

# *To Elevate or Not To Elevate?* Protecting Historic Structures from Flooding



MEADORS CONSERVATION

Fillmore Wilson, Member of Charleston Board of Architectural Review (S)  
Betty Prime, AIA, Architectural Conservator

# [OBJECTIVES]

- *Discuss the future of coastal communities facing rising sea level.*
- *Review how the city of Charleston is attempting to plan for rising water and flooding.*
- *Review issues to consider when developing guidelines for elevating historic structures.*
- *Share two case studies that demonstrate methods of dealing with repeated flooding.*



# [THE PROBLEM]

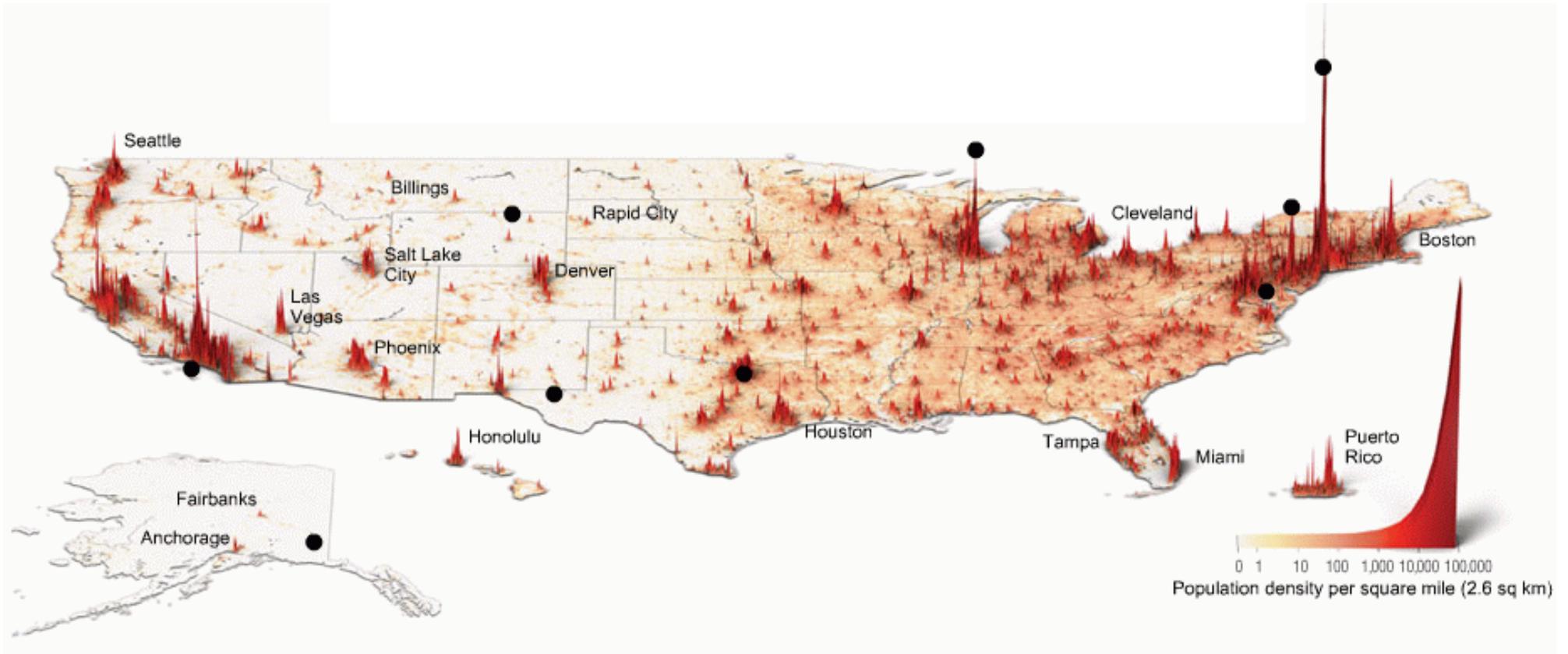


## ***GLOBAL WARMING AND SEA RISE-***

***Three major flooding events in three years has brought attention to the issue.***



# [POPULATION DISTRIBUTION]



- *2010 Census- 39% of the US population lived in coastal regions*
- *2020 Census Projections- 49% of the US population will be living in coastal regions*
- *259 people a week move to the lowcountry, equates to over 13,000 people a year*



[Infil]



City of Charleston 1857

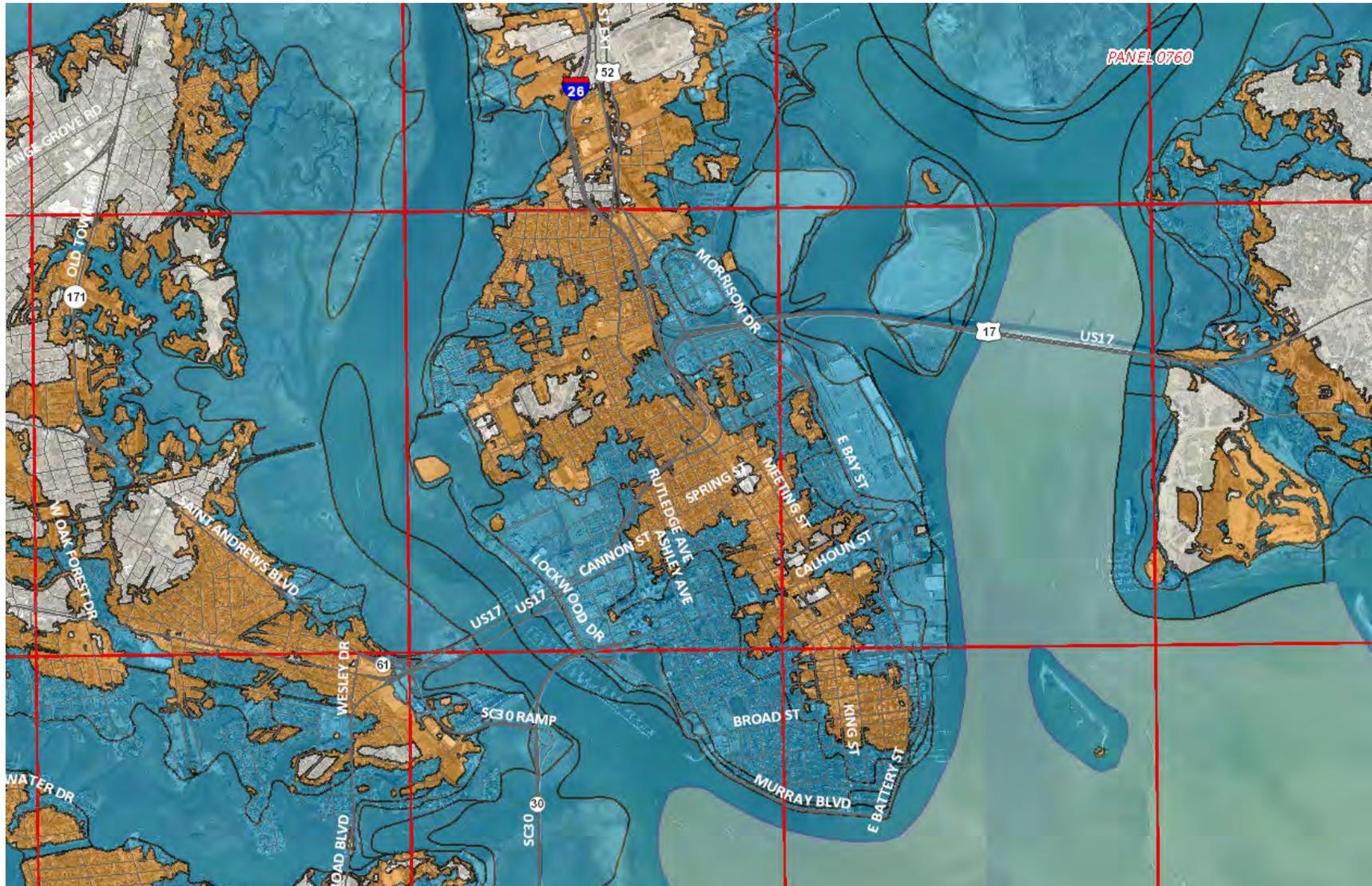
Source: David Rumsey Map Collection



City of Charleston today

Source: City of Charleston

# Preliminary FEMA Flood Map





***4 ft. sea level rise***



***1670 high ground map***



Maps: NOAA Sea Level Rise Viewer

Maps: City of Charleston

***conservative estimates state that by the end of the century  
sea level rise will be 2.5 ft above current sea level  
(the high end estimate is 8 ft.)***





***[MORE SEVERE AND FREQUENT NUSANCE FLOODING DURING RAINS]***

[INCREASED HIGH TIDE LEVELS]



*Average King tides have risen as much as a foot in the past 100 years, projections estimate that tides will rise by ~2.5 ft by 2040*

# [INCREASED FREQUENCY OF KING TIDES]

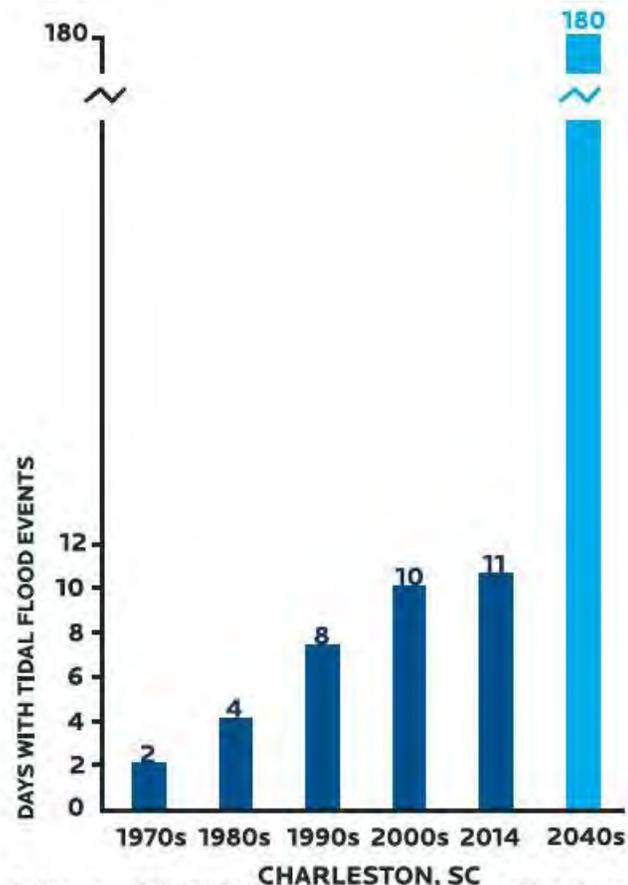


Figure 1: Days with Tidal Flooding Events, Charleston, SC

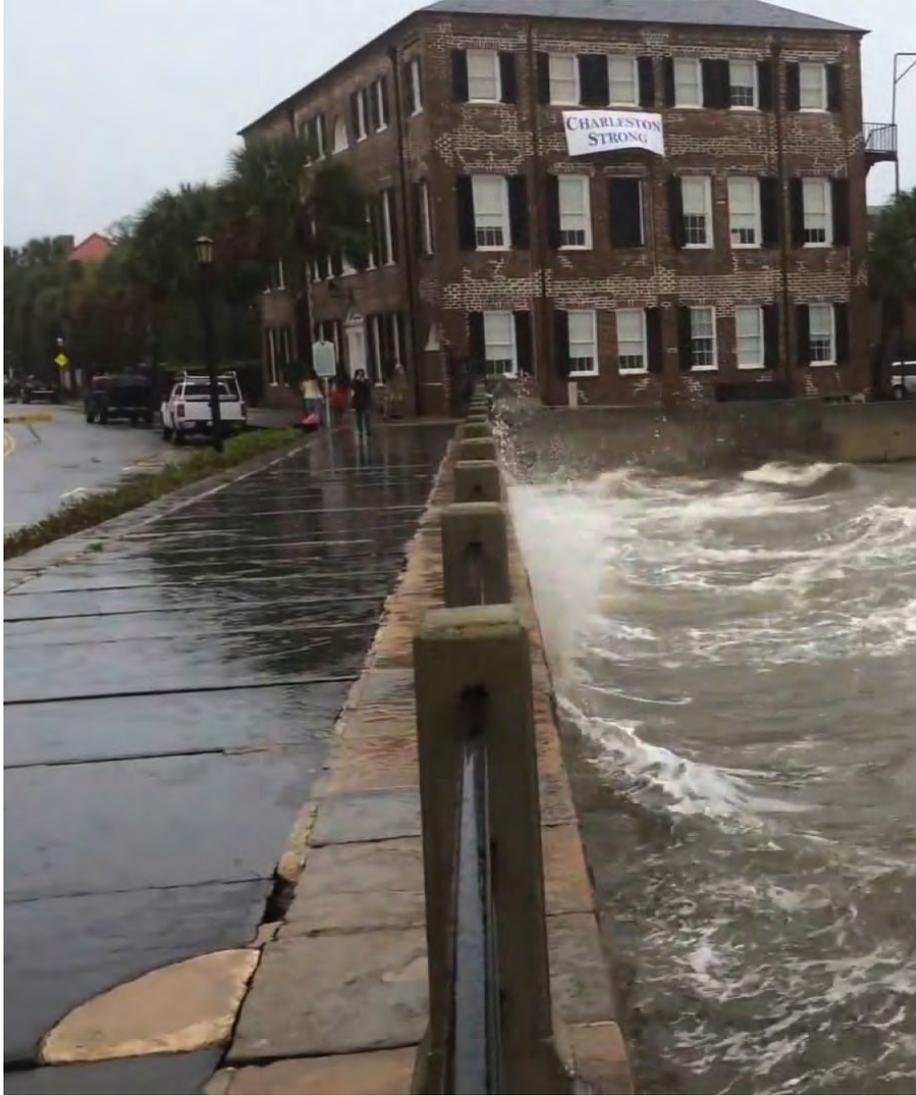
Source: UCS Analysis; Morales and Alsheimer 2014;



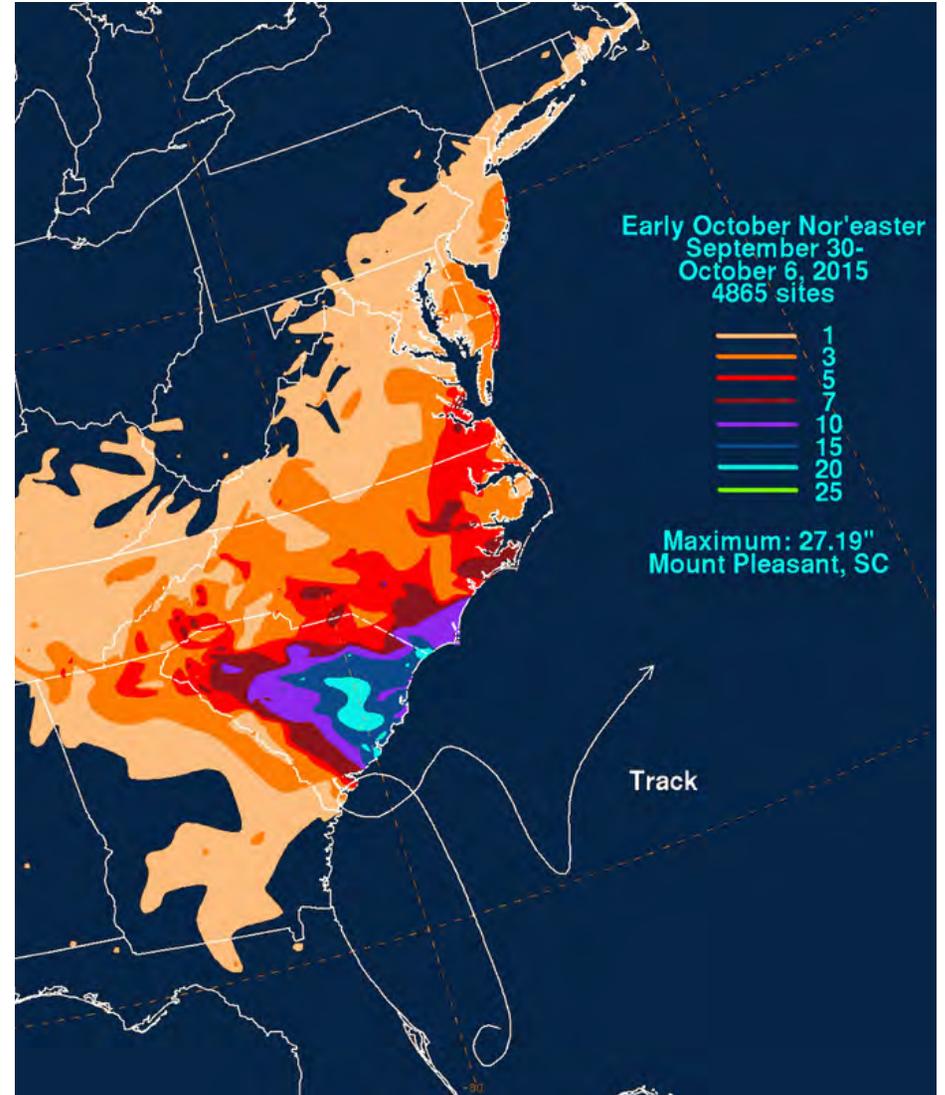
***By 2040, Charleston will experience sunny day tidal flooding 180 days out of the year.***



# [INCREASED RATE OF WEATHER EVENTS]



*2015 Flood Event  
October 2015  
over 20" of rainfall*



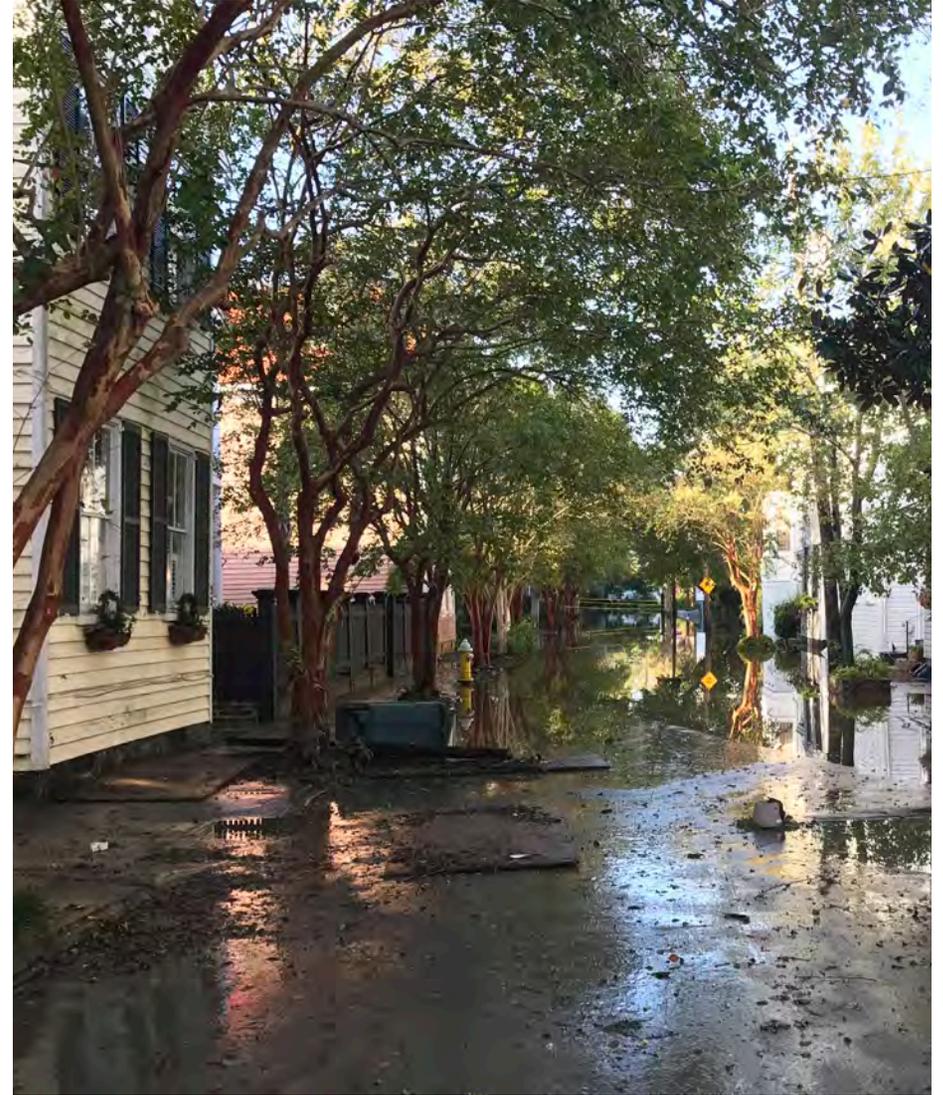
*'1000 - year' rain*

# [INCREASED RATE OF WEATHER EVENTS]

*Increased storm surge during tropical storms/hurricanes*



*Hurricane Matthew  
October 2016  
6 ft. storm surge*



*Hurricane Irma  
September 2017  
10 ft. tides  
3rd highest tide on record*



# [Impact of Rising Sea Levels and Flooding]

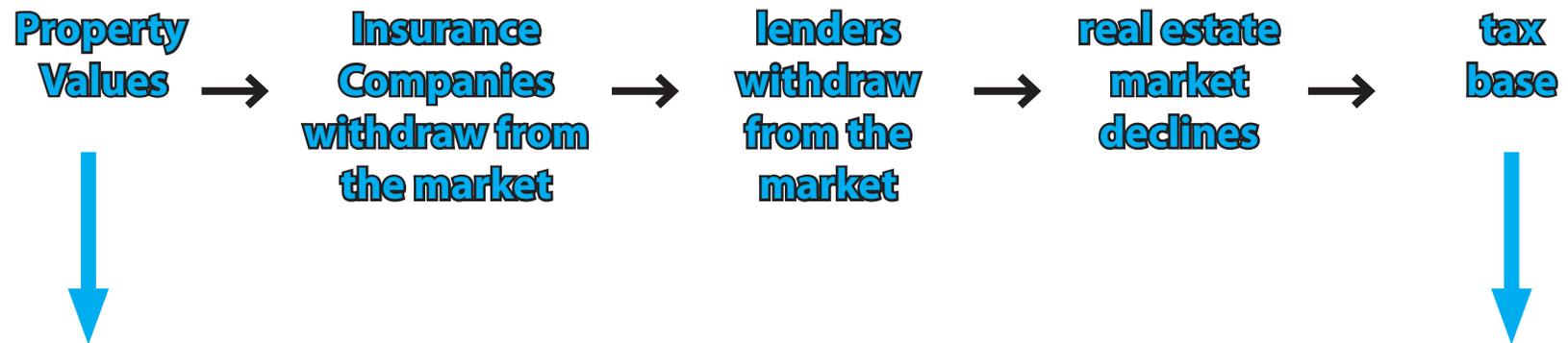
- *Loss of built environment*
- *Cultural loss, physical connection to the past*
- *Economic impact (short and long-term)*



***flood waters threaten cultural heritage as well as economic future of the city***

# [Economic Impact]

***Disaster aid and insurance are meant to respond to occasional catastrophes. What will happen as the seas rise and major flooding goes from the occasional to the near constant?***





***Charleston's environmental, historic, and cultural resources are at risk.  
WHAT CAN WE DO?***

# [WHAT CAN WE DO?]

## *Three Options:*

1) ~~Abandon~~

2) **Armor**  
**city, county, state, regional level**

3) **Adapt**  
**buildings**



# [ARMOR]

*At the scale of the city, county, state, and region.*

## City of Charleston Goals:

- Improve stormwater drainage
- Protect Buildings (zoning/BAR)
- Mitigate Repetitive Flooding



# Major Drainage Improvement Projects



Source: City of Charleston

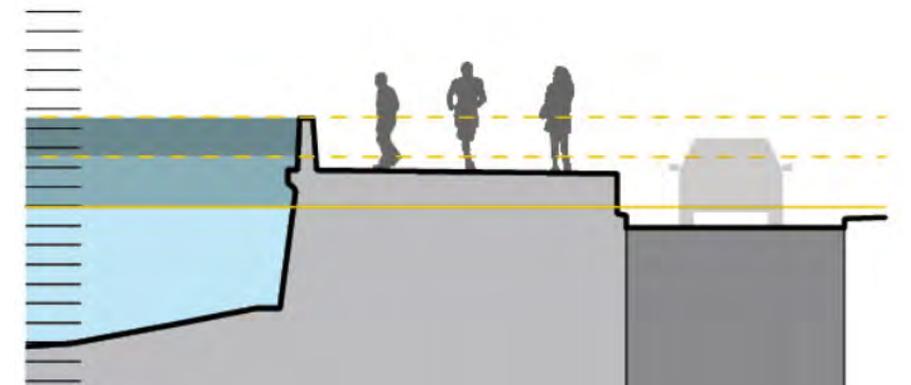


***tunnel collection, pumping, upgrading outdated stormwater drainage***



MEADORS

# [ARMOR- LOW BATTERY SEAWALL REPAIR]



Source: City of Charleston



# [ARMOR- CHURCH CREEK BASIN (WEST ASHLEY)]



***flooding is not an isolated problem confined to the historic district of Charleston, it is throughout SC's coastal region***

# [ADAPT]

## *2 Options:*

1. Elevate Structures
2. Mitigate the affects of flooding at existing elevation

## *Protecting Historic Structures- Factors to Consider:*

- How will modifications affect architectural integrity of the building, streetscape, city?
- Zoning height requirements
- Impact on National Flood Insurance Program



# [National Flood Insurance Program]



***elevating a structure above base flood elevation can significantly reduce flood insurance premiums***

***Currently- NO credit is given for flood proofing***



# [ELEVATING STRUCTURES]

## *Previous Approach:*

The City previously recommended FEMA variances as opposed to elevating historic structures.

## *Current Approach:*

The City of Charleston now approves elevating structures to base flood plus 1 ft. free-board and is working to provide appropriate architectural guidelines.

The Department of Preservation Planning and Sustainability has held 2 Public forums to discuss guidelines for elevating structures.

## *Factors to Consider when elevating historic structures:*

- Streetscape (height, scale, mass)
- Building Pattern
- Context/Site Design
- Preservation of architectural elements



# [Challenges of Elevating Historic Structures]



**Adjoined Buildings**



**Sister Houses**



**Freedman's Cottages**



**Category 1 & 2 Bldgs.**

# [Category 1 & 2 vs. Category 3 & 4 Structures]

Category 1 & 2 structures are typically older, grander, and built on elevated high ground and therefore do not need to be raised to meet base flood.

Many Category 3 & 4 structures are in flood zones.



# [Successful Streetscape Examples ]



Source: City of Charleston



MEADORS

# [Unsuccessful Streetscape Examples ]

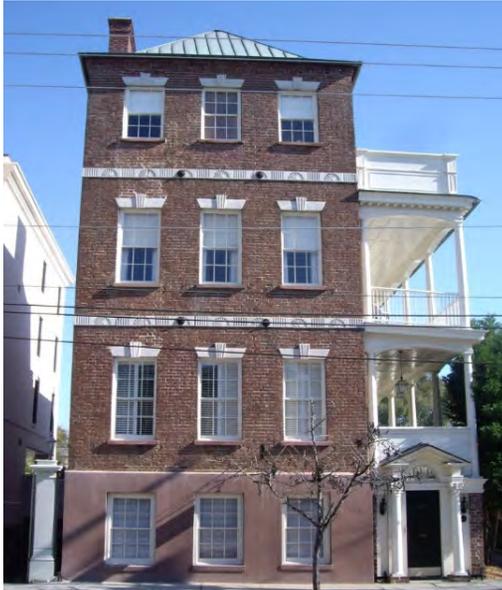


Source: City of Charleston



MEADORS

# [Scale of Foundation Design]



**Successful**



**Unsuccessful**

[Recently BAR(s) Approved plans to Elevate an Historic Structures ]



*42 Rutledge Avenue*



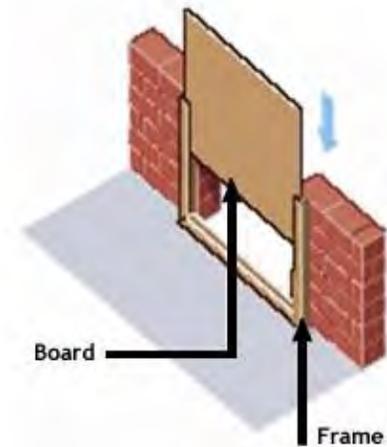
*15 Council Street*



# [Methods of Mitigation ]

*Dry Flood Mitigation reduces the potential for flood damage by reducing the probability that the building interior will be inundated.*

- Flood barriers
- Generally considered for commercial structures, but available for residential structures as well
- National Flood Insurance Program (NFIP) gives no credit for barriers on residential structures



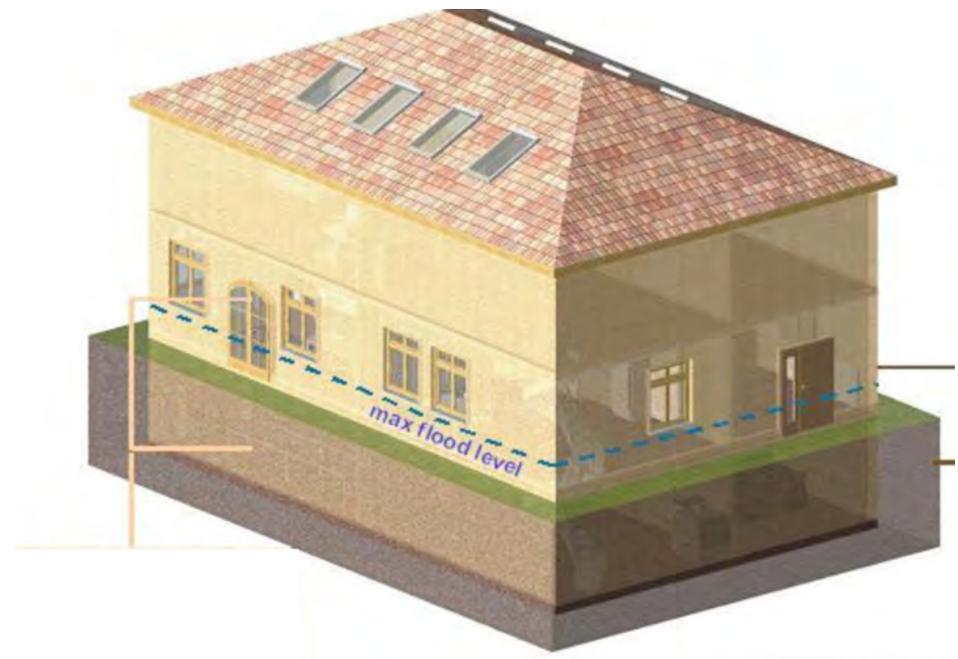
# [Dry Mitigation]



# [Methods of Mitigation ]

## *Wet Flood Mitigation*

- Allowing water to enter and exit the structure
- Employs flood resistant materials
- Raising interior floors and abandoning lower flood prone areas
- Improving foundations to resist flooding



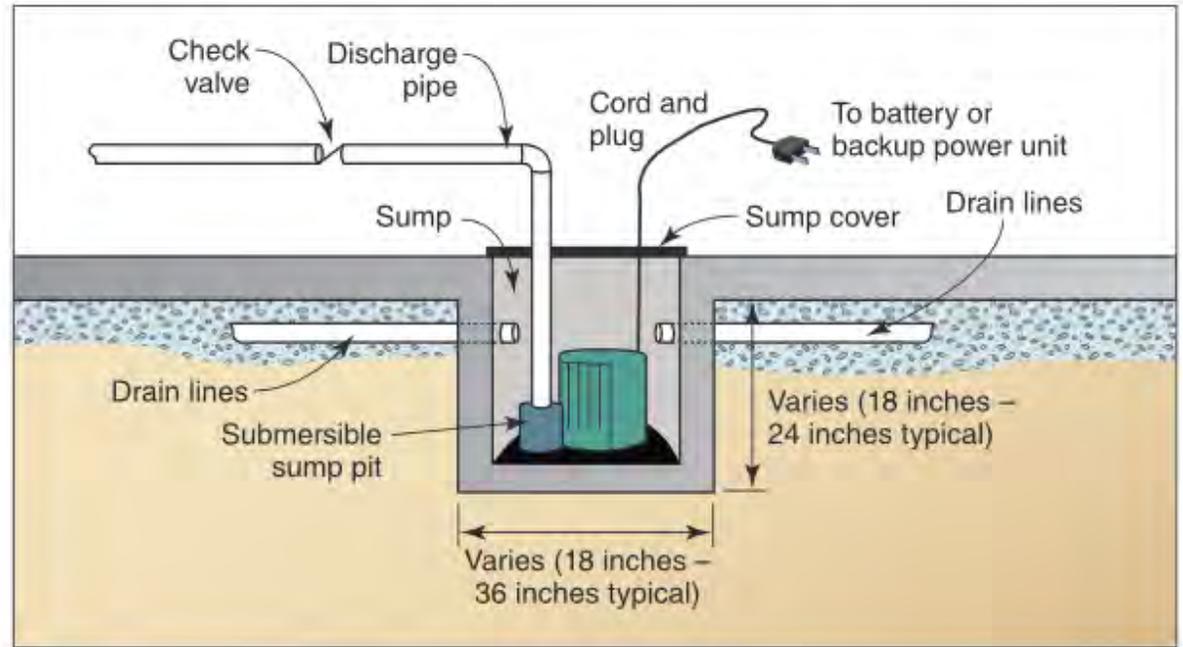
# [Mitigation Case Study: East Battery Residence]







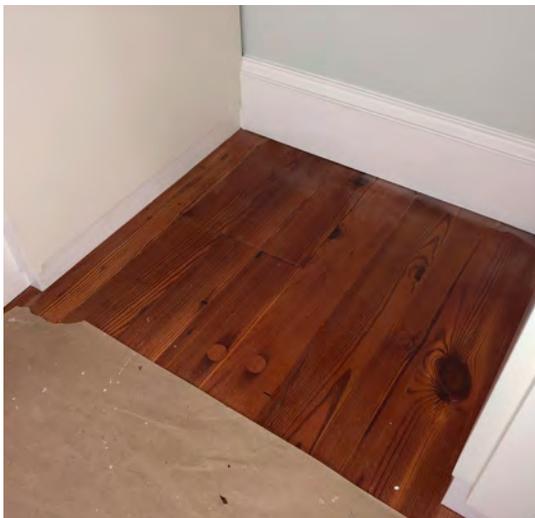
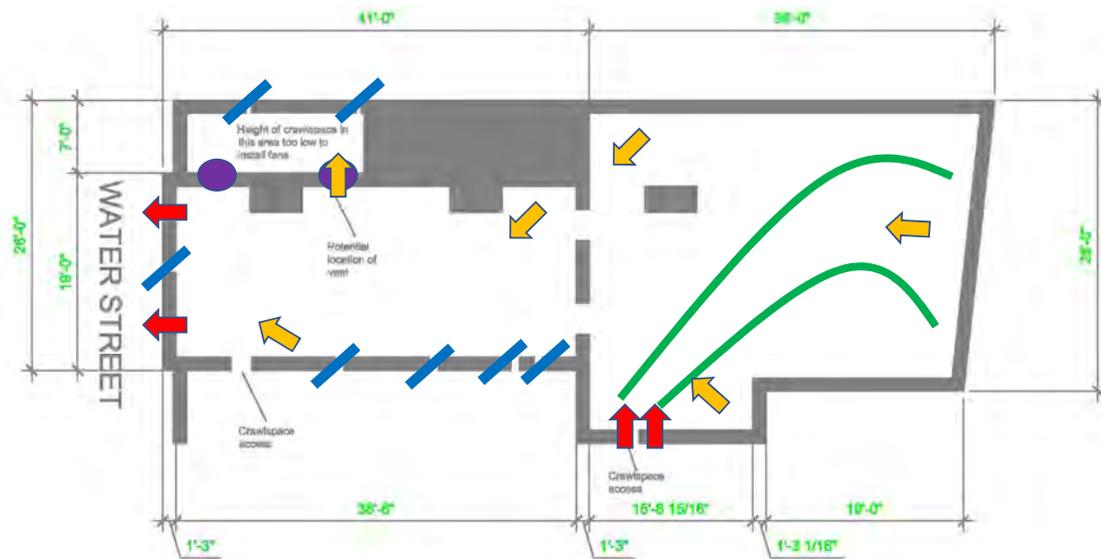
# [Mitigating Nuisance Flooding: Sump Pump]



- *installed 4 new sump pumps hard piped into storm drainage system*
- *regraded the crawlspace to slope towards pumps*



# [Mitigating Nuisance Flooding & Severe Flood Events: Atmox Controlled Ventilation Systems]

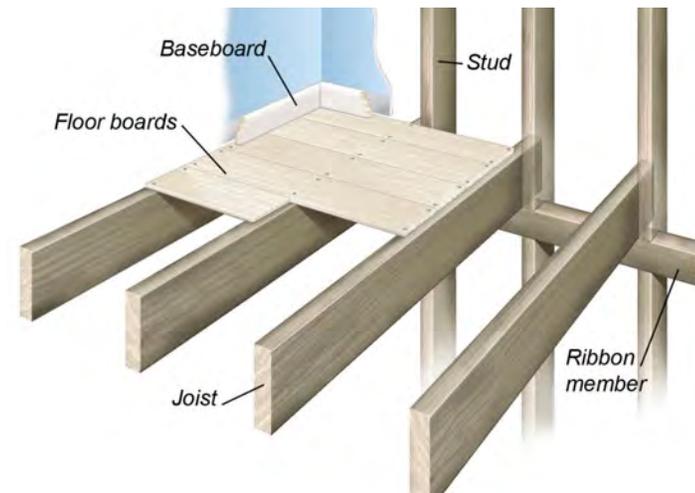
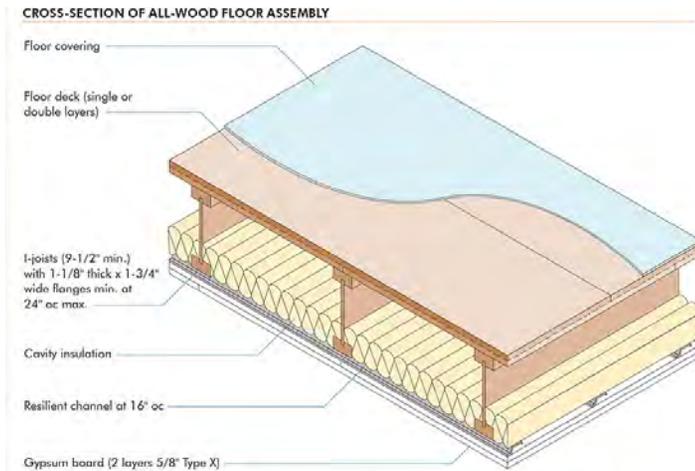


# [Mitigating Moisture in Masonry Wall Systems]



- *isolated marble from masonry wall*

# [Mitigating Moisture- Hardwood Floors]



- ***modern flooring and subfloor replaced with reclaimed 5/4 tongue and groove flooring***
- ***reclaimed heart pine flooring installed directly on floor joists less susceptible to flood damage***



# [Mitigating Moisture- Interior Walls in Flood Prone Zone]



- *treated wood used for all trim and wall panels below 3 ft.*
- *all walls were panelized with water resistant panels, so that they can be taken off to dry out*
- *no insulation installed in walls below 3 ft.*

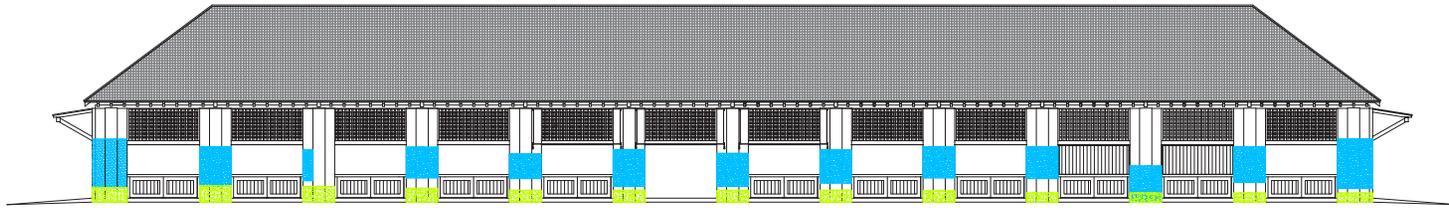
# [Mitigation Case Study: Charleston City Market]



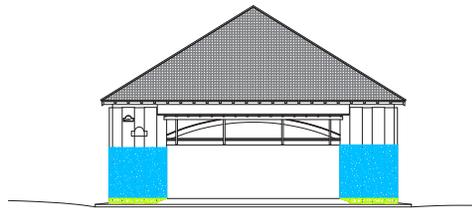




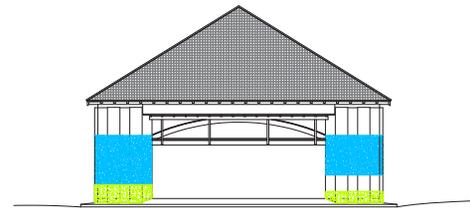
# [Conditions Drawings: Findings]



1 NORTH ELEVATION – SHED A  
SA-4201



2 EAST ELEVATION – SHED A  
SA-4201



3 WEST ELEVATION – SHED A  
SA-4201



4 SOUTH ELEVATION – SHED A  
SA-4201

MARKET SHED A

1/16" = 1'-0"



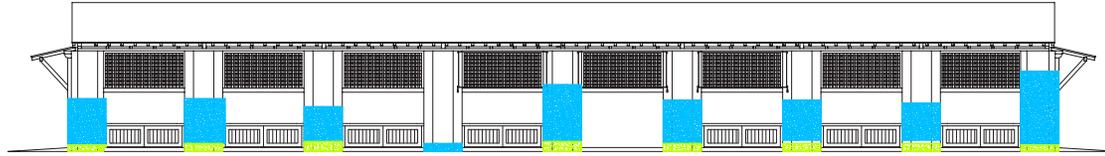
Biogrowth



Deteriorated Mortar



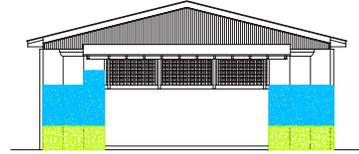
# [Conditions Drawings: Findings]



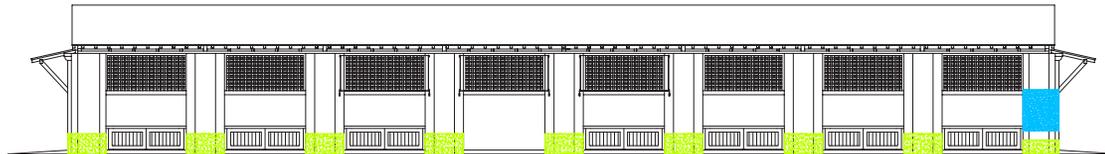
1 SOUTH ELEVATION – SHED B  
SB-4201



2 EAST ELEVATION – SHED B  
SB-4201



3 WEST ELEVATION – SHED B  
SB-4201



4 NORTH ELEVATION – SHED B  
SB-4201

MARKET SHED B

1/16" = 1'-0"



Biogrowth



Deteriorated Mortar





1883 image, rising damp



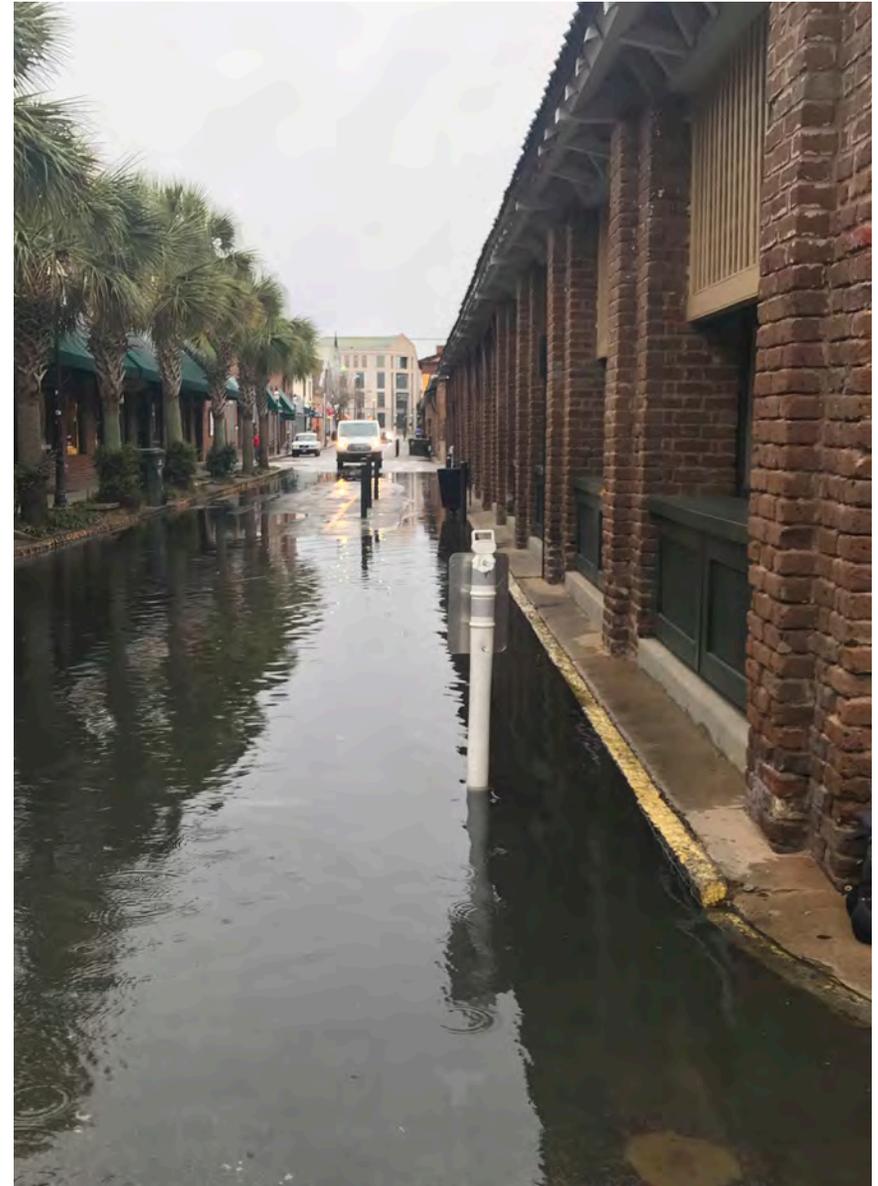
1907 image, limewash/render



# [Summary of Conditions]

## *Information Yielded from Conditions Assessment & Materials Analysis:*

- Headhouse and sheds have been dealing with rising damp since construction.
- c. 2010 restoration mortar was a Type O containing 1-part cement, 2- parts hydrated lime, 9- parts sand.
- A reaction is occurring between the cement particles and sulfate ion. Subsequent sulfate attack on the hydrated cement particles forms gypsum, another expansive mineral.
- Salt attack is occurring as sub-florescence where microscopic salt crystals develop in the pore space of the mortar and masonry.
- Salt crystals are exerting enormous pressure causing degradation of the mortar- crystallization pressure is approximately 56MPa or 8,122 psi



# [Recommendations: Primary Issues & Considerations]

- Structure cannot be elevated nor isolated from the salt water.
- There is no perfect solution.
- Existing Type O mortar is inappropriate in the aggressive salt-laden environment.
- Any future cement-lime repairs are likely to fail due to their low porosity and susceptibility to sulfate attack.
- A NHL 3.5 mortar is recommended as an appropriate repair material for this situation due to its resistance to sub-florescence, high permeability, moderate compressive strengths, compatibility with the historic masonry, low modulus of elasticity, and overall workability.
- Surface efflorescence may become more prominent following the repointing campaign with NHL mortars, indication that the salts present in the environment are moving through the masonry wall system.





[Next Steps]



MEADORS

# [Where Do We Go From Here?]

- ***Formalize Guidelines for Elevating Historic Structures:***
  - 1st set of guidelines will be put out for public review and comment, and then formally adopted by the City of Charleston Board of Architecture Review.
  - These will be guidelines, not mandates. Every historic structure is unique and will be considered on its merits.
- ***Continue to develop solutions and best practices for mitigation.***
- ***Advocate that the National Flood Insurance Program (NFIP) more sensitively address historic and residential structures, providing relief for owners who mitigate flooding damage in every way- not just elevating.***

