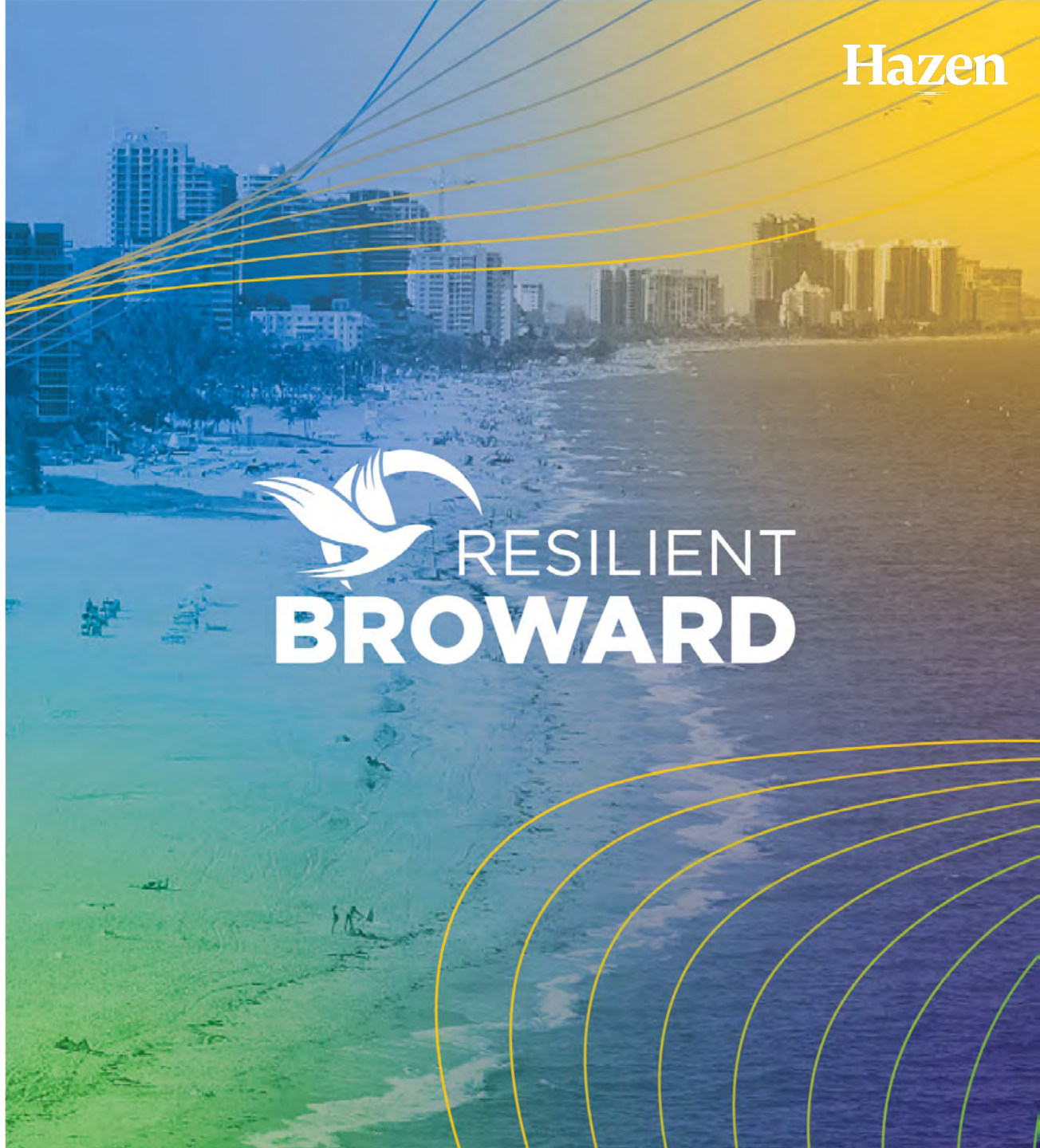
COUNTYWIDE RISK ASSESSMENT AND RESILIENCE PLAN

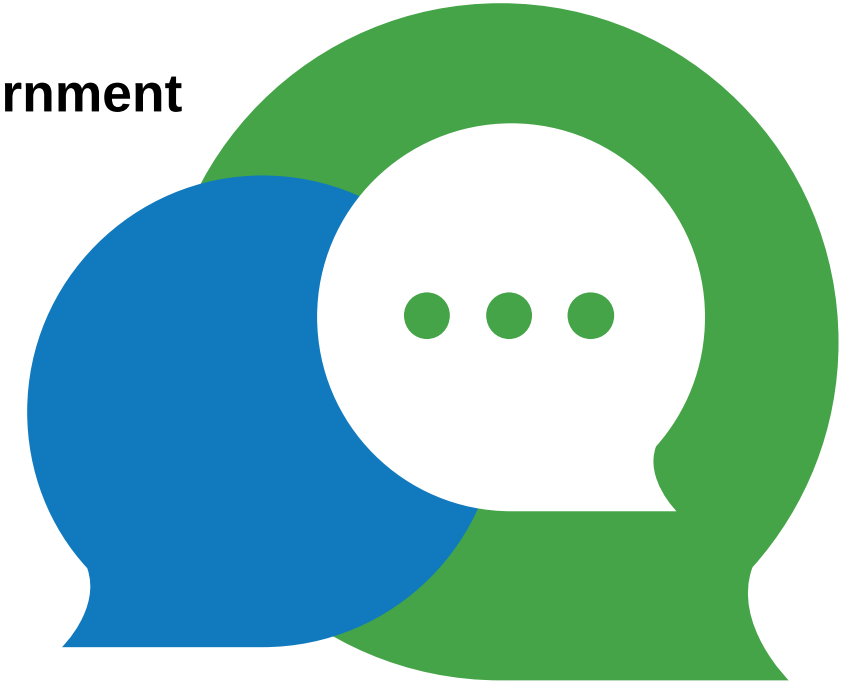
Resilience Steering Committee

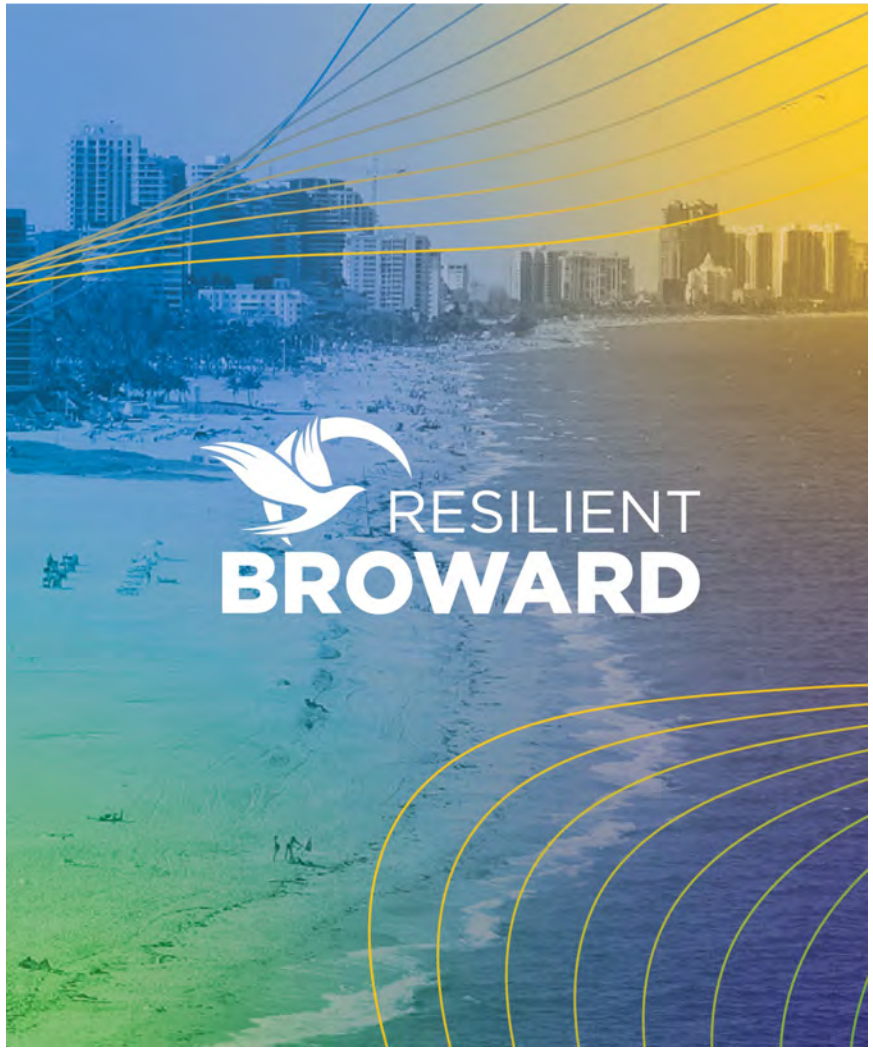
February 7, 2024



Outline

1. Welcome
2. Roll Call
3. Economic Modeling Update – Airport/Port Valuation
4. Stakeholder Engagement Update
5. Adaptation Strategies Update
6. Platform Update
7. Adjournment

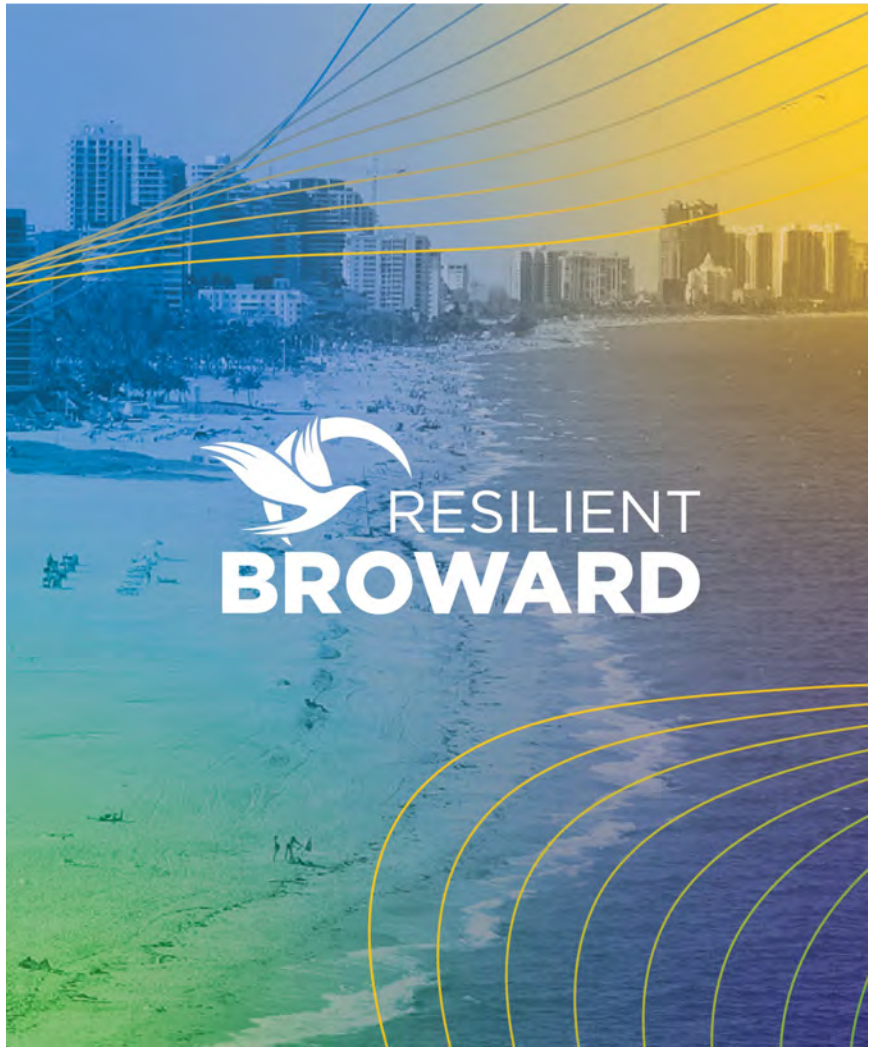




1

Welcome

Hazen



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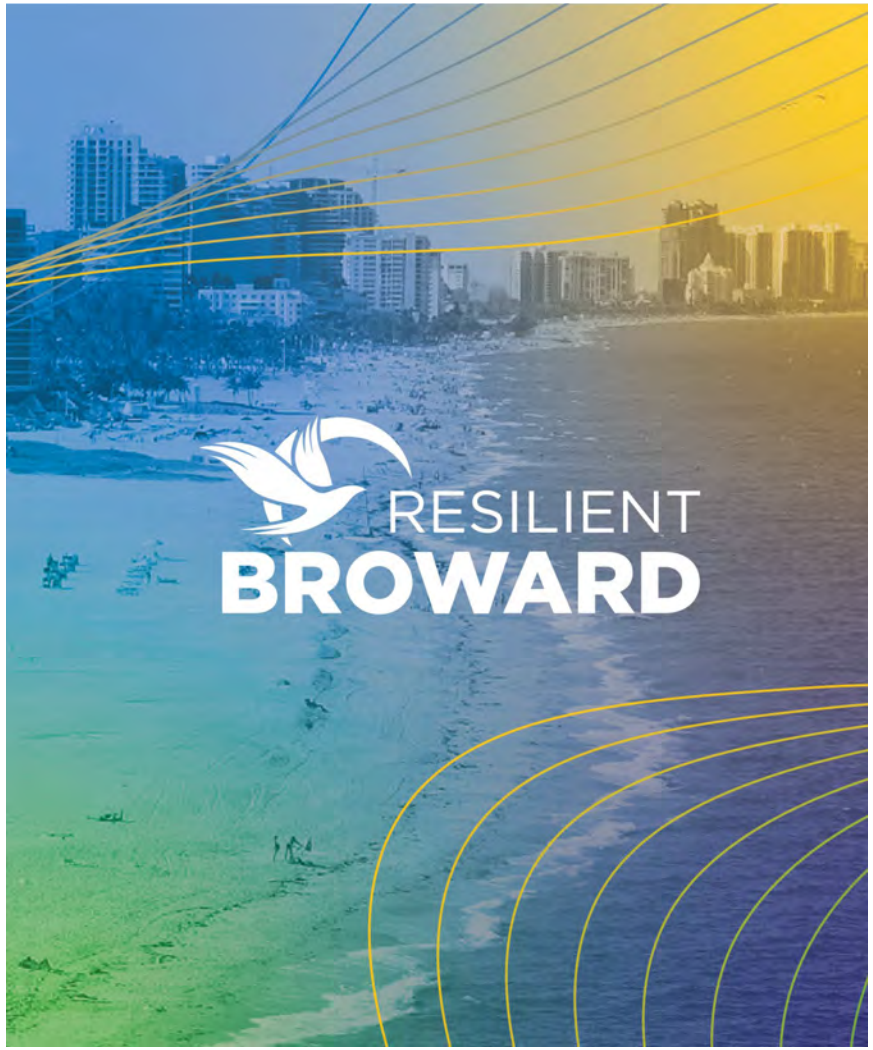
Roll Call

Hazen



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Economic Modeling Update
Airport/Port Valuation

Hazen

A separate economic analysis was requested for the Port and Airport

- The team met with FLL Airport on January 25, 2024

  1. Carlos Hernandez described damages to runway after April 12, 2023 event and damages from Dec. 23, 2019 event

  2. Post-meeting, Carlos/Malu provided “Damage Assessment Report – Impacts of the Rain Event of April 12 & 13, 2023 on FLL”

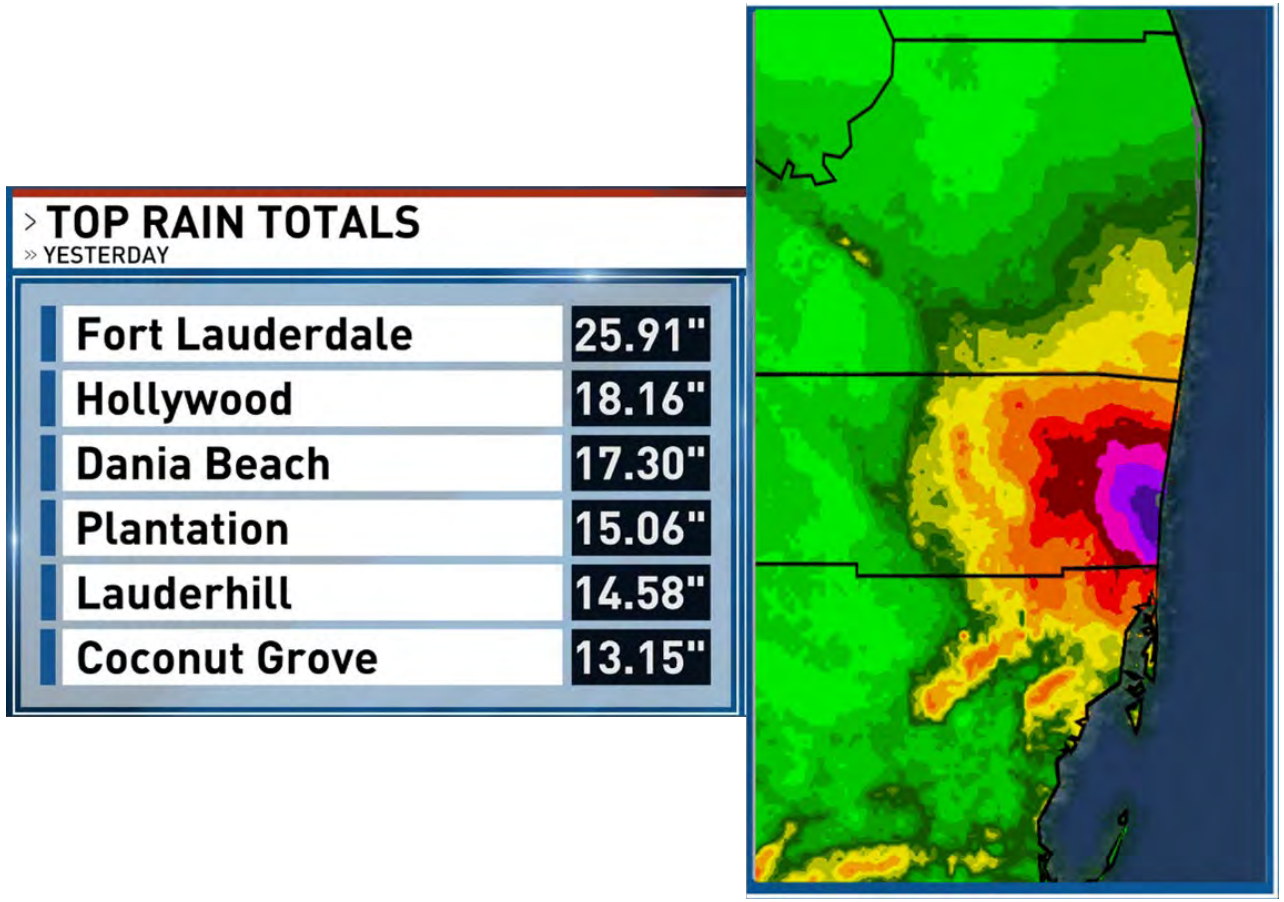
  3. Grace/Hazen and Zach/McKinsey agreed to use data as starting point and summarize analysis

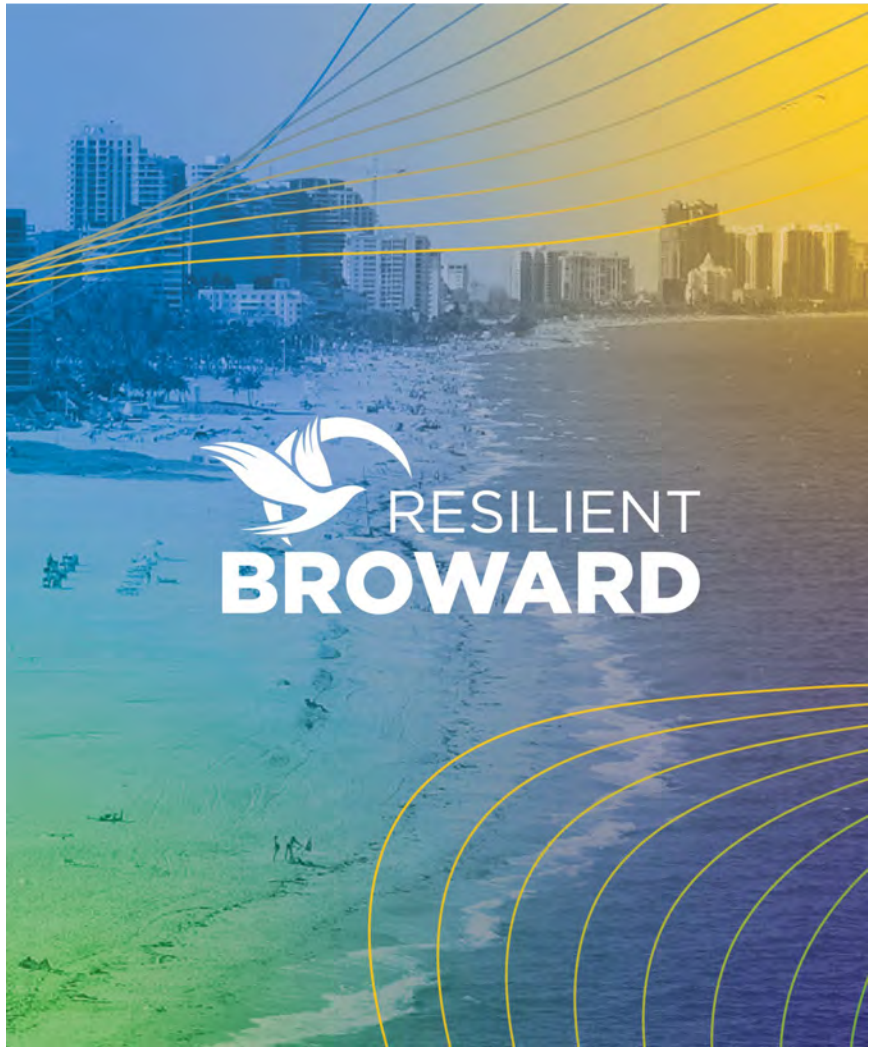
- The team will meet with Erik Neugaard to discuss Port Everglades flooding issues on February 12, 2024

Flooded FLL Airport Perimeter Road on April 13, 2023

Preliminary Approach to Assessment of Airport and Port Everglades

- Assess direct damage at each facility, with and without adaptation, using the flood data
- Quantify downtime at each facility using business/travel disruption modeling (converting downtime to financial loss)
- Conduct literature research on impact of flooding/climate risk on travel and ocean-based cargo demand to south Florida or analogous geographies
- Summarize historical impacts to each facility based upon public data and information, as well as data and information shared by county personnel (e.g., engineered materials arrestor system (EMAS) replacement at FLL)





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Stakeholder Engagement Update

Hazen

Listening Session to Inform Countywide Risk Assessment And Resilience Plan

Urban League of Broward County

HISPANIC UNITY of FLORIDA

COMMUNITY FOUNDATION OF BROWARD

Listening to the Students Yielded Applicable Solutions

"Improve drainage systems, collect rainwater, purify, and reuse it."

"Make bus stops heat-friendly with more shade and amenities."

Construction Incentives: Integrate flood mitigation requirements into new construction guidelines. Leverage peer pressure and branding to incentivize developers to adopt advanced technologies and sustainable practices.

Sponge Function Enhancement: Encourage the increase of natural "sponge" functions by reducing concrete and asphalt in urban areas. This involves incorporating green spaces and permeable paving to absorb and manage excess water.

"Focus on wetland restoration, particularly in the Everglades, to absorb water."

"Install more water fountains and create a map for easy access."

Permeable Paving: Promote the use of permeable paving in parking lots to facilitate water absorption, reducing runoff and flooding risks.

Mitigate storm surges by focusing on dune protection."

Mangrove Protection: Implementing mangroves to safeguard coastal areas serves as a natural barrier against flooding and storm surges. This involves strategic planting and preservation efforts.

Natural Cooling in Urban Areas: Encourage natural cooling strategies in urban planning, such as green and complete streets, de-paved parking lots, and the installation of permeable paving to counteract the urban heat island effect.

MUSEUM OF DISCOVERY AND SCIENCE
AutoNation IMAX 3D Theater

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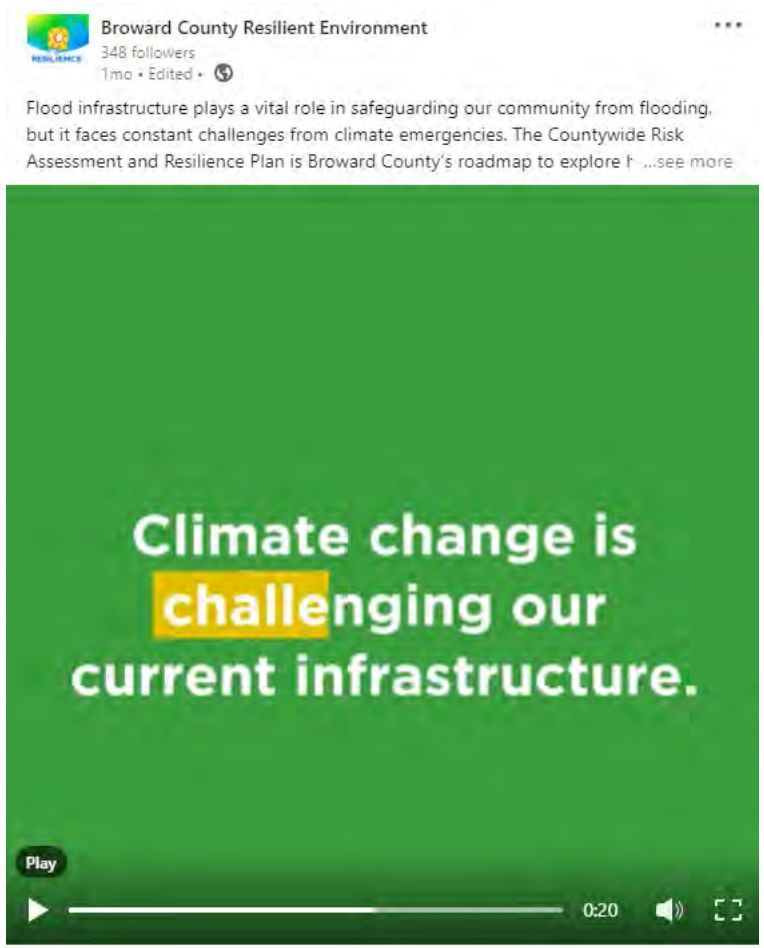
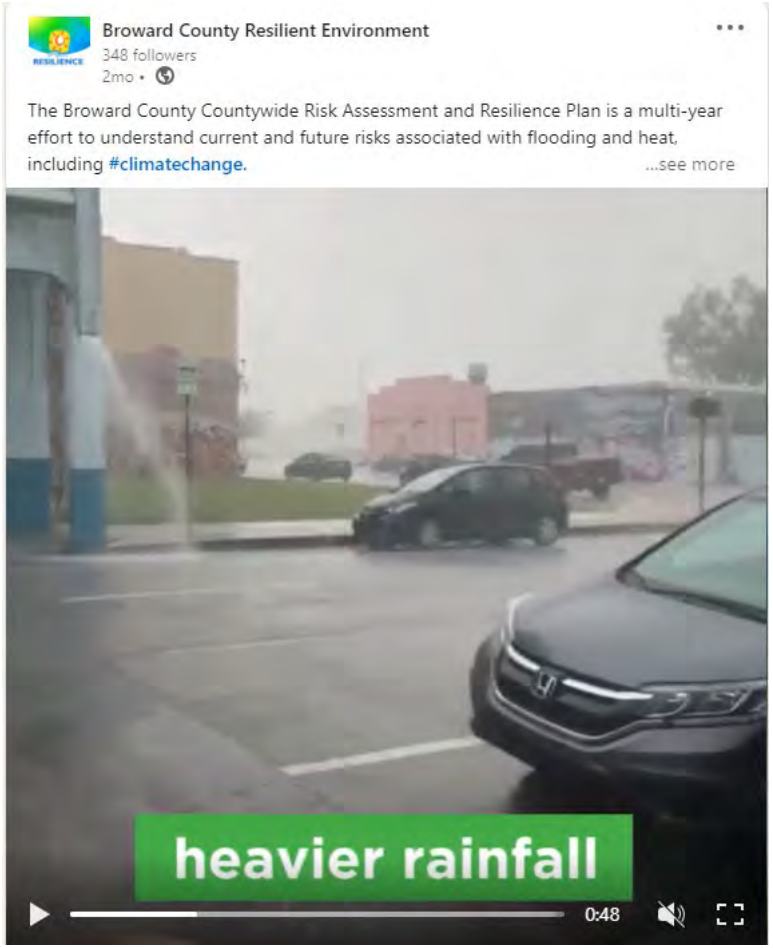
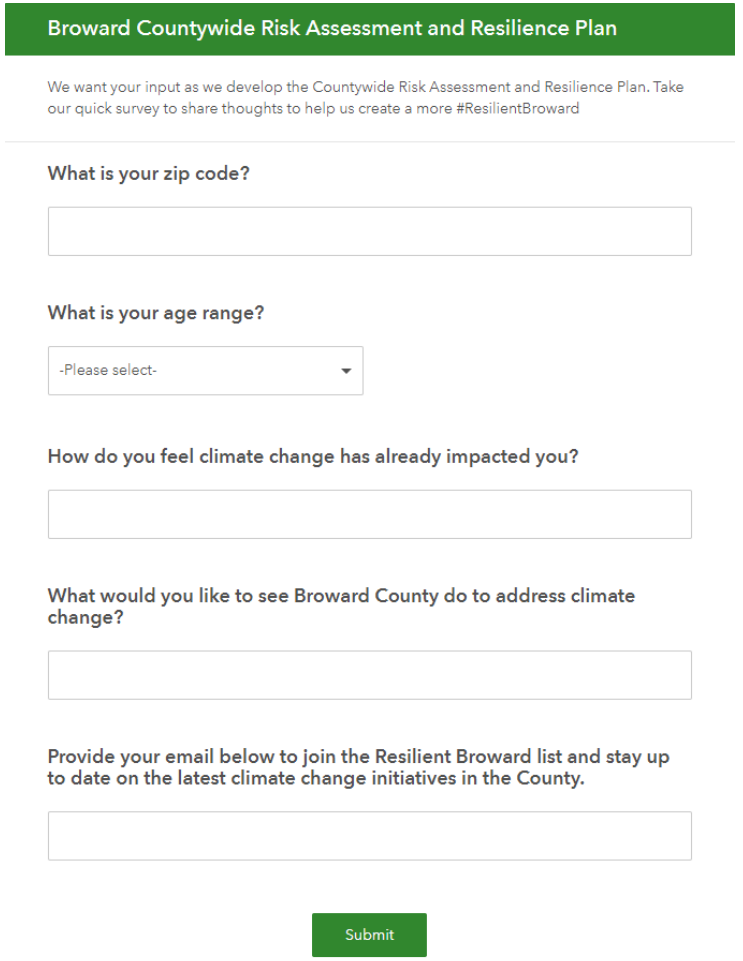
Broward County RED posts routinely to social media…



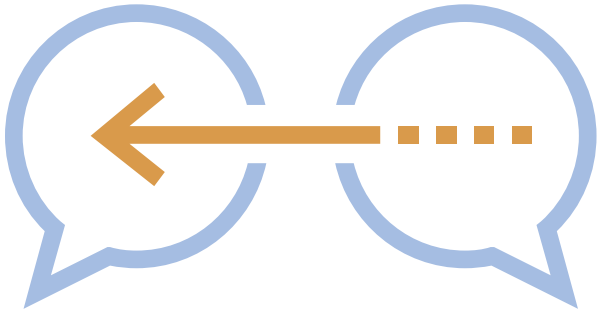




Link: https://arcg.is/1Obqje2

…and solicits input from the public.

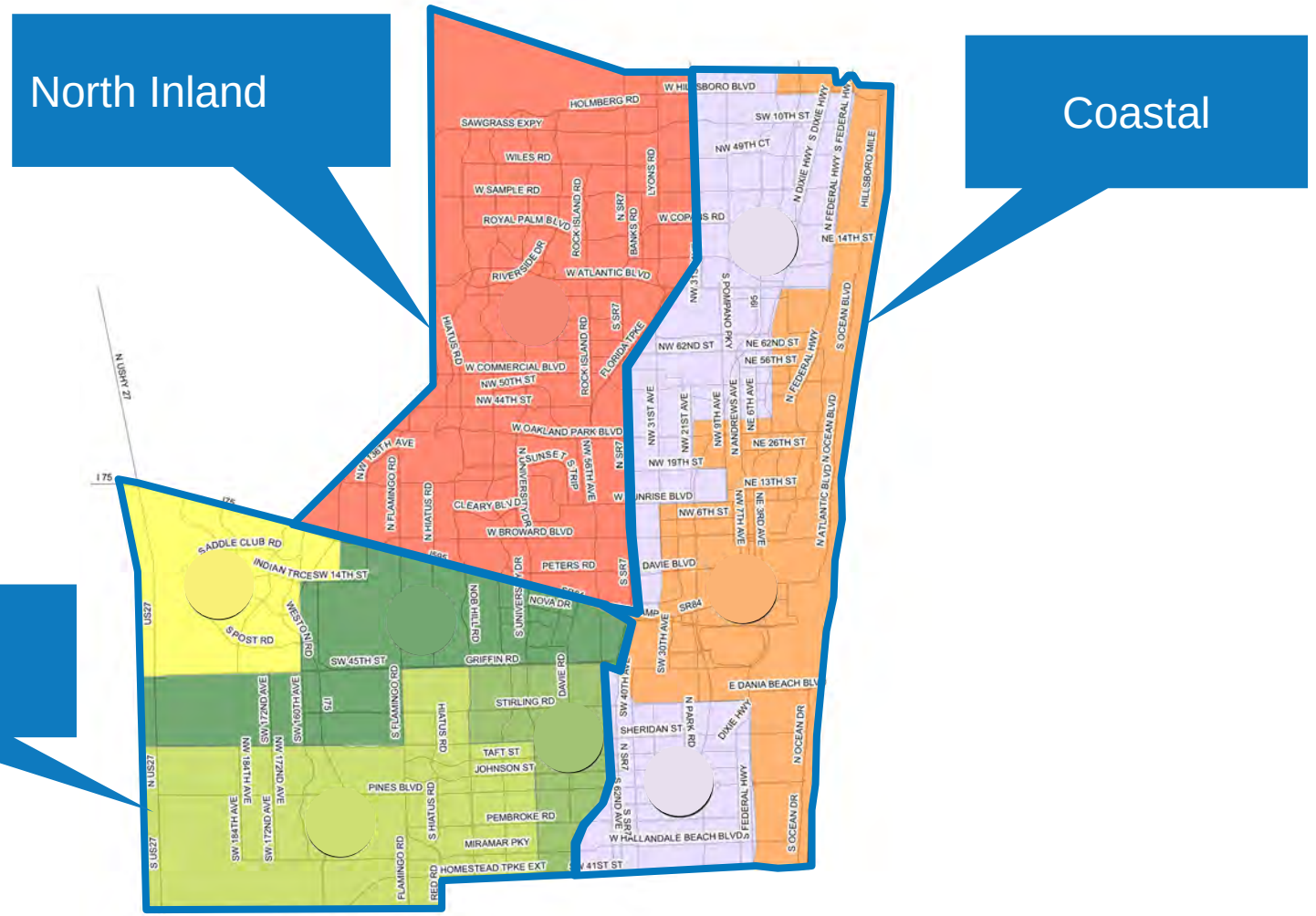
Additional public outreach to inform the community about the Resilience Plan includes a video message from Dr Jurado

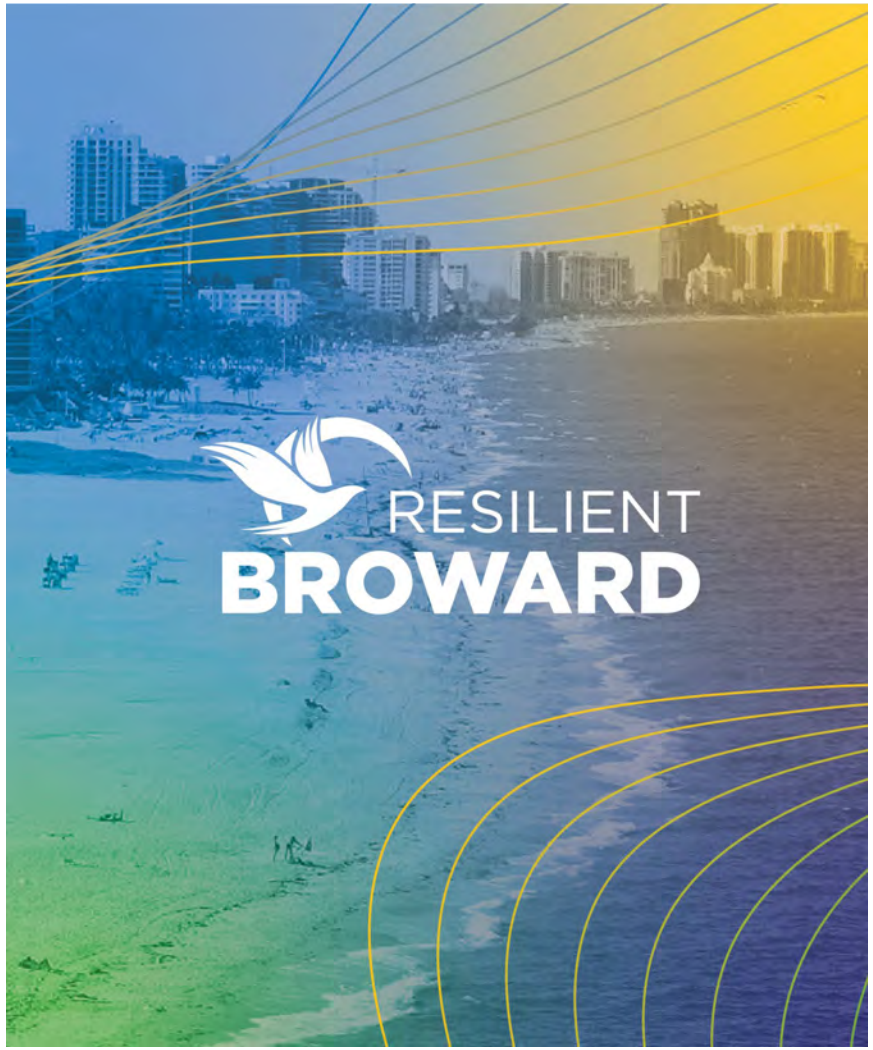


Jennifer Jurado Ph.D.
CRO and Deputy Director, Resilient Environment Department, Broward County

The next phase of stakeholder engagement is to inform municipalities, water control districts, and other entities about possible adaptations

- Report to RSC February 7, 2024
- Plan Engagement – County/Hazen/Brizaga Meeting February 14, 2024
- Communication with Stakeholders – March 2024
  - **Unique local insight is critical**
  - **Garnering community support is essential**





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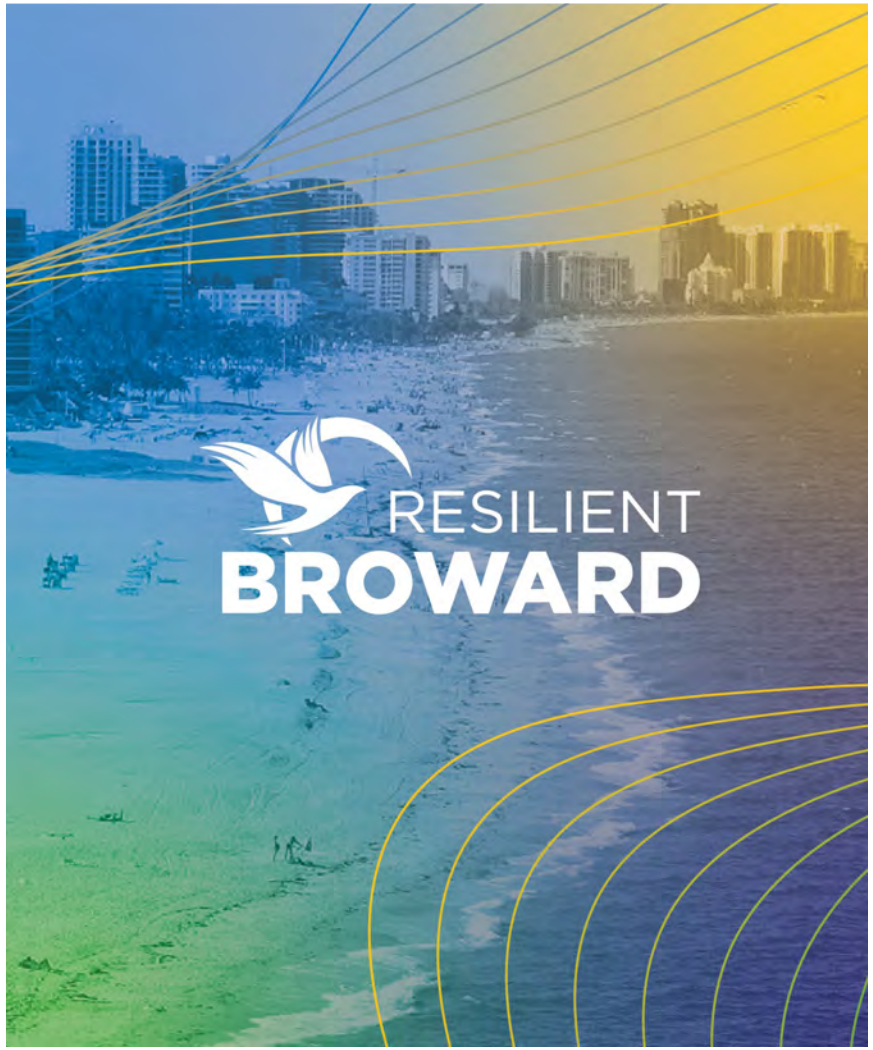
Adaptation Strategies Update

Hazen



Adaptation Concepts

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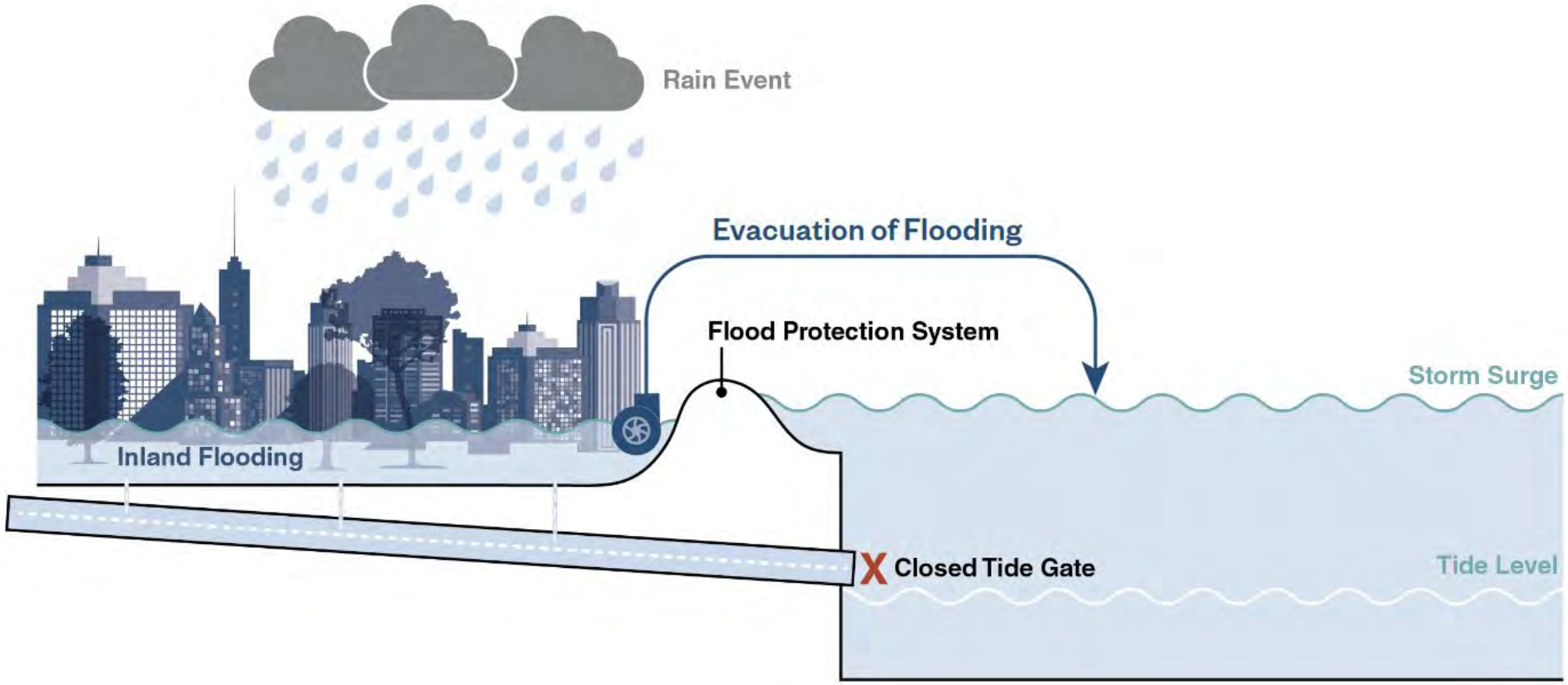
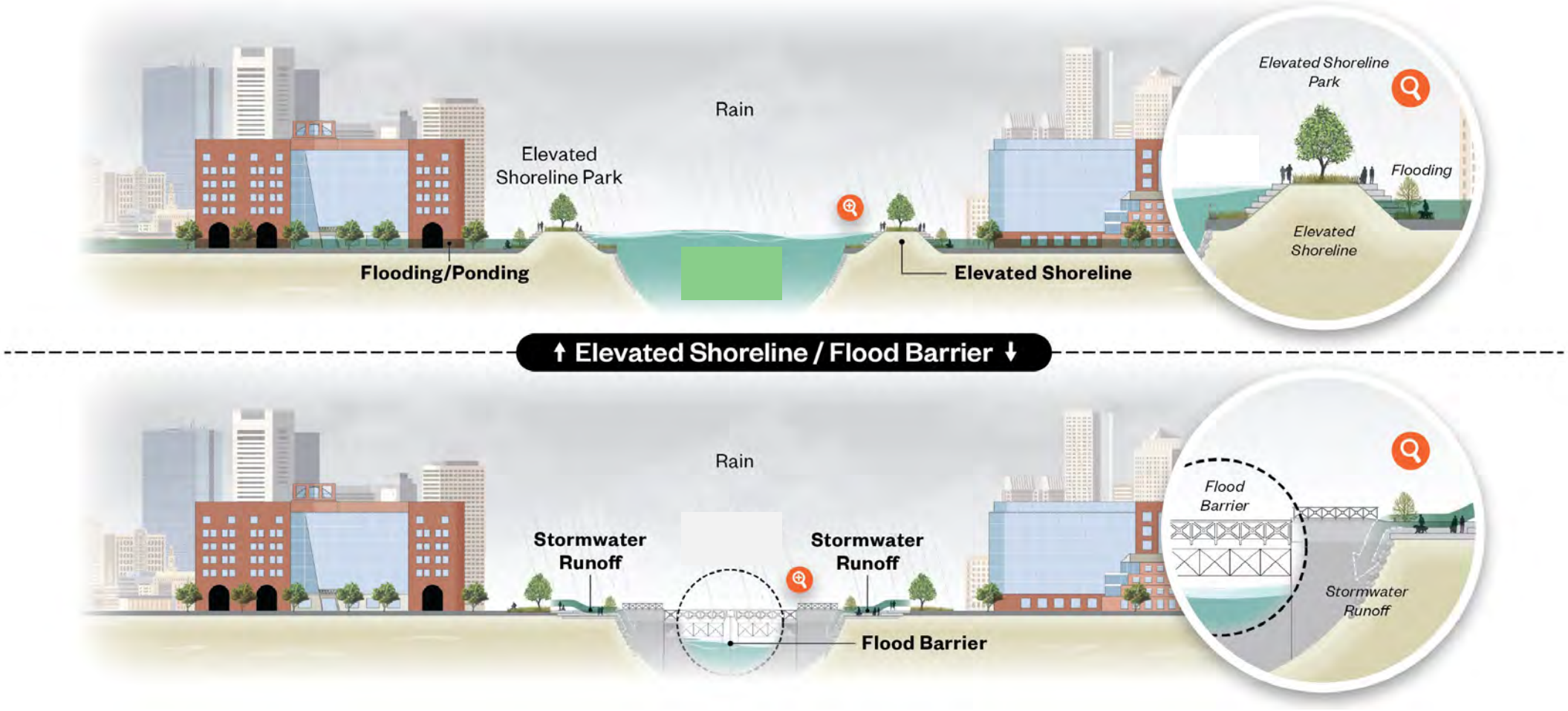
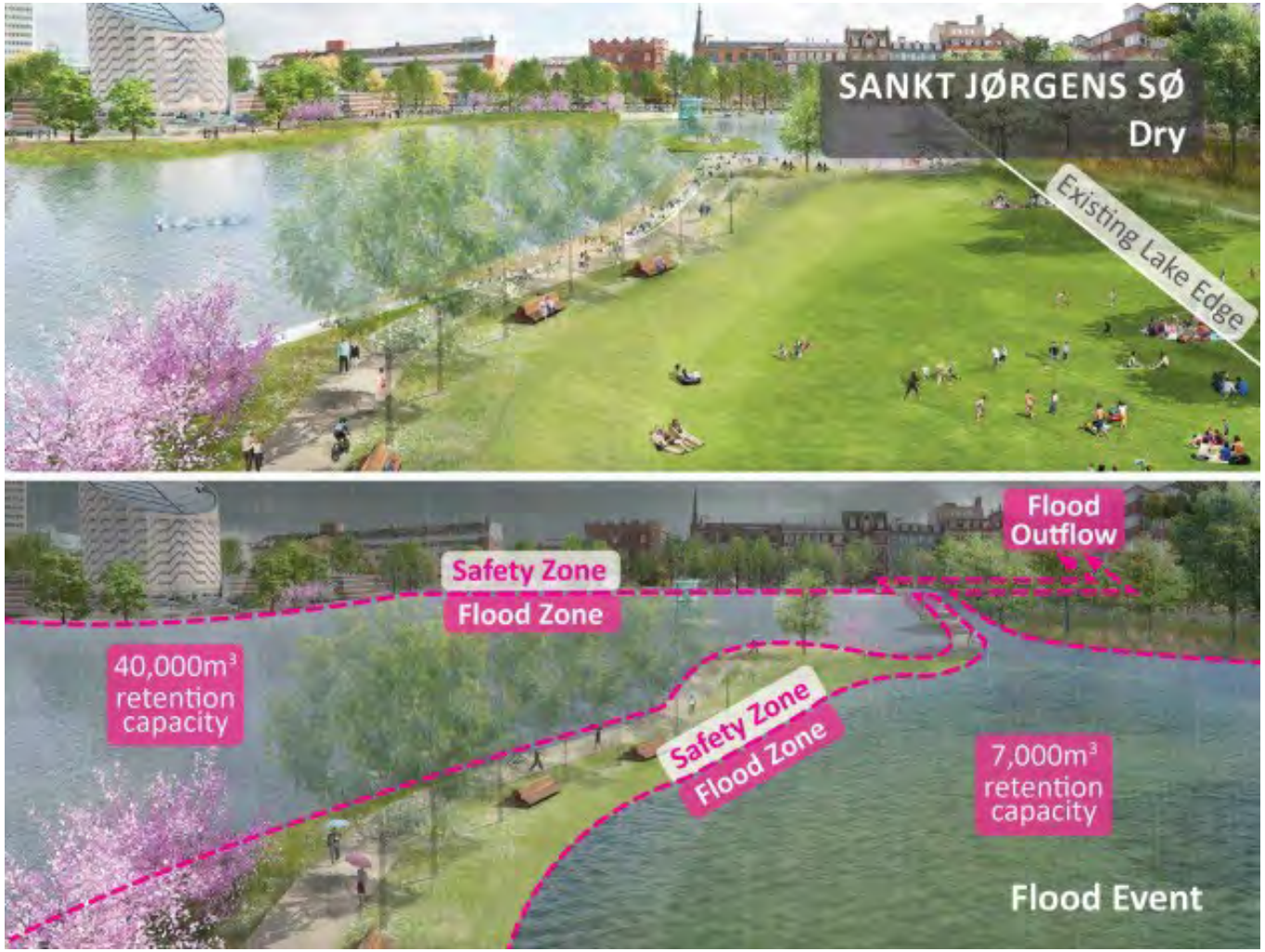
In big picture terms, we are protecting from storm surge and sea level rise with additional pumping while adding storage



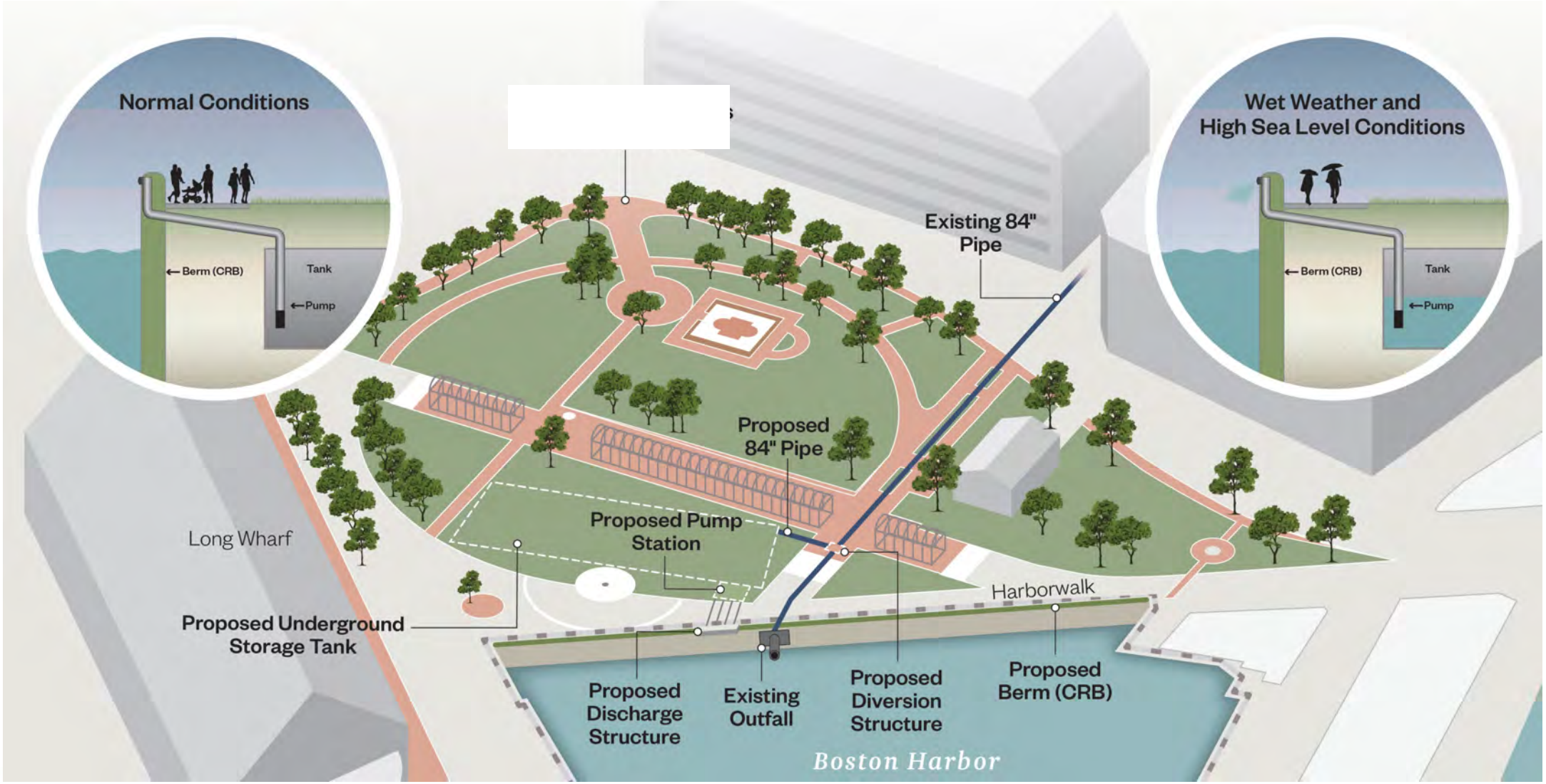
Elevated shorelines and flood barriers are considered where appropriate



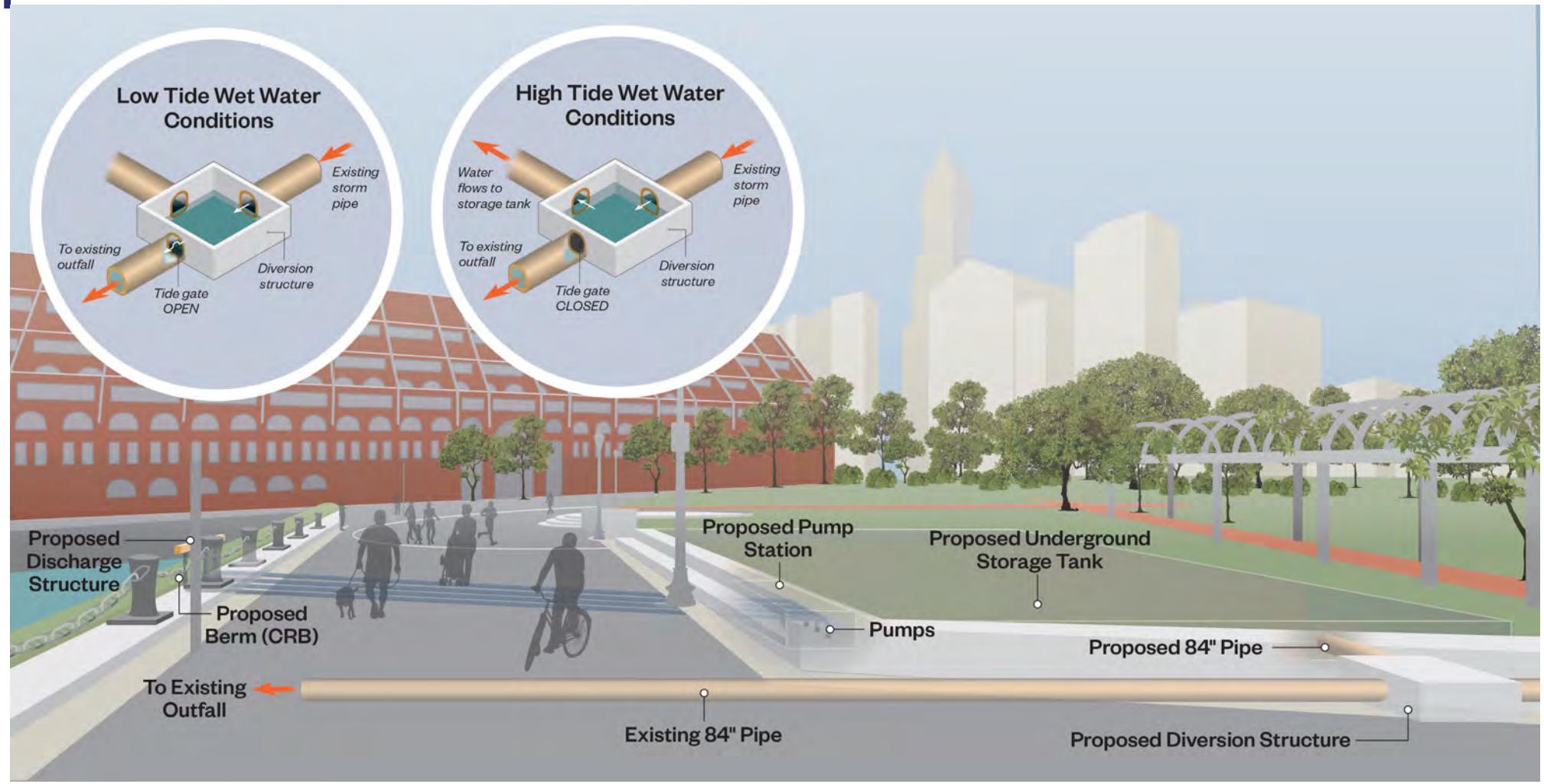
Where possible, we will leverage existing landscapes for nature-based solutions and improved public access



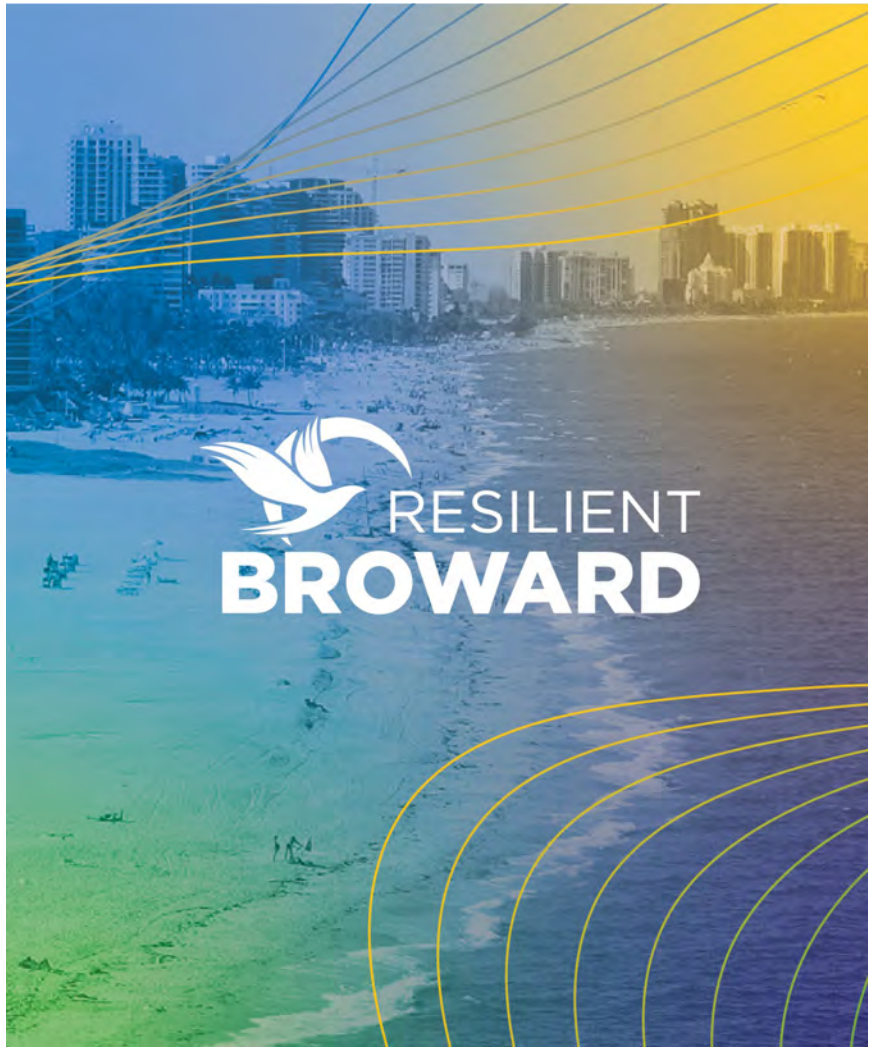
Concepts utilized elsewhere will be modified and considered for Broward County



Oakland Park, for example, is installing a tank under Stevens Field like this example



Future projects should consider storage concepts such as this.



Adaptation Specifics

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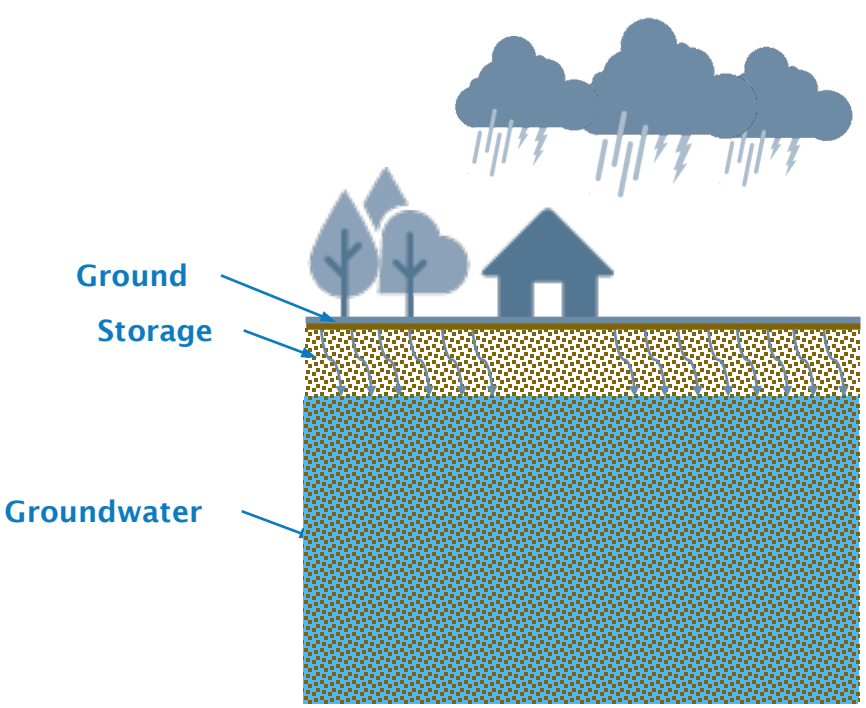
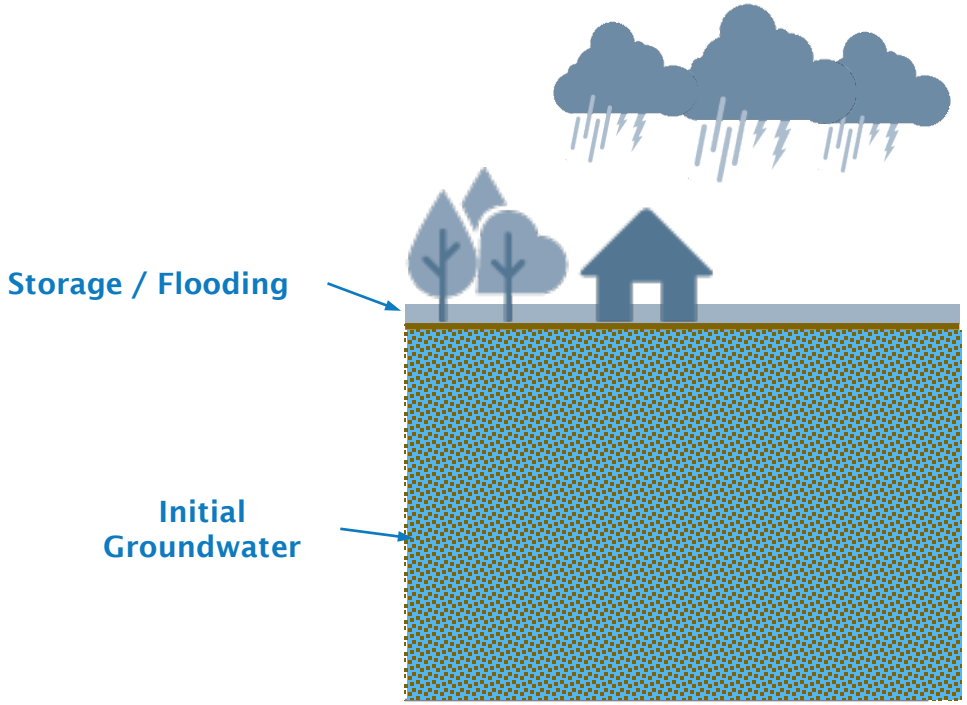
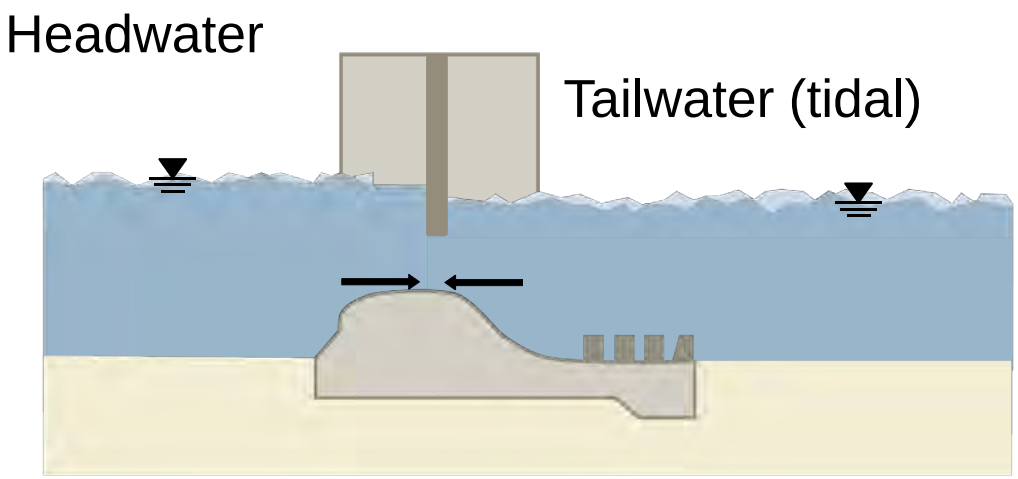
In previous meetings, we have discussed the Stormwater Management System dependency on Ground Storage

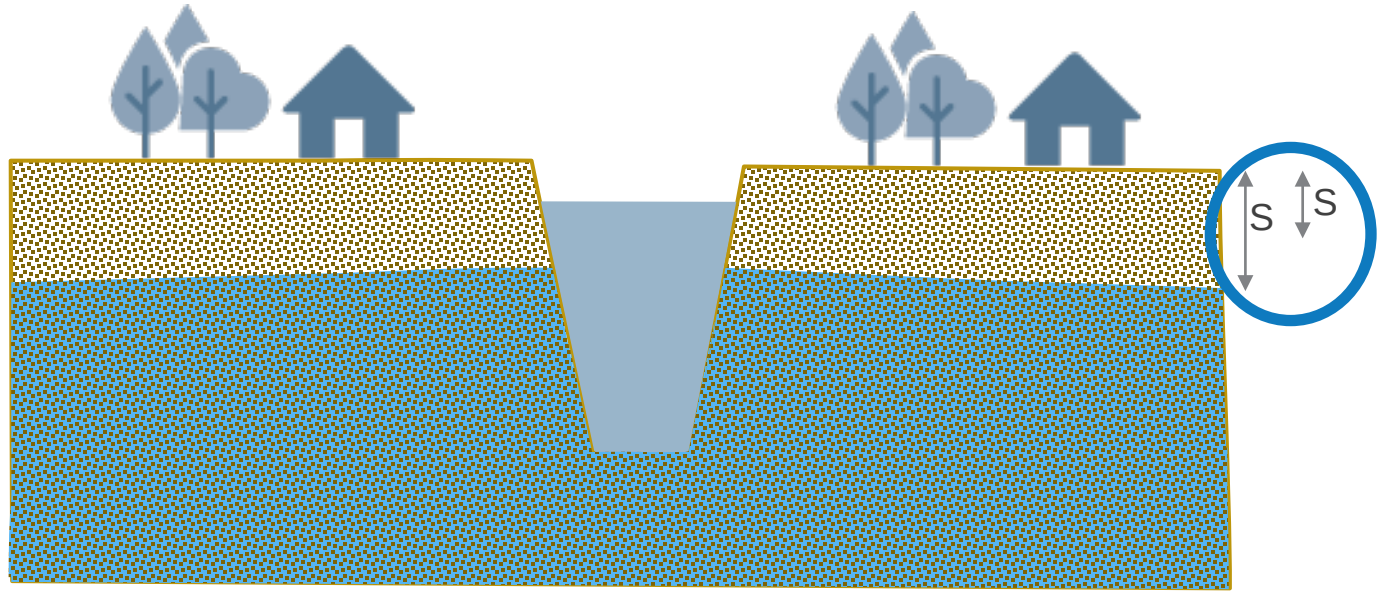




Groundwater Level at the beginning of the storm largely affects how much storage is available, and how much flooding the storms will cause

Sea Level Rise will cause an increase in Groundwater Levels, which translates to reduced storage



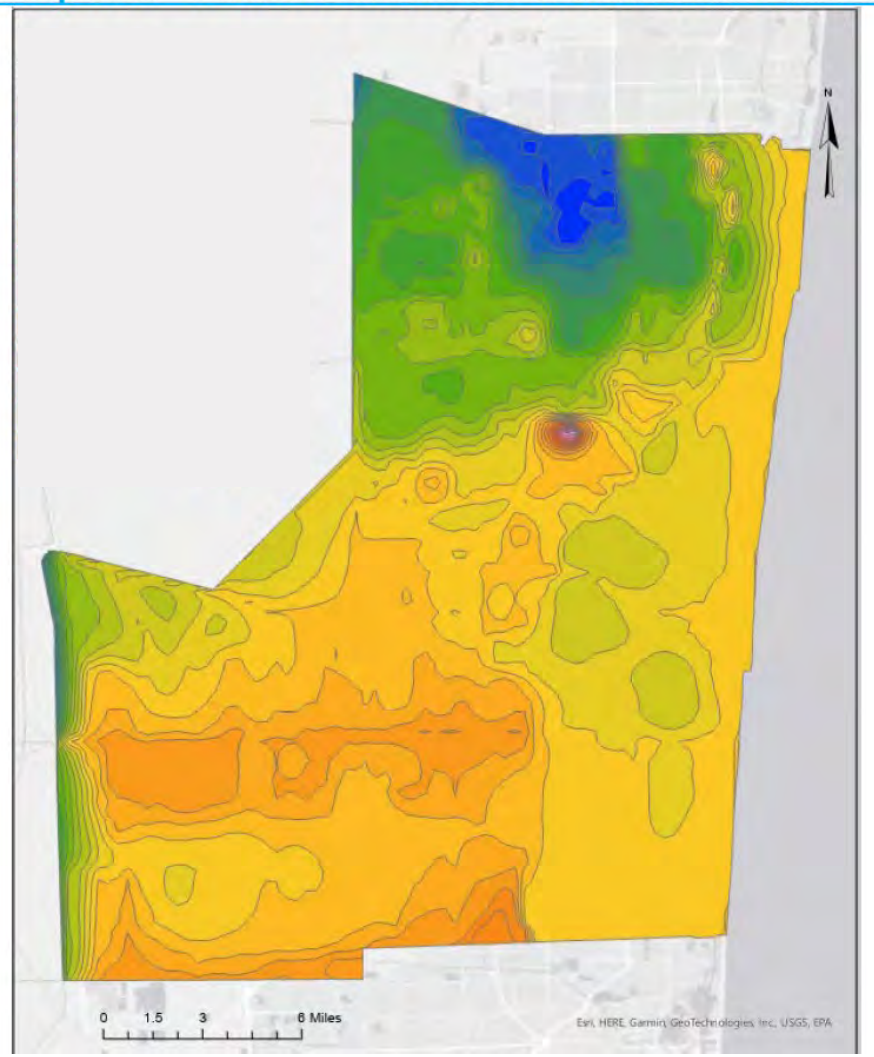


The storage capacity will be reduced as the headwater elevation increases to limit saltwater intrusion as the sea level rises over time.

The County has analyzed the effect of SLR on Groundwater Level

- The County is updating the map that shows the effect of 3.3 ft Sea Level Rise (shown in this slide).
- The map shows Future Groundwater Levels for **Average** Conditions
- During High Tides and other events, the operation of the water management system creates even higher Groundwater Levels than those shown in the map

2023 Update – Future Conditions Groundwater Elevation



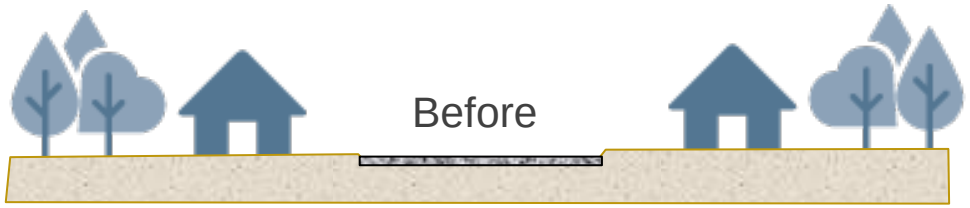
Fundamental to the efficacy of most of the strategies is managing the Groundwater Level

Adaptation Strategies Evaluated

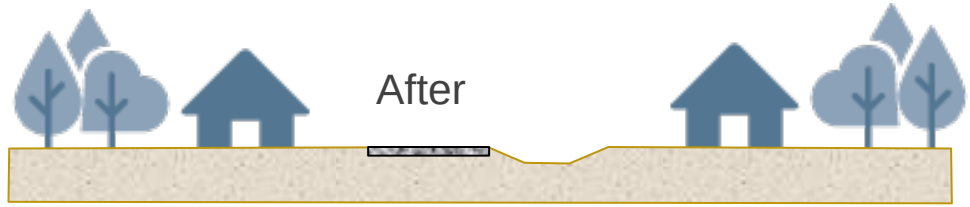
- Storage
  - Above ground storage (large)
  - Recovering underground storage
- **Green Infrastructure**
- Reducing Impervious area
  - Adding localized surface storage
- Conveyance
  - Improving existing conveyance structures (canals, culverts, etc.)
  - Additional Pumping
- Barriers
  - Property level seawalls
  - Nature-based and/or engineered structures
  - Large scale levees and other close out structures

This adaption strategy is linked to the development of Green Infrastructure. Most Green Infrastructure solutions are based on the idea of increasing infiltration by reducing impervious area. Infiltration can only be increased if there is available ground storage to receive rainwater.

Green Infrastructure – Reducing Impervious Area and Adding Storage



- Local roads were evaluated to assess their suitability for conversion.
- Evaluated factors included:
  - Depth to Groundwater
  - Fire Department Access
  - Traffic
  - Increase in Travel Time (1 minute Increase, ½ mile)
  - Number of Entrances



Green Infrastructure – Reducing Impervious Area and Adding Storage

Converting

1,760

Miles of two-way roads to one-way road plus swales

2,134

Acres created

1,247

Acres-ft of storage

Recovering Underground Storage

Modifications Required in

169

Controls Structures

- Control Structures in Secondary system to be modified to allow a change on control elevation
- Most Structures are fixed. The proposed Adaptation Strategy will require modification of structures by adding a movable element (gate or weir crest)
- It is desirable to add telemetry to allow for easier operation of the structure and facilitate SFWMD enforcement of return to normal levels.

Conveyance Improvements

Upsize Culverts or Crossings in areas identified as bottlenecks, Addition of Pumping Stations

- Several model runs were executed under “uncorked” conditions to identify the performance of the systems under “unrestricted” conditions
- Unrestricted conditions in the case of the culvert analysis correspond to a condition with no culverts or canals constrictions
- Unrestricted conditions in the case of the pump stations correspond to addition with “free fall” (no downstream restriction) in all canal connections.
- Evaluated the areas in the system that showed significant improvements in the unrestricted runs as compared to the baseline
- Define improvements needed in those areas based on local conditions

28

New Pump Stations

50

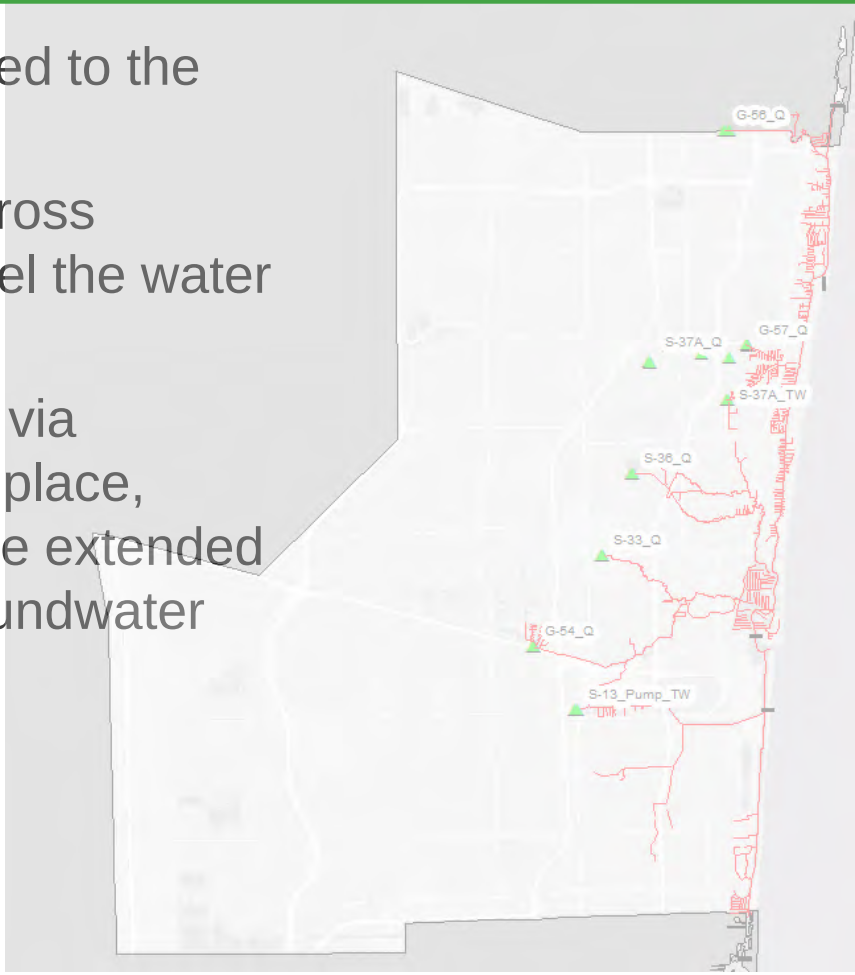
Upgraded Crossings

Barriers

190

Miles of Seawall and Enhanced Natural Barriers

- 5 ft NAVD Seawalls were added to the coastal line in the model
- Seawalls were added to the cross sections that are used to model the water bodies.
- To obtain complete protection via seawalls after SLR has taken place, these walls will also need to be extended downwards to reduce the groundwater flow under them.



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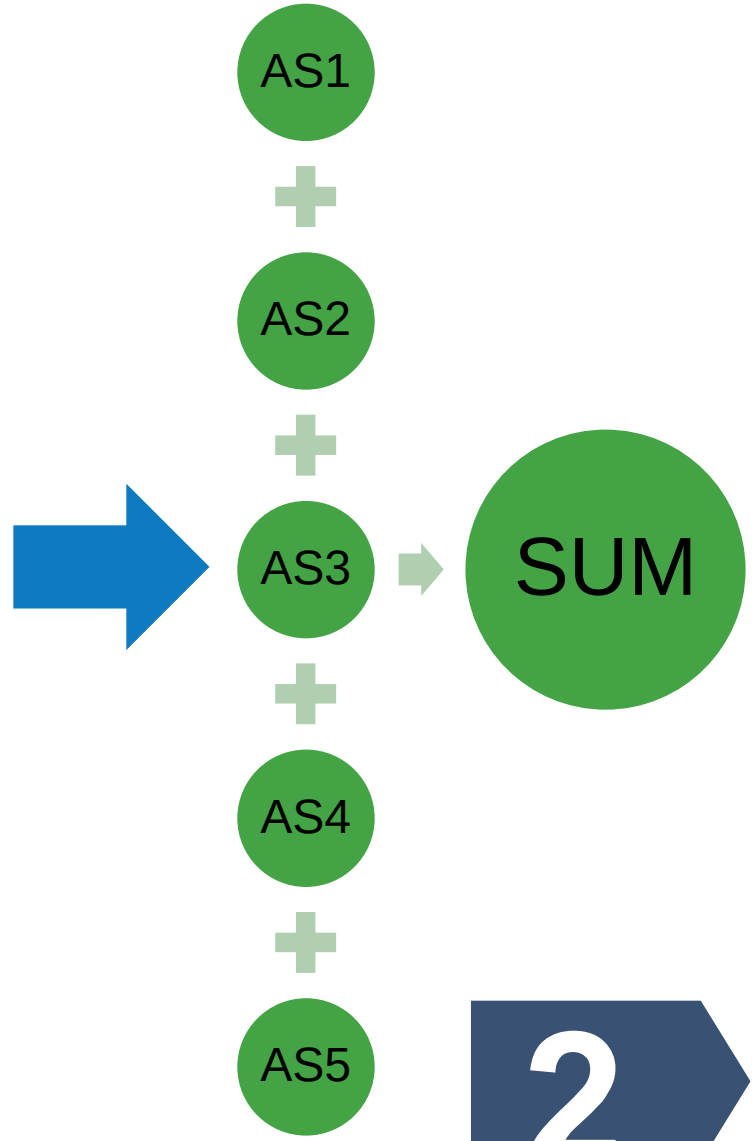
Evaluation Process

- Increasing Groundwater storage
- Increasing Conveyance Capacity
- Reducing Impervious Area and adding local storage
- Adding Seawalls
- Adding Pumping Capacity



1 The **first step** was to evaluate all Adaptation Strategies (AS) independent from the rest.

2 The **second step** combined Adaptation Strategies to obtain the cummulative effects

Evaluation Process

SUM

Areas that are not addressed in the first iteration will be looked at closely, adding new Adaptation Strategies

- Above ground storage
- Adding Pumping Capacity
- Re-development guidance

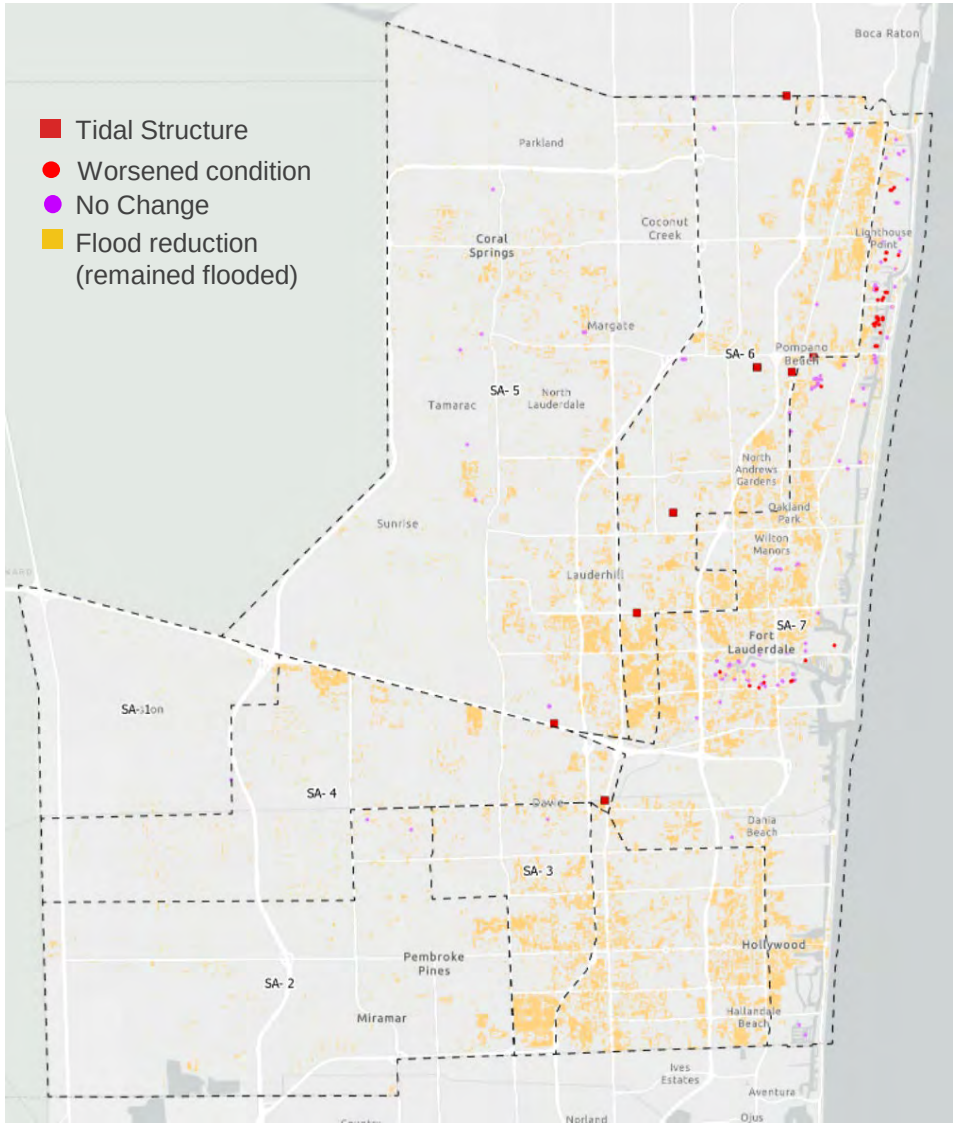
The AS listed so far will not address certain scenarios (e.g. major surge events, etc). A more intense future intervention is conceptualized to address this.

- Polder like structures. Combining coastal barriers, pump stations, navigational locks, salinity control measures, etc.

Modeling Results

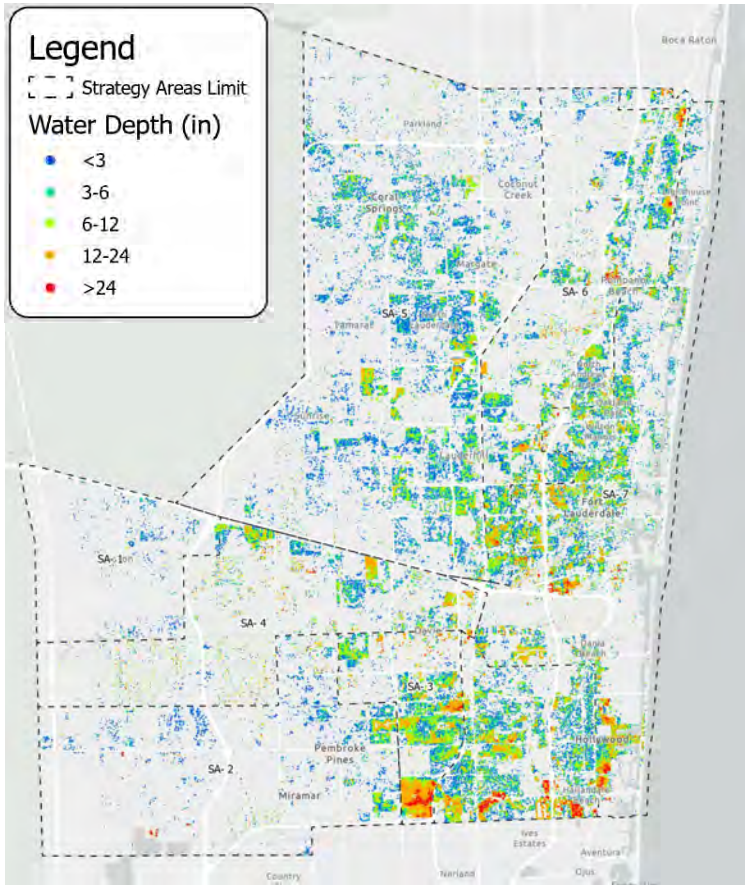
Results from several modeling scenarios were analyzed. Several plots and graphics were used to evaluate the results:

- Improvement/No Improvement maps like the one shown to the right, that broadly show areas that are benefited or negatively impacted in the scenario
- Maps of Flood Depth comparing Pre- v. Post-Adaptation Strategy conditions at a property level.
- Maps summarizing results for larger areas (Census Tracts) will be prepared to help analyze/interpret the results
- Tables with summaries and metrics at property level



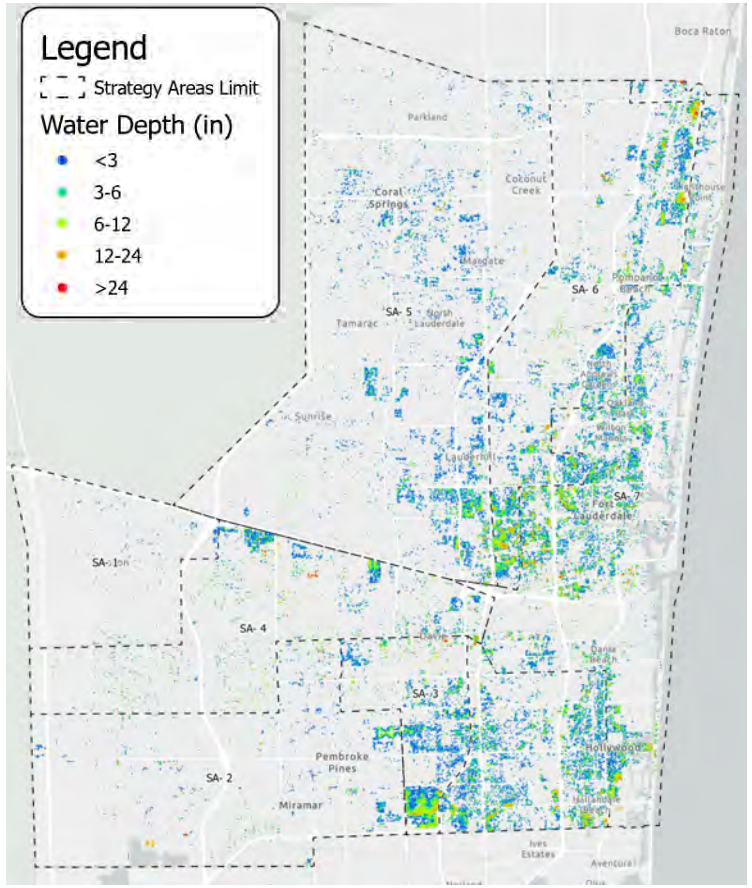
Combined Strategies for 100-yr., 3d., and 2ft. SLR Scenario

Increasing Groundwater storage (1ft) – Properties Flooded



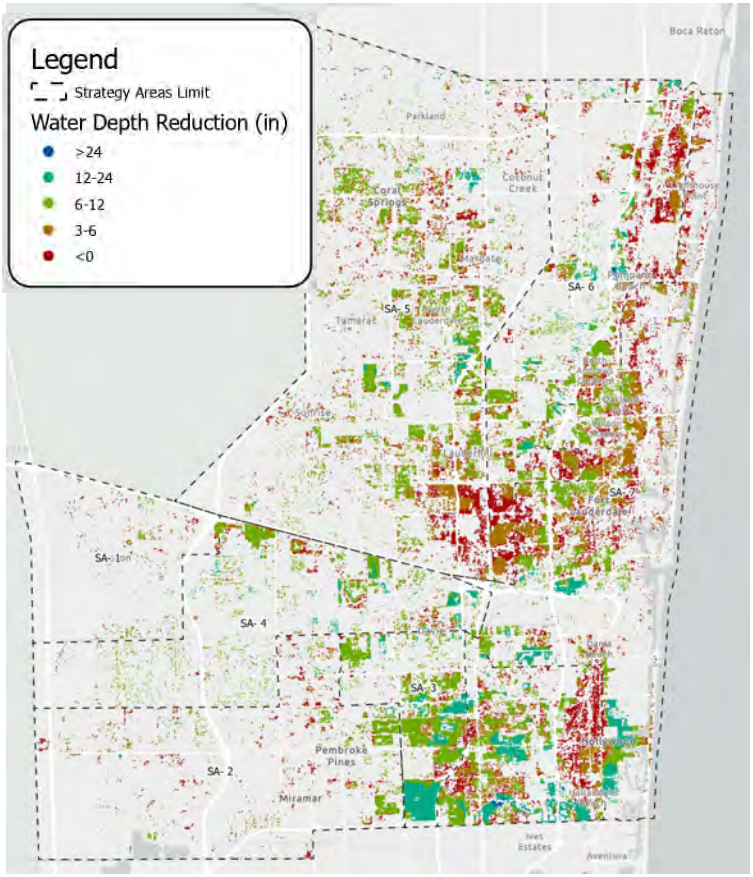
Base Scenario Water Depth

Rain	SLR	Tidal
100-yr. 3d	2 ft	King Tide



Adaptation Strategy Water Depth

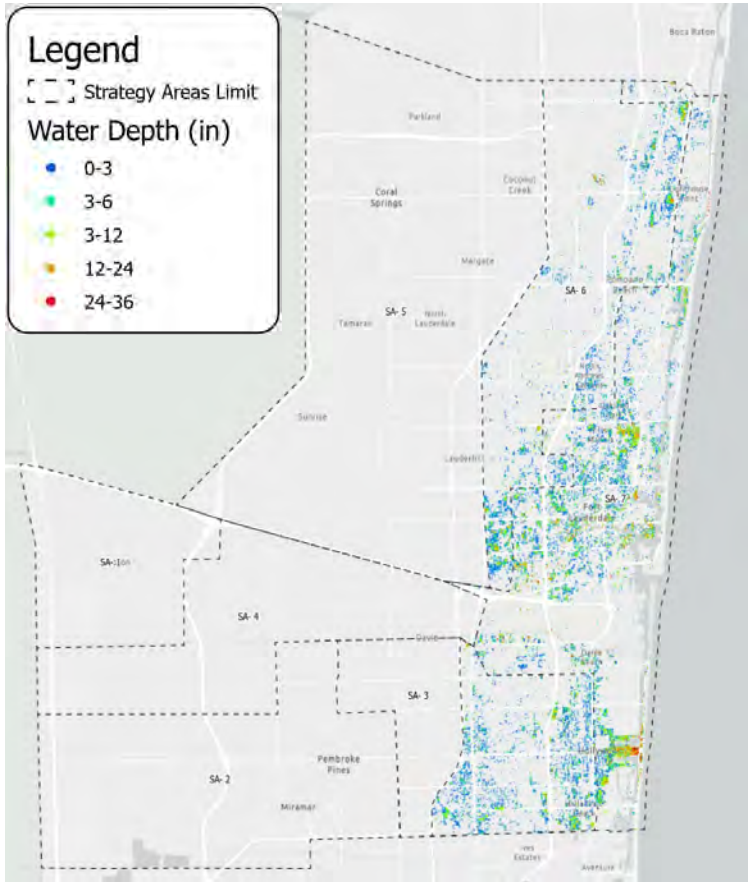
All secondary structures have the control elevation (CE) reduced by 1'



Water Depth Reduction (148,843 Properties)

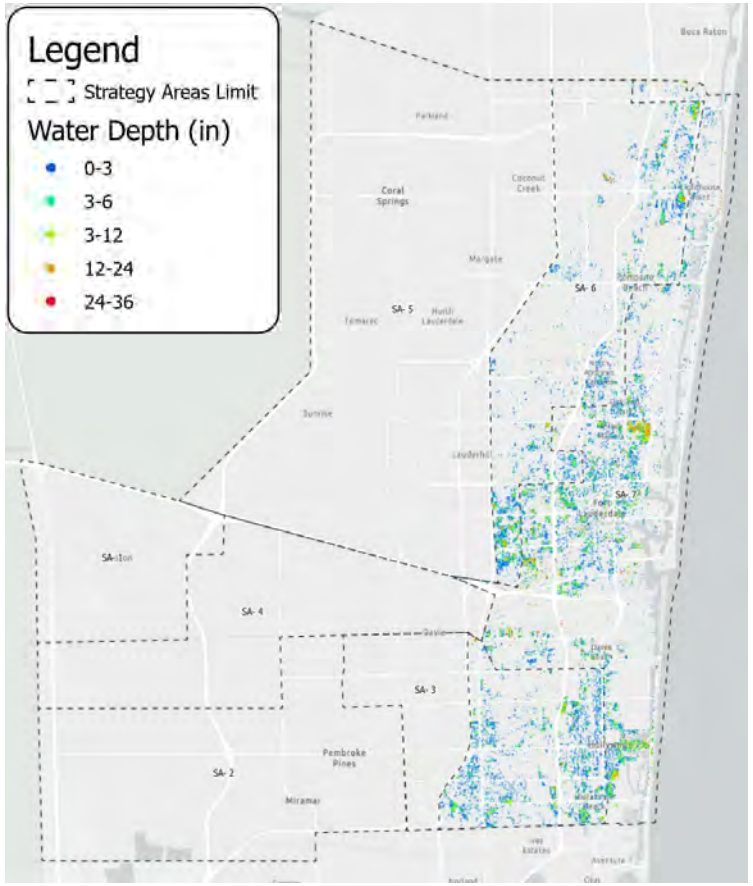
Delta Flood Depth (inches)	%
> = 24	0.3
from 12 to 24	13.1
from 6 to 12	37.1
from 3 to 6	25.4
from 0 to 3	24.1

Construct Seawalls – Properties Flooded

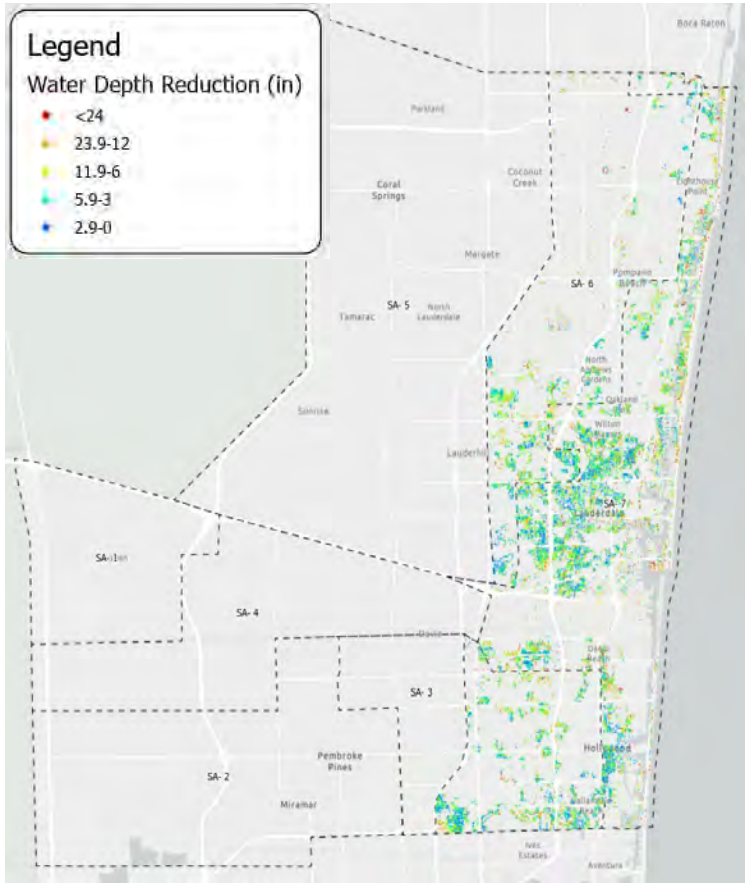


Base Scenario Water Depth

Rain	SLR	Tidal
25-yr. 3d	2 ft	King Tide



Adaptation Strategy Water Depth



Water Depth Reduction (26,804 Properties)

Delta Flood Depth (inches)	%
> = 24	19.3
from 12 to 24	11.7
from 6 to 12	9.0
from 3 to 6	6.6
from 0 to 3	53.4

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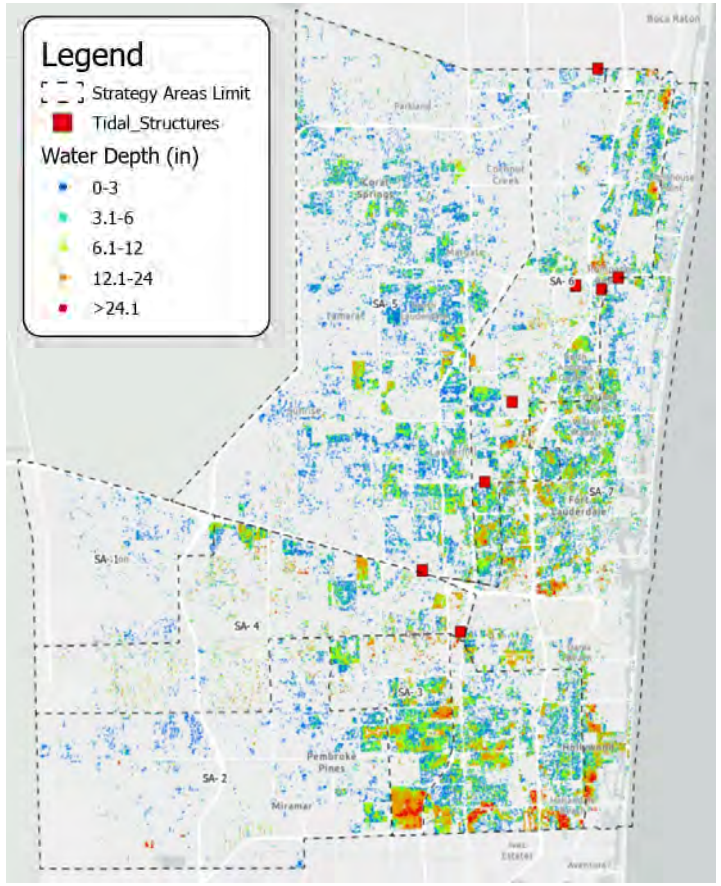
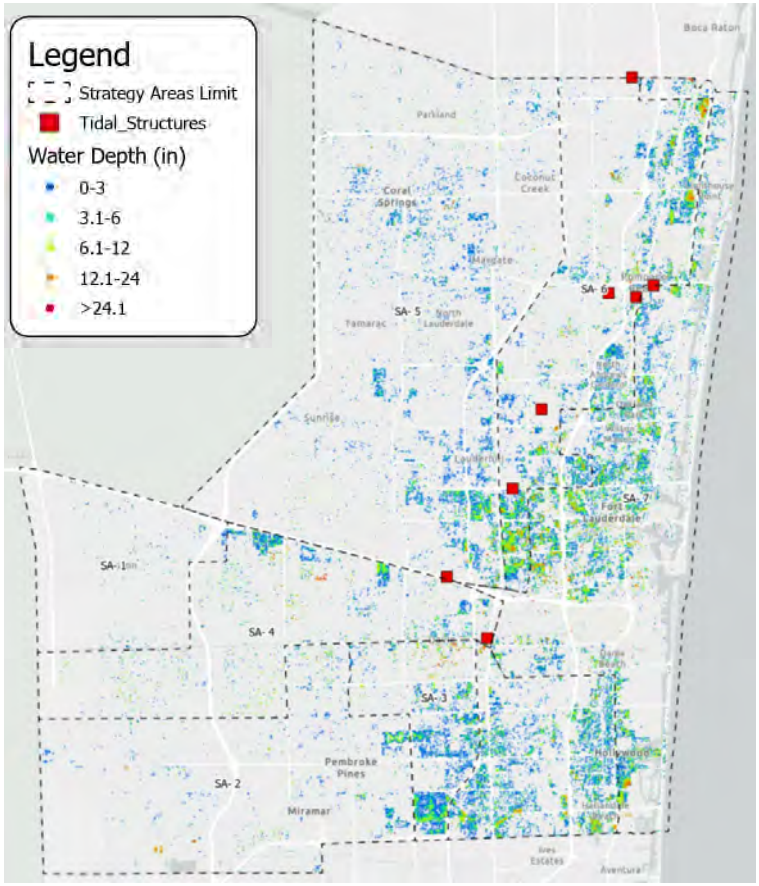
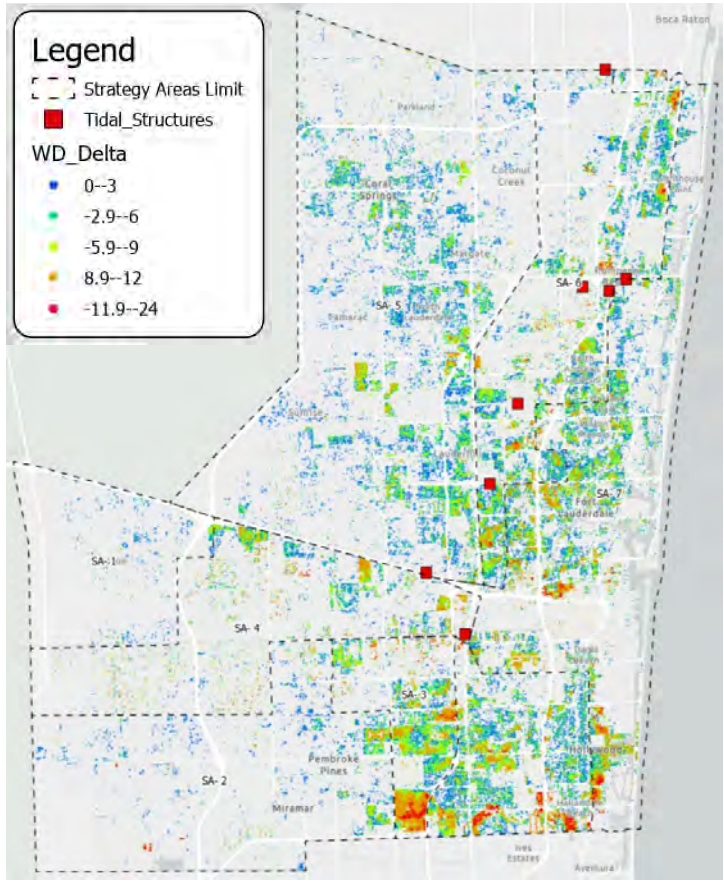
All Adaptation Strategies Working in Combination



Base Scenario Water Depth



Adaptation Strategy Water Depth



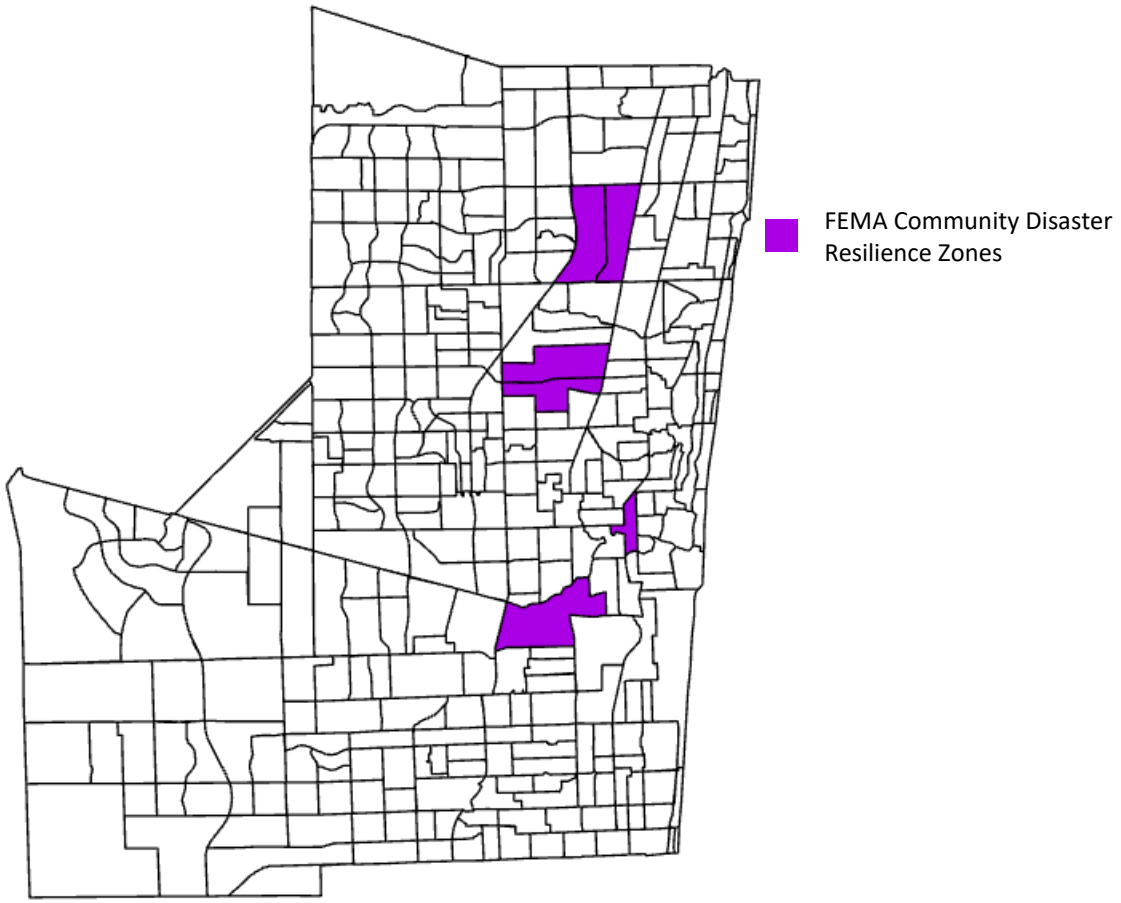
Water Depth Reduction (148,045 Prop)

Delta Flood Depth (inches)			%
from	12	to 24	14.0
from	9	to 12	14.0
from	6	to 9	20.5
from	3	to 6	22.7

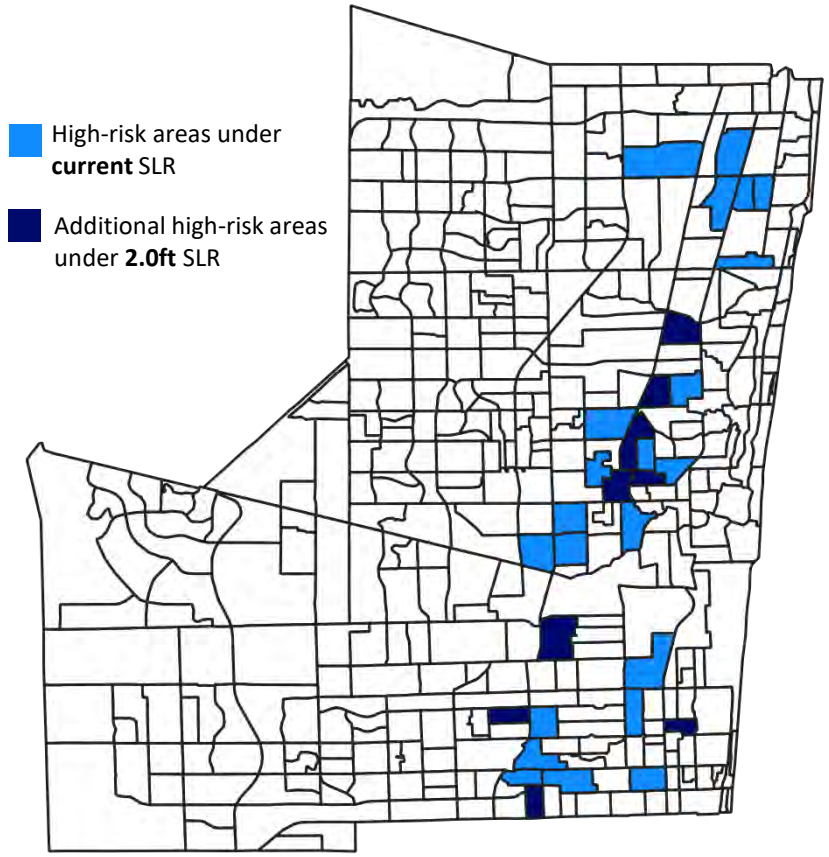
Rain	SLR	Tidal
100-yr 3-day	2 ft	King Tide

All secondary structures have the control elevation (CE) reduced by 1'.
Includes also: Pumps, Crossings, Seawalls.

We are currently evaluating localized adaptation strategies in areas of Low and Moderated Income



FEMA Community Disaster Resilience Zones



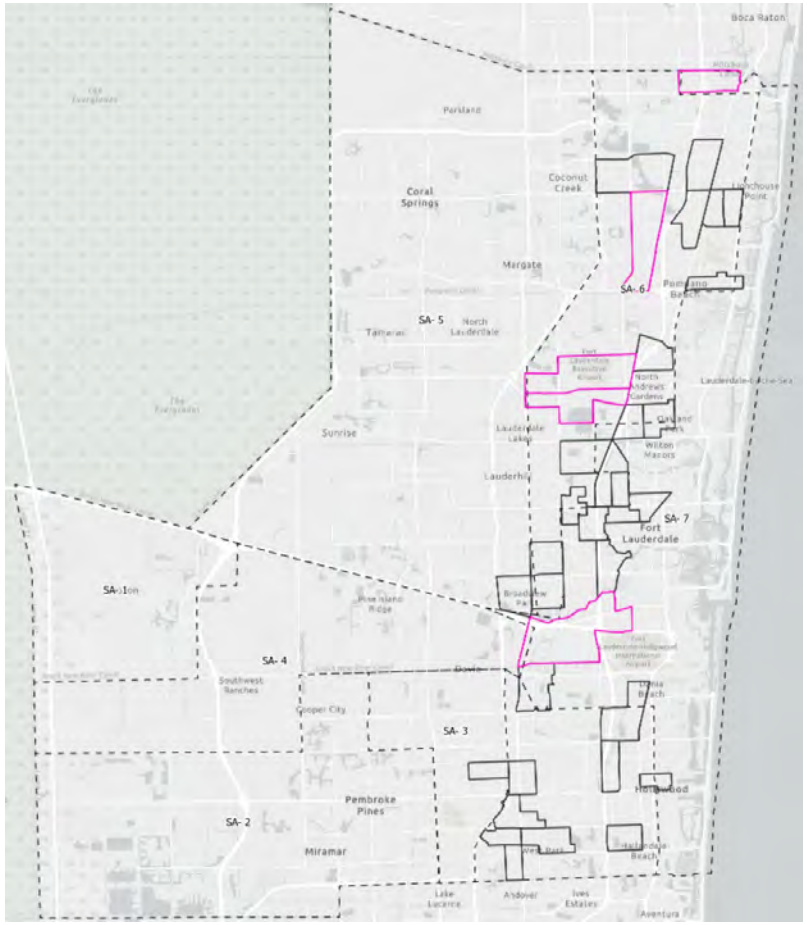
High-risk areas under **current** SLR

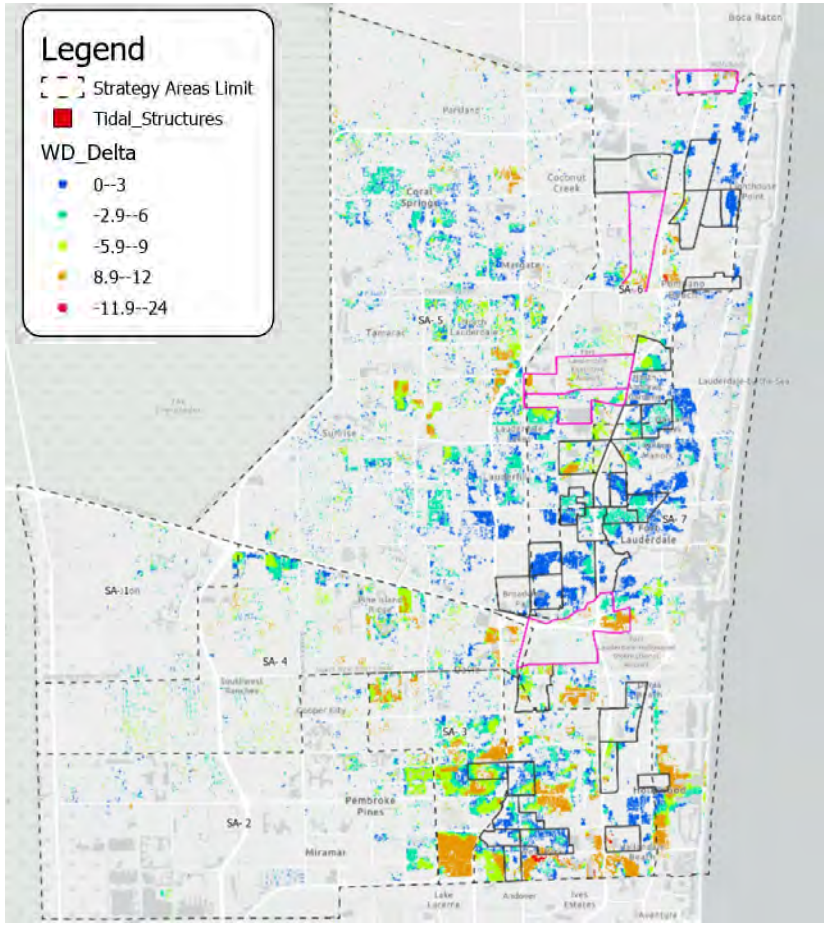
Additional high-risk areas under **2.0ft** SLR

Zooming in areas within LMI and FEMA Disaster Resilience. Will define strategies specific for this areas.

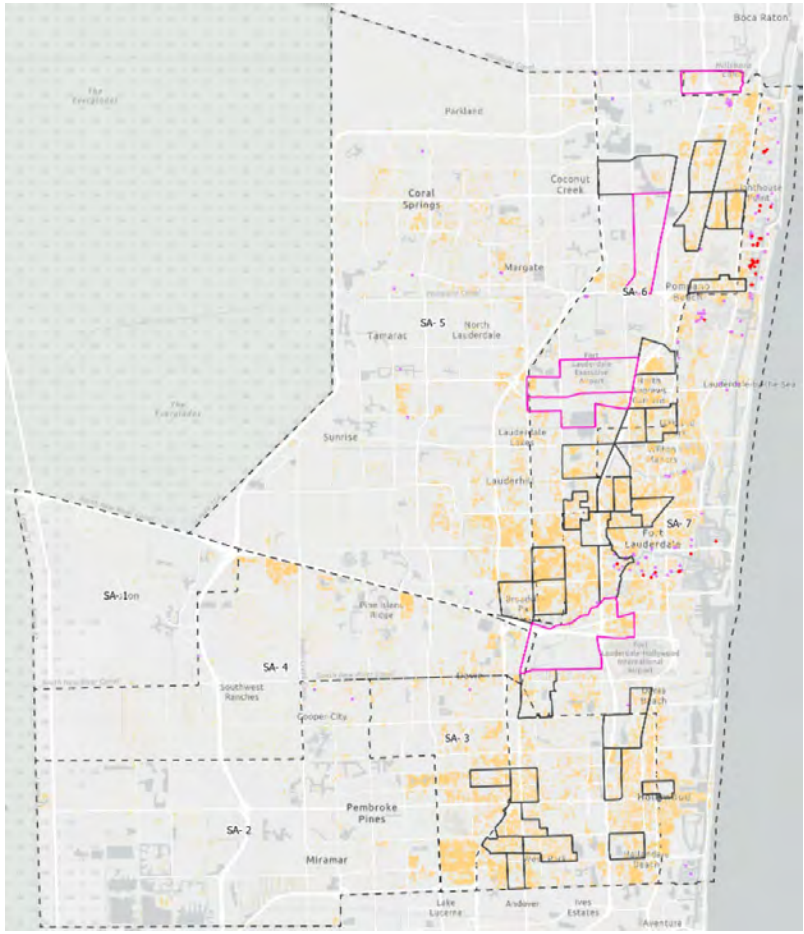
Modeling of Adaptation Strategies shows improvements in flooding conditions in critical areas. Evaluations will continue to explore more localized solutions.

Rain	SLR	Tidal
100-yr 3-day	2 ft	King Tide





Flood Reduction Provided by Adaptations



Properties with Flooding after Adaptations

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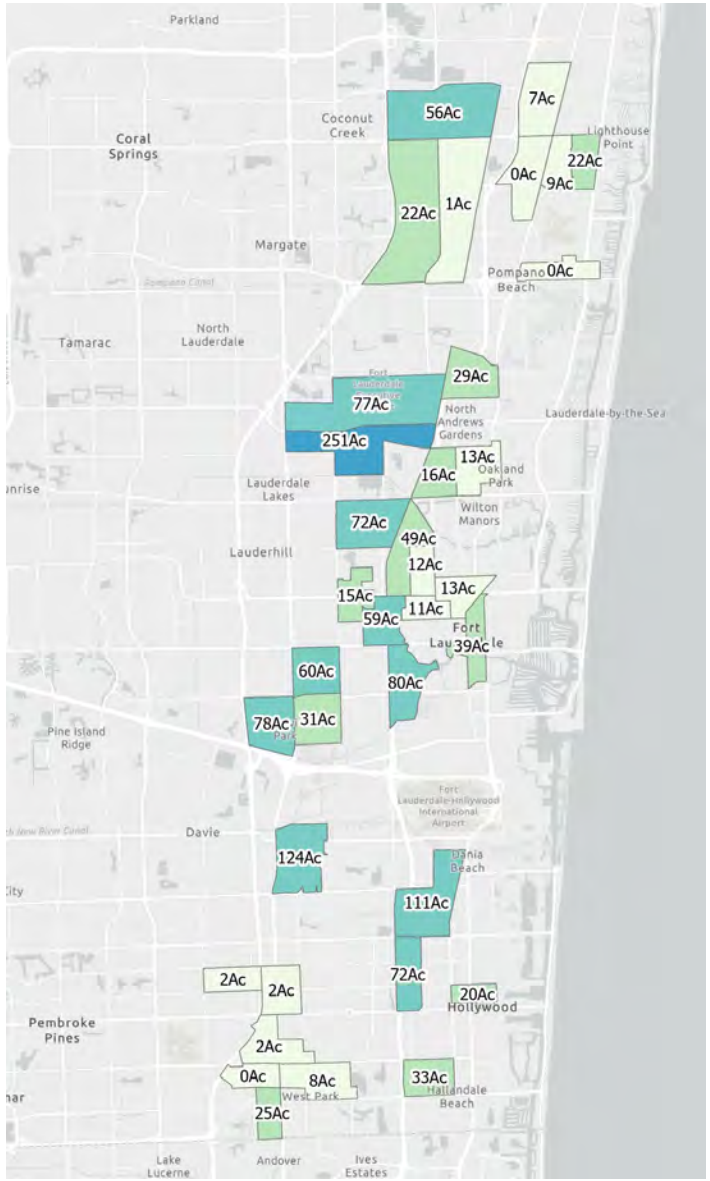
Stormwater Storage Requirement in Critical Areas.

Storage requirements per census tract in acres



Storage requirements expressed as a percentage of the total census tract area

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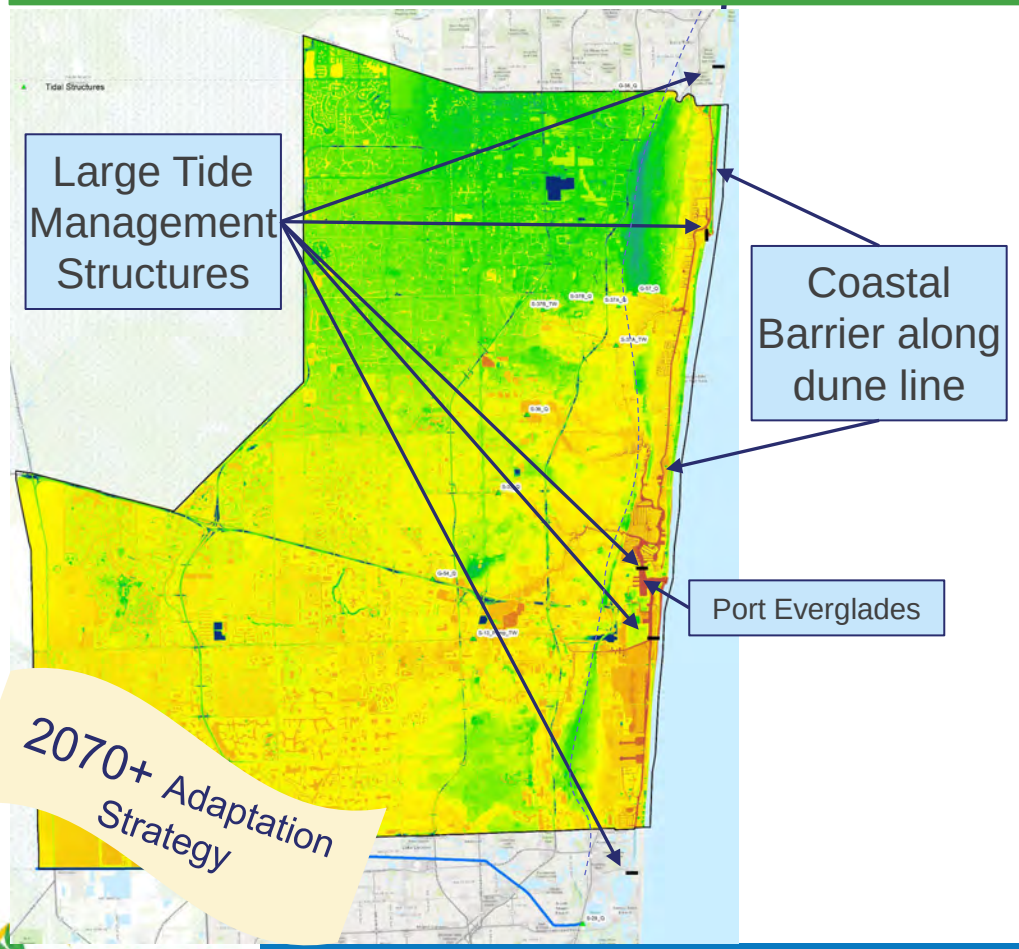
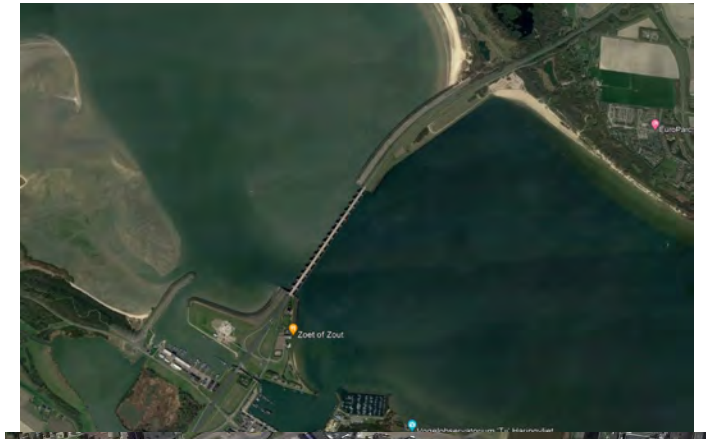
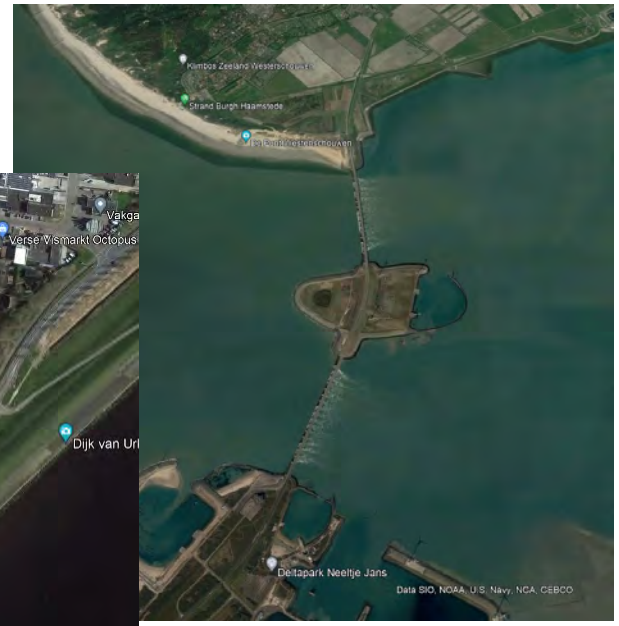
Combination of Higher Barriers and Large Tide Management Structures

Structural and Nature-based barriers plus large tide management structures including locks, gates and pump stations. This strategy will require active participation/leadership of federal and state agencies, as well as coordination with neighboring counties.

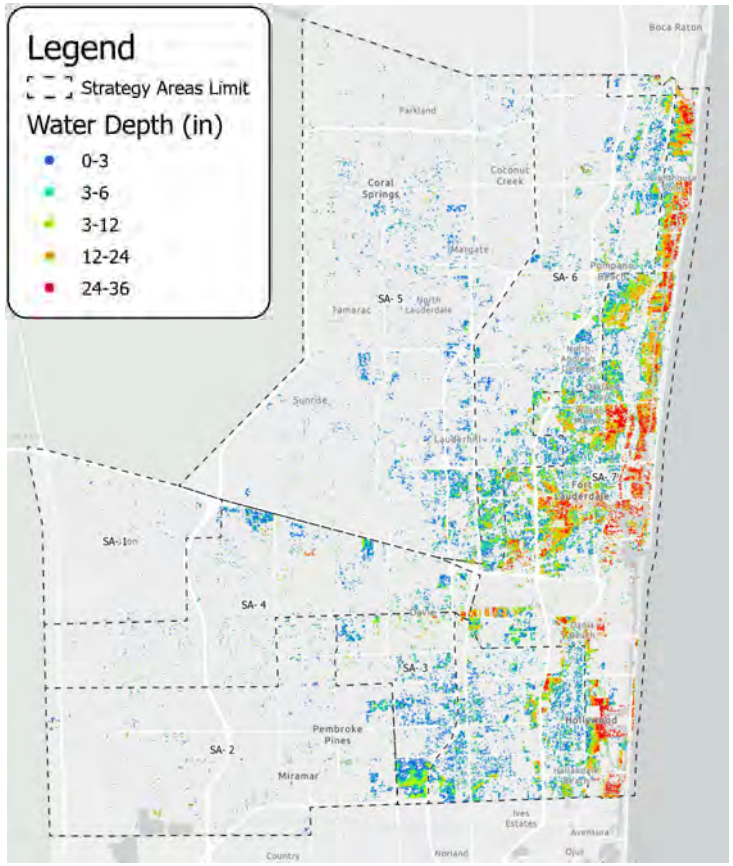




Sample of similar structures in The Netherlands. South Florida will add groundwater management to the challenges faced in the Netherlands

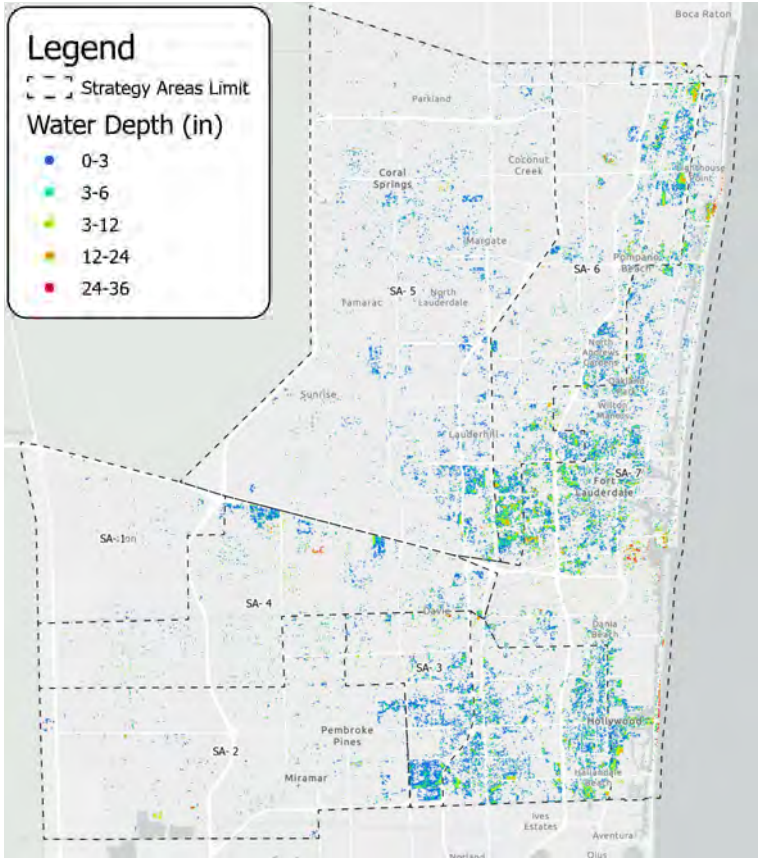


Combination of Higher Barriers and Large Tide Management Structures

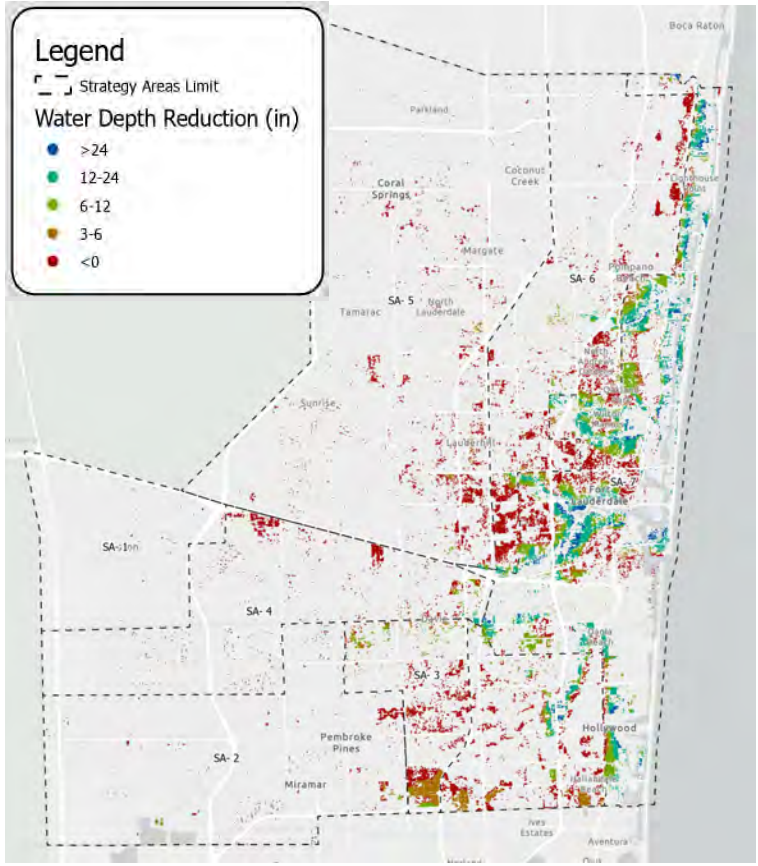


Base Scenario Water Depth

Rain	SLR	Tidal
50-yr. 3d	3.3 ft	100-yr. Storm Surge



Adaptation Strategy Water Depth

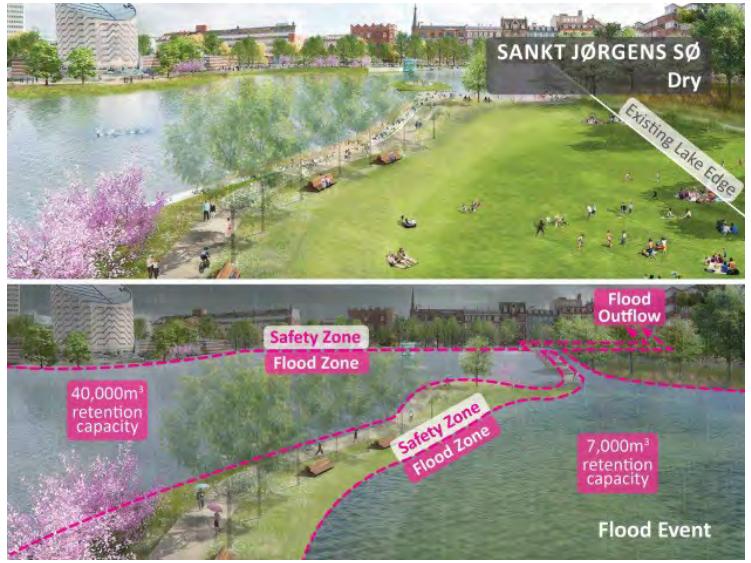


Water Depth Reduction (124,076 Properties)

Delta Flood Depth (inches)	%
> = 24	15.0
from 12 to 24	14.2
from 6 to 12	15.7
from 3 to 6	15.6
from 0 to 3	39.5

We've evaluated adaptation strategies, identified where these strategies are effective and identified where additional adaptation is necessary

- Next Steps
  - **Meet with the other experts**
    - *Key County Staff*
    - *Team Subject Matter Experts*
  - **Continue development of targeted adaptations**
    - **LMI and FEMA Disaster Resilience Zones**
    - **Areas not adequately improved by initial strategies**
  - **Review results with Stakeholders**
  - **Process results from all 52 scenarios**
  - **Complete Economic Analysis (compare to baseline)**

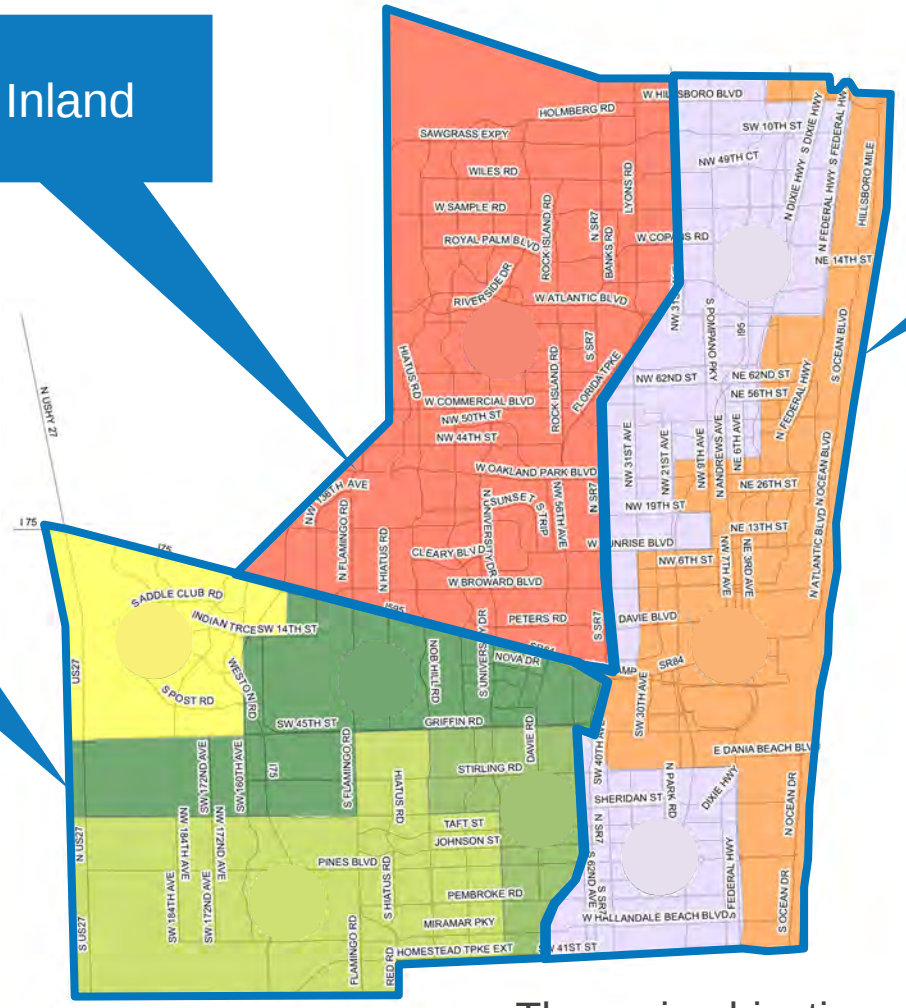


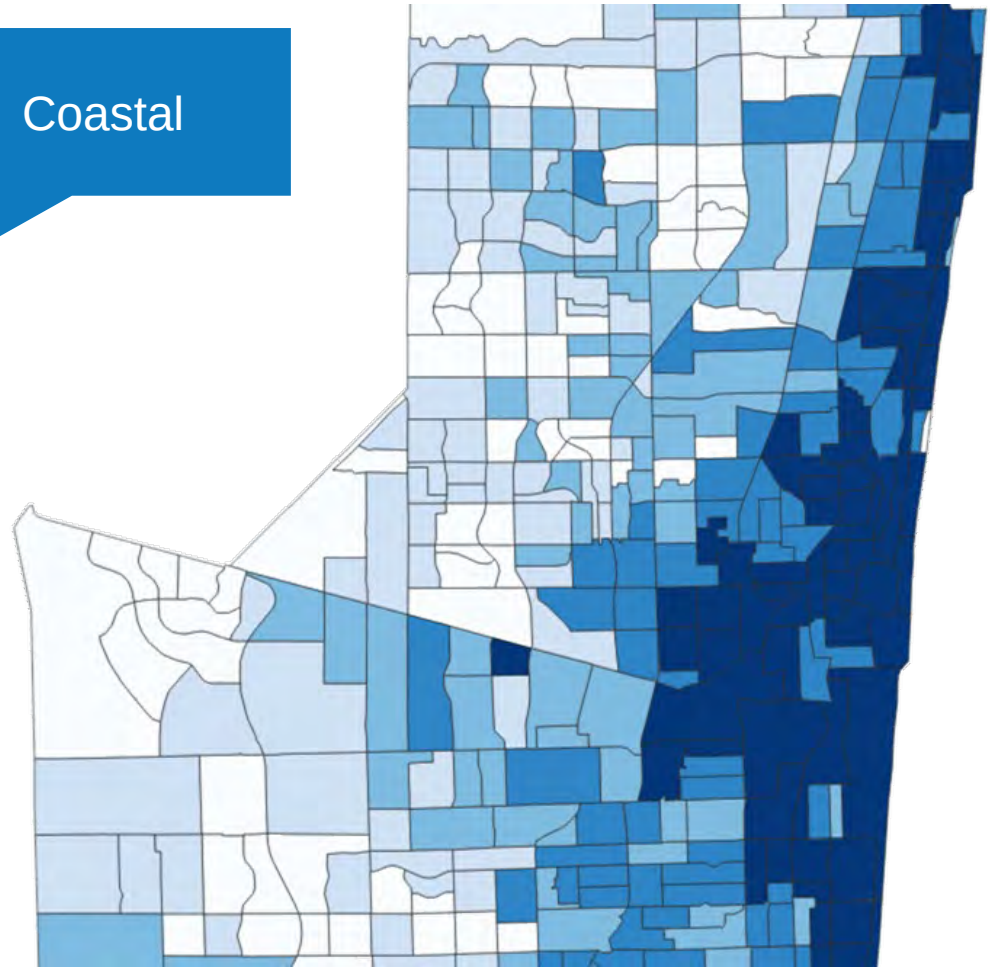
Results will be presented to stakeholders in Three Subregional Meetings

North Inland

South Inland

Coastal





The main objective of these meetings is to emphasize the fact that everybody is part of the solution. Every idea counts !

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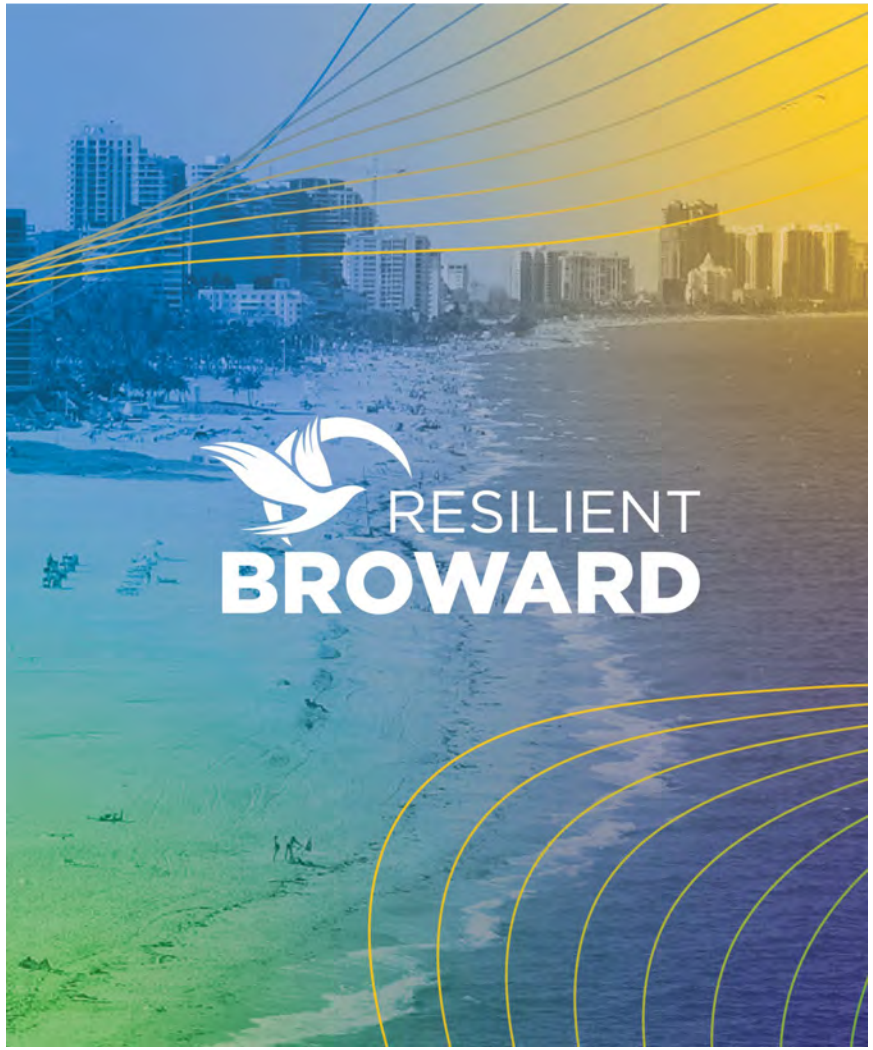
Upon incorporation of stakeholder comments, the tools developed under baseline will be used to estimate economic impact of adaptation strategies

1. Using flood damages and durations by area after adaptation strategies implemented…
2. Estimate economic impacts in dollar values:
   - **Short-term economic impacts - business downtime, transport system disruption, and indirect impacts to economy**
   - **Increased insurance premia / reduced insurance affordability**
   - **Lowered real estate values**
   - **Heightened fiscal risks to the County**
3. Describe other economic impacts to the County:
   - **Disruption to public services \ Reduced investment**
   - **Demographic change \ Reduced tourism**
   - **Human capital impacts**

   Economic benefits are the differences in impacts with and without the adaptation strategies.



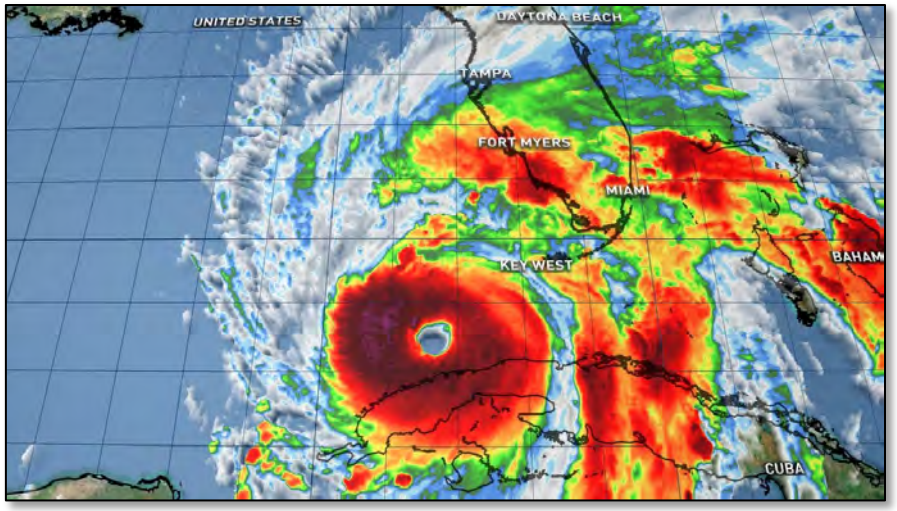
6

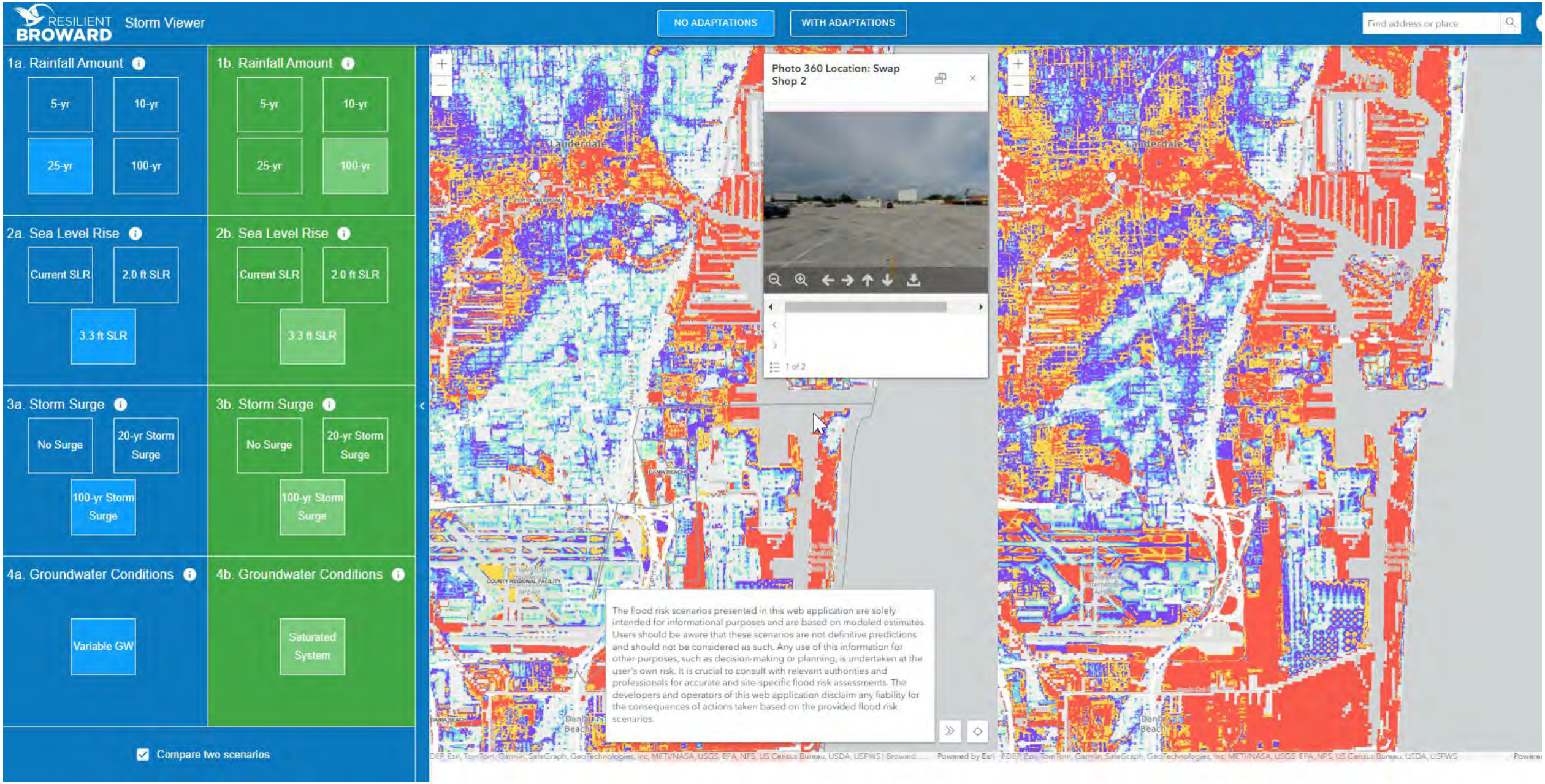
Platform Update

Hazen

The flood viewer is updated with all scenarios (>50)

- User can click on the SLR scenario
- Rainfall events pop up for that scenario, user picks
- User also selects storm surge
- 360 photos are embedded; user can click and view under each scenario





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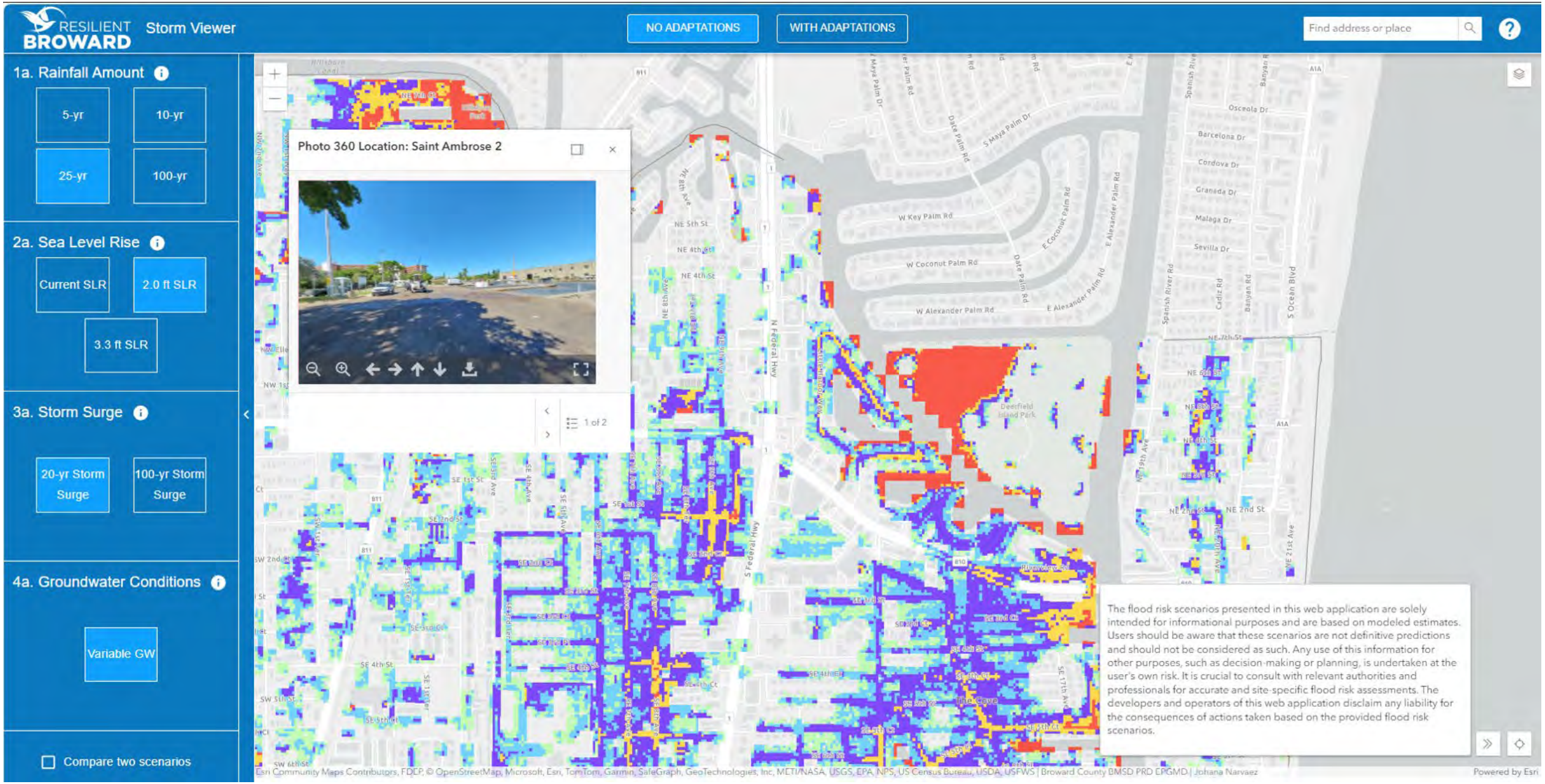

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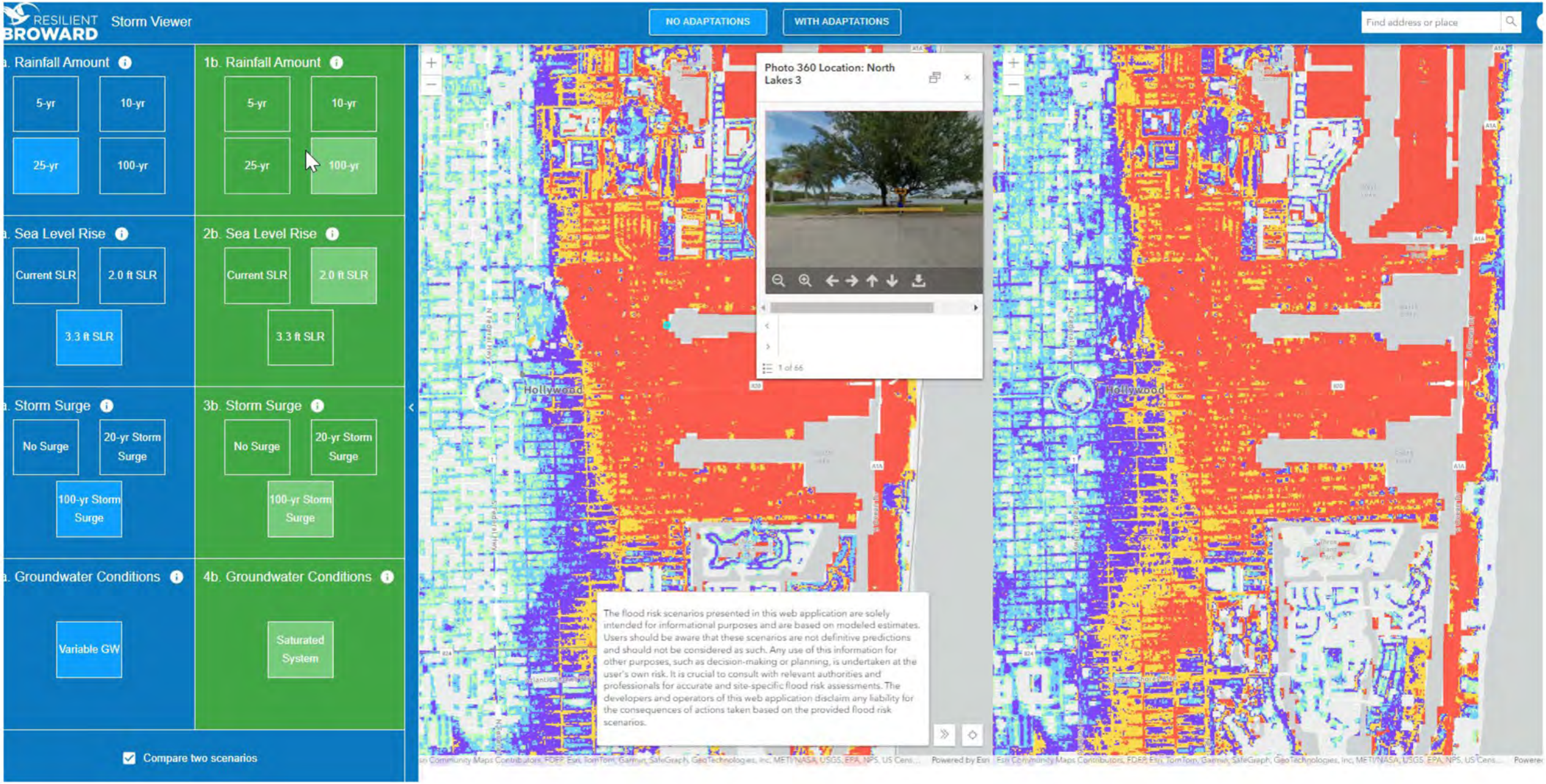

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Examples of 360 Photo

https://app.holobuilder.com/app/ LAS OLAS SITE 360 PHOTO

RP-07 Rain	SLR	Tidal
25-yr	2 ft	100-yr Surge

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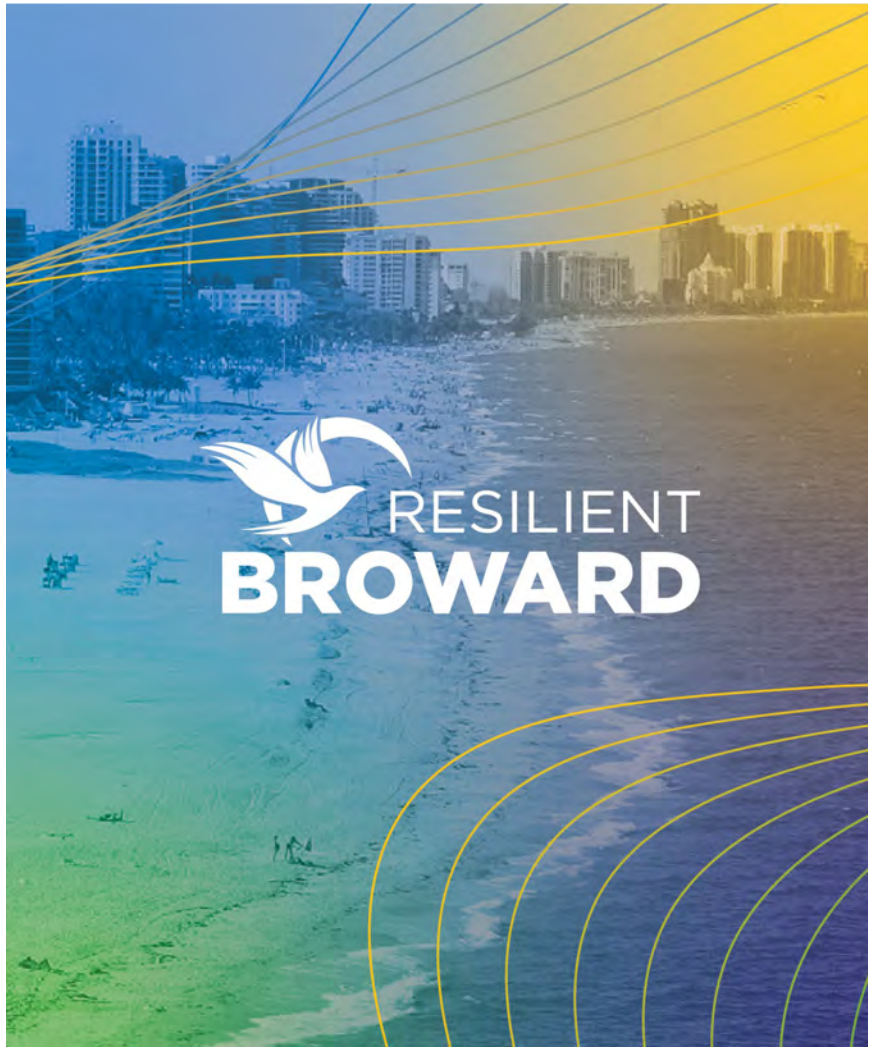

Adjournment – Thank You!

Hazen