NONSTRUCTURAL ANALYSES
APPENDIX

NEW JERSEY BACK BAYS
COASTAL STORM RISK MANAGEMENT
FEASIBILITY STUDY

PHILADELPHIA, PENNSYLVANIA

APPENDIX D

March 2019

U.S. Army Corps of Engineers
Philadelphia District

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D-1) NONSTRUCTURAL FLOOD PROOFING METHODDS

Non-Structural measures fall into four groups: Acquisition / Relocation, Building Retrofit (flood proofing, elevations, ring levees), Enhanced Flood Warnings (evacuation planning, emergency response systems), and Land Use Management (zoning, undeveloped land preservation).

Acquisition / Relocation

Acquisition and Relocation remove the structure from the floodplain. Acquisition is the outright purchasing of a structure and zoning the property as open space. The home and utilities are removed from the property.

Relocation involves moving a structure to a location that is less prone to flooding or flood-related hazards such as erosion. The structure may be relocated to another portion of the current site or to a different site. The surest way to eliminate the risk of flood damage is to relocate the structure out of the floodplain.

Relocation is an appropriate measure in high hazard areas where continued occupancy is unsafe or owners want to be free from flood worries. It is also a viable option in communities that are considering using the resulting open space for more appropriate floodplain activities. Relocation may offer an alternative to elevation for substantially damaged structures that are required under local regulations to meet NFIP requirements.

Figure 1. Structure place on a wheels vehicle for relocation to a new site

Relocation of a structure requires steps that typically increase the cost of implementing this retrofitting method compared to elevation. These additional costs include moving the structure to its new location, purchase and preparation of a new site to receive the structure (with utilities), construction of a new foundation, and restoration of the old site. Most types and sizes of structures can be relocated either as a unit or in segments. One-story wood-frame houses are usually the easiest to move, particularly if they are located over a crawlspace or basement that provides easy access to floor joists. Smaller, lighter wood-frame structures may also be lifted with ordinary house-moving equipment and often can be moved without partitioning. Homes constructed of brick, concrete, or masonry are also movable, but usually with more difficulty and increased costs.

Structural relocation professionals should help owners to consider many factors in the decision to relocate. The structural soundness should be thoroughly checked and arrangements should be made for temporary housing and storage of belongings. Many States and communities have requirements governing the movement of structures in public rights-of-way.

Table 1. Advantages and Disadvantages of Acquisition/Relocation

Advantages	Disadvantages
Allows substantially damaged or improved structure to be brought into compliance with the NFIP	May be cost-prohibitive
Significantly reduces flood risk to the structure and its contents	A new site must be located
Uses established techniques	Requires addressing disposition of the flood-prone site
Can be initiated quickly because qualified contractors are often readily available	May require additional costs to bring the structure up to current building codes for plumbing, electrical, and energy systems
Can eliminate the need to purchase flood insurance or reduce the premium because the home is no longer in the floodplain	
Reduces the physical, financial, and emotional strains that accompany flood events	

NFIP = National Flood Insurance Program

Building Retrofit

Appropriately applied retrofitting measures have several advantages over other damage reduction methods. Individual owners can undertake retrofitting projects without waiting for government action to construct flood control projects. Retrofitting may also provide protection in areas where large structural projects, such as dams or major waterway improvements, are not feasible, warranted, or appropriate. Some general considerations when implementing a retrofitting strategy include:

- Substantial damage or improvement requirements under the NFIP, local building codes, and floodplain management ordinances render some retrofitting measures illegal.

- Codes, ordinances, and regulations for other restrictions, such as setbacks and wetlands, should be observed.
- Retrofitted structures should not be used nor occupied during conditions of flooding.
- Most retrofitting measures should be designed and constructed by experienced professionals (engineers, architects, or contractors) to ensure proper consideration of all factors influencing effectiveness.
- Most retrofitting measures cannot be installed and forgotten. Maintenance must be performed on a scheduled basis to ensure that the retrofitting measures adequately protect the structure over time.
- Floods may exceed the level of protection provided in retrofitting measures. In addition to implementing these protective measures, owners should consider continuing (and may be required to purchase) flood insurance. In some cases, owners may be required by lending institutions to continue flood insurance coverage.
- When human intervention is most often needed for successful flood protection, a plan of action must be in place and an awareness of flood conditions is required.

Figure 2. Elevation of existing residence on extended foundation walls

Elevation

Elevating a structure to prevent floodwaters from reaching damageable portions is an effective retrofitting technique. The structure is raised so that the lowest floor is at or above the Design Flood Elevation (DFE) to avoid damage from a base flood.

While elevation may provide increased protection of a structure from floodwaters, other hazards must be considered before implementing this strategy. Elevated structures may encounter additional wind forces on wall and roof systems, and the existing footings may experience additional loading. Extended and open foundations (piers, posts, columns, and piles) are also subject to undermining, movement, and impact failures caused by seismic activity, erosion, scour, ice or debris flows, mudslides, and alluvial fan forces, among others.

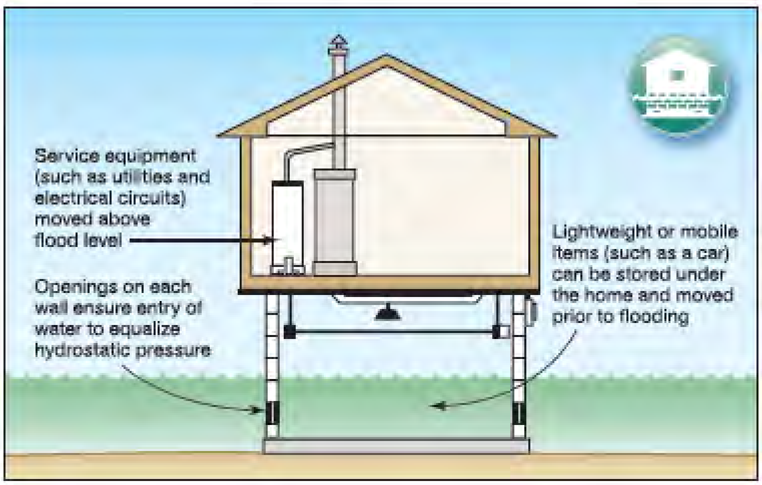
Table 2. Advantages and Disadvantages of Elevation

Advantages	Disadvantages
Brings a substantially damaged or improved building into compliance with the NFIP if the lowest horizontal structural member of the lowest floor is elevated to the BFE	May be cost-prohibitive
Reduces flood risk to the structure and its contents	May adversely affect the structure’s appearance
Eliminates the need to relocate vulnerable items above the flood level during flooding	Does not eliminate the need to evacuate during floods
Often reduces flood insurance premiums	May adversely affect access to the structure
Uses established techniques	Cannot be used in areas with high-velocity water flow, fast-moving ice or debris flow, or erosion unless special measures are taken
Can be initiated quickly because qualified contractors are often readily available	May require additional costs to bring the structure up to current building codes for plumbing, electrical, and energy systems
Reduces the physical, financial, and emotional strains that accompany flood events	Requires consideration of forces from wind and seismic hazards and possible changes to building design
Does not require the additional land that may be needed for floodwalls or levees	

NFIP = National Flood Insurance Program BFE = Base Flood Elevation

Solid Perimeter Foundation Walls

- ✓ low to moderate water depth and velocity
- ✓ Deep floodwaters can generate loads great enough to collapse the structure regardless of the materials used. Constructing solid foundation walls with openings or vents will help alleviate the danger by allowing hydrostatic forces to be equalized on both sides.

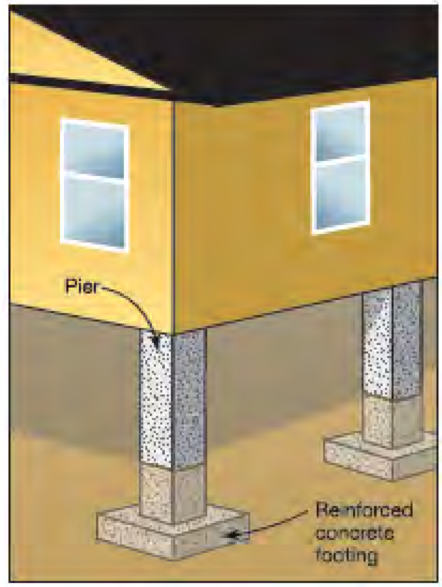


Elevation on Open Foundation Systems

Open foundation systems are vertical structural members that support the structure at key points without the support of a continuous foundation wall. Open foundation systems include piers, posts, columns, and piles.

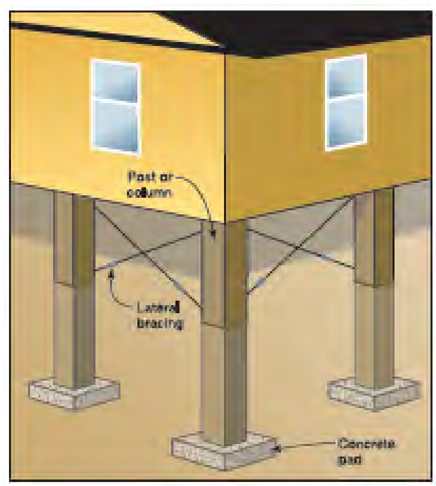
Elevation on Piers (concrete)

- ✓ Vertical structure members supported by a reinforced concrete footing
- ✓ piers are often the elevation technique least suited for withstanding significant horizontal flood forces
- ✓ Piers are generally used in shallow depth flooding conditions with low-velocity ice, debris, and water flow potential



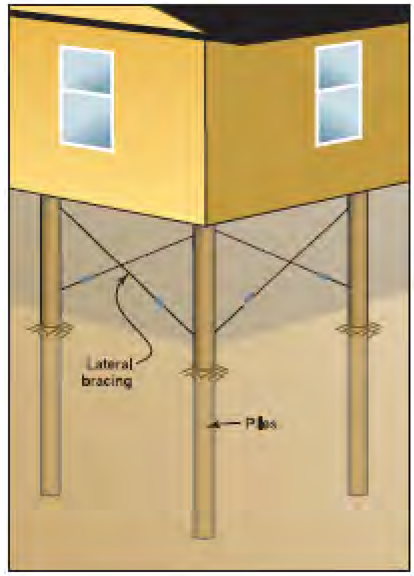
Elevation on Posts or Column

- ✓ wood, steel, or precast reinforced concrete
- ✓ moderate depths and velocities
- ✓ posts must be braced
- ✓ posts are smaller than columns



Elevation on Piles

- ✓ driven, jetted, or set (augured)
- ✓ less susceptible to the effects of high-velocity floodwaters, scouring, and debris impact
- ✓ rest on bedrock or be driven deep enough to create enough friction



Dry Flood Proofing

In dry flood proofing, the portion of a structure that is below the DFE (walls and other exterior components) is sealed to make it watertight and substantially impermeable to floodwaters. Such watertight impervious membrane sealant systems can include wall coatings, waterproofing compounds, impermeable sheeting and, supplemental impermeable wall systems, such as cast-in-place concrete. Doors, windows, sewer and water lines, and vents are closed with permanent or removable shields or valves.

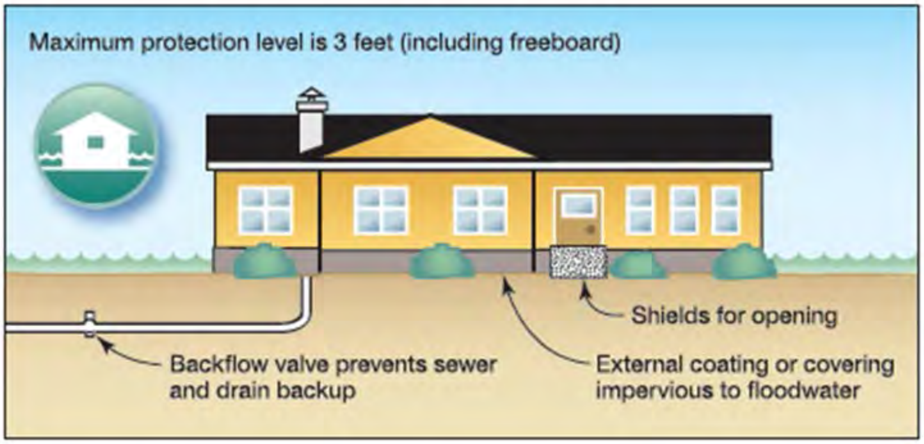


Figure 3. Dry Flood Proofed Structure

The expected duration of flooding is critical when deciding which sealant systems to use because seepage can increase over time, rendering the flood proofing ineffective. Waterproofing compounds, sheeting, or sheathing may fail or deteriorate if exposed to floodwaters for extended periods. Sealant systems are also subject to damage (puncture) in areas that experience water flow of significant velocity, or ice or debris flow. The USACE National Flood Proofing Committee has investigated the effect of various depths of water on masonry walls. The results of their work show that, as a general rule, no more than 3 feet of water should be allowed on a non-reinforced concrete block wall that has not previously been designed and constructed to withstand flood loads. Therefore, application of sealants and shields should involve a determination of the structural soundness of a building and its corresponding ability to resist flood and flood-related loads. An engineer should be involved in any design of dry flood proofing mitigation systems so that they can evaluate the building and run calculations to determine the appropriate height of dry flood proofing.

Dry flood proofing is also not recommended for structures with a basement. These types of structures can be susceptible to significant lateral and uplift (buoyancy) forces. Dry flood proofing may not be appropriate for a wood-frame superstructure; however, in some instances, buildings constructed of concrete block or faced with brick veneer may be considered for dry flood proofing retrofits. Weaker construction materials, such as wood-frame superstructure with siding, will often fail at much lower water depths from hydrostatic forces.

Table 3. Advantages and Disadvantages of Dry Flood Proofing

Advantages	Disadvantages
Reduces the flood risk to the structure and contents if the design flood level is not exceeded	Does not satisfy the NFIP requirement for bringing substantially damaged or improved residential structures into compliance
May be less costly than other retrofitting measures	Requires ongoing maintenance
Does not require the extra land that may be needed for floodwalls or reduced levees	Does not reduce flood insurance premiums for residential structures
Reduces the physical, financial, and emotional strains that accompany flood events	Usually requires human intervention and adequate warning time for installation of protective measures
Retains the structure in its present environment and may avoid significant changes in appearance	May not provide protection if measures fail or the flood event exceeds the design parameters of the measure
	May result in more damage than flooding if design loads are exceeded, walls collapse, floors buckle, or the building floats
	Does not eliminate the need to evacuate during floods
	May adversely affect the appearance of the building if shields are not aesthetically pleasing
	May not reduce damage to the exterior of the building and other property
	May lead to damage of the building and its contents if the sealant system leaks

NFIP = National Flood Insurance Program

Wet Flood Proofing

Another approach to retrofitting involves modifying a structure to allow floodwaters to enter it in such a way that damage to the structure and its contents is minimized. This type of protection is classified as wet flood proofing.

Wet flood proofing is often used when all other mitigation techniques are technically infeasible or are too costly. Wet flood proofing is generally appropriate if a structure has available space where damageable items can be stored temporarily. Utilities and furnaces may need to be relocated or protected along with other non-movable items with flood damage-resistant building materials. Wet flood proofing may also be appropriate for structures with basements and crawlspaces that cannot be protected technically or cost-effectively by other retrofitting measures.

Compared with the more extensive flood protection measures described in this manual, wet flood proofing is generally the least expensive. The major costs of this measure involve the rearrangement of utility systems, installation of flood damage-resistant materials, acquisition of labor and equipment to move items, and organization of cleanup when floodwaters recede. Major disruptions to structure occupancy often result during conditions of flooding.

Table 4. Advantages and Disadvantages of Wet Flood Proofing

Advantages	Disadvantages
Reduces the risk of flood damage to a building and its contents, even with minor mitigation	Does not satisfy the NFIP requirement for bringing substantially damaged or improved structures into compliance
Greatly reduces loads on walls and floors due to equalized hydrostatic pressure	Usually requires a flood warning to prepare the building and contents for flooding
May be eligible for flood insurance coverage of cost of relocating or storing contents, except basement contents, after a flood warning is issued	Requires human intervention to evacuate contents from the flood-prone area
Costs less than other measures	Results in a structure that is wet on the inside and possibly contaminated by sewage, chemicals, and other materials borne by floodwaters and may require extensive cleanup
Does not require extra land	Does not eliminate the need to evacuate during floods
Reduces the physical, financial, and emotional strains that accompany flood events	May make the structure uninhabitable for some period after flooding
	Limits the use of the floodable area
	May require ongoing maintenance
	May require additional costs to bring the structure up to current building codes for plumbing, electrical, and energy systems
	Requires care when pumping out basements to avoid foundation wall collapse

NFIP = National Flood Insurance Program

Ring Levees

Another retrofitting approach is to construct a barrier between the structure and source of flooding. There are two basic types of barriers: floodwalls and levees. They can be built to any height, but are usually limited to 4 feet for floodwalls and 6 feet for levees due to cost, aesthetics, access, water pressure, and space. Local zoning and building codes may also restrict use, size, and location.

Floodwalls are engineered barriers designed to keep floodwaters from coming into contact with the structure. Floodwalls can be constructed in a wide variety of shapes and sizes, but are typically built of reinforced concrete and/or masonry materials.

Figure 4. Home Protected by a Levee

A floodwall can surround an entire structure or, depending on the flood levels, site topography, and design preferences; it can also protect isolated structure openings such as doors, windows, or basement entrances. Floodwalls can be designed as attractive features to a residence, utilizing decorative bricks or blocks, landscaping, and garden areas, or they can be designed for utility at a considerable savings in cost.

Because their cost is usually greater than that of levees, floodwalls would normally be considered only on sites that are too small to have room for levees or where flood velocities may erode earthen levees. Some owners may believe that floodwalls are more aesthetically pleasing and allow preservation of site features, such as trees.

A levee is typically a compacted earthen structure that blocks floodwaters from coming into contact with the structure. To be effective over time, levees must be constructed of suitable materials (i.e., impervious soils) and with correct side slopes for stability. Levees may completely surround the structure or tie to high ground at each end.

Levees are generally limited to homes where floodwaters are less than 5 feet deep. Otherwise, the cost and the land area required for such barriers usually make them impractical for the average owner.

Special design considerations must be taken into account when floodwalls or levees are used to protect homes with basements because they are susceptible to seepage that can result in hydrostatic and saturated soil pressure on foundation elements.

The costs of floodwalls and levees can vary greatly, depending on height, length, and availability of construction materials, labor, access closures, and the interior drainage system. A levee could be constructed at a lower cost if the proper fill material is available nearby.

Table 5. Advantages and Disadvantages of Floodways and Levees

Advantages	Disadvantages
Protects the area around the structure from inundation without significant changes to the structure	Does not satisfy the NFIP requirements for bringing substantially damaged or improved structures into compliance
Eliminates pressure from floodwaters that would cause structural damage to the home or other structures in the protected area	May fail or be overtopped by large floods or floods of long duration
Costs less to build than elevating or relocating the structure	May be expensive
Allows the structure to be occupied during construction	Requires periodic maintenance
Reduces flood risk to the structure and its contents	Requires interior drainage
Reduces the physical, financial, and emotional strains that accompany flood events	May affect local drainage, possibly resulting in water problems for others
	Does not reduce flood insurance premiums
	May restrict access to structure
	Requires considerable land (levees only)
	Does not eliminate the need to evacuate during floods
	May require warning and human intervention for closures
	May violate applicable codes or regulations

NFIP = National Flood Insurance Program

Coastal Storm Plans and Preparedness

<u>Hazard Mitigation Plans</u>: Hazard mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. It is most effective when implemented under a comprehensive, long-term mitigation plan. State, tribal, and local governments engage in hazard mitigation planning to identify risks and vulnerabilities associated with natural disasters, and develop long-term strategies for protecting people and property from future hazard events. The State of New Jersey and all five counties in the study area have FEMA-approved hazard mitigation plans.

<u>Emergency and Evacuation Plans</u>: Emergency and evacuation planning is imperative for areas with limited access, such as barrier islands, high density housing areas, elderly population centers, cultural resources, and areas with limited transportation options. When a coastal storm threatens many of the communities in the study area, the limited number of bridges and causeways that connect the islands with the mainland become overcrowded, making evacuations

from the barrier islands to the mainland difficult. Timely evacuation depends on well-defined emergency evacuation plans used in conjunction with accurate flood forecasting.

The State of New Jersey Office of Emergency Management completed a hurricane evacuation study in 2007 with the support of the USACE and FEMA that provides the State of New Jersey with updated local and regional hurricane evacuation clearance times. The State also developed a hurricane survival guide and coastal evacuation maps. Prior to an emergency local, county or State emergency management officials notify neighborhoods of the need to evacuate or take other protective actions prior to the arrival of a storm event. This done via Emergency Alert System messages on local radio and TV. They may also alert entire areas via community notification systems such as “Reverse 911,” which sends messages to home telephones.

Early Flood Warning Systems: A critical component of successful emergency and evacuation plans are early flood warning systems. Despite improved tracking and forecasting techniques, the uncertainty associated with the size of a storm, the path, or its duration necessitate that warnings be issued as early as possible.

The National Hurricane Center and National Weather Service are responsible for preparing hurricane and nor’easter forecasts and warnings respectively. Both agencies are able to predict storm surge in real-time and asses potential storm surge flooding while the track of the storm is still changing. A limiting factor in the accuracy of early forecasts are predictions of storm track and intensity.

In addition to NHC and NWS storm surge forecasts, the New Jersey Tide Telemetry System (NJTTS) is able to report observed tidal elevations and weather data at 20 tide gages, 5 tide/weather stations, and 31 tidal crest-stage gages in 13 New Jersey counties. The tide level at each of the tide gages is automatically transmitted by NOAA and to specific critical decision-making centers. Additional work needs to be accomplished with Early Flood Warning Systems so local flood risk managers understand the severity of each event as it relates to their location based on the surge forecast and the regional topography. Descriptions such as “high”, “medium” and “low” risks for flooding, without definitions of what that means for local residents are not meaningful. Without two critical pieces of information, surge level compared to topography, a flood warning system may not communicate the specific level of risk to that community. More standardized systems, based on surge prediction networks, and local topography, and standardized elevation data can help local municipalities understand the risk for each surge event.

Public Education and Risk Communication: Hazard mitigation plans, emergency and evacuation plans, and early flood warning systems are of little value without communicating risk to local officials, community leaders, and decision-makers who are responsible for land use, evacuation planning, and implementation of mitigation measures. Public acceptability of coastal storm risk management measures, the difficulty individuals and communities have in understanding their own risk, and a lack of community engagement about coastal storm risk management options have all been cited as barriers to implementing good coastal management strategies.

Communities and residents often struggle navigating the complicated network of Federal, State, and local coastal programs. Hurricane Sandy generated huge public interest and awareness in flood risk management; however, it also led to several new initiatives and programs that may make communities feel overwhelmed and calloused to flood risk management opportunities.

Zoning Changes

Effective local floodplain management could potentially reduce the risk of flood peril even before the next storm event occurs. Communities at risk of flood peril have the regulatory authority to address local land use, zoning, and building codes to avoid siting development in floodplains. Communities participating in the NFIP must incorporate flood resistant construction standards into building codes. Local ordinances have been established in in some municipalities to reduce impervious surfaces such as driveways and parking areas, promote uniform bulkhead elevations, and require buildings to have an additional 2-3 feet of freeboard above the FEMA Base Flood Elevation (BFE).

An interagency task force could help municipalities incorporate climate change and sea level change in their planning, zoning, and adaptation plans.

National Flood Insurance Program Refinement

<u>Increase homeowner participation</u>: Residents that are uncertain about reducing risk to their belongings may be prone to attempt to remain in vulnerable areas during storm events, creating further risk. Knowing that personal property is insured, residents may be more comfortable with evacuating vulnerable areas at the approach of a storm. Flood insurance rates and regulations directly and indirectly impact property owners' decisions to reduce risk to their property though favorable construction practices.

<u>Increase municipal participation in Community Rating System (CRS)</u>: Community participation in the National Flood Insurance Program (NFIP) is conditional on meeting program guidelines. Participating communities must manage development within their floodplains in accordance with FEMA standards or risk removal from the program, which risks cancellation of all flood insurance policies within the community. Under the CRS, flood insurance premium rates are discounted to reward community actions that meet the three goals of the CRS, which are: (1) reduce flood damage to insurable property; (2) strengthen and support the insurance aspects of the NFIP; and (3) encourage a comprehensive approach to floodplain management. Participation in the CRS helps strengthen and enforce floodplain management policies.

<u>Voucher system to assist lower income groups</u>: One way to increase participation in the NFIP is a voucher system to provide assistance to lower income groups. Rising insurance rates and expanded flood plains have a greater burden on low income groups who may not be able to afford the increasing premiums associated with the Biggert-Waters Flood Insurance Reform Act.

D-2) DESIGN FLOOD ELEVATION

The design flood elevation or DFE was developed considering past, present, and future conditions. The State of New Jersey's requirement for building within a flood zone is an additional foot above the FEMA Base Flood Elevation, or BFE. Intermediate sea level rise is also accounted for in the development of the DFE. A rounding error factor was also applied to the Design Flood Elevation.

Base Flood Elevation (BFE): The hydraulics used for determination of the Base Flood Elevation are from the FEMA National Flood Hazard Layer geodatabase. The hydraulics were developed by FEMA and used for the study area. Preliminary data was used where available and the current effective floodplain data was used if the preliminary data was not available. To add the FEMA floodplain data to the structure database involves using GIS to spatially determine the static BFE and the Flood Zone where the structure is located. The static BFE and flood zone varies throughout the study and each structure is populated with the value for the BFE based on its spatial location. The structure inventory was updated to include attributes for the FEMA Flood Zone, FLD_ZONE, and the static BFE, STATIC_BFE.

Sea Level Rise: Intermediate curve 2080 expects the sea level rise to be 1.84 ft.

Table 6. USACE Sea Level Change Scenarios

Year	USACE - Low (ft, MSL[1])	USACE - Int (ft, MSL[1])	USACE - High (ft, MSL[1])
1992	0.00	0.00	0.00
2000	0.11	0.11	0.13
2019	0.35	0.42	0.62
2030	0.50	0.63	1.03
2050	0.76	1.06	2.01
2080	1.15	1.84	4.02
2100	1.41	2.54	5.74
2130	1.81	3.50	8.87

[1]Mean Sea Level based on National Tidal Datum Epoch (NTDE) of 1983-2001

Rounding Error: FEMA publishes the elevations with up to a 0.5 ft. rounding error to report the whole number elevation. This rounding error was captured by applying an additional 0.16 ft. of elevation to the Design Flood elevation. This was chosen to keep the design flood elevation a whole number for future implementation.

DFE = BFE + Local Ordinance + Sea Level Rise + Rounding Error Factor

D-3) FLOOD ELEVATIONS

The flood elevation is the elevation that the flood water for a given reoccurrence interval is expected to be at its highest. ERDC developed 226 different locations within the study area and calculated the flood elevations for multiple return intervals within each location. Each of the 226 areas within the study area had its own unique hydraulics. The 5% ACE, 10% ACE, and 20% ACE return periods were looked at in more detail to determine the number of homes at risk within each reoccurrence interval in order to calculate costs. The total structure inventory consists of 182,930 unique structures. The 20% return period flood elevation captured 5,958 structures with first floor elevations at or below the associated flood elevation. The 10% ACE return period flood elevation captured 17,556 structures with first floor elevations at or below the associated flood elevation. The 5% ACE return period flood elevation captured 31,660 structures with first floor elevations at or below the associated flood elevation.

Each structure within the study area was added to a geodatabase and given a unique identifier. The flood zone was determined by overlaying the structure layer with the FEMA National Flood Hazard Layer floodplain polygons. Once the flood zones were determined for each structure the static BFE for that flood zone was input into the structure inventory. The DFE was determined for each structure by adding 3 ft. to account for freeboard, sea level rise, and rounding errors to the coinciding BFE for the structure. The elevation difference between the first floor elevation and the DFE to determine how many structures are below the DFE and the BFE. Figure X shows the additional fields added to the geodatabase.

New columns are added to the attribute tables for the structure inventory:

Table

Atlantic_NBB_Inventory

IndexName	SaveID	Lake	IndexNumbe	FLD_ZONE	STATIC_BFE	DFE	Elev_DIFF	Freeboard
POR_082_11258	11258	n/a	108	AE	11	14	10.479	3
PLS_072_11315	11315	n/a	95	AE	11	14	10.5	3
GLW_081_11261	11261	n/a	106	AE	11	14	10.5	3
GLW_081_11261	11261	n/a	106	AE	11	14	10.5	3
GLW_081_11261	11261	n/a	106	AE	11	14	10.5	3
POR_082_11258	11258	n/a	108	VE	13	16	10.5	3
POR_082_11258	11258	n/a	108	VE	13	16	10.5	3
POR_082_11258	11258	n/a	108	VE	13	16	10.5	3
POR_082_11258	11258	n/a	108	AE	12	15	10.5	3
GLW_081_11261	11261	n/a	106	AE	11	14	10.5	3
GLW_081_11261	11261	n/a	106	AE	11	14	10.5	3
GLW_081_11261	11261	n/a	106	AE	11	14	10.5	3
POR_082_11258	11258	n/a	108	VE	13	16	10.5	3
POR_082_11258	11258	n/a	108	AE	11	14	10.5	3
POR_082_11258	11258	n/a	108	VE	13	16	10.5	3

FLD_ZONE – this was added to the inventory. The values used were taken from the FEMA NFHL based on where the centroid of the structure is located. This is the Flood Zone designation given to the area by FEMA.

STATIC_BFE – this was added to the inventory. The values used were taken from the FEMA NFHL based on where the centroid of the structure is located. This is the Base Flood Elevation with no adjustments calculated by FEMA for the flood zone the structure is in.

DFE – this was added to the inventory. This is the STATIC_BFE + 3. Three is the chosen freeboard to include +1 local regulations and +2 for sea level rise and rounding errors combined.

Elev_DIFF – this was added to the inventory. The Elev_DIFF is used to calculate the difference between the First Floor Elevation and the Design Flood elevation. ***(Elev_DIFF = DFE – FFE)***
{If – no mitigation} {If + Elevation Recommended}

Freeboard – this was added to the inventory. The chosen freeboard by the PDT is 3 ft. This includes +1 local regulations and +2 sea level rise and rounding errors.

Figure 5. Sample Geodatabase Development

Analysis by County

This analysis was completed to show the number of structures within the study area that are above or below the Design Flood Elevation, DFE. Additional analysis was completed to show which structures may be above the current standard of Base Flood Elevation, BFE + 1 but are below the DFE. The following image shows where a structure may be located compared to the DFE and BFE + 1. The image to the left is both above the BFE + 1 and the DFE. The image in the center is above the current regulatory requirement of BFE +1 but are below the DFE. The image on the right shows the structure below the BFE + 1. These were determined by subtracting the First Floor Elevation, FFE from the Design Flood Elevation within the GIS Database.

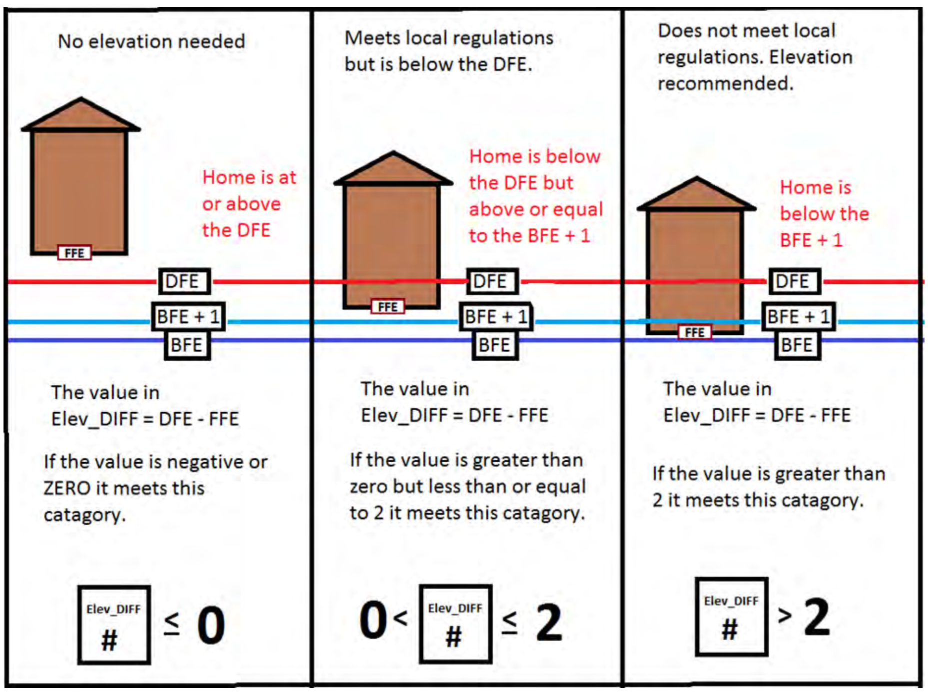


Figure 6. Visual of Home Location Compared to the Flood Elevation

FEMA Flood Zones

Analysis was completed on the structure locations within the FEMA flood hazard areas, which are identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. Moderate flood hazard areas, labeled Zone B or Zone X (shaded) are also shown on the FIRM, and are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood. The areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood, are labeled Zone C or Zone X (unshaded).

Atlantic County

DFE = BFE + 3 ft.

Municipalities: 19

Structures: 32,825

Total number of structures within a FEMA flood zone located in the study area.	
# Structures	**FLD_ZONE**
3034	0.2 PCT ANNUAL CHANCE FLOOD HAZARD
8	A
26307	AE
54	VE
3422	X
32825	**TOTAL STRUCTURES**

Analysis was completed on the structure locations within the FEMA flood hazard area shapefile. Atlantic county has a total of 32,825 structures within the study area. The table shows the number of structures within each flood zone.

Further analysis was completed to show the number of structures above the DFE, between the DFE and BFE + 1, and below the BFE + 1. The table shows the breakdown and percentages.

Atlantic Mitigation based on DFE and BFE + 1			Elev Recommend
Total Structures	Above DFE	Between BFE + 1 and DFE	Below BFE + 1
	no mitigation	*possible mitigation*	*mitigation*
32,825	6,994	5,746	20,085
Percent of Total structures within the county 15,658	21.31%	17.50%	61.19%

The following two tables show the number of structures above the DFE and the number of homes below the DFE. This captures all of the structures below the Design Flood Elevation within the study area.

Atlantic USING DFE ONLY		
Total Structures	No Mitigation	Elevation Recommended
	Above or equal DFE	*Below DFE*
32,825	6,994	25,831
100%	21.31%	78.69%
DFE = FEMA BFE + 3		

nh

This table shows the breakdown of how many structures are estimated to be above the DFE. The DFE used is the FEMA BFE + 3. The freeboard of 3 includes the local ordicance, sea level rise, and rounding error correction factors. This table shows the breakdown separated into Municipality from tax data.

MUN_NAME	**# Structures**	# Above DFE No Mitigation	Above DFE % No Mitigation	# Below DFE Elevation	Below DFE % Elevation
ABSECON CITY	791	608	77%	183	23%
ATLANTIC CITY CITY	7782	212	3%	7570	97%
BRIGANTINE CITY	6285	984	16%	5301	84%
CORBIN CITY CITY	106	57	54%	49	46%
EGG HARBOR CITY	4	3	75%	1	25%
EGG HARBOR TWP	1600	839	52%	761	48%
ESTELL MANOR CITY	23	19	83%	4	17%
GALLOWAY TWP	249	149	60%	100	40%
HAMILTON TWP	492	404	82%	88	18%
LINWOOD CITY	752	575	76%	177	24%
LONGPORT BORO	1227	15	1%	1212	99%
MARGATE CITY CITY	5510	447	8%	5063	92%
MULLICA TWP	296	77	26%	219	74%
NORTHFIELD CITY	165	141	85%	24	15%
PLEASANTVILLE CITY	627	373	59%	254	41%
PORT REPUBLIC CITY	250	154	62%	96	38%
SOMERS POINT CITY	1878	1124	60%	754	40%
VENTNOR CITY	4574	651	14%	3923	86%
WEYMOUTH TWP	214	162	76%	52	24%

Burlington County

DFE = BFE + 3 ft.

Municipalities: 2

Structures: 322

# Structures	FLD_ZONE
150	AE
172	X
322	**TOTAL STRUCTURES**

Analysis was completed on the structure locations within the FEMA flood hazard area shapefile. Atlantic county has a total of 322 structures within the study area. The table shows the number of structures within each flood zone.

Further analysis was completed to show the number of structures above the DFE, between the DFE and BFE + 1, and below the BFE + 1. The table shows the breakdown and percentages.

Burlington Mitigation based on DFE and BFE + 1			Elev Recommend
Total Structures	Above DFE	Between BFE + 1 and DFE	Below BFE + 1
	no mitigation	*possible mitigation*	*mitigation*
322	174	21	127
Percent of Total structures within the county 322	54.04%	6.52%	39.44%

The following two tables show the number of structures above the DFE and the number of homes below the DFE. This captures all of the structures below the Design Flood Elevation within the study area.

Burlington USING DFE ONLY		
Total Structures	No Mitigation	Elevation Recommended
	Above or equal DFE	*Below DFE*
322	174	148
100%	54.04%	45.96%
DFE = FEMA BFE + 3		

This table shows the breakdown of how many structures are estimated to be above the DFE. The

MUN_NAME	**# Structures**	# Above DFE No Mitigation	Above DFE % No Mitigation	# Below DFE Elevation	Below DFE % Elevation
BASS RIVER TWP	311	167	54%	144	46%
WASHINGTON TWP	11	7	64%	4	36%

Cape May County

DFE = BFE + 3 ft.

Municipalities: 15

Structures: 57,923

# Structures	FLD_ZONE
46689	AE
134	AO
1908	AREA NOT INCLUDED
102	VE
9090	X
57923	**TOTAL**

Analysis was completed on the structure locations within the FEMA flood hazard area shapefile. Atlantic county has a total of 57,923 structures within the study area. The table shows the number of structures within each flood zone.

Further analysis was completed to show the number of structures above the DFE, between the DFE and BFE + 1, and below the BFE + 1. The table shows the breakdown and percentages.

Cape May Mitigation based on DFE and BFE + 1				Elev Recommend
Total Structures	Above DFE	Between BFE + 1 and DFE	Below BFE + 1
	no mitigation	*possible mitigation*	*mitigation*
57,923	12,619	12,046	33,258
Percent of Total structures within the county 57,923	21.79%	20.80%	57.42%

The following two tables show the number of structures above the DFE and the number of homes below the DFE. This captures all of the structures below the Design Flood Elevation within the study area.

Cape May USING DFE ONLY		
Total Structures	No Mitigation	Elevation Recommended
	Above or equal DFE	*Below DFE*
57,923	12,619	45,304
100%	21.79%	78.21%
DFE = FEMA BFE + 3		

This table shows the breakdown of how many structures are estimated to be above the DFE. The DFE used is the FEMA BFE + 3. The freeboard of 3 includes the local ordicance, sea level rise, and rounding error correction factors. This table shows the breakdown separated into Municipality from tax data.					
MUN_NAME	**# Structures**	# Above DFE No Mitigation	Above DFE % No Mitigation	# Below DFE Elevation	Below DFE % Elevation
AVALON BORO	5304	790	14.89%	4514	85.11%
CAPE MAY CITY	3788	1924	50.79%	1864	49.21%
CAPE MAY POINT BORO	611	163	26.68%	448	73.32%
DENNIS TWP	150	110	73.33%	40	26.67%
LOWER TWP	1907	1907	100.00%	0	0.00%
MIDDLE TWP	1831	1275	69.63%	556	30.37%
NORTH WILDWOOD CITY	5681	94	1.65%	5587	98.35%
OCEAN CITY CITY	17882	2065	11.55%	15817	88.45%
SEA ISLE CITY CITY	6330	606	9.57%	5724	90.43%
STONE HARBOR BORO	3114	802	25.75%	2312	74.25%
UPPER TWP	1559	778	49.90%	781	50.10%
WEST CAPE MAY BORO	920	531	57.72%	389	42.28%
WEST WILDWOOD BORO	670	1	0.15%	669	99.85%
WILDWOOD CITY	3078	4	0.13%	3074	99.87%
WILDWOOD CREST BORO	5098	1542	30.25%	3556	69.75%

Monmouth County

DFE = BFE + 3 ft.

Municipalities: 19

Structures: 10,598

# Structures	FLD_ZONE
1225	0.2 PCT ANNUAL CHANCE FLOOD HAZARD
15	A
3251	AE
1	D
205	VE
5901	X
10598	**TOTAL STRUCTURES**

Analysis was completed on the structure locations within the FEMA flood hazard area shapefile. Atlantic county has a total of 10,598 structures within the study area. The table shows the number of structures within each flood zone.

Further analysis was completed to show the number of structures above the DFE, between the DFE and BFE + 1, and below the BFE + 1. The table shows the breakdown and percentages.

Monmouth Mitigation based on DFE and BFE + 1			Elev Recommend
Total Structures	Above DFE	Between BFE + 1 and DFE	Below BFE + 1
	no mitigation	*possible mitigation*	*mitigation*
10,598	7,268	930	2,400
Percent of Total structures within the county 10,598	68.58%	8.78%	22.65%

The following two tables show the number of structures above the DFE and the number of homes below the DFE. This captures all of the structures below the Design Flood Elevation within the study area.

Monmouth USING DFE ONLY		
Total Structures	No Mitigation	Elevation Recommended
	Above or equal DFE	*Below DFE*
10,598	7,268	3,330
100%	68.58%	31.42%
DFE = FEMA BFE + 3		

This table shows the breakdown of how many structures are estimated to be above the DFE. The DFE used is the FEMA BFE + 3. The freeboard of 3 includes the local ordicance, sea level rise, and rounding error correction factors. This table shows the breakdown separated into Municipality from tax data.

MUN_NAME	**# Structures**	# Above DFE No Mitigation	Above DFE % No Mitigation	# Below DFE Elevation	Below DFE % Elevation
ALLENHURST BORO	52	48	92%	4	8%
ASBURY PARK CITY	477	450	94%	27	6%
AVON BY THE SEA BORO	714	508	71%	206	29%
BELMAR BORO	2170	1713	79%	457	21%
BRADLEY BEACH BORO	808	777	96%	31	4%
BRIELLE BORO	554	346	62%	208	38%
DEAL BORO	19	19	100%	0	0%
INTERLAKEN BORO	70	66	94%	4	6%
LAKE COMO BORO	328	273	83%	55	17%
LOCH ARBOUR VILLAGE	121	78	64%	43	36%
LONG BRANCH CITY	17	14	82%	3	18%
MANASQUAN BORO	2044	499	24%	1545	76%
NEPTUNE CITY BORO	409	394	96%	15	4%
NEPTUNE TWP	1488	1139	77%	349	23%
OCEAN TWP	76	68	89%	8	11%
SEA GIRT BORO	487	416	85%	71	15%
SPRING LAKE BORO	551	309	56%	242	44%
SPRING LAKE HEIGHTS BOR	151	111	74%	40	26%
WALL TWP	62	26	42%	36	58%

Ocean County

DFE = BFE + 3 ft.

Municipalities: 29

Structures: 81,262

# Structures	FLD_ZONE
9856	0.2 PCT ANNUAL CHANCE FLOOD HAZARD
34	A
58586	AE
313	AO
1310	VE
11163	X
81262	**TOTAL**

Analysis was completed on the structure locations within the FEMA flood hazard area shapefile. Atlantic county has a total of 10,598 structures within the study area. The table shows the number of structures within each flood zone.

Further analysis was completed to show the number of structures above the DFE, between the DFE and BFE + 1, and below the BFE + 1. The table shows the breakdown and percentages.

Ocean Mitigation based on DFE and BFE + 1			Elev Recommend
Total Structures	Above DFE	Between BFE + 1 and DFE	Below BFE + 1
	no mitigation	*possible mitigation*	*mitigation*
81,262	22,103	7,175	51,984
Percent of Total structures within the county 81,262	27.20%	8.83%	63.97%

The following two tables show the number of structures above the DFE and the number of homes below the DFE. This captures all of the structures below the Design Flood Elevation within the study area.

Ocean USING DFE ONLY		
Total Structures	No Mitigation	Elevation Recommended
	Above or equal DFE	*Below DFE*
81,262	22,103	59,159
100%	27.20%	72.80%
DFE = FEMA BFE + 3		

This table shows the breakdown of how many structures are estimated to be above the DFE. The DFE used is the FEMA BFE + 3. The freeboard of 3 includes the local ordicance, sea level rise, and rounding error correction factors. This table shows the breakdown separated into Municipality from tax data.

MUN_NAME	**# Structures**	# Above DFE No Mitigation	Above DFE % No Mitigation	# Below DFE Elevation	Below DFE % Elevation
BARNEGAT LIGHT BORO	1189	392	32.97%	797	67.03%
BARNEGAT TWP	755	191	25.30%	564	74.70%
BAY HEAD BORO	1014	102	10.06%	912	89.94%
BEACH HAVEN BORO	2384	441	18.50%	1943	81.50%
BEACHWOOD BORO	57	16	28.07%	41	71.93%
BERKELEY TWP	4374	112	2.56%	4262	97.44%
BRICK TWP	9772	4500	46.05%	5272	53.95%
EAGLESWOOD TWP	305	124	40.66%	181	59.34%
HARVEY CEDARS BORO	1182	297	25.13%	885	74.87%
ISLAND HEIGHTS BORO	716	645	90.08%	71	9.92%
LACEY TWP	4772	1588	33.28%	3184	66.72%
LAKEWOOD TWP	5	5	100.00%	0	0.00%
LAVALLETTE BORO	2551	245	9.60%	2306	90.40%
LITTLE EGG HARBOR TWP	4964	992	19.98%	3972	80.02%
LONG BEACH TWP	8217	1597	19.44%	6620	80.56%
MANTOLOKING BORO	479	28	5.85%	451	94.15%
OCEAN GATE BORO	1075	307	28.56%	768	71.44%
OCEAN TWP	1849	498	26.93%	1351	73.07%
PINE BEACH BORO	99	69	69.70%	30	30.30%
POINT PLEASANT BORO	4818	2536	52.64%	2282	47.36%
PT PLEASANT BEACH BORO	2869	688	23.98%	2181	76.02%
SEASIDE HEIGHTS BORO	1958	302	15.42%	1656	84.58%
SEASIDE PARK BORO	2020	654	32.38%	1366	67.62%
SHIP BOTTOM BORO	1883	316	16.78%	1567	83.22%
SOUTH TOMS RIVER BORO	93	48	51.61%	45	48.39%
STAFFORD TWP	4864	567	11.66%	4297	88.34%
SURF CITY BORO	2248	270	12.01%	1978	87.99%
TOMS RIVER TWP	13689	3276	23.93%	10413	76.07%
TUCKERTON BORO	1061	284	26.77%	777	73.23%

D-4) FIRST FLOOR ELEVATION ANALYSIS

First floor elevations of the structures were extrapolated from the centroid of the tax data polygons and LIDAR. Analysis was done on a random sample of structures to compare the centroid elevation of the polygon to the ground elevation of the ground adjacent to the entrance of the structure. The height from the adjacent ground elevation to the first floor was also considered. These heights were estimated by counting the number of steps to the entrance and any other elevations that needed to be included. The following factors have been developed to be used only within the study area to be applied to the entire study area.

Shows the First Floor Elevation approximatly 3 ft. above the ground elevation. This factor is referred to as the foundation height.

Figure 7. First Floor Elevation

The first floor elevation above the ground elevation of the centroid of the structure were developed for six property types. These foundation heights can be seen in Figure X.

Residential 1 story	+1.5 ft
Residential 2+ story	+2.5 ft
Apartment	+0.5 ft
Commercial	+0.5 ft
Industrial	+0.5 ft
Public	+0.5 ft

Figure 8. Estimated Foundation Height Factors

This methodology uses existing information to develop estimates of first floor elevations. Assumptions made are that every home is the same height above the building centroid. In reality some of these homes will be at grade and others will be higher than the estimate. This estimate is a good starting point for developing nonstructural measures for a very large structure database.

The study team also collected existing FEMA Elevation Certificates, EC, for the study area as a potential means for estimating first floor elevations for the entire structure inventory. More than 5,600 ECs were collected from the five counties. Many of the ECs were scanned copies and extrapolating the pertinent information from them proved to be difficult. In addition, it was determined by the team that the ECs would not be indicative of a representative sampling of the structure inventory. ECs are often collected because they are necessary for flood insurance rating purposes or for building code verification. That means that the EC sampling was likely to be for the buildings at highest risk of flooding and may skew the first floor elevations lower.

D-5) STRUCTURE INVENTORY AND LOT FOOTPRINT ANALYSIS

To determine the median square footage for each construction type, we used the building footprint shapefiles provided by NJDEP. The building footprints were spatially compared to the tax map centroids. There multiple issues in this analysis, some of which are illustrated in Figure X. Sometimes an apartment complex may have 1 footprint and multiple centroids, and sometimes the centroids were not inside of a footprint. These outliers were left out of the calculations of the footprint estimates.

Figure 9. Tax Map Centroid versus Building Footprint

We were able to estimate the footprint size for 62% of the structures within the study area. The building footprint size was calculated for single story residential, two or more story residential, and apartments, commercial, industrial, pubic, and vacant /other. The calculated footprint for the structures is for the first floor of the structure, not including additional stories, and does not represent the total square footage of the home. The median and average footprint size were calculated for each structure type within each of the five counties in the study area. A new Area field was added to the dataset and the field is populated with the estimated areas for each structure. The medians for each structure type were used in the analysis.

Atlantic County				
		Residential	Atlantic County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Residential			
2	1 story	6322	1830.75	1582.97
2	2+ story	14,492	2624.64	1706.3

		Apartment	Atlantic County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Apartment			
4C	Apartment	153	6197.16	2840.48

		Commercial	Atlantic County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Commercial			
4A	Commercial	995	16203.16	4475.47

		Industrial	Atlantic County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Industrial			
3A	Industrial	3	2763.94	2927.86
3B	Industrial	0		
4B	Industrial	7	24436.61	9406.2
5A	Industrial	0		
5B	Industrial	0		
6A	Industrial	0		
6B	Industrial	0		

		Public	Atlantic County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Public			
15A	Public	16	60,236,312	44827.52
15B	Public	0		
15C	Public	44	10,402.23	5649
15D	Public	93	13863.46	4255.43
15E	Public	0		

		Other	Atlantic County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Other			
1	Vacant	0		
15F	Other	187	12682.79	2148.62

Burlington County				
		Residential	Burlington County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Residential			
2	1 story	6	2,636.22	1866.63
2	2+ story	1	1,824.64	1,824.64

		Apartment	Burlington County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Apartment			
4C	Apartment	0		

		Commercial	Burlington County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Commercial			
4A	Commercial	0		

		Industrial	Burlington County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Industrial			
3A	Industrial	1	993.33	993.33
3B	Industrial	0		
4B	Industrial	0		
5A	Industrial	0		
5B	Industrial	0		
6A	Industrial	0		
6B	Industrial	0		

		Public	Burlington County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Public			
15A	Public	0		
15B	Public	0		
15C	Public	0		
15D	Public	0		
15E	Public	0		

		Other	Burlington County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Other			
1	Vacant	0		
15F	Other	0		

Cape May County				
		Residential	Cape May County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Residential			
2	1 story	10,939	2,155.01	1596.36
2	2+ story	17,323	3,251.05	2182.09
		Apartment	Cape May County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Apartment			
4C	Apartment	240	2,652.89	2281.53
		Commercial	Cape May County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Commercial			
4A	Commercial	1,197	7,158.48	4573.73
		Industrial	Cape May County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Industrial			
3A	Industrial	5	3,542.31	2179.91
3B	Industrial	0		
4B	Industrial	4	12,997.84	13657.89
5A	Industrial	0		
5B	Industrial	0		
6A	Industrial	0		
6B	Industrial	0		
		Public	Cape May County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Public			
15A	Public	7	116,688	75332.18
15B	Public	2	7,507.87	7,507.87
15C	Public	53	11,433.16	6587.1
15D	Public	68	6603.43	4078.6
15E	Public	0		
		Other	Cape May County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Other			
1	Vacant	0		
15F	Other	65	5855.57	2431.72

Monmouth County				
		Residential	Monmouth County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Residential			
2	1 story	2174	1852	1376.8
2	2+ story	3711	2607.88	1699.98
		Apartment	Monmouth County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Apartment			
4C	Apartment	25	3451	2153.86
		Commercial	Monmouth County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Commercial			
4A	Commercial	216	9546	4857.5
		Industrial	Monmouth County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Industrial			
3A	Industrial	0		
3B	Industrial	0		
4B	Industrial	17	16630	15366.46
5A	Industrial	0		
5B	Industrial	0		
6A	Industrial	0		
6B	Industrial	0		
		Public	Monmouth County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Public			
15A	Public	1	56,851	56,851
15B	Public	2	31451	31451
15C	Public	15	5,047.00	2449.32
15D	Public	13	10367	7692.38
15E	Public	0		
		Other	Monmouth County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Other			
1	Vacant	0		
15F	Other	10	2653	1676.57

Ocean County

		Residential	Ocean County	
Code	Type	Total Structures	Average Area ft^2	Median Area ft^2
	Residential			
2	1 story	28,846	1863.98	1553.77
2	2+ story	24,325	2,256.39	1749.18
		Apartment	**Ocean County**	
Code	**Type**	**Total Structures**	**Average Area ft^2**	**Median Area ft^2**
	Apartment			
4C	Apartment	50	2,675.78	2092.12
		Commercial	**Ocean County**	
Code	**Type**	**Total Structures**	**Average Area ft^2**	**Median Area ft^2**
	Commercial			
4A	Commercial	1,047	5,670.45	3265.52
		Industrial	**Ocean County**	
Code	**Type**	**Total Structures**	**Average Area ft^2**	**Median Area ft^2**
	Industrial			
3A	Industrial	0		
3B	Industrial	0		
4B	Industrial	8	6,881.89	5390.57
5A	Industrial	0		
5B	Industrial	0		
6A	Industrial	0		
6B	Industrial	0		
		Public	**Ocean County**	
Code	**Type**	**Total Structures**	**Average Area ft^2**	**Median Area ft^2**
	Public			
15A	Public	11	41,957	35,383.13
15B	Public	1	9,568.31	9,568.31
15C	Public	97	5,620.51	3072.53
15D	Public	62	5128.32	3974.67
15E	Public	0		
		Other	**Ocean County**	
Code	**Type**	**Total Structures**	**Average Area ft^2**	**Median Area ft^2**
	Other			
1	Vacant	0		
15F	Other	203	2549.11	1946.74

D-6) COSTS

Significant research when into the economic analysis to mitigate each structure. This cost was applied to elevation, relocation, acquisition, and wet/dry flood proofing. The further determination of which methods would be used will be developed later in the study. When we are able to differentiate which method will be used we can apply costs to those different measures. Further analysis will also be completed with historical data to develop an expected participation rate for each of the mitigation methods.

The two primary sources of cost information are the North Atlantic Coast Comprehensive Study (NACCS) and the recent Southwest Coastal (SWC) Louisiana Study, which had a large nonstructural component.

The NACCS provided parametric cost estimates for various coastal storm risk management measures, including nonstructural options. Real estate costs are not included in the development of the parametric unit costs. Figure X shows Table VIII-5 from the NACCS Appendix C which illustrates the parametric cost estimate for elevating a typical 1,400 square foot residential structure 8-feet.

Table VIII-5. Elevation (bldg. retrofit) - Construction Quantities & Costs

	Quantity		Parametric Estimate	
Item	Number	Unit	Unit Cost	Total Cost
Elevation 8 feet	1	ea	$122,600	$122,600
Temporary rehousing	1	ea	$10,000	$10,000
Subtotal				$132,600
Contingency	25%			$33,150
Total Construction				$165,750
E&D	$10,000			$10,000
S&A	10%			$16,575
Total Estimated First Construction Cost				$192,325
Annualized First Costs				$8,200
O&M	N/A			$0
Total Estimated Annual Average Cost				$8,200

Figure 10. NACCS Parametric Cost Estimate for Building Elevation

The SWC Louisiana Study developed cost-to-elevate estimates using thorough research, which included estimates from industry experts. The New Jersey Back Bay Study Team compared the two methods on a cost-to-elevate per square foot basis, but ultimately used the NACCS parametric cost estimate with a slight modification based on median square footage of the building footprint.

As mentioned above, the NACCS cost estimate is based on a typical 1,400 square foot residential structure. The results of the footprint analysis resulted in a median square footage of 1,559 square feet for single story buildings and 1,839 square feet for multi-story buildings. The resulting cost estimates for the study are shown in Figure 11 and Figure 12.

NACCS		SFR1		
Item	Number	Unit	Unit Cost	Total Cost
Elevation 8 feet	1559	SQFT	$87.57	$136,483
Temporary rehousing	1	ea	$10,000	$10,000
Subtotal				*$146,483*
Contingency	25%			$36,621
Total Construction				*$183,104*
E&D	$10,000			$10,000
S&A	10%			$18,310
Total Estimated First Construction Cost				**$211,414**

Figure 11. Elevation Cost Estimate for Single Building (NACCS-based)

NACCS		SFRM		
Item	Number	Unit	Unit Cost	Total Cost
Elevation 8 feet	1839	SQFT	$87.57	$161,016
Temporary rehousing	1	ea	$10,000	$10,000
Subtotal				*$171,016*
Contingency	25%			$42,754
Total Construction				*$213,770*
E&D	$10,000			$10,000
S&A	10%			$21,377
Total Estimated First Construction Cost				**$245,147**

Figure 12. Elevation Cost Estimate for Multi-Story Building (NACCS-based)

D-7) REFERENCES

Flood Proofing Tests – Tests of Materials and Systems for Flood Proofing Structures (USACE, 1988).

FEMA's NFIP Technical Bulletin 2-08, Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program (FEMA, 2008a),