“A Coastal Condo Climate Risk Primer”

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Climate Change, a Risk Multiplier

INTRODUCTION

Humans love the oceans and the beaches. We love watching the play of light on the water, the sound of the waves, and the soft warmth of the sand. This is just in our nature and, it probably hasn't changed much from when our species first evolved. So, great numbers of us, a majority in fact, live close to the earth's coastlines. Some fortunate ones even live in coastal high-rise buildings that are along the ocean or the bays, with valuable, direct water views. But, in the aftermath of the horrific and tragic condo collapse in Surfside, Florida, many coastal condo owners, renters, HOAs and property managers are asking such appropriate questions as: "Is my building safe, now?" "How can we better understand routine inspection and engineering reports?" "I hear a lot about climate change, more frequent storms, more intense rainfall, and sea level rise. What do they mean for my building, now, and in the future?"

In order to provide some climate risk context to these issues and others that have been brought to the forefront by the Surfside condo collapse, Coastal Risk Consulting has teamed up with Dr. Randall Parkinson, a Research Associate Professor at Florida International University's Institute of Environment, to offer a complimentary, educational "Coastal Condo Climate Risk Primer". [1]

This primer is not meant to provide engineering, architectural or legal advice. Rather, it is meant to help you better understand the natural forces that affect many coastal condo buildings and act as "risk multipliers" on the maintenance, architectural and engineering problems that may arise over the course of time.

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[1] **Some links to resources that will help educate HOAs include**:
(1) https://www.theinvadingsea.com/2021/06/28/surfside-building-collapse-is-a-shocking-wake-up-call-for-coastal-condo-homeowner-associations/; (2) https://www.washingtonpost.com/video/national/expert-cautions-climate-change-could-destabilize-more-buildings/2021/06/27/b740dc7a-2385-467d-863d-6967c7e3cc30_video.html?tid=a_classic-iphone&no_nav=true; (3) https://www.youtube.com/watch?v=lXMAkEiuem4; (4) https://grist.org/climate/the-surfside-tragedy-could-be-a-bellwether-moment-for-managed-retreat/.

Concrete and steel and salt water are not mortal enemies. Most coastal buildings are designed to live well with salt water. But major increases in global warming, more extreme weather, and heat, rising ocean and groundwater levels and saltwater intrusion are unprecedented in our modern era. Coastal buildings and their owners and operators, therefore, need to accommodate these climate changes in many aspects of their design, operation, maintenance, and planning for the future.

BACKGROUND

Traditionally, buildings and other structures (e.g., roads, bridges) constructed in the coastal zone were designed according to the physical and environmental conditions present at the time they were built. Along the coast, however, these conditions change with time because the area is very dynamic. The shoreline may erode or expand, storms come and go, and there maybe periodic flooding during heavy rainfall events or storm surge. Under conditions of climate change, our oceans are rising, and sea level will continue to rise ever faster. So, buildings and other structures located in the coastal zone will be subject to an increasingly hostile physical environment. It is not surprising then that some of these climate related changes are being discussed as possible contributing factors to the collapse of the Champlain Condominium in Surfside, Florida. To help condo HOAs, property owners and residents alike, we have prepared a summary of these phenomenon.

"Though the Champlain Towers South collapse is at the catastrophic level, failure of structural elements in coastal high-rise buildings, such as deck and balcony failures, has been an ongoing concern of the engineering and building official communities for decades," said Clifford Oliver, formerly an engineer with FEMA and now a Professor at University of Maryland and Principal of Nanticoke Global Strategies, ***"With the explosive development along the east coast of the U.S. since the 1970s, there are thousands of coastal buildings that have been exposed to corrosion associated with salt spray, periodic coastal flood water inundation, and seawater/ground water intrusion."***

In 2016, Miami-Dade County published a study entitled: "Report on Sea Level Rise and Saltwater Intrusion"(http://www.miamidade.gov/green/library/sea-level-rise-flooding-saltwater-intrusion.pdf). The purpose of the study was to help the public and key stakeholders better understand the implications of sea-level rise on increased risks for flooding and saltwater intrusion on both public infrastructure and privately-owned buildings. The study also made recommendations to building owners on how to adapt to sea-level rise and saltwater intrusion. The study documented higher water-table elevations caused by rising sea level. It found: "Higher sea levels increased the percentage of time water-table elevations were less than 0.5 foot below land surface."

Some building experts are concerned that this kind of environmental assault could have played a role in the Surfside condo collapse. "Sea-level rise does cause potential corrosion and, if that was happening, it's possible it could not handle the weight of the building," Zhong-Ren Peng, Professor and Director of University of Florida's International Center for Adaptation Planning and Design, told The Palm Beach Post. "I think this could be a wakeup call for coastal developments." Greg Batista, an engineer who specializes in concrete repair projects, told the Miami Herald that he suspects concrete spalling, a process whereby saltwater seeps into concrete and ultimately causes support beams to rust, expand, and weaken, to be a factor in the building's collapse.

THE SCIENCE

Sea Level Rise and Tidal Flooding

"As sea levels rise, the risks of flooding increase. Just as there are multiple causes of flooding there are similarly many different impacts from rising sea levels. Higher average water levels can contribute directly to higher high tides and storm surges. This type of flooding can be observed most easily when water "overtops" existing sea walls and floods the urban areas during seasonally higher tides." "Report on Sea Level Rise and Saltwater Intrusion." (http://www.miamidade.gov/green/library/sea-level-rise-flooding-saltwater-intrusion.pdf)

Prior to the 1980s, it was not commonly known that sea-level was rising albeit at a very slow rate; almost imperceptible (<0.0787 inches per year). Many buildings that were constructed before then are still intact, having withstood the test of time. However, our climate has begun to change and more rapidly. Sea level is now rising at 0.13 inches per year and is expected to continue accelerating to as fast as 1 inch per year by the end of this century (Figure 1).

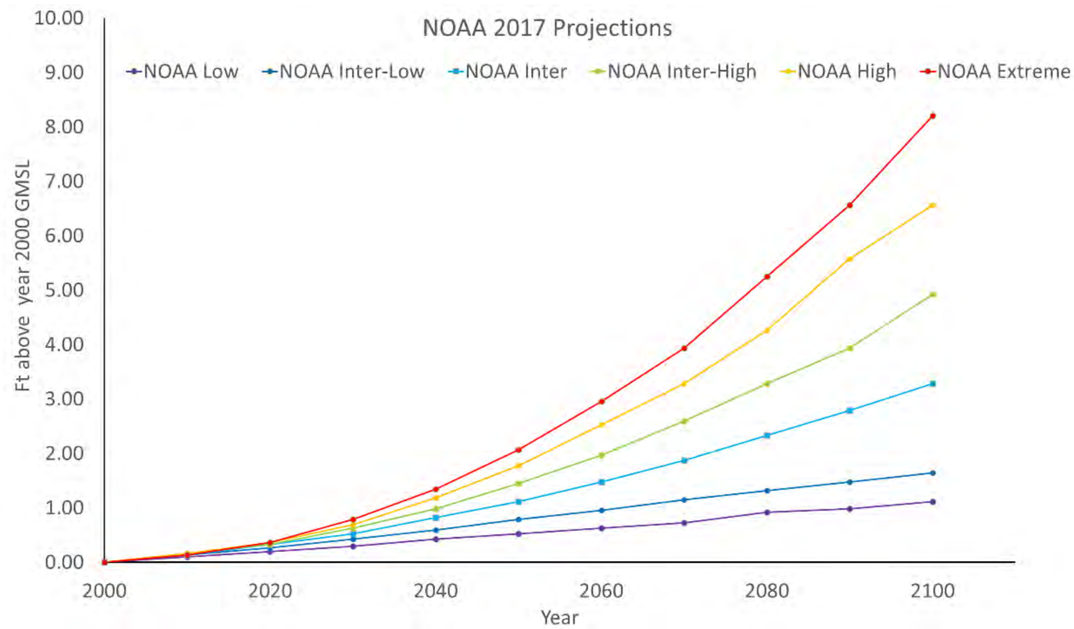


Figure 1. Sea-level rise projections as forecast by NOAA (2017).

The effects of sea-level rise on the structural integrity of a high-rise building are illustrated in Figure 2.

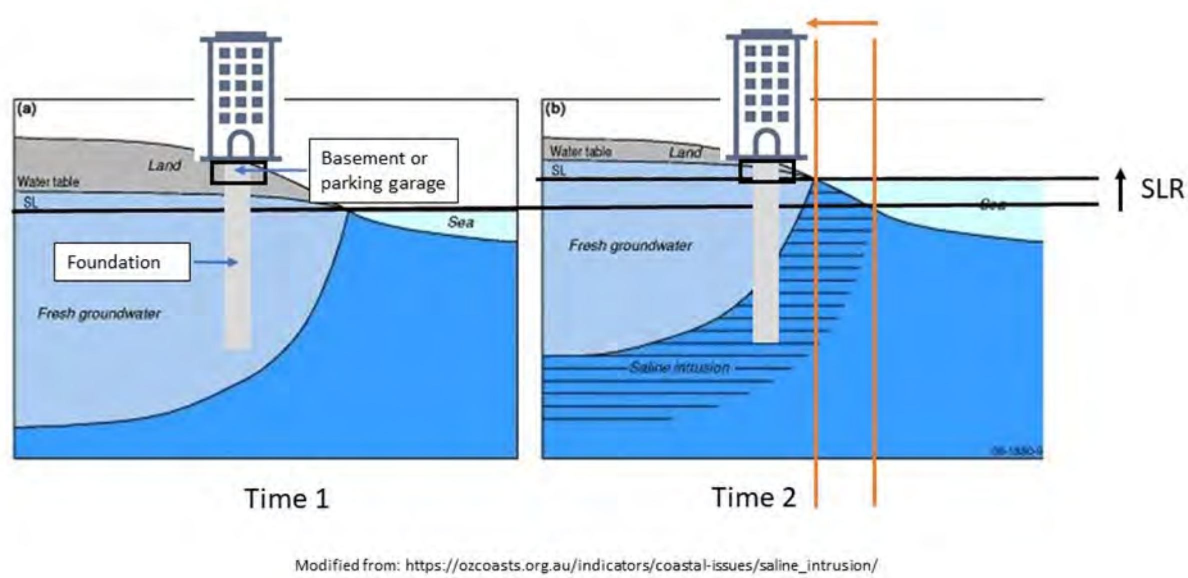


Figure 2. Subsurface hydrological conditions before (Time 1, left) and after (Time 2, right) sea-level rise.

The left panel represents the physical conditions of the subsurface at the time of construction. Beneath the building in this example is land (soils, sediment, limestone). Some of that land is above the groundwater table, but most of it is below the water table and, therefore, saturated with freshwater. Under conditions of rising sea level, shown in the right panel, the water table rises, and the freshwater is combined or mixed with seawater by a process called saltwater intrusion. In this illustration, the basement or parking garage is now below the water table; a condition for which it may not have been initially designed. Furthermore, the building's foundation is now located in a saline environment. Again, a condition for which it may not have been not designed. These physical changes could lead to flooding of the subterranean portion of the building and accelerated corrosion of the foundation's rebar (Figure 3). Over the past 40 years, sea level has risen about 6 inches. Experts predict between 1 and 2 feet of sea level rise by the year 2050 and 3 to 10 feet by 2100.

Source: http://www.dot.ga.gov/BuildSmart/research/Documents/07-30.pdf

Figure 3. Structural integrity of pilings in seawater compromised by saltwater intrusion.

The intensity and frequency of major tropical storms and hurricanes are also predicted to increase as a consequence of climate change. That means flooding caused by heavy rainfall and storm surge will become more common. And, as sea level continues rising, surging seawater will penetrate ever further inland. All of this is expected to introduce new risks to coastal buildings and infrastructure.

But even now, flooding of low-lying areas during exceptional high tides is increasingly common. Also referred to as “sunny day” or “king tide” flooding, these are caused by years of relative sea level increases. It occurs when tides reach anywhere from 1 to 2 feet above the daily average high tide and start spilling onto streets (Figure 4) or bubbling up from storm drains (Figure 5).

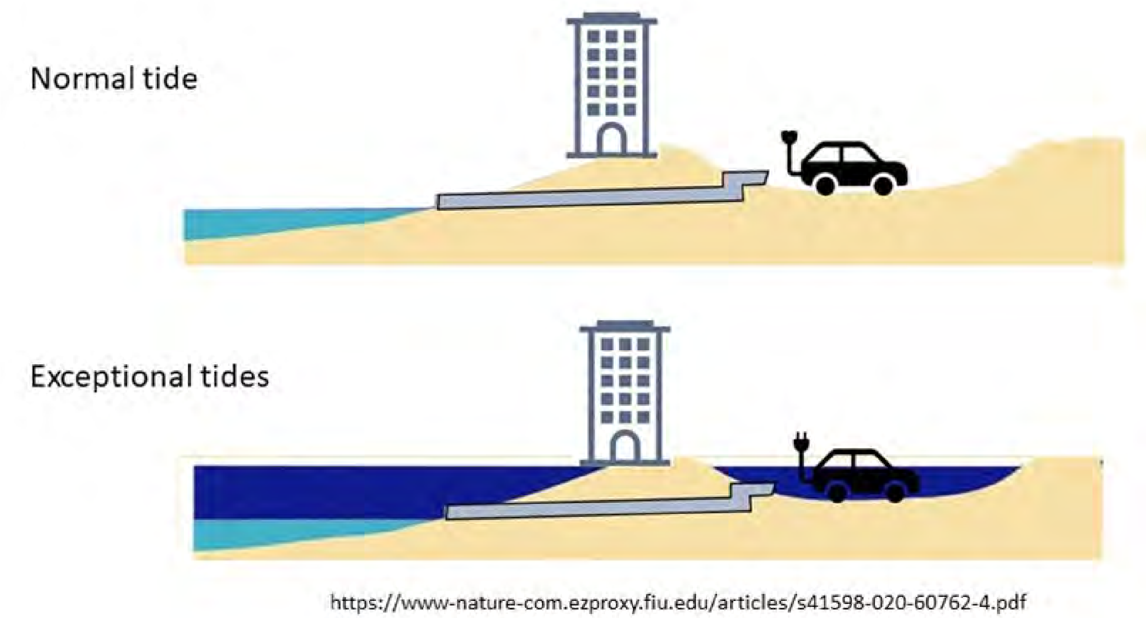


Figure 4. .When built, storm water generated during heavy rainfall drained by gravity into the ocean, even during exceptional tides (top). But because sea level has risen by more than a foot over since the 1920's salt water now flows through the aging stormwater pipes and into low-lying streets, sidewalks and yards (bottom) where it saturates the soils upon which they were constructed.

Figure 5. Saltwater bubbling onto the street from a stormwater drain during exceptional tide event.

As sea level rise continues, damaging floods that decades ago happened only during a storm now happen more regularly (Figure 6). Eventually, the rising ocean may render gravity driven stormwater infrastructure non-functional, if substantial and expensive adaptation investments are not made, and the ground is permanently saturated with sea water. Perhaps more importantly, higher sea levels also contribute indirectly to flooding by impacting groundwater levels and the drainage network. As groundwater levels rise, lands that were drained by stormwater drainage systems may be more difficult to protect from flooding. As the groundwater rises it is also possible to lose the storage capacity in the soil that typically helps alleviate flooding after rain events. With some loss of the capacity to infiltrate, water levels may remain higher for longer periods of time, particularly during the rainy season. Higher groundwater and sea levels may also incrementally reduce the effectiveness of the drainage infrastructure meaning that the extent or duration of flooding may last longer than it has in the past. For example, if French drains in underground parking garages or basements or other exfiltration systems become saturated, this may compromise their effectiveness.

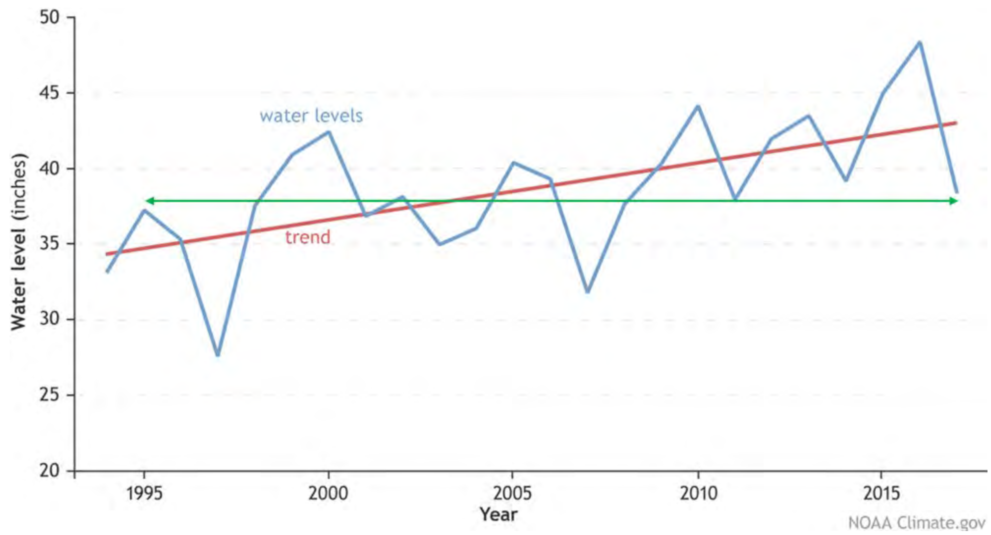
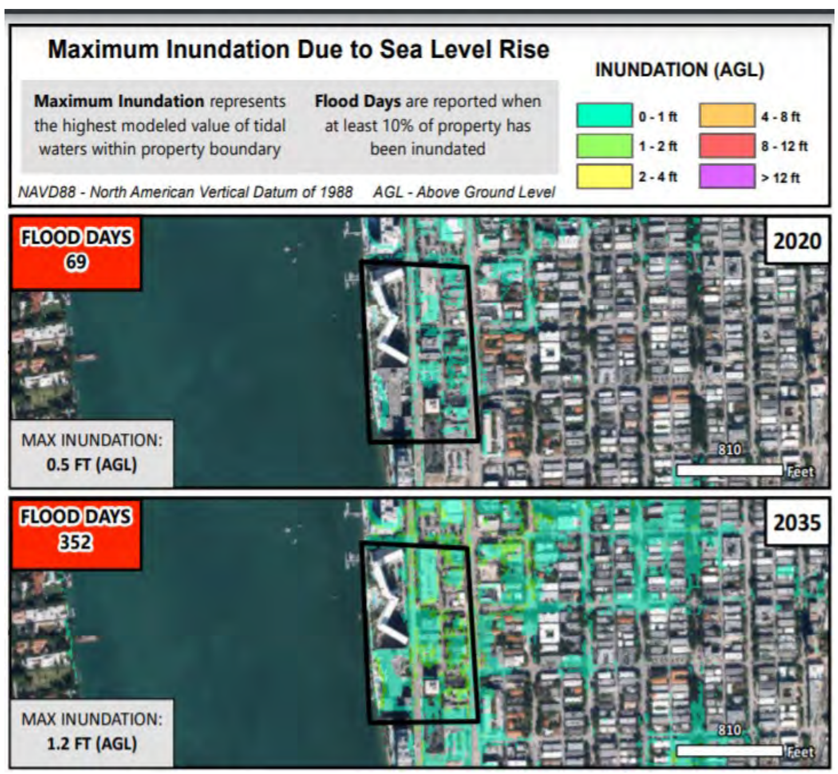


Figure 6. Virginia Key between 1994 and 2017 has risen by more than 5 inches because of sea-level rise (red line). Water level elevations during low tide are now greater than the high tides that occurred 20 years earlier.

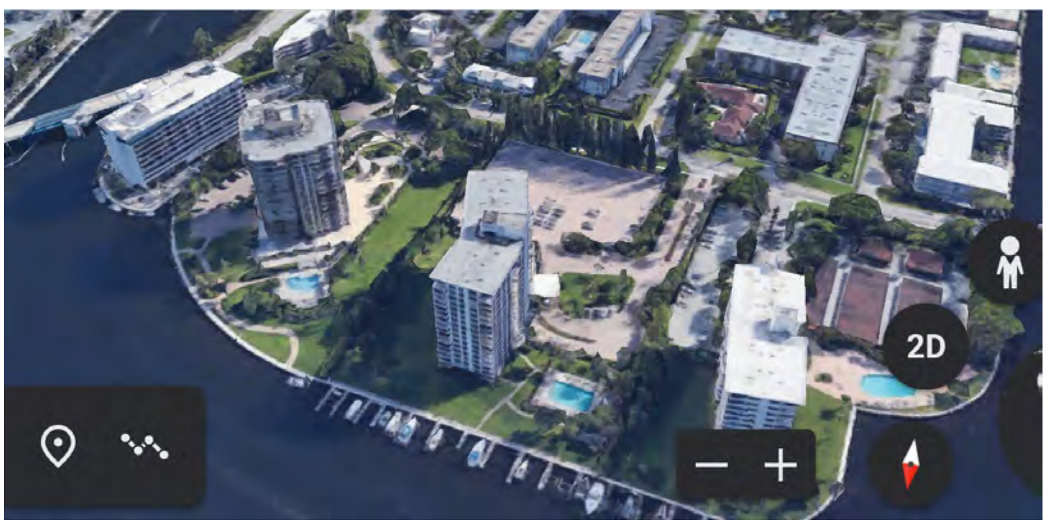
Finally, as sea levels rise they affect beach profiles and erosion rates. While beach nourishment can help slow these changes to the adjacent beaches and dunes and provide important storm protection benefits, these are often expensive and not guaranteed to occur when most needed.

West Ave. Condos Miami Beach (Google Earth)



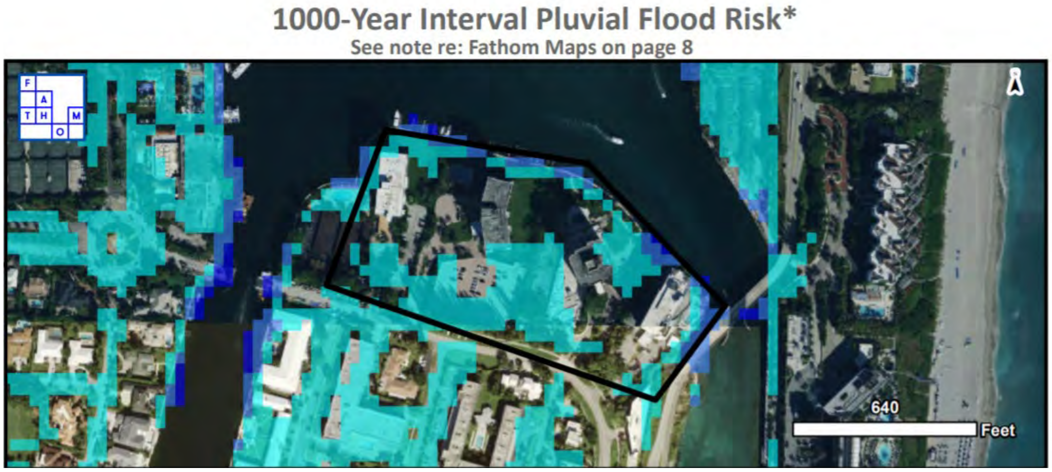
Modeling of Sea Level Rise flooding at West Ave. Condos by RiskFootprint™, www.riskfootprint.com

Image of King Tide or “sunny day” flooding, Miami Beach



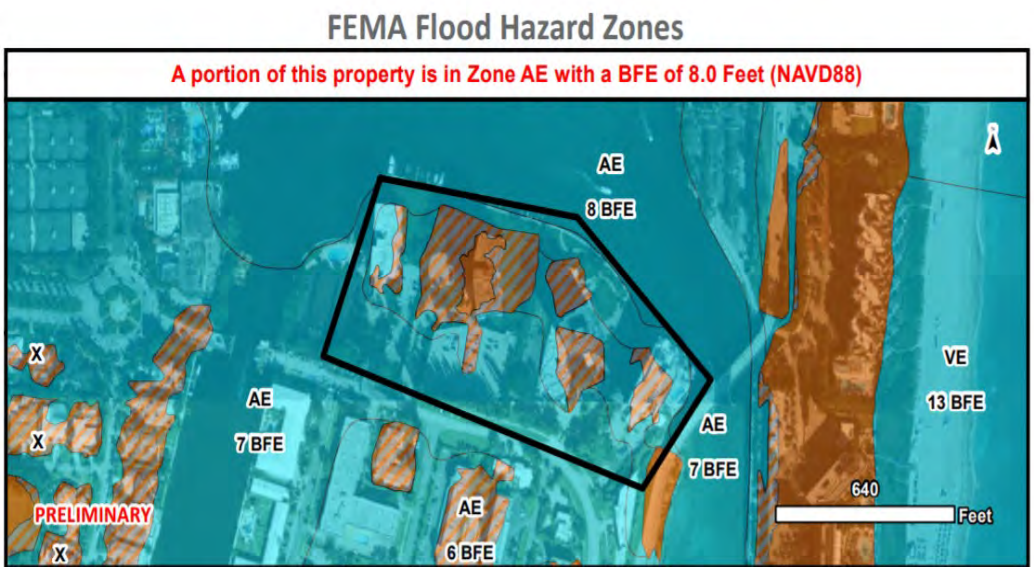
Increased Heavy Rainfall and Hurricane Storm Surges

Lake Boca Condos, Boca Raton, FL (Google Earth)



Heavy Rainfall Flood Risks Increasing

Modeling of Pluvial or Heavy Rainfall flooding at Lake Boca Condos by RiskFootprint™, www.riskfootprint.com

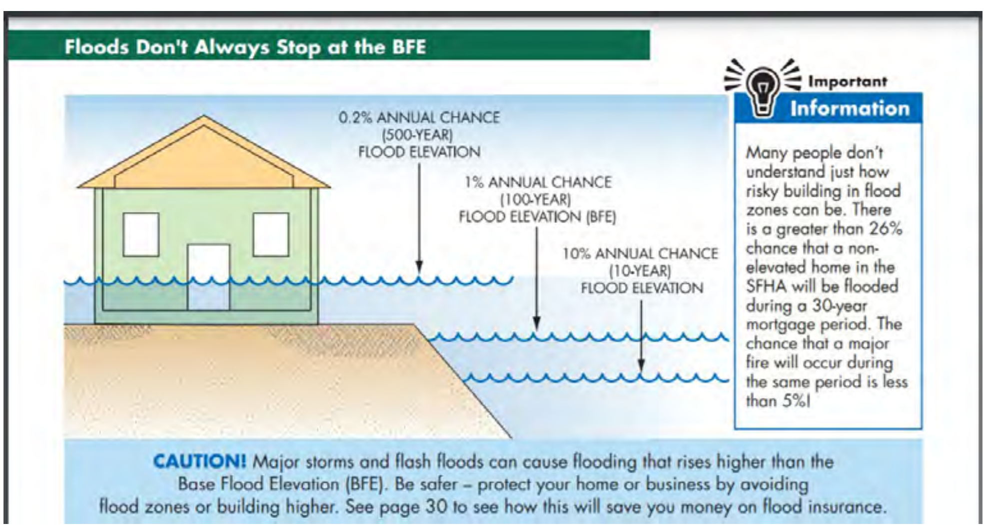


FEMA Flood Map and Base Flood Elevations (BFEs) Lake Boca Condos

FEMA Flood Zones and the BFE

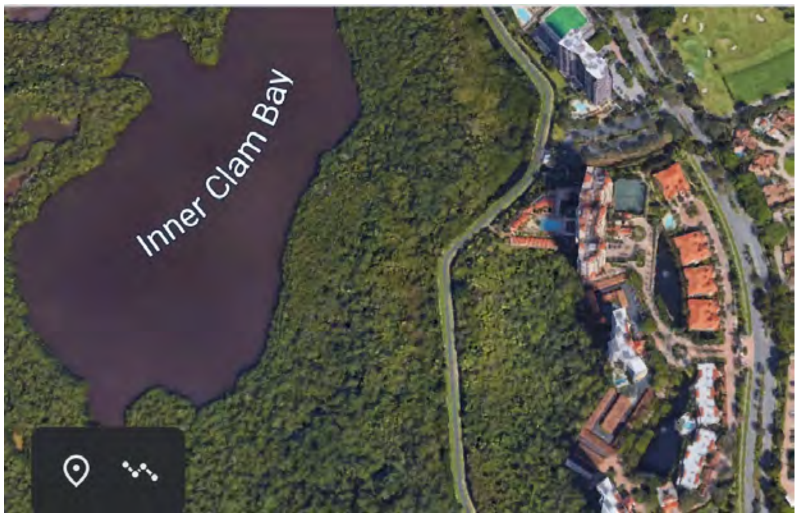
Communities must join the National Flood Insurance Program (NFIP) and administer floodplain management requirements before residents and businesses can purchase Federal flood insurance and to be eligible for some types of Federal assistance, including flood mitigation grants. In partnership with communities and the States, FEMA produces flood maps in accordance with FEMA standards. The maps are used by communities, insurance agents, real estate professionals, and others. The FEMA flood maps detail various risk zones and Base Flood Elevations (BFEs). Generally, the pricing of flood insurance is set by NFIP, and private insurance companies based in part on the height of the elevation of the building's first floor (usually the ground floor) in relation to the established BFE. Condo HOAs and owners can determine the "effective" BFE applicable to their building from the most recent FEMA flood maps. The height of the building's first floor can be determined from the building's Elevation Certificate.

In the example above, the condos on Lake Boca are located in a FEMA AE Zone (a "so called" 100-year flood zone) with a BFE of 8-feet above sea level. The AE zone is shaded blue. The brown shaded areas are FEMA X zones, where FEMA has modeled the rise to be less than a .2% annual risk (a "so called" 500-year flood zone). But floods don't always stop at the BFE. "Floodplain Management in Florida, A Quick Guide (2017)," (https://www.floridadisaster.org/contentassets/5a671dfdfadf45ab9a2c61635e2a4fed/quick-guide-for-floodplain-management.pdf). Many people do not realize that, in the 100-year FEMA flood zone, there is a greater than 26% chance that a non-elevated, home or condo lobby will be flooded during a 30-year period. During the same period, the risk that a major fire would occur in the building is less than 5%.

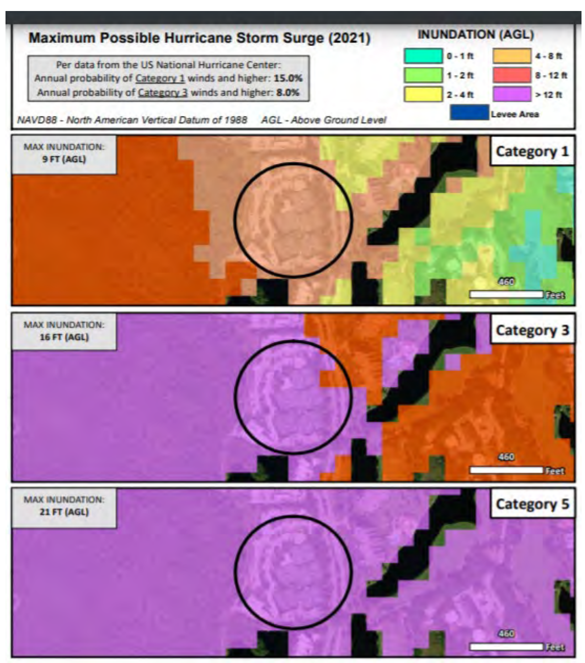


Storm Surge

Storm surge is the abnormal rise of water created extreme weather. In South Florida, a significant storm surge is typically associated with a tropical storm or hurricane. The storm surge results in temporarily higher water levels that recede after the storm has passed. Rising sea-level and ground water impact both the height and extent of the surge, as well as the duration of flooding after the storm has passed.



Condos, Naples, FL



Modeling of Hurricane Storm Surge flooding at Naples, FL condos by RiskFootprint™, www.riskfootprint.com

Land Subsidence

Another process that may compromise the structural integrity of roads, bridges, and buildings is subsidence. Subsidence is the lowering of the land's surface caused by surface loading or the withdrawal of fluids (e.g., groundwater, etc.). The result is a reduction in the void space or porosity of the soils or sediments. This causes compaction and is expressed at the surface as subsidence, which is expressed as distance of displacement over time (e.g., inchers per year). The potential effects of compaction on buildings or other structures are illustrated in Figure 7. The two panels above depict conditions of the subsurface and surface before (time 1, left) and after subsidence (time 2, right). Two buildings are shown, one with a deep foundation (left) and the other with a shallow foundation (right). They respond differently to the same amount of subsidence because the structural attributes of each are different. This is referred to as differential subsidence, which occurs at spatial scales of 10s of feet to 100s of miles.

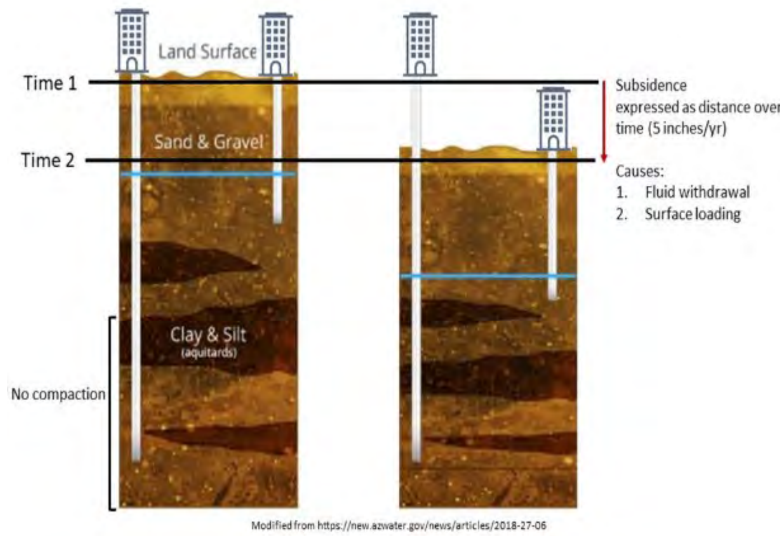


Figure 7. Effects of subsidence on two buildings with different foundations.

Our changing climate is causing an acceleration in the rate of sea-level rise, but also warmer temperatures, changes in precipitation patterns and intensity, and an increase in the frequency and intensity of tropical storms and hurricanes. All of these will alter the physical and environmental conditions of the coastal zone and have the potential to compromise the structural integrity of our buildings, bridges, and roads; either over time or in an instant.

CONCLUSIONS AND RECOMMENDATIONS

The Miami-Dade study made important recommendations for building owners to which the condo HOAs, owners and residents should be aware, along with local governmental staff and elected officials.

<u>Some of the recommendations included</u>:

- Elevate buildings
- Flood-proof buildings with wet flood-proofing; dry flood-proofing; passive flood barriers; improvised flood protection (sandbags or moving equipment to higher elevations); deployable flood panels
- Elevate the height of the interior finished floor elevation
- Elevate mechanical systems
- Avoid below grade parking or basements
- Construct flood barriers to protect specific infrastructure
- Elevate seawalls and bulkheads
- Install backflow preventers to restrict the flow of seawater into the stormwater system
- Increase the use of porous pavements in areas where infiltration is possible
- Increase the use of green roofs and facades to reduce urban run-off
- Floodproof critical facilities
- Install additional stormwater pumps, as required
- Install seepage barriers to reduce the flow of groundwater
- Disclose building hazards and vulnerability to potential condo purchasers

The goal of these recommendations is to reduce both short-term and chronic flooding of buildings from extreme weather and climate change-induced sea level rise.

The "Floodplain Management in Florida, Quick Guide," https://www.floridadisaster.org/contentassets/5a671dfdfadf45ab9a2c61635e2a4fed/quick-guide-for-floodplain-management.pdf, also provides guidance to building owners from NFIP and the Florida Building Code:

Fundamentals of Flood Resistant Construction

The flood resistant construction requirements of the NFIP and the Florida Building Code (FBC) share the common objective of increasing resistance to flooding. Although there are some differences between specific requirements, they all include the following fundamentals – buildings should have:

- **Foundations** capable of resisting flood loads (including dry floodproofed nonresidential buildings)
- **Structurally sound walls and roofs** capable of minimizing penetration by wind, rain, and debris
- **Lowest floors elevated** high enough to prevent floodwaters from entering during the design event
- **Equipment and utilities** elevated or designed to remain intact and be restored easily
- **Enclosures below elevated floors** limited to parking, limited storage, and building access and are designed to minimize damage
- **Flood damage-resistant materials** used below elevated lowest floors

Coastal condo HOA boards, management companies and residents can better understand current and future impacts of flooding, sea level rise, rising groundwater, saltwater intrusion, and hurricane storm surges by obtaining physical climate risk assessments for their buildings. Armed with this information, the boards, owners, and residents can make more informed decisions about risk mitigation investments, plan for needed reserve funds, and identify other adaptation actions that may be appropriate for their specific location and building, including infrastructure upgrades needed by the local/county/state governments that provide services to their buildings.

QUICK SUMMARY

BUILDING OWNERS AND MANAGERS NEED TO:

- **HAVE THEIR BUILDINGS ASSESSED FOR CURRENT AND FUTURE RISKS OF CLIMATE CHANGE AND SEA LEVEL RISE. PROPERLY EDUCATE THEMSELVES AND RESIDENTS ABOUT BOTH CURRENT AND FUTURE CONDITIONS, SO THAT THEY CAN TAKE NECESSARY AND APPROPRIATE ACTIONS IN A TIMELY MANNER.**
- **HAVE THEIR BUILDINGS INSPECTED MORE FREQUENTLY FOR THE IMPACTS OF CORROSION DUE TO FLOODING, SALTWATER INTRUSION, SEA LEVEL RISE AND OTHER FACTORS.**
- **MAKE NEEDED INVESTMENTS FOR REPAIRS AND STRUCTURAL SAFETY.**
- **COASTAL CONDO RESERVE FUNDS SHOULD BE REVIEWED FOR ADEQUACY BOTH FOR NORMAL AND PLANNED MAINTENANCE AND REPAIRS AND THE FUTURE IMPACTS OF CLIMATE CHANGE, EXTREME WEATHER, RISING SEA LEVELS AND GROUNDWATER AND HIGHER HURRICANE STORM SURGES.**

For further information, please contact: customerservice@riskfootprint.com or call 844-Sea-Rise (732-7473), www.riskfootprint.com.