that can be supported by the local water depth, the wave heights utilized for building design need not exceed the breaking wave height.

Overland wave heights may be calculated using the “ratio wave height method.” For this method, the future wave height may be calculated by multiplying the wave height derived from an FIS by the ratio of the future stillwater depth to the 100-year stillwater depth (also known as the 1% annual-chance flood depth) in the FIS. The design parameters in Figure 7 used in conjunction with Step 11 of Figure 8 (equations shown in figure) further detail this process. As shown in Figure 7, the process outlined in Figure 8 assumes 70% of the total wave height is above the stillwater elevation.

Assuming the wave height will equal the breaking wave height is more conservative than calculating the wave height with the ratio wave height method. In Zone V, areas where there is minimal coastal protection or obstruction, and areas where breaking waves are present, FEMA recommends that the breaking wave assumption be used unless a detailed analysis has been completed to verify the survival of the dune or the effectiveness of the seawall. In the remaining flood zones, the ratio wave height method may be used.

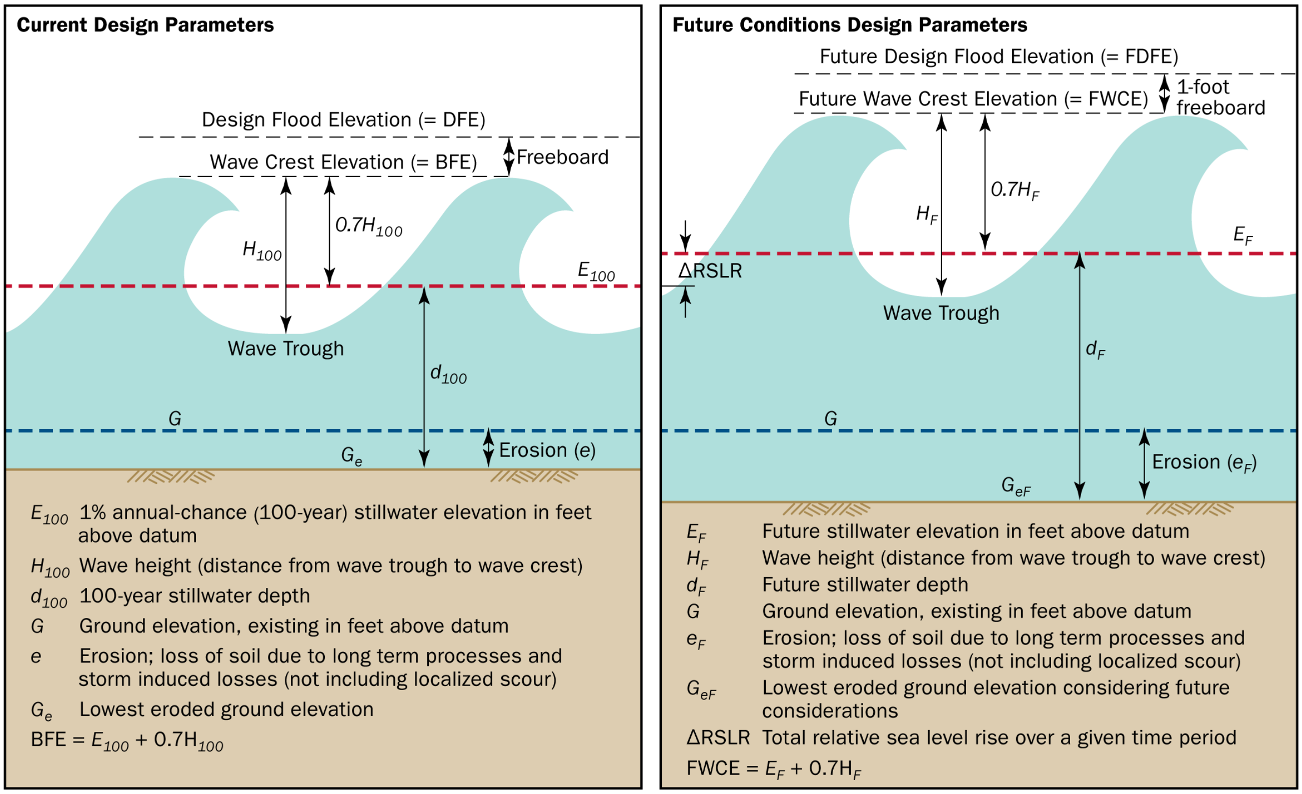


Figure 7: Overview of design parameters for current and future flood conditions

4.2.4. DETERMINING FLOOD ELEVATIONS BASED ON FUTURE CONDITIONS

Future flood condition design parameters, as depicted in Figure 7 and discussed in the previous subsections, may be determined by numerous methods, one of which is outlined in 14 steps in Figure 8 and summarized in the following bulleted list. The 14 steps include:

Data Collection (Step 1)

- Base Flood Elevation (BFE)
- 1% annual-chance (100-year) stillwater elevation (E_{100})
- ground elevation (G)
- total relative sea level rise (ΔRSLR)

Defining Current Design Parameters (Step 2 through Step 6)

- Eroded ground elevation (G_e),
- 1% annual-chance stillwater depth (d_{100})
- Mapped wave height (H_{100})

Defining Future Conditions Design Parameters (Step 7 through Step 11)

- Future stillwater elevation[14] (E_F)
- Future vertical erosion (e_F)
- Future eroded ground elevation (G_{eF})
- Future 1% annual-chance stillwater depth (d_F) d
- Future wave height (H_F)

Defining Future Conditions Design Elevations and Anticipated Flood Zone (Step 12 through Step 14)

- Future wave crest elevation (FWCE)
- Future Design Flood Elevation (FDFE)[15,16]
- Future flood zone

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[14] Future storm intensification is not noted in Step 7 of Figure 7, but should be included in the future stillwater elevation when data are available.

[15] The FDFE calculation, shown in Step 13 of Figure 8, includes 1 foot of recommended freeboard to account for the uncertainty of the 100-year storm used to determine the initial BFE as well as some uncertainty in the accuracy of future projections.

[16] Although the FDFE contains the DFE terminology, the FDFE is non-regulatory.

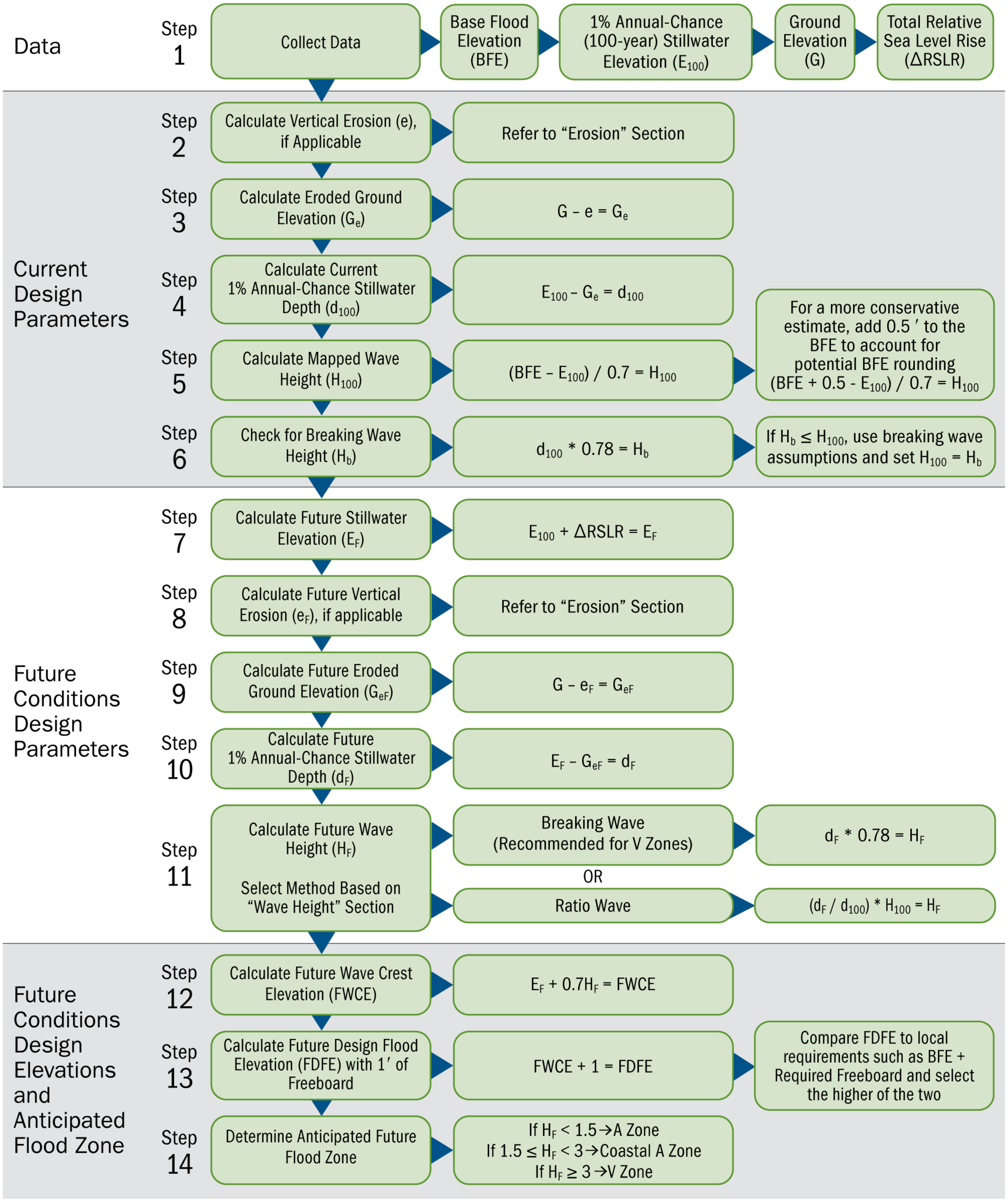

Figure 8: Process for determining flood elevations based on future conditions (Units: feet)

4.2.5. ANTICIPATING FUTURE FLOOD ZONES

While selecting an elevation above the projected future flood elevation is critical for resilience, considering the future flood zone is also important. Constructing a building that meets the requirements of the future flood zone, as depicted in Figure 9, will help ensure the building has a foundation that can withstand future flood conditions. For example, using a deep open foundation as shown in Figure 9 (A), would benefit a building being retrofitted or to be constructed in a Zone A that is anticipated to be in either a Zone V or a Coastal A Zone in the future. The deep open foundation will enable future waves to pass below the structure without damaging the foundation. Chapter 10 of FEMA P-55 provides guidance on foundation design in coastal areas. Additionally, elevating a building to the FDFE by utilizing a crawlspace as shown in Figure 9 (B), or other acceptable Zone A foundation type, would benefit a building being retrofitted or to be constructed in a Zone X that is anticipated to be Zone A in the future. The FDFE in a Zone X can be calculated by utilizing the 100-year stillwater elevation from the adjacent Zone A as the BFE because wave effects are not anticipated in mapped Zone X areas.

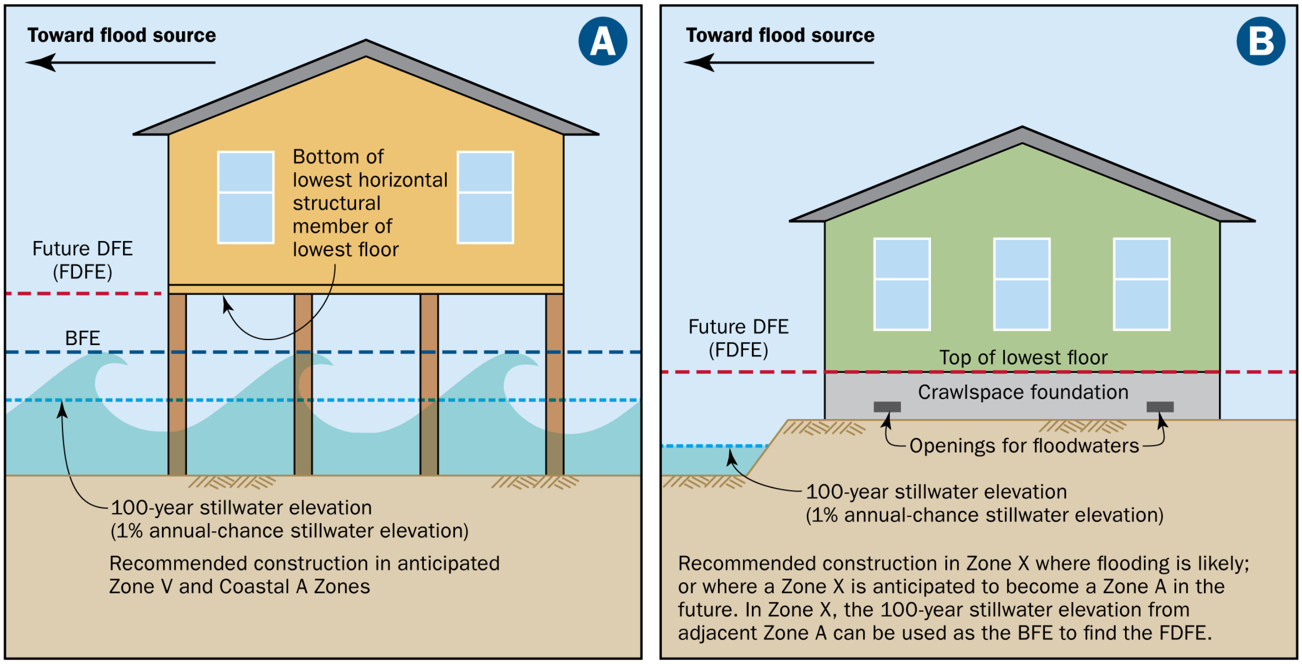

Figure 9: Examples of recommended construction and elevation for anticipated future flood zones

4.3. Summary of Considerations for Selecting a Building's Elevation

In summary, when selecting how high a building should be elevated, many factors should be considered. First, all applicable building codes and floodplain management regulations must be met. Further, if the project is being funded by a federal grant, all applicable federal grant requirements must also be met. Once the minimum elevation that meets all requirements is determined, additional factors that inform an increase above the minimum elevation should be considered, including future conditions, preliminary FIRMs, age of the effective flood analysis, and tolerance for damage, displacement, and downtime, as well as residual risk. Lastly, the desired elevation must not exceed any height restrictions.

5. Additional Design Considerations for Mitigating Flood Damage

In addition to the design considerations described in other sections of this Recovery Advisory, the following recommendations can help building owners minimize damage in the event that future flood events occur above the minimum required elevation. While not addressed in this Recovery Advisory, FEMA recommends that buildings within a hurricane-prone region[17] that are retrofitted to account for additional flood elevation also be retrofitted to resist high-wind hazards. Retrofitting for high-wind hazards such as wind-driven rain and wind-borne debris will increase the resilience of the building such that it may not only survive the flood hazards but also the wind hazards associated with hurricanes. Guidance for wind retrofits can be found in various FEMA publications, including FEMA P-804, *Wind Retrofit Guide for Residential Buildings: In Hurricane-Prone Regions* (2023); FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds* (2007); and FEMA P-499, *Home Builder's Guide to Coastal Construction* (2010a).

5.1. Design Loads

In flood zones, design loads and conditions (e.g., hydrostatic, hydrodynamic, wave, floating debris impact, or other loads, and long-term and storm induced erosion and scour) should be calculated using the future stillwater elevation and wave conditions. As a best practice, loads can be based on the FDFE, which includes freeboard.

Property owners sometimes ask if elevating a home will result in higher wind loads on the building. Calculations indicate that although wind pressures on elevated buildings are nominally higher than for non-elevated buildings and will need to be designed for, the greatly increased resilience from flood loads more than offsets this relatively minor cost (FEMA 2009b). Although the incremental wind load is generally small, the increased wind loads should be considered in the building's foundation design, overall load path from its roof to the foundation, as well as the components and cladding of the building's envelop system.

5.2. Use Strong Connections

A building's continuous load path resists loads acting on the building such as wind, seismic, and flood. The continuous load path starts at the location where loads are applied, moves through the building, continues to the foundation, and terminates where the loads are transferred to the soils that support the building. To be effective, each link in the load path chain must be strong enough to transfer loads without breaking.

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[17] Hurricane-prone regions are defined in FEMA P-804, *Wind Retrofit Guide for Residential Buildings: In Hurricane-Prone Regions* (2023), Section 2.1.

Where flooding is present, additional consideration must be given to the connections between the foundations and the elevated building. The connections must be strong enough to prevent the building from floating or washing off the foundation if flood levels, including waves, reach the lowest horizontal member supporting the lowest floor. The connection between an elevated floor and a pile foundation is only one of many connections that must be strong enough to transfer loads without failing; refer also to Hurricane Sandy Recovery Advisory No. 1, *Improving Connections in Elevated Coastal Residential Buildings* (2013), for additional information on connections and resources.

Additionally, using connections that minimize corrosion over time is critical. NFIP Technical Bulletin 8, *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas* (FEMA 2019), provides guidance on selecting corrosion-resistant connectors. Annual inspection and maintenance should also be performed to ensure connectors remain corrosion free and are replaced as needed to maintain proper structural connections.

5.3. Use Flood Damage–Resistant Materials

Flood damage–resistant building materials and methods should be used below the higher of the BFE or the lowest floor, and also for wall construction and floor finishes sitting directly on the lowest floor. For new construction, repair of substantially damaged buildings, and substantial improvement of existing buildings in SFHAs, all construction below the BFE must consist of flood damage-resistant building materials for NFIP compliance.

Flood damage resistant materials should also be used when wet floodproofing is implemented as a voluntary retrofit measure. Where compliance is not required (i.e., building is not substantially improved/damaged), wet floodproofing may be implemented to reduce flood damage by enabling the equalization of hydrostatic loads. Wet floodproofing cannot be implemented to bring a non-elevated building into compliance, but owners of compliant elevated buildings may elect to wet floodproof above a lowest floor to reduce the chances of flood damage in the event that flood levels rise above the lowest floor. Refer to NFIP Technical Bulletin 7, *Wet Floodproofing Requirements and Limitations* (FEMA 2022), for additional guidance on wet floodproofing.

For example, consider using drainable, dryable interior wall assemblies. This allows interior walls to be opened up and dried after a flood that rises above the lowest floor. To prevent wicking and limit flood damage, building owners can use the following flood damage–resistant methods and materials:

- Construct walls with pressure-treated wood framing and with horizontal gaps in the wallboard (a chair rail can be used to conceal the gap)
- Elevate electrical outlets, wiring, and circuit panels to a location above the horizontal gap
- Install rigid or closed-cell insulation in lower portions of walls
- Below the horizontal gaps, use non-paper-faced gypsum wallboard, concrete board, or a removable wainscot; use a water-resistant drywall primer and finish with latex paint
- Use water-resistant flooring with waterproof, marine-grade adhesive

Refer to NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (FEMA 2008), for additional guidance on flood damage–resistant materials.

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Reducing “Loss of Utility” Impacts to Critical Facilities

Recovery Advisory 2

August 2023

FEMA

DR-4673-FL RA 2

Table of Contents

1. Purpose and Intended Audience 1
   1.1. This Recovery Advisory Addresses 2
2. Considerations for Utilities Needed to Operate Critical Facilities 3
3. Electricity 4
   3.1. Determining Electrical Requirements 5
      3.1.1. Loads Required by Codes/Life Safety Protection 5
      3.1.2. Loads Required for Function 6
      3.1.3. Potable Water Systems 7
      3.1.4. Sanitary Sewer Systems 8
   3.2. Duration of Service 8
   3.3. Alternate Electrical Sources 9
4. Fuels and Combustible Gases 10
5. Potable Water 11
6. Sanitary Sewer 14
   6.1. Portable Facilities 14
   6.2. On-Site Storage 16
   6.3. Sewer Lift Stations 17
   6.4. On-Site Wastewater Treatment Systems 18
7. References and Additional Resources 19

Cover photo: Standby generator

Figures

Figure 1: Utilities that serve critical facilities.......3
Figure 2: Example of a flow-through tank system to meet water supply needs, with separate fire flow storage capacity.......13
Figure 3: Example of a groundwater well that was used only to provide water for flushing toilets.......14
Figure 4: Example of portable shower trailer in Port Carlos Cove, FL.......15
Figure 5: Example of portable water closets for use in a garage that was converted into an HES.......16
Figure 6: Example Backflow Preventor for sewer lateral.......17

Table

Table 1: Electrical Equipment Needed for Critical Facility Functioning during Short-, Intermediate-, and Long-Duration Outages.......9

1. Purpose and Intended Audience

This Recovery Advisory outlines observations from Hurricane Ian in Florida, DR-4673-FL, that provide insights regarding building improvement opportunities. These recommendations are applicable to buildings experiencing similar issues and need not be limited to the state or disaster in which they were observed.

Hurricane Ian caused widespread damage across Southwest Florida to houses, commercial buildings, and critical facilities. Additionally, Hurricane Ian resulted in widespread outages of utilities, including, but not limited to, power, water, and wastewater. The loss of utility service, and in some cases standby generators, severely impacted the ability of critical facilities to operate as intended. For example, loss of potable water was a particularly significant impact of Hurricane Ian. Although many evacuated in advance of Hurricane Ian's arrival, those who remained (e.g., first responders, hospital staff and occupants, those who took refuge in hurricane evacuation shelters [HES][1]) were sometimes left without potable water service.

This loss of potable water service often rendered affected facilities without fire protection and left occupants without proper sanitation facilities (toilets, handwashing, and cleaning). Many endured several days of finding alternative sources of drinking water and water for flushing toilets, but the loss of fire protection capability eventually required some facilities to be evacuated. Hospitals were among the facilities that were hardest hit. Three hospitals in Lee County were forced to evacuate, move patients to alternate hospitals, and halt hospital operations as a direct result of being left without fire protection due to loss of potable water supply. Shutting down hospital operations placed additional strain on the community and hampered its ability to recover more quickly from the event. The closure of hospitals also exposed patients receiving critical care to the risks associated with being evacuated and transported to another hospital.

Essential Facilities vs Critical Facilities

The forthcoming 2024 International Building Code (IBC) and American Society of Civil Engineers (ASCE) standard ASCE 7-22, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE/SEI, 2021), define "essential facilities" as "buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, tornado, snow, or earthquakes." Essential facilities are also designated as Risk Category IV structures.

Critical facilities are defined by FEMA as buildings that are essential for the delivery of vital services or protection of a community. Critical facilities include emergency operation centers, healthcare facilities, police and fire stations, schools, and power stations. These facilities

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[1] Hurricane Evacuation Shelter, or HES, is used in this Recovery Advisory as a general term for any hurricane shelter. However, there are more specific terms for the various types of shelters. Refer to Section 5.3 of the Hurricane Ian Mitigation Assessment Team (MAT) report for a discussion of the different shelter types and their definitions. Facilities constructed to provide near-absolute protection in a tornado or hurricane are called safe rooms. Safe rooms are required to be designed to FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms* (2021) and the International Code Council's (ICC's) standard ICC 500, *Standard for the Design and Construction of Storm Shelters* (2020). These documents provide guidance on backup power, water, and sanitary sewer systems to maintain operations of the safe room in the event of a utility outage.

support critical community lifelines that enable the continuous operation of critical business and government functions and are essential to human health and safety or economic security. For this Recovery Advisory, essential and critical facilities are synonymous. All essential facilities fit within the definition of critical facilities; however, not all critical facilities serving a community, such as a water treatment plant, are designed as Risk Category IV structures.

Critical facilities require utilities to function in order to carry out their critical operations. Hurricane Ian and other recent natural hazard events have demonstrated that critical facilities do not have to be structurally damaged to render them unable to function and perform their critical missions. The loss of utilities can prevent them from functioning even when their building envelopes, structures, and mechanical, electrical, and plumbing (MEP) systems survive an event with little or no damage. A vulnerability assessment of a critical facility should be performed prior to the start of designing projects where the overall goal is to improve utility resilience. The critical facility should be analyzed for the potential loss of its utility systems required to operate as well as its vulnerabilities to physical damage, such as wind, flood, seismic, and other applicable hazards. Reducing a critical facility's vulnerability to service loss can occur either at the utility level (often by strengthening the utility and its distribution system or by providing redundancy) or at a facility level (by providing alternate systems that can provide services normally provided by utilities). This Recovery Advisory focuses on the latter, providing guidance for on-site systems that can temporarily deliver services normally present and enable the critical facilities to function even when utilities are no longer available.

This Recovery Advisory is intended for owners and operators of critical facilities; architects and engineers who design them; various state, local, tribal, and territorial planners; and emergency managers who deal with critical facilities whether in support of emergency preparedness, planning, response, and disaster recovery efforts or administration of mitigation grants and operations. It also provides valuable considerations and guidance for utility providers. Readers are encouraged to review the entire document to gain an understanding of the general principles; consultation with a design professional may be needed for implementation. Note that this Recovery Advisory provides recommendations that are primarily applicable to critical facilities.

1.1. This Recovery Advisory Addresses

- Considerations for Utilities Needed to Operate Critical Facilities
- Electricity
- Fuels and Combustible Gases
- Potable Water
- Sanitary Sewer
- Useful Links and Resources

2. Considerations for Utilities Needed to Operate Critical Facilities

Municipal or private providers bring electricity, water, fuel, and communication and information technology (IT) services to critical facilities and dispose of liquid and solid waste that critical facilities generate. Critical facility operations can become severely limited or terminate completely in the event of a utility or service outage. The effects of the loss of a utility can be instantaneous, as with the loss of electricity, or the effects can be felt after some delay, as with potable water and sanitary sewer. The loss of some utilities and services, such as waste collection services, may not be felt for several days. Figure 1 illustrates some of the typical utilities that serve most critical facilities. Some critical facilities, such as hospitals, may have over 30 different utility systems. Although only the main utility systems are covered herein, some of the same general concepts can be applied to other systems as applicable.

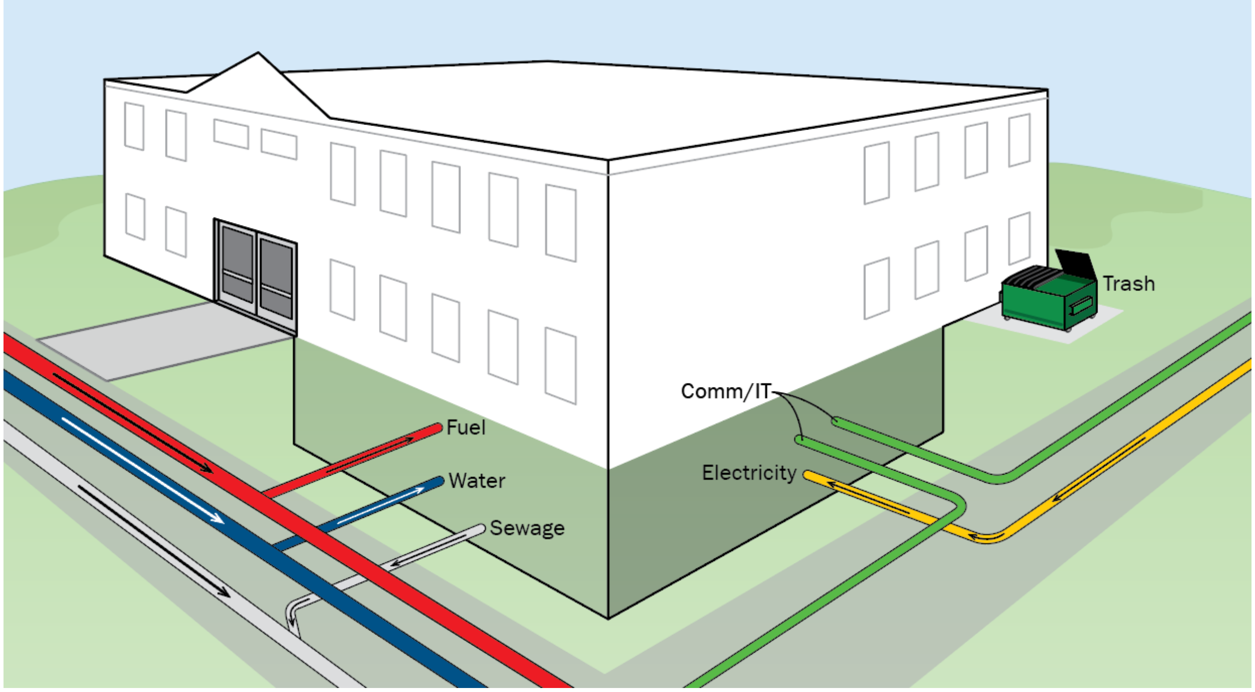

Figure 1: Utilities that serve critical facilities

For critical facilities to continue to operate during the loss of services provided by utilities, measures must be in place to accommodate those losses of service. The measures must have the capacity to provide the necessary services for the duration of the outages. When planning for continued operations through a utility outage, critical facilities should identify the following:

- What utilities are needed for a critical facility to perform its intended function/mission?
- What portion(s) of operations would be impacted by loss of service from the various utilities?
- Which building functions/operations need to remain at full capacity?

- Which building functions/operations, if any, can be reduced or shutdown while enabling the critical facility to remain operational and perform its mission?
- How many people might reasonably be expected to be on site performing, or being part of, the critical mission? Note that some critical facilities, such as emergency operations centers (EOCs) and HESs, may have orders of magnitude of additional people on site during a natural disaster or other critical operations compared to normal operations. This significant increase in occupancy must be accounted for by the various utility systems.
- What are the projected durations of the utility outages that the critical facility must overcome while remaining operational?

Continuity of Operations Planning

A Continuity of Operations Plan, or COOP, is a planning tool for individual departments and agencies to ensure continuity of critical functions during a wide range of emergencies.

FEMA offers a template for use in developing a COOP. This template helps agencies to define their critical functions, analyze vulnerabilities, plan for emergencies, and maintain and update the COOP based on lessons learned. The template is available at https://www.fema.gov/pdf/about/org/ncp/coop/continuity_plan_federal_d_a.pdf.

3. Electricity

Most critical facilities rely on a public utility grid that transmits and distributes power over long distances from where the power is generated to where it is consumed. Those long distances leave utility power supplies vulnerable to a variety of natural hazards, even for sophisticated redundant networks.

Modern building codes and standards acknowledge the vulnerability of utility power and require that most buildings have emergency power to supply select loads when normal power is interrupted. In many occupancies, code-required emergency power is dictated by what is needed to detect fires and enable occupants to exit a building quickly and safely. Those requirements are contained in the National Fire Protection Association's (NFPA's) NFPA 101, Life Safety Code, and are referred to as Life Safety loads. In other facilities, emergency power is needed for smoke control or to support firefighting actions. Although codes and standards, such as Article 708 Critical Operations Power Systems (COPS) of the National Electrical Code (NFPA 70), have been developed for power systems for critical operations, most facilities that provide essential or critical services are not covered by those codes and standards and the code requirements that govern their design will not allow them to function when normal power is lost.

Accommodating the loss of utility power requires determining *what* equipment must operate for a critical facility to function, *how* much power that equipment draws, and *how* best to provide that power. For this document, required equipment is considered equipment that must operate to allow a critical facility to provide critical services without placing building occupants at undue risk.

3.1. Determining Electrical Requirements

The electrical requirements of critical facilities vary greatly. The requirements for a hospital, fire station, or an EOC differ greatly from those of an HES. Determining the electrical needs of a facility requires knowing what equipment needs to be powered, when that equipment needs to operate, and for how long. FEMA P-1019, *Emergency Power Systems for Critical Facilities* (2014) contains extensive guidance on determining electrical needs.

Healthcare facilities are particularly challenging. *Healthcare Facilities and Power Outages* (FEMA 2019a) provides guidance for state, local, tribal, territorial, and private-sector partners on improving healthcare facility resilience to power outages. FEMA developed that guide in collaboration with the U.S. Department of Health and Human Services Office of the Assistant Secretary for Preparedness and Response and other partners to meet, in part, the requirements of Section 1208 of the Disaster Recovery Reform Act.

The following guidance will help identify *what* equipment must be operational to enable a critical facility to function.

3.1.1. LOADS REQUIRED BY CODES/LIFE SAFETY PROTECTION

Code-required loads are those required by building codes and standards to supply life-safety equipment, equipment that reduces hazards, and equipment that helps conduct rescue or fire-fighting operations.

Exit and Egress Lighting: Codes require that designated exit doors be identified and egress routes be illuminated so occupants can safely leave a building even when utility power is lost. However, code requirements typically only require emergency supplies for exit and egress lighting to last 1.5 hours, which can be provided by batteries. For critical or essential facilities that must remain operational for longer periods, standby or emergency power that can supply exit and egress lighting for longer durations should be provided.

Fire Detection, Alarm, and Communication Equipment: Fire detection, alarm, and communication equipment detects the presence of fire or smoke, either through automatic means, manual fire alarm initiation, or the operation of fire suppression systems such as sprinklers; provides alarms to notify building occupants of a fire; and communicates the detection of a fire to alert emergency personnel. However, like exit and egress lighting, the emergency power supplies required by code for fire detection, alarm, and communication equipment are often of relatively short duration. Standby or emergency power that can supply fire detection, alarm, and communication equipment for longer periods should be provided for critical facilities that must remain operational beyond code-required minimum durations.

Fire Pumps: Fire pumps for fire suppression systems boost water system pressures and ensure adequate water flow to sprinklers for fire suppression. When fire pumps are only powered from electrical utilities and not from standby or emergency power sources, local fire officials may limit how long facilities equipped with fire pumps can remain occupied when utility power is lost. If critical facilities must remain operational beyond that period, standby power to fire pumps should be provided. Diesel-driven fire pumps, which do not need electrical power to operate, are an alternative when supplying fire pumps from standby power sources is not practical.

3.1.2. LOADS REQUIRED FOR FUNCTION

Some systems are not required by code but are needed to allow a critical or essential facility to provide critical services without placing building occupants at undue risk.

Lighting: For most facilities, code-required lighting will not be adequate for operations during prolonged power outages. For example, code requirements for egress lighting range from an average initial illumination of 1 foot-candle (fc) to 10 fc for stairs. By contrast, office areas are typically illuminated to 50 fc and corridors at 15 fc.

FEMA P-1019 considers illumination levels of 30% to 50% of the normal lighting levels to be appropriate for most areas to function at a base level. For areas where visual tasks are demanding, such as hospital operating rooms and intensive care units, full lighting levels should be provided.

Power requirements for lighting are generally low and do not place large demands on standby power systems.

Heating, Ventilation, and Air Conditioning (HVAC): HVAC equipment controls the temperature and humidity levels within a building and provides fresh air for ventilation. In cold climates, heating is required for both occupant protection and to prevent damage from frozen pipes. In hot climates, air conditioning (AC) equipment is needed when interior temperatures and humidity levels must be kept within specific levels. Code research completed when FEMA P-1019 was developed circa 2014 found that while model building codes generally required that buildings be heated and provided with ventilation, they did not require buildings to be air conditioned.

With few exceptions, HVAC systems components require power to operate and, if they need to operate when utility power is lost, require standby power.

HVAC systems components that provide fresh air to buildings that require power can include supply fans, exhaust fans, and controls. HVAC systems components that provide heat can include furnaces, air handling units (AHUs), boilers, circulating pumps, and controls. They may also include electrical heating coils, variable air volume (VAV) boxes, or motorized dampers to control air flow rates to individual areas; equipment to chemically treat make-up water in hydronic (hot water) systems; and fuel oil pumps.

Many HVAC systems components do not draw large amounts of power and, in some cases, can be supplied from existing standby power systems. Exceptions are cases where standby power systems are sized to only supply code-required loads and heating systems that use electrical heating coils.

The HVAC systems components required to air condition a building depends on the type of AC system used. There are two common types: DX (direct expansion) systems and chilled water systems. DX system components include interior AHUs and exterior compressor and condensing units. Chilled water systems include interior AHUs and either air- or water-cooled chillers. Water cooled chillers are used with evaporative cooling towers that are connected to the chillers by condenser water loops or they may be connected to geothermal loops. Both DX and chilled water systems may have VAV boxes.

For both AC systems, power is needed for AHUs and HVAC controls and, when present, VAV boxes. DX systems require power for the exterior compressor and condensing units. Chilled water systems require power for the chillers, chilled water pumps, and, when present, the cooling towers and condenser water or geothermal pumps.

Dedicated Air Conditioning: AC systems are often needed to serve areas that contain heat-generating equipment such as IT network server rooms and communication equipment rooms. Dedicated AC systems units are typically DX style and require power be provided to their AHUs and compressor and condensing units.

AC equipment is often the single largest electrical load in a facility and can place large demands on standby power systems. When a critical facility must be air conditioned, standby power systems often must be doubled, tripled or larger in size, Because of the large electrical demand AC requires, providing AC only to the portions of a critical facility that need to be air conditioned to allow the facility to function and provide critical services is often appropriate.

3.1.3. POTABLE WATER SYSTEMS

Plumbing fixtures generally need about 30 pounds per square inch (psi) of water pressure to operate, and in many facilities, potable water from a utility is delivered with adequate pressure to meet that need without relying on utility power. Since codes often limit the operating pressure of potable water systems to 80 psi, static water pressures drop approximately 5 psi per floor, and additional pressure is lost when water flows through pipes, buildings over five stories often need booster pumps to provide sufficient water pressure to the upper floors. To maintain a potable water supply throughout a structure, the booster pumps will require standby power to operate when utility power is lost.

Producing domestic hot water when utility power is lost requires that additional equipment be supplied by standby power systems, including fuel-fired domestic hot water boilers, electric water heaters, and, when used, domestic hot water circulator pumps.

The electrical demand for standby power is greater when water service is interrupted and critical facilities must rely on on-site water sources. In addition to providing power to booster pumps and equipment for domestic hot water, power may also be needed for well pumps, lift pumps to fill elevated storage tanks, and, when the quality of the water produced from on-site water sources dictate, treatment equipment such as reverse osmosis systems. Alternative sources of potable water are discussed further in Section 5 of this Recovery Advisory.

3.1.4. SANITARY SEWER SYSTEMS

Sewer lift pumps are needed in buildings that discharge sewage to municipal sewer lines that are at higher elevations. Lift pumps, also called macerator or grinder pumps because they must handle solids and liquids, are normally placed in sewer sumps that have storage capacity that can handle the effluent produced for short periods. Although the duration depends on the volume of the sumps and on the rate that effluent is produced, storage durations of 4 to 8 hours are not uncommon. For power outages that exceed storage durations, sumps can overflow and contaminate the building unless standby power is provided to the lift pumps.

Municipal sewer or wastewater systems often have lift pumps, particularly in areas where local topography prevents sewage from being conveyed by gravity. Like lift pumps within buildings, municipal sewer pump stations have sumps, generally called wet wells, where sewage can collect when the lift pumps cannot operate. Municipal lift stations can often accommodate longer-duration outages than the sewer sumps within buildings. Twelve to 24 hours of storage is not uncommon. When lift stations lose power for longer durations, sewage levels in municipal wastewater collection systems can rise and can eventually enter buildings that are connected to the municipal system, particularly buildings that are not equipped with backwater valves. Further discussion of lift pumps for sanitary sewer lines is provided in Section 6 of this Recovery Advisory.

3.2. Duration of Service

Although the loss of utility power generally happens immediately, the impacts of a loss of utility power are not all felt at once. Loss of power is often noticed immediately when lights go out or computers shut down, but the effects of the loss of utility power on other systems may not be felt for several hours or occasionally days. Consequently, considering the duration of the loss of power or the duration that critical facilities must operate when not supplied by the electrical utility is critically important.

Table 1 summarizes electrical equipment that must operate for a critical facility to function during short-, intermediate-, and long-duration utility outages. Because the services that critical facilities provide and their reliance on electrical equipment vary greatly, what constitutes short-, intermediate-, and long-duration outages should be determined by the individual critical facility owners and operators, given their mission(s). However, for the illustrative and guidance purposes of this Recovery Advisory, short-duration outages are generally considered those that last 24 hours or less; intermediate-duration outages are generally considered those that last 24 to 72 hours; and long-duration outages are those that last 72 hours or longer. These durations are consistent with the guidance provided by FEMA P-1019.

Table 1: Electrical Equipment Needed for Critical Facility Functioning during Short-, Intermediate-, and Long-Duration Outages

Short-Duration	Intermediate-Duration	Long-Duration
Code Required/Life Safety ▪ Exit Signs ▪ Egress route illumination ▪ Fire Detection & Notification ▪ Smoke Control Equipment ▪ Fire Pumps & Jockey Pumps Illumination ▪ Operation centers ▪ Rest rooms ▪ Mechanical & electrical rooms ▪ Corridors & Stairwells Communication/IT ▪ EMS/Fire/Police ▪ Telephone HVAC Equipment ▪ AHU Circulation Fans ▪ HVAC Controls (min)	Short-Duration Equipment and Services Plus Illumination ▪ Shelter areas MEP ▪ Sewer lift pumps ▪ Potable water (well, booster) pumps ▪ Sump pumps ▪ Water treatment (on-site water sources) HVAC Equipment ▪ Supply & Exhaust Fans ▪ Local Air Conditioning ○ Operation centers ○ First Aid areas ○ Special needs areas ○ Cooling rooms ○ Communication/IT server rooms ▪ Environmental Management & Control Systems Communication/IT ▪ Network Servers & Routers	Short- and Intermediate-Duration Equipment and Services Plus HVAC Equipment(a) ▪ Boilers ▪ Air cooled chillers/water cooled chillers/cooling towers ▪ Hot water circulating pumps ▪ Chilled water circulating pumps Communication/IT ▪ WiFi

AHU = air handling unit; EMS = emergency medical services; HVAC = heating, ventilation, and air conditioning; IT = information technology; MEP = mechanical, electrical, and plumbing

(a) Flanged piping connection can allow portable boilers and chillers to provide hot and chilled water to HVAC equipment when it is impractical to supply HVAC equipment from standby power sources.

3.3. Alternate Electrical Sources

Accommodating the loss of utility power requires on-site energy sources sufficient to enable the facility to perform its critical functions for the community, region, or state for the duration of the loss. Energy can be provided by on-site generation, portable generation, stored energy devices, or combinations of these three. On-site generation is typically provided by standby or emergency generators, often powered by diesel engines but occasionally powered from liquid propane (LP) or natural gas (NG) units. Stored energy is nearly always provided by battery energy storage systems (BESS), which can range in size from tens of watthours for small devices such as emergency lighting fixtures to tens of megawatt hours for large systems. For on-site generation, renewable energy sources such as wind and solar systems are being considered more frequently. However, their reliance on wind or sunlight requires energy storage systems that enable them to operate through periods when wind turbines or photovoltaic (PV) arrays are not generating electricity.

For a standby energy system to power a critical facility, it must have the capacity to supply all critical loads for the duration of the power loss or for the minimum required time it is to remain operational without potentially having public utility power. The electrical needs of a critical facility and the ability of standby power systems to meet those needs must be determined and addressed.

Short-Duration Outages: Alternate electrical sources for short-duration outages include standby generators, and, when adequate storage is achievable, BESS. When BESS is used, the maximum electrical demand and the minimum charge state anticipated at the onset of the loss of utility power should be considered.

Intermediate-Duration Outages: Alternate electrical sources for intermediate-duration outages include standby generators, standby generators augmented with BESS, and possibly standby generators augmented with renewable generation. The latter should only be considered when renewable sources can be designed to survive the event that interrupts utility power.

Long-Duration Outages: Alternate electrical sources for long-duration outages include standby generators, standby generators augmented with BESS, renewable generation, and portable standby generators. Provisions should be installed to facilitate the connection of portable generators.

4. Fuels and Combustible Gases

Fuels and combustible gases are often needed for heating and, in some facilities, for AC, the production of domestic hot water, cooking, and operating standby power sources. Diesel and fuel oil are common liquid fuels. LP and NG are common combustible gases. Manufactured gas, often called town gas, is another combustible gas provided by utilities.

Because the focus of this Recovery Advisory is reducing risks to critical facilities from the loss of utilities, the risk from a loss of NG or town gas should also be considered.

The transmission and distribution of combustible gases is primarily through underground piping that is not directly affected by environmental hazards such as high winds and winter storms. Consequently, combustible gases are generally considered highly reliable. However, in preparation for natural hazard events, combustible gas service can be preemptively shut down to reduce fire risk during and after an event. Combustible gas lines can be damaged by high-wind events that topple and uproot trees after their roots have grown and are entangled around NG service lines as well as by earthquakes when gas lines can be damaged by ground movement.

The effects of the loss of NG service on a critical facility vary. Although the loss of NG service may prevent the production of domestic water and the operation of gas-fired heating systems, its loss will not immediately impact the function of a critical facility. However, for critical facilities with emergency or standby generators that operate on NG, the loss of NG service will immediately prevent them from functioning if the loss of NG service coincides with the loss of utility power.

For critical facilities that have several systems that operate on NG, compressed natural gas (CNG), which can be stored on site, is an alternative to NG provided by a utility. For critical facilities that only rely on NG for emergency or standby power systems, dual fuel (NG/diesel) generators, which can operate on NG, diesel, or both, are alternatives for improved resiliency.

5. Potable Water

The loss of potable water will severely impact the operational capabilities of critical facilities and prolonged outages can ultimately result in the inability of critical facilities to perform their critical mission/function(s). Potable water is most commonly associated with fulfilling the drinking water requirements for building occupants but has numerous other uses within a building to ensure operation and occupancy. Potable water is also commonly used for the following functions:

- Fire protection/suppression systems (fire flow)*
- HVAC systems and evaporation coolers*
- Steam/boiler makeup*
- Hand washing, showers, and toilet flushing (sanitary)

*A component outage could lead state, health, fire, or other regulatory authorities to require the building be evacuated because of unsafe conditions

Similar to electricity, potable water usage ranges from desired functions to critical needs, such as fire protection. Interruption of the potable water supply can adversely impact or restrict and stop critical operations. As in the case of fire protection, the evacuation of a building can sometimes be required by codes, regulations, or authorities having jurisdiction (AHJ) because of the risk of inhabiting a structure that lacks a fully functioning fire protection system. Additionally, some HVAC equipment, such as evaporative coolers, require water to operate; the loss of water service can limit or prevent their proper operation. The inability to heat or cool a critical facility can result in extreme temperatures and humidity levels, which can degrade equipment and personnel operations and place occupants at unnecessary risk.

The duration of the loss of potable water and the number of building occupants will influence the decisions to determine which building functions are required to remain operational and how much water is required for those building functions. The duration of outages can vary greatly from hours to days and perhaps weeks. Operators of critical facilities generally have two choices, they can either accommodate the loss of water or they can relocate personnel, equipment, and/or responsibilities to another facility that provides those critical services. Appropriate planning and preparedness for a potential outage can minimize the impact to the critical facility, by either having countermeasures in place or being ready for contingencies, until the duration of the outage can be determined. Critical facilities need to identify which potable water–dependent functions need to remain operational in order to enable operations to continue. Additionally, the maximum daily water usage for the facility should be identified for the various facility demands, such as HVAC equipment and water consumed by building occupants. This operational understanding will help in developing a plan to identify what outage duration is to be bridged and how the potable water demand is to be met until potable water distribution from the local utility can be restored. To bridge the gap, potable water needs to be either stored on site or supplied via alternative means, such as an on-site groundwater well.

Prior to an event that can result in a potable water outage, the critical facility owners/operators should perform a vulnerability assessment to determine whether the building plumbing system(s) should be modified to enable alternative or stored water sources to be used or how best to enable these water sources to effectively supply critical building functions. Additionally, FEMA recommends that critical facility owners, operators, and other interested stakeholders discuss and develop a plan and a prioritization system with the local water utility for how they will restore water service faster to the critical facility. Similar meetings could also be held with other local utility providers, such as electricity or wastewater, to help expedite restoration of services.

For short-duration outages, critical facilities should prioritize the building functions that need to remain operational and ensure that drinking water is available on site for occupants. Drinking water can be provided by bottled and canned water or can be stored in portable tanks, which typically range from 50 to 500 gallons.

One of the most critical building functions supplied by potable water is the fire suppression system. If the fire suppression system is offline, the AHJ or local codes and regulations may require a fire watch to be staffed. If a fire watch cannot be staffed or the potable water outage is anticipated to be more than a few hours, the AHJ or local codes and regulations may require the critical facility to be evacuated. Although the International Fire Code (IFC) and NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, establish criteria for when a fire watch is to be staffed and when a building needs to be evacuated, the local AHJ or facility stakeholders often have more stringent requirements. To provide redundancy for the fire suppression system, an on-site potable water storage tank can be installed that is sized in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, and NFPA 22, *Standard for Water Tanks for Private Fire Protection*, with a corresponding supply pump.

For other potable water needs, such as water to flush toilets, clean, use in kitchens, and address various other building needs, potable water trucks can be prepositioned at the critical facility. If potable water trucks are to be used, consider having multiple/redundant contracts for potable water trucks, as they may be scarce or have long travel times in the event a truck needs to be refilled.

Manually Flushing of Toilets

Many occupied critical facilities in Southwest Florida lost potable water during Hurricane Ian. Occupants continued to use the restroom, causing a sanitary crisis. Critical facility operators used the syphon effect to manually flush toilets by filling the toilet bowl with water. Because water service was interrupted, critical facility operators used 5-gallon buckets filled with stormwater collected from on-site stormwater ponds or potable water from pre-positioned water trucks to fill the toilet bowl.

One method to bridge the gap of a multi-day outage is to size and construct a flow-through tank. With a flow-through tank, the water main feeding the critical facility would first fill/enter the tank. Once the water is inside the tank, a pump will pull water from the tank and distribute the water to the critical facility under the required pressure. During periods of normal water supply, water is allowed to continually flow through, eliminating the concern of the water diminishing in quality. When water supply from the utility is interrupted, the backflow preventor prevents water in the flow-through tank from leaving the tank via the inlet pipe. The flow-through tank would need to be sized for the total water demand of critical functions (e.g., drinking water consumption, HVAC systems, boiler systems, sanitary) for the anticipated outage. If fire suppression systems utilize the same flow-through tank, the capacity of the tank will need to include the necessary storage volume for the fire suppression system. To prevent water required for the fire suppression system from being used by other building functions, two separate outlet pipes at different elevations can be used, as shown in Figure 2. The outlet pipe for building functions would be at an elevation that is above the necessary volume of water required for fire suppression while the outlet pipe for the fire suppression system would be located on the floor of the tank.

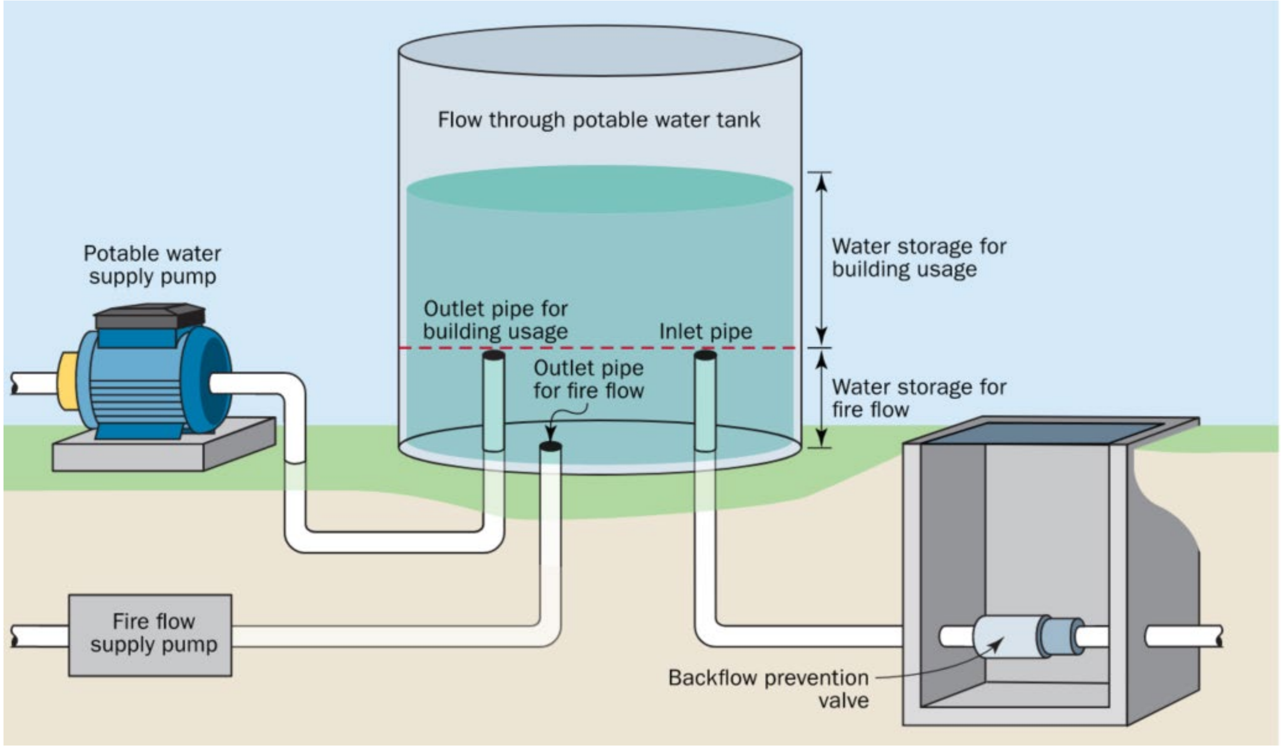

Figure 2: Example of a flow-through tank system to meet water supply needs, with separate fire flow storage capacity

Although sizing a tank to accommodate outages of multiple days is possible, the size of the tank may be too large for the site, be cost prohibitive, or result in water quality issues as chlorine residual decreases. For long-duration outages, drilling a groundwater well or network of groundwater wells may be necessary to fulfill the potable water demand for the critical facility. Depending on the groundwater quality, either a carbon filter or reverse osmosis treatment system may be necessary to treat the water to be used for drinking or in HVAC systems. Alternatively, if certain critical facility functions do not require water to be drinking water quality, the groundwater well can be used for sanitary water needs, as shown in Figure 3.

Figure 3: Example of a groundwater well that was used only to provide water for flushing toilets

The solutions for intermediate and long outages can also be used for shorter-duration events, and these potable water solutions may have components that need to be powered by standby power; therefore, standby power will need to be sized for the increased load.

6. Sanitary Sewer

After potable water is consumed or utilized, it becomes sanitary sewer water, which needs to be disposed of from the facility. Sanitary sewer comprises blackwater (product of toilet flushing, dishwashers, and food preparation sinks), graywater (product of bathtubs/showers, bathroom/nonfood preparation sinks, and laundry), and, in some cases, stormwater discharge (such as rainwater from gutters or basement sump pumps). Stormwater may be discharged to surface water or directly reused within the building; however, blackwater and graywater must be properly treated before being disposed of or reused. Facilities discharge sanitary sewer water either through a system that is operated by a wastewater service provider or through a system that is independent of a utility provider.

6.1. Portable Facilities

A short-term solution to loss of sanitary sewer is deploying portable facilities. Portable water closets (e.g., porta potties, showers, laundry trailers) are classified as a short-term solution (cannot be temporarily isolated for long durations) because they require routine servicing for proper maintenance. Portable water closets should be serviced/pumped weekly at a minimum (VIP Restrooms 2021) but up to three to four times a week in high-traffic areas (Kerkstra 2023). Increasing the quantity of portable water closets will extend the duration between pumping, though routine servicing is recommended for sanitary reasons. As guidance on determining the number of water closets needed, the International Code Council's (ICC's) standard ICC 500, *Standard for the Design and Construction of Storm Shelters,* recommends one water closet for every 50 occupants

(ICC 500, Section 703.3) for use within a storm shelter. Alternatively, Occupational Safety and Health Administration (OSHA) regulations for general industry require up to six water closets for the first 150 occupants and one additional fixture for each additional 40 employees thereafter.[2]

Portable water closets, handwashing stations, showers, or laundry units can be purchased or rented. Figure 4 shows an example of an eight-station shower trailer providing services to a heavily damaged area of Florida following Hurricane Ian. Power for the trailer is supplied by a portable generator, circled within Figure 4, and hot water is provided by an LP on-demand water heater with propane tanks, located on the “tongue” or front of the trailer. The trailer features a mechanical room (not shown in the photo) with a water tank. A waste holding tank stores the graywater. Maintenance of this trailer includes refilling of the propane tanks and water tank, and disposal of the waste holding tank.

Figure 4: Example of portable shower trailer in Port Carlos Cove, FL

The Hurricane Ian Mitigation Assessment Team (MAT) visited a parking garage at a retirement community that deployed portable water closets for community residents prior to activation of the facility as an HES (Figure 5). The Team also visited several shelters and hospitals that brought in portable water closets, showers, and/or laundry units after the hurricane made landfall, once the facilities were accessible. These portable systems are an option to enable continued facility functionality during utility outages. Contracting with a portable sanitation company well in advance of an event will lessen supply challenges, which are often exacerbated given the high demand for these portable units following an event.

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[2] See OSHA Standards – 29 CFR, Part 1910 (OSHA Section 1910.141(c)(1)(i) and Table J.1) https://www.osha.gov/laws-regs/regulations/standardnumber.

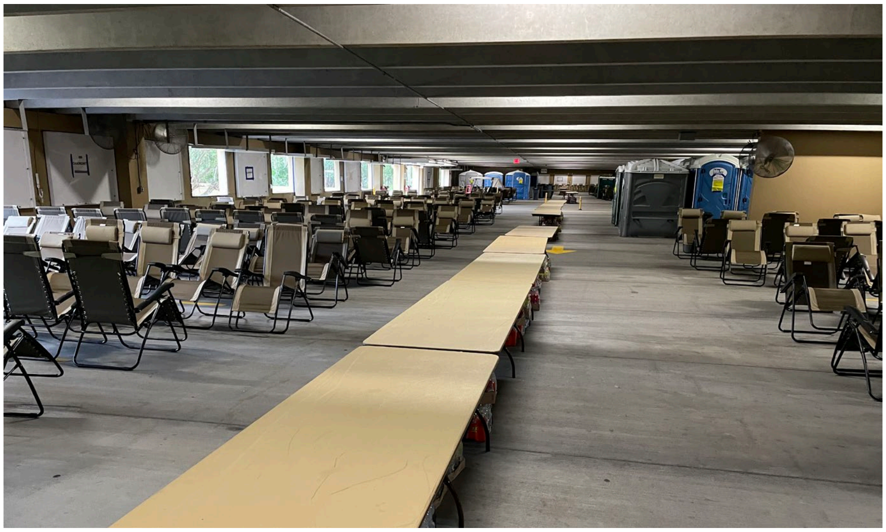

Figure 5: Example of portable water closets for use in a garage that was converted into an HES

When determining whether portable facilities are the appropriate solution, location of the portable facilities and additional utilities needed for their operation must be considered. After an event, portable facilities are used temporarily during the recovery process. These portable facilities are typically placed in a parking lot or grassy area outside of the building. However, for facilities used as an HES that are not specifically designed with hardened/resilient restrooms (e.g., ICC 500 storm shelters) within them, portable water closets should be delivered in advance of the storm event and located within the facility. This will prevent occupants from having to go outside to use the restrooms during the event, which is unsafe. The location of interior portable facilities may be restricted by logistical challenges or may limit shelter space use for other operations. In either case, this reality should be properly planned for in advance for improved shelter operations. Utility hookups are also a consideration. Laundry and shower facilities need to be connected to adequate power and water supply to function properly. Close utility connections to the portable facility are preferred to minimize electrical losses, maximize water pressure, and minimize flow reductions within the system. Some of these facilities, such as laundry and showers, are more commonly used after the event occurs, but before utilities for the given area are functioning again. For heavily damaged areas, it can sometimes take weeks or months for power and/or water to be restored to certain locations.

6.2. On-Site Storage

When a longer isolation period may be required following an event, an on-site sewer storage holding tank may be used as an intermediate solution. Holding tanks are closely related to septic tanks, which are discussed further in the next section. Sizing is an important consideration for holding tanks as capacity dictates the length of time between pumping. Larger critical facilities require larger holding tanks, which the site must be able to accommodate. Facilities with holding tanks may use water conservation techniques to avoid overflow of the tank. The holding tank is pumped by a tanker truck approximately every 2 weeks to a month, or sooner, depending on sewer use and tank capacity (Scherer 2021). This timeframe governs the amount of time the facility can function before access to the holding tank is required. Traditional holding tanks do not require electrical power to operate;

however, if the wastewater disposal piping is discharged via a pump, backup power would be needed in the event of an electrical outage.

6.3. Sewer Lift Stations

Electrical outages will cause loss of function of lift station pumps. Accumulation of sewage in lift stations that lose pumping capabilities can result in overtopping of the lift station if the lift station does not have sufficient capacity. It can also allow sewage levels to rise in wastewater collection systems. Consequently, providing permanent backup power at lift stations without sufficient retention capacity to contain sewage in the event of a power outage is a best practice. Lift stations with adequate retention capacity may be equipped with a quick disconnect to affix a portable generator for temporary backup power following an event.

Failures Due to Backflow

Stormwater and sewer failures can have disastrous consequences outside of loss of wastewater service. Backflow from sanitary sewers and stormwater conveyance systems can cause significant damage to building interiors. During Hurricane Ian, an assisted living community in Orlando, FL, experienced flooding due to the failure of a nearby lift station. This water intrusion from the lift station failure contributed to the flooding of the facility and caused the evacuation of all 122 residents.

To prevent raw sewage from flowing into a building, some type of check valve or backflow preventer (**Figure 6**) can often be installed to prevent floodwaters from pressurizing the system and entering the building. To mitigate the potential pressurization in the sanitary sewer system from floodwaters, an ejector pump can be installed to force the raw sewage past the backflow prevention device.

Figure 6: Example Backflow Preventor for sewer lateral

For more information, refer to FEMA P-2022, *Hurricane Harvey in Texas Mitigation Assessment Team Report* (2019b) and Hurricane Harvey in Texas Recovery Advisory 1, *Dry Floodproofing: Planning and Design Considerations* (FEMA 2019b).

6.4. On-Site Wastewater Treatment Systems

On-site wastewater treatment systems are an alternative for facilities served by municipal utilities or other wastewater service providers. On-site systems typically include septic tanks, in which solids and liquids collect, and methods to dispose of the liquid effluent that flows beyond the septic tanks. Effluent disposal can range from discharging effluent to drainage fields, often called leach fields, where effluent slowly drains/leaches into the soils below, to packaged treatment systems that provide secondary treatment that reduces organic materials in the effluent or tertiary treatment that removes harmful contaminants from wastewater. Packaged plants can also disinfect wastewater.

Packaged wastewater treatment plants should be provided with on-site standby power systems or the ability to connect portable generators for critical facilities that must remain operational when utility power is lost. For smaller critical facilities, with low daily water-usage rates, septic systems with drainage fields can be a viable alternative. When drainage fields are at higher elevations than the septic tanks, pumps are needed to pump effluent from the tanks to the drain fields and those pumps should include provisions for connecting standby power.

Reducing Wastewater Discharge

Because septic systems have a finite capacity, reducing the load to the system may be warranted. The wastewater discharge load may be reduced in several ways:

- Separation: Separating stormwater, blackwater, and graywater. As previously mentioned, stormwater may be discharged without treatment. Blackwater and graywater may be reused or recycled in different ways after treatment.
- Wastewater reuse: Collecting and treating wastewater for other uses, such as recycling graywater, originally used for example in handwashing, for toilet flushing.
- Wastewater recycling: Collecting and treating wastewater for reuse for the same function, such as recycling toilet water, where the toilet water is treated and reused, for toilet flushing (EPA 2002).

Numerous alternative on-site wastewater treatment systems are available that either enhance or replace waste disposal systems. Filtrations systems can either replace a septic tank or be installed downstream of a septic tank. These systems use sand, peat, or a synthetic or artificial material to filter and treat effluent, much in the same way as typical municipal wastewater treatment systems (Scherer 2021). Other package systems utilize aerobic reactors, which use microorganisms and oxygen, pumped into the wastewater, to treat the water. After the water passes through the reactor and solids have been removed, sodium hypochlorite is often added to disinfect the water before discharge.

When determining whether an on-site wastewater treatment system is the right solution, or which on-site wastewater treatments system is the right solution, consider the following:

- The system must be designed for the characteristics of the wastewater produced by the facility (i.e., daily volumes, rates of flow, pollutant load). This is most notable for nonresidential structures where wastewater produced by the facility may be highly variable and dependent on the facility type. Depending on the wastewater composition, advanced treatment or accommodation for elevated organic loads may need to be considered (EPA 2002).
- When locating the on-site wastewater treatment system, the site must have sufficient space for the required treatment system. This may limit the type of system that can be used. Caution should be taken in siting the system so it does not interfere with other on-site utilities, such as drinking wells (Scherer 2021).
- Similar to holding tanks, septic systems do not require electrical power to function unless a pump is used. However, alternative on-site wastewater systems almost always require electrical power to function. On-site standby power systems or provisions to connect portable generators should be installed for critical facilities whose waste disposal systems require power to operate for those facilities that must remain functional when utility power is lost.
- Operations and maintenance are critical for the success of the system. Routine maintenance will extend the lifespan of the system. However, negligence of routine maintenance may lead to malfunctioning of the system, clogging of pipes and drain fields, nuisance odors, public health issues, and contamination of surface water and/or groundwater.

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Reducing Water Intrusion Through Windows and Doors

Recovery Advisory 3

August 2023

FEMA

DR-4673-FL RA 3

Table of Contents

1. Purpose and Intended Audience 1
  1.1. Key Issues 1
  1.2. This Recovery Advisory Addresses 1
2. Performance Grade Ratings for Windows and Doors and Water Intrusion 2
  2.1. Testing requirements for windows and sliding doors 3
    2.1.1. AAMA/WDMA/CSA 101/I.S.2/A440 3
    2.1.2. TAS 202 5
  2.2. Testing requirements for side-hinged doors 8
3. Florida Building Code Exceptions to Water Intrusion Testing for Doors 9
4. Installation, Flashing, and Sealing of Windows and Doors 10
  4.1. Installation/anchorage 10
  4.2. Flashing and Sealing 10
  4.3. Important Considerations for Sliding Doors 12
5. Maintenance of Windows and Doors 14
  5.1. Sealant Joints 14
  5.2. Other Maintenance 14
6. Resources 15

Figures

Figure 1: Typical temporary supplement window label for a product tested to AAMA/WDMA/CSA 101/I.S.2/A440. Figure used with permission..5
Figure 2: Typical temporary supplemental window label for a product tested to TAS 202. Figure used with permission..6
Figure 3: Overhang exception to water penetration testing for doors in the FBCB and FBCR...............9
Figure 4: Using a removable stop to protect exposed sealants. Source: FEMA P-499........................11
Figure 5: Pan flashing for window and door openings. Source: FEMA P-499......................................12
Figure 6: Typical sill riser detail for sliding doors. Figure used with permission. 13
Figure 7: Sill riser on sliding door. Photo used with permission..13
Figure 8: Typical drainage weepholes (red circles). Photo used with permission................................15

Tables

Table 1: AAMA/WDMA/CSA 101/I.S.2/A440 PG Ratings – Wind Design Pressure and Water Penetration Resistance 4
Table 2: Summary of Water Penetration Testing Requirements in the FBCB and FBCR 8

1. Purpose and Intended Audience

This Recovery Advisory outlines observations from Hurricane Ian in Florida, DR-4673-FL, that provide insights regarding building improvement opportunities. These recommendations are applicable to buildings experiencing similar issues and need not be limited to the state or disaster in which they were observed.

This Recovery Advisory provides important recommendations to reduce water intrusion through and around windows and doors due to wind-driven rain during extreme wind events. Water intrusion through and around windows and doors can damage interior finishes and interior contents. Water intrusion can also lead to algae and mold growth and may result in degradation or complete loss of building function, until adequate repairs are made. This Recovery Advisory addresses specific issues observed by the FEMA Hurricane Ian Mitigation Assessment Team (MAT) in Florida and provides recommended techniques to reduce water intrusion through windows and doors during extreme wind events. This advisory does not address water intrusion through windows and doors due to flooding.

The primary audience for this Recovery Advisory includes building owners, operators, and managers; design professionals; building officials; contractors; and municipal building and planning officials.

1.1. Key Issues

The key issues addressed in this advisory for consideration during rebuilding and mitigation activities are as follows:

- Water intrusion through and around windows and doors due to wind-driven rain can result in costly damage to interior finishes and furnishings.
- Water intrusion around window and door openings can cause dry rot and fastener corrosion that weaken the window or door frame or the wall itself.
- Window and door assemblies that are not tested for water penetration resistance, or are not tested to the required level can enable water to penetrate through the product and into the building, resulting in costly damage.
- Inadequate flashing techniques can enable water to enter the building around windows and doors, resulting in costly damage.
- The lack of proper product maintenance as specified by the manufacturer can result in poor water penetration resistance around windows and doors, resulting in costly damage.

1.2. This Recovery Advisory Addresses

This Recovery Advisory addresses the following:

- Performance Grade (PG) Ratings for Windows and Doors and Water Intrusion
- Florida Building Code Exceptions to Water Intrusion Testing for and Doors
- Installation, Flashing, and Sealing of Windows and Doors
- Maintenance of Windows and Doors
- Resources

This Recovery Advisory was developed primarily for the State of Florida as a result of observations from the FEMA Hurricane Ian MAT. However, the recommendations and issues addressed can be applied throughout the United States to minimize damage caused by water intrusion through windows and doors.

Florida Product Approval

The State of Florida requires product approval for the building envelope components addressed in this Recovery Advisory. A Florida Product Approval (Product Approval) certifies that the product has been designed or tested to the standards required in the building code. Although local product approval is permitted, most manufacturers opt for statewide Product Approval. The database of products approved through the statewide Product Approval system is available at www.floridabuilding.org. A Miami-Dade Notice of Acceptance (NOA) is a local product approval that is similar to a statewide Product Approval. Miami-Dade NOAs are product certifications offered by Miami-Dade County that certify that products have been designed or tested to the High-Velocity Hurricane Zone (HVHZ) requirements in the Florida Building Code. Because the HVHZ requirements typically meet or exceed the requirements in the rest of the state, most jurisdictions in Florida will also accept Miami-Dade NOAs as well as statewide Product Approvals. Manufacturers with products that also meet the HVHZ requirements can list their products as complying with the HVHZ requirements as part of their statewide Product Approval. Miami-Dade NOAs are available at https://www.miamidade.gov/building/pc-searchapp.asp. Windows and doors with statewide Product Approvals and/or NOAs can be relied upon by applicable stakeholders to provide a level of confidence of given standards of performance during wind events.

2. Performance Grade Ratings for Windows and Doors and Water Intrusion

Water intrusion through and around windows and doors as observed after Hurricane Ian, often occurs during the high winds and heavy rain that typically accompany hurricanes. Most windows and doors are required to be subjected to a series of tests that include air infiltration, wind pressure, and water penetration resistance in addition to other operability tests. (Note: American Architectural Manufacturers Association [AAMA] / Window and Door Manufacturers Association [WDMA] / CSA Group [CSA] 101/I.S.2/A440[1] characterizes a product's water intrusion resistance as water penetration resistance. In this section, where the term water penetration resistance is used, it refers to a product's resistance to water intrusion.) For windows and doors tested to AAMA/WDMA/CSA 101/I.S.2/A440, a product's performance grade (PG) rating correlates to the lowest outcome of

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[1] AAMA/WDMA/CSA 101/I.S.2/A440 is the *North American Fenestration Standard/Specification for Windows, Doors, and Skylights*.

each of these applicable performance tests. A product with a higher PG rating will have better resistance to water infiltration.

2.1. Testing requirements for windows and sliding doors

Flashing and sealing methods are used to mitigate the effects of water intrusion around windows and doors. However, windows and doors should also be tested for water intrusion that may occur through the product or assembly. The resistance of water penetration through the product is determined by testing specified in AAMA/WDMA/CSA 101/I.S.2/A440 or TAS (Testing Application Standard) 202.[2]

The Florida Building Code, Building (FBCB) and Florida Building Code, Residential (FBCR) require windows and sliding doors to be tested and labeled to indicate compliance with AAMA/WDMA/CSA 101/I.S.2/A440 or TAS 202. In the HVHZ, all windows and doors are required to be tested to TAS 202. Although AAMA/WDMA/CSA 101/I.S.2/A440 and TAS 202 are similar tests, they differ somewhat in how water penetration resistance is qualified.

2.1.1. AAMA/WDMA/CSA 101/I.S.2/A440

AAMA/WDMA/CSA 101/I.S.2/A440 is a standard that certifies window and door products for air leakage resistance, wind pressure resistance, water penetration resistance and other performance tests as applicable. The water penetration resistance of products tested to AAMA/WDMA/CSA 101/I.S.2/A440 does not always directly correlate to the wind design pressure (DP) rating, and therefore, the DP rating is not always an indication of water penetration resistance. The important designation regarding water penetration resistance is the PG rating. This designator is well understood in the window industry but is not typically well understood outside the industry. The PG rating indicates that the product has met a specific set of performance tests that include wind pressure resistance and water penetration resistance. A product’s PG rating correlates to the lowest outcome of each of the applicable performance tests.

A product with the PG rating of 60 has a minimum DP rating of 60 pounds per square foot (psf) and has passed the water penetration resistance test at 15% of the positive DP rating, 9 psf. The higher the PG rating, the more resistant the product is to water penetration. A PG 60 product has been tested for water penetration resistance at four times the pressure of a PG 15 product. Table 1 compares some common PG ratings and the water penetration resistance test pressures and shows how PG and DP ratings can diverge and affect the water penetration resistance test pressure. Using the rows below with the asterisks as an example, the positive DP ratings are same, but the one with a higher PG rating is tested to a higher water penetration resistance test pressure.

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[2] TAS 202 is the *Criteria for Testing Impact & Non-impact Resistant Building Envelope Components Using Uniform Static Air Pressure*, which is contained in the *Florida Building Code Test Protocols for the High-Velocity Hurricane Zones* (ICC 2020).

Table 1: AAMA/WDMA/CSA 101/I.S.2/A440 PG Ratings – Wind Design Pressure and Water Penetration Resistance

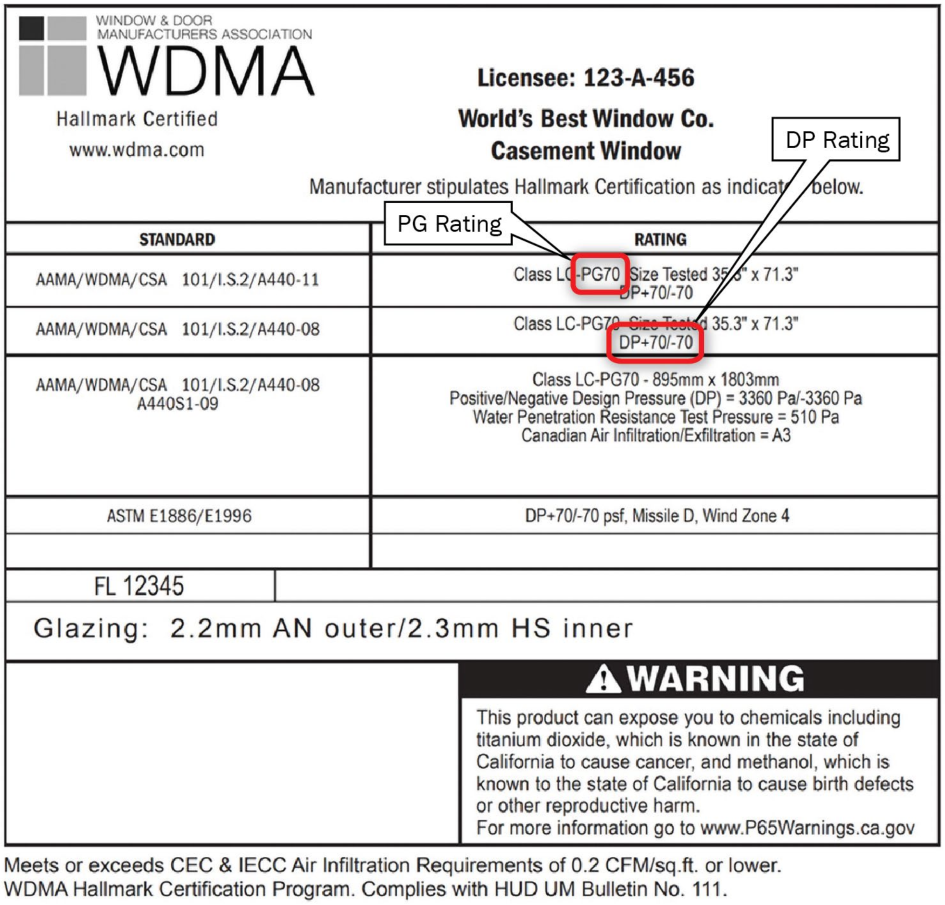
PG Rating	Wind DP Rating (positive)	Water Penetration Resistance Test Pressure (15% of PG Rating)
15	15 psf	2.25 psf
30	30 psf	4.5 psf
40	40 psf	6 psf
40*	50 psf*	6 psf*
50*	50 psf*	7.5 psf*
60	60 psf	9 psf

psf = pounds per square foot
*PG rating is less than DP rating

It is commonly assumed that windows and doors are tested for water penetration resistance at 15% of the positive DP rating. While that is true for products tested to TAS 202 (see TAS 202 section in this advisory), it is not necessarily true for products tested to AAMA/WDMA/CSA 101/I.S.2/A440, which specifically states that the positive DP rating is not an indicator of water penetration resistance performance. For the AAMA/WDMA/CSA 101/I.S.2/A440 standard, the water penetration resistance is tested at 15% of the PG, which may not always correspond to 15% of the positive DP rating.

The FBCB and FBCR require products to have a permanent label, marking, or etching that provides traceability to the manufacturer and product. They also require additional information about the product that includes the positive and negative DP rating, in addition to other items, to be on the permanent label or a temporary supplement label that can be removed after the final inspection (most manufacturers opt to put the additional information on the temporary supplemental label).

Although the FBCB and the FBCR require the positive and negative DP ratings to be shown on the product label, they do not specifically require the PG rating to be on the label. However, AAMA/WDMA/CSA 101/I.S 2/A440 does require the product label to include the PG rating, in addition to the DP rating. Code enforcement personnel and others look at labels to ensure the product has met the required DP rating. For water penetration resistance, the PG rating is the most important designation. A product with a higher PG rating has been tested for water penetration resistance at a higher level. The PG rating should be on the product label alongside the positive and negative DP rating. Figure 1 shows a typical temporary supplemental window label and points out the PG rating and DP rating. **The PG rating should equal the positive DP rating.** The negative DP rating is not correlated to water penetration resistance and, therefore, its absolute value may exceed the PG rating.



WINDOW & DOOR MANUFACTURERS ASSOCIATION
WDMA
Hallmark Certified
www.wdma.com

Licensee: 123-A-456
World's Best Window Co.
Casement Window
Manufacturer stipulates Hallmark Certification as indicated below.

STANDARD	RATING
AAMA/WDMA/CSA 101/I.S.2/A440-11	Class LC-PG70 Size Tested 35.3" x 71.3" DP+70/-70
AAMA/WDMA/CSA 101/I.S.2/A440-08	Class LC-PG70 Size Tested 35.3" x 71.3" DP+70/-70
AAMA/WDMA/CSA 101/I.S.2/A440-08 A440S1-09	Class LC-PG70 - 895mm x 1803mm Positive/Negative Design Pressure (DP) = 3360 Pa/-3360 Pa Water Penetration Resistance Test Pressure = 510 Pa Canadian Air Infiltration/Exfiltration = A3
ASTM E1886/E1996	DP+70/-70 psf, Missile D, Wind Zone 4

FL 12345

Glazing: 2.2mm AN outer/2.3mm HS inner

⚠ WARNING

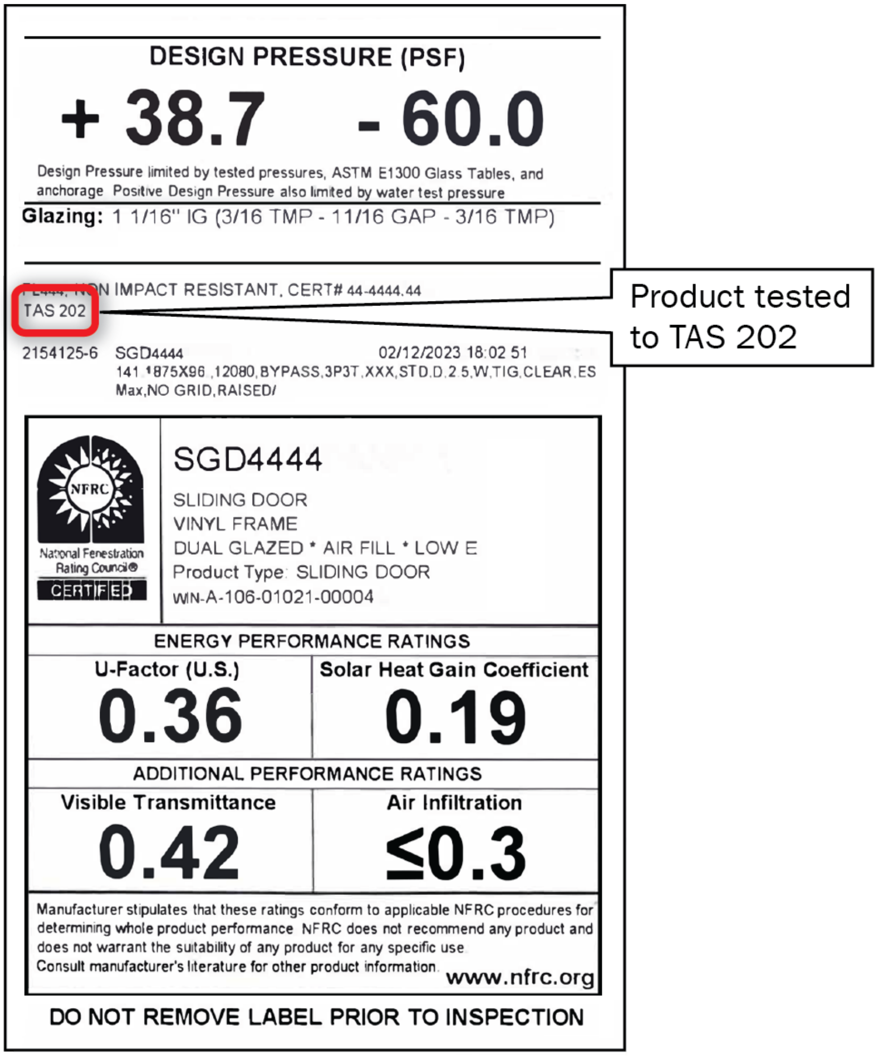
This product can expose you to chemicals including titanium dioxide, which is known in the state of California to cause cancer, and methanol, which is known to the state of California to cause birth defects or other reproductive harm.
For more information go to www.P65Warnings.ca.gov

Meets or exceeds CEC & IECC Air Infiltration Requirements of 0.2 CFM/sq.ft. or lower.
WDMA Hallmark Certification Program. Complies with HUD UM Bulletin No. 111.

Figure 1: Typical temporary supplement window label for a product tested to AAMA/WDMA/CSA 101/I.S.2/A440. Figure used with permission.

2.1.2. TAS 202

Windows and sliding doors are permitted to be tested in accordance with TAS 202 as an alternative to AAMA/WDMA/CSA 101/I.S.2/A440. In the HVHZ, all windows and doors are required to be tested to TAS 202. Figure 2 shows a typical temporary window label with the DP rating and TAS 202 testing standard. The performance tests in TAS 202 are similar to those in AAMA/WDMA/CSA 101/I.S.2/A440. However, TAS 202 specifically requires windows and doors to be tested for water penetration resistance at 15% of the positive DP rating. The water penetration test in TAS 202 directly correlates to the positive DP rating. Consequently, some products could actually qualify for a higher positive DP rating in TAS 202 but are limited to a lower positive DP rating because of the performance during the water penetration resistance part of the test. As in AAMA/WDMA/CSA 101/I.S.2/A440, the negative DP rating does not correlate with the water penetration resistance of the product.



DESIGN PRESSURE (PSF)

+ 38.7 - 60.0

Design Pressure limited by tested pressures, ASTM E1300 Glass Tables, and anchorage Positive Design Pressure also limited by water test pressure

Glazing: 1 1/16" IG (3/16 TMP - 11/16 GAP - 3/16 TMP)

FL444, NON IMPACT RESISTANT, CERT# 44-4444.44
TAS 202

2154125-6 SGD4444 02/12/2023 18:02 51
141 1875X96 ,12080,BYPASS,3P3T,XXX,STD,D,2.5,W,TIG,CLEAR,ES Max,NO GRID,RAISED/

National Fenestration Rating Council®
CERTIFIED

SGD4444
SLIDING DOOR
VINYL FRAME
DUAL GLAZED • AIR FILL • LOW E
Product Type: SLIDING DOOR
WN-A-106-01021-00004

ENERGY PERFORMANCE RATINGS

U-Factor (U.S.)	Solar Heat Gain Coefficient
0.36	0.19

ADDITIONAL PERFORMANCE RATINGS

Visible Transmittance	Air Infiltration
0.42	≤0.3

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance NFRC does not recommend any product and does not warrant the suitability of any product for any specific use Consult manufacturer's literature for other product information.

www.nfrc.org

DO NOT REMOVE LABEL PRIOR TO INSPECTION

Product tested to TAS 202

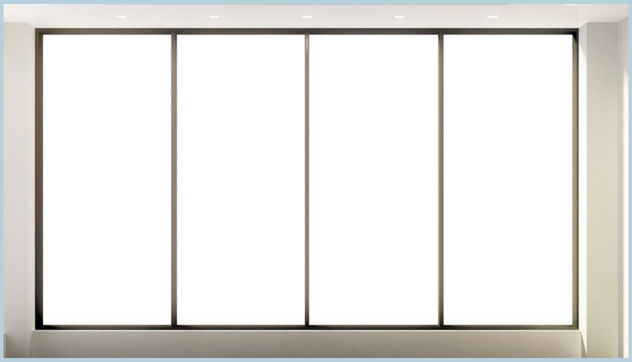
Figure 2: Typical temporary supplemental window label for a product tested to TAS 202. Figure used with permission.

Best Window Types for Water Penetration Resistance

Fixed windows and operable window and door products with compression seals provide the best resistance to water infiltration. Operable products include awning and casement type windows. These products seal directly against the frame and provide the best resistance to water penetration.

Examples of Windows with Most Effective Water Intrusion Resistance

Casement Window



Fixed Window

Examples of Windows with Less Effective Water Intrusion Resistance

Double Hung Window

Sliding Window

Key Recommendation:

For products tested to AAMA/WDMA/CSA 101/I.S.2/A440, ensure all windows and sliding doors have a PG rating that equals the positive DP rating for the product. Alternatively, ensure all windows and doors have been tested to TAS 202.

2.2. Testing requirements for side-hinged doors

In the HVHZ, all doors, including side-hinged doors, are required to be tested for water penetration resistance except windows and doors that meet the exceptions to water intrusion testing (see next section). Outside the HVHZ, side-hinged doors are not required to be tested for water penetration resistance but are required to have a DP rating determined using the uniform static air pressure test of ASTM International (ASTM) E330.[3] Products that have not been tested for water penetration resistance will most likely not be effective in resisting wind-driven rain during a hurricane.

Table 2 provides a summary of water penetration testing requirements in the FBCB and FBCR.

Table 2: Summary of Water Penetration Testing Requirements in the FBCB and FBCR

Product	Requirement	Outside the HVHZ			HVHZ
Windows and Sliding Doors	**Testing Standards**	AAMA/WDMA/CSA 101/I.S.2/A440		TAS 202	TAS 202
	Water Penetration Resistance Test	15% of PG		15% of Positive DP Rating	15% of DP Pressure Rating
	Labeling Requirements	DP and PG		DP	DP
Side-swinging Doors	**Testing Standards**	AAMA/WDMA/CSA 101/I.S.2/A440	TAS 202	ASTM E330	TAS 202
	Water Penetration Resistance Test	15% of PG	15% of Positive DP Rating	None	15% of DP Pressure Rating
	Labeling Requirements	DP and PG	DP	DP	DP

Key Recommendation:

- Side-hinged doors should be tested for compliance with AAMA/WDMA/CSA 101/I.S.2/A440 or TAS 202. For products tested to AAMA/WDMA/CSA 101/I.S.2/A440, ensure all doors, including side-hinged doors, have a PG rating that equals the positive DP rating for the product. Alternatively, ensure all windows and doors have been tested to TAS 202.

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[3] ASTM E330 is the *Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*.

3. Florida Building Code Exceptions to Water Intrusion Testing for Doors

The FBCB and FBCR provide a couple of exceptions to water testing for doors complying with AAMA/WDMA/CSA 101/I.S.2/A440 or TAS 202. These exceptions also apply in the HVHZ. Doors in the following locations are not required by the code to be tested for water penetration:

- Door assemblies installed in non-habitable areas where the door assembly and area are designed to accept water infiltration, and
- Door assemblies installed where the overhang ratio (OH ratio) (see Figure 3) is equal to 1 or more.

Non-habitable areas are areas not used for living, sleeping, eating, or cooking. They include but are not necessarily limited to bathrooms, toilet rooms, closets, halls, screen enclosures, and sunrooms. However, the phrase “areas that are designed to accept water infiltration,” is not well defined. Non-habitable areas have commonly been interpreted to also include doors that open to a foyer where a foyer is connected to a living area but is interpreted to be a non-habitable area. Although the code does not require doors in these areas to be tested for water penetration resistance, water infiltration in these areas can still cause damage to interior contents and finishes.

The overhang exception, shown in Figure 3, applies where the length of the overhang is greater than or equal to the overhang height (OH ratio equal to or greater than 1). While the overhang exception may provide sufficient protection in areas outside hurricane-prone regions, it will not protect doors from the wind-driven horizontal rain that commonly occurs during hurricanes.

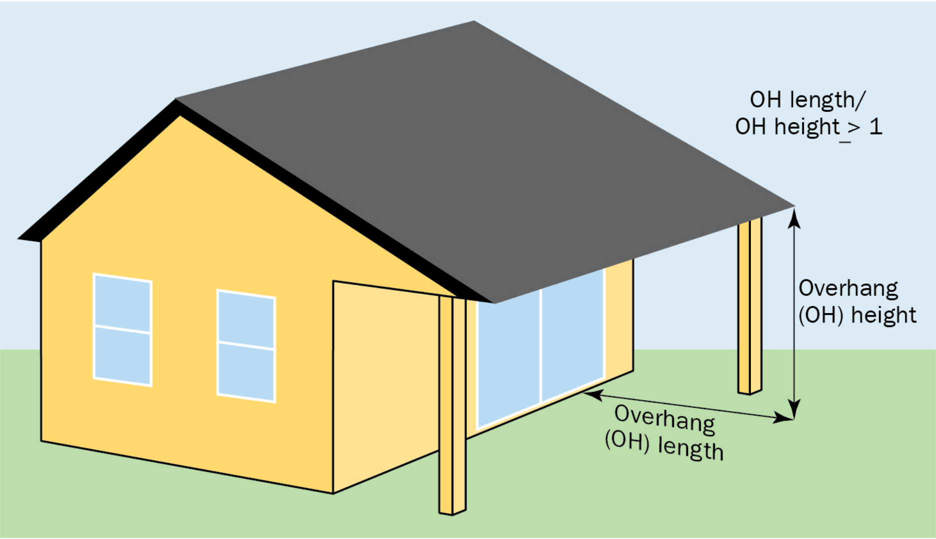

Figure 3: Overhang exception to water penetration testing for doors in the FBCB and FBCR.

Key Recommendations:

- As a best practice, do not apply the exceptions to water penetration resistance testing in the FBCB and FBCR. Ensure all doors have been tested for water penetration resistance even in areas where the FBCB and FBCR do not require it.
- For products tested to AAMA/WDMA/CSA 101/I.S.2/A440, ensure all doors have a PG rating that equals the positive DP rating for the product.
- Alternatively, ensure all doors have been tested to TAS 202 and include the water penetration resistance test.

4. Installation, Flashing, and Sealing of Windows and Doors

Windows and doors must be installed, flashed, and sealed as specified by the manufacturer and/or building code to provide the expected level of performance.

4.1. Installation/anchorage

Installation of windows and doors is not generic and is specific to each manufacturer to achieve the required performance ratings such as the design wind DP rating and water penetration resistance. Window and door manufacturers are required to provide installation instructions for their products with their Product Approval. See the Florida Product Approval text box on page 2 of this advisory for information on how to find Product Approvals for any product that has a Statewide Product Approval or a Miami-Dade NOA. The installation instructions will vary by manufacturer and can also vary for the same product depending on7 the required DP rating for the site-specific conditions where the product is being installed. Section R609.7 of the 7th Edition (2020) FBCR specifies minimum anchorage requirements, but primarily defers to the manufacturer's installation instructions. It is critical that windows and doors be installed as specified by the manufacturer.

4.2. Flashing and Sealing

Proper flashing and sealing of windows and doors is integral to preventing water infiltration due to wind-driven rain. The primary function of flashing is to prevent the entry of water into a building from a joint or opening. Flashing is required to be applied in shingle-like fashion, where the top layer laps over the bottom layer to direct water down and out of a structure. One of the more common window and door flashing mistakes is the failure to layer flashing in a shingle-like fashion. In addition, flashing must extend to the surface of the exterior wall or to the water-resistive barrier for subsequent drainage and/or to direct the water to weep holes.

Flashing for windows and doors generally falls into two categories: surface barrier method and drainage system method. The barrier method primarily relies on installation and sealants to prevent water penetration. The drainage system method permits water to enter but uses flashing, such as metal/vinyl and self-adhered membranes and tapes, to direct water to the exterior of the building or the water-resistive barrier.

A common problem with the barrier method is that sealants can degrade over time and will need to be replaced once they exhibit signs of edge curling, cracking, and/or other breaks or delamination (see Section 5 in this advisory). FEMA P-499, *Homebuilders Guide to Coastal Construction* (2010) recommends that a removable "stop" be installed over exposed sealant to protect the sealant from direct exposure to weather and reduce the wind-driven rain demand on the sealant (see Figure 4).

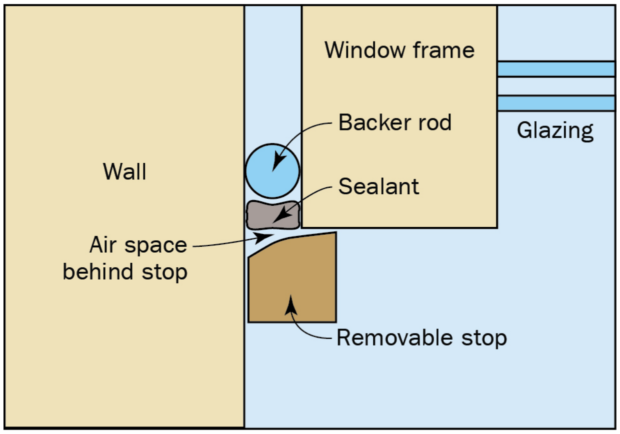

Figure 4: Using a removable stop to protect exposed sealants. Source: FEMA P-499

The FBCB and FBCR specify several methods for flashing windows and doors, including:

- The fenestration manufacturer's installation and flashing instructions
- The flashing manufacturer's instructions
- The flashing design or method developed by a registered design professional
- FMA/AAMA 100, FMA/AAMA 200, FMA/WDMA 250, FMA/AAMA/WDMA 300, or FMA/AAMA/WDMA 400[4]

The FMA, AAMA, and WDMA standards were developed by the window industry to address common installation methods in the State of Florida. The flashing/sealing methods in these standards have been tested by the industry and have been shown to be effective in preventing water intrusion.

Where flashing instructions or details are not provided, the FBCB and FBCR require pan flashing to be installed at the sill of exterior window and door openings. Pan flashing must be sealed or sloped in such a manner as to direct water to the surface of the exterior wall finish or to the water-resistive barrier for subsequent drainage. Pan flashing is required to incorporate flashing or protection at the head and sides (rear leg and end dam). Minimum recommended end dam and rear leg heights are addressed in Technical Fact Sheet No. 6.1 of FEMA P-499. See Figure 5.

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[4] FMA/AAMA 100, FMA/AAMA 200, FMA/WDMA 250, FMA/AAMA/WDMA 300, or FMA/AAMA/WDMA 400 are the Fenestration Manufacturers Association (FMA), American Architectural Manufacturers Association (AAMA), and Window & Door Manufacturers Association's (WDMA's) Installation Resources for Waterproofing.

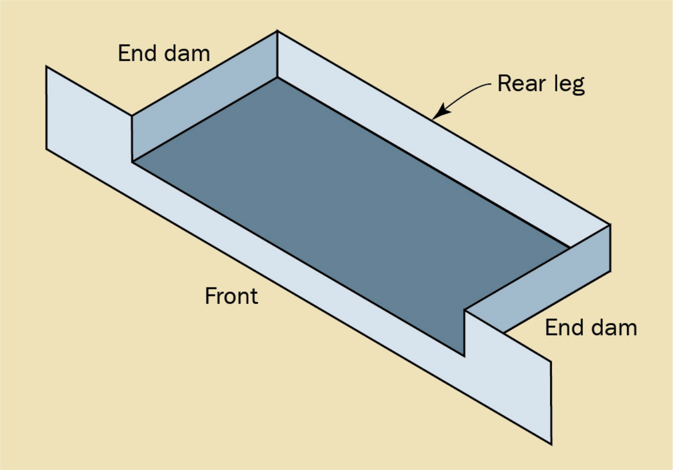

Figure 5: Pan flashing for window and door openings. Source: FEMA P-499

Additionally, while not specifically referenced in the FBCB or FBCR, ASTM E2112, *Standard Practice for Installation of Exterior Windows, Doors and Skylights*, also provides comprehensive details for window and door installation, including flashing techniques.

If the window and door assemblies are not anchored properly as specified by the Product Approval, flashings and sealants may be less effective during a windstorm, resulting in water intrusion.

4.3. Important Considerations for Sliding Doors

Sliding doors are prone to water infiltration because of the nature of their construction. Most sliding doors are considered “contain and drain” products in that they allow water penetration to occur but contain the water in an integral sill pan and allow the water to drain to the exterior. This integral sill pan includes a sill riser (sill dam) on the interior side of the door; see Figure 6 and Figure 7. The height of the sill riser depends on the water penetration resistance rating of the product. The higher the riser, the better the water penetration resistance. However, because the FBCB and FBCR provide some exceptions to water penetration testing (for example, the overhang exception previously discussed), some manufacturers may offer a “no riser” option on their products. Many homeowners do not understand the importance of this riser and consider it a trip hazard or unsightly attachment to their door and remove it. Without a riser or sill dam, sliding doors have little resistance to water infiltration. Additionally, the termination ends of the integral sill pan must be sealed with an approved sealant to the jambs at a height equal to the height of the sill riser.

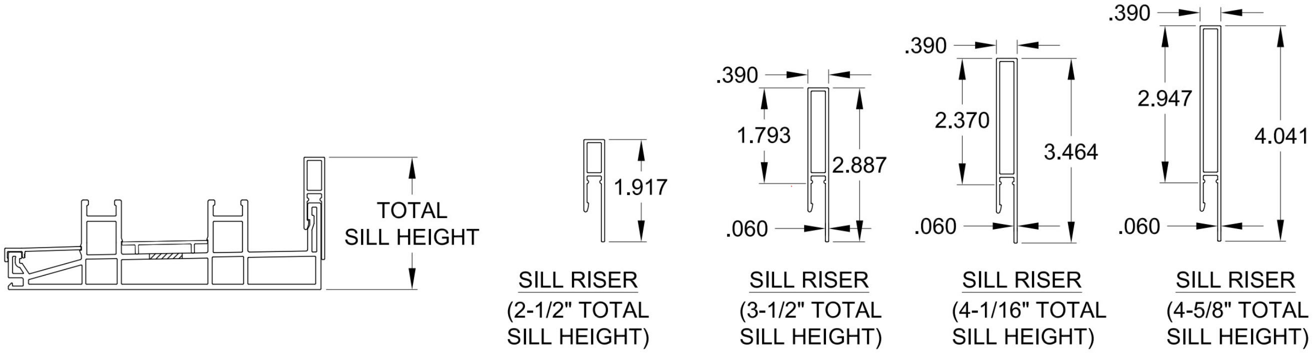

Figure 6: Typical sill riser detail for sliding doors. Figure used with permission.

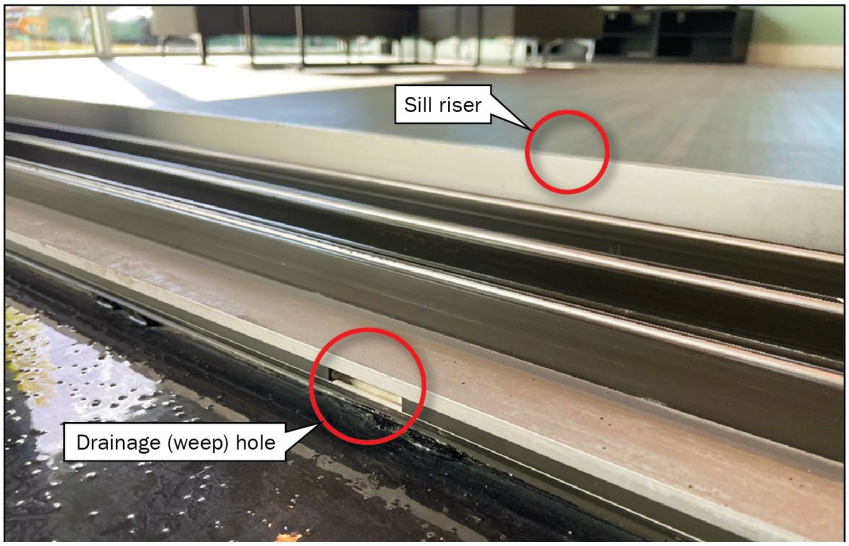

Figure 7: Sill riser on sliding door. Photo used with permission.

Another key consideration for sliding doors is that the rough opening should be plumb and level. In addition to affecting door operability, an unlevel surface under the track can cause cracks and crevices under the track that enable water to infiltrate under the door. While wood shims can be used to plumb the door on the sides and top of the rough opening, wood shims should not be used to level the surface under the track. Wood shims will quickly rot and deteriorate if exposed to water. The bottom on the rough opening should be leveled with grout or a similar product. Grout can provide a solid level for the bottom track and impede water intrusion under the track.

5. Maintenance of Windows and Doors

Windows and doors require periodic maintenance to ensure their continued operability and ability to resist water infiltration.

5.1. Sealant Joints

Sealant joints require periodic inspection and replacement. If the sealant is cracked, discontinuous, or delaminated, or there is a gap between the window or door frame and the wall, the entire joint should be replaced. Two important things should be considered when replacing sealants:

- Always use sealants that comply with AAMA 800, ASTM C920 Class 25 Grade NS or greater, ASTM C1281, or AAMA 812.[5] Check the product labeling to ensure that one of these standards is identified and the product is indicated for exterior use.
- Ensure the sealant is compatible with the material it will be adhered to (i.e., masonry, aluminum, wood, vinyl). Even a high-quality sealant will not remain in the joint if it is not compatible with the product to which it is being adhered.
- Ensure that the sealant does not block any weep holes and/or misdirect the path of water runoff.

5.2. Other Maintenance

Periodically clean weatherstripping with soap and water. If the weatherstripping is damaged, contact the window or door manufacturer for replacement.

Periodically inspect drainage openings (weep holes). As discussed previously in this Recovery Advisory, drainage holes are a key element of "contain and drain" products and should not be covered or plugged with caulk. They must be kept clean and free of debris to allow water that gets in the product to drain to the exterior of the building as shown in Figure 8.

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[5] These standards are AAMA 800, *Voluntary Specifications and Test Methods for Sealants*; ASTM C920, *Standard Specification for Elastomeric Joint Sealants*; ASTM C1281, *Standard Specification for Preformed Tape Sealants for Glazing Applications*; and AAMA 812, *Voluntary Practice for Assessment of Frame Deflection When Using One Component Polyurethane Foams for Air-Sealing Rough Openings of Fenestration Installations*.

Figure 8: Typical drainage weepholes (red circles). Photo used with permission.

Ensure all windows and doors close tightly and firmly latch. Windows and doors that do not close tightly may facilitate cracks and gaps between the window or door and the frame. These cracks and gaps can permit water to infiltrate through the window or door when exposed to wind-driven rain.

6. Resources

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ASTM. 2021. *Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.* ASTM E330. Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference (ansi.org)

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Hurricanes Maria and Irma in Puerto Rico Recovery Advisory 5*, Protecting Windows and Openings in Buildings*. https://www.fema.gov/sites/default/files/documents/hurricanes_irma_maria_in_pr_1-6_0.zip

FEMA. 2020. Hurricane Michael in Florida Mitigation Assessment Team Report, FEMA P-2077. Mitigation Assessment Team Report: Hurricane Michael in Florida, Building Performance Observations, Recommendations, and Technical Guidance, FEMA P-2077/February 2020

Hurricane Michael in Florida Recovery Advisory 2, *Best Practices for Minimizing Wind and Water Infiltration Damage*. https://www.fema.gov/sites/default/files/documents/hurricane_michael_recovery_advisories.zip

FMA/AAMA (Fenestration Manufacturers Association / American Architectural Manufacturers Association). 2012a. *Standard Practice for the Installation of Windows with Flanges or Mounting Fins in Wood Frame Construction for Extreme Wind/Water Conditions*. FMA/AAMA 100-12. Fenestration Manufacturers Association (hubspot.net)

FMA/AAMA. 2012b. *Standard Practice for the Installation of Windows with Frontal Flanges for Surface Barrier Masonry Construction for Extreme Wind/Water Conditions*. https://infostore.saiglobal.com/en-us/Standards/AAMA-800-2016-157_SAIG_AAMA_AAMA_314/

FMA/AAMA/WDMA. 2012. *Standard Practice for the Installation of Exterior Doors in Wood Frame Construction for Extreme Wind/Water Conditions*. FMA/AAMA/WDMA 300-12. fma-aama-wdma_300-12_wdma_c.pdf

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All documents were prepared with accessibility and compliance with Section 508 of the Rehabilitation Act of 1973 in mind. For further information or clarification regarding items such as technical drawings or maps, please contact the FEMA Building Science Helpline at FEMA-BuildingScienceHelp@fema.dhs.gov or 866-927-2104.

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Appendix C: Hurricane Ian NFIP Claims Analysis Technical Advisory

Hurricane Ian NFIP Claims Analysis

December 2023

FEMA

DR-4673-FL

FEMA Advisory | Building Science

Detailed NFIP Claims Analysis from Hurricane Ian of Single-Family Houses in Representative Areas of Interest

Introduction

Through 2022, Hurricane Ian is the fourth highest flood disaster by National Flood Insurance Program (NFIP) payouts, behind Hurricanes Katrina, Harvey, and Sandy. Based on the areas impacted by Hurricane Ian, there were several sites that enabled a comparison of newer versus older single-family houses. With over 37,000 Hurricane Ian NFIP claims throughout Florida, and over 22,000 claims in Lee County alone, representative areas were selected based on a high percentage of NFIP policies in force and a large age-of-construction distribution, whenever possible. The primary purpose of the comparison was to quantify the differences in damage to single-family residential houses based on building characteristics and help make recommendations to floodplain managers, building code officials, designers, contractors, home owners, and emergency managers to improve flood-resistant design and construction practices.

To support a comparison of flood damage to single-family residential buildings, FEMA's Mitigation Assessment Team (MAT) used NFIP policy claims data. The MAT selected 12 Areas of Interest with varying flood sources in Desoto, Lee, and Collier counties with most of them (nine) in Lee County. Figure 1 provides a map of the 12 areas along with the Hurricane Ian track. Parcel data were gathered for over 2,800 properties across the 12 areas and NFIP policy information was collected for over 1,200 of these properties (about a 45% penetration rate for flood insurance take-up across the areas). Parcel data attributes included the year built and size of the house in square feet. The size of each house was used to help quantify a claim per square foot of house, because the average size of a single-family house has increased over time. Table 1 provides a summary of the number of single-family residential buildings across the 12 Areas of Interest along with the number of insured buildings grouped by year built. The percentages in Table 1 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade. Note the percent distribution of buildings by decade and average size are relatively consistent across the total number of buildings versus those with a flood insurance policy. The distribution is not always as consistent and varies by specific Area of Intertest.

FEMA

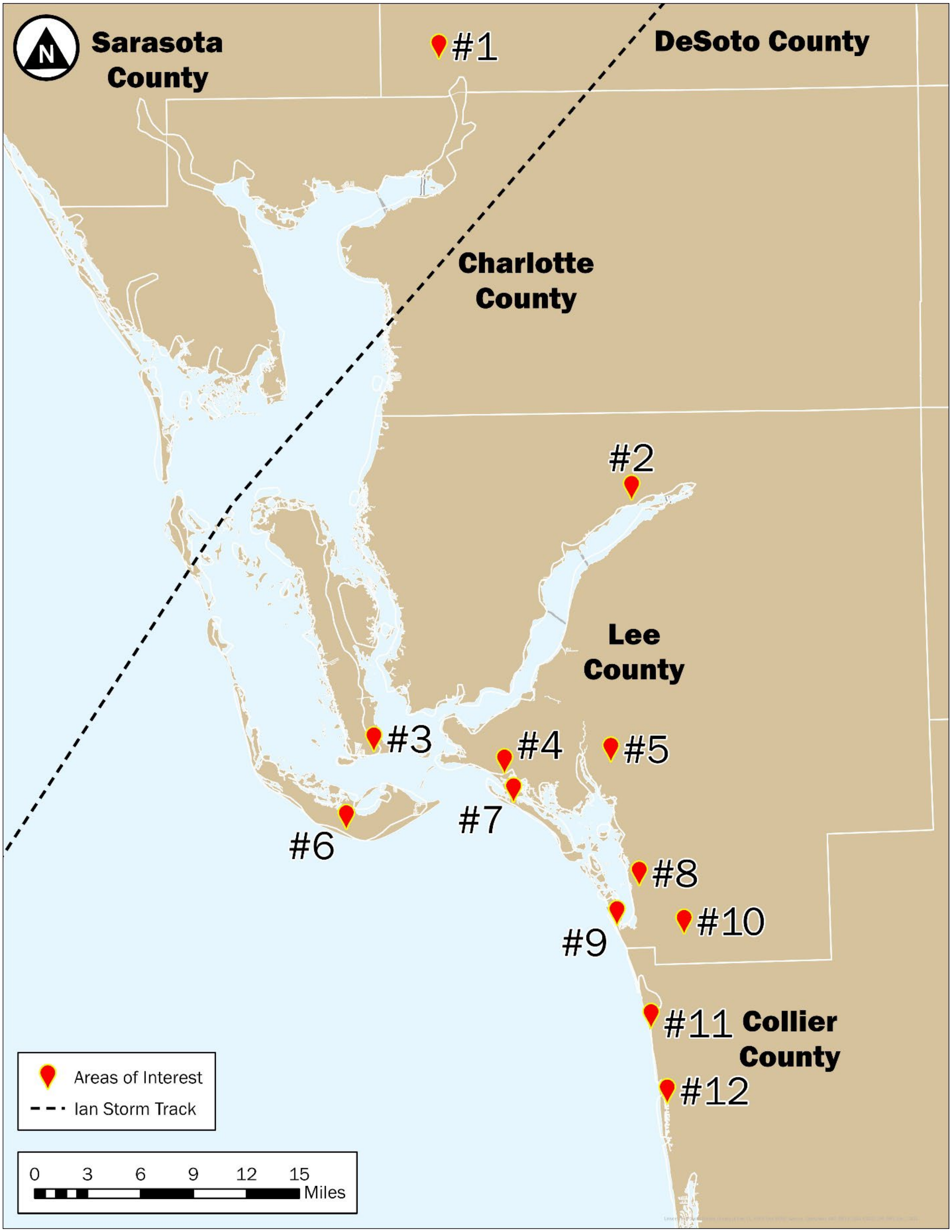

Figure 1: Areas of Interest evaluated in this Appendix

Table 1: Single-Family Residential Building Summary across the 12 Areas of Interest

Decade Built	Number of Buildings	Percent of All Buildings	Average Size (square feet)	Number of Buildings with Policies	Percent of All Policies	Average Size (square feet)
Pre 1980	1,057	37%	1,695	426	34%	1,799
1980s	695	24%	1,826	344	27%	1,863
1990s	342	12%	2,262	173	14%	2,256
2000s	433	15%	2,634	205	16%	2,675
Post 2010	341	12%	3,035	122	10%	2,977
All	**2,868**		**2,095**	**1,270**		**2,133**

The MAT collaborated with Federal Emergency Management Agency (FEMA) Flood Insurance staff to collect policy and claims data throughout the 12 areas. Various attributes, including, but not limited to, claims status, *elevated* versus *non-elevated building*, pre- versus post-Flood Insurance Rate Map (FIRM) construction, primary residence, claims payment, and building and contents coverage limits, were pulled from NFIP policy data for the 1,270 NFIP policies that were active prior to Hurricane Ian across the 12 Areas of Interest. Table 2 provides a summary of select NFIP policy data attributes. The numbers in Table 2 indicate the quantity (and percentages) of all the insured single-family buildings (of 1,270). For example, there were 413 *elevated buildings*, which equates to 33% of the total insured single-family buildings. Note, while not every policy analyzed had contents coverage (only 76%), they each had building coverage.

Table 2: Summary of NFIP Insured Single-Family Building Attributes

	Elevated	Post-FIRM	Primary Residence	Contents Coverage	Average Building Coverage	Average Contents Coverage
Yes	413 (33%)	638 (50%)	944 (74%)	963 (76%)	$236,984	$74,342
No	857 (67%)	632 (50%)	326 (26%)	307 (24%)		
All	**1,270**					

The 12 Areas of Interest were selected because they represented most of the flood sources visited by the MAT during the pre-MAT in October 2022 or the full MAT deployment in January 2023. Most of the sites were near a high-water mark (HWM) either collected by the U.S. Geological Survey (USGS) and/or the FEMA MAT itself. Using these HWMs and the effective Flood Insurance Study, an annual exceedance probability was estimated near 11 of the 12 sites, see Figure 2 based on the nearest HWM. Based on the estimated annual exceedance probabilities, Hurricane Ian flood levels exceeded the base flood elevation (BFE) (or 100-year/1-percent-annual-chance flood) in all coastal areas analyzed and was below the base flood in most inland areas.

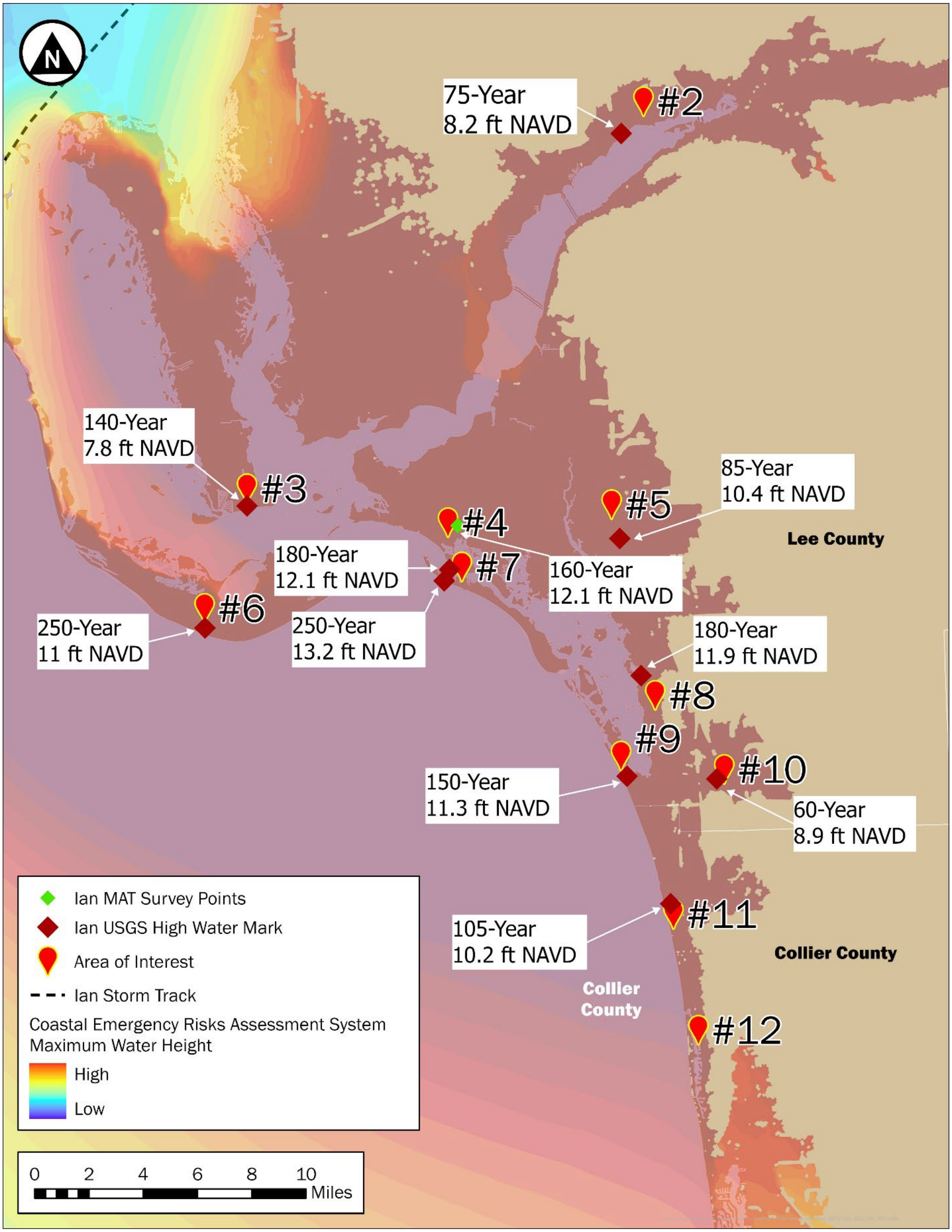

Figure 2: Estimated annual exceedance probability for Areas of Interest No. 2 through 12

The 12 Areas of Interest selected in Desoto, Lee, and Collier Counties have various flood sources and the inundation depths within each varied, based on site conditions, especially storm surge levels. Table 3 provides a summary of the estimated flood depths for each of the 12 areas. These depths are primarily representative of the flood depth above the lowest floor of older *non-elevated buildings* within the areas studied.

Table 3: Estimated Flood Depths across Areas of Interest 1 through 12

Area of Interest	Estimated flood depth (feet) in at-grade buildings
1 – DeSoto County along Peace River	2–3
2 – Lee County along Caloosahatchee River	2–3
3 – Pine Island	1–2
4 – San Carlos Bay	7–8
5 – Tenmile Canal	3–4
6 – Sanibel Island	4–5
7 – Fort Myers Beach/Estero Island	8–9
8 – Estero Bay	5–6
9 – Bonita Beach	5–6
10 – Lee County along Imperial River	2–3
11 – Collier County – Vanderbilt	4–5
12 – Venetian Bay	2–3

Based on field observations, structural damage in these areas typically depended on whether or not the building experienced wave action or high-velocity flood loads. Debris-impact loads were also a contributing factor to structural damage. For the most part, unless buildings were subject to hydrodynamic loads or experienced scour and erosion damage to foundations, buildings did not typically have structural damage. Nevertheless, extensive damage was observed to non-structural building components and non-flood damage–resistant materials that were exposed to flooding. While *elevated buildings* were more flood-damage resilient than *non-elevated buildings*, finished enclosures with various elements that did not appear to comply with flood-damage-resistant material requirements and had functions beyond the only allowable uses of parking, building access, and storage below the lowest floor, were prevalent. These common issues reduced building and community resilience by generating avoidable flood damage, creating debris that caused the closing and blocking of countless roads, required cleanup and repairs, and unnecessarily tied up limited resources.

To reinforce field observations related to flood damage of single-family residential buildings and help recommend improvements for flood-resistant design and construction requirements, the MAT collected NFIP policy claims data along with county parcel data and analyzed building and contents claims. The policy data from the FEMA Flood

Insurance Directorate included claims status, *elevated* versus *non-elevated building* type, pre- versus post-FIRM construction, primary residence, claims payment, and building and contents coverage limits. Parcel data attributes included the year built and size of the house in square feet. The building size was used to help quantify a claim per square foot of each house as the average size of a single-family house has increased over time. For example, in some Areas of Interest, the average building claim reflected greater damage in newer larger construction, but when comparing the average building claim per square foot the newer construction claims were lower compared to older construction. Table 4 through Table 7 provide a summary of the NFIP claims in the representative areas. Table 4 provides a comparison of the average total, building, and contents claims across the 12 representative areas. Table 5 compares average total, building, and contents claim by decade. The summaries show a decrease by decade indicating newer construction had less insured flood damage claims, which is consistent with field observations. Table 6 compares average total, building, and contents claims by *elevated* vs *non-elevated building* type; the average *non-elevated building* claims were considerably higher as expected. Table 7 provides similar elevation by pre- versus post-FIRM construction; pre-FIRM damages were considerably higher as expected. Note, not every insurance policy analyzed had contents coverage, so the combined averages will not equal the total average claim.

Per 44 CFR 59.1 ELEVATED BUILDING

For insurance purposes, an *elevated building* is a non-basement building that has its lowest elevated floor raised above ground level by foundation walls, shear walls, posts, piers, pilings, or columns.

Table 4: Comparison of Hurricane Ian NFIP Claims across Areas of Interest 1 through 12

Area of Interest	Active Policies	Average Total Claim	Average Building Claim	Average Contents Claim
1 – DeSoto County along Peace River	16	$115,660	$109,428	$12,463
2 – Lee County along Caloosahatchee River	67	$171,796	$148,058	$34,574
3 – Pine Island	70	$58,049	$48,033	$11,309
4 – San Carlos Bay	106	$130,645	$114,517	$19,209
5 – Tenmile Canal	103	$143,095	$126,131	$26,474
6 – Sanibel Island	100	$82,646	$72,517	$11,380
7 – Fort Myers Beach/Estero Island	101	$115,242	$108,917	$10,867
8 – Estero Bay	62	$86,127	$75,908	$13,774
9 – Bonita Beach	56	$85,186	$79,007	$8,873
10 – Lee County along Imperial River	235	$84,856	$73,349	$17,244

Area of Interest	Active Policies	Average Total Claim	Average Building Claim	Average Contents Claim
11 – Collier County – Vanderbilt	246	$160,367	$132,914	$32,784
12 – Venetian Bay	108	$194,506	$154,724	$43,398
All	**1,270**	**$123,168**	**$105,662**	**$23,053**

Table 5: Comparison of Hurricane Ian NFIP Claims across Representative Areas by Decade

Decade Built	Quantity	Average Total Claim	Average Building Claim	Average Contents Claim
Pre 1980	426	$191,378	$164,891	$38,265
1980s	344	$117,074	$100,584	$22,781
1990s	173	$73,857	$62,496	$13,017
2000s	205	$73,898	$61,791	$13,562
Post 2010	122	$54,894	$48,091	$9,651
All	**1,270**	**$123,168**	**$105,662**	**$23,053**

Table 6: Comparison of Hurricane Ian NFIP Claims across Representative Areas by Elevated versus Non-elevated Building Type

Type	Quantity	Average Total Claim	Average Building Claim	Average Contents Claim
Elevated	413	$50,287	$46,033	$5,077
Non-elevated	857	$158,291	$134,398	$33,133
All	**1,270**	**$123,168**	**$105,662**	**$23,053**

Table 7: Comparison of Hurricane Ian NFIP Claims across Representative Areas by Pre- versus Post-Firm Construction

Type	Quantity	Average Total Claim	Average Building Claim	Average Contents Claim
Pre-FIRM	632	$171,181	$148,708	$34,476
Post-FIRM	638	$75,607	$63,020	$14,548
All	**1,270**	**$123,168**	**$105,662**	**$23,053**

The remainder of this Appendix provides a brief description of the 12 Areas of Interest analyzed along with tables summarizing age of construction, building size, average building and contents coverage, average building and contents claims from Hurricane Ian, and other pertinent information.

With the amount of enclosure damage observed, it is important to keep in mind that NFIP coverage below the lowest floor of an *elevated building* is limited and does not cover finishes. Therefore, damage to enclosures is probably not fully represented in these statistics and damage in *elevated building*s is likely higher. In addition, several claims reached the maximum NFIP coverage limit and/or the maximum coverage for their policy. Not every NFIP flood insurance policy holder carries full building coverage ($250,000), nor do they carry full contents coverage ($100,000); actually, most policy holders do not carry contents at all because it is not required. While the current NFIP maximum coverage for building and contents is $250,000 and $100,000, not every policy had full coverage. In general, older construction had less coverage and newer construction had full coverage. The average building and contents coverage reflects the average across the polices analyzed in the respective table,

Note, pictures of houses throughout this Appendix are intended to provide representative examples of the size and type of single-family construction within each Area of Interest; the representative houses do ***not*** imply they had a flood insurance policy or claim.

Area of Interest No. 1.

Area of Interest No. 1 is a predominantly residential neighborhood with approximately 75 single-family houses along the Peace River in DeSoto County. Development in this area started in the 1950s. Approximately 75% of the houses were built before 1980 and about 15% were built post-2000. Almost the entire area is within the Special Flood Hazard Area, Zone AE with a BFE of 10.8 feet North American Vertical Datum of 1988 (NAVD 88) or higher. See Figure 3 for a general map of the area.

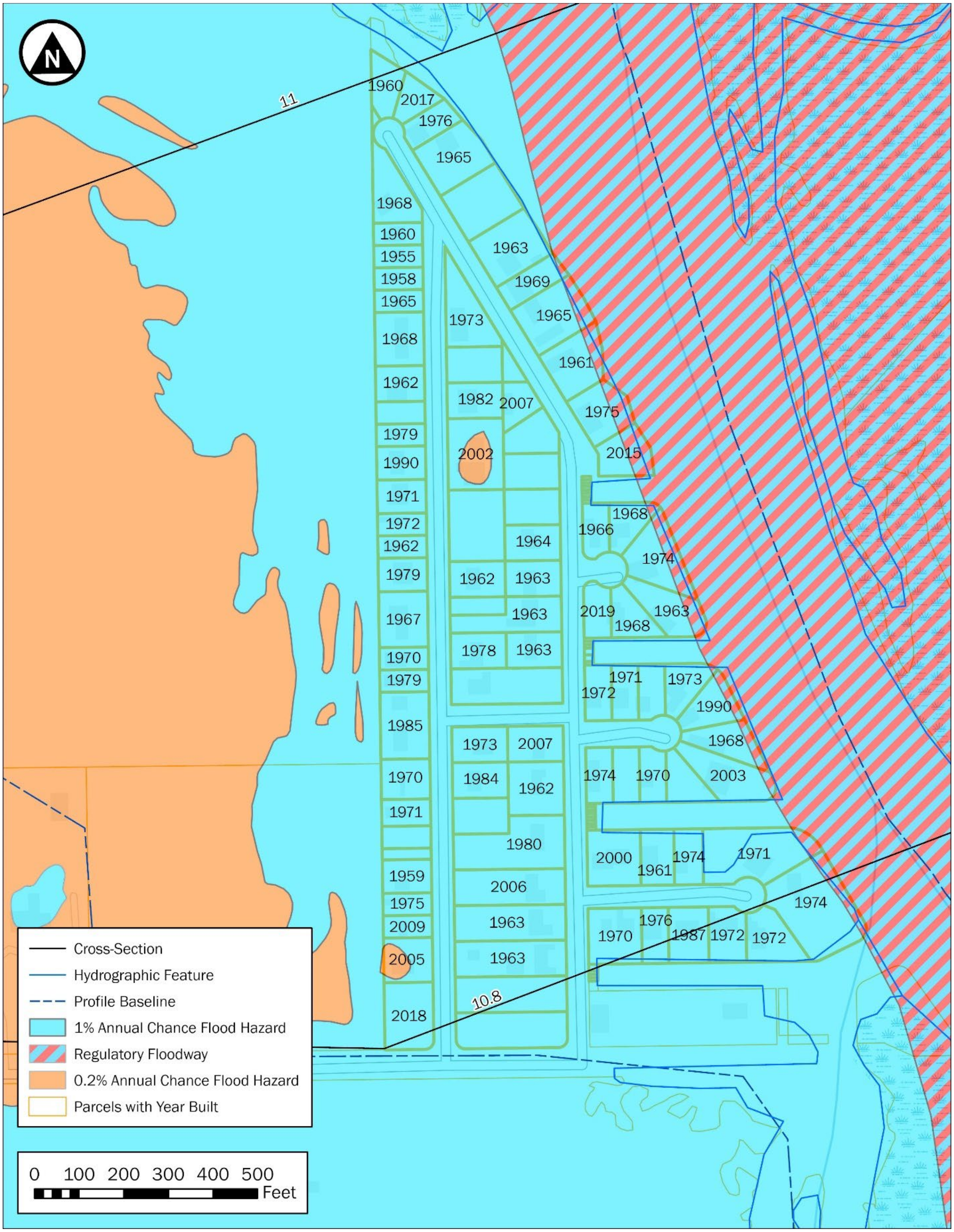

Figure 3: Map of Area of Interest No. 1

The houses in this area are predominantly non-elevated; in rare circumstances where the houses are elevated, areas below the lowest floor are enclosed (either partially or fully). Although no HWMs were identified by the MAT in the vicinity of this neighborhood, estimated flood levels were approximately 4 feet in older slab-on-grade houses based on interviews with homeowners during site visits. No major structural damage was observed; damage was predominantly related to interior walls and finishes, which had been or were being removed. Figure 4 provides examples of representative single-family houses within Area of Interest No. 1.

The 20% flood insurance take up rate (16 of 76 buildings with flood insurance) is not adequate to be considered truly representative, but this area was selected because it is consistent with observations seen within DeSoto, Highlands, Lake, Orange, Osceola, and other inland counties. The one *elevated building* claim in this area was built in 2003, is considerably larger than the average building size in the area (2,352 square feet versus 1,628 square feet) and had considerably less insured building damage compared to the other claims (less than $10,000 compared to an average building claim of over $115,000 for the other 15 insured properties in the area). Table 8 through Table 12 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 8 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Figure 4: Representative single-family houses in Area of Interest No. 1 from 1961 to 2019

Table 8: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 1

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	57	75%	1,311	14	88%	1,637
1980s	5	7%	1,368	1	6%	1,500
1990s	2	3%	1,648	0	0%	-
2000s	8	11%	1,593	1	6%	2,352
Post 2010	4	5%	2,021	0	0%	-
All	**76**		**1,390**	**16**		**1,673**

The “Quantity Max NFIP Coverage” column in Table 9 through Table 12 indicates the number of claims that reached the maximum NFIP coverage ($250,000 for building and $100,000 for contents). The “Quantity Max Building Coverage” and “Quantity Max Contents Coverage” indicate the number of claims that reached the maximum coverage under the policy. For example, if a homeowner opted for $200,000 in building coverage and the building claim payment was $200,000, then the claim reached the “Max Building Coverage” but did not meet “Max NFIP Coverage.” The same column headings are used throughout this Appendix for all 12 Areas of Interest.

Table 9: Hurricane Ian NFIP Building Claims within Area of Interest No. 1 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	14	$126,432	$119,311	1,637	$73.22	$238,346	0	4
1980s	1	$70,836	$70,836	1,500	$47.22	$246,073	0	0
1990s	0	$-	$-	-	$-	$296,833	0	0
2000s	1	$9,671	$9,671	2,352	$4.11	$242,397	0	0
Post 2010	0	$-	$-	-	$-	$250,000	0	0
All	**16**	**$115,660**	**$109,428**	**1,673**	**$67.28**	**$245,320**	**0**	**4**

Table 10: Hurricane Ian NFIP Contents Claims within Area of Interest No. 1 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	7	$154,083	$14,243	1,851	$8.70	$31,086	0	4
1980s	0	$-	$-	-	$-	$-	0	0
1990s	0	$-	$-	-	$-	$-	0	0
2000s	1	$9,671	$0	2,352	$0.00	$100,000	0	0
Post 2010	0	$-	$-	-	$-	$-	0	0
All	**8**	**$136,031**	**$12,463**	**1,914**	**$7.61**	**$39,700**	**0**	**4**

Table 11: Hurricane Ian NFIP Building Claims within Area of Interest No. 1 by Elevated versus Non-elevated Building Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	15	$122,726	$116,079	1,628	$71.49	$167,387	0	4
Elevated	1	$9,671	$9,671	2,352	$4.11	$250,000	0	0
All	**16**	**$115,660**	**$109,428**	**1,673**	**$67.28**	**$245,320**	**0**	**4**

Table 12: Hurricane Ian NFIP Contents Claims within Area of Interest No. 1 by Elevated versus Non-elevated Building Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	7	$154,083	$14,243	1,851	$8.70	$31,086	0	4
Elevated	1	$9,671	$0	2,352	$0.00	$100,000	0	0
All	**8**	**$136,031**	**$12,463**	**1,914**	**$7.61**	**$39,700**	**0**	**4**

Area of Interest No. 2.

Area of Interest No. 2 is approximately 15 miles upstream from the mouth of the Caloosahatchee River in Lee County. The area analyzed has approximately 120 single-family houses, with the first house built in 1957. Approximately 75% of the houses were built before 1980 and less than 10% were built post-2000. The entire area is within the Special Flood Hazard Area, with a majority of the area being Zone AE with a BFE of 7 to 9 feet NAVD 88, the southernmost part of the area is Zone VE with a BFE of 10 feet NAVD 88. Multiple USGS HWMs were measured in this area at 8 feet North American Vertical Datum of 1988 (NAVD 88). See Figure 5 for a general map of the area.

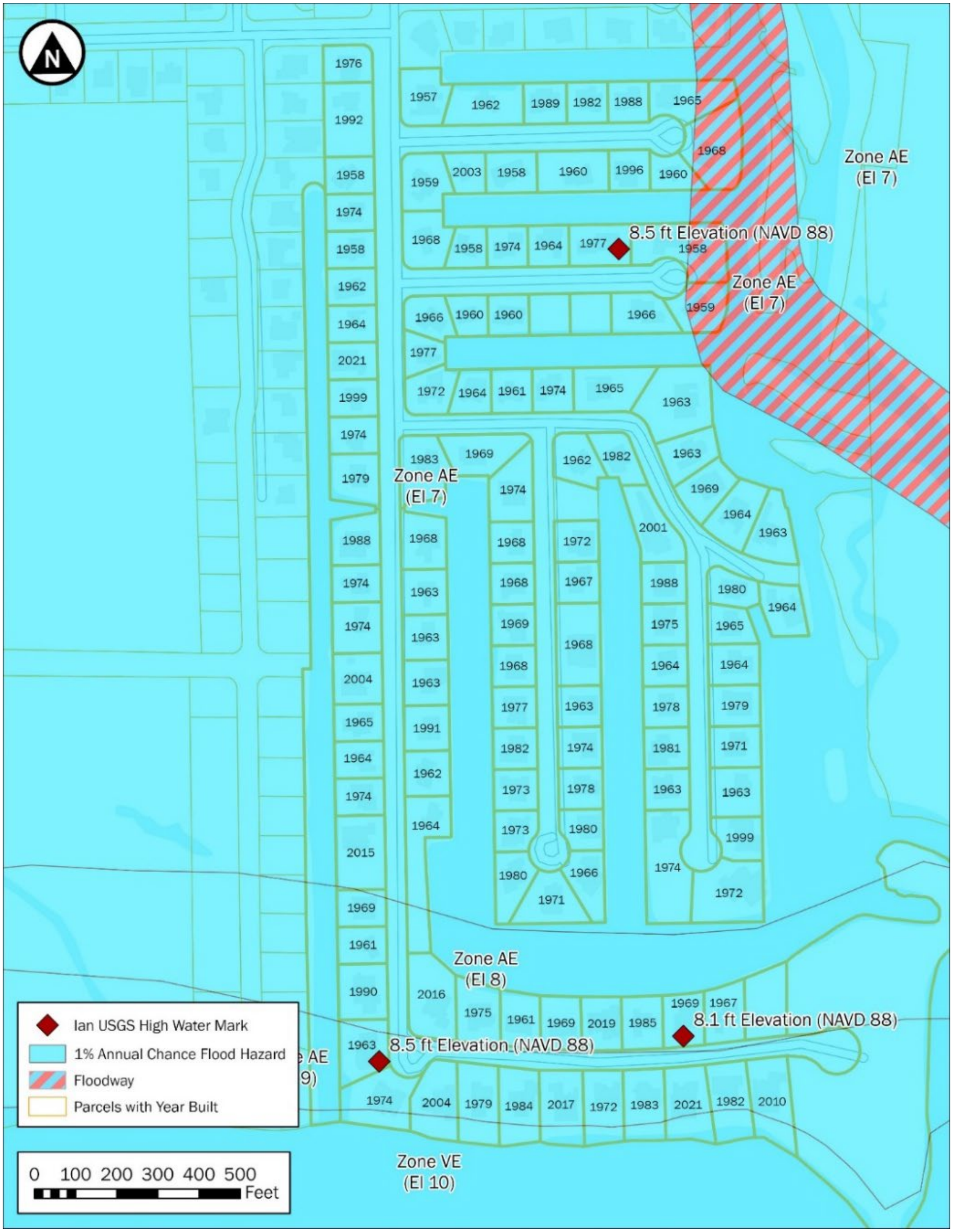

Figure 5: Map of Area of Interest No. 2

Most houses in this area are built on fill, with newer post-FIRM construction built to the required elevation at the time of construction. The elevation of older slab-on-grade houses is approximately 5 feet NAVD 88 based on recordings from surveyors embedded with the MAT; estimated flood depths in older houses were approximately 3 feet. No major structural damage was observed, damage was predominantly related to interior walls and finishes, which had been or were being removed. Figure 6 provides examples of representative single-family houses within Area of Interest No. 2.

The greater than 50% flood insurance take up rate (67 of 123 buildings with flood insurance) makes this area a good candidate for using claims to quantify flood damage. Although the MAT observed a very small percentage of *elevated buildings* within this Area of Interest (likely less than 5%), the houses with active insurance policies are all *non-elevated buildings*. The one post-2010 policy had a considerably lower average building claim compared to other houses ($15,933 compared to $148,058 average across the 67 buildings). However, the post-2010 average contents claim of over $65,000 is higher than any other decade and higher than the $34,574 across all 67 buildings. One potential explanation for this finding is that the property had full ($100,000) contents coverage and the average contents claim for houses with full contents coverage in this area is over $56,000. In addition, most of the living area within this house appears to be elevated on a stem wall foundation so the claim is likely associated with contents in the garage (not on the stem wall foundation) and other damage throughout the lowest floor. No noticeable difference was observed in the field or in the policy data for the few buildings in the floodway.

Table 13 through Table 17 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in

Table 13 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Figure 6: Representative single-family houses in Area of Interest No. 2 from the 1960s to 2020

Table 13: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 2

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	90	73%	1,765	50	75%	1,712
1980s	16	13%	1,981	9	13%	1,883
1990s	6	5%	2,098	4	6%	2,266
2000s	4	3%	2,731	3	4%	2,986
Post 2010	7	6%	2,591	1	1%	2,433
All	123		1,887	67		1,836

Table 14: Hurricane Ian NFIP Building Claims within Area of Interest No. 2 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	50	$169,914	$150,212	1,712	$88.49	$238,346	5	3
1980s	9	$202,608	$165,269	1,883	$88.93	$246,073	0	0
1990s	4	$176,104	$132,380	2,266	$61.05	$296,833	0	0
2000s	3	$134,979	$125,477	2,986	$43.06	$242,397	0	0
Post 2010	1	$81,786	$15,933	2,433	$6.55	$250,000	0	0
All	**67**	**$171,796**	**$148,058**	**1,836**	**$83.65**	**$245,320**	**5**	**3**

Table 15: Hurricane Ian NFIP Contents Claims within Area of Interest No. 2 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	31	$189,932	$31,777	1,792	$17.08	$50,065	1	13
1980s	7	$211,576	$48,008	1,929	$26.11	$82,143	0	1
1990s	4	$176,104	$43,724	2,266	$19.87	$71,475	1	1
2000s	3	$134,979	$9,502	2,986	$3.09	$40,333	0	0
Post 2010	1	$81,786	$65,853	2,433	$27.07	$100,000	0	0
All	**46**	**$186,088**	**$34,574**	**1,946**	**$18.00**	**$57,259**	**2**	**15**

Table 16: Hurricane Ian NFIP Building Claims within Area of Interest No. 2 by Elevated versus Non-elevated Building Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	67	$171,796	$148,058	1,836	$83.65	$232,296	5	3
Elevated	0	$-	$-	-	$-	$-	0	0
All	**67**	**$171,796**	**$148,058**	**1,836**	**$83.65**	**$245,320**	**5**	**3**

Table 17: Hurricane Ian NFIP Contents Claims within Area of Interest No. 2 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	46	$186,088	$34,574	1,946	$18.00	$57,259	2	15
Elevated	0	$-	$-	-	$-	$-	0	0
All	**46**	**$186,088**	**$34,574**	**1,946**	**$18.00**	**$57,259**	**2**	**15**

Area of Interest No. 3.

Area of Interest No. 3 consists of approximately 140 single-family houses and is located on the southern portion of Pine Island in Lee County. Approximately 75% of the houses were built before 1980 and less than 10% were built post-2000. Development in this area started in the 1970s. Approximately 50% of the houses were built before 1990 and about 30% were built post-2000. The entire area is within the Special Flood Hazard Area, with a majority of the area being Zone AE with a BFE of 7 feet NAVD 88; the southern part of the area is Zone VE with a BFE of 10. A USGS HWM was measured in this area at approximately 8 feet NAVD 88. See Figure 7 for a general map of the area.

Figure 7: Map of Area of Interest No. 3

The houses in this area are a relatively even mixture of *elevated* and *non-elevated buildings*, with a slightly higher percentage of *non-elevated buildings*. Areas below the lowest floor are enclosed (either partially or fully) in two-thirds to three-quarters of the *elevated buildings*. No major structural damage was observed; damage was predominantly related to interior walls and finishes, which had been or were being removed. During site visits, homeowners reported 3 feet of water in non-elevated houses as well as in in enclosures, including garages below the lowest floor of elevated houses. Relative to the other 11 Areas of Interest, this area is closest to the hurricane track and houses had noticeable wind damage as well. Figure 8 provides examples of representative single-family houses within Area of Interest No. 3.

Figure 8: Representative single-family houses in Area of Interest No. 3 from 1971 to 2018

The 48% flood insurance take up rate (70 of 145 buildings with flood insurance), a mixture of older and new construction (50% before and after 1990) along with a relatively consistent age of construction distribution between total and insured properties, and an almost even mixture of *elevated* and *non-elevated buildings* (33 of the 70 insured buildings are elevated) makes this area a good candidate for using claims to compare flood damage, particularly to compare newer versus older construction. Based on field observations, older houses were considerably more damaged than newer houses and the claims data are consistent with that finding, with the average pre-1980 building claim being almost 4.5 times the average post-1980 building claim ($116,595 versus about $26,050). One noticeable trend observed in the field was the number of *non-elevated buildings* in newer, most recent construction. The NFIP policy data substantiated this trend as 5 of 6 (83%) post-2010 buildings are rated as non-elevated; only 6 of 29 (21%) houses built from 1990 to 2010 are rated as non-elevated. This construction practice likely explains the increase in the average building claim from the 1990s and 2000s, $9,106 and $5,979, to $54,726 in post-2010 construction. Overall, the building claims are consistent with observations made in the field as average damages for *non-elevated buildings* are more than six times greater than *elevated buildings* ($79,980 vs $12,314). Table 18 through Table 22 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 18 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 18: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 3

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	38	26%	1,449	17	24%	1,434
1980s	38	26%	1,577	18	26%	1,602
1990s	27	19%	1,934	19	27%	1,885
2000s	19	13%	2,306	10	14%	2,006
Post 2010	23	16%	2,140	6	9%	1,854
All	**145**		**1,795**	**70**		**1,717**

Table 19: Hurricane Ian NFIP Building Claims within Area of Interest No. 3 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	17	$140,675	$116,595	1,434	$84.56	$238,346	0	0
1980s	18	$53,133	$45,501	1,602	$30.35	$246,073	0	0
1990s	19	$10,674	$9,106	1,885	$5.21	$296,833	0	0
2000s	10	$6,079	$5,979	2,006	$3.01	$242,397	0	0
Post 2010	6	$75,326	$54,726	1,854	$27.81	$250,000	0	0
All	**70**	**$58,049**	**$48,033**	**1,717**	**$32.57**	**$245,320**	**0**	**0**

Table 20: Hurricane Ian NFIP Contents Claims within Area of Interest No. 3 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	15	$147,852	$27,291	1,468	$17.47	$48,720	0	4
1980s	15	$56,060	$9,158	1,569	$6.41	$57,640	0	2
1990s	17	$11,651	$1,753	1,891	$1.07	$62,088	0	0
2000s	10	$6,079	$100	2,006	$0.04	$79,990	0	0
Post 2010	5	$89,633	$24,720	1,869	$12.18	$95,800	0	0
All	**62**	**$60,737**	**$11,309**	**1,727**	**$7.06**	**$63,384**	**0**	**6**

Table 21: Hurricane Ian NFIP Building Claims within Area of Interest No. 3 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	37	$98,167	$79,890	1,621	$53.83	$238,505	0	0
Elevated	33	$13,068	$12,314	1,826	$8.73	$243,636	0	0
All	**70**	**$58,049**	**$48,033**	**1,717**	**$32.57**	**$245,320**	**0**	**0**

Table 22: Hurricane Ian NFIP Contents Claims within Area of Interest No. 3 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	32	$104,493	$21,132	1,616	$12.99	$60,394	0	5
Elevated	30	$14,064	$830	1,846	$0.72	$66,573	0	1
All	**62**	**$60,737**	**$11,309**	**1,727**	**$7.06**	**$63,384**	**0**	**6**

Area of Interest No. 4.

This Area of Interest currently has approximately 170 single-family houses with development starting in 1959 and continuing today with several houses under construction. The area is located along San Carlos Bay just north of Estero Island in Lee County and was largely developed from east to west with the western most street still under development. The entire area is within the Special Flood Hazard Area, Zone AE with a BFE of 12 feet NAVD 88. Note, a new effective FIRM was released for this area in November 2022. The primary difference between the 2008 and 2022 FIRMs is that the 2022 FIRM designates areas of the neighborhood within the Limit of Moderate Wave Action (Coastal A Zone). Two USGS HWMs were measured in this area at 12 feet NAVD 88. See Figure 9 for a general map of the area.

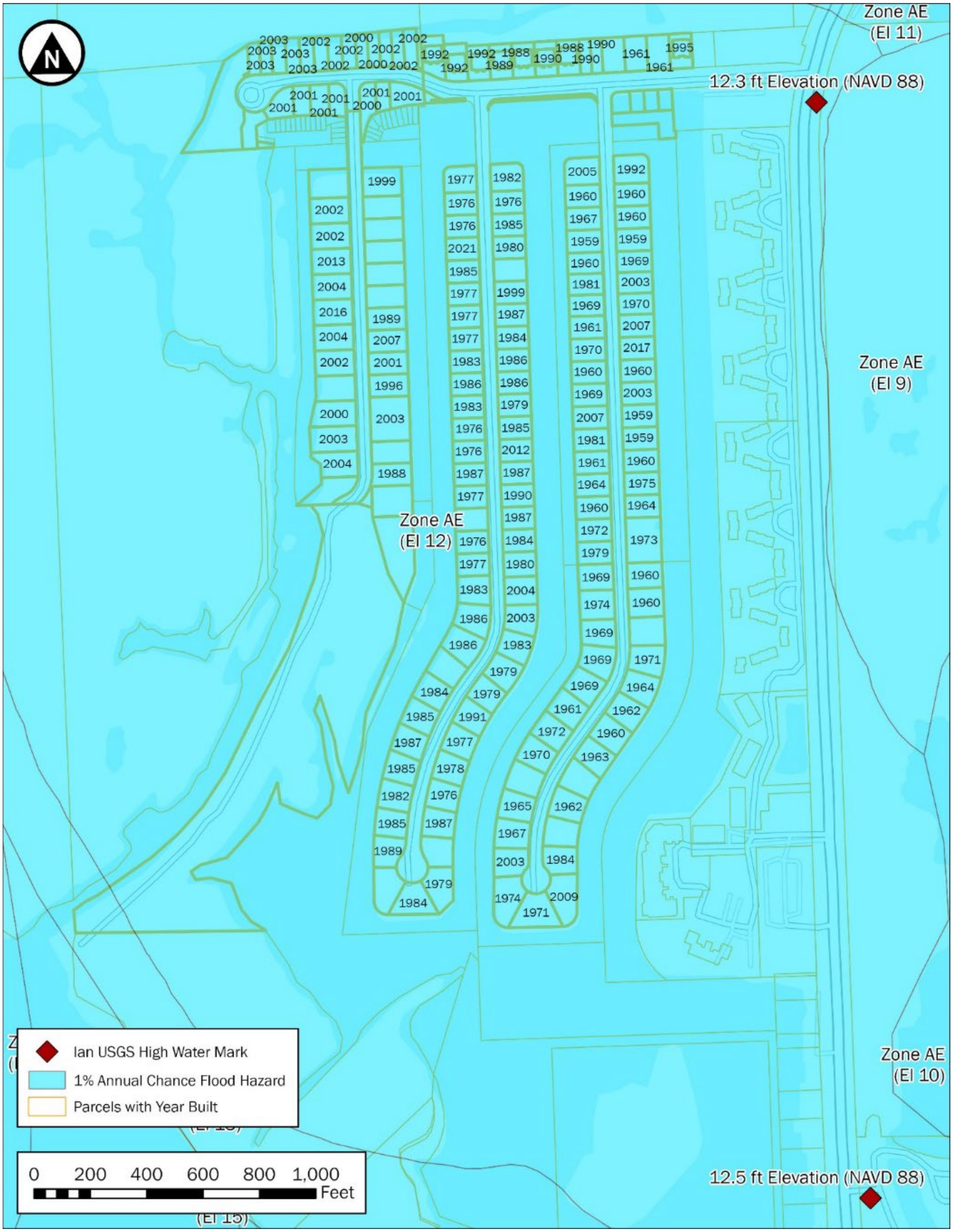

Figure 9: Map of Area of Interest No. 4

The MAT studied this area further because construction practices are considerably different along one street compared to the others. Along the eastern most street, the first street developed in the area, most houses are slab-on-grade, whereas on each of the other streets, houses are predominantly elevated on foundation walls, posts, piers, pilings, or columns. Figure 10 provides examples of representative single-family houses within Area of Interest No. 4.

Figure 10: Representative single-family houses in Area of Interest No. 4 from the 1960s to present

Conditions in this area during Hurricane Ian included inundation from surge with some evidence of velocity and wave action, including boats and other flood-borne debris impacting buildings. Ground elevations generally ranged from 4 to 6 feet NAVD 88, and homeowners reported flood depths of 6 to 8 feet of water in their ground floors/enclosures. As a note, most *elevated buildings* throughout the area had enclosures. In addition, more than 60% of the houses (106 of 171) had an active flood insurance policy, and the distribution of the age of construction for these insured houses was relatively consistent with the entire area. The MAT Survey Team was able to collect some representative elevations including garage, lowest floor, and mechanical equipment along the eastern most street; non-elevated houses were estimated at 6 feet NAVD 88, and the lowest floor elevations in *elevated buildings* were 11 feet NAVD

88 or higher. Building types were noticeably different along the three primary streets in this area, with the eastern most street having mostly slab-on-grade/*non-elevated buildings*; the center street having buildings elevated on foundation walls, posts, piers, pilings, or columns; and the western most street with newest construction having a relatively even mixture of *elevated* and *non-elevated buildings*. The primary difference between the eastern most street and the center street is one has 6% *elevated buildings* and the other has 74%. Table 23 and Table 24 quantify the *non-elevated* and *elevated buildings* by street and decade built. The building type of insured buildings is consistent with building type observations in the field with 94% of the insured buildings on the eastern street being *non-elevated buildings*(33 of 35), 26% along the center street (10 of 38), and 30% along the eastern street (4 of 13).

Table 23: Number of *Non-elevated Buildings* by Street in Area of Interest No. 4

Street	Non-Elevated Buildings	Pre 1980	1980s	1990s	2000s	Post 2010
East	33	26	3	1	3	0
Center	10	3	6	0	0	1
West	4	0	0	0	2	2
All	**47**	**29**	**9**	**1**	**5**	**3**

Table 24: Number of *Elevated Buildings* by Street in Area of Interest No. 4

Street	Elevated Buildings	Pre 1980	1980s	1990s	2000s	Post 2010
East	2	0	0	0	2	0
Center	28	8	18	0	2	0
West	9	0	1	1	7	0
All	**39**	**8**	**19**	**1**	**11**	**0**

The MAT visited this area in January and despite a considerable amount of immediate repairs and debris removal having been completed, the team observed a considerable amount of damage along the eastern most street primarily because of the predominant building type—a high percentage of *non-elevated buildings*. The policy data supports this observation as the average building claim along the eastern most street was more than twice the average when compared to the other two streets ($200,069 versus approximately $87,118). The center street with more *elevated buildings* had an average building claim less than half the eastern most street; it had less than half as much construction and demolition debris as well. Table 25 provides a comparison of the average total claim, building claim, and building size per street.

Table 25: Hurricane Ian NFIP Building Claims within Area of Interest No. 4 by Street

Street	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Claim per square foot	Quantity Max NFIP Coverage	Quantity Max Building Coverage
East	35	$228,866	$200,069	2,329	$100.69	18	4
Center	38	$99,272	$87,830	2,303	$40.50	1	0
West	13	$103,128	$85,036	3,444	$25.55	2	0
All	**86**	**$152,597**	**$133,086**	**2,486**	**$62.74**	**21**	**4**

Because flood insurance coverage is fairly limited below the lowest floor of an *elevated building*, the claims data do not reflect the full extent of damage. To further attempt to quantify and compare flood damage, the MAT requested debris removal data from Lee County. The County provided the location and type of each debris load removed throughout unincorporated Lee County; however, the volume for each load was not readily available. The eastern and center street in this Area of Interest have approximately the same number of buildings (58 along eastern street and 56 along center), so the MAT compared the number of construction and demolition (C&D) loads removed by the County along each street. More than twice as many C&D debris loads, 282 vs 125, were removed along the eastern street compared to the center street in this Area of Interest. The amount of debris is consistent with observations in the field and building type (elevated vs non-elevated) made a significant difference in building performance. While *elevated building* construction practices were effective at reducing damage, damage was still associated with them, particularly in enclosures below the lowest floor where a lack of flood damage–resistant materials was prevalent. See Figure 11 for a map of C&D debris loads in Area of Interest No. 4.

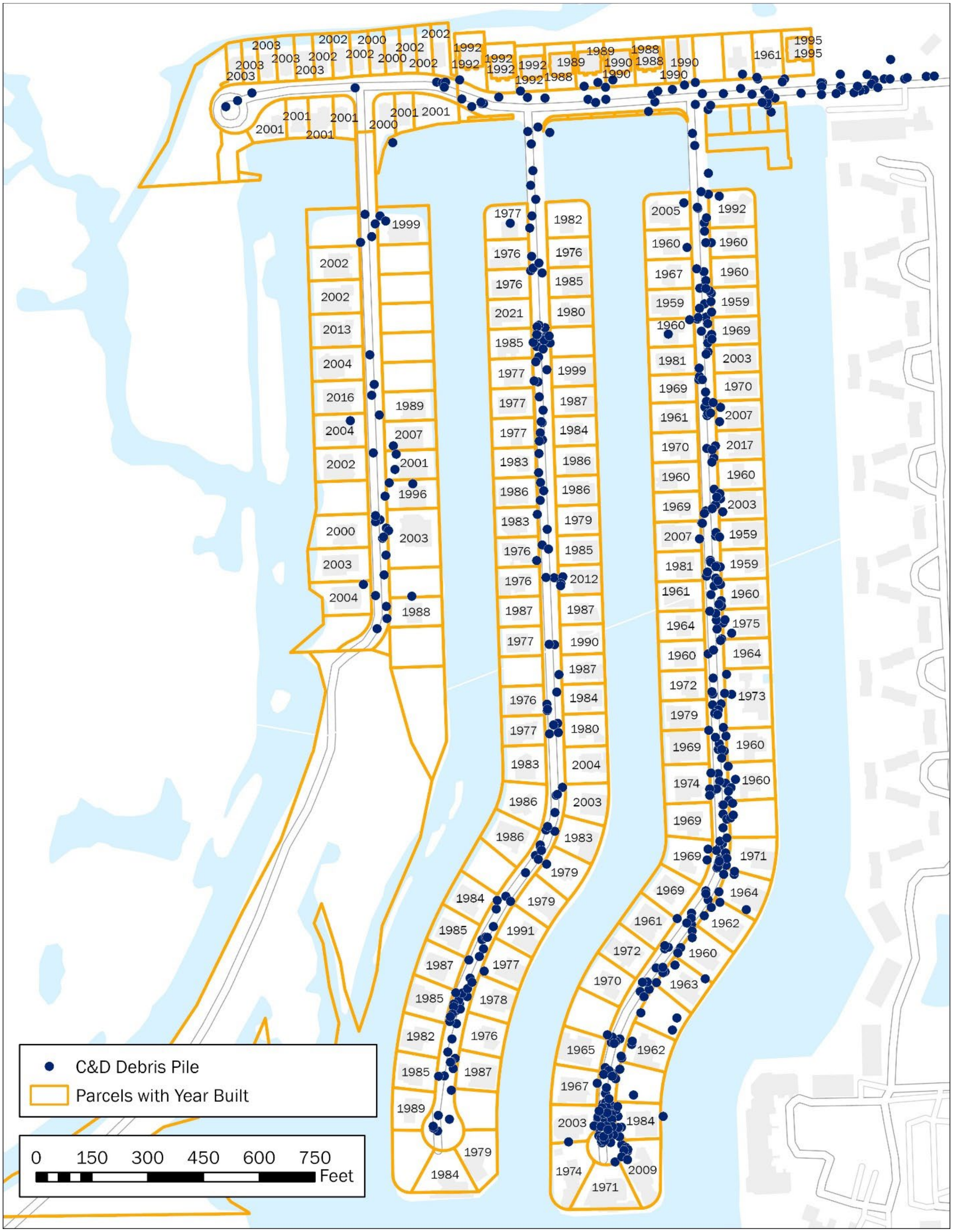

Figure 11: Map of C&D debris loads in Area of Interest No. 4

Flood insurance claims data across the entire Area of Interest indicate differences in damage based on year built and show a significant difference in damage based on *elevated* vs *non-elevated building* with the average building claim for a *non-elevated building* being more than triple that of an *elevated building* ($179,150 versus $54,584). The tables also illustrate an increase in average building size over time, which is expected based on current construction practices. The three post-2010 houses have a considerably higher average building claim compared to most post-1980 construction ($146,847 versus approximately $72,470). All three of these are *non-elevated buildings*, which likely explains the increase (compared to the 30 insured buildings constructed in the 2000s, when 22, or 73%, were *elevated buildings*). Table 26 through Table 30 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 26 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 26: Number of Buildings and Insurance Policies along with Average Building Size in Area of Interest No. 4

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	67	39%	2,047	37	35%	2,040
1980s	41	24%	2,216	30	28%	2,235
1990s	18	11%	2,232	6	6%	2,038
2000s	40	23%	2,877	30	28%	2,914
Post 2010	5	3%	2,768	3	3%	3,031
All	**171**		**2,322**	**106**		**2,371**

Table 27: Hurricane Ian NFIP Building Claims within Area of Interest No. 4 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	37	$213,346	$186,897	2,040	$97.71	$238,346	14	3
1980s	30	$86,425	$77,029	2,235	$36.59	$246,073	3	0
1990s	6	$75,165	$71,330	2,038	$32.28	$296,833	1	0
2000s	30	$79,713	$68,141	2,914	$23.90	$242,397	3	1
Post 2010	3	$173,149	$146,847	3,031	$47.17	$250,000	0	0
All	**106**	**$130,645**	**$114,517**	**2,371**	**$54.39**	**$245,320**	**21**	**4**

Table 28: Hurricane Ian NFIP Contents Claims within Area of Interest No. 4 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	30	$215,454	$32,621	2,095	$15.95	$63,163	2	14
1980s	24	$77,711	$11,745	2,282	$6.34	$83,392	1	1
1990s	4	$90,111	$5,752	2,168	$2.50	$89,000	0	0
2000s	29	$81,135	$11,971	2,959	$3.47	$95,169	1	0
Post 2010	2	$172,759	$39,453	2,972	$12.97	$100,000	0	0
All	**89**	**$127,950**	**$19,209**	**2,450**	**$8.62**	**$81,036**	**4**	**15**

Table 29: Hurricane Ian NFIP Building Claims within Area of Interest No. 4 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	51	$205,505	$179,150	2,281	$86.05	$241,545	21	3
Elevated	55	$61,230	$54,584	2,454	$25.04	$239,729	0	1
All	**106**	**$130,645**	**$114,517**	**2,371**	**$54.39**	**$245,320**	**21**	**4**

Table 30: Hurricane Ian NFIP Contents Claims within Area of Interest No. 4 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	40	$209,144	$33,603	2,365	$14.14	$70,078	3	14
Elevated	49	$61,670	$7,459	2,520	$4.12	$89,982	1	1
All	**89**	**$127,950**	**$19,209**	**2,450**	**$8.62**	**$81,036**	**4**	**15**

Area of Interest No. 5.

Area of Interest No. 5 is a residential subdivision with approximately 150 single-family houses along the Tenmile Canal in Lee County. Development in this area started in the 1980s with approximately 70% of the houses built in that first decade and less than 10% built post-2000. The entire area is within the Special Flood Hazard Area, Zone AE with a BFE of 10 feet NAVD 88, which is the same elevation recorded by the USGS at a HWM immediately southeast of this subdivision. See Figure 12 for a general map of the area.

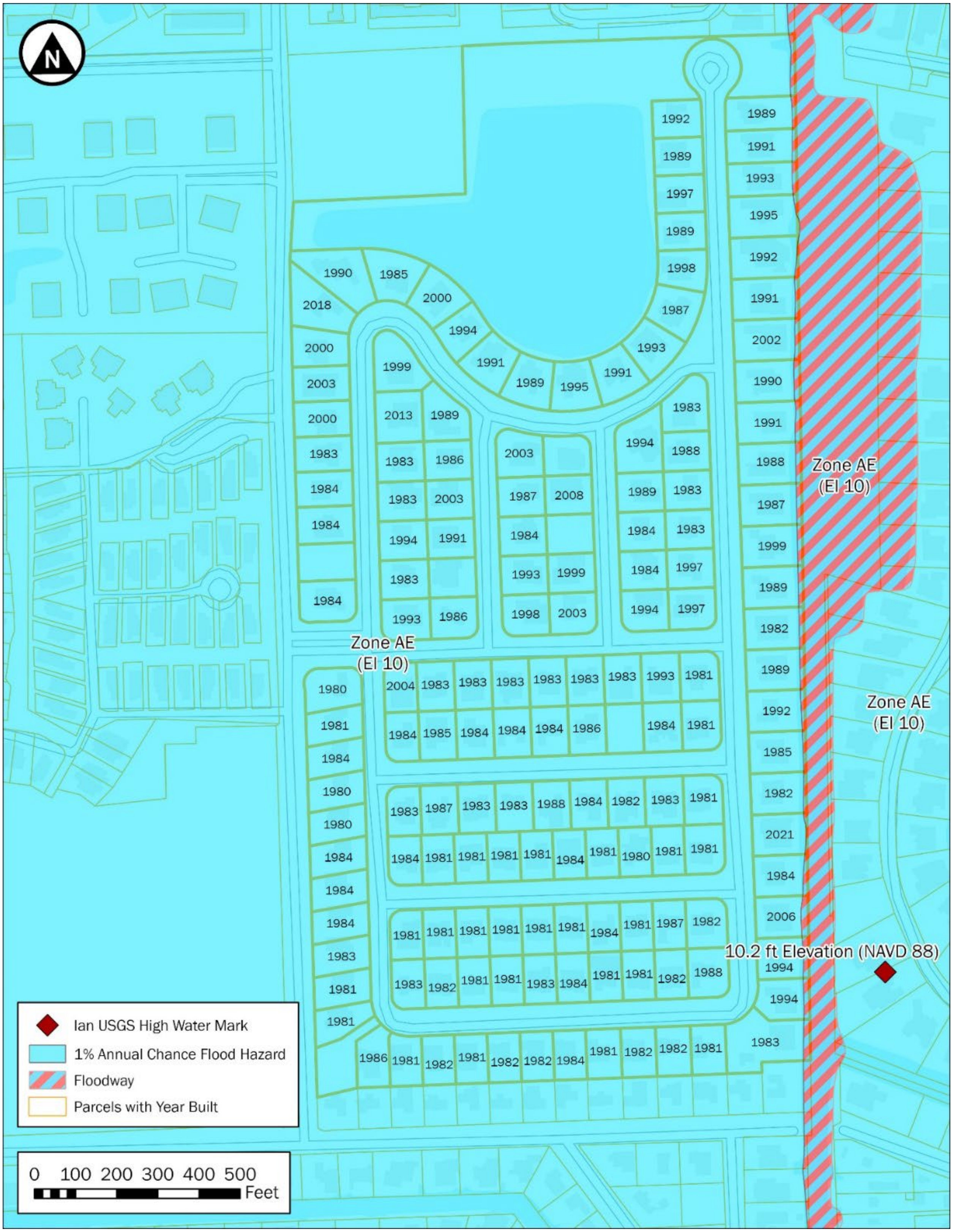

Figure 12: Map of Area of Interest No. 5

Most houses in this area are built on fill, in some cases 3 or more feet of fill, with newer post-FIRM construction built to the required elevation at the time of construction. Approximately 10% of the houses are *elevated buildings* with lowest floors at or above the BFE. Estimated flood levels were approximately 4 feet in older slab-on-grade houses based on interviews with homeowners during site visits. Some reported more than 5 feet of water in their houses. Figure 13 provides examples of representative single-family houses within Area of Interest No. 5.

Figure 13: Representative single-family houses in Area of Interest No. 5 from the 1980s to present

Non-elevated buildings had extensive interior damage, whereas damage to *elevated buildings* varied based on the amount elevated and the use flood damage–resistant materials in enclosures. Building performance in this subdivision was generally as expected with newer *elevated buildings* having considerably less damage than older *non-elevated buildings*. Considering the HWM is equal to the BFE (10 feet NAVD 88) in this area, a primary differentiator was whether or not the building was constructed to exceed the NFIP minimum elevation requirement. The policy data across the 103 buildings with polices in this area, a 65% insurance take up rate, was consistent with the observations in the field. The average building claims for houses built after 1990 are about half those built in the 1980s and building claims for the limited number of *elevated buildings* are about half those for *non-elevated buildings*, which is the predominant building type in this area. Table 31 through Table 35 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 31 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 31: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 5

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	0	0%	-	0	0%	-
1980s	111	70%	1,794	73	71%	1,803
1990s	32	20%	2,369	19	18%	2,397
2000s	12	8%	2,636	8	8%	2,688
Post 2010	3	2%	2,118	3	3%	2,118
All	**158**		**1,981**	**103**		**1,991**

Table 32: Hurricane Ian NFIP Building Claims within Area of Interest No. 5 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	0	$-	$-	-	$-	$238,346	0	0
1980s	73	$168,660	$149,791	1,803	$88.25	$246,073	6	5
1990s	19	$92,027	$77,254	2,397	$34.43	$296,833	0	0
2000s	8	$77,583	$66,437	2,688	$29.11	$242,397	0	0
Post 2010	3	$19,130	$19,130	2,118	$8.76	$250,000	0	0
All	**103**	**$143,095**	**$126,131**	**1,991**	**$71.42**	**$245,320**	**6**	**5**

Table 33: Hurricane Ian NFIP Contents Claims within Area of Interest No. 5 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	0	$-	$-	-	$-	$-	0	0
1980s	45	$178,574	$30,610	1,804	$17.90	$54,038	0	21
1990s	16	$102,174	$17,542	2,423	$7.92	$74,919	0	0
2000s	5	$73,548	$17,835	2,504	$7.52	$100,000	0	0
Post 2010	0	$-	$-	-	$-	$-	0	0
All	**66**	**$152,097**	**$26,474**	**2,007**	**$14.70**	**$62,582**	**0**	**21**

Table 34: Hurricane Ian NFIP Building Claims within Area of Interest No. 5 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	96	$147,494	$129,698	1,952	$74.13	$239,982	6	5
Elevated	7	$82,765	$77,204	2,529	$34.17	$243,429	0	0
All	**103**	**$143,095**	**$126,131**	**1,991**	**$71.42**	**$245,320**	**6**	**5**

Table 35: Hurricane Ian NFIP Contents Claims within Area of Interest No. 5 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	62	$153,591	$27,554	1,957	$15.36	$62,135	0	21
Elevated	4	$128,925	$9,732	2,790	$4.35	$69,500	0	0
All	**66**	**$152,097**	**$26,474**	**2,007**	**$14.70**	**$62,582**	**0**	**21**

Area of Interest No. 6.

Area of Interest No. 6 consists of approximately 150 single-family houses and is located near the center of Sanibel Island north of W Gulf Drive in Lee County. Based on parcel data, the first house constructed in this area was built in 1955. Approximately 50% of the houses were built in the 1980s, and less than 15% were built post 2000. The entire area is within the Special Flood Hazard Area, with a majority of the area in Zone AE with a BFE of 8 to 10 feet NAVD 88. Two USGS HWMs were measured in this area and ranged from 9 to 11 feet NAVD 88. See Figure 14 for a general map of the area.

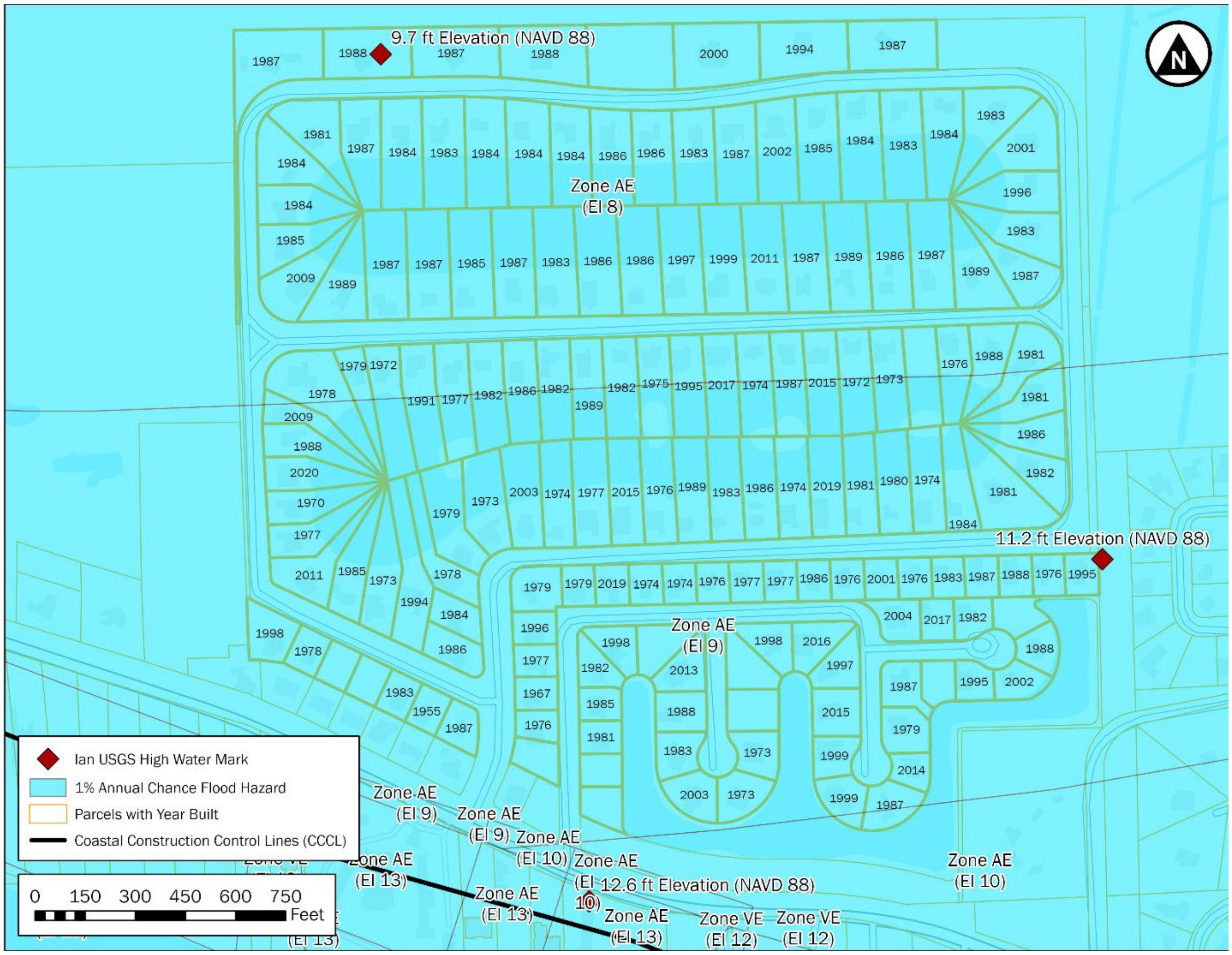

Figure 14: Map of Area of Interest No. 6

The houses in this area are predominantly elevated, likely because of the proximity to the coast as this Area of Interest is just north of Gulf Drive on Sanibel Island. Approximately 4 feet of water was reported by homeowners in garages and other enclosures below *elevated buildings*. Limited to no damage was reported above the lowest floor of the *elevated buildings* visited. Some structural damage was observed to *non-elevated buildings* and a few slab-on-grade houses were already demolished. Figure 15 provides examples of representative single-family houses within Area of Interest No. 6.

Source: NSF StEER

Figure 15: Representative single-family houses in Area of Interest No. 6 from 1970 to 2020

The performance of *elevated buildings* was likely influenced by the proximity of the area to the coast, as some buildings appeared to be constructed to meet Zone V requirements even though the area was Zone AE. In general, building performance was consistent with what would be expected, especially the performance of *elevated buildings* with an average building claim more than 3.5 times less than *non-elevated buildings* ($40,023 versus $144,842). There are 11 post-2010 buildings, 8 elevated and 3 non-elevated; the average building claim for the *elevated buildings* is $34,585, or $13.53 per square foot, which is relatively close to the $11.31 per square foot for houses built in the 2000s in this area, compared to $190,939 for the three *non-elevated buildings*. The building type also likely explains the increased average building claim in post-2010 buildings compared to previous decades (post-2010 average is $77,227 versus $25,453 for buildings built in 2000s). Table 36 through Table 40 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 36 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 36: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 6

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	38	25%	1,807	19	19%	1,906
1980s	76	50%	1,804	46	46%	1,771
1990s	16	10%	2,234	14	14%	2,252
2000s	10	7%	2,447	10	10%	2,447
Post 2010	13	8%	2,599	11	11%	2,527
All	**153**		**1,959**	**100**		**2,015**

Table 37: Hurricane Ian NFIP Building Claims within Area of Interest No. 6 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	19	$224,819	$189,550	1,906	$105.54	$238,346	5	0
1980s	46	$44,742	$41,045	1,771	$23.25	$246,073	0	0
1990s	14	$50,392	$47,012	2,252	$20.39	$296,833	0	0
2000s	10	$25,453	$25,453	2,447	$11.31	$242,397	0	0
Post 2010	11	$88,625	$77,227	2,527	$30.27	$250,000	0	0
All	**100**	**$82,646**	**$72,517**	**2,015**	**$38.07**	**$245,320**	**5**	**0**

Table 38: Hurricane Ian NFIP Contents Claims within Area of Interest No. 6 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	15	$242,706	$44,675	1,894	$24.11	$66,893	15	$242,706
1980s	43	$47,230	$3,954	1,759	$2.22	$84,067	43	$47,230
1990s	13	$40,616	$3,639	2,259	$1.49	$93,231	13	$40,616
2000s	9	$22,923	$0	2,564	$0.00	$94,444	9	$22,923
Post 2010	9	$100,004	$13,931	2,534	$6.26	$100,000	9	$100,004
All	**89**	**$82,088**	**$11,380**	**2,014**	**$5.99**	**$85,172**	**89**	**$82,088**

Table 39: Hurricane Ian NFIP Building Claims within Area of Interest No. 6 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	31	$172,090	$144,842	1,968	$75.92	$242,710	5	0
Elevated	69	$42,461	$40,023	2,036	$21.06	$250,000	0	0
All	**100**	**$82,646**	**$72,517**	**2,015**	**$38.07**	**$245,320**	**5**	**0**

Table 40: Hurricane Ian NFIP Contents Claims within Area of Interest No. 6 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	26	$177,674	$32,488	2,006	$16.72	$73,596	1	4
Elevated	63	$42,640	$2,669	2,018	$1.56	$89,949	0	3
All	**89**	**$82,088**	**$11,380**	**2,014**	**$5.99**	**$85,172**	**1**	**7**

Area of Interest No. 7.

Area of Interest No. 7 consists of approximately 220 single-family houses and is located near the western end of Estero Island/Fort Myers Beach north of Estero Boulevard in Lee County. Based on parcel data, the first house constructed in this area was built in 1939. Approximately 75% of the houses were built before 1980, and less than 20% were built post 2000. The entire area is within the Special Flood Hazard Area, with a majority of the area in Zone AE with a BFE of 10 to 13 feet NAVD 88; the southernmost part of the area is Zone VE with a BFE of 14 feet NAVD 88. A USGS HWM was measured in this area at approximately 13 feet NAVD 88. See Figure 16 for a general map of the area.

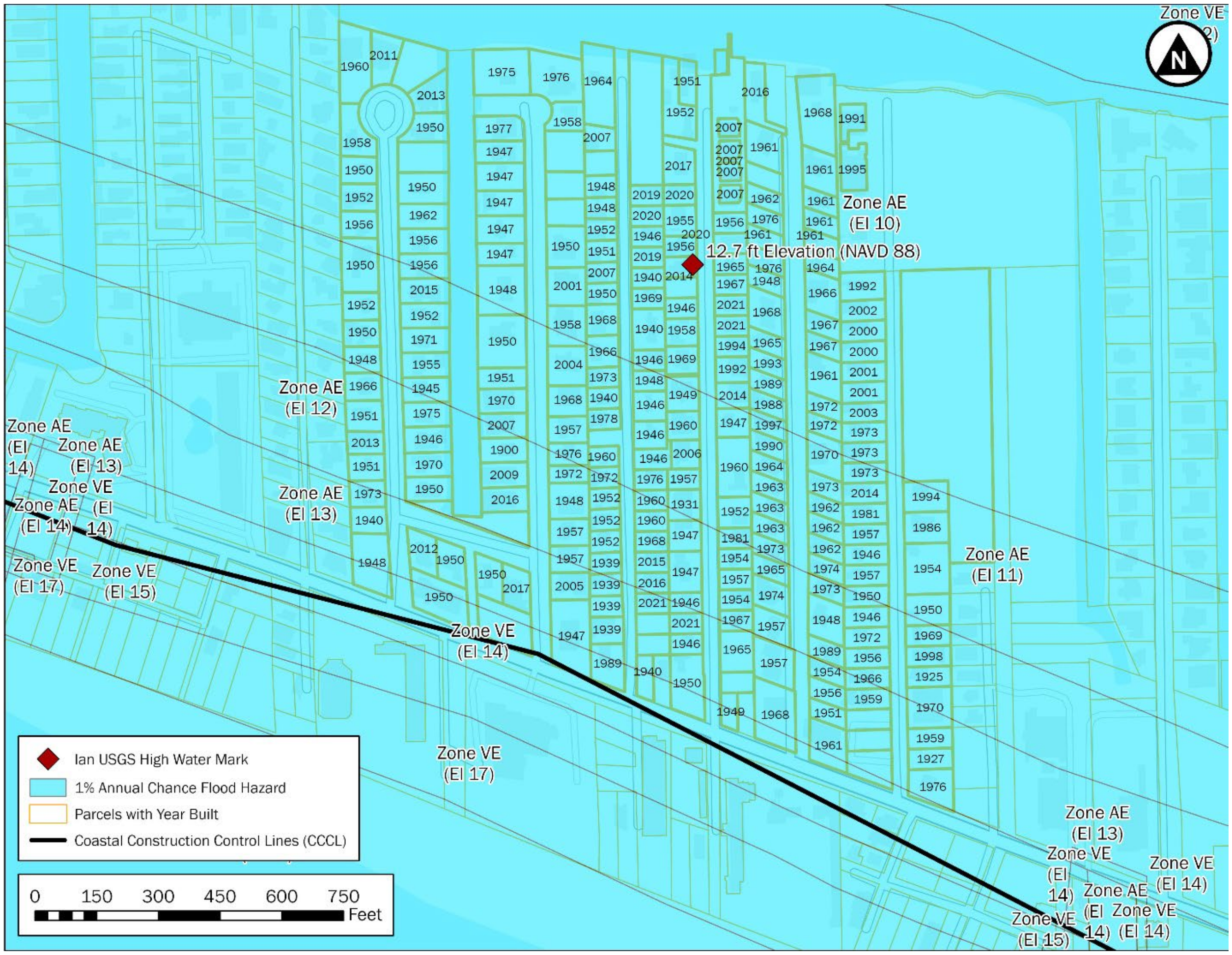

Figure 16: Map of Area of Interest No. 7

The houses in this area are a relatively even mixture of *elevated* and *non-elevated buildings*, with the pre-1980 construction being predominantly non-elevated and the newer post-1980 construction being predominantly *elevated buildings*. Areas below the lowest floor were enclosed (either partially or fully) in two-thirds to three-quarters of the *elevated buildings*. During site visits, homeowners reported 8 feet of water inundation in non-elevated houses and enclosures below *elevated buildings* during the hurricane. Figure 17 provides examples of representative single-family houses within Area of Interest No. 7.

Figure 17: Representative single-family houses in Area of Interest No. 7 from 1946 to 2021

Some structural damage was observed in this area, especially to slab-on-grade, single-story construction and older *elevated buildings* with insufficient loads or foundations to withstand the storm surge on Estero Island; in some cases, mainly older *non-elevated buildings*, houses were being demolished. Most buildings, unless sufficiently elevated above the floodwaters, had extensive interior damage with finishes having been or being removed. Some of highest flood depths observed by the MAT were noted in this area; however, like other areas, observed building performance was generally as expected with newer *elevated buildings* having considerably less damage than older *non-elevated buildings*. The policy data, including the average building claims being consistently lower for newer houses, reinforced observations made in the field. Note this area had one of the highest average building claims per square foot for pre-1980 construction ($131.18), which was expected considering the excessive flood depths and the higher percentage of older *non-elevated buildings*. Table 41 through Table 45 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 41 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 41: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 7

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	163	74%	1,278	65	64%	1,294
1980s	6	3%	1,550	3	3%	1,433
1990s	9	4%	1,734	7	7%	1,246
2000s	20	9%	1,872	12	12%	1,714
Post 2010	23	10%	1,950	14	14%	1,942
All	**221**		**1,427**	**101**		**1,434**

Table 42: Hurricane Ian NFIP Building Claims within Area of Interest No. 7 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	65	$161,844	$152,106	1,294	$131.18	$238,346	7	17
1980s	3	$136,388	$135,563	1,433	$88.04	$246,073	1	0
1990s	7	$49,809	$49,809	1,246	$43.42	$296,833	0	0
2000s	12	$14,272	$13,997	1,714	$7.98	$242,397	0	0
Post 2010	14	$13,602	$13,602	1,942	$7.70	$250,000	0	0
All	**101**	**$115,242**	**$108,917**	**1,434**	**$92.07**	**$240,603**	**8**	**17**

Table 43: Hurricane Ian NFIP Contents Claims within Area of Interest No. 7 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	32	$162,020	$19,176	1,191	$18.67	$27,969	0	20
1980s	1	$86,788	$2,474	990	$2.50	$33,600	0	0
1990s	6	$34,071	$0	1,270	$0.00	$35,883	0	0
2000s	9	$12,275	$366	1,787	$0.28	$49,578	0	0
Post 2010	9	$17,084	$0	1,871	$0.00	$59,533	0	0
All	**57**	**$100,704**	**$10,867**	**1,397**	**$10.57**	**$37,296**	**0**	**20**

Table 44: Hurricane Ian NFIP Building Claims within Area of Interest No. 7 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	46	$159,921	$151,049	1,403	$124.81	$200,285	6	11
Elevated	55	$77,873	$73,679	1,460	$64.68	$223,984	2	6
All	**101**	**$115,242**	**$108,917**	**1,434**	**$92.07**	**$240,603**	**8**	**17**

Table 45: Hurricane Ian NFIP Contents Claims within Area of Interest No. 7 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	21	$159,147	$18,510	1,314	$17.28	$32,224	0	13
Elevated	36	$66,612	$6,408	1,446	$6.66	$40,256	0	7
All	**57**	**$100,704**	**$10,867**	**1,397**	**$10.57**	**$37,296**	**0**	**20**

Area of Interest No. 8.

Area of Interest No. 8 consists of approximately 220 single-family houses and is located along Estero Bay in Lee County. Development in this area started in the 1950s. Approximately 50% of the houses were built before 1980 and less than 20% were built post 2000. Almost the entire area is within the Special Flood Hazard Area, Zone AE with a BFE of 10 feet NAVD 88 or higher. See Figure 18 for a general map of the area.

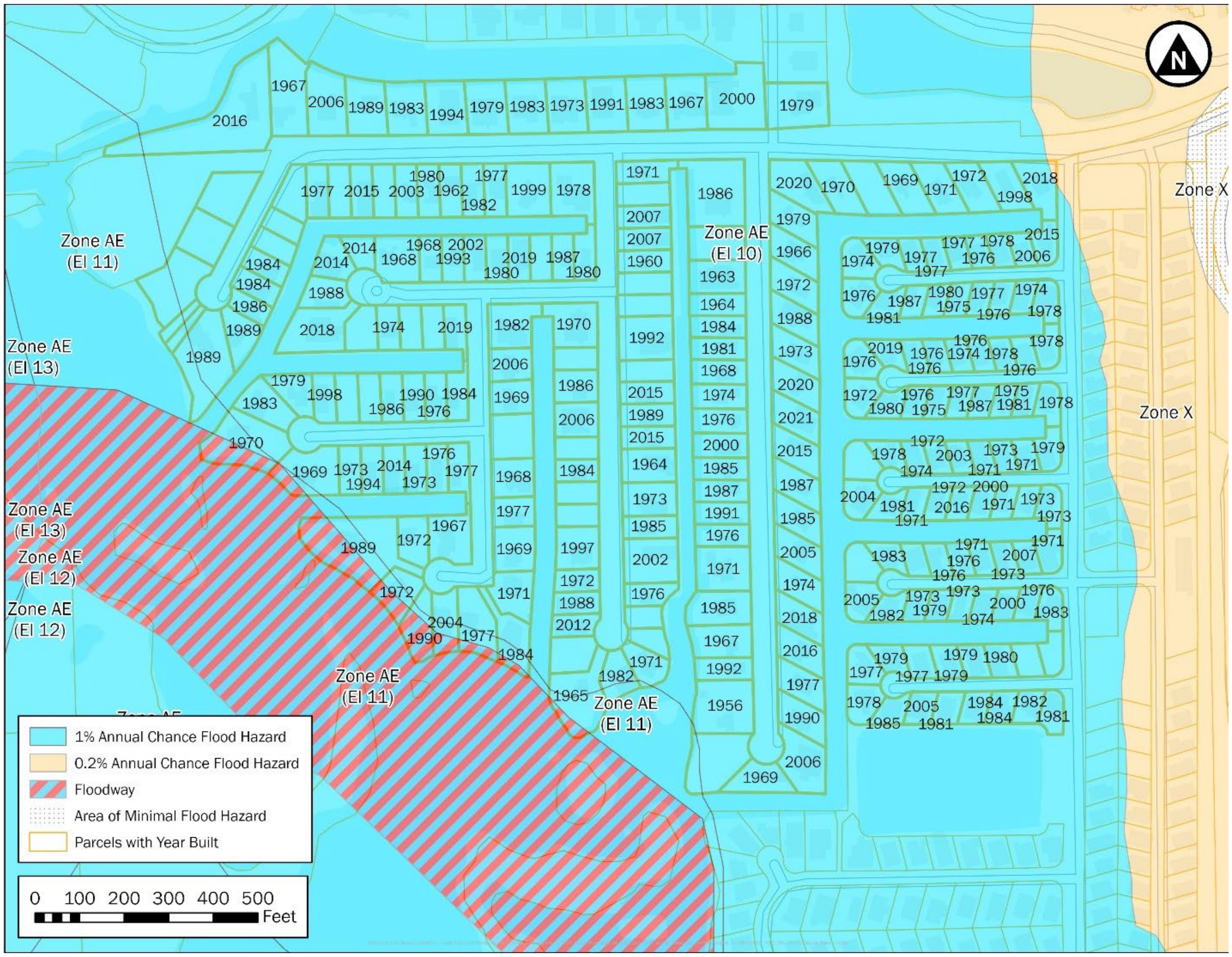

Figure 18: Map of Area of Interest No. 8

The houses in this area are a relatively even mixture of elevated and *non-elevated buildings*, with a slightly higher percentage of *elevated buildings*. Areas below the lowest floor are enclosed (either partially or fully) in three-quarters or more of the *elevated buildings*. No major structural damage was observed; damage was predominantly related to interior walls and finishes, which had been or were being removed. During site visits, homeowners reported 6 feet of water in non-elevated houses as well as in in enclosures below the lowest floor of elevated houses. Figure 19 provides examples of representative single-family houses within Area of Interest No. 8.

Figure 19: Representative single-family houses in Area of Interest No. 8 from the 1960s to 2019

The 28% flood insurance take up rate (62 of 222 buildings with flood insurance) is not ideal for a representative analysis, but this area was selected because it is representative of observations along Estero Bay. Based on field observations, older houses had more damage than newer houses and the claims data are consistent with that finding with the average pre-1980 building claim being triple the average post-1980 claim ($129,943 versus about $41,780). The post-2010 average building claim ($31,889) is higher than the approximately $18,000 average for houses built in the 1990s and 2000s. This is largely because one of the nine post-2010 buildings is a *non-elevated building* and has a building claim of approximately $165,000; excluding this *non-elevated building* reduces the post-2010 average building claim to approximately $15,200. Overall, the building claims are consistent with observations made in the field as average damages for *non-elevated buildings* are more than triple the *elevated buildings* ($144,223 vs $38,284). No noticeable difference was observed in the field for the few buildings in the floodway; the policy data reflects a slightly higher average building claim for properties closer to or in the floodway. Table 46 through Table 50 provide the number of houses built by decade, the number of insured buildings, and a summary of

NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 46 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 46: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 8

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	112	50%	1,098	24	39%	1,276
1980s	54	24%	1,223	13	21%	1,396
1990s	14	6%	1,488	7	11%	1,784
2000s	21	9%	1,831	9	15%	2,162
Post 2010	21	9%	1,756	9	15%	2,022
All	**222**		**1,285**	**62**	**28%**	**1,595**

Table 47: Hurricane Ian NFIP Building Claims within Area of Interest No. 8 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	24	$148,051	$129,943	1,276	$103.28	$238,346	1	5
1980s	13	$91,962	$77,238	1,396	$59.65	$246,073	0	2
1990s	7	$18,162	$18,162	1,784	$11.98	$296,833	0	0
2000s	9	$19,371	$18,828	2,162	$8.05	$242,397	0	0
Post 2010	9	$32,188	$31,889	2,022	$15.33	$250,000	0	0
All	**62**	**$86,127**	**$75,908**	**1,595**	**$57.23**	**$245,320**	**1**	**7**

Table 48: Hurricane Ian NFIP Contents Claims within Area of Interest No. 8 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	16	$161,320	$27,162	1,281	$21.03	$35,438	1	9
1980s	11	$97,737	$17,401	1,485	$13.61	$54,773	0	4
1990s	5	$11,628	$0	1,939	$0.00	$60,400	0	0
2000s	9	$19,371	$544	2,162	$0.43	$72,611	0	0
Post 2010	5	$20,038	$539	2,408	$0.25	$82,000	0	0
All	**46**	**$86,715**	**$13,774**	**1,696**	**$10.68**	**$55,109**	**1**	**13**

Table 49: Hurricane Ian NFIP Building Claims within Area of Interest No. 8 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	28	$144,223	$126,424	1,306	$98.23	$199,632	1	4
Elevated	34	$38,284	$34,307	1,833	$23.47	$216,615	0	3
All	**62**	**$86,127**	**$75,908**	**1,595**	**$57.23**	**$245,320**	**1**	**7**

Table 50: Hurricane Ian NFIP Contents Claims within Area of Interest No. 8 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	19	$156,756	$26,231	1,275	$20.47	$41,105	1	8
Elevated	27	$37,427	$5,008	1,993	$3.79	$64,963	0	5
All	**46**	**$86,715**	**$13,774**	**1,696**	**$10.68**	**$55,109**	**1**	**13**

Area of Interest No. 9.

Area of Interest No. 9 consists of approximately 200 single-family houses and is located along the Gulf of Mexico in Lee County. The area has a mixture of single-family houses, multi-family residential, mixed-use, and commercial buildings. This analysis focuses on single-family residential to be consistent with other Areas of Interest. Development in this area started in the 1950s. Approximately 25% of the houses were built before 1980, 50% were built between 1980 and 2010, and 25% were built post 2010. The entire area is within the Special Flood Hazard Area, Zone VE with a BFE of 15 feet NAVD 88 or higher. The area is also seaward of the Florida Department of Environmental Protection (FDEP) Coastal Construction Control Line. Multiple USGS HWMs were measured in this area between 10 to 12 feet NAVD 88. See Figure 20 for a general map of the area.

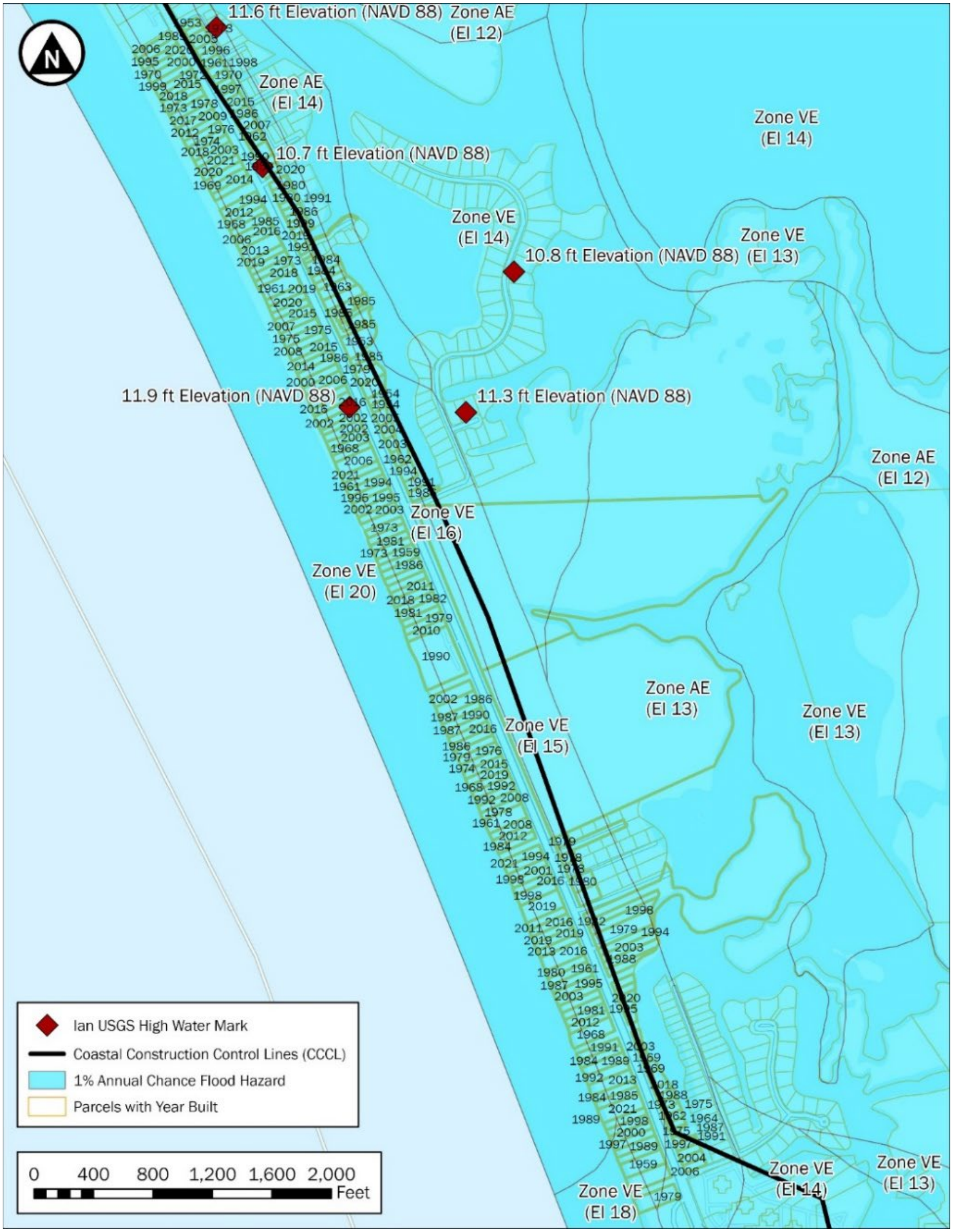

Figure 20: Map of Area of Interest No. 9

The 28% flood insurance take up rate (56 of 197 buildings with flood insurance) is not ideal for a representative analysis, but this area was selected because it is representative of observations for single-family construction immediately along the coast of the Gulf of Mexico. The houses in this area with NFIP policies are a relatively even mixture of *elevated* and *non-elevated buildings*, with a slightly higher percentage of *elevated buildings* and with the pre-1980 construction being predominantly non-elevated and the newer post-1980 construction being predominantly elevated. Building performance varied greatly in this area, with several older non-elevated or insufficiently *elevated buildings* immediately along the coast destroyed by storm surge, in many cases only leaving remnants of the building foundation. On the other hand, several newer, properly *elevated buildings* sustained minimal structural damage with damage limited to the loss of breakaway walls, interior finishes, and other non-flood damage–resistant materials below the lowest floor of the *elevated buildings*. Figure 21 provides examples of representative single-family houses within Area of Interest No. 9.

Source: FDEP

Figure 21: Representative single-family houses in Area of Interest No. 9 from 1961 to 2021

One immediately noticeable observation in this area was the size of construction. Newer houses were considerably larger than older ones and the active insurance policy data supports this trend with the average building size in post-

2010 construction being almost triple the size of pre-1980 construction (5,084 square feet versus 1,704 square feet). This area also had a considerable number of older buildings that were destroyed; the policy data confirmed this observation as this area had the highest average building claims per square foot for pre-1980 construction ($134.71), which was expected considering the immediate vicinity to the coast, storm surge, and percentage of older *non-elevated buildings*. One outlier in the policy data was an increase in the average building claim for post-2010 construction compared to houses built in the 2000s. While the average house size is larger post 2010, which contributes to more damage/cost to repair, the size is not the only contributing factor. There are 14 post-2010 houses, 6 of them elevated and 8 *non-elevated buildings*. The average claim for the *elevated buildings* is half that of *non-elevated buildings* ($20,299 versus $41,476); reinforcing that the building type is likely the key factor affecting the average building claim. The performance of *elevated* versus *non-elevated buildings* is not unique to post-2010 houses, across the 56 insured properties there is a considerable difference with the average building claim per square foot being triple in *non-elevated* versus *elevated buildings* ($77.58 versus $23.29). Pre- versus post-FIRM construction is another policy data attribute that clearly differentiated performance in this Area of Interest with the average building claim per square foot of $78.56 for pre-FIRM versus $14.56 for post-FIRM. Table 51 through Table 55 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 51 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 51: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 9

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	47	24%	1,541	12	21%	1,704
1980s	34	17%	1,876	11	20%	1,945
1990s	30	15%	2,596	11	20%	2,285
2000s	33	17%	4,124	7	13%	4,719
Post 2010	53	27%	4,960	15	27%	5,084
All	**197**		**3,112**	**56**		**3,148**

Table 52: Hurricane Ian NFIP Building Claims within Area of Interest No. 9 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	12	$213,992	$191,921	1,704	$134.71	$238,346	5	0
1980s	11	$114,159	$106,906	1,945	$64.42	$246,073	0	0
1990s	11	$33,693	$33,563	2,285	$14.61	$213,500	0	0
2000s	7	$14,285	$14,285	4,719	$3.61	$242,397	0	0
Post 2010	15	$31,745	$31,745	5,084	$6.41	$250,000	0	0
All	**56**	**$85,186**	**$79,007**	**3,148**	**$46.56**	**$240,603**	**5**	**0**

Table 53: Hurricane Ian NFIP Contents Claims within Area of Interest No. 9 by Decade Built Example

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	9	$212,098	$29,428	1,922	$18.15	$55,378	0	2
1980s	8	$81,053	$9,972	1,890	$7.03	$56,838	0	0
1990s	9	$32,947	$159	2,185	$0.11	$73,967	0	0
2000s	6	$10,604	$0	4,509	$0.00	$97,833	0	0
Post 2010	7	$40,098	$0	5,032	$0.00	$98,571	0	0
All	**39**	**$82,004**	**$8,873**	**2,932**	**$5.66**	**$74,251**	**0**	**2**

Table 54: Hurricane Ian NFIP Building Claims within Area of Interest No. 9 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	24	$135,737	$123,920	3,006	$77.58	$249,000	4	0
Elevated	32	$47,273	$45,322	3,254	$23.29	$238,647	1	0
All	**56**	**$85,186**	**$79,007**	**3,148**	**$46.56**	**$240,603**	**5**	**0**

Table 55: Hurricane Ian NFIP Contents Claims within Area of Interest No. 9 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	13	$159,278	$21,815	2,714	$12.86	$75,185	0	2
Elevated	26	$43,367	$2,402	3,042	$2.05	$73,785	0	0
All	**39**	**$82,004**	**$8,873**	**2,932**	**$5.66**	**$74,251**	**0**	**2**

Area of Interest No. 10.

Area of Interest No. 10 is a residential neighborhood with approximately 670 single-family houses along the Imperial River in Lee County. Development in this area started in the 1950s. Approximately 25% of the houses were built before 1980, 33% were built in the 1980s, and about 33% were built post 2000. Almost the entire area is within the Special Flood Hazard Area, Zone AE with a BFE of 10 feet NAVD 88. Multiple USGS HWMs were measured in this area at 9 feet NAVD 88. See Figure 22 for a general map of the area.

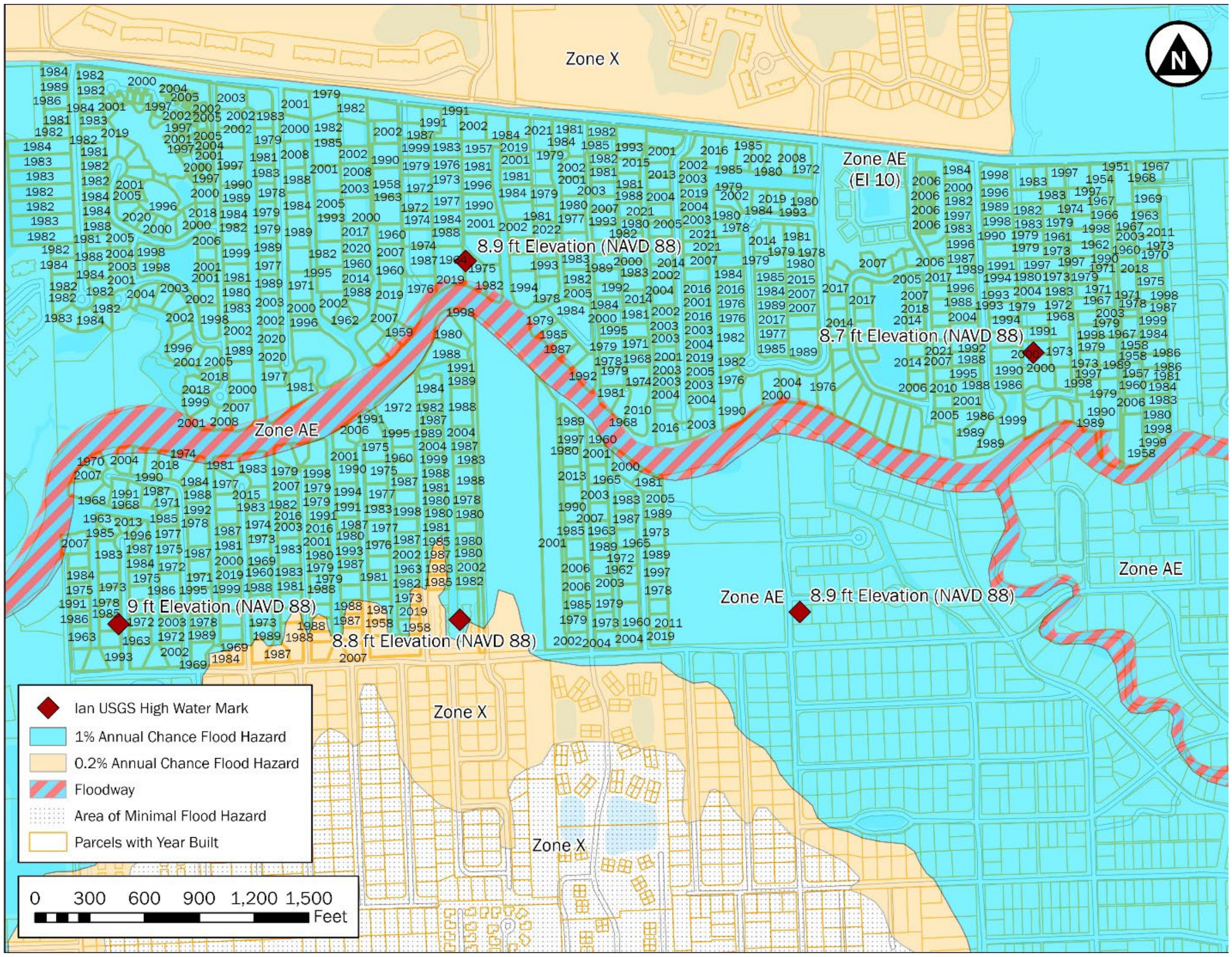

Figure 22: Map of Area of Interest No. 10

The houses in this area are predominantly non-elevated (about 75%). In cases where the houses are elevated, areas below the lowest floor are enclosed (either partially or fully). The MAT recorded HWMs ranging from 2 to 3 feet above the lowest floor in slab-on-grade houses. Homeowners verified flood depths ranged anywhere from 0 to 3 feet throughout the area. No major structural damage was observed. Damage was predominantly related to interior walls and finishes, which had been or were being removed. Figure 23 provides examples of representative single-family houses within Area of Interest No. 10 along with a HWM recorded by the MAT on a 1984 house during the pre-MAT visit in October.

Figure 23: Representative single-family houses in Area of Interest No. 10 from 1984 to 2021

The 35% flood insurance take up rate (235 of 669 buildings with flood insurance) is not ideal for a representative analysis, but this area was selected because it is representative of observations along the Imperial River. Building performance in this area was generally as expected with newer *elevated buildings* having considerably less damage than older *non-elevated buildings*. The policy data support field observations as newer buildings have lower average building claims, are larger in size, and are predominantly *elevated buildings*. The policy data especially reinforce the effectiveness of *elevated buildings* as the average building claim for a *non-elevated building* is more than five times that of an *elevated building* ($88,306 versus $16,574). Although *elevated buildings* performed noticeably well in this area, several *elevated buildings* were observed by the MAT to have damage to enclosures, especially to non-flood damage–resistant materials that had to be removed (this damage is likely not reflected in the policy data as it is unlikely to be covered under the standard NFIP insurance policy). Table 56 through Table 60 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 56 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 56: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 10

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	156	23%	1,604	57	24%	1,665
1980s	214	32%	1,739	93	40%	1,734
1990s	90	13%	1,978	34	14%	2,246
2000s	146	22%	2,353	44	19%	2,493
Post 2010	63	9%	2,481	7	3%	2,878
All	**669**		**1,943**	**235**		**1,968**

Table 57: Hurricane Ian NFIP Building Claims within Area of Interest No. 10 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	57	$132,856	$118,360	1,665	$74.05	$238,346	1	5
1980s	93	$118,494	$100,613	1,734	$59.60	$246,073	2	3
1990s	34	$17,649	$15,606	2,246	$6.56	$213,500	0	0
2000s	44	$15,265	$11,998	2,493	$4.98	$242,397	0	0
Post 2010	7	$10,949	$10,710	2,878	$3.55	$250,000	0	0
All	**235**	**$84,856**	**$73,349**	**1,968**	**$43.53**	**$240,603**	**3**	**8**

Table 58: Hurricane Ian NFIP Contents Claims within Area of Interest No. 10 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	32	$148,703	$25,383	1,806	$16.05	$47,656	0	15
1980s	57	$125,122	$29,173	1,737	$17.88	$64,033	1	20
1990s	31	$18,349	$2,240	2,249	$1.05	$82,842	0	0
2000s	33	$15,308	$4,355	2,582	$1.63	$83,224	0	0
Post 2010	3	$14,581	$559	3,157	$0.18	$100,000	0	0
All	**156**	**$83,385**	**$17,244**	**2,059**	**$10.38**	**$69,163**	**1**	**35**

Table 59: Hurricane Ian NFIP Building Claims within Area of Interest No. 10 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	186	$102,253	$88,306	1,916	$52.63	$230,680	3	8
Elevated	49	$18,818	$16,574	2,165	$9.01	$247,612	0	0
All	**235**	**$84,856**	**$73,349**	**1,968**	**$43.53**	**$240,603**	**3**	**8**

Table 60: Hurricane Ian NFIP Contents Claims within Area of Interest No. 10 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	114	$106,717	$22,632	2,018	$13.58	$64,573	1	35
Elevated	42	$20,058	$2,618	2,171	$1.70	$81,621	0	0
All	**156**	**$83,385**	**$17,244**	**2,059**	**$10.38**	**$69,163**	**1**	**35**

Area of Interest No. 11.

Area of Interest No. 11 is a residential neighborhood with approximately 450 single-family houses along the Vanderbilt Bay/Vanderbilt Beach Intercoastal Waterway in Collier County. Development in this area started in the 1950s. Approximately one-third of the houses were built before 1980, one-third were built in the 1980s and 1990s, and one-third were built post 2000. Almost the entire area is within the Special Flood Hazard Area, predominantly Zone AE with a BFE of 9 feet NAVD 88 or higher. See Figure 24 for a general map of the area.

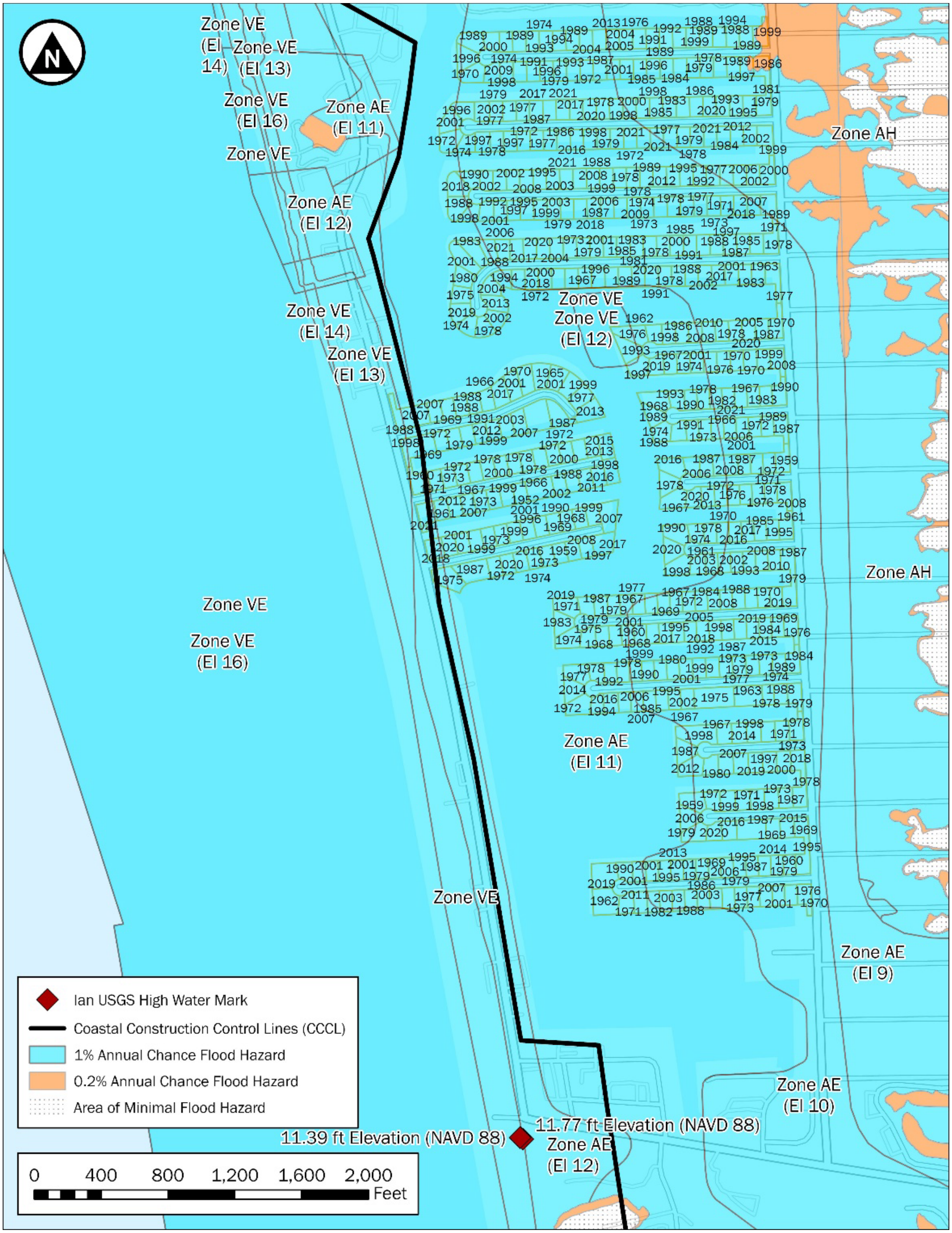

Figure 24: Map of Area of Interest No. 11

The houses in this area are about two-thirds non-elevated and one-third *elevated buildings*, and in cases where the houses were *elevated buildings*, areas below the lowest floor are enclosed (either partially or fully). The MAT recorded HWMs ranging from 4 to 5 feet above the lowest floor in slab-on-grade houses. Homeowners verified flood depths ranged anywhere from 2 to 6 feet throughout the area. No major structural damage was observed, damage was predominantly related to interior walls and finishes, which had been or were being removed. Figure 25 provides examples of representative single-family houses within Area of Interest No. 11 along with a HWM recorded by the MAT on a 1979 house during the pre-MAT visit in October.

Figure 25: Representative single-family houses in Area of Interest No. 11 from 1969 to 2022

Building performance in this area was generally as expected with newer *elevated buildings* having considerably less damage than older *non-elevated buildings*. The primary field observation was the extent and depth of flooding in this area approximately 40 miles south of Hurricane Ian's track. The policy data was consistent with field observations as this Area of Interest has the third highest average building claim per building ($132,914) and fifth average building claim per square foot ($62.48) amongst all 12 Areas of Interest. On average *elevated buildings* had about one-third the damage compared to *non-elevated buildings* ($56,846 versus $166,921) and post-2010 buildings had about one-quarter of the damage compared to pre-1980 buildings ($23.43 per square foot versus $108.37 per square foot). Although *elevated buildings* performed noticeably well in this area, several *elevated buildings* were observed by the MAT to have damage to enclosures, especially non-flood damage–resistant materials that had to be removed (this damage is likely not reflected in the policy data as it is unlikely to be covered under the standard NFIP insurance policy). Table 61 through Table 65 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 61 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 61: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 11

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	161	35%	1,921	74	30%	1,909
1980s	76	17%	2,124	40	16%	2,190
1990s	81	18%	2,475	45	18%	2,413
2000s	78	17%	2,562	52	21%	2,613
Post 2010	58	13%	2,650	35	14%	2,810
All	**454**		**2,257**	**246**		**2,324**

Table 62: Hurricane Ian NFIP Building Claims within Area of Interest No. 11 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	74	$245,175	$203,840	1,909	$108.37	$238,346	29	3
1980s	40	$124,449	$98,966	2,190	$46.10	$246,073	5	0
1990s	45	$150,739	$125,386	2,413	$53.13	$213,500	7	0
2000s	52	$135,497	$111,859	2,613	$44.13	$242,397	8	0
Post 2010	35	$71,437	$62,714	2,810	$23.43	$250,000	4	0
All	**246**	**$160,367**	**$132,914**	**2,324**	**$62.48**	**$240,603**	**53**	**3**

Table 63: Hurricane Ian NFIP Building Claims within Area of Interest No. 11 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	56	$260,084	$54,621	1,914	$28.81	$70,289	11	19
1980s	32	$126,695	$31,854	2,188	$14.44	$93,472	4	2
1990s	40	$148,791	$28,523	2,420	$11.66	$89,972	4	4
2000s	50	$137,123	$24,584	2,598	$9.91	$98,982	4	1
Post 2010	28	$76,059	$10,903	2,721	$4.34	$98,429	0	0
All	**206**	**$162,895**	**$32,784**	**2,330**	**$15.34**	**$88,501**	**23**	**26**

Table 64: Hurricane Ian NFIP Building Claims within Area of Interest No. 11 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	170	$203,584	$166,921	2,251	$79.44	$247,188	49	2
Elevated	76	$63,699	$56,846	2,488	$24.52	$248,026	4	1
All	**246**	**$160,367**	**$132,914**	**2,324**	**$62.48**	**$240,603**	**53**	**3**

Table 65: Hurricane Ian NFIP Contents Claims within Area of Interest No. 11 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	140	$208,699	$44,519	2,252	$20.88	$85,067	21	25
Elevated	66	$65,736	$7,892	2,496	$3.58	$95,786	2	1
All	**206**	**$162,895**	**$32,784**	**2,330**	**$15.34**	**$88,501**	**23**	**26**

Area of Interest No. 12.

Area of Interest No. 12 is a residential neighborhood with approximately 280 single-family houses along the Venetian Bay in Collier County. Development in this area started in 1977. Approximately 50% of the houses were built before 1980, 25% were built between 1980 and 2010, and another 25% were built post 2010. Almost the entire area is within the Special Flood Hazard Area, predominantly Zone AE with a BFE of 9 through 11 feet NAVD 88. See Figure 26 for a general map of the area.

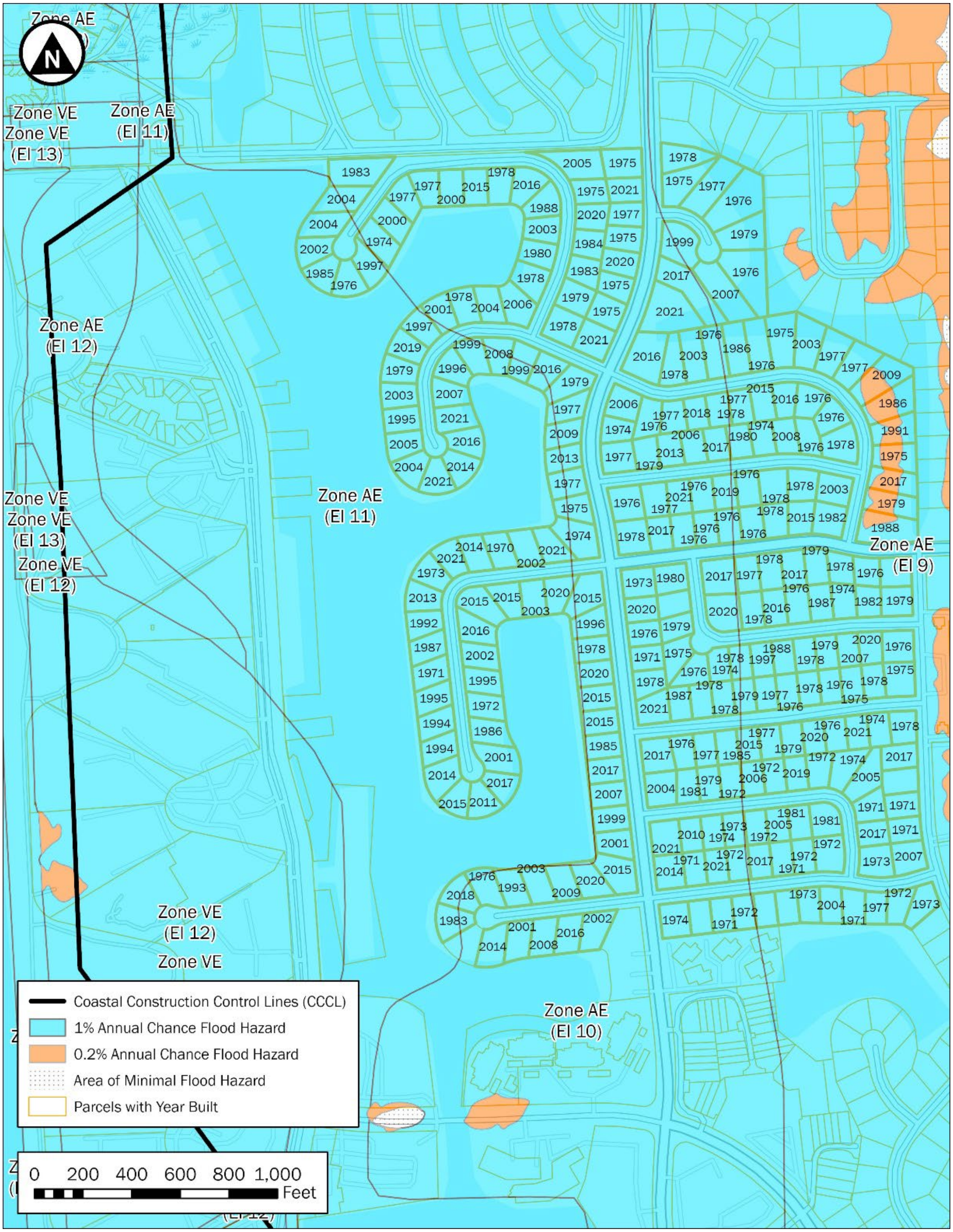

Figure 26: Map of Area of Interest No. 12

The houses in this area are predominantly non-elevated. In rare circumstances where the houses are elevated, areas below the lowest floor are enclosed (either partially or fully). Estimated flood levels were approximately 2 to 3 feet in older slab-on-grade houses based on HWMs recorded by the MAT and interviews with homeowners during site visits. No major structural damage was observed; damage was predominantly related to interior walls and finishes, which had been or were being removed. Figure 27 provides examples of representative single-family houses within Area of Interest No. 12 along with a HWM recorded by the MAT on a 1977 house during the pre-MAT in October.

Figure 27: Representative single-family houses in Area of Interest No. 12 from 1977 to 2020

Building performance in this area was generally as expected with newer buildings having considerably less damage than older buildings. Two primary field observation were the extent and depth of flooding in this area approximately 45 miles south of Hurricane Ian's track and the large size of the houses. The policy data was consistent with field observations as this Area of Interest has the highest average building claim per building ($154,724) and the second largest average building size (3,029 square feet). The data also correlate with the lack of *elevated buildings* as only 2 of the 108 polices are for *elevated buildings*, both of which were built in the 1970s. On average, post-2010 building claims are one-fifth those of pre-1980 buildings ($15.19 per square foot versus $77.02 per square foot). The average building claim for houses built in the 2000s is greater than those in the 1990s, which is unexpected. Aside from verifying 7 of the 19 buildings built in the 2000s have a $250,000 maximum building claim, a preliminary explanation for the reduced building performance in newer buildings could not be determined. Table 66 through Table 70 provide the number of houses built by decade, the number of insured buildings, and a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated). The percentages in Table 66 are intended to help illustrate how similar the distribution of buildings built by decade is compared to the distribution of policies by decade.

Table 66: Number of Single-Family Residential Buildings by Decade Built and NFIP Insurance Policies within Area of Interest No. 12

Decade Built	Total Buildings	Percent of All Buildings	Average Size	Buildings w/ Policy	Percent of All Policies	Average Size
Pre 1980	128	46%	2,611	57	53%	2,641
1980s	24	9%	2,953	7	6%	2,948
1990s	17	6%	3,587	7	6%	3,538
2000s	42	15%	3,492	19	18%	3,416
Post 2010	68	24%	3,688	18	17%	3,682
All	**279**		**3,095**	**108**		**3,029**

Table 67: Hurricane Ian NFIP Building Claims within Area of Interest No. 12 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	57	$251,712	$200,434	2,641	$77.02	$238,346	22	1
1980s	7	$228,762	$169,636	2,948	$59.75	$246,073	3	0
1990s	7	$105,054	$76,752	3,538	$23.46	$213,500	1	0
2000s	19	$170,734	$137,315	3,416	$42.09	$242,397	7	0
Post 2010	18	$59,912	$52,877	3,682	$15.19	$250,000	0	0
All	**108**	**$194,506**	**$154,724**	**3,029**	**$55.98**	**$240,603**	**33**	**1**

Table 68: Hurricane Ian NFIP Contents Claims within Area of Interest No. 12 by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	51	$258,074	$57,311	2,651	$21.65	$88,255	13	10
1980s	6	$266,788	$68,980	2,932	$23.91	$100,000	3	0
1990s	6	$116,905	$33,019	3,244	$10.35	$91,667	1	0
2000s	19	$170,734	$33,419	3,416	$10.66	$97,842	2	1
Post 2010	17	$58,797	$7,449	3,642	$2.14	$100,000	0	0
All	**99**	**$199,065**	**$43,398**	**3,021**	**$15.64**	**$93,030**	**19**	**11**

Table 69: Hurricane Ian NFIP Building Claims within Area of Interest No. 12 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Non-elevated	106	$192,609	$153,020	3,027	$55.51	$247,642	32	1
Elevated	2	$295,036	$245,036	3,123	$80.81	$250,000	1	0
All	**108**	**$194,506**	**$154,724**	**3,029**	**$55.98**	**$240,603**	**33**	**1**

Table 70: Hurricane Ian NFIP Contents Claims within Area of Interest No. 12 by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Non-elevated	97	$197,086	$43,262	3,019	$15.69	$92,887	18	11
Elevated	2	$295,036	$50,000	3,123	$13.56	$100,000	1	0
All	**99**	**$199,065**	**$43,398**	**3,021**	**$15.64**	**$93,030**	**19**	**11**

Summary

The 12 Areas of Interest in this Appendix are representative examples of building performance and areas visited by the Hurricane Ian MAT across Lee, Collier, and DeSoto Counties (predominantly Lee). They cover areas as far south as 45 miles from the Hurricane Ian track along the Gulf Coast in Naples (Collier County), 15 miles upstream from the mouth of the Caloosahatchee River in Fort Myers (Lee County), and 6 miles north of Ian Track along the Peace River in Arcadia (DeSoto County). The Areas of Interest also reflect various flood sources and flooding characteristics (depth, velocity, wave action, debris, etc.) as well as construction type (open and closed foundation, single vs multi-story, wood-frame versus masonry, etc.). The flood insurance take up rate is not ideal for every Area of Interest, but across each area there is a representative distribution of age of construction to help evaluate building performance and make recommendations towards improving flood-resistant design and construction requirements.

Figure 28 illustrates the average building claim across all buildings as well as elevated versus non-elevated by Area of Interest. On average, the *non-elevated building* damages are consistently higher. Note there were no *elevated buildings* in Area of Interest No. 2, and Area of Interest No. 12 had two *elevated buildings* out of 108 policies, both of which were built in the 1970s.

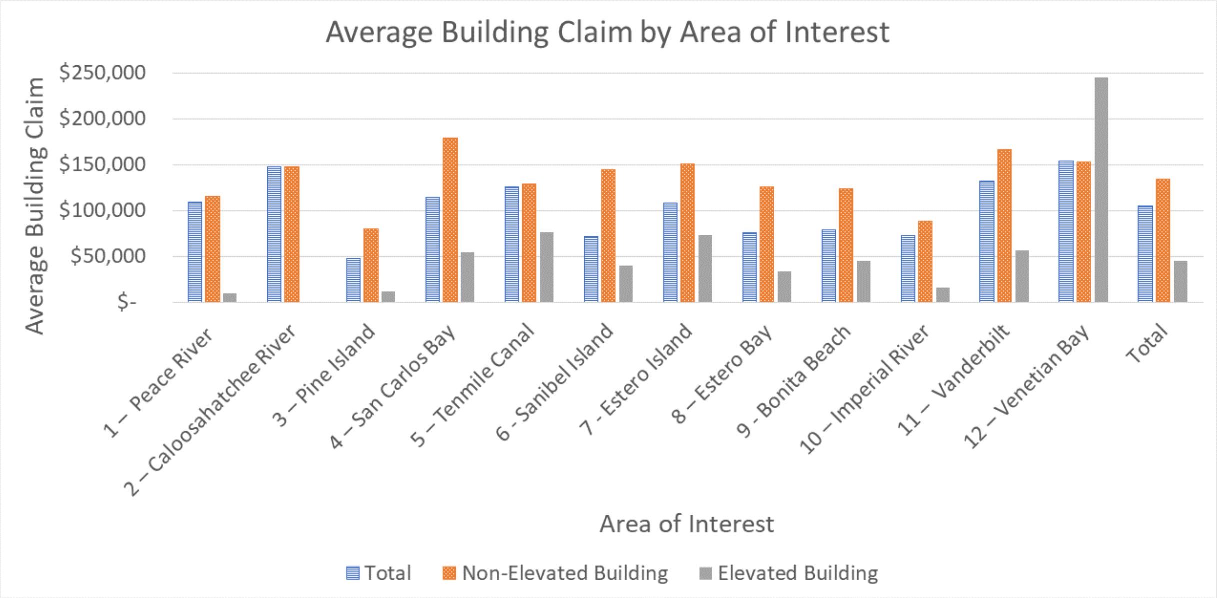

Figure 28: Average building claim in *elevated* versus *non-elevated buildings* by Area of Interest

There are outliers in the data to compare across each area. For example, there were no *elevated buildings* in Area of Interest No. 2 – Lee County along Caloosahatchee River. In Areas of Interest No. 1 – DeSoto County along Peace River and No. 2 – Lee County along Caloosahatchee River, 75% or more of the buildings were built before 1980, and the two *elevated buildings* in Area of Interest No. 12 – Venetian Bay were built in the 1970s. However, the overall trends in the data were consistent with field observations related to flood damage.

Age of construction is also an indicator of building performance. The average post-2010 building claim ($48,091) is more than a third less than the average pre-1980 building claim ($164,891) and more than 50% less than the overall average building claim ($105,662). These averages are consistent with field observations. Figure 29 illustrates the average building claim across all buildings as well as *elevated* versus *non-elevated* building by decade. On average the damages in newer buildings are consistently lower.

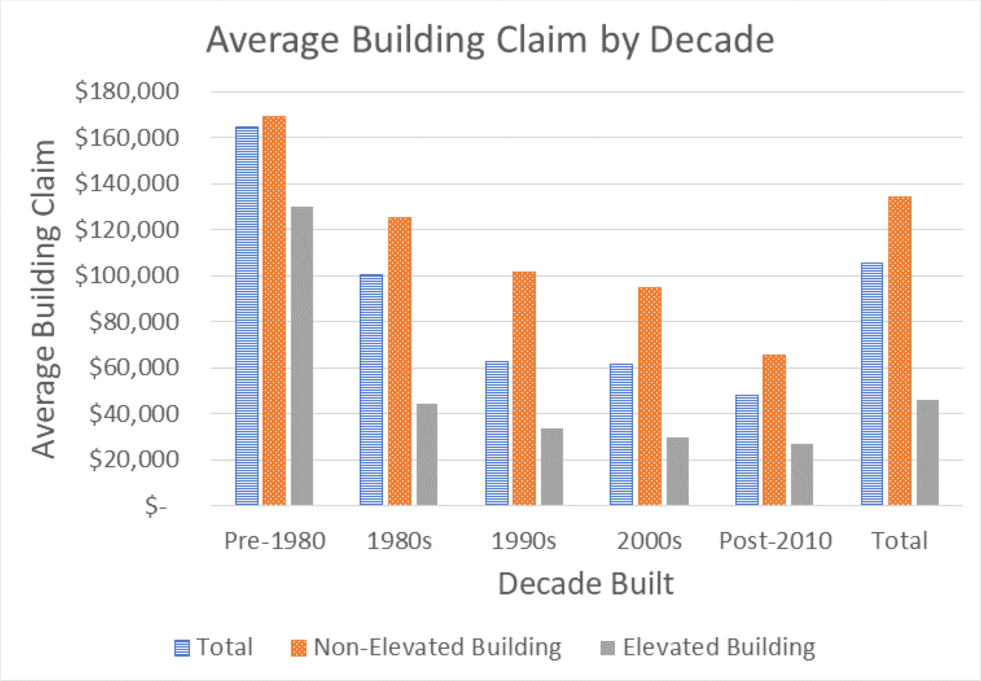

Figure 29: Average building claim in *elevated* versus *non-elevated buildings* by decade

Comparing across decades can be challenging because the average size of the buildings varied by area as well as by decade; newer construction was observed to be considerably larger and the claims are consistent with that observation. However, the overall results were consistent with field observations related to flood damage. Building performance, elevation, and foundation type matter and newer construction is a likely indicator of improved building performance. One indicator that is helpful in comparing across the building age of construction and other attributes is the average building claim per square foot. Figure 30 shows the average building claim per square foot in *non-elevated buildings* versus depth of flooding. The results of this graph are consistent with observations in the field, which indicates the claims data are a reasonable supplement to field observations and likely representative of the buildings throughout the areas studied.

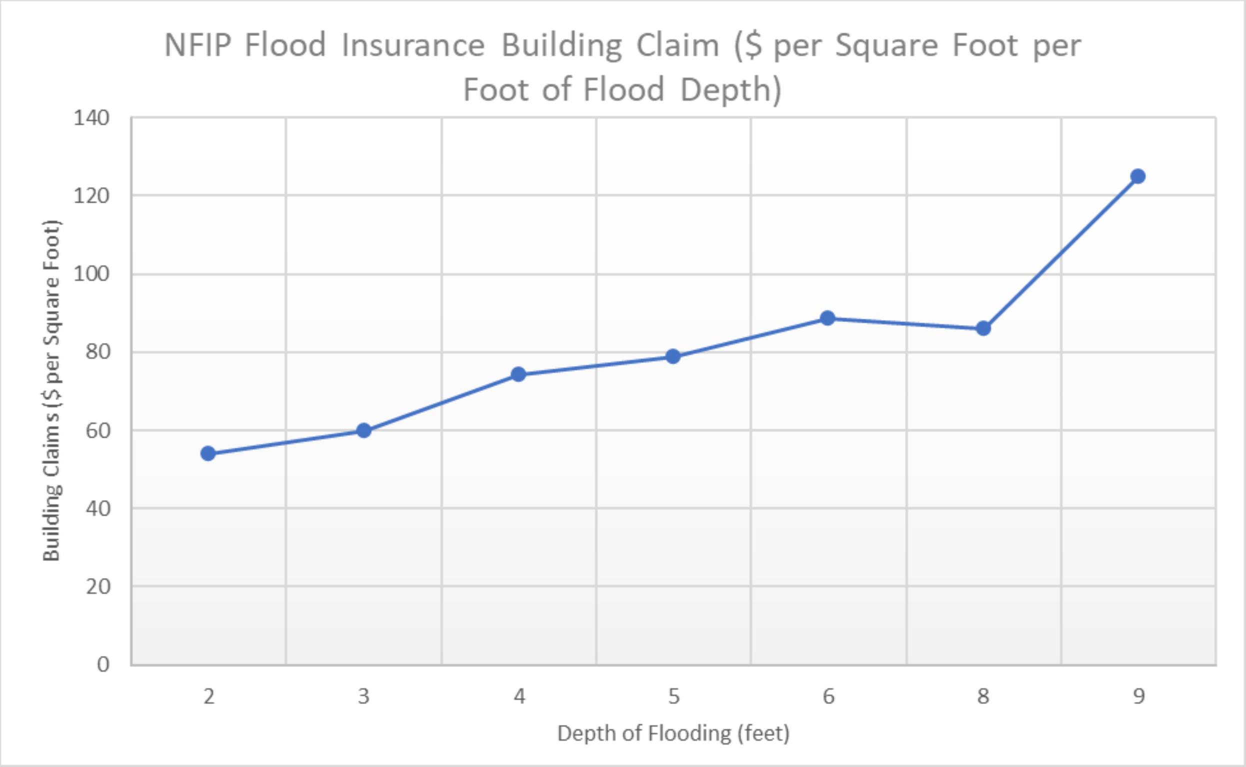

Figure 30: Average building flood insurance claim per square foot in *non-elevated buildings* versus depth of flooding

A few key observations from field notes as well as flood insurance policy and Hurricane Ian claims data include:

- **Elevation and foundation type matter** – The *elevated* versus *non-elevated building* attribute is likely the largest indicator of building performance within the flood insurance policy and claims data. This is consistent with field observations and expected because standard NFIP policy building and contents coverage is relatively limited below the lowest floor of an *elevated building*.
    - *Elevated buildings* constructed above ground level by foundation walls, shear walls, posts, piers, pilings, or columns are generally more likely to have a lowest floor that exceeds the minimum NFIP and building code elevation requirements. Based on discussions with homeowners in the field, most indicated they extended their foundation beyond the minimum requirement to allow for an enclosure as well as provide some additional flood risk reduction. The higher the lowest floor is elevated on a proper foundation with flood damage–resistant materials below it, the less likely there will be flood damage.
    - *Elevated buildings* without structural damage were generally repaired and habitable faster as areas below the lowest floor can typically be repaired while the house is occupied; they are generally simpler to retrofit as well. However, securing the damaged enclosures below the lowest floor and separating areas normally used for parking, storage, and access was a common challenge.
    - The majority of the policies, 94% (132 out of 140), with a maximum building claim ($250,000) were non-elevated.

- In newer (post-2000 construction), 52 policies have building claims between $125,000 and $250,000 (50% to 99% of the maximum building claim allowed); of these, only four (or less than 8%) are *elevated buildings*. Ten of the 52 are post 2010; none of them are *elevated buildings*. These data support field observations that indicate a clear difference in building performance of *elevated buildings* (constructed above ground level by foundation walls, shear walls, posts, piers, pilings, or columns). Note, there are 148 *elevated* and 159 *non-elevated* post-2000 buildings with insurance claims. The average building claim per square foot is $11.53 in *elevated buildings* versus $29.15 in *non-elevated buildings*.

- Two of the streets in Area of Interest No. 4 provide a good comparison with approximately the same number of buildings, similar sizes, similar eras of construction, etc. The primary difference between the two streets is that one has 6% *elevated buildings* and the other has 74% *elevated buildings*. The street with more *elevated buildings* had an average building claim less than half the other street; it had less than half as much construction and demolition debris as well. See Area Interest No. 4 Table 23 through Table 25 for more details.

- The lowest 10% of building claims are $6,400 or less; of these 127 claims, 78 claims, or approximately 60%, are from *elevated buildings*.

- The average building claim per square foot is 2.7 times greater in *non-elevated buildings* ($72.42 per square foot versus $26.46). In addition, all but one of the top 10 average building claim per square foot by Area of Interest and building type were associated with *non-elevated buildings* (see Table 71).

- Based on limitations in the standard NFIP flood insurance policy, *elevated buildings* generally create less exposure to the National Flood Insurance Fund.

Table 71: Average Building Claim per Square Foot by Area of Interest and Building Type (sorted in descending order)

Area of Interest	Quantity	Average Building Claim per square foot	Building Type
5 – Tenmile Canal	96	$74.13	Non-Elevated
8 – Estero Bay	10	$71.22	Non-Elevated
2 – Lee County along Caloosahatchee River	17	$69.43	Non-Elevated
11 – Collier County – Vanderbilt	98	$58.07	Non-Elevated
4 – San Carlos Bay	22	$57.69	Non-Elevated
1 – DeSoto County along Peace River	1	$47.22	Non-Elevated
10 – Lee County along Imperial River	130	$43.50	Non-Elevated

Area of Interest	Quantity	Average Building Claim per square foot	Building Type
6 – Sanibel Island	14	$38.18	Non-Elevated
5 – Tenmile Canal	7	$34.17	Elevated
9 – Bonita Beach	15	$32.99	Non-Elevated
12 – Venetian Bay	51	$32.46	Non-Elevated
3 – Pine Island	22	$30.59	Non-Elevated
7 – Fort Myers Beach/Estero Island	4	$24.34	Non-Elevated
11 – Collier County – Vanderbilt	74	$22.42	Elevated
7 – Fort Myers Beach/Estero Island	32	$21.07	Elevated
6 – Sanibel Island	67	$18.91	Elevated
4 – San Carlos Bay	47	$18.74	Elevated
9 – Bonita Beach	29	$17.10	Elevated
8 – Estero Bay	28	$12.77	Elevated
10 – Lee County along Imperial River	48	$7.38	Elevated
3 – Pine Island	31	$5.46	Elevated
1 – DeSoto County along Peace River	1	$4.11	Elevated
All	**1,270**	**$57.47**	

- **Newer construction had considerably less flood damage, but there is room for improvement** – The average post-2010 building flood insurance claim ($48,091) is more than three time less than the average pre-1980 building claim ($164,891) and greater than 50% less than the overall average building claim ($105,662). While the claims indicate improved performance, there was extensive damage to non-structural building components and non-flood damage–resistant materials that were exposed to flooding (likely not reflected in the claims data because coverage below an *elevated building* is limited). Although *elevated buildings* were more flood-damage resilient than *non-elevated buildings*, finished enclosures that had various elements that did not appear to comply with flood damage–resistant material requirements and had functions beyond the allowable uses of parking, building access, and storage below the lowest floor were prevalent. These common issues reduced building and community resilience by generating avoidable flood damage and creating extensive debris that resulted in closing and blocking roads, requiring repairs, and unnecessarily tying up limited resources.

- **Trends in *elevated* vs *non-elevated buildings*** – Although the *elevated* versus *non-elevated building* attribute was likely the largest indicator of building performance, newer buildings are less likely to be *elevated buildings*. In most areas where the claims were analyzed, new *elevated* and *non-elevated buildings* are allowed and the MAT commonly observed newer houses built on fill or stem wall foundations, all of which appeared to be built to the required elevation. The flood insurance policy and claims data reinforced this trend as the ratio of *elevated* to *non-elevated buildings* was greatest in the 1990s. Post-2010 construction is more likely to be a *non-elevated building* type than elevated on foundation walls, shear walls, posts, piers, pilings, or columns. Table 72 provides a ratio of *non-elevated* to *elevated building* by decade built across the 1,270 buildings analyzed for this report. Several factors could be contributing to this trend, including availability of materials, planning and zoning requirements, construction time, construction cost, and/or homeowner preference.

Table 72: Ratio of *Non-elevated* to *Elevated Building* by Decade Built

Building Type	Quantity	Pre 1980	1980s	1990s	2000s	Post 2010
Non-elevated	857	377 (88%)	239 (69%)	73 (42%)	101 (49%)	67 (55%)
Elevated	413	49 (12%)	105 (31%)	100 (58%)	104 (51%)	55 (45%)
Ratio	**2:1**	**7.7:1**	**2.3:1**	**1:1.4**	**1:1**	**1.2:1**

- **Increasing average house size** – The increasing average building size has far outpaced the NFIP maximum flood insurance coverage cap The average building size by Area of Interest ranged from 1,285 square feet to 3,112 square feet. Across all 1,270 policies, the average building size was 2,133 square feet, the average pre-1980 insured house was 1,799 square feet, and the average post-2010 insured house was 2,977 square feet (see Table 75). Based on field observations, the increased size in waterfront properties was significant and especially noticeable.

- **Proximity to track** – While the high water/depth of flooding and building characteristics (age of construction, foundation type, building size, etc.) are key indicators of damage, the proximity to the track is not as evident an indicator. Table 73 provides a summary of average building claims by Area of Interest along with Annual Exceedance Probability based on nearest HWM and the distance from the area to Hurricane Ian's track. This is consistent with observations in the field as substantial flood damage was observed several miles away from the track. Unlike wind damage where proximity to the track was a key indicator of damage; based on field observations age of construction, building type and size, extent of surge and depth of flooding, and other parameters were more critical indicators of flood damage and building performance. Given the significant size and strength of Hurricane Ian, there was widespread and significant flooding along the coast and up the river and extensive canal systems.

Table 73: Comparison of Hurricane Ian NFIP Claims by Area of Interest and Distance from Track

Location	Quantity	Estimated Annual Exceedance Probability (Mean Recurrence Interval)	Distance from Track (miles)	Average Total Claim
1 – DeSoto County along Peace River	16	No HWM available	6	$115,660
2 – Lee County along Caloosahatchee River	67	75-year	19	$171,796
3 – Pine Island	70	140-year	19	$58,049
4 – San Carlos Bay	106	160-year	25	$130,645
5 – Tenmile Canal	103	≈85-year	29	$143,095
6 – Sanibel Island	100	250-year	21	$82,646
7 – Fort Myers Beach/Estero Island	101	250-year	27	$115,242
8 – Estero Bay	62	≈180-year	35	$86,127
9 – Bonita Beach	56	150-year	36	$85,186
10 – Lee County along Imperial River	235	60-year	39	$84,856
11 – Collier County – Vanderbilt	246	≈105-year	41	$160,367
12 – Venetian Bay	108	No HWM available	45	$194,506
All	**1,270**			**$123,168**

– **Pre-FIRM Construction and Substantial Damage** – Although numerous pre-FIRM buildings were flooded, how many were sufficiently damaged to trigger Substantial Damage is unclear. Based on the insurance policy data for pre- versus post-FIRM construction, the average pre-FIRM ($148,708) building claim was more than twice the post-FIRM construction average ($63,020). In addition, 70% of the policies (99 out of 140) with a maximum building claim ($250,000) were pre-FIRM construction. Table 74 provides a summary of building claims that reached maximum coverage and claims that exceed an estimated market value based on an assumption of $150 per square foot (note this assumption is for illustrative purposes only and not a FEMA standard value or assumption). Based on the claims data, 3% to 15% of the buildings across these Areas of Interest will be deemed Substantially Damaged, triggering NFIP and building code compliance requirements.

Table 74: Number of Maximum Building Coverage Claims by Area of Interest

Area of Interest	Active Policies	Quantity Max NFIP Coverage	Quantity Max Building Coverage	Quantity Building Claim > Value at $150 per square foot
1 – DeSoto County along Peace River	16	0	4	0
2 – Lee County along Caloosahatchee River	67	5	8	0
3 – Pine Island	70	0	0	1
4 – San Carlos Bay	106	21	25	4
5 – Tenmile Canal	103	6	11	3
6 - Sanibel Island	100	5	5	1
7 - Fort Myers Beach/Estero Island	101	8	25	19
8 – Estero Bay	62	1	8	4
9 - Bonita Beach	56	5	5	7
10 – Lee County along Imperial River	235	3	11	1
11 – Collier County – Vanderbilt	246	53	56	3
12 – Venetian Bay	108	33	34	0
All	**1,270**	**140 (11%)**	**192 (15%)**	**43 (3%)**

Finally, Table 75 through Table 78 provide a summary of NFIP building and contents claims by decade as well as by building type (elevated vs non-elevated) for all 12 Areas of Interest combined (similar to what is provided for each Area of Interest throughout this Appendix). To illustrate the difference in new construction, Table 79 and Table 80 compare NFIP building claims for 2000–2022 and for 2010–2022 by building type (elevated vs non-elevated) for all 12 Areas of Interest combined. While the differences in average claims between *elevated* and *non-elevated buildings* are not as extreme in newer construction, there is still a considerable difference.

Table 75: Hurricane Ian NFIP Building Claims for all Areas of Interest by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Pre 1980	426	$191,378	$164,891	1,799	$98.03	$224,593	89	41
1980s	344	$117,074	$100,584	1,863	$56.85	$237,892	20	10
1990s	173	$73,857	$62,496	2,256	$27.77	$244,554	9	0
2000s	205	$73,898	$61,791	2,675	$23.09	$247,078	18	1
Post 2010	122	$54,894	$48,091	2,977	$17.50	$250,000	4	0
All	**1,270**	**$123,168**	**$105,662**	**2,133**	**$57.47**	**$236,985**	**140**	**52**

Table 76: Hurricane Ian NFIP Contents Claims for all Areas of Interest by Decade Built

Decade Built	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Pre 1980	294	$209,007	$38,265	1,898	$20.48	$58,916	29	115
1980s	249	$115,867	$22,781	1,878	$12.71	$71,564	9	53
1990s	151	$74,217	$13,017	2,258	$5.40	$79,524	6	5
2000s	183	$78,448	$13,562	2,707	$4.95	$89,464	7	2
Post 2010	86	$63,757	$9,651	2,933	$3.83	$93,847	0	0
All	**963**	**$126,007**	**$23,053**	**2,195**	**$11.67**	**$74,342**	**51**	**175**

Table 77: Hurricane Ian NFIP Building Claims for all Areas of Interest by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Elevated	413	$50,287	$46,033	2,189	$26.46	$66,641	8	11
Non-elevated	857	$158,291	$134,398	2,106	$72.42	$51,422	132	41
All	**1,270**	**$123,168**	**$105,662**	**2,133**	**$57.47**	**$236,985**	**140**	**52**

Table 78: Hurricane Ian NFIP Contents Claims for all Areas of Interest by *Elevated* versus *Non-elevated Building* Type

Building Type	Active Policies	Average Total Claim	Average Contents Claim	Average Size	Average Contents Claim per square foot	Average Contents Coverage	Quantity Max NFIP Coverage	Quantity Max Contents Coverage
Elevated	346	$49,025	$5,077	2,216	$3.09	$79,545	4	18
Non-elevated	617	$169,177	$33,133	2,184	$16.48	$71,424	47	157
All	**963**	**$126,007**	**$23,053**	**2,195**	**$11.67**	**$74,342**	**51**	**175**

Table 79: Hurricane Ian NFIP Building Claims for all Areas of Interest by *Elevated* versus *Non-elevated Building* Type Post-2000 Construction

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Elevated	159	$30,021	$28,745	2,626	$11.52	$247,320	1	1
Non-elevated	168	$101,624	$83,117	2,940	$29.98	$248,870	21	0
All	**327**	**$66,608**	**$56,680**	**2,788**	**$21.00**	**$248,167**	**22**	**1**

Table 80: Hurricane Ian NFIP Contents Claims for all Areas of Interest by *Elevated* versus *Non-elevated Building* Type Post-2010 Construction

Building Type	Active Policies	Average Total Claim	Average Building Claim	Average Size	Average Building Claim per square foot	Average Building Coverage	Quantity Max NFIP Coverage	Quantity Max Building Coverage
Elevated	55	$29,175	$27,088	2,705	$10.40	$250,000	1	0
Non-elevated	67	$76.007	$65,332	3,201	$23.32	$250,000	3	0
All	**122**	**$54,894**	**$48,091**	**2,977**	**$17.50**	$250,000	**4**	**0**

Appendix D: Acknowledgements

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