7

Appendices

7.1 // APPENDIX I | SCOPE ISSUES & COST PROJECTION

The full expression of the strategies for improvements and adaptation developed by the team requires an understanding of possible scope issues and ramifications of current zoning and building codes.

Resiliency improvements will require bringing the building up to current building code if:

1. Scope of structural work > 50% of area of footprint of building
2. Scope of all work > 50% of value of current improvement (building only)

As basic resiliency improvements are likely to exceed one of these thresholds, the team believes it is prudent to imagine that any work in Scenario 1 and 2 will likely need to be upgraded for code compliance. Additionally, most required code compliance improvements (structure strengthened against lateral loads; impact resistant windows and doors; upgraded fire protection, electrical, plumbing systems) translate to improved building resilience.

Apartment Building

Structural/building shell

- Foundations – combination of new helical piles, pin piles, micro piles, and auger piles.
- Reinforce walls (generally channel block walls, add rebars and grout.)
- Impact windows; reinforce jambs (generally channel block, add rebars and grout.)
- Provide fall protection for windows below 42" above floor.
- Upgrade roof structure using UL roofing assembly (generally add hurricane ties)
- Install roofing membrane with Florida product approval or Miami-Dade County NOA.
- Upgrade roof drainage to internal leaders; provide overflow scuppers.
- Masonry remedial work.
- Stucco remedial work including decorative elements.

Electrical

- Upgrade main electrical disconnect and panel.
- Possible upgrade of wiring and switching, depending on age of building/current state of system.
- Currently FPL transformers/vaults don't need to be dry floodproofed, but the Switch-Gear room does.

Fire Protection

- Fire alarm and fire protection upgrade. (sprinklers in large building, stand pipes, FPC (Siamese cat connection) etc.
- Code compliant fire alarm system.
- PDA communication system.

Plumbing

- Revise gas connections.
- Revise water main connections.
- Revise sanitary connections.
- Replace plumbing fixtures to meet new Energy Conservation code.

Air conditioning

- Remove all wall-thru air conditioning systems.
- Replace with split system.
- New/existing roof mounted compressors with tie-downs.

Landscape

- Meet minimum landscaping requirements.
- Provide irrigation for landscaped areas.
- Relocate irrigation valves and landscape lights.

Civil

- Improve drainage to retain all water on site; install injection well.
- 24hr percolation for site water.
- Relocate all ground clean outs and raise inlets of existing site drainage catch of area.

Basement (if any)

- Dry floodproof.
- Sewage ejector.

- Backwater valves.
- Waterproofing all perimeter walls and penetrations up to BFE.

Accessibility
- FHA compliance not required in buildings occupied prior to March 13, 1991.

Trash Collection
- Trash rooms need to be dry floodproofed with walls waterproofed up to BFE+1.

Hotels

Structural/building shell
- Foundations – combination of new helical piles, pin piles, micro piles, and auger piles.
- Reinforce walls (generally channel block walls, add rebars and grout)
- Impact windows; reinforce jambs (generally channel block, add rebars and grout)
- Provide fall protection for windows below 42" above floor.
- Upgrade roof structure using UL roofing assembly (generally add hurricane ties)
- Install roofing membrane with Florida product approval or Miami-Dade County NOA.
- Upgrade roof drainage to internal leaders; provide overflow scuppers.
- Masonry remedial work.
- Stucco remedial work including decorative elements.

Electrical
- Upgrade main electrical disconnect and panel.
- Upgrade main electrical disconnect and panel.
- Upgrade wiring and switching, depending on age of building/current state of system.
- New emergency generator.
- For historic hotels not up to current code, smoke evacuation plans for open lobbies.

Fire Protection:?
- Fire alarm upgrade.
- Code compliant fire alarm system.
- PDA communication system.
- Annunciator (large hotels only)
- Emergency lighting at egress path.

Plumbing
- Revise gas connections.
- Revise plumbing connections.
- Revise sanitary connections.
- Replace plumbing fixtures to meet efficiency code.

Air conditioning
- Remove all wall-thru air conditioning systems. Replace with split system
- New/existing roof mounted compressors with tie-downs.

Landscape
- Meet minimum landscaping requirements
- Provide irrigation for landscaped areas
- Relocate irrigation valves and landscape lights

Civil
- Improve drainage to retain all water on site; install injection well
- 24hr percolation for site water
- Relocate all ground clean outs and raise inlets of existing site drainage catch of area

Basement (if any)
- Dry floodproof
- Sewage ejector
- Backwater valves
- Waterproofing all perimeter walls and penetrations up to BFE.

Accessibility
- FHA compliance not required in buildings occupied prior to March 13, 1991

Trash Collection
- Trash rooms need to be dry floodproofed with walls waterproofed up to BFE+1.

Strategy 1a | internal raise

- Brace and shore existing building facades.
- Design, engineer and install steel shoring system; coordinate shoring for installation of new structure.
- Demolish wood floor framing, wood wall framing, wood roof framing and all interior finishes at all levels.
- Install new structure within shell and tie the shell back to the new structure; remove shoring system.
- Upgrade foundation in consistent with current code requirements, including support of new slab.
- Upgrade existing structure with new perimeter tie-beams at new floor levels.
- Install new concrete floor system at new ground floor level.
- Install new wood framed floor, walls and roof at new levels.
- Extension of vertical circulation at ground floor.
- Install new finishes, fixtures, equipment, systems
- Install new impact windows; provide fall protection at windows less than 42" above finish floor
- New water and sewer connections at ground floor.
- Relocate electric and gas meters to new levels.

Strategy 1b – Adaptive use

Front of building.
- Brace and shore existing shell for removal of wood floor framing and wood wall framing at ground floor.
- Design, engineer and install steel shoring system; coordinate shoring for installation of new floor/column structure supporting upper floors.
- Demolish wood floor framing, wood wall framing and flooring system at ground floor.
- Install wet or dry-floodproofed concrete floor system at existing ground floor below BFE+1.
- Dry-floodproofed system.
- Foundational walls upgraded to be watertight, substantially impermeable to the passage of water, and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy
- waterproof foundation walls both sides.
- Install helical or pin piles.
- Install hydrostatic slab at current floor elevation.
- Provide flood barriers at doors/window openings below BFE+1
- Design floor for commercial use
- Create blind recess at location of former crawl space vents; retain decorative vent covers, if any.

Wet-floodproofed system
- Foundational walls upgraded to be watertight, substantially impermeable to the passage of water, and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy
- waterproof foundation walls both sides.
- Install new clean structural fill.
- Install new slab on grade (hydrostatic?)
- Install smart floodvents.
- Create blind recess at location of former crawl space vents; retain decorative vent covers, if any
- Install steel columns/beams at rear to transfer loads from upper floors of building.
- Install water-resistant finishes on ground floor spaces; no drywall.

Code compliance of front of building

- Upgrade front of building to code compliance
- Provide ADA access ramp/lift to ground floor commercial use.

*Note: building improvements in the front of the building may be kept under full code compliance threshold if it would be possible to allow replacement of ground floor wood framing with concrete structural system without ‘penalty’

Back of building.

- Brace and shore existing building facades
- Design, engineer and install steel shoring system; coordinate shoring for installation of new structure.
- Install new multi-story concrete/steel structure within building adaptation zone of lot and tie to existing building walls.
- Auger cast or micro piles.
- Pile caps.
- Foundation walls.
- Concrete floor slabs of 2 new units/floor (new floor structure footprint approx. 1300sf/ floor + 250sf/floor balcony.
- 2 stairs (or scissor stair)
- Traction machine room-less elevator
- Exterior walls 50% masonry & stucco; 50% floor to ceiling glass window wall or sliding glass doors
- Habitable roof and roofing system (note large area of roof to be covered by mechanical equipment.)

Scenario 1c – Matroyshka Doll approach

- Brace and shore existing building facades
- Design, engineer and install steel shoring system; coordinate shoring for installation of new structure.
- Retain and upgrade first 20’ of floor structures from Avenue-facing front building façade; behind, demolish wood floor framing, wood wall framing, wood roof framing and all interior finishes at all levels .
- Reinforce existing building facades behind first 20’ for free-standing condition.

Install new structure within shell; remove shoring system

- Install new auger cast piles.
- Install new pile caps.
- Install new foundation walls.
- Install new concrete floor system at new floor levels.
- Install 2 stairs .
- Install traction machine room-less elevator
- Exterior walls 50% masonry & stucco; 50% floor to ceiling glass window wall or sliding glass doors.
- Habitable roof and roofing system.
- Install new finishes, fixtures, equipment, systems.
- Install new impact windows; provide fall protection at windows less than 42” above finish floor

Scenario 2a – Individual approch

Building raise

- Prepare steel supports and cribbing/ stabilize structure (ideally steel supports can be designed to remain in place for future raising)
- Cut attached stoops, planters and fountains for separate raise.
- Raise building to necessary height (8’-12’) for construction of new foundations and installation of new infrastructure.
- Lower building to final height.
- Reinstall stoops, planters and fountains at new elevation.

New foundations

- Helical, pin or micro piles (most buildings not currently on piles)
- New pile caps.
- New foundation walls.
- Waterproof foundation walls both sides to

BFE+1; membrane waterproofing on inside, applied waterproofing on outside.

Site

- Raise lot in parallel with building raise
- Construct new masonry retaining wall on piles and continuous footer
- Add fill between waterproof new foundation wall and new masonry retaining wall
- Construct new stairs to connect main walkway from building entrances to sidewalk and alley
- Construct new stair to connect secondary walkway (if any to alley)

Landscape

- New landscape and irrigation on new raised site/planters.

Code compliance

- Upgrade building to code compliance.

Cost Projection

A construction cost model was developed by Arup in parallel with the design and engineering effort of the resiliency strategies prepared for the City of Miami Beach. Individual estimates were generated for each of the different typologies and scenario permutations. Within each estimate, there were three different cost groupings: resiliency, code compliance, and sustainability. The resiliency grouping contains all of the costs involved with increasing the structures' abilities to withstand rising sea levels and other climate change related events. The code compliance grouping contains the costs engendered by updating the structures to code if the resiliency designs within each scenario triggered a Level 3 Structural Alteration as described by Florida's building code when implemented. The sustainability cost grouping contains costs associated with additional design measures in each scenario that further add to the structures' and the City of Miami Beach's adaptability and long-term prosperity.

Given the variability of structures within each building typology, a representative structure of each typology was chosen to base the required quantification of elements upon. Available as-built drawings and structural inspection reports were analysed for quantities and cost elements. Unit rates for the proposed elements were then applied using Arup's internal construction cost database, publicly available historical information, and outreach with regional contractors. The product of the quantities and unit rates were then used to generate direct costs for each element. The direct costs for each typology in each scenario were summed, with indirect costs being calculated based on a percentage of the total direct cost summation. The total cost was then calculated as the sum of the total direct and indirect costs.

The table included shows the relative cost of each scenario as compared to the least and most expensive building types with red being the most expensive and green being the least expensive. The gray squares represent the typologies that have been omitted from the matrix conditioning due to their absence from the given scenario. It is important to note however, that the level of protection and resilience resulting from each adaptation scenario are not equivalent. While Scenario 0 is overall the least expensive, the building remains in place and is not elevated to be protected internally from floodwaters. Therefore, while the comparison gives an idea of cost per typology and scenario, the cost comparisons are not equivalent to resiliency value.

Typology	Scenario 0	Scenario 1A	Scenario 1B	Scenario 1C	Scenario 2A
T1 - Home					
T2 -Urban Villa					
T3 - Rambler					
T4 - Walk Up					
T5 - Interior Corridor					
T6 - Catwalk					
T7 - Dingbat					
T8 - Low Rise Hotels					
T9 - High Rise Hotels					

Total Cost by Structure Type and Scenario

7.3 // APPENDIX II | SUPPLEMENT WATER PROJECTIONS / DATA

7.3.1 Quantifying water summary | Coastal systems analysis

A. National Geodetic Vertical Datum (NGVD 29) versus North American Vertical Datum (NAVD 88)

Two vertical datums are commonly referenced to measure ground and flood elevations within Miami Beach. The National Geodetic Vertical Datum (NGVD 29) is a system that has been used nationally for most of the 20th century. This datum was established by the National Geodetic Survey (NGS) in 1929 based on an established network of 26 tidal gauges within the United States and Canada.

Recent satellite technology discovered distortions in surveyed elevations, causing the NGS to develop a new system to establish elevation measurements. Specifically, the North American Vertical Datum (NAVD 88) was developed by NGS in 1988 to account for local variations caused by currents, wind, barometric pressures, temperature, topography of the sea bed, salinity differences and varying mean sea levels.

The elevations in Miami Beach can be easily converted from the NAVD to NGVD datum by adding 1.56 feet. For example, an elevation of +6.4 feet NAVD is equivalent to +8.0 feet NGVD.

Previously, most FEMA flood maps had used the NGVD datum as their reference. More recently, these maps are being converted to the NAVD datum. The FEMA flood zone maps published for Miami Beach are referenced to NGVD and prescribe a base flood elevation of +8 feet NGVD within the AE8 zone referenced for the Flamingo Park Historical District. It is important that all flood, ground and building elevations use the same datum when assessing flood risk. For the purpose of this report, all elevations will be converted and referenced to the NGVD datum.

B. Sea Level Rise

Human-caused global warming is contributing to the thermal expansion of seawater and the melting of land-based ice sheets and glaciers, resulting in sea level rise. Scientists determined that mean sea level has risen 6.3 to 8.3 inches between 1900 and 2016. More precise data measurements indicate an acceleration of 3.0 inches of mean sea level rise between 1993 and 2017. Predicting sea level rise is challenging due to the many factors influencing climate change.

Organizations researching climate change and its influence on sea level rise include, among many, the Intergovernmental Panel on Climate Change (IPCC) – an intergovernmental body of the United Nations, the U.S. Army Corps of Engineers (USACE) – a U.S. federal agency associated with flood protection, and the National Oceanic and Atmospheric Administration (NOAA) – an American scientific agency focused on oceans, waterways and the atmosphere. In January 2009, Broward, Miami-Dade, Monroe and Palm Beach Counties united to form the Southeast Florida Climate Compact (Compact) to coordinate climate change mitigation and adaptation activities. The Compact created a Regional Climate Action Plan to outline recommended mitigation and adaptation strategies, including a unified sea level rise projection for the region.

Specifically, the Compact formed an ad-hoc working group, identified as the Sea Level Rise Work Group, to update the 2011 Unified Sea Level Rise Projection report. The updated report was drafted and released in 2015, after the National Oceanic and Atmospheric Administration (NOAA) et al. 2012 and U.S. Army Corps of Engineers (USACE) 2013 projections were released.

The Compact utilized the updated projections throughout their 2015 Report, and based their adaptation measures on the updated

Estimated Relative Sea Level Change Scenarios for Miami Beach, FL (2020-2100) *All values are expressed in feet (NGVD 29)*							
Source	**NOAA et al. 2012**				**USACE 2013**		
Scenario	**NOAA Low**	**NOAA Int Low**	**NOAA Int High**	**NOAA High**	**USACE Low**	**USACE Int**	**USACE High**
1992 (-18YR)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
2020 (Today)	0.82	0.89	1.04	1.22	0.82	0.89	1.11
2030 (+10YR)	**0.90**	**1.03**	**1.31**	**1.64**	**0.90**	**1.03**	**1.43**
2040 (+20YR)	0.98	1.18	1.64	2.15	0.98	1.18	1.83
2060 (+40YR)	**1.13**	**1.54**	**2.46**	**3.50**	**1.13**	**1.54**	**2.85**
2080 (+60YR)	1.29	1.98	3.50	5.25	1.29	1.98	4.16
2100 (+80YR)	**1.45**	**2.48**	**4.78**	**7.41**	**1.45**	**2.48**	**5.77**

Table 2.1: Unified Sea Level Rise Projection, Southeast Florida Regional Climate Change Compact,

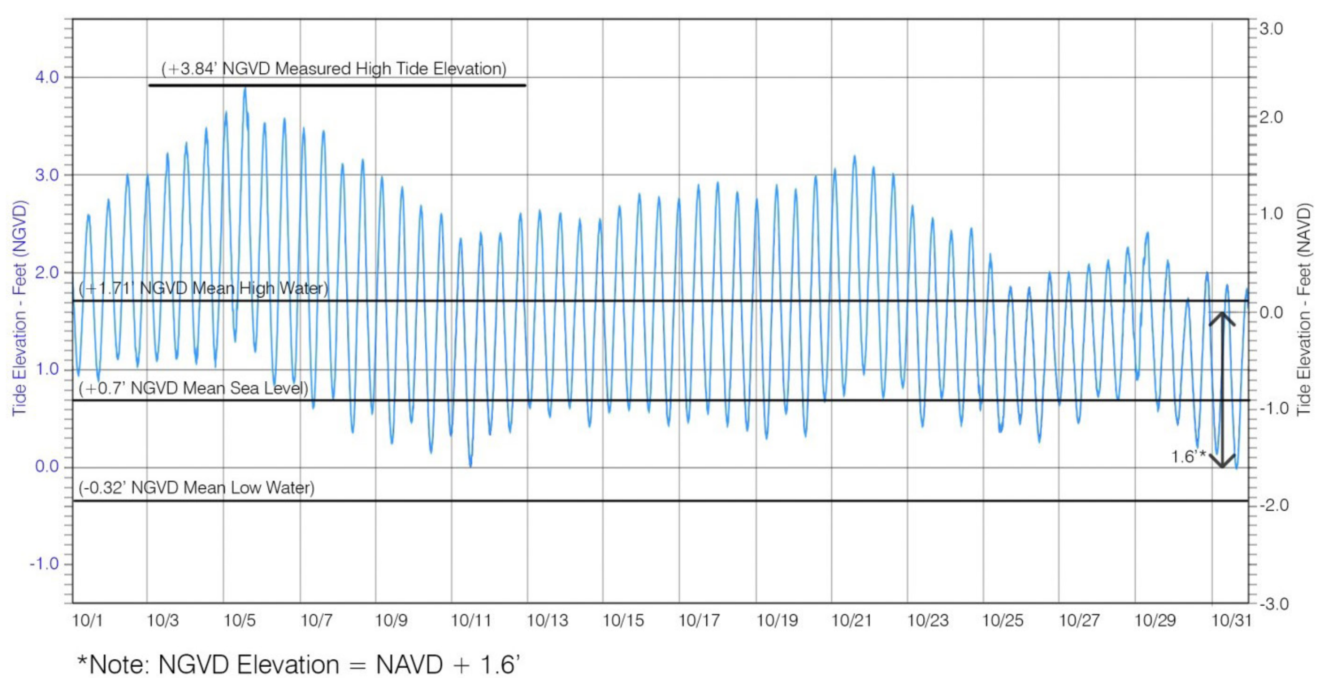

Figure 3.1: High and Low Tide Elevations Observed at Virginia Key, FL.

projections. According to the Compact, the 2015 Projection update shifted the sea level rise projection start date to 1992, which is the "center of the current mean sea level National Tidal Datum Epoch of 1983-2001" (Compact, 2015).

Within the 2015 Report, the Sea Level Rise Work Group recommends that the updated unified sea level rise projection include three curves: the NOAA High Projection, the USACE High Projection, and a projection corresponding to the median of the IPCC AR5 RCP8.5 scenario (Compact, 2015). These recommendations are summarized in Figure 2.1 and Table 2.1 as presented below.

Guidance is provided within the Regional Climate Action Plan regarding the recommended use of the curves and tables for planning of various municipal projects:

- The lower curve (blue dashed line) is recommended for use in the design of low risk projects with short design lives.
- The shaded zone (in blue, between the IPCC AR5 and the USACE High) is recommended to be applied for most projects, within a short term planning horizon. This zone is projected to reflect the most likely range of sea level rise for the remainder of the 21st century.
- The NOAA High curve (solid orange line) is recommended for projects with medium to long term applications, which are not easily replaceable or removable or have a long design life of more than 50 years.

It is recommended that the NOAA High curve be used for planning purposes in assessing alternatives and recommending code changes in the Historic Districts.

C. King Tides

King Tides are the cause of nuisance, or "sunny-day", flooding, and usually occur during the months of September, October and November on Miami Beach. Tides are a result of the movement of water over the earth's surface caused by the gravitational forces of the moon, sun and earth's rotation. The moon moves around the earth in an elliptical orbit approximately every 29 days while the earth moves around the sun in a similar elliptical orbit approximately every 365 days. King Tides are the highest predicted high tides of the year, occurring when the moon and the sun are closest to the earth during their respective orbits, and when the planets are most closely aligned to a single axis in space.
This infrequent but predictable occurrence results in the greatest combined gravitational pull of water across the earth's surface, causing higher than average tide water levels, referred to as King Tides. Measured King Tides may be further amplified by local weather or ocean influences occurring simultaneously with the alignment of peak planetary gravitational forces.

The graphic below (Figure 3.1) depicts tide levels observed at the Virginia Key tide station between October 1, 2017 and October 31, 2017. This station is the closest tide gauge station to Miami Beach, and is representative of tides within the region. The highest King Tide was measured on October 5, 2017 at +3.8 feet NGVD, with each of the two daily high tide events occurring between October 4 and October 7 equaling or exceeding +3.5 feet NGVD.

The documented mean high water, mean low water and mean sea level elevations are also presented on the graph – referenced at +1.7 feet NGVD, -0.3 feet NGVD and +0.7 feet NGVD, respectively. It is noted that the mean range of tide elevations during the peak King Tides are abnormally higher than the documented mean range occurring during normal tide conditions.

D. Predicted Flooding within the Districts due to King Tides

The depth of King Tide flooding within the Districts is determined by subtracting the actual surveyed sidewalk or building floor elevations from the highest measured King Tide elevation. Future flooding is similarly calculated, with the inclusion of sea level rise predictions superimposed on top of the highest King Tide elevation.

The predicted change in sea level rise in 20, 40, and 60 years is calculated as the difference between the predicted sea level elevation in 2017 (time of the maximum King Tide) and each of the future years considered. Table 4.1 summarizes the predicted highest water surface elevation in 20, 40, and 60 years, by adding the 2017 measured King Tide to the projected differences. Figures 4.1 and 4.2 illustrate ground and road elevations relative to the NGVD datum within each of the Flamingo Park and Collins Waterfront Historic Districts, respectively.

The Flamingo Park and Collins Waterfront Historic Districts have ground elevations ranging from +3.6 to +5.0 feet NGVD. With King Tide elevations predicted to reach +5.1 feet NGVD by 2040 these districts will be subject to regular King Tide flooding within 20 years. Flooding will continue to increase in regularity and flood depth out 50 years and beyond. It is recommended that any major improvements to existing buildings be designed with a minimum first floor elevation above +7.0 feet NGVD.

E. Storm Surge

Storm surge is the abnormal rise in seawater level during a tropical storm, measured as the height of the water above the normal predicted tide. Storms are measured by their return period or recurrence level. Storms having a 10- 20-, 50-, 100- or 500-year period (recurrence level) are significant when assessing vulnerability and flood risk. The Federal Emergency Management Agency (FEMA) prepares flood maps indicating levels of flood risk based on the 100-year storm event, which is a storm having a one percent probability of occurring in any given year.

Various numerical models have been developed by both public and private entities for calculating storm surge elevations at a given location for storms having different probabilities of occurrence. Storm parameters generally used as input into the numerical models include wind stress, bottom stress, dynamic wave set up, topology, astronomical tide, storm speed, size and atmospheric pressure. The Florida Department of Environmental Protection (DEP) uses a model developed by R.G. Dean and T.Y. Chui, (Dean 2003) as the basis of their Coastal Construction Control Line Program. The Federal Emergency Management Agency (FEMA) most commonly uses the "FEMA Coastal Flooding – Hurricane Storm Surge Model" (FEMA Surge) for assessing flood hazard (FEMA 2009). The accuracy of model predictions depends on the quality of available data and precision of each model.

Coastal Systems reviewed the studies published by DEP and FEMA, and compared the water surface level predictions associated with storm surge events in Miami Beach, resulting from each study. Figure 5.1 presents a graph illustrating the storm surge versus return period storm from each of these two studies. It is noted FEMA predicted the 100-year storm surge at +7.1 feet NGVD, which translated to a prescribed flood hazard zone of AE8 within the Historic Districts. The DEP model predicts a storm surge elevation of +13.6 feet NGVD for the same 100-year storm, representing a 6.5 foot difference in predicted flood elevations.

For reference purposes, the literature review as conducted by U-Surge, presents a summary of historical storm surge elevations measured for 28 storm events that occurred in Miami since 1880. The storm surge elevations for four storms impacting the Miami area are summarized in Table 5.1. Documented storm surge elevations of these historical storms support the storm surge predictions as presented in the DEP report.

Archived photos of the 1926 Great Miami Hurricane and Hurricane Betsy in 1965 are presented as Exhibits 5.1 - 5.3, below. The storm surge flooding and resulting impacts within the Miami Beach region further support storm surge predictions as presented in the DEP report. Storm surge elevations associated with the 25-year, 50-year, 100-year, and 500-year storms as presented in the 2003 DEP report are listed as Present Day elevations. However, as sea levels rise, so too will the storm surge wave heights from the various return period storms. These elevations are adjusted for sea level rise increases between 2003 (the date of the DEP study) and for years 2040, 2060, and 2080. The results are listed below in Table 5.2. Figures 5.2 and 5.3 present east-west cross sections illustrating the 100-year storm surge elevations within the Flamingo Park and Collins Waterfront Historic Districts, respectively. Under present conditions, the 100-Year storm surge elevation is +13.6 feet NGVD, representing significant flooding of the first floor of the buildings within these districts.
In 60 years, sea level elevations are projected to increase by 4.4 feet as summarized in Table 5.2, thus translating to a 100-Year storm surge elevation of +18.0 feet NGVD – similar to the predicted 500-Year storm surge elevation for present conditions, which is +17.7 feet NGVD.

The second floor of the buildings within the Historic Districts will be flooded during the 100-Year storm in 50 to 60 years. Crest elevations of dunes along Miami Beach dune are approximately +14 feet NGVD. In 60 years with sea level rise, the wave crests associated with the 100-Year storm surge elevations will be higher than the existing dune system, resulting in additional damage impacts associated with both the increased storm surge water level elevation, plus the force of propagating waves.

It is recommended that code revisions allow for existing buildings within the Historic Districts to be raised to achieve habitable floor elevations above +17.7 feet NGVD. Alternatively, the code could provide for flood proofing of a newly created ground floor and foundation system along with a change in use to provide for a revenue-producing use of the building. Similarly, code revisions should provide for an increase of the ground floor elevation, to be above the predicted King Tide elevations in 60 years, or above +7.9 feet NGVD.

F. Rainfall

In order to analyze other possible water levels anticipated throughout the historic districts, Coastal Systems reviewed the most current Draft Basin Studies of Indian Creek Parkway and Flamingo Park prepared by AECOM. The reports models a closed stormwater system which includes a total of 5 pump stations for the Flamingo and Collins Historic Districts, designed to provide a positive Level of Service for a 10-Year, 1-Day Storm event. The model also includes a tailwater equivalent to the projected 60-Year Sea Level and yields a maximum stage below the crown of the road. Assuming the system is water tight and check valves are installed at the outfall locations, it is conceivable that the seawater will not intrude into the stormwater system. This will allow the stormwater system to operate exclusively during rain events. However, several existing catch basins and surrounding grade elevations are below the projected 60-Year sea level.
Due to the porosity of the soils, the water table may rise above the surrounding grounds. This scenario will fully saturate the soils and excess water will run off into the catch basins resulting in continuous running of the stormwater pumps. It is recommended that additional studies be conducted to determine if specific roads or historic buildings will need to be raised in the future to remain dry and above the water table elevation. This will result in a dry system, as originally designed by AECOM, and allow the pumps to operate exclusively during rain events.

Rainfall Events: Coastal Systems referred back to the 2011 CDM Stormwater Master Plan

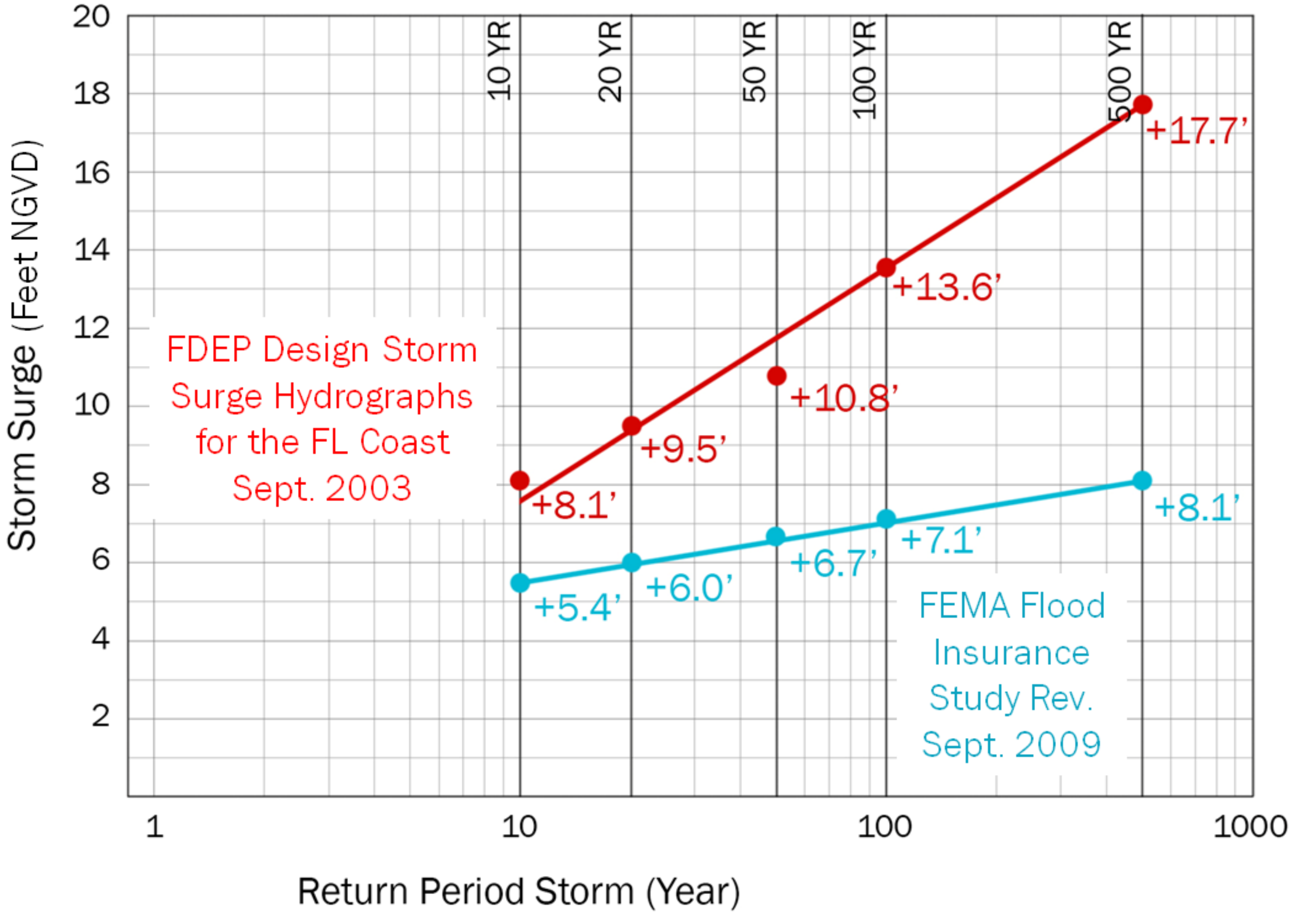

Figure 5.1: Storm Surge associated with Return Period Storms.

Report prepared for the City of Miami Beach. As part of the report, the existing conditions were modeled, the water levels for various rainfall events were recorded, and rainfall volumes were used to calibrate and validate the modeled results. Based on the models and observed water levels throughout the region, the following water levels were determined:

- 1-Year Storm: +4.10’ NGVD
- 2-Year Storm: +4.30’ NGVD
- 5-Year Storm: +4.35’ NGVD
- 10-Year Storm: +4.50’ NGVD

Exhibit 5.2: The Great Miami Hurricane of 1926 generated a 15-ft (4.57-m) storm tide in Miami. Submerged palm trees reveal the extraordinary water levels in this historic photo. Source: U-Surge

Exhibit 5.1: Hurricane Betsy’s storm tide in Miami Beach, FL (1965). Source: Getty Images, U-Surge

Exhibit 5.3: Miami Beach following the Great Miami Hurricane of 1926. Source: U-Surge

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A4 General buildings strategies

A4.1 Backflow prevention

While floodwaters can cause direct damage alone, many of the secondary effects caused by rising waters can be equally damaging to property and create other health hazards. For example, elevated water levels can cause waste in sanitary sewer lines to back up through drain pipes and overflow out into homes through toilets and other drains. Sanitary sewer systems can often become inundated with floodwater during storm events. Combined sanitary and storm sewer systems are even more susceptible to backflow problems caused by flooding as they are designed to capture both wastewater and stormwater drainage.

Rising sea levels add an additional problem to existing drainage systems. Beyond just flooding events causing sewers to back up, some sewer systems that eventually drain into ocean waters can also back up during high tide events on sunny days. When first constructed, these pipe outfalls were always above the surface elevation of the water. However, as oceans rise, the water easily backs up into pipe openings during high tides unless a valve is installed to prevent this. During major emergency events, failure of a municipal sewer pump station can also cause sewage to back up into a home.

One solution to this issue is to install backflow prevention valves on sewer lines exiting homes. Backflow prevention valves allow flow in only one direction. Waste or stormwater can flow out through the sewer pipe, but is also prevented from flowing back into the home. There are different kinds of valves available for backflow prevention as outlined below. A backflow prevention valve should be always installed correctly by a trained/licensed plumber or contractor who has obtained any necessary building permit documentation before commencing work.

It is important to note that when a backflow prevention device is engaged during a flood event, it will not be possible to use the plumbing system within the home. The sanitary lines will not be able to drain until the flood levels recede and the valve can be opened again. However, this system downtime will reduce the need for costly restoration work that is the alternative if a backflow valve is not used.

Backflow Prevention Valve Types:

Gate Valves

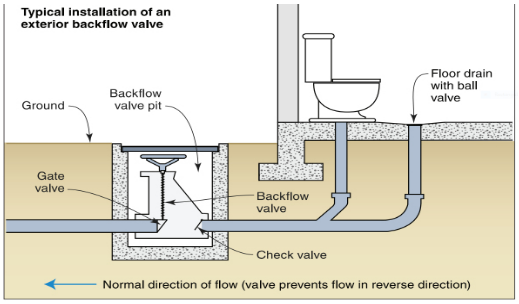
- require manual operation
- provide a tighter seal against backflowing liquid
- more expensive

Flap/Check Valves

- operate automatically
- can become blocked by debris and fail to close properly and prevent backflow
- require regular inspection and cleaning
- least expensive

Dual Backflow Valves

- most expensive
- more complex
- offer redundancy in case failure occurs in one portion of the valve system



Source: FEMA Homeowner's Guide to Retrofitting

A4.2 Mechanical System Flood Prevention

Mechanical equipment primarily includes heating, ventilation, and air conditioning (HVAC) systems. These pieces of equipment contain sensitive components such as monitoring instruments and calibration devices that are easily impacted by flooding or even increased moisture levels. Small amounts of saltwater can quickly corrode mechanical systems, rendering them inoperable. Not only are the major components of mechanical systems at risk, but also their secondary components that easily serve as pathways for floodwaters to travel through. These include ducts, grilles, registers, and control valves—all openings that floodwater can enter.

One of the simplest and most effective ways to protect primary mechanical system components (boilers, air handling units, compressors, fans, etc.) is to elevate them above design flood elevations. Primary components are high value items to replace, typically making the cost of elevating these units worth the investment. If the entire home is being raised, the unit can be raised with the house and if necessary, placed alongside the house on a new cantilevered structural platform. If just the mechanical equipment is being raised, a standalone pedestal or portion of raised earth can provide the required elevation to protect the unit from floodwaters.

If there is sufficient structural capacity, primary units can also be relocated to the roof of the buildings they serve. However, consideration should be given to the visual impact of this move, especially on low-rise structures. Screening of this equipment may be appropriate to provide cover from the street. Any screening, however, must still provide adequate manufacturer clearances and free area openings to not restrict performance of the equipment. In addition, when relocating to the roof existing utility points of entry may require significant re-routing of mechanical system secondary components to reach the new unit location.

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If elevating or relocating is not feasible, mechanical equipment can also be protected in place by constructing watertight walls around the unit. This is not a desirable option as it will require the clearance between the equipment and the water-tight walls to be large enough to allow for a person to have adequate access and perform maintenance. In addition, space must be provided in accordance with manufacturer requirements for recommended heat of reject clearances and other air inflow/outflow requirements. Given the possibility of failure or water overtopping the walls in extreme events, the equipment should also be adequately anchored to its base to resist floodwater buoyancy forces. For other considerations related to protecting equipment in place, see the Dry Floodproofing section.

Similar to primary units, secondary components of mechanical systems should also be relocated above design flood elevations if feasible. HVAC ductwork can be relocated to run within ceiling soffit or attic space, as opposed to crawlspace below the first floor. Ductwork can be sizable; however, and therefore relocation may require significant interior finish renovations to integrate fully with the desired interior layout and structural framing system. Alternatively, a ductless split system (“mini-split”) could be utilized as a new installation. This would reduce or eliminate the need for ductwork in the building and help in facilitating retrofit construction and cost.

Any mechanical system control devices or electrical components should be relocated above flood elevations, something that can usually be done for minimal cost. For both controls and primary units, access for maintenance operations must be considered.

For regulations regarding new construction or substantial improvements to a building within a flood hazard area, refer to the Florida Building Code, Chapter 3, Section R322 – Flood Resistant Construction.

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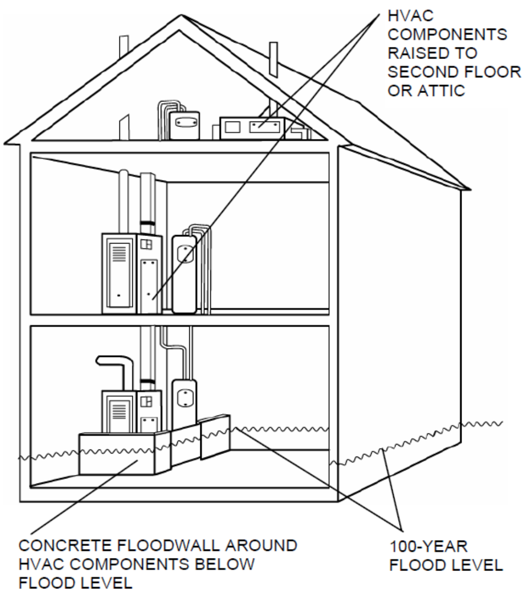


Source: FEMA Homeowner's Guide to Retrofitting

A4.3 Power & life-safety/ utilities flood prevention

Unless an electrical system is specifically designed to be submerged underwater, floodwater severely damages its various components. These include electric panels, meters, switches, outlets, light fixtures, and the wiring that connects them all together. Even with just a short period of contact with water, electrical system components can be destroyed beyond repair and require complete replacement. Beyond the loss of function and inconvenience of a power outage, electrical components interacting with floodwaters can also trigger fire hazards and hold the risk of electrocution. In an emergency situation, sustained power loss is not only an inconvenience but can prevent the ability for speedy cleanup and recovery after a flood or other event.

Like mechanical systems, the easiest way to protect electrical systems is to locate them as high above the design flood elevation. For new construction, this is relatively easy to incorporate into design plans for the home. For mitigating risk to existing electrical systems, relocating them to high elevations is still the preferred solution for ensuring protection and resiliency to flooding. When locating electrical system components at higher elevations, however, it is important to remember that code guidelines often have access requirements that can limit how high major components (such as meters and panels) can be located unless direct access is available through a deck or other secondary structure. In addition to electric power components, the same considerations should also be taken for IT and communication system components (phone, Internet, television). If electrical components must be located in areas that can see potential flooding, there are certain kinds of equipment better designed to handle exposure to water and other considerations that can be made:

• Attach utilities and conduits on the side of the building facing inland and anchor to foundation elements

• Do not mount any conduit or cables on walls or framing structures design to break away during flood events

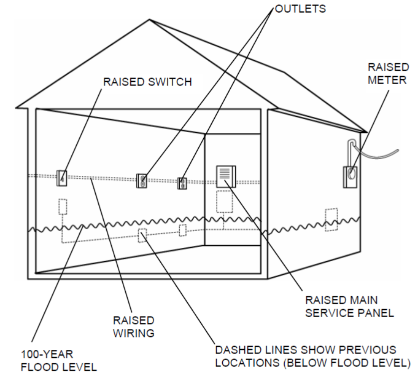
• Design and orient electrical components to properly drain and not retain water

• Circuits located below the design flood elevation should be designed in a way that allows them to be isolated electrically from the remainder of the power system. This can be done by using separate GFCI breakers (Ground Fault Circuit Interrupter) that are clearly labeled in the electric panel box

• If permitted by code, install conduit that is non-metallic, corrosion resistant, and easily cleaned after a flood event

• GFCI outlets should be used in any area located below the design flood elevation. These outlets are typically installed in locations that see everyday exposure to water such as above kitchen counters and in bathrooms

For regulations regarding new construction or substantial improvements to a building within a flood hazard area, refer to the Florida Building Code, Chapter 3, Section R322 – Flood Resistant Construction.



A4.4 Dry Floodproofing

As the name implies, dry floodproofing involves taking measures to make a building watertight to prevent entry of water into interior spaces. Dry floodproofing can be done for the entirety of a building or for a select portion of an enclosed area that requires higher levels of protection from water (for example, key utility equipment that cannot be elevated).

Some key concerns that must be considered when dry floodproofing a building including the following:

1) Shielding doors, windows, and other openings where water can easily infiltrate. See the Flood Barriers section for more information.

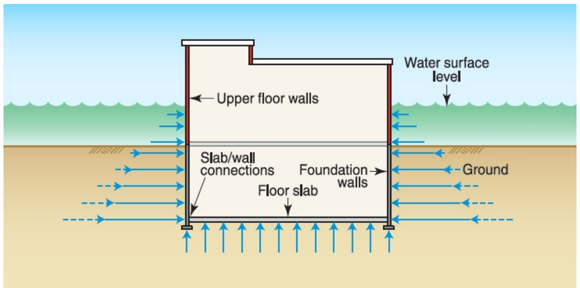
2) Reinforcing walls to withstand floodwater pressures from the weight of water pushing against the building. A licensed structural engineer should be consulted for evaluation of these loads and measures that can be taken.

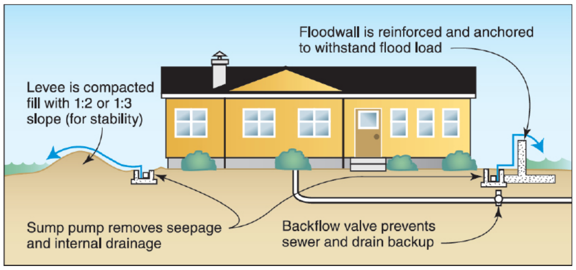
3) Reinforcing or anchoring a building slab to resist flotation from uplift pressures and other buoyancy forces as water pushes up on the building from underneath. Again, a licensed structural engineer can assist with understanding these forces and determining if action is required during dry floodproofing.

4) Removing any water that inevitably leaks into the building, despite efforts to prevent its infiltration. This will include drainage systems and sump pumps to collect the water. Sump pumps should be installed with an emergency power source such as a battery or generator that can ensure operation even if electricity is lost during a flooding event or other emergency,

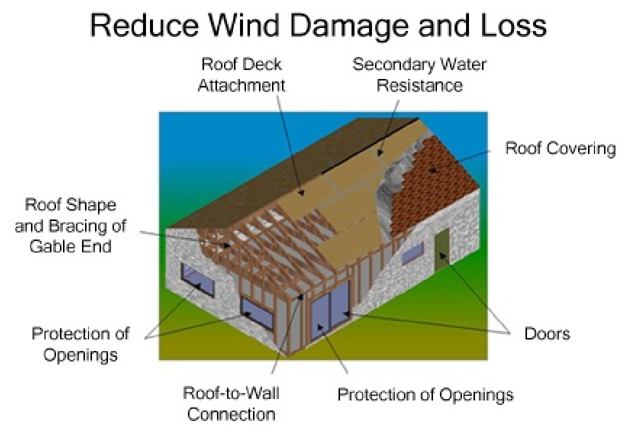
5) Providing membranes or other sealant techniques to prevent floodwater gradually seeping through walls and minor penetrations. See the Seepage and Waterproofing section for additional information.

Chapter 54 of Miami Beach, FL – Code of Ordinances provides criteria for dry floodproofing.





A4.5 Wind mitigation



Wind mitigation is the implementation of certain building techniques in order to limit damage caused by intense wind. Following Hurricane Andrew, Florida passed a law requiring insurance companies to offer their customers discounts and credits for existing building features and home improvements that reduce damage and loss from wind.1

These building features include opening protection of the doors and windows, appropriate roof deck and roof to wall attachment, use of appropriate roof coverings and implementation secondary water resistance systems.

Opening protection refers to the level of wind resistance of the windows and doors in the building, whether applied to the openings in case of an intense wind event (hurricane shutters) or integral to the construction of the windows and doors (impact resistant products).

Roof deck construction and attachment to the building's walls is crucial to the integrity of the structure in case of high winds. This is achieved by originally designing the structure up to code or retrofitting it to comply with the appropriate building codes through the implementation of appropriate anchors, installation patterns, and hurricane straps.

Roof coverings and secondary water resistance systems are part of the construction of the outermost roof layers. Properly secured roof shingles and waterproof underlayments are the first line of defense against storm winds and rain. The installation of products with notice of acceptance (NOA's) or Florida Product Approvals for the HVHZ (High Velocity Hurricane Zone) is a building code requirement for all new construction and substantial renovation of existing buildings.

1 Wind Mitigation by Nick Gromicko and Kenton Shepard, https://www.nachi.org/wind-mitigation.htm

A4.6 Seepage & waterproofing

While most building materials appear solid and impenetrable to the naked eye, when sustaining flood loads there is a greater likelihood of water passing through walls to interior spaces. The seepage rate of water through the building envelope will vary wildly based on material type, construction type,
building condition, building age, depth, elevation, and the properties of the groundwater and soil adjacent to thebuilding. How fast and how much water penetrates the building will also depend on how the duration and intensity of a storm and/or level of flooding that occurs.

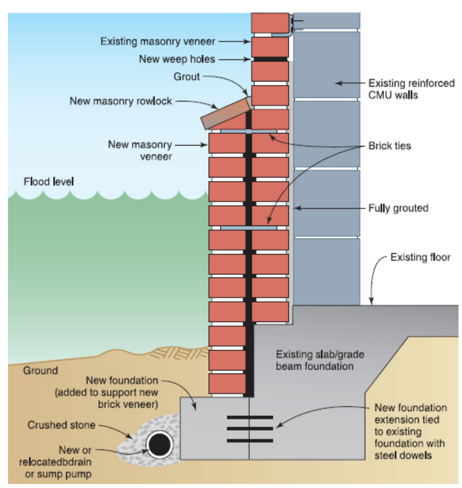
Despite all of this variance, there are waterproofing techniques that can be used during dry floodproofing that can make a building envelope more impermeable and reduce the amount of water than can infiltrate. As mentioned previously, however, a building being waterproofed in the context
of dry floodproofing needs to be evaluated for its structural capability to withstand unbalanced hydrostatic pressure from floodwater and saturated soils.

Some considerations and options for waterproofing to reduce building seepage include:

- Permanently seal all structural joints
- Seal around all utility penetrations and other openings for windows and vents
- Waterproofing can be applied from either inside or outside a building wall depending on the type ofsealant used. Refer to manufacturer guidelines for installation details and recommendations
- Typical materials for sealants include cement and asphalt-based coatings that can be applied to the exterior of the building. However, some aesthetic properties of the building facade may be lost the building.

However, some aesthetic properties of the building facade may be lost

- Clear coatings can be applied using epoxy materials and polyurethanes if preserving the visual
appearance is of major concern. However, their waterproofing effectiveness is often reduced compared to other techniques
- Other products are painted onto the inside of wall surfaces or foundation walls above ground. These
include liquid rubber coatings or other sealers that cover cracks and defects while providing additional
waterproofing protection
- In addition to coatings and sealants, another protection method consists of adding an additional
waterproof veneer to exterior walls to block water from infiltrating from the outside
- Impermeable membranes can also be used to waterproof foundation walls below grade to resist
groundwater seepage



A4.7 Wet floodproofing

Rather than working to prevent water from infiltrating your home, wet floodproofing is a concept that follows the logic of accepting that some level of flooding will occur and impact the property. It is an approach that best works when raising of the lowest occupied floor to be at or above the design flood elevation is possible. The space below this elevation is then modified with the understanding that inundation will likely occur during a storm or flood event.

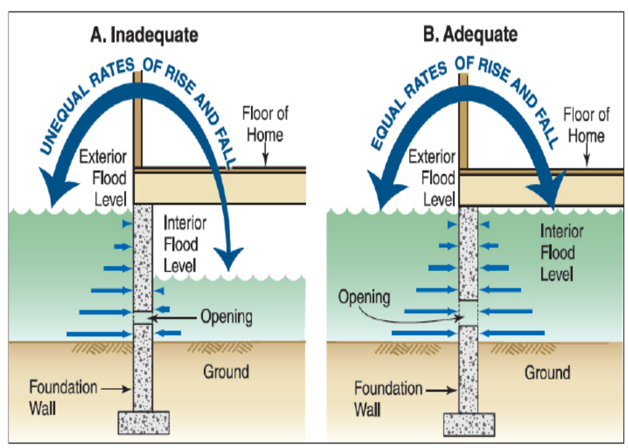
Wet floodproofing offers structural advantages to the force of floodwater that can impact your home during a flood event. These only includes hydrostatic pressure—the weight of standing water pushing against the walls and the foundation of your house (both exposed portions and those underground). Rather than working to reinforce your structure against these additional loads, it works with the floodwater pressures. Wet floodproofing, however, will not protect your home any more than other floodproofing techniques when considering hydrodynamic forces (the force of flowing water against your home) or the potential damage caused by flood-borne debris hitting your home or any long-term impact from flood-borne contaminants and pollutants.

Wet floodproofing provides this structural advantage against hydrostatic pressure by allowing forces to equalize both inside and outside the building. Strategically designed and placed openings in the wet flood-proofed space allow floodwaters to automatically enter and exit the enclosed area. A key component of this design is that water levels must rise and fall at the same rate both inside and outside the home. Typically, pumps are not needed to discharge water once floodwaters have receded from wet flood-proofed areas. However, proper cleaning and drying of the space is still required after a flooding event to ensure excess moisture does not encourage the growth of mold or other bacteria.

Any space that is to be wet flood-proofed should be modified with flood-damage resistant building materials that can survive long-term exposure to water. For the Miami area, these flood-resistant materials need to be especially designed to withstand the saltwater that will typically be involved with flooding due to storm surge, sea level rise, and tidal impacts.

For practical purposes, no high value contents or property should be stored in the wet flood proofed space. Flooding can sometimes occur with minimal advanced warning for property owners to remove items from these enclosed areas. The National Flood Insurance Program only allows for wet flood proofing to be used in spaces reserved for storage, access, or parking.

Chapter 54 of Miami Beach, FL – Code of Ordinances provides criteria for wet floodproofing.



Source: FEMA Homeowner’s Guide to Retrofitting

A4.8 Flood resistant building materials

Using flood-resistant building materials can both reduce the damage caused by floodwaters and make cleanup easier following a flooding event. Building materials are considered flood-resistant if they can withstand direct contact with flood waters for at least 72 hours without being significantly damaged. In this case, significantly damaged designates damage requiring more than cosmetic or low-cost repairs.

More generally, materials that are considered non-flood-resistant are those that easily absorb or retain water or can dissolve and deteriorate in water. It is important to consider not only the primary building material, but all the components that are used in the complete construction process including adhesives, sealants, connectors, and fasteners. Given Miami's coastal location, preference should be for flood-resistant materials that are also non-corrosive and can withstand saline environments or saltwater inundation.

Flood-resistant building materials can be used in combination with typical building materials if cost is a concern by prioritizing use of flood-resistant building materials in portions of the building below the design flood elevation. However, coastal environments include airborne salts that contribute to corrosion, so exposed building materials even not seeing direct water inundation can still be affected. In the context of historic structures, care should be given to selecting flood-resistant
building materials that fit within the historic and aesthetic context of the structure and overall neighborhood.

Note: Flood-resistant building materials must be rated as Class 4 or 5 to meet FEMA national flood insurance program requirements. See FEMA NFIP Technical Bulletin 2-08 for more information on ratIng systems.

Material Type	Acceptable	Unacceptable
Structural Flooring Materials	• Concrete • Naturally decay-resistant lumber • Pressure-treated plywood	• Engineered wood or laminate flooring • Oriented-strand board (OSB)
Finish Flooring Materials	• Clay tile • Ceramic or porcelain tile • Terrazzo tile • Vinyl tile or sheets	• Engineered wood or laminate flooring • Carpeting • Wood flooring
Structural Wall and Ceiling Materials	• Brick face, concrete, or concrete block • Cement board / fiber-cement board • Pressure-treated plywood • Solid, standard structural lumber (2x4) • Non-paper-faced gypsum board	• Fiberglass insulation • Paper-faced gypsum board • OSB
Finish Wall and Ceiling Materials	• Glass blocks • Metal cabinets or doors • Latex paint	• Wood cabinets and doors • Non-latex paint • Particleboard cabinets and doors • Wallpaper

Source: "Reducing Floor Risk to Residential Buildings that Cannot be Elevated" FEMA, 2015

A4.9 ADA Accessibility features

More than 50 million Americans with disabilities are potential customers for retail businesses across the country. These 50-million-plus customers, along with their families and friends, patronize clothing boutiques, mall outlets, grocery stores, and more, if the businesses are accessible.

The Americans with Disabilities Act (ADA) requires businesses that serve the public to remove barriers from older buildings and to design and build new facilities to provide access to customers with disabilities. A key component of ADA compliance is maintaining those features so they remain usable. Even brand-new buildings designed for complete accessibility can become inaccessible without proper attention. If key elements - often including the parking, building entrance, route into and through the establishment, access to the store's goods and services, restrooms, cashier stations, and egress - are not maintained, then access is reduced or eliminated. 2

Where commercial uses are proposed on the ground floor of the building accessible routes shall be provided. These may include access ramps that comply with the applicable building and accessibility codes, wheelchair lifts if space does not allow for ramps, and appropriate clearances for wheelchair access through the commercial space. Public restrooms shall comply with the accessibility requirements of the Accessibility section of the Florida Building Code as well.

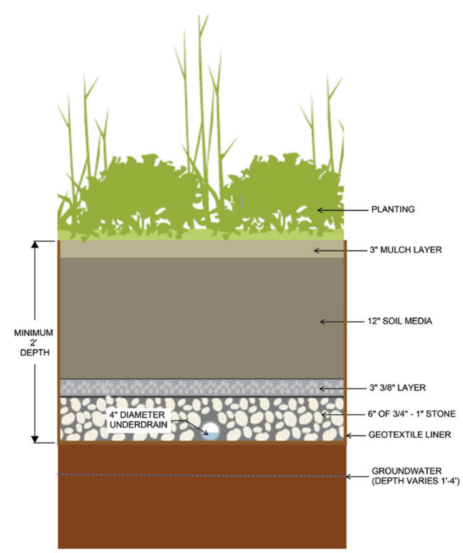
B4 Green Infrastructure
B4.1 Rain Gardens

Rain gardens are special planting areas designed to capture and store rainwater. They are one of the most common ways green infrastructure is used to offer relief to conventional sewer and storm networks that become overwhelmed during storms. Not only do rain gardens assist in reducing overall storm runoff quantity, but can also aid in purifying water from pollutants and contaminants using natural filtration processes present in soil and plants. Allowing for both temporary rainwater storage and infiltration, bioretention practices help effectively manage stormwater during storms.

It is important to select vegetation types for planting that can withstand routine flooding and the saline environment of Miami Beach. Once installed, a regular maintenance and inspection regime to remove trash, trim overgrown vegetation, weed unwanted plants, and reduce excess sediment can help ensure green infrastructure practices are functioning properly and helping to manage stormwater runoff quantity and quality.

Rain gardens are usually located within a small depression in a property to allow water to naturally flow to low points. In addition, to prevent potential damage to adjacent buildings, rain gardens should be located a minimum five feet away from any structures because of the impact from infiltrating water.

Within the rain garden is a slightly elevated overflow drain inlet to allow excess rainwater to be piped away from the plantings and prevent overwhelming inundation. To allow for proper infiltration, rain gardens should be installed in areas where the groundwater table is deepest (ideally four feet).
However, given Miami's underlying porous limestone and eventual rising groundwater table, typical construction of rain gardens will likely be challenging in the near future. One alternative is to provide for an alternative water storage structure or soil/ground replacement beneath the rain garden installation.

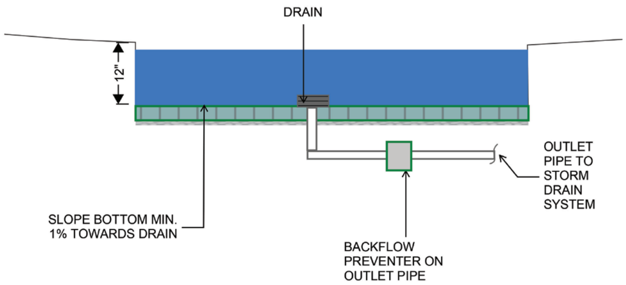


B4.2 Green Roofs

A typical building roof is often underutilized space that contributes heavily to the amount of impervious surface in a given property. By utilizing the roof for stormwater storage, water is captured before it reaches the ground or a piped drainage system. Green and blue roofs can also provide localized cooling benefi ts while serving as a home for attractive vegetation. When retrofi tting existing buildings and historic properties, additional structural reinforcement is likely to be required to allow a roof to support the weight of new soil and planting layers (green roof) or temporary storage of rainwater (blue roof). Blue roofs capture rainwater by functioning as a tank-like structure and often collect it for re-use within the building through non-potable (water not used for drinking or cooking) needs such as irrigation and fl ushing toilets. Typically, stored water is designed to be drained within 24 hours if not within an enclosed system to prevent insects and other issues that can come with standing bodies of water. Excess water is channeled to a building's sewer system or typical gutters and roof leaders that would provide drainage for a normal roof.

Due to the high expense of installing a green or blue roof and related structural renovations, they are typically more costeffective for larger properties or commercial buildings. In general roofs also need to be relatively fl at with minimum pitch. The amount of water that will be stored within a green or blue roof varies with the roof size and potential depth of planting and storage medium layers. They also must be designed to allow for safe access for maintenance and inspection.

B4.3 Sunken Plaza & Patios



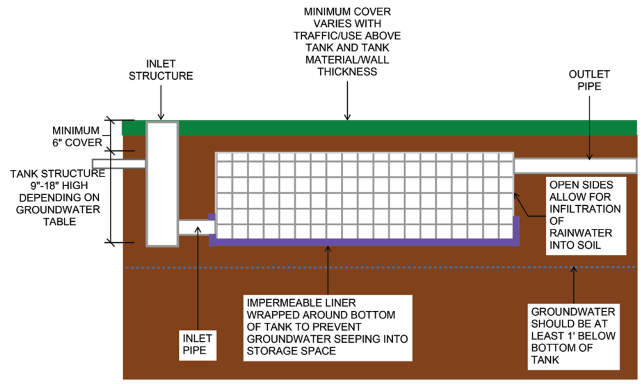
Recessed parks, building courtyards, and public plazas are impervious surfaces that can be designed to temporarily store water during extreme events to prevent flooding from overwhelming both the storm system and adjacent properties. For smaller properties, even patios and outside seating areas can be sunken lower than the surrounding landscape by several inches to a foot to serve a depression for water to accumulate during storm events. The storage capacity of a sunken plaza or patio will vary with how deep the depression is and how large of an area is being utilized.

Sunken plazas and patios fill up with water during a period of rapid rainfall and alleviate localized flooding around a wider site or property. Once the storm has passed, this collected rainfall can be drained to a storm sewer system or other storage area. When not being utilized for stormwater management, the area can serve as a dynamic outside area for recreation and relaxation. Depending on the design and construction of the area amid the larger property topography, the sunken plaza or patio can be drained naturally through gravity, pumps, or a combination of the two.

Because of sometimes minimal warning before intense rain events, any furniture or equipment to be used in this area should be of a material capable of withstanding inundation with water, or of low enough cost to be easily replaceable. Sunken patios should be designed to drain within 24 hours to prevent insects utilizing the standing water for breeding.

B4.4 Unerground Retention Storage Systems

While detention systems capture and hold water during and after a storm event for longer periods,retention systems function by temporarily providing a place for water to collect during a storm event.
Retention systems are also tanks, chambers, or storage area where water can collect rather than ponding or flooding a property. However, retention systems typically do not drain by pump or gravity
through a pipe system, but allow water to infiltrate out into the surrounding ground as floodwaters recede and the ground is no longer saturated with water. Retention systems are available from a variety of manufacturers that offer proprietary underground devices to contain stormwater during flooding events. Often a retention system can become a detention system by wrapping the storage system with an impermeable liner or other material that restricts water flow.



In its simplest form, a retention system can be a gravel pit installed within the ground that provides more storage capacity than normal, compacted soil. However, water within a gravel pit can only be stored within the spaces between stones (approximately 40% of the total gravel volume), resulting in a much-reduced capacity when compared to more open, chamber-like systems.

The high water table of Miami Beach makes it difficult for retention systems to be used extensively in the area. A retention system would need to be constructed at a shallow depth to utilize the unsaturated ground above the water table. While partially sealing certain sides of the retention system can prevent groundwater from seeping into the rainwater storage space, there is still the concern over groundwater uplift pressure pushing up on the system.

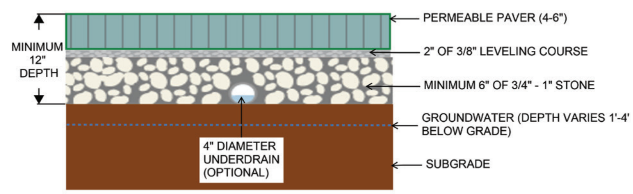
B4.5 Permeable pavement

Permeable pavements and surfaces allow for direct infiltration of water into the ground that typical hard surface pavement materials (standard asphalt and concrete) prevent. Together with building roofs, typical hard surfaces are significant contributors to stormwater runoff and ponding during storm events. By allowing water to naturally infiltrate into the ground, stormwater can be stored underground, recharge local freshwater aquifers, and be taken up by nearby plants. Permeable surfaces may see reduced effectiveness, however, given Miami Beach's relatively high ground water table.

Permeable pavements and surfaces can vary greatly in material type, overall look, and effectiveness at managing stormwater. At the simpler end are gravel surfaces or similar natural stone pathways and driveways. Other paving units and block pavers are installed with grass or fine gravel between them to allow for infiltration, as opposed to typical mortar mixes. The most complex permeable pavements resemble closely typical asphalt and concrete surfaces, but use a unique mix of stones and binding agents to allow water to filter through into the ground. Permeable pavements are also frequently installed over a perforated drainage pipe that can direct excessive infiltrated water to an additional storage area or outlet of a piped drainage system.

Permeable surfaces are most effective when used over well-draining, sandy, natural soils. As with any surfacing installation, it is also important to check the maximum manufacturer recommended loads (i.e. how much weight the pavement or surface can withstand before failing) for specific products against your expected use and traffic loads in the area (i.e. will heavy vehicles frequently be driving over the surface). Typically, a permeable surface will require a minimum of four inches of well-draining gravel to be placed beneath the paving surface itself, where surfacing depth will vary based on material type.

Permeable pavements and surfaces also lose effectiveness if installed on steep slopes. As with most stormwater management techniques, routine maintenance of the system is also required often in the form of flushing pavements with high pressure water. If not cared for, clogging of voids with debris, organic particles, and mud will reduce the ability for permeable pavements to infiltrate water in the ground—making them functionally equivalent to typical pavements that contribute to stormwater runoff.

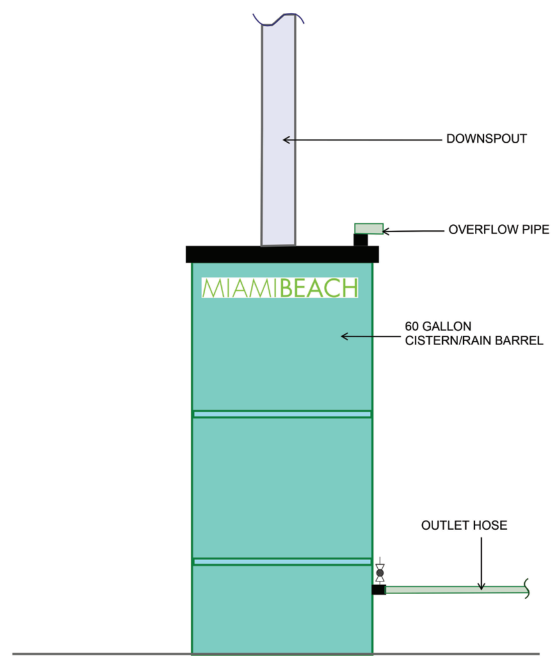


B4.6 Cisterns

Cisterns, also frequently referred to as rain barrels, are a simple and affordable way for property owners to both reduce the amount of stormwater that can impact their property while also harvesting rainwater for other uses. Rain cisterns can be installed to manage the stormwater that falls onto a building roof that would typically be routed to the ground or a piped drainage system through gutters and downspouts. Rain barrels can capture that water for later use in irrigation or even cleaning purposes.

A typical capacity for a single rain cistern is around 60-gallons. While installing even a few cisterns may not capture a substantial amount of water during intense storms, cisterns can reduce the stormwater runoff and local flooding impacts for typical, everyday rain events. One important consideration when installing a rain barrel is to provide an emergency overflow pipe at the top of the barrel to allow for rainwater to escape if the barrel reaches capacity during intense storms or infrequent periods of use. Rainwater harvest pipes and systems should also be inspected routinely to check for clogging with debris or any potential leaks. Filters or screens installed on gutters and inlet pipes can help capture large material that could lead to reduced cistern capacity.

In Miami Beach, an important concern is the ability for standing water to serve as mosquito breeding grounds. Beyond just the nuisance factor of increased mosquitos and other insects in an area, there is concern over increasing the likelihood for transmission of insect-borne diseases such as the West Nile virus. For rain barrels, an easy solution to discourage mosquito breeding in captured stormwater is to only utilize closed system barrels rather than open-topped cisterns. Additionally, frequently using and draining down your barrel is an easy and effective way to prevent long-term standing water. As a last resort, trace amounts of additives such as liquid dish soap or vegetable oil can prevent mosquitos from being able to breed, while treatment with bacterial larvicides can be used for water held over longer periods.



C4 Stormwater Managment

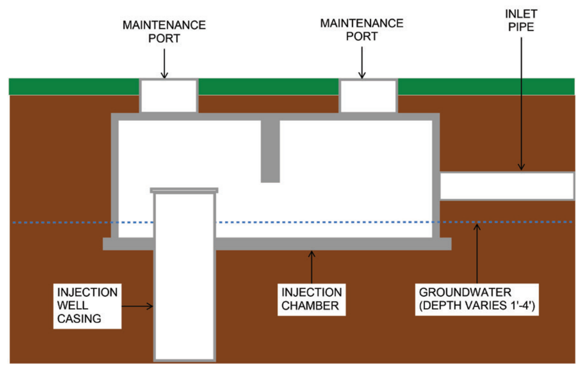
C4.1 Blue roofs

A typical building roof is often underutilized space that contributes heavily to the amount of impervious surface in a given property. By utilizing the roof for stormwater storage, water is captured before it reaches the ground or a piped drainage system. Green and blue roofs can also provide localized cooling benefi ts while serving as a home for attractive vegetation. When retrofi tting existing buildings and historic properties, additional structural reinforcement is likely to be required to allow a roof to support the weight of new soil and planting layers (green roof) or temporary storage of rainwater (blue roof). Blue roofs capture rainwater by functioning as a tank-like structure and often collect it for re-use within the building through non-potable (water not used for drinking or cooking) needs such as irrigation and fl ushing toilets. Typically, stored water is designed to be drained within 24 hours if not within an enclosed system to prevent insects and other issues that can come with standing bodies of water. Excess water is channeled to a building's sewer system or typical gutters and roof leaders that would provide drainage for a normal roof.

Due to the high expense of installing a green or blue roof and related structural renovations, they are typically more costeffective for larger properties or commercial buildings. In general roofs also need to be relatively fl at with minimum pitch. The amount of water that will be stored within a green or blue roof varies with the roof size and potential depth of planting and storage medium layers. They also must be designed to allow for safe access for maintenance and inspection.

C4.2 Injection Wells

The core idea of stormwater management is finding a place for water to go during a rain event rather than collecting in locations that can damage property or prevent people from traveling. The strategies outlined previously rely on using natural storage areas or creating additional stormwater storage space above or immediately underground. However, what if there is no space either above or below ground for the water generated during a storm event to be stored? Miami Beach's unique geology and high groundwater table can often make storage of rainwater difficult. To put it simply, if the ground is already full of water, rainfall will have minimal space to be stored.



One alternative is to use injection wells to send water into an area of the earth where more space is available for water to infiltrate. Stormwater injection wells are used throughout Miami for larger, developed sites where there is minimal space available for natural infiltration or storage at or near the surface. Large pipes that are typically two feet in diameter or more are drilled deep into the earth. Conventional drainage systems (drains and catch-basins) collect rainwater and direct it to injection well pipes so it can be pushed deep underground. While efficient, careful consideration needs to be made for understanding the local geology of a site and avoiding potential impacts to below ground drinking water sources.

D4 Future Proofing

D4.1 Solar panels

Solar photovoltaic (PV) systems directly convert a portion of light (photo) energy from the sun into electricity (voltage) that can be used at home or sold back to your local utility. These systems are assembled from a set of interconnected components operating in one of three general ways: grid-tied; off-grid; and hybrid. [1] Florida laws require solar panel systems to be grid-tied. Grid-tied PV systems typically offer the fastest rate of return on their investment as many utilities offer incentives. At a minimum, qualified renewable energy generator in Florida owning PV systems up to 2 megawatts (MW) in size may take advantage of the "one for one" net-metering rules implemented by the Florida Public Service Commission.[2]

"One-for-one" net metering means that each kilowatt-hour (Kwh) of exported power offsets the cost of another kWh at a time your solar system couldn't service the electric demand of your home.

If your solar system is producing more energy than what is needed in the home the excess power is sold to FPL via through the grid. FPL are required by law to value each kWh sold to them at the retail price you pay for power. What makes net metering such a great incentive is because most homeowners use little power during the day, this means more power sent to the grid and credited by FPL.2

Great sunshine and amazing incentives make Miami Beach one of the greatest cities in America to install solar panels. As a Miami Beach resident, you most likely purchase your power from Florida Power and Light (FPL). Once again, this month FPL put up their residential rates and this is set to continue in following years. There has never been a better time as an FPL customer to install solar panel systems. [2]

Given the inherent risk of hurricanes and strong wind events in South Florida along with the typical installation of solar systems on the roofs of buildings, proper installation and engineering of roof stands and attachments is crucial to the long-term life and productivity of photovoltaic panel arrays. All products installed on building roofs shall be approved for use in the High Velocity Hurricane Zone (HVHZ) by a Florida Product Approval, Notice of Acceptance (NOA) or through engineering calculations of all anchoring and structural elements.

1 http://www.myfloridahomeenergy.com/help/library/energy-services/home-solar-pv

2 https://www.solar-estimate.org/solar-panels/miami-florida

D4.2 Wind turbines

Florida residents have become accustomed to paying attention to the wind. In fact, we are usually concerned with too much wind from hurricanes and other severe weather events. We can use wind to our advantage, by harnessing and converting it into electricity using a turbine. Wind turbine is the term now used for what has historically been called a windmill. When the wind is blowing, it turns blades, around a rotor. This rotor is connected to a main shaft that spins a generator to produce electricity. [1]

Wind energy in the U.S. is increasing, yet there are many factors that determine the feasibility and cost effectiveness of wind energy from one geographic location to the next. Wind energy in Florida and the Southeastern U.S. is not as practical or cost effective as in other parts of the country. However, Florida does play an important role in national and global markets for wind energy. Furthermore, two main factors are very important when determining where to site a wind turbine for maximum efficiency: wind speed and duration.[1]

Ideal wind turbine sites include the tops of smooth, rounded hills, open plains or shorelines, and mountain gaps that funnel and intensify wind.1 Due to the coastal location of Miami Beach, shoreline winds are significant enough to provide a substantial amount of power. It is important to recognize, however, that even within a region of high wind energy potential, specific sites should be evaluated on a case-by-case basis as proximity to buildings, water and many other factors can affect wind speed and duration. [1]

Wind duration is also an important factor that affects the wind potential capacity from one site to another. At most sites, wind duration is much more difficult to forecast over long periods of time, so electricity produced on site using wind energy goes directly to the power grid rather than being consumed or stored on site. This means that the electricity you use by pulling from the power grid comes indirectly not only from the power your wind system produced, but also from all the other sources of electricity providing power to the grid. Research is continuing to develop the means to store distributed power, once generated on site, for later use both on site and at the utility (power grid) level.[1]

As is the case with solar panel arrays, attachment of wind turbine systems atop of buildings require engineering and approval of attachments, anchoring and structural members by means of Florida Product Approvals, NOA's or engineering calculations in compliance with the Florida Building Code.

1 http://www.myfloridahomeenergy.com/help/library/energy-services/wind-energy

D4.3 Water recycling systems

Water reuse plays an important role in water resource, wastewater and ecosystem management in Florida. When reclaimed water is used, it eases the demand on traditional, often limited, sources of water. By recycling or reusing gray water, communities can still grow while minimizing or even reducing their impact on the water resources around them.[1]

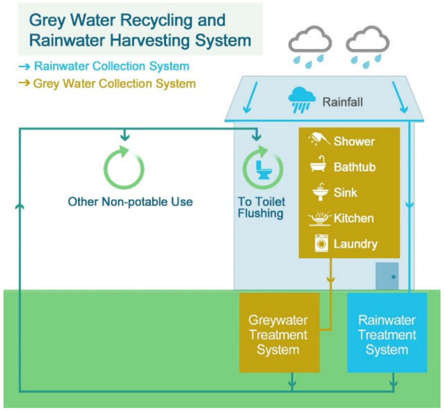
The exact definition of gray water varies from state to state, but generally includes any household wastewater other than that which comes in direct contact with human waste (such as water used for toilet flushing) or that has the potential to contain a large amount of organic material (such as food waste from kitchen sinks). As defined in Chapter 381 of the Florida Statutes, gray water includes water from baths, showers, clothes washers, laundry trays, and sinks, but does not include wastewater from kitchen sinks (Florida Statutes 2008).[2]

Reusing gray water reduces the use of drinking-quality (potable) water for non-drinking quality (non-potable) needs. Potable water is often used unnecessarily around the household for purposes for which gray water would be acceptable. Replacing some or all the potable water used for non-potable needs (such as toilet flushing and irrigation of non-edible portions of the landscape) can significantly reduce demand for fresh water.[2]

Water reuse involves using highly treated domestic wastewater for a new purpose. Reclaimed water systems are continually monitored to ensure the health and welfare of the public and the environment are protected.[1]

There are several requirements for gray water systems for flushing toilets (water closets) and urinals in Florida. Distribution piping must be clearly identified as containing non-potable water by pipe color or with metal tags. Gray water must be filtered, disinfected, and dyed. Gray water storage reservoirs must be appropriately sized and must have a make-up potable water supply. Storage reservoirs must also have drains and overflow pipes which must be indirectly connected to the sanitary drainage system.

Using reclaimed water reduces discharges to surface waters, recharges ground water and postpones costly capital investments in the development of new, more costly water sources and supplies.[1]



1 Water Reuse, South Florida Water Management District, https://www.sfwmd.gov/our-work/alternative-water-supply/reuse

2 Gray Water Reuse in Florida, Christopher J. Martinez, https://edis.ifas.ufl.edu/ae453#FOOTNOTE_2

Building Raise Procedures

While not a common practice in Miami Beach, there are numerous examples of existing buildings being raised in the country today. In the Northeast, elevations are being done in New York (Brooklyn, Queens, and Staten Island) and Atlantic City, New Jersey. These cities are densely populated with structures built almost on top of each other. Elevation companies strategically develop lift plans that include using multiple smaller steel I-beams along with toe jacks to raise structures in any environment. In some urban areas, a temporary street closing or sidewalk closing is utilized in order to enhance safety while equipment is in use.

When concentrating work within a neighborhood or block, cost savings are possible due to economies of scale. The savings are a result of supply chain, transportation and project management. Team member SJ Hauck's experience comes from a grant program located in a community in North Jersey where the entire program of 30 houses was located in one square mile; many were next-door neighbors. This allowed for the sharing of resources between jobsites, less drive time between sites, and one project manager for the collective job. SJ Hauck estimates the economies of scale on this grant allowed for a +/- 10% cost savings.

Building Raising Technology

- In every case, a unified jacking machine is utilized in lifting a structure. The unified jacking machine ensures that each jack will receive exactly the same volume of oil and extend at the same rate, regardless of the weight or pressure on it. The jacks are what apply the pressure to the steel beams in order to elevate the structure.
- Besides the typical jacks with dog ear clamps you find on most elevations, toe jacks can be used as well. Toe jacks are also connected to the unified jacking machine with the hydraulic lines and support the home from the exterior. The benefit here is a home on a crawl space with limited space under it can be lifted in order to safely place the steel under the structure.

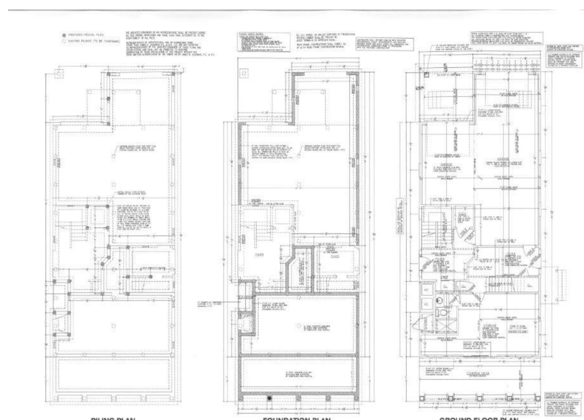
Methodology

1

In Miami Beach, there are a few different methods to raise that are dependent on the type of building construction.

1. Concrete Framed Structures

When elevating a concrete framed structure on a crawl space, the foundation wall is saw cut every few feet in order to run steel under the flooring system. Once the steel is in place, larger main beams are placed under the perpendicular support steel. The crib stacks support the main beams and receive the pressure from the jacks. The main beams are elevated and catch the support beams. The support beams catch the floor system and support the exterior concrete walls.



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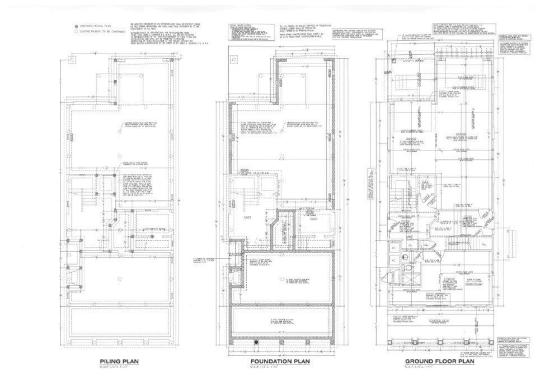
2. Wood Framed Building on Crawlspace

This is more common along the East Coast up into the Mid Atlantic due to the frost line but can also be found in Miami. The building in this case has the steel inserted into the crawlspace perpendicular to the floor joists. The structure is lifted and supported on the cribs while the foundation is built.

When elevating a structure, the goal is to raise it only as high as is necessary. Typically the elevation contractor will elevate high enough for the foundation to be built safely. If the foundation is to be completely removed or if helical pilings are to be driven, it is safest for the building to be elevated 9 feet above grade in order for the heavy machinery to access the area for demolition and pile driving. If the structure is to be elevated over 10 feet above grade, it is recommended that cross bracing is added between crib stacks to ensure structural integrity.



Best practices:

- Identify a neighborhood or city block to consolidate work.
- Educate the building owner in order to ensure expectations are set.
- Standardize the engineered drawings to ensure common language.
  - o Example – Use common footings size for new foundations, common helical piling material if needed.
- Expedite permits and inspections.
- Pre-qualify contractors and require an elevation contractor's license.
  - o Set a minimum requirement on experience, equipment, and insurance.
- Ensure funding and payment schedules are understood. Set up milestones.
- Create guidelines on approved scope of work items.