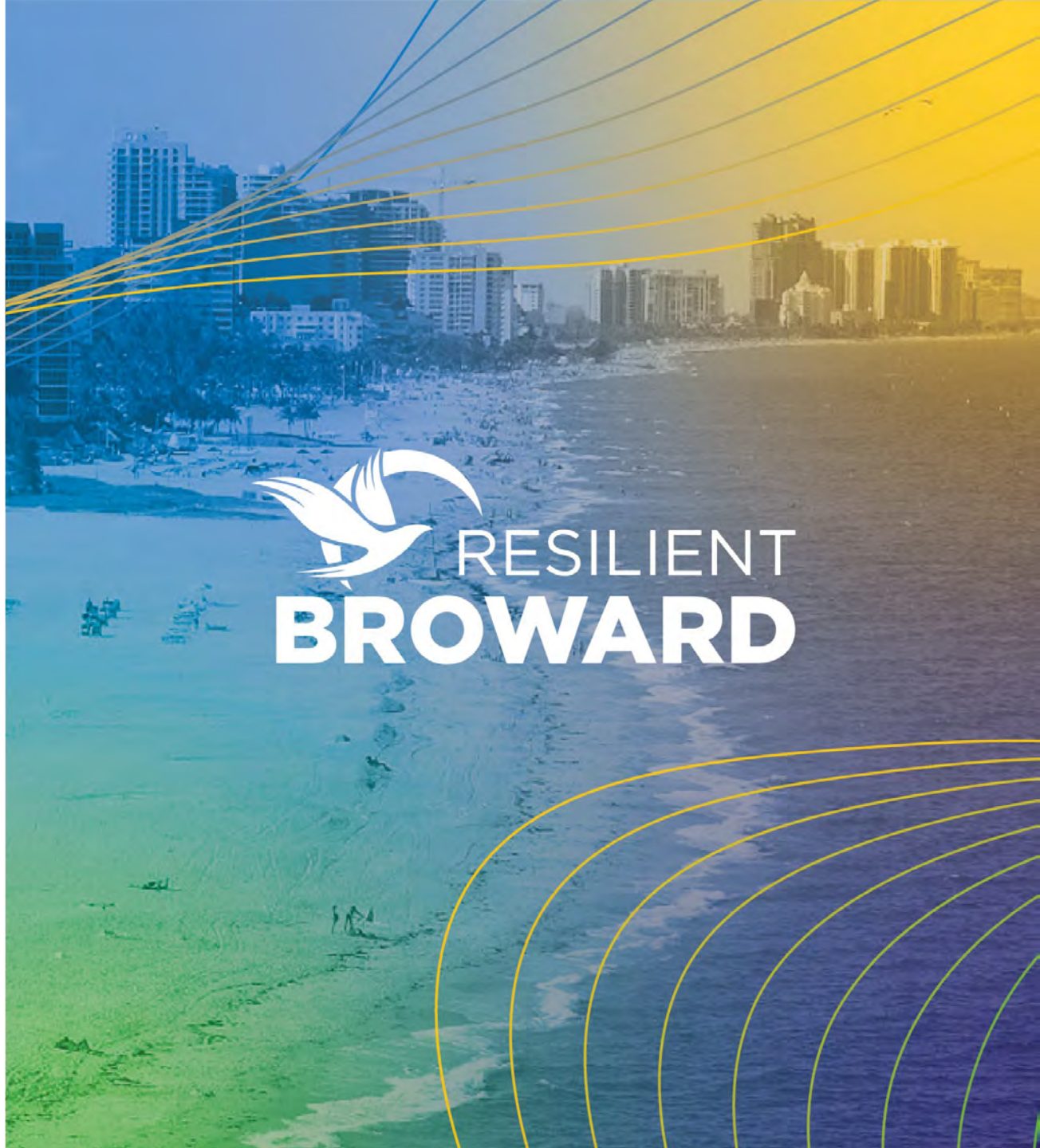
COUNTYWIDE RISK ASSESSMENT AND RESILIENCE PLAN

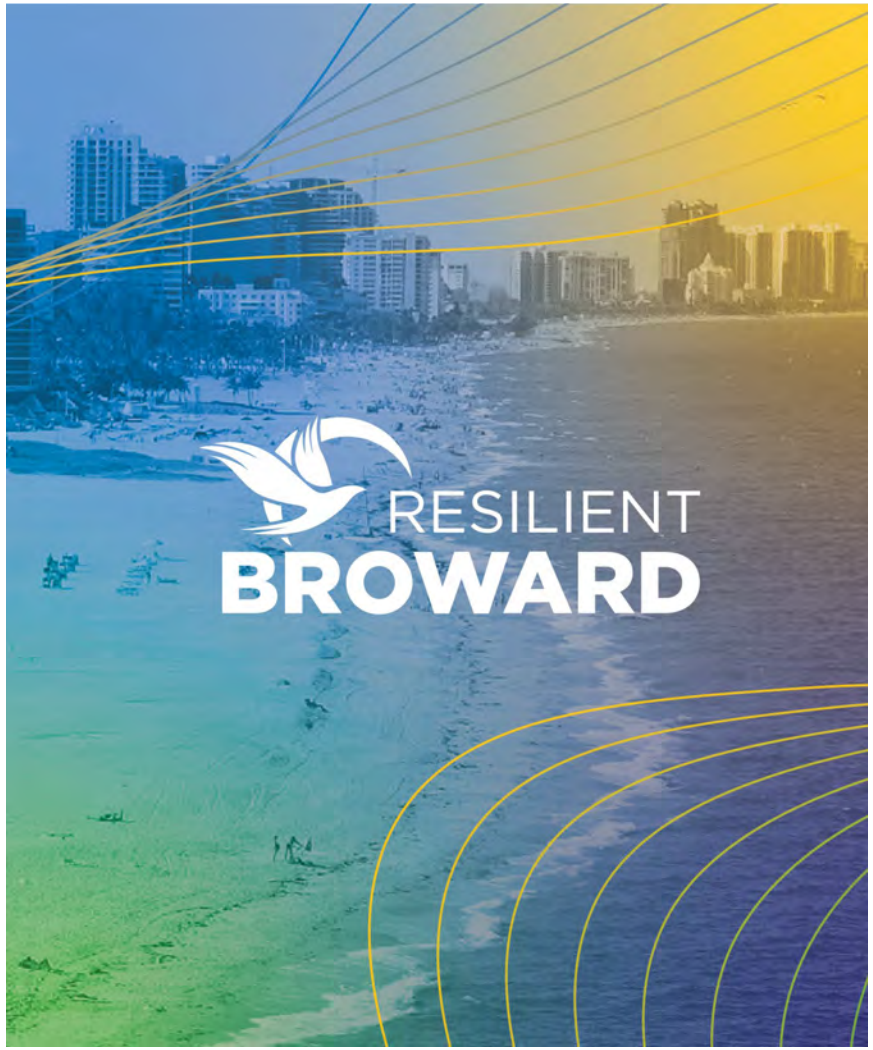
Resilience Plan Steering Committee

August 28, 2024



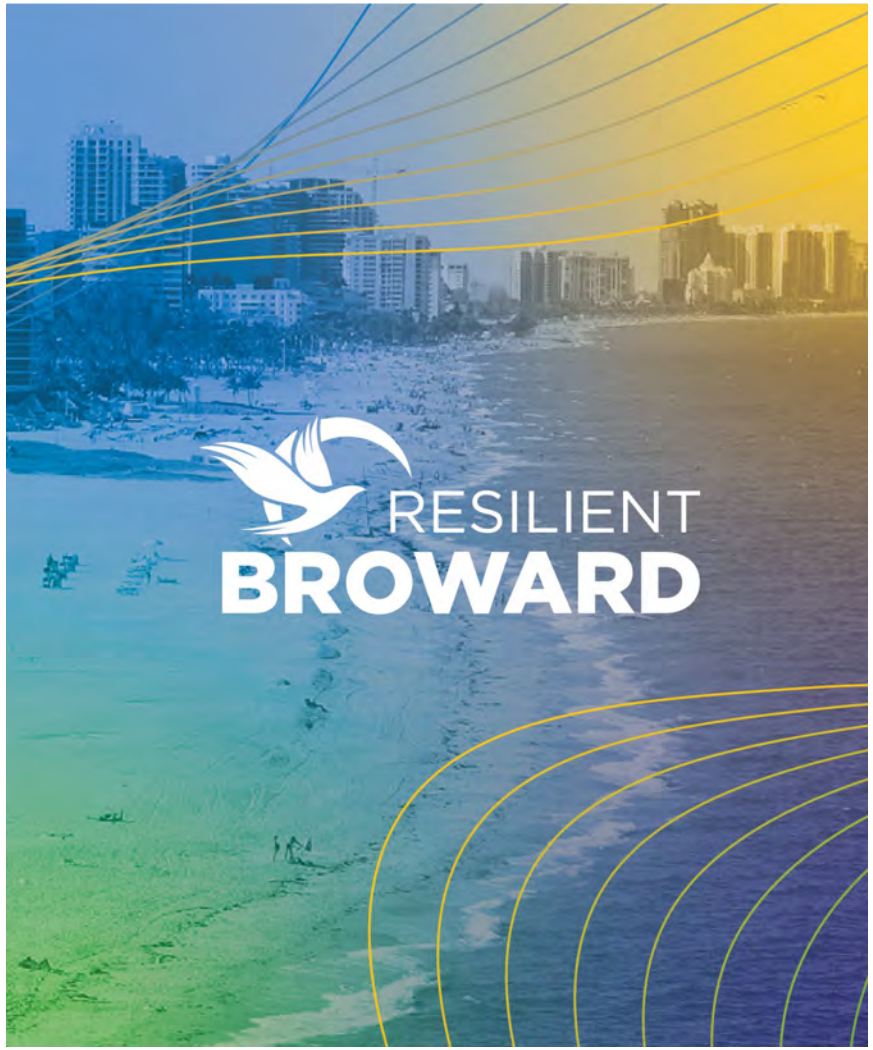
Outline

1. Welcome
2. Roll Call
3. Adaptations
4. Economics Analysis
5. Conceptual Site Representations
6. Property Scale Proposals
7. Next Steps



Welcome

Hazen



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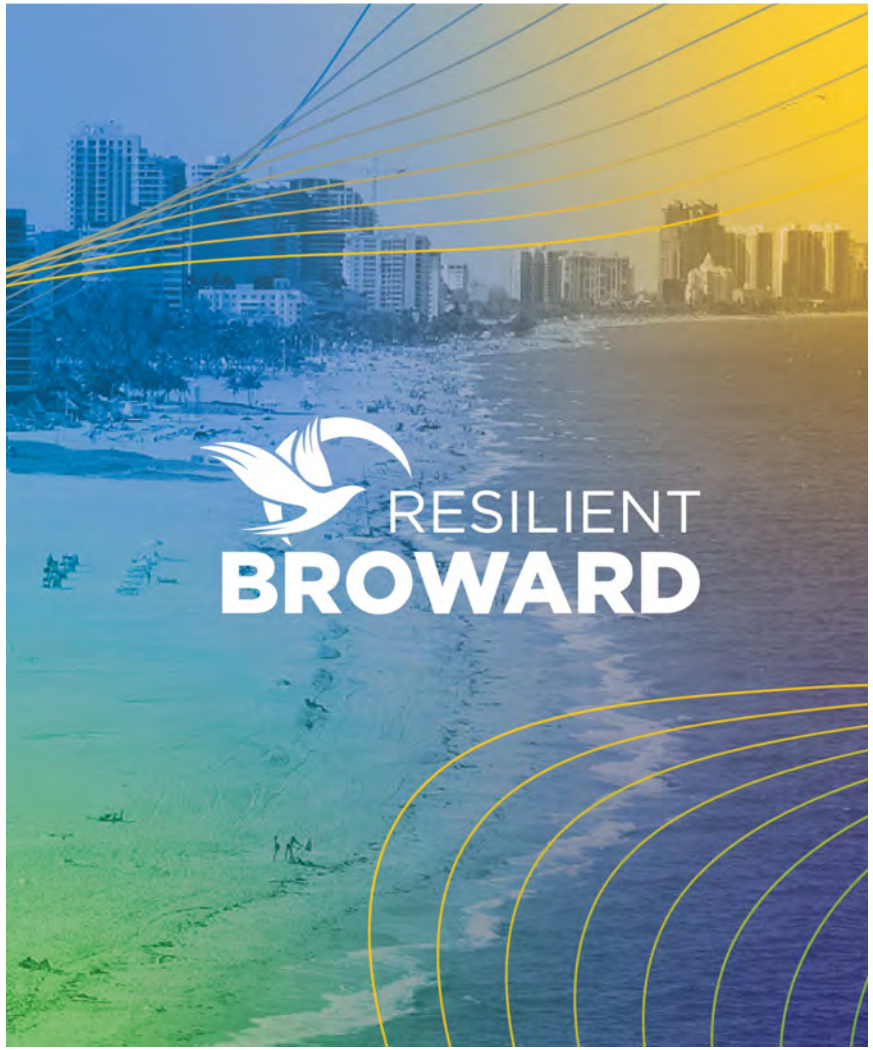
Roll Call

Hazen



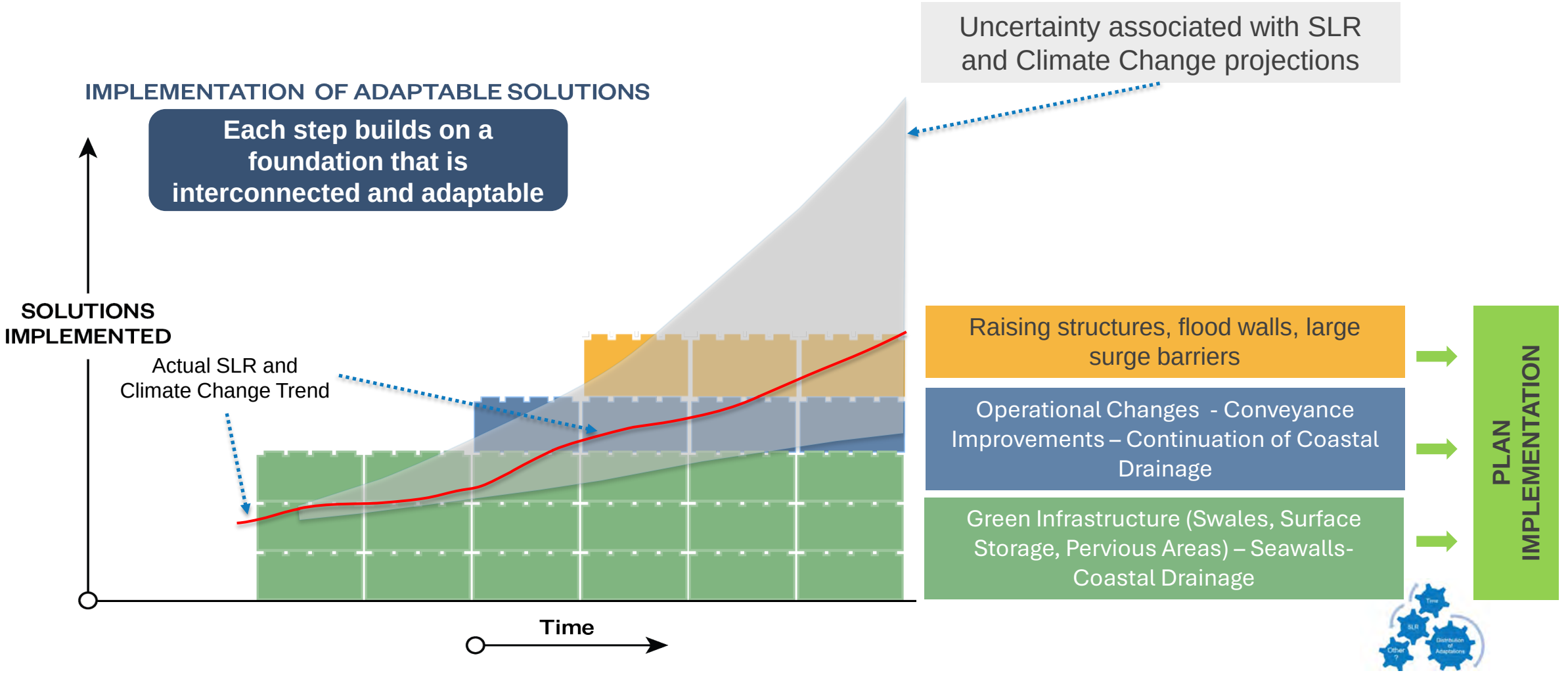
3

Adaptations

Hazen

Overview of Suites Considered

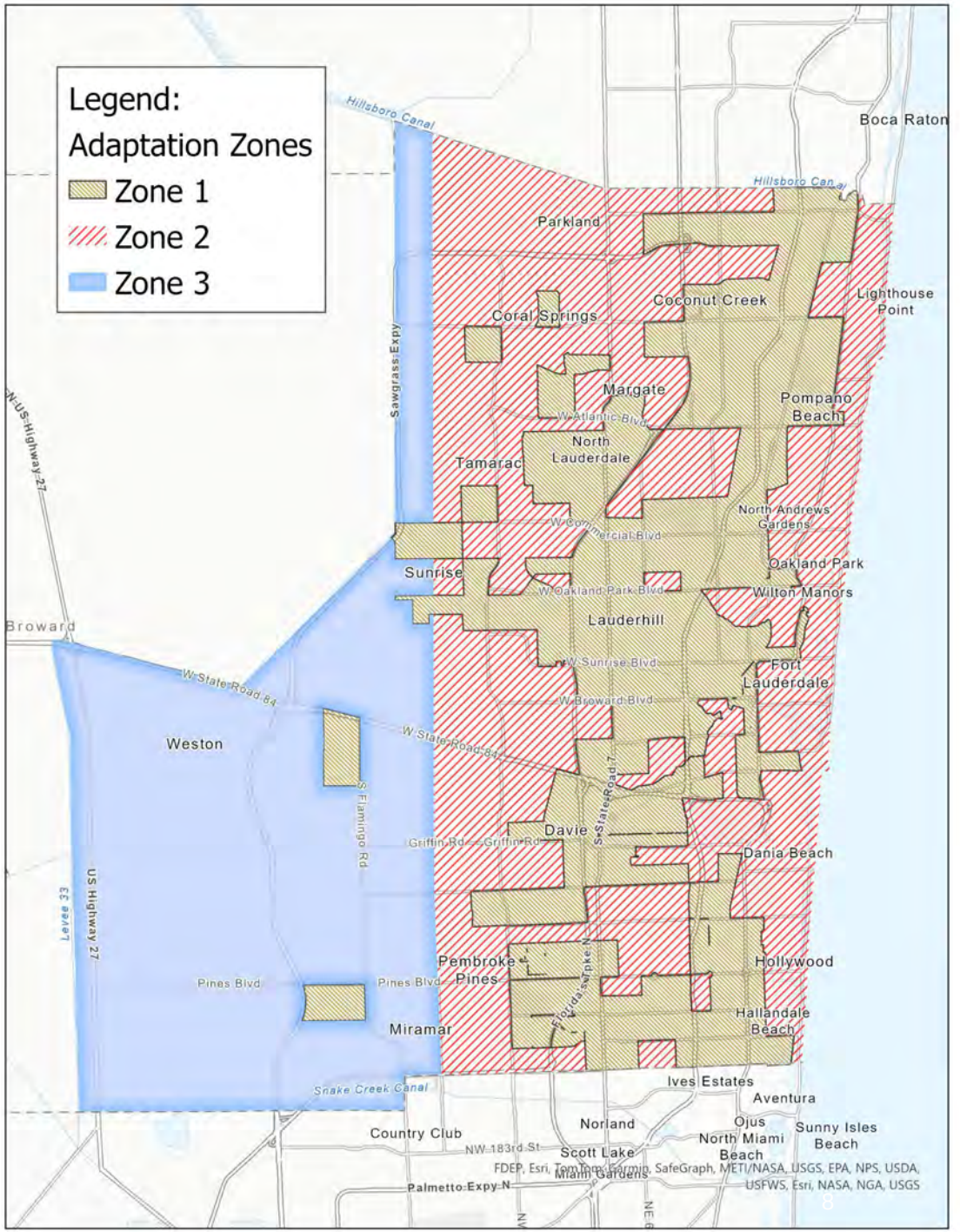
Adaptations will be developed and constructed over time… and as opportunities to construct arise.



Suites of Adaptations were developed incorporating three adaptation zones

- Zone 1 – Highest Vulnerability Areas
- Zone 2 – Coastal
- Zone 3 – Inland

- Six Suites of Adaptations were evaluated using the Hydraulic & Hydrologic Model to gather information required to define the adaptation plan components and sequence
- A seventh suite was defined to address gaps observed in the simulation and after receiving feedback from stakeholders.



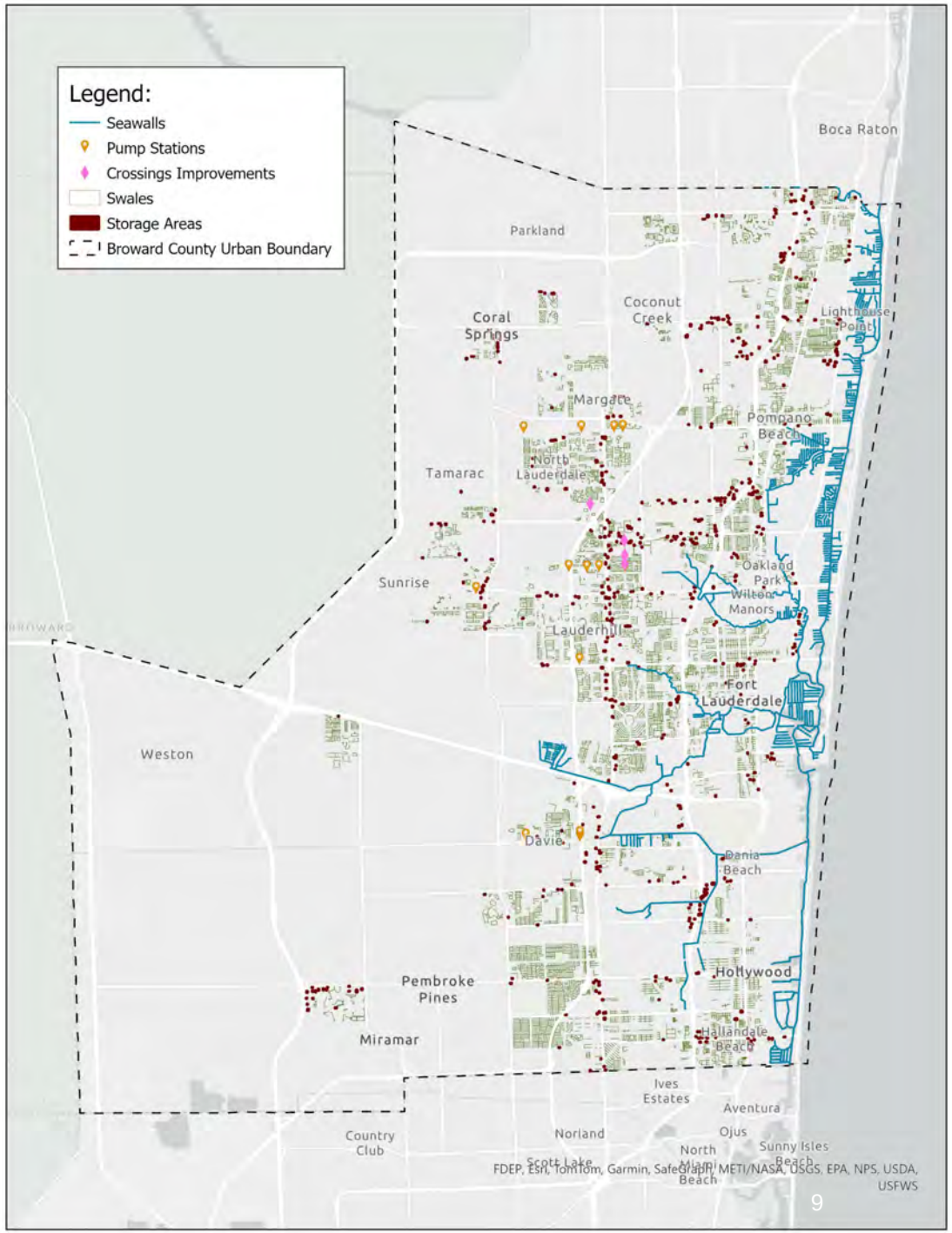
RESILIENT BROWARD

Hazen

Adaptation Suite 1 – Zone 1 Areas

- Two-way roads converted (Swales)
- Pumping stations and culvert improvements
- Storage areas
- All seawalls elevated to 5.0 ft NAVD

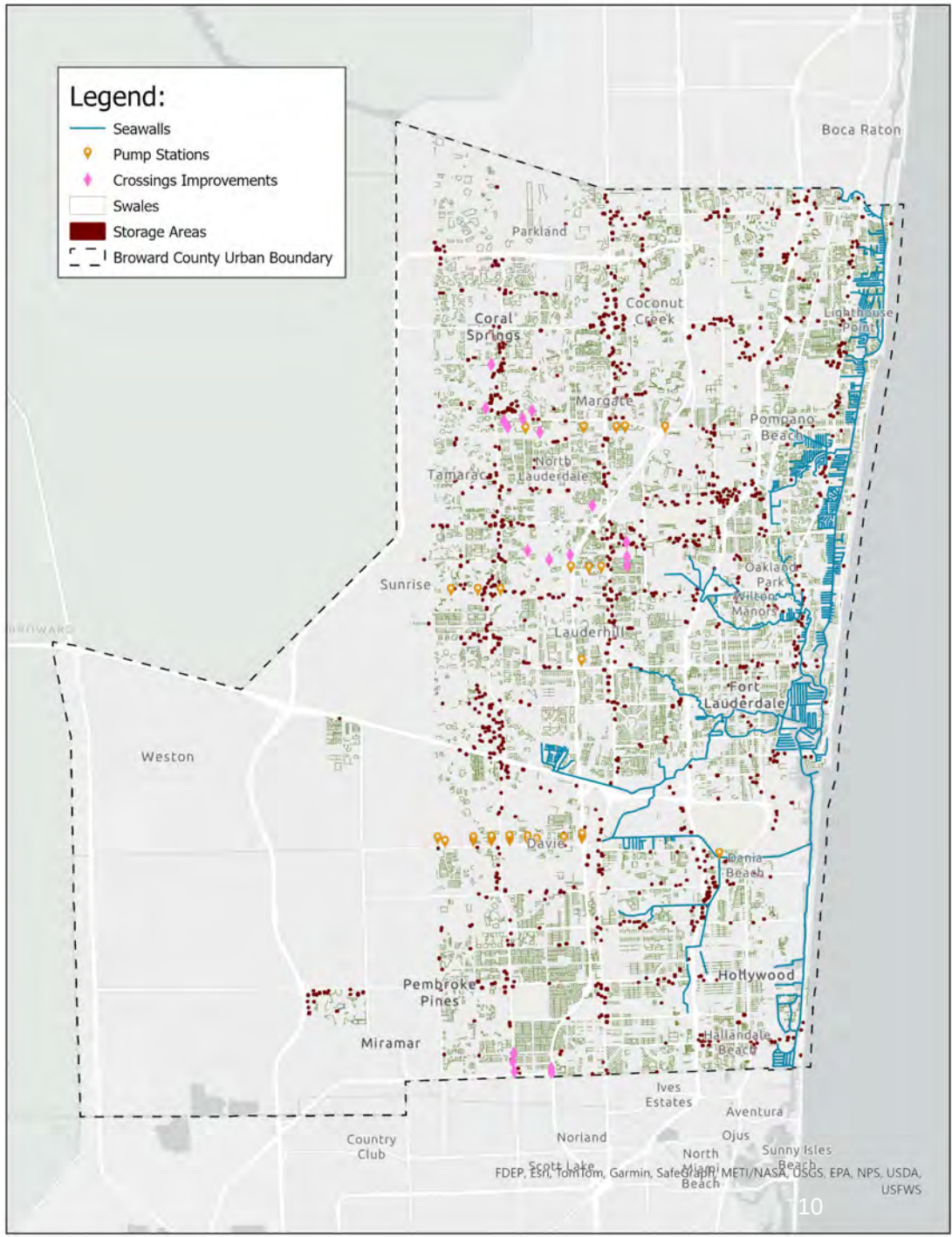
No Control Elevation Changes



Adaptation Suite 2 – Zone 1 and 2 Areas

- Two-way roads converted (Swales)
- Pumping stations and culvert improvements
- Storage areas
- All seawalls elevated to 5.0 ft NAVD

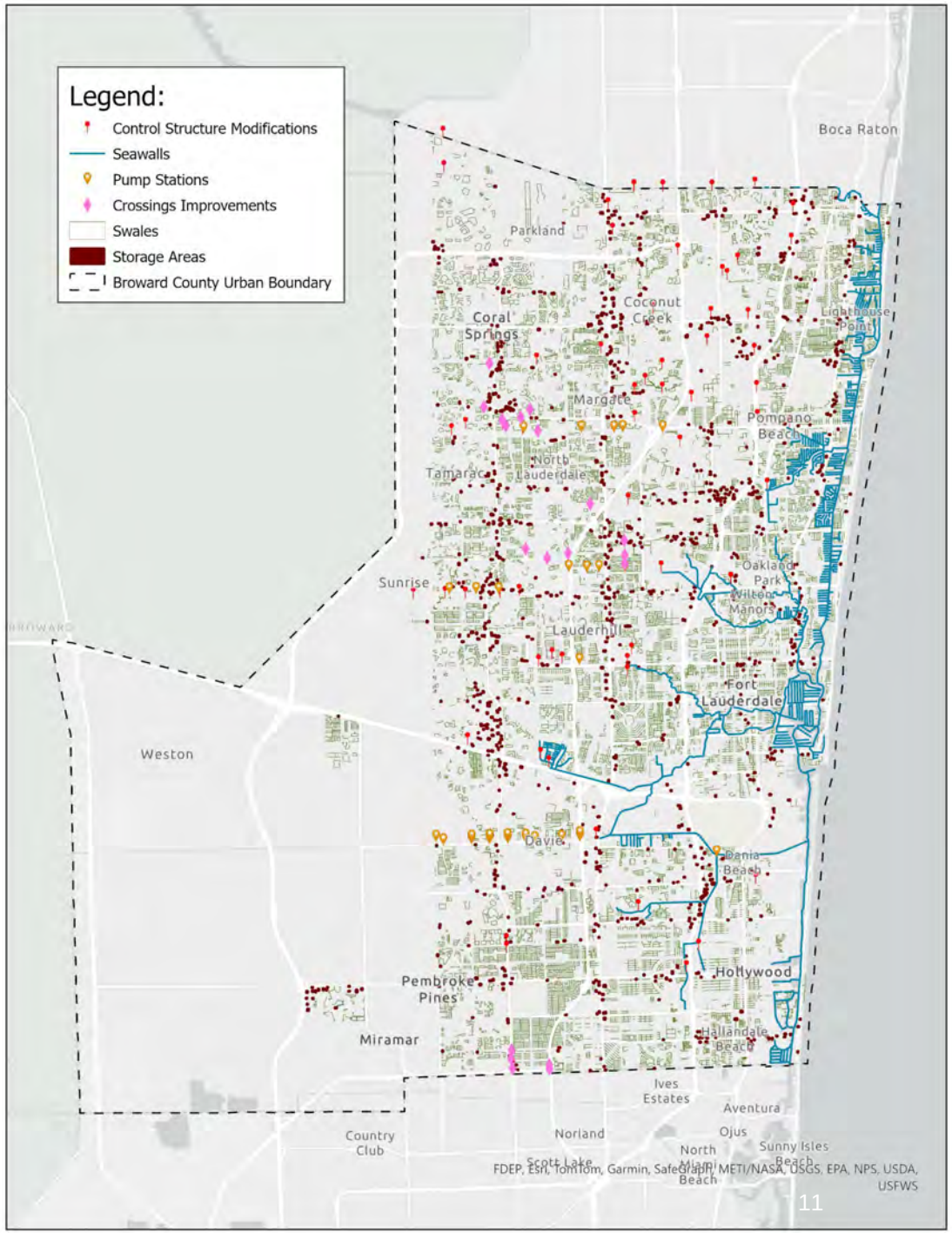
No Control Elevation Changes



Adaptation Suite 3 – Zone 1 and Zone 2 Areas with Control Elevation Changes

- Two-way roads converted (Swales)
- Pumping stations and culvert improvements
- Storage areas
- All seawalls elevated to 5.0 ft NAVD

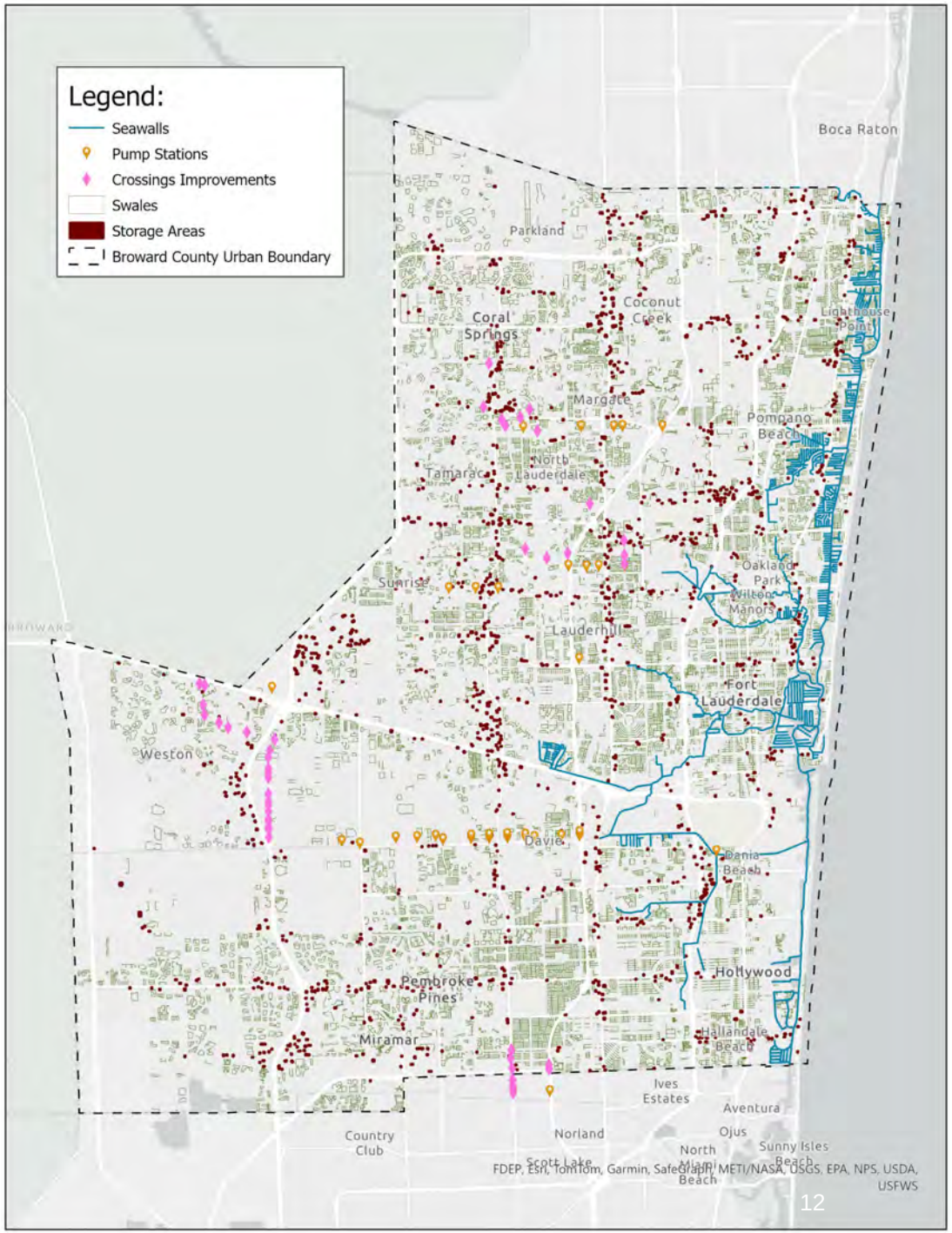
Selective Control Elevation Changes (lower 1-ft)



Adaptation Suite 4 - Countywide

- Two-way roads converted (Swales)
- Pumping stations and culvert improvements
- Storage areas
- All seawalls elevated to 5.0 ft NAVD

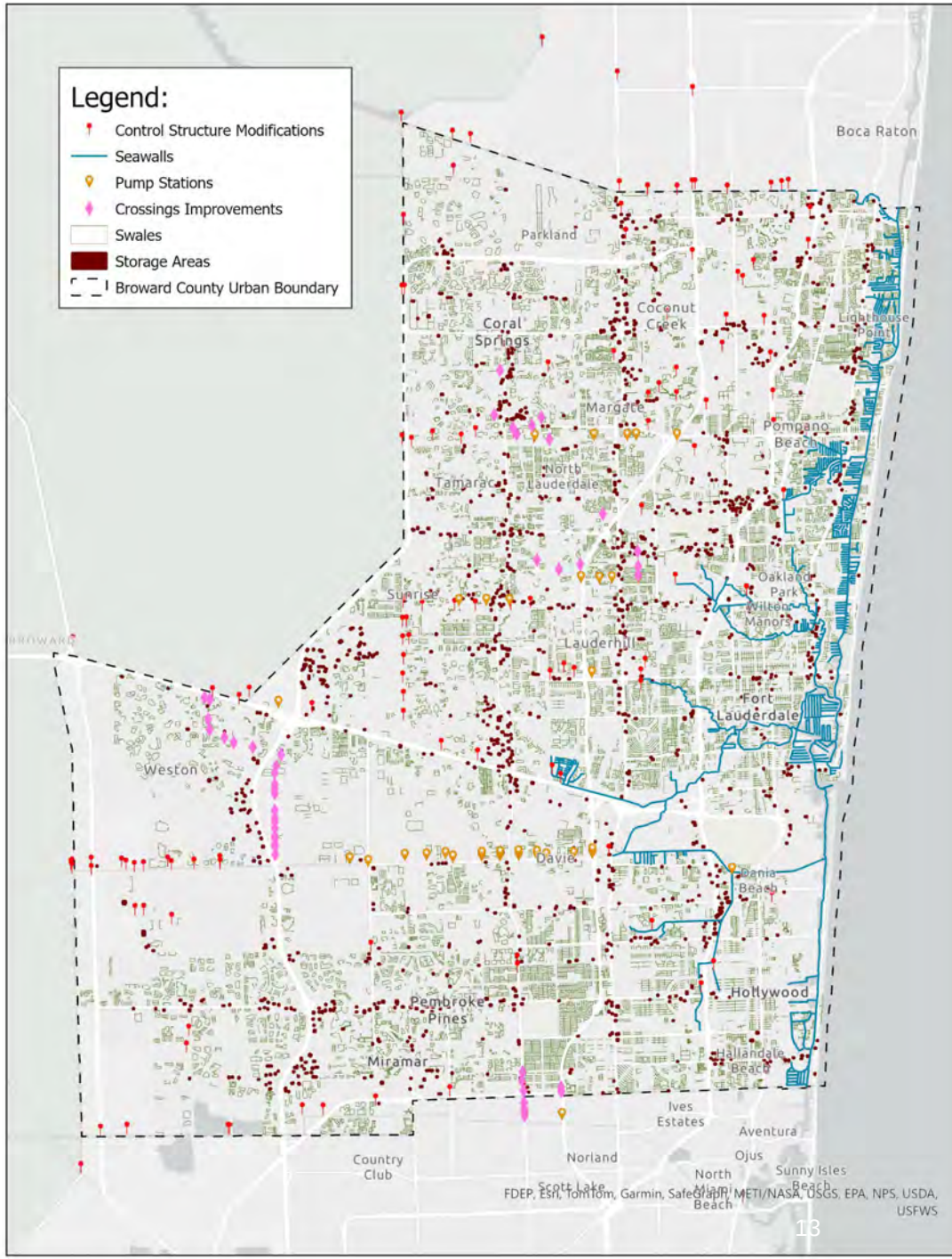
No Control Elevation Changes



Adaptation Suite 5 – Countywide with Control Elevation Changes

- Two-way roads converted (Swales)
- Pumping stations and culvert improvements
- Storage areas
- All seawalls elevated to 5.0 ft NAVD

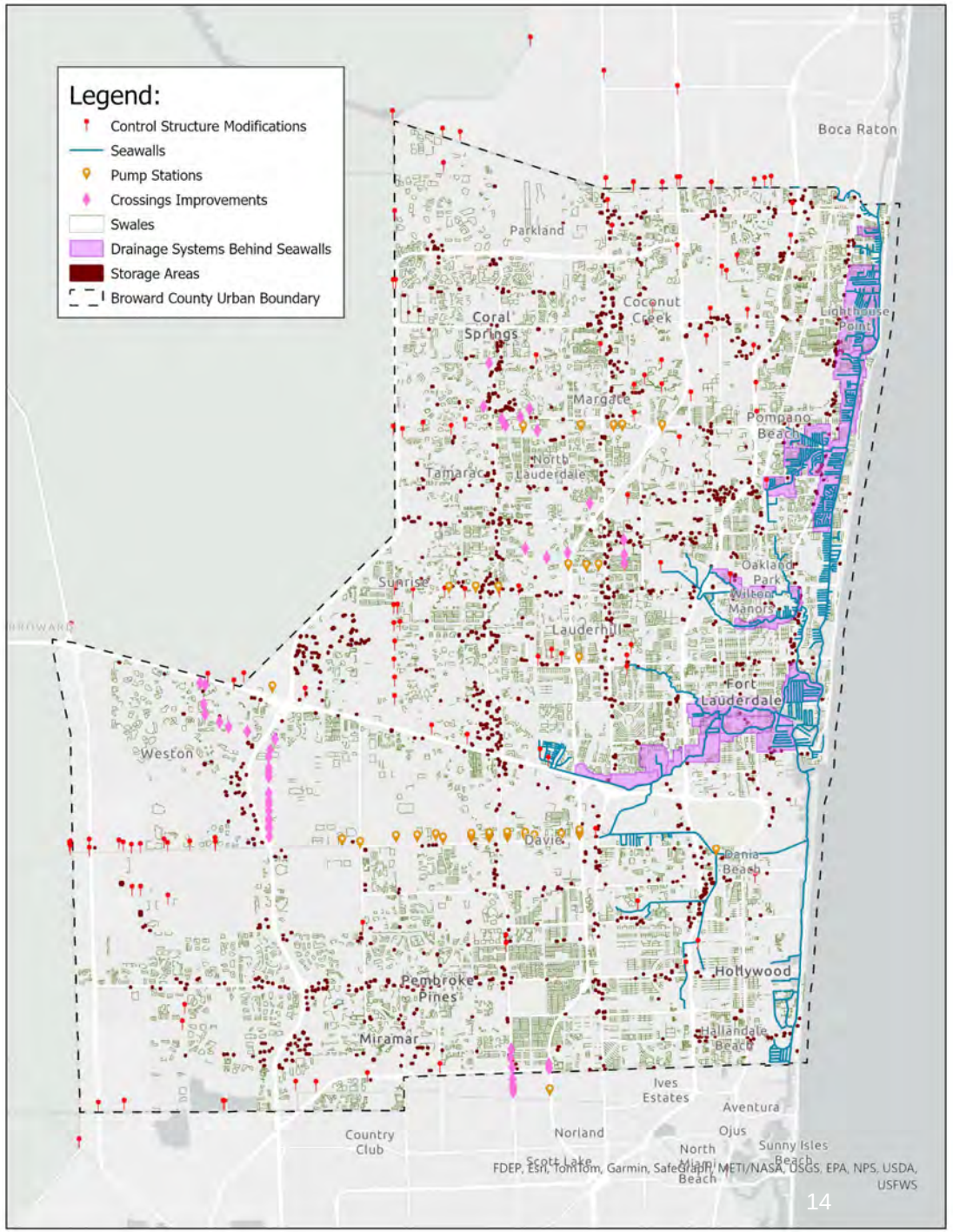
Selective Control Elevation Changes (lower 1-ft)



Adaptation Suite 5B – Countywide with Control Elevation Changes

- Two-way roads converted (Swales)
- Pumping stations and culvert improvements
- Storage areas
- Drainage Systems in Coastal Areas
- All seawalls elevated to **7.0 ft NAVD**

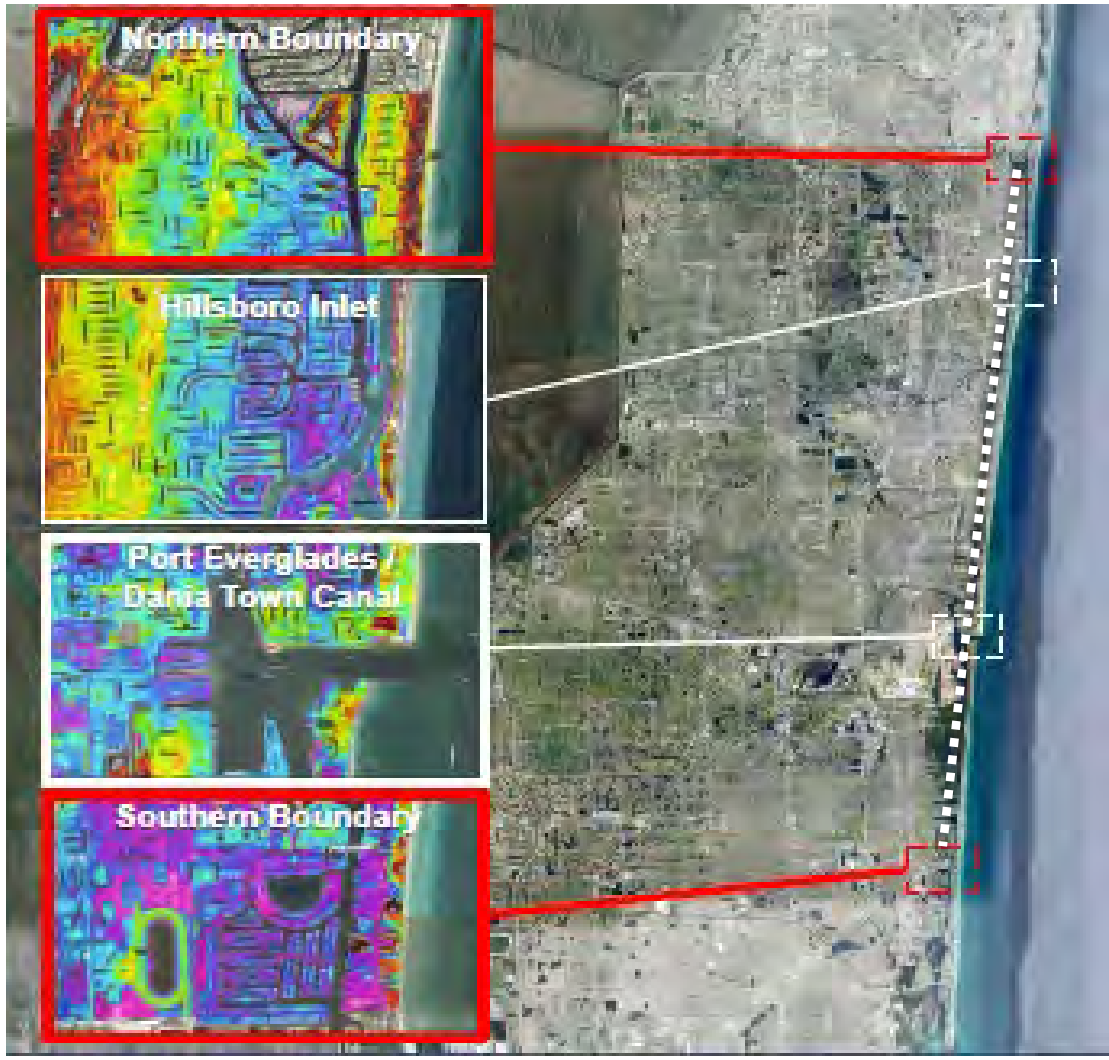
Selective Control Elevation Changes (lower 1-ft)



Adaptation Suite 6 – Countywide with Control Elevation Changes and Large Surge Barriers

- Includes incorporation of all Adaptation Suite 5 strategies…

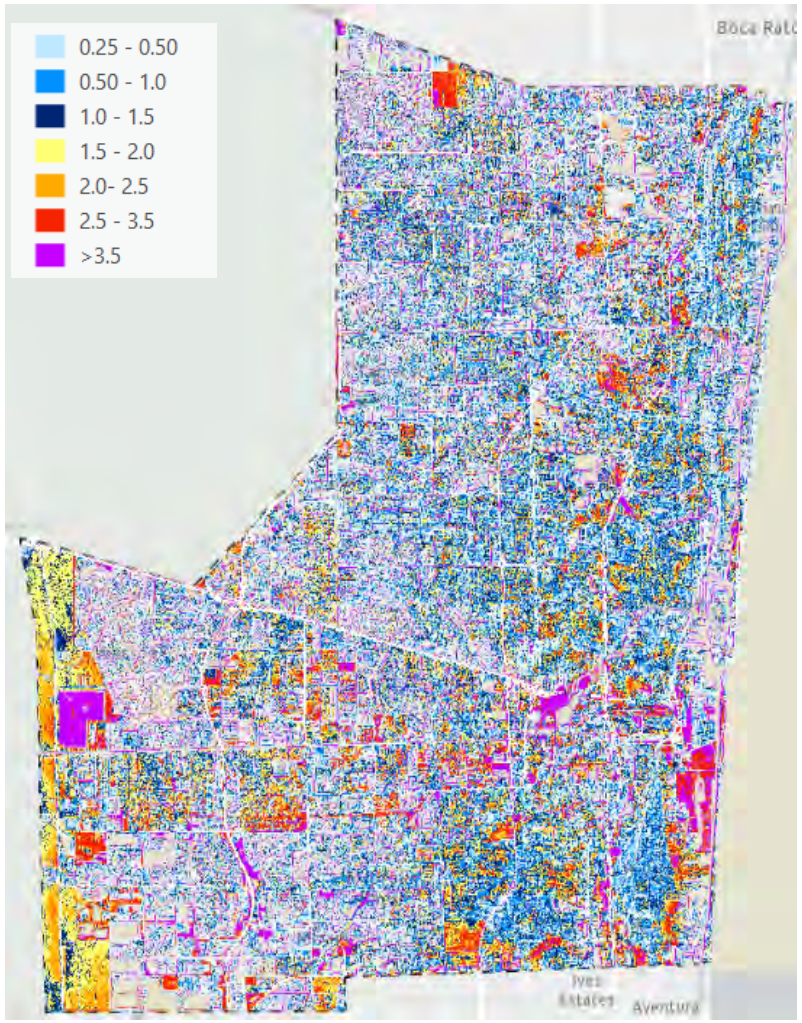
PLUS, LONG TERM ADAPTATION: ***Large Surge Barriers and Tidal Coastal Structures with navigation locks and Pump Stations.***



Performance of Adaptations

Comparison of Suite 5 vs Suite 5B Performance

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



Base Scenario - Flooding Depth (feet)

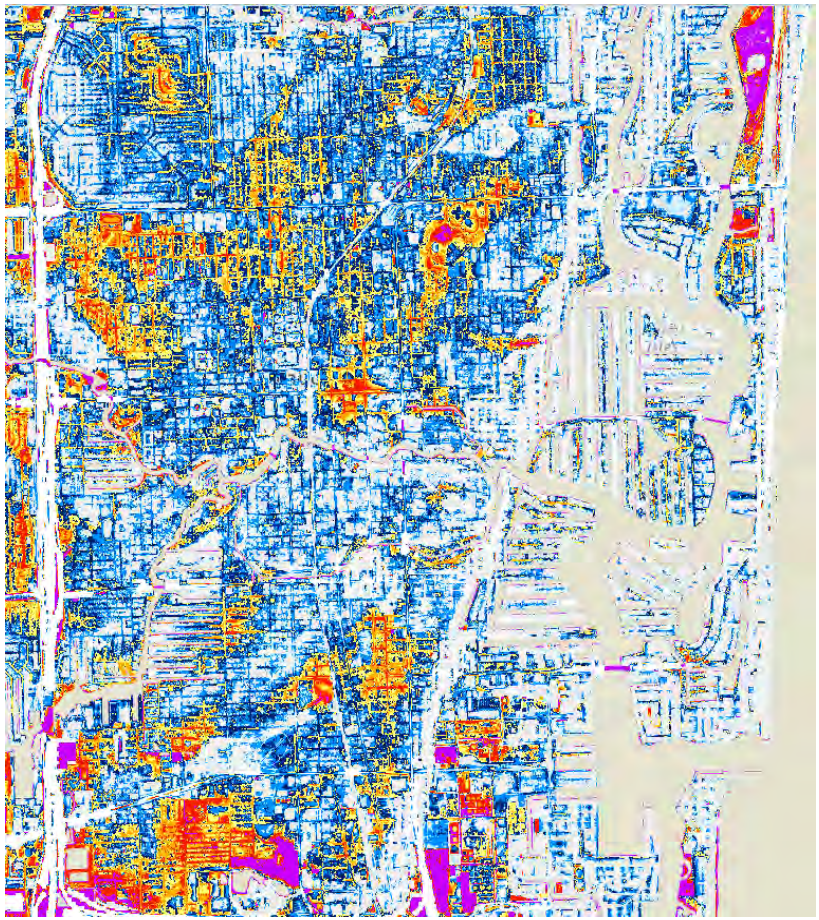
AS5 - Flooding Depth (feet)

AS5b - Flooding Depth (feet)

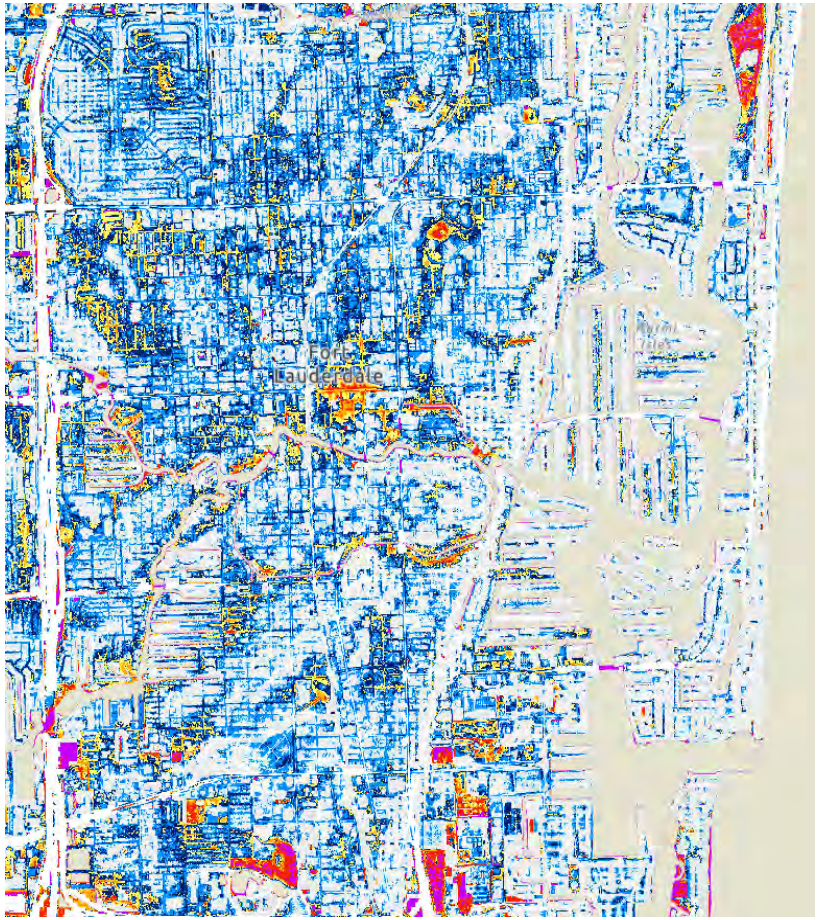
Comparison of Suite 5 vs Suite 5B Performance

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

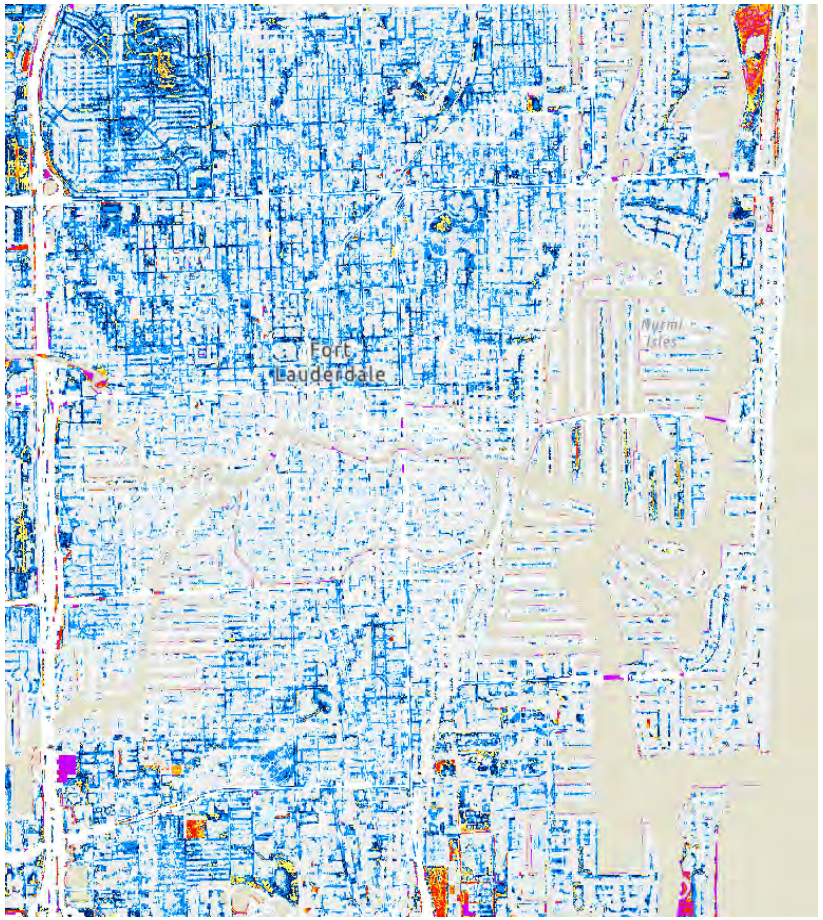
0.25 - 0.50
0.50 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0- 2.5
2.5 - 3.5
>3.5



Base - Flooding Depth (feet)



AS5 - Flooding Depth (feet)



AS5B - Flooding Depth (feet)

Distribution of Buildings by Flood Depth Impact

Base (No-Action), Suite 5, and Suite 5B

Number of Properties

Percent Relative to Total Number of Properties in Database

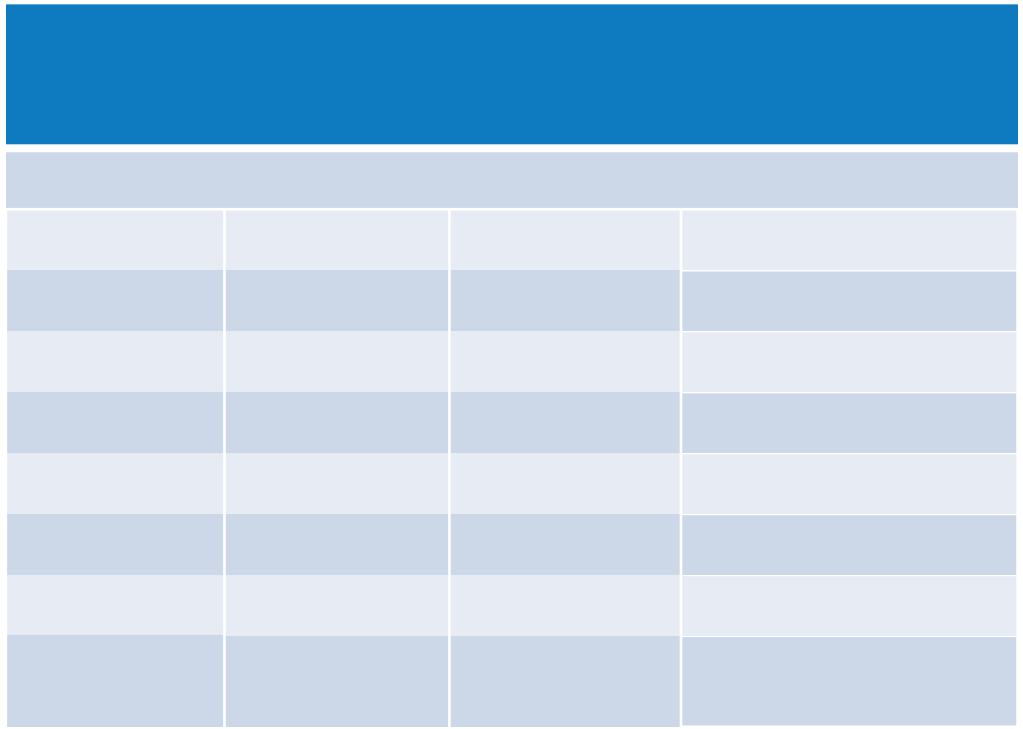
Scenario

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

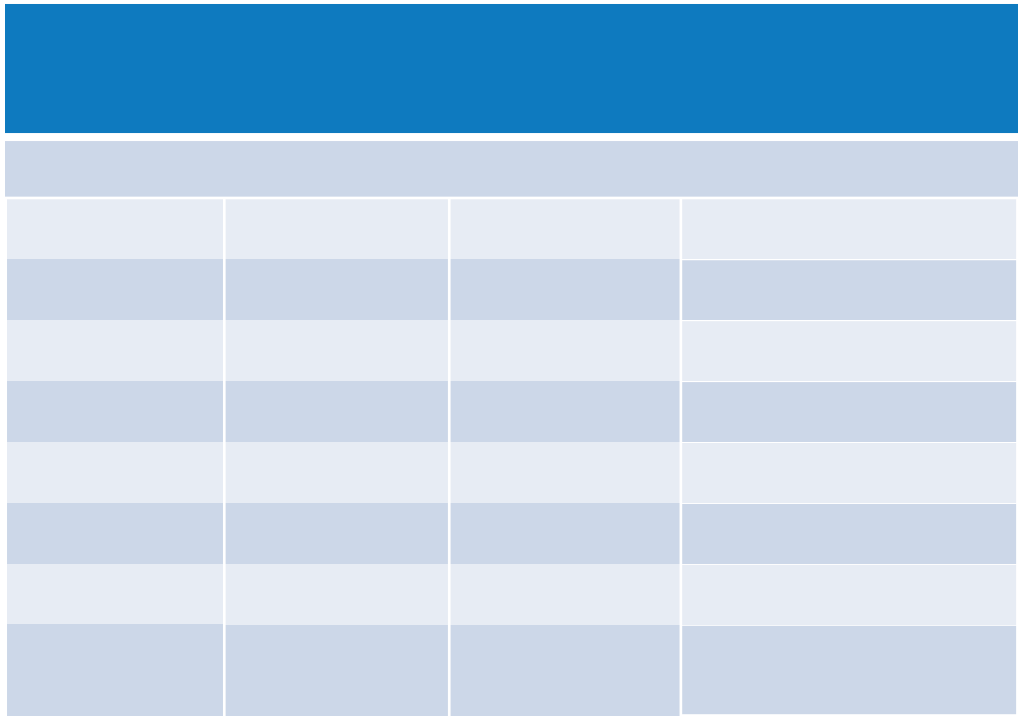
Distribution of Buildings by Flood Depth Impact

Base (No-Action), Suite 5, and Suite 5B

Number of Properties

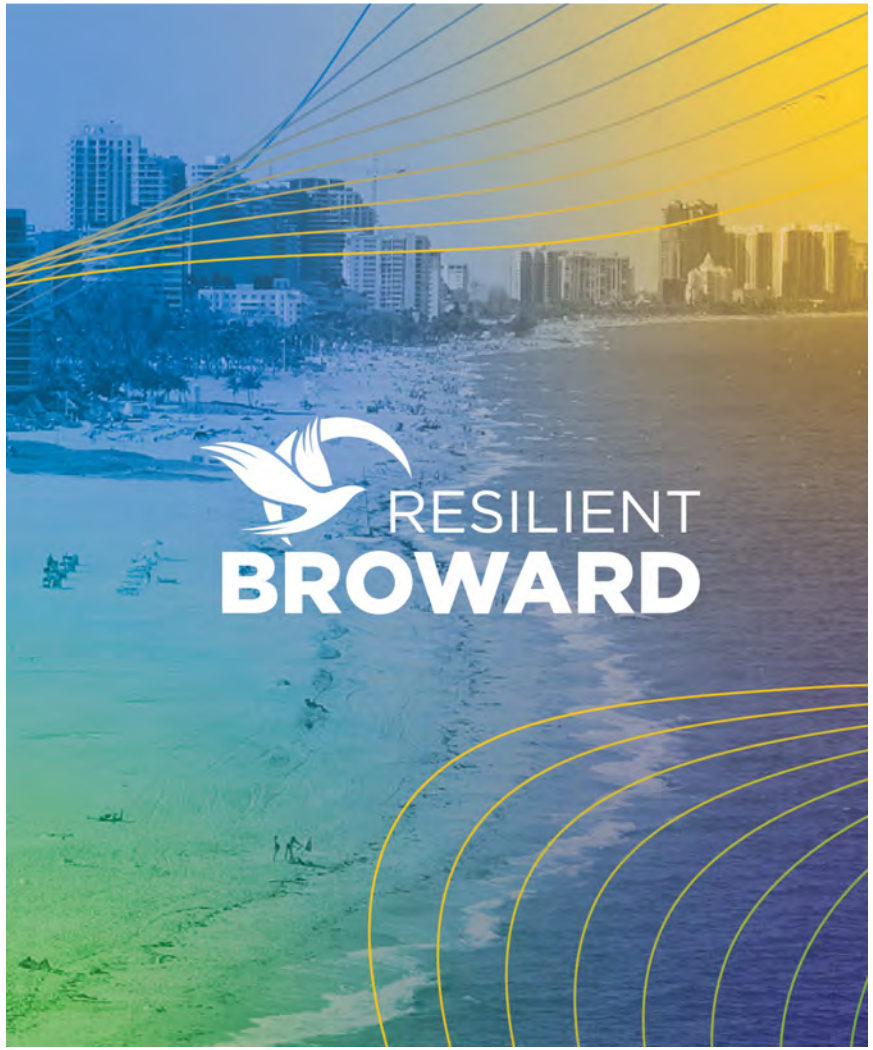


Percent Relative to Total Number of Properties in Database



Scenario

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



4

Economic Analyses

Hazen

Dollar value of five benefit categories were estimated under different adaptation strategies

Property damage savings from avoided costs of repairing and replacing assets damaged by floods

Economic activity (Gross Value Added) benefits from avoided business and transport disruption

Increased Flood Insurance Coverage as risk and premia are lower due to flood mitigation

Increased Real Estate Value resulting from lower flood damage costs, insurance premia savings, and rental income losses

Increased Property Tax collections to County and cities because of higher property values

All dollar values are in 2024 (today's) dollars.

Source: Hazen, FEMA

Benefits values were estimated for adaptation strategies that differ based on zone where measures are implemented, and type of measures used

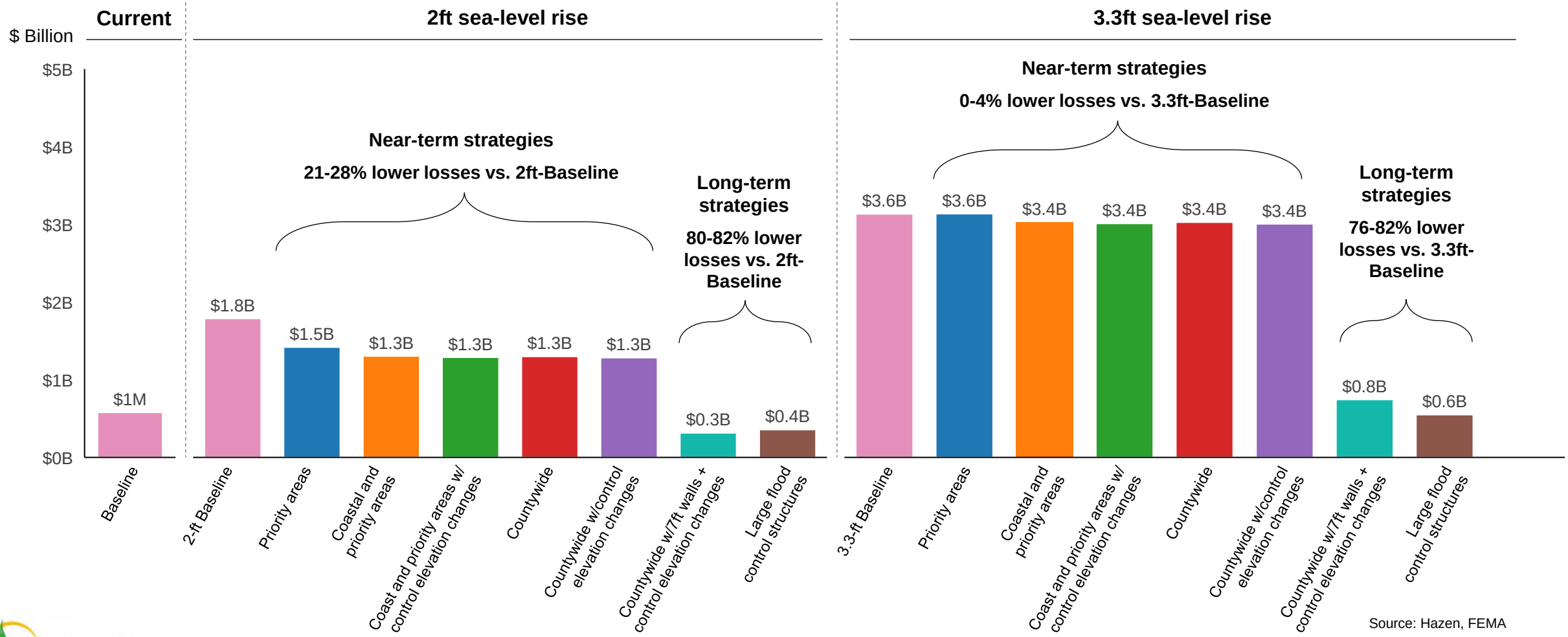
Existing conditions Additional measures

Adaptation suite	County area where measures implemented, %	Two-way roads converted	Pumping stations	Storage areas	Control elevation changes	Sea walls	Surge & tidal coastal barriers
Baseline	~0%	✗	✗	✗	✗	✗	✗
Priority areas	~30% (Zone 1)	✓	✓	✓	✗	5ft	✗
Coastal areas	~60% (Zone 1&2)	✓	✓	✓	✗	5ft	✗
Coastal areas w/ control elevation changes	~60% (Zone 1&2)	✓	✓	✓	✓	5ft	✗
Countywide	~100% (Zones 1-3)	✓	✓	✓	✗	5ft	✗
Countywide w/control elevation changes	~100% (Zones 1-3)	✓	✓	✓	✓	5ft	✗
Countywide w/7ft walls & control elevation changes	~100% (Zones 1-3)	✓	✓	✓	✓	7ft	✗
Large flood control structures	~100% (Zones 1-3)	✓	✓	✓	✓	5ft	✓

Source: Hazen, FEMA

Adaptations reduce residential property damage by at least 21% under 2ft sea-level rise. Under 3.3ft sea-level rise, only the larger investment strategies provide significant damage reduction.

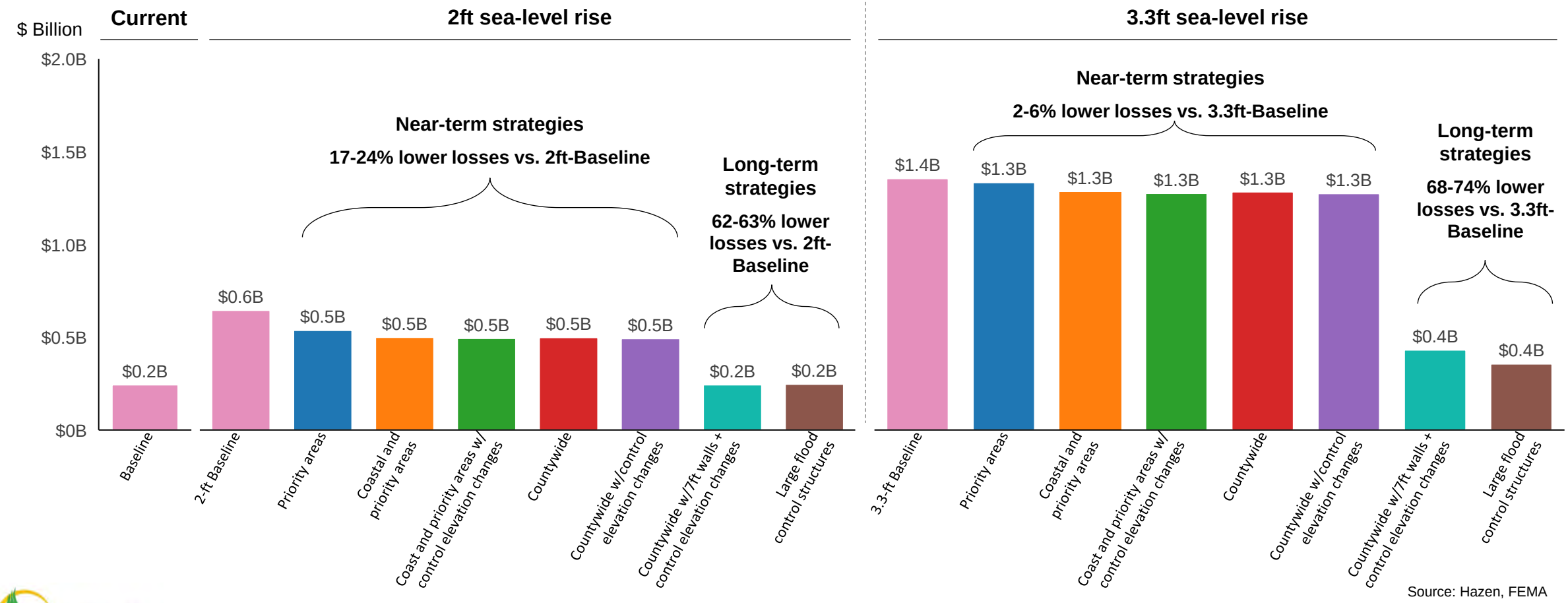
Annual average damages to residential assets ($B damages)



Source: Hazen, FEMA

Adaptations reduce damage to productive assets by at least 17% under 2ft sea-level rise. Under 3.3ft sea-level rise, only the larger investment strategies provide significant damage reduction.

Annual average damages to productive assets ($B damages)



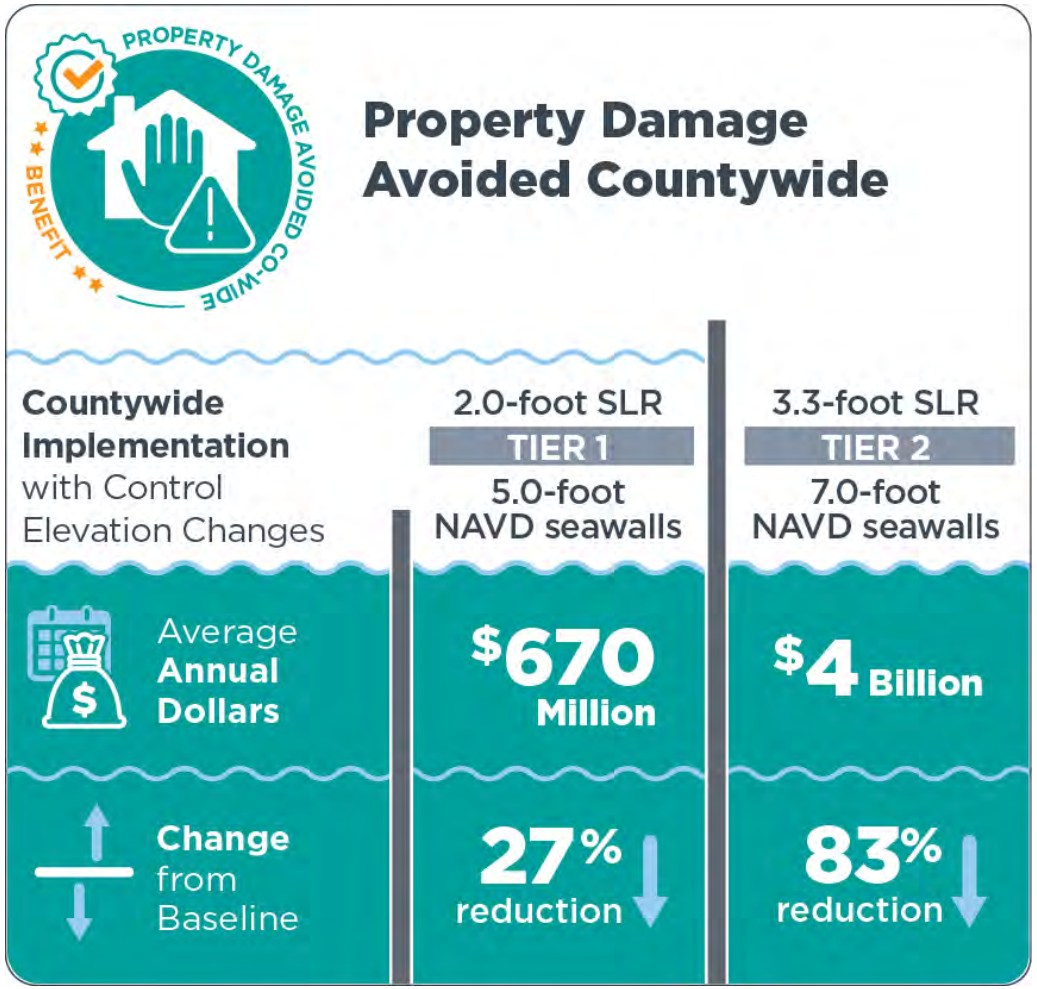
Source: Hazen, FEMA

Economic feasibility evaluated for two adaptation strategies fully implemented by 2050 and 2070

	Tier 1 – Countywide with Control Elevation Changes	Tier 2 – Countywide with Control Elevation Changes and 7ft NAVD seawalls
Assumed completion date	**2050** to prepare for 2ft sea-level rise	**2070** to prepare for 3.3ft sea-level rise
Adaption measures	Two-way roads converted Pumping stations and culvert improvements Storage areas Control Elevation Changes All seawalls are up to 5 ft NAVD with drainage	Same but all the seawalls are up to **7 ft NAVD** with drainage
Zone of implementation	Countywide	Countywide

Source: Hazen, FEMA

Major benefit and primary factor impacting all other benefits is the property damage avoided as the Adaptation Strategies are implemented



Damages are the estimated average annual repair and replacement cost under 15 flood conditions and associated probabilities for each of two SLR scenarios: 2.0-foot and 3.3-foot.

Property Damage Avoided is the difference in average annual damages under the Baseline (no action) and under the Tier.

For Tier 1 the Baseline is 2.0-foot SLR.

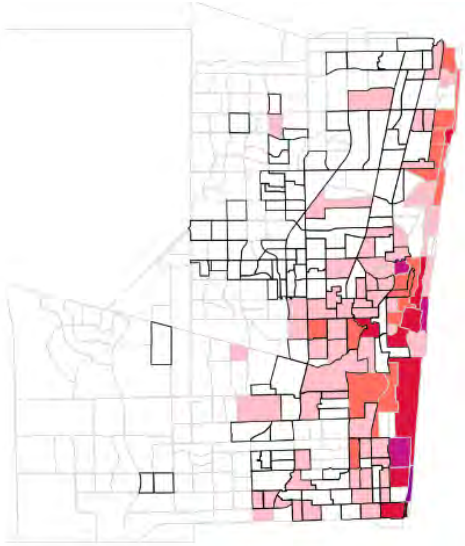
For Tier 2 the Baseline is 3.3-foot SLR.

Source: Hazen, FEMA

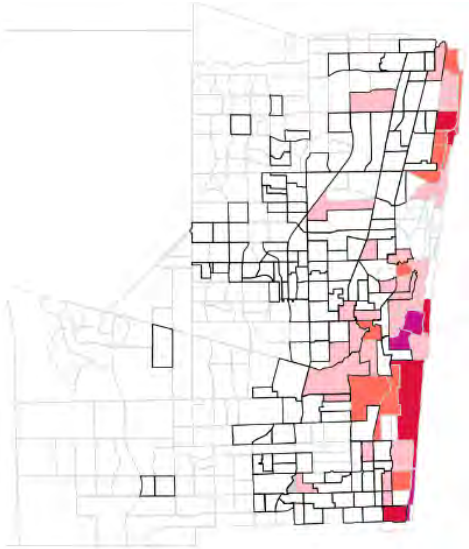
Tier 1 and Tier 2 reduce property damage across much of Broward County with significant countywide benefits realized under Tier 2

Annual average damages to residential assets as share of property value across the county

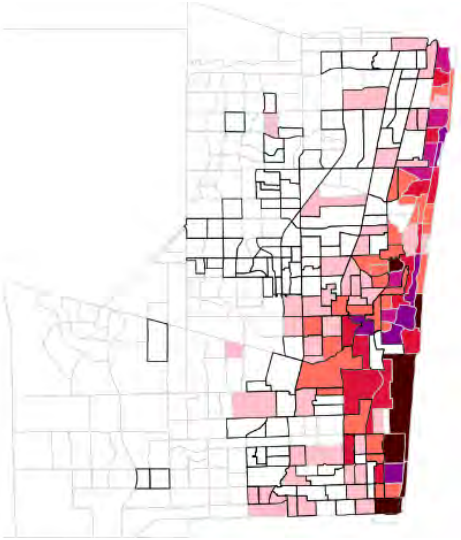
Baseline – 2ft



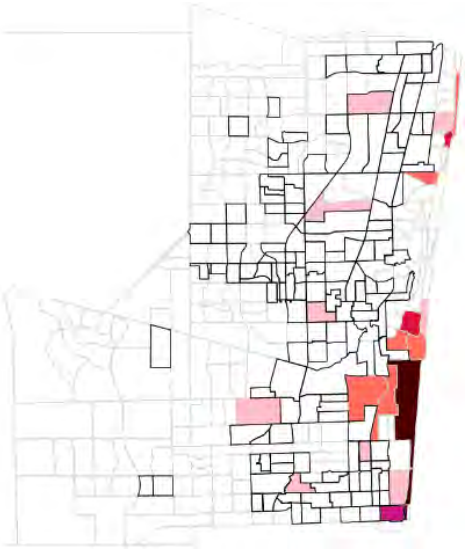
Countywide adaptations w/ control elevation changes – 2ft



Baseline – 3.3ft



Countywide adaptations w/ control elevation & 7ft seawalls- 3.3ft



Damages as share of property value:

- 15-18%
- 12-15%
- 9-12%
- 6-9%
- 3-6%
- 1-3%
- <1%

Areas outlined in black relate to zone 1

Source: Hazen, FEMA

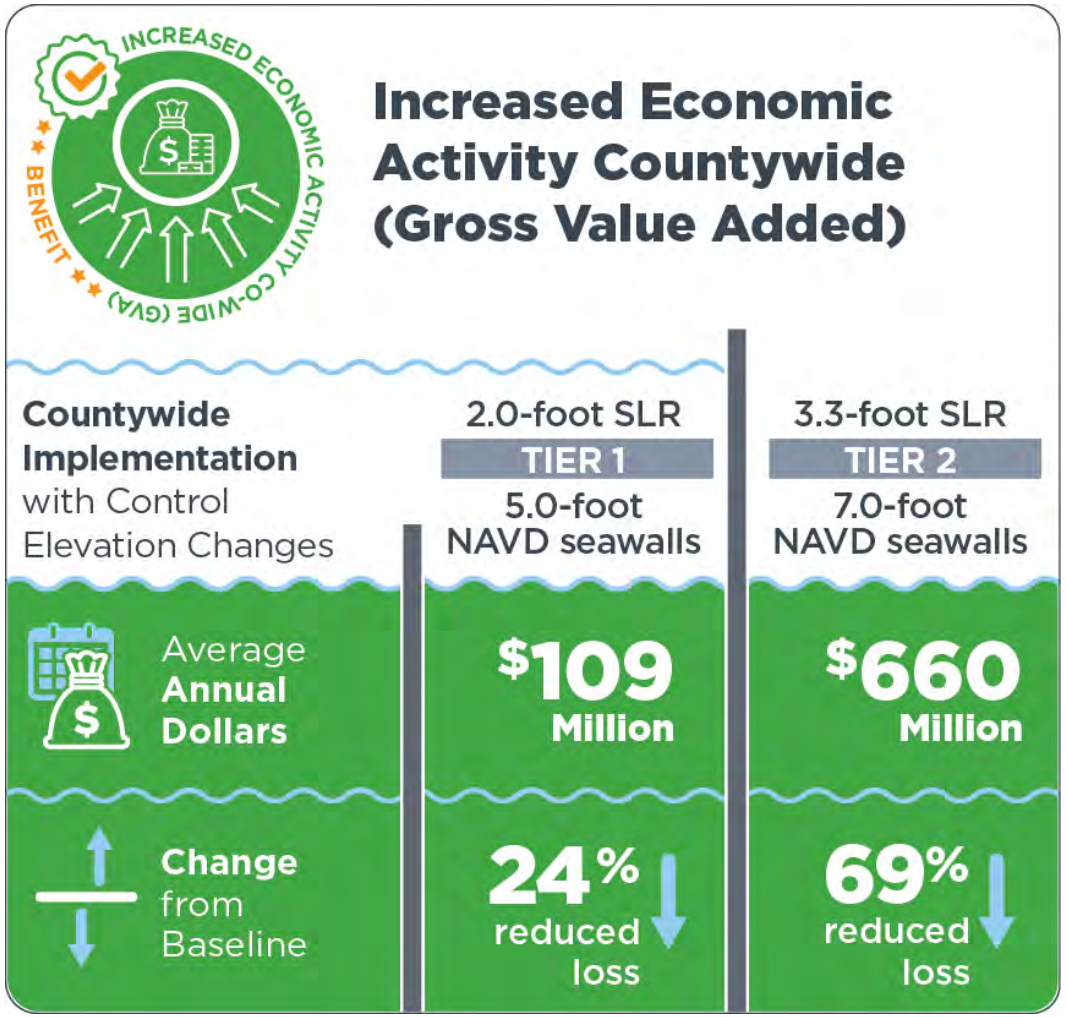
Most cities would enjoy a significant reduction in property damage under the Tier 1 and 2 investments

Residential property damage avoided among cities from Tier 1 and Tier 2 investments, sorted by percentage of avoided property damage relative to baseline

Annual Damage Avoided Range as percentage of baseline	Property Damage Avoided - Countywide with w/ control elevation changes at 2ft SLR		Property Damage Avoided - Countywide w/7ft NAVD seawalls + control elevation changes at 3.3ft SLR	
	Number of Cities and Unincorporated County	$M / Year	Number of Cities and Unincorporated County	$M / Year
70-99% reduction	5	$67	11	$2,666
60-70% reduction	6	$53	7	$87
40-60% reduction	8	$266	6	$111
20-40% reduction	6	$77	3	$12
>0-20%reduction	4	$158	2	$4
Total	29	$622	29	$2,881

Source: Hazen, FEMA

Tier 1 and Tier 2 strategies could reduce short term economic losses from sea level rise by 24% and 69%, respectively



Gross Value Added (GVA) measures the contribution of different sectors to overall economic activity

GVA impacts were assessed as an average annual difference between the baseline and each adaptation strategy

These economic benefits could arise from:

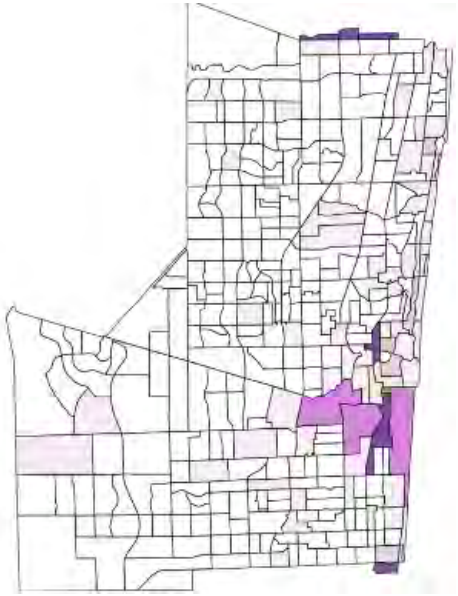
1. **Lower direct flooding impacts** to businesses (which also lowers knock-on impacts)
2. **Reduced disruption to roads**

Source: Hazen, FEMA

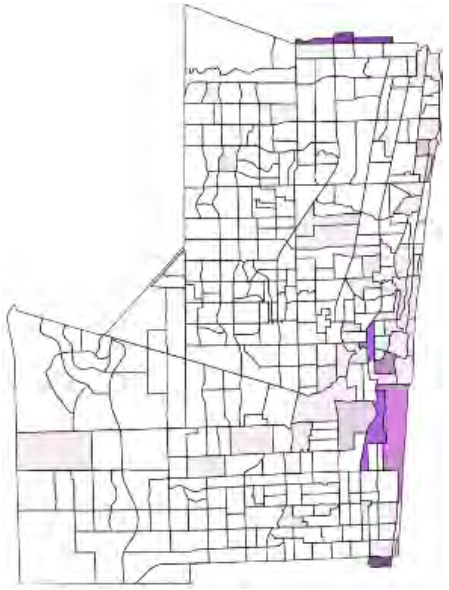
Tier 2 investments could reduce business sales losses along the coast, while realizing Tier 1 benefits along the I-595 corridor

Annual average sales revenue loss ($M)

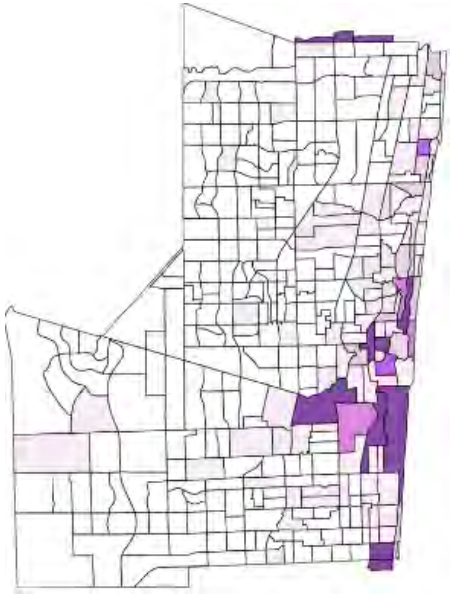
Baseline – 2ft



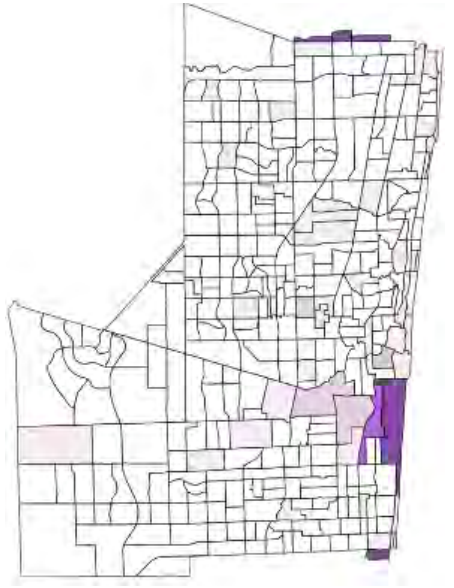
Countywide adaptations w/ control elevation changes – 2ft



Baseline – 3.3ft



Countywide adaptations w/ control elevation & 7ft seawalls- 3.3ft

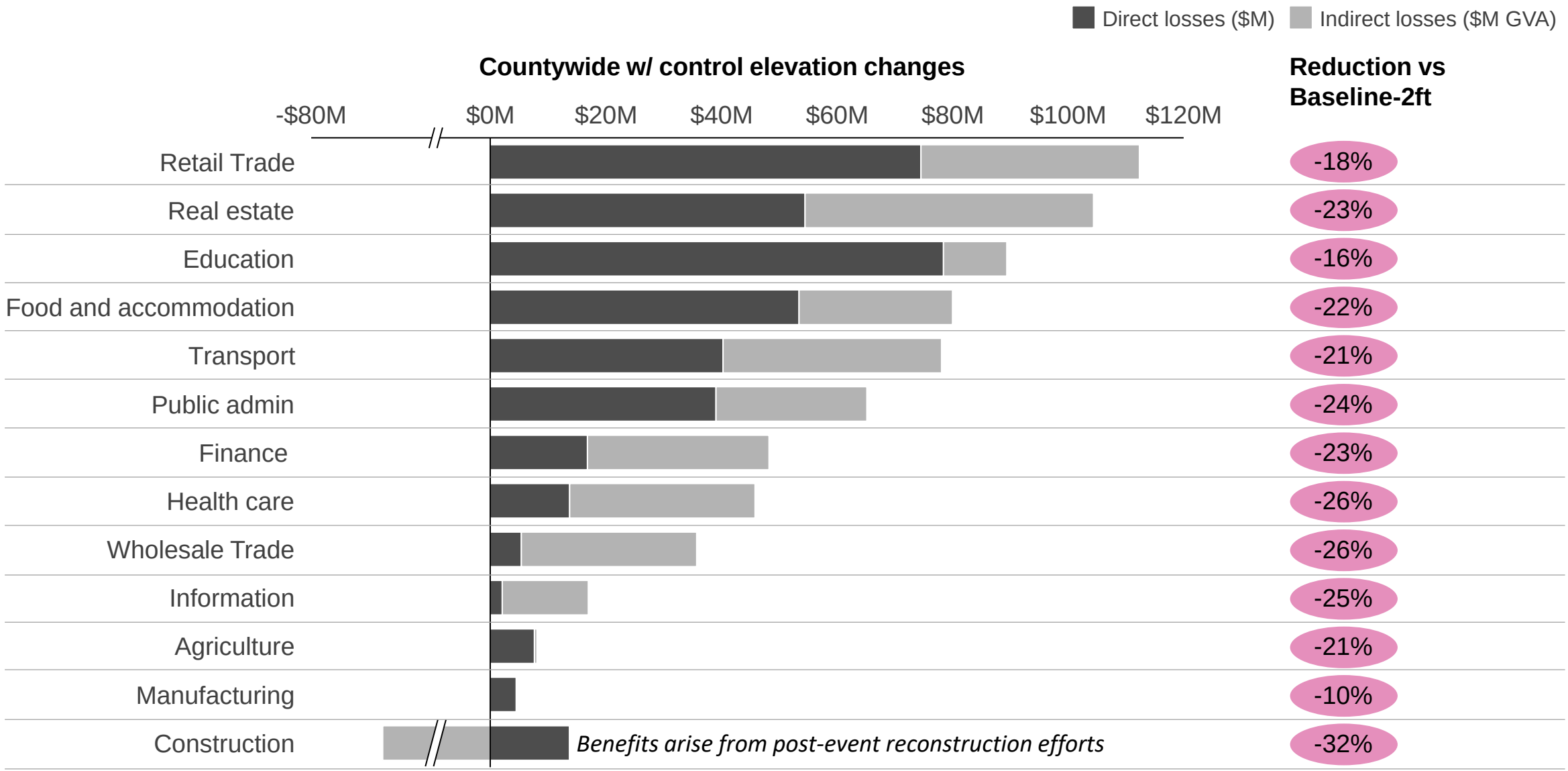


$millions in sales revenue loss

- >$100M
- $76-100M
- $51-75M
- $26-50M
- $1-25M
- <$1M

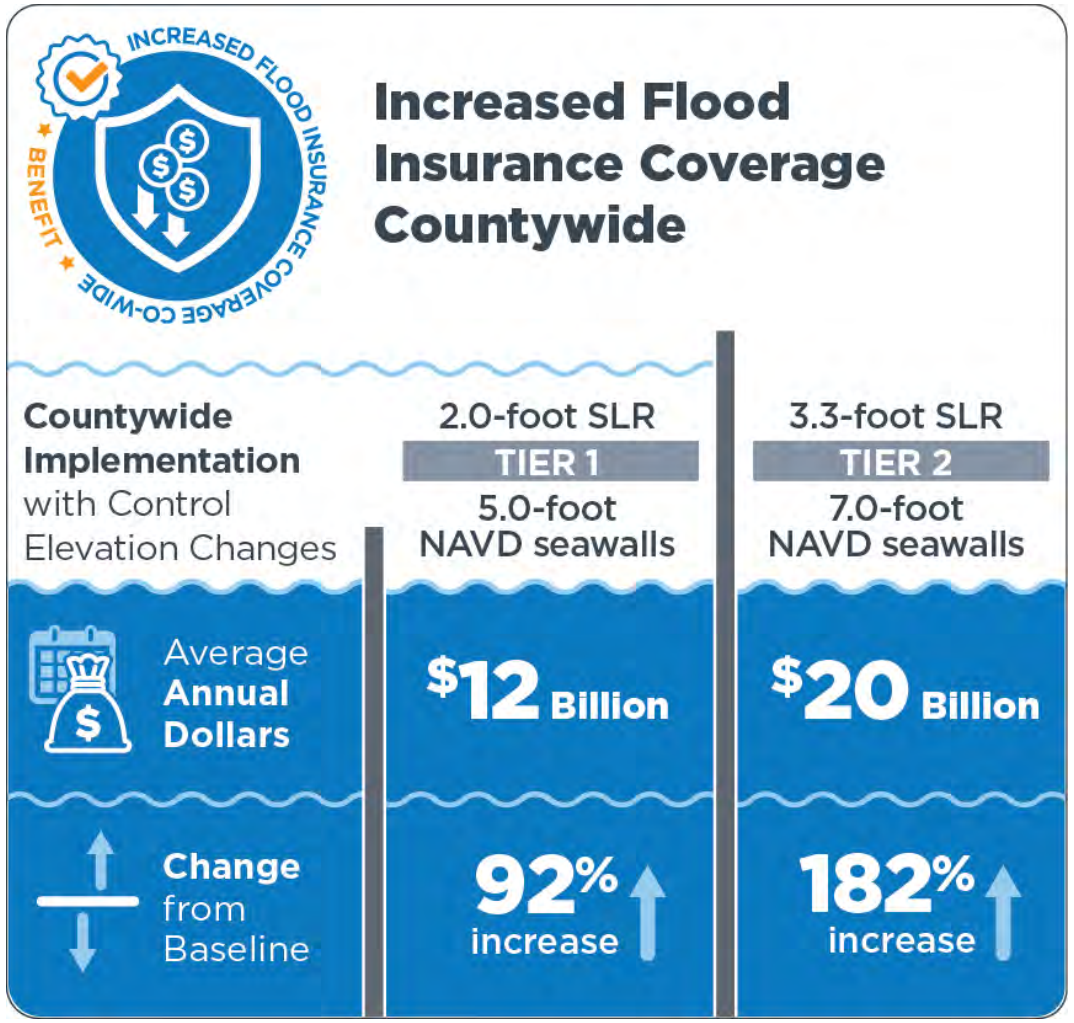
Source: Hazen, FEMA

All sectors could see a reduction in direct and indirect losses



Source: Hazen, FEMA

Tier 1 and Tier 2 Adaptation Strategies could increase flood insurance coverage countywide



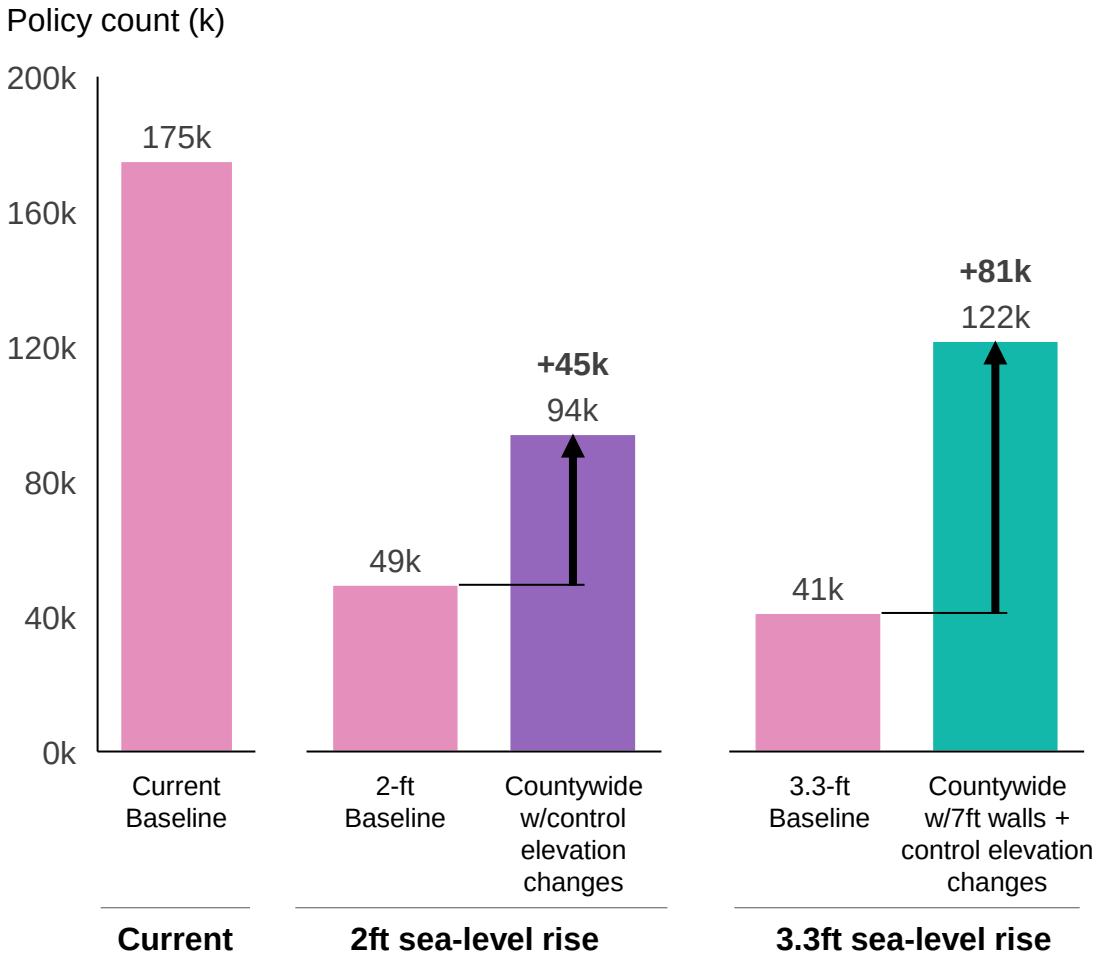
Avoided flood damages could have several benefits for insurance markets including:

- **Higher number of homes maintaining flood insurance policies** (assuming pricing is risk-based)
- As a result, **higher continued flood insurance coverage** (and less uninsured costs to households)
- **Lower average premiums** for those that maintain insurance

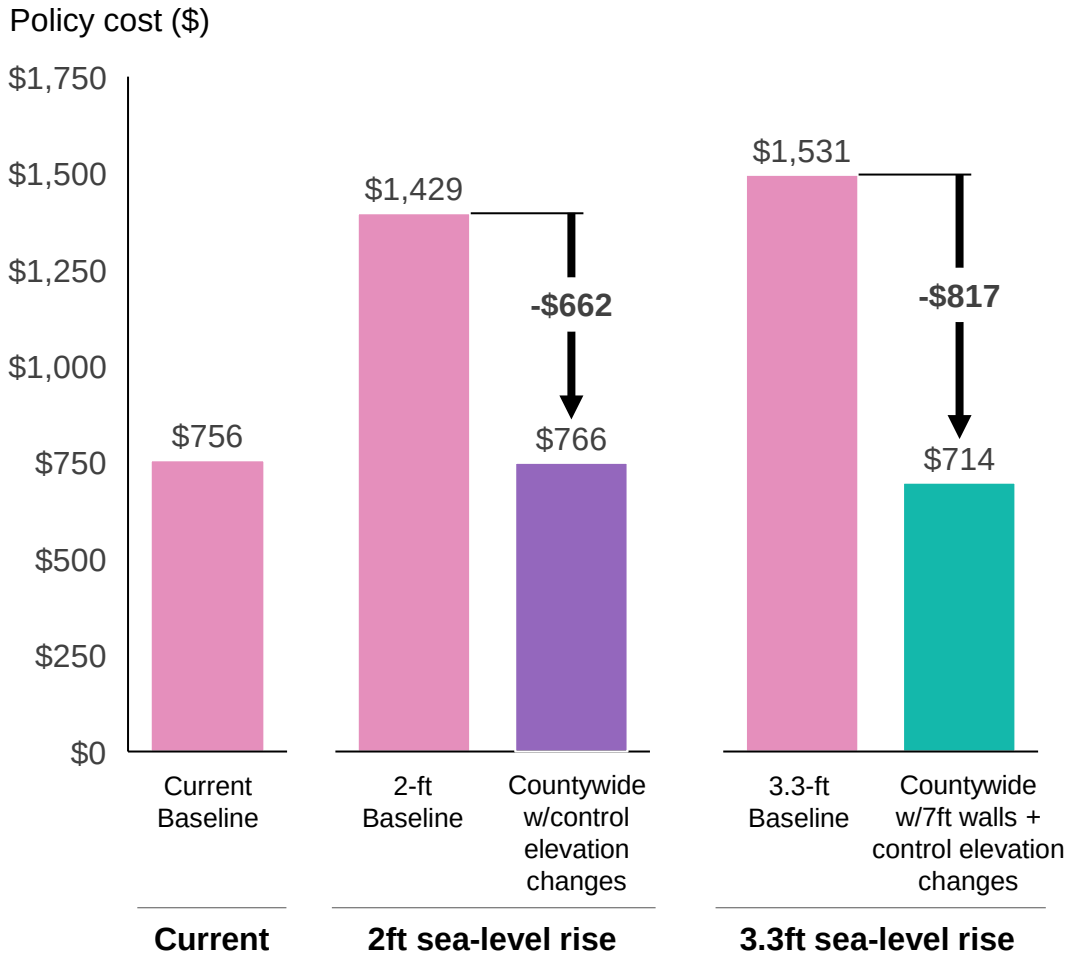
Source: Hazen, FEMA

Number of homes with insurance policies could be 45K to 81K higher, with policy premiums at similar level as today

Number of National Flood Insurance Program policies



Average insurance premiums for single-family homes



Source: Hazen, FEMA

Benefits of reduced flood insurance premia across the County are evident under both Tiers, including in vulnerable areas

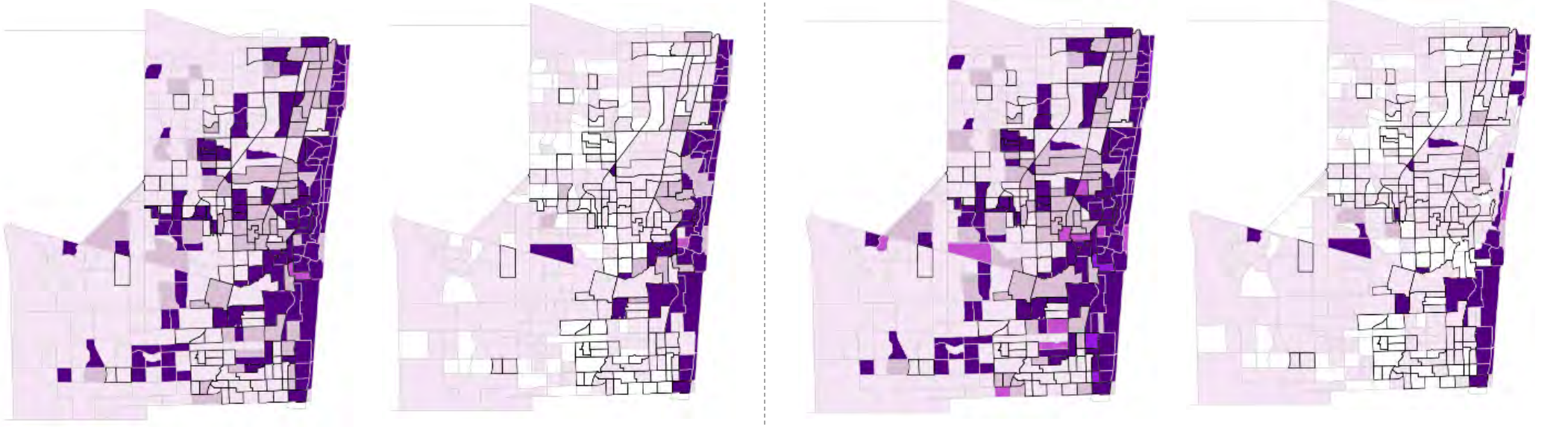
Single-family home premiums ($ premium cost) across the County

Baseline – 2ft

Countywide adaptations w/ control elevation changes – 2ft

Baseline – 3.3ft

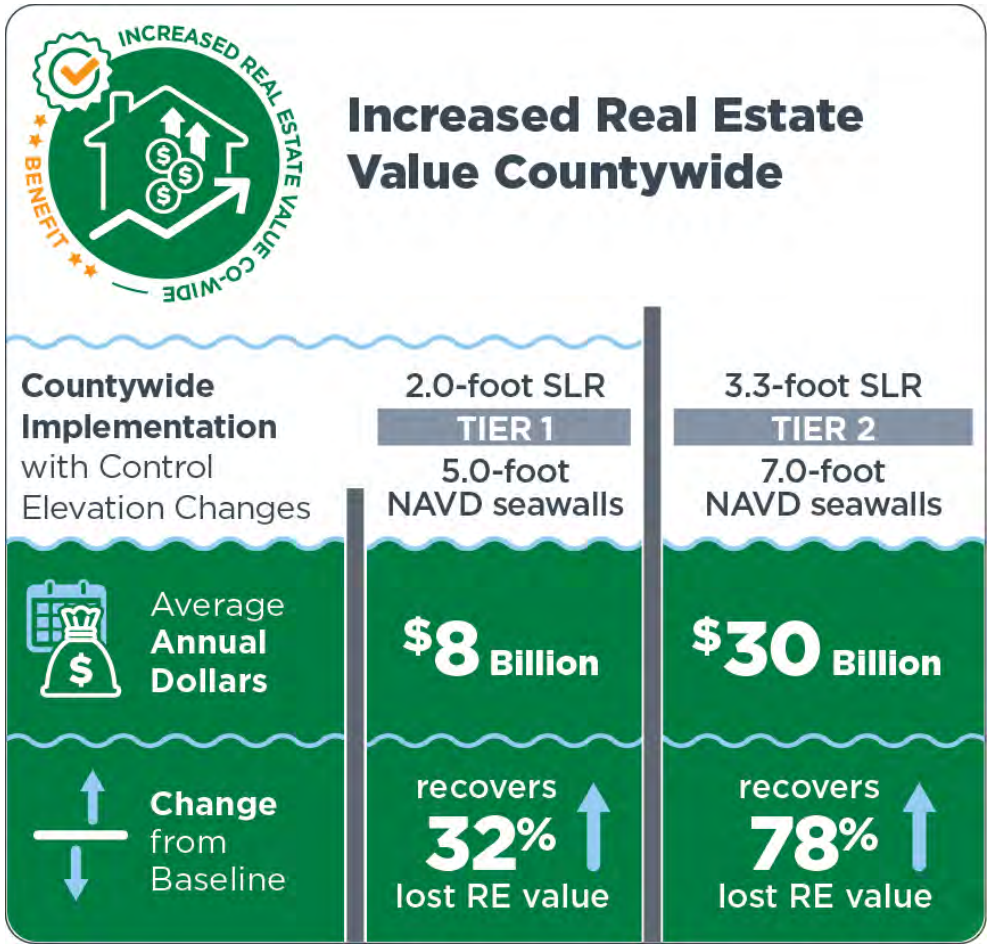
Countywide adaptations w/ control elevation & 7ft seawalls- 3.3ft



Areas outlined in black relate to zone 1

Source: Hazen, FEMA

Tier 1 and Tier 2 Adaptation Strategies could increase residential real estate values relative to the baseline



Tier 1 and Tier 2 Strategies **reduce homeowner costs and potential property de-valuation** from flooding

This reduced costs means that **property values could be higher** than it would have been under the no action baseline

It does not mean property value will necessarily increase. Other factors like the supply and demand for housing influence the value of real estate

Source: Hazen, FEMA

Benefits of higher property values across the County are evident under both Tiers

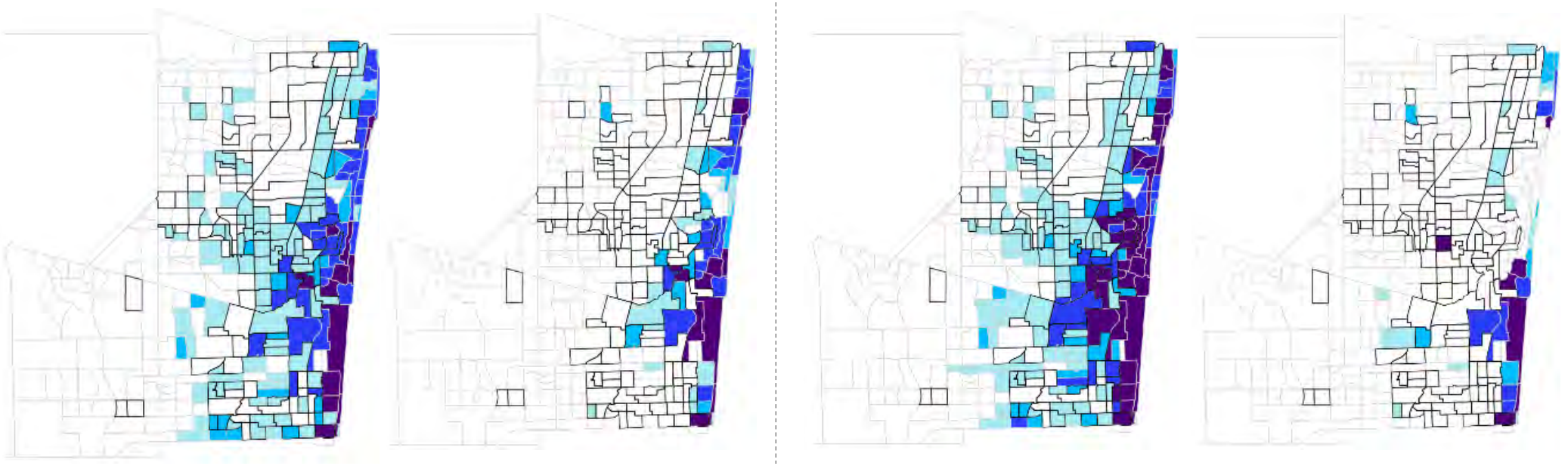
Real estate value losses across the County ($M losses)

Baseline – 2ft

Countywide adaptations w/ control elevation changes – 2ft

Baseline – 3.3ft

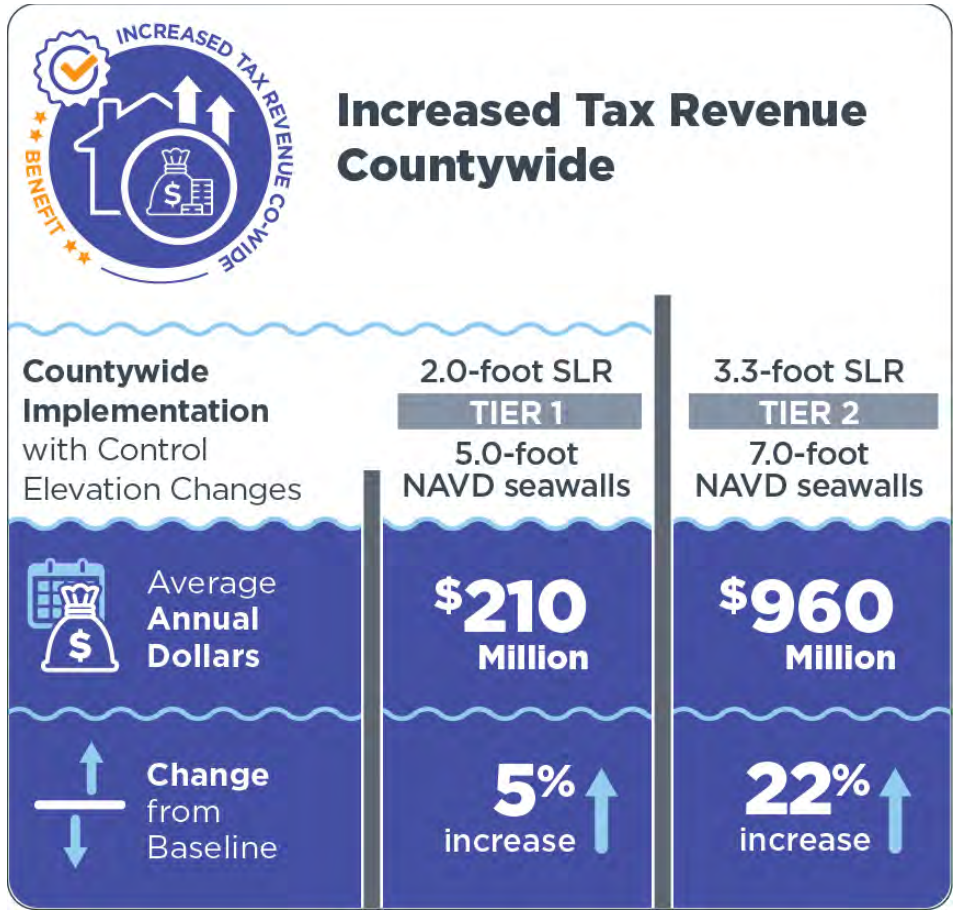
Countywide adaptations w/ control elevation & 7ft seawalls- 3.3ft



Areas outlined in black relate to zone 1

Source: Hazen, FEMA

Tier 1 and Tier 2 Adaptation Strategies could increase Business and Property Tax Revenues



The potential economic impacts discussed so far could have implications for the County's tax revenues:

- **Business tax revenue** could be affected by short-run economic losses to sales revenues and gross value added from flooding
- **Property tax revenue** could be affected as it is mainly based on market value

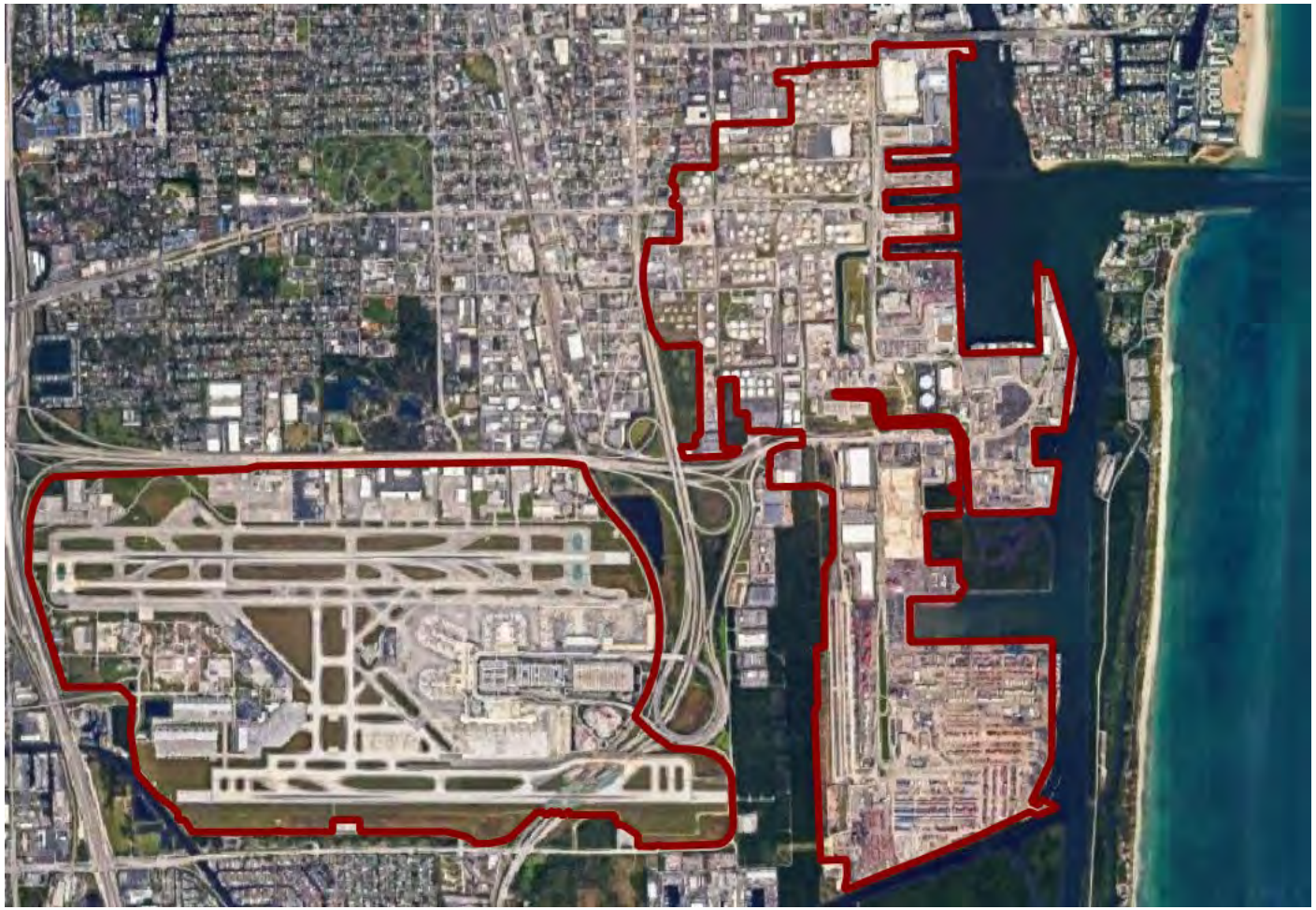
Reduced average annual impacts on both of these metrics could increase both business and property tax revenues for the County relative to the no-action baseline

Two critical pieces of economic infrastructure, Fort Lauderdale Airport and Port Everglades, could benefit from reduced operational disruption

In addition to the other benefits discussed so far, adaptation strategies could reduce impacts on two pieces of critical infrastructure:

- Downtime for key parts of **Fort Lauderdale Airport** could reduce by 50% for severe events.[1]
- Downtime for key parts of **Port Everglades** could reduce by 25-30% for severe events.[1]

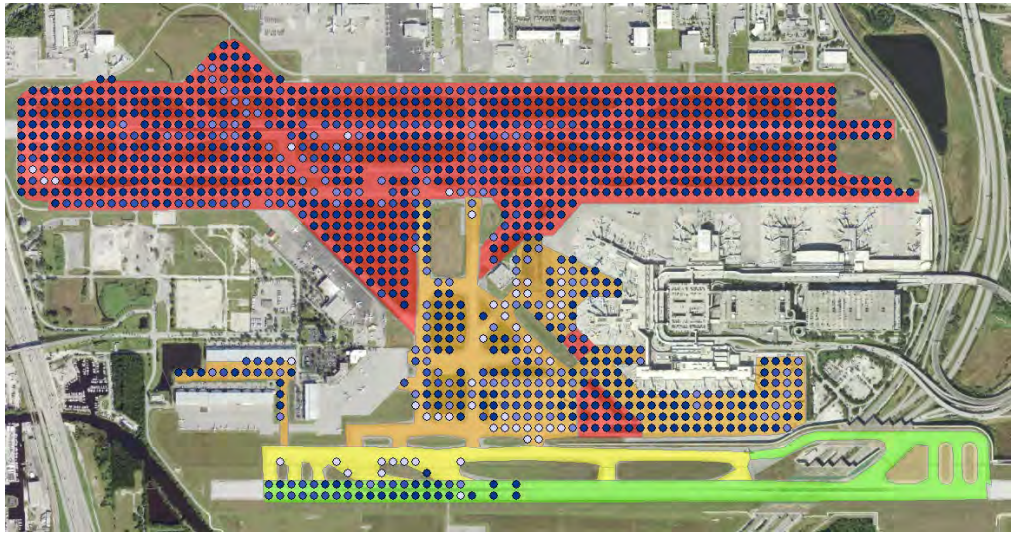
1 100-year flood event with no storm surge under 2ft of sea-level rise



Source: Hazen, FEMA

Economic losses from disruption to passengers and airlines could be lower under Tier 1 and Tier 2 adaptations

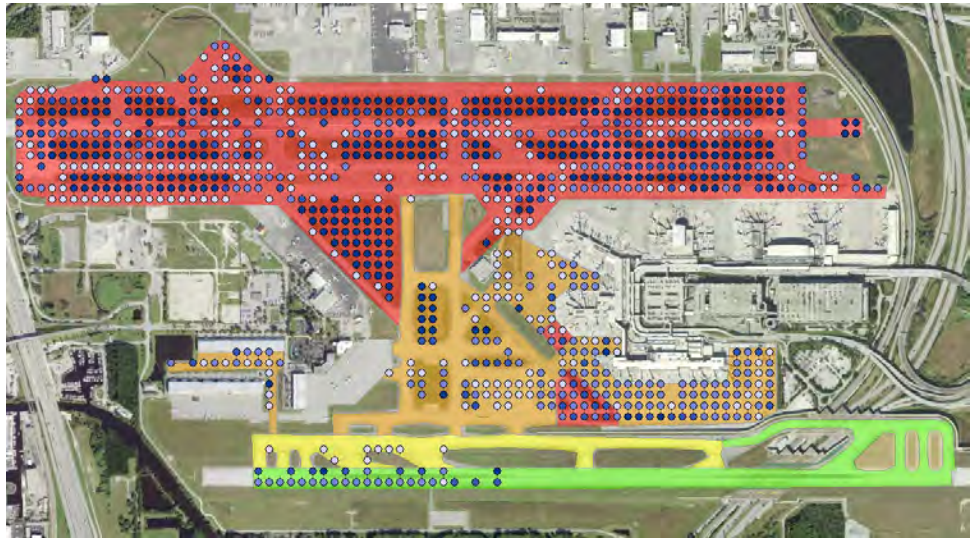
Baseline – 2ft of sea-level rise



Average flood duration across zone, annual hours

- North runway (97)
- South entrance, bridge & runway (77)
- T2,3,4 access (56)
- South runway (13)

Coast and priority areas w/ control elevation changes



- North runway (48)
- South entrance, bridge & runway (24)
- T2,3,4 access (17)
- South runway (1)

North Runway could see the **annual hours of severe flood disruption reduce by 50%** relative to the 2ft Baseline

Shorter flood events would reduce airport closures and transit problems

Source: Hazen, FEMA

… and Port Everglades could also see less disruption to its operations due to shorter flood events

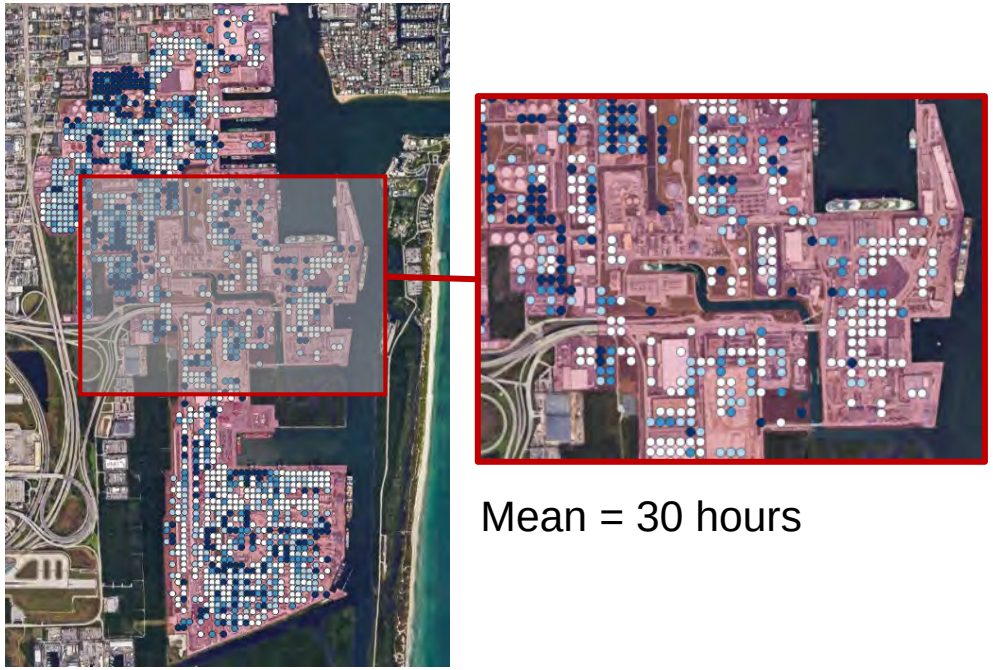
Port Everglades flood duration

Annual hours of flood duration 2.0ft sea-level rise for 100-year rainfall, no surge

Flood duration at location, annual hours

1 – 5 hours | 6 – 25 hours | 26 – 50 hours | >50 hours

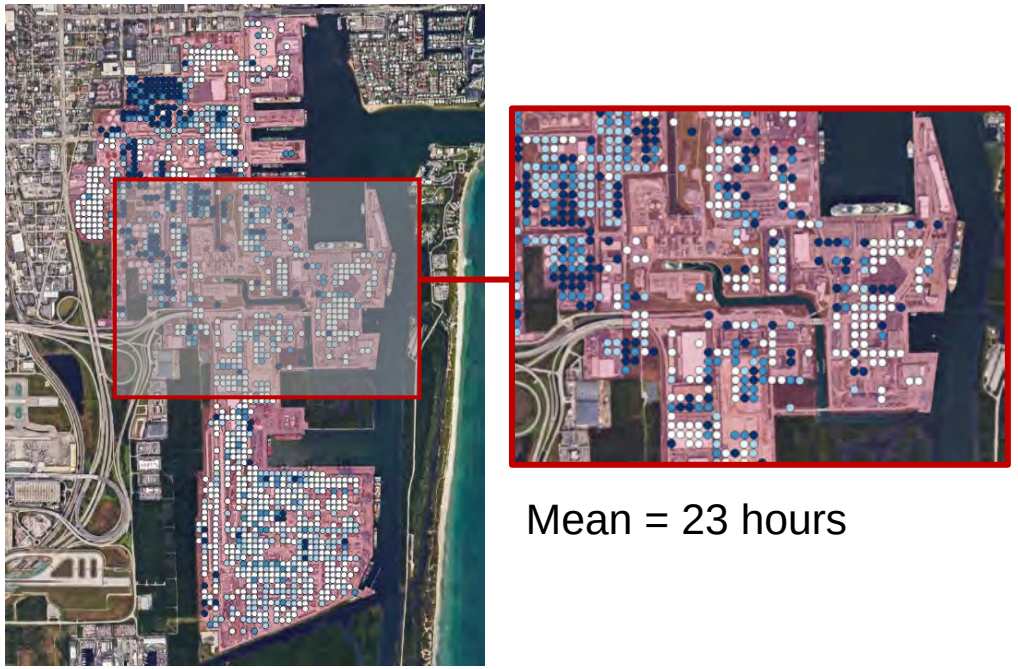
Baseline – 2ft sea-level rise



Mean = 26 hours

Mean = 30 hours

Coast and priority areas w/ control elevation changes – 2ft sea-level rise



Mean = 18 hours

Mean = 23 hours

Port access and storage areas could see the **annual hours of severe flood disruption reduce by 25-30%** relative to the 2ft Baseline

Source: Hazen, FEMA

Summary of Tier 1 and Tier 2 Benefit Value Estimates

For those benefits whose values were estimated during this study

Summary of Tier 1 and Tier 2 Benefit Value Estimates		
Benefit Category	**Tier 1 Adaptation Strategy to Mitigate 2-foot SLR**	**Tier 2 Adaptation Strategy to Mitigate 3.3-foot SLR**
Property Damage Avoided, average annual	$670,000,000	$4,000,000,000
Increased Short-term Economic Activity, average annual	$109,000,000	$660,000,000
Increased Property Tax Collected, average annual	$211,000,000	$962,000,000
Increased Flood Insurance Coverage	$12,000,000,000	$20,000,000,000
Increased Real Estate Value	$8,000,000,000	$30,000,000,000

Other benefit categories were not estimated during this study

These additional benefits of the Tier 1 and Tier 2 Strategies also help stabilize the County's wellbeing and economy by reducing negative impacts of sea-level rise.

Tier 1 and Tier 2 adaptations would be expected to mitigate these negative effects from increased flooding that further erode the County's economy and wellbeing beyond that valued during this study:

- **Disruption to public services** such as power grids and road networks that can propagate to other services (e.g. communication and health care) with cascading effects on health and wellbeing.
- **Reduced investment** as perceived investment risk grows resulting in higher borrowing costs and potentially stifling economic investment, growth and wellbeing.
- **Demographic change** as quality of life and public safety suffer causing increased out-migration and lower in-migration resulting in lower consumer demand, employment, real estate value, and tax revenue.
- **Reduced tourism** capacity and the County's attractiveness as a vacation destination, resulting in a contraction of the County's economy.
- **Harmful human capital impacts** include physical and mental health problems, reduced household productivity and wealth, constrained education, and diverted public money away from productive investments to flood rehabilitation.

Mitigating these negative impacts are benefits of the Adaptation Strategies

Estimated Capital and Annual Cost of the Conceptual Tier 1 and Tier 2 Adaptation Strategies

Based on conceptual plans

Estimated Costs of the Tier 1 and Tier 2 Adaptation Strategies, 2024 dollars			
Item	Tier 1	Tier 2	Additional Cost of Tier 2 Once Tier 1 is Constructed
	Countywide - 5ft NAVD seawalls	Countywide - 7ft NAVD seawalls	
(1)	(2)	(3)	(4) = (3) – (2)
Capital Cost (a)	$15,300,000,000	$20,000,000,000	$4,700,000,000
Annual O&M and R&R Cost (b)	$153,000,000	$200,000,000	$47,000,000

(a) Capital cost includes real estate, construction, engineering design, permitting, and construction management.

(b) O&M stands for Operation and Maintenance and R&R stands for Renewal and Replacement. The total cost of these items is estimated at 1% of the Tier's Capital Cost.

Benefit Cost Analysis of Tier 1 and Tier 2 Adaptation Strategies

Estimated annual benefits and costs used to calculate present value of net benefits and investment rate of return

Assumption	Tier 1 – Countywide with Control Elevation Changes and 5ft NAVD Seawalls Under 2ft SLR	Tier 2 – Countywide with Control Elevation Changes and 7ft NAVD Seawalls Under 3.3ft SLR
Study Period	100 Years from 2025 to 2125	100 Years from 2025 to 2125
Year Construction Begins	2026	2051
Year Construction Completed	2050 (25 years)	2070 (20 years)
Year Benefit Phase-In Begins (a)	2031 at increments of 500 basis points per year (5% incremental increases each year)	2051 at increments of 500 basis points per year (5% incremental increases each year)
Years 100% of Benefits Realized	2050 to 2125	2070 to 2125
(a) Considers the proportion of the Tier constructed and a phase-in of the 2.0ft and 3.3ft sea-level rise (SLR) scenarios		

Estimated Benefit Cost Ratio and Investment Rate of Return Reported Here are Minimum Values

Benefit categories included:

Property Damage Avoided – Yes

Increased Economic Activity (directly affected by flood and resulting induced impacts) – Yes

Increased Real Estate Value – 60% of estimated value to account for changes in values not estimated – increased flooding depresses prices of nearby directly affected properties and increases prices of properties not as affected by sea-level rise.

Flood premium savings – No, accounted for in Property Damage Avoided

Reduced Property Taxes Collected – No, this is an in-county transfer of income from people to government

Benefit categories to include if values were estimated:

The increased economic activity (GVA) from:

- Avoided disruption to public services
- Increased investment
- Avoided population exodus
- Increased tourism
- Favorable human capital impacts

Tier 1 and Tier 2 Estimated Rate of Return on Investment and Benefit-Cost Ratio

Benefit Cost Analysis of Tier 1 and Tier 2 Investments to Mitigate Flood Risk			
Benefit Categories are Estimated Avoided Property Damage, Increased Economic Activity, and Increased Real Estate Value			
Economic Metric	Tier 1 and Tier 2	Tier 1 Only	Marginal Value of Tier 2
(1)	(2)	(3)	(4) = (2) - (3)
Rate of Return on Investment (a.k.a. internal rate of return), real annual	At least 9%	At least 2%	

There is Uncertainty in the Estimated Benefits, Costs, and Timing of Tier 1 and Tier 2 Adaptation Strategies

Largest source of uncertainty is timing and extent of sea level rise (SLR):

- This analysis used a case study of 2.0-foot SLR by 2050 and 3.3-foot SLR by 2070.
- Significant deviations in SLR will impact the need for and optimal timing of the measures that comprise each Adaptation Strategy.
- Given these SLR scenarios, the best available information was used to assess benefits, costs and ROI.

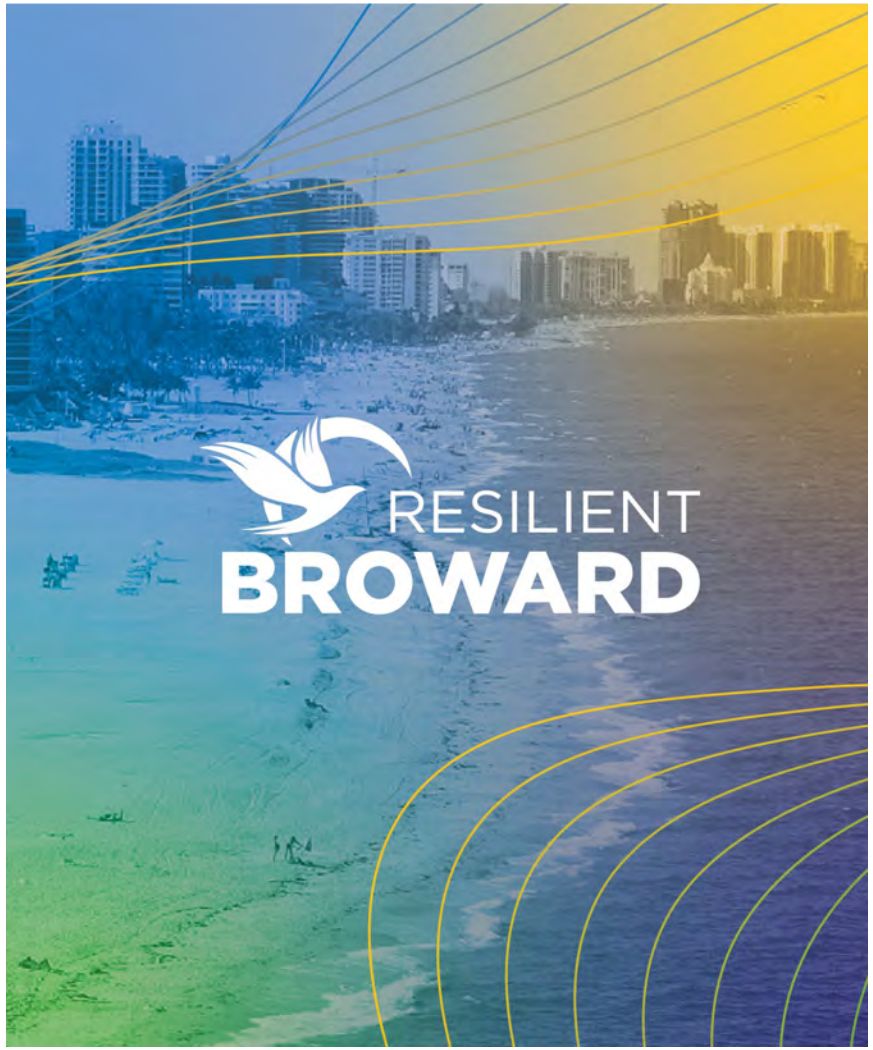
Other uncertainties are those typical when evaluating conceptual projects:

- Land uses, economic conditions and drainage infrastructure existing at the time of this study could be different during engineering design and construction resulting in differences in benefits and costs.
- While the data used to assess damages and economic activity are of good quality, human and business responses to emergencies, regulations, incentive systems, and prices do not always mimic their past behavior as reflected in the historic and current data used in this study.

For these reasons, the economic feasibility of adaptation measures and strategies should be revisited on a regular basis as investment decisions are being contemplated.

Conclusions from the Economic Evaluation

- Economic analysis provides solid demonstration of positive benefits to be realized with organized resilience investments implemented county-wide.
- Tier 1 strategies provide 19 municipalities with a 40% reduction in flood damage (or greater), increasing to 24 municipalities with tier 2, when overall damages are reduced 97% county-wide.
- Accordingly, coupled Tier 1 and Tier 2 implementation substantially mitigate negative economic consequences across our community.
- Economic findings show positive results for all metrics assessed, including at least $660M in preserved economic activity, $30B in preserved property value, $4 Billion in avoided damage, and preservation of flood insurance coverage and prices.
- This plan, when implemented, is anticipated to substantially aid the county's near and long-term economic position, with a comprehensive resilience approach that reinforces the county's commitment to both understanding and addressing climate risk.
- Ultimately, the Broward community is the heart of the plan, with the goal to deliver a more stable environment that protects our residents, businesses, assets, and jobs – with new opportunity for all who live, work, and play in Broward County.

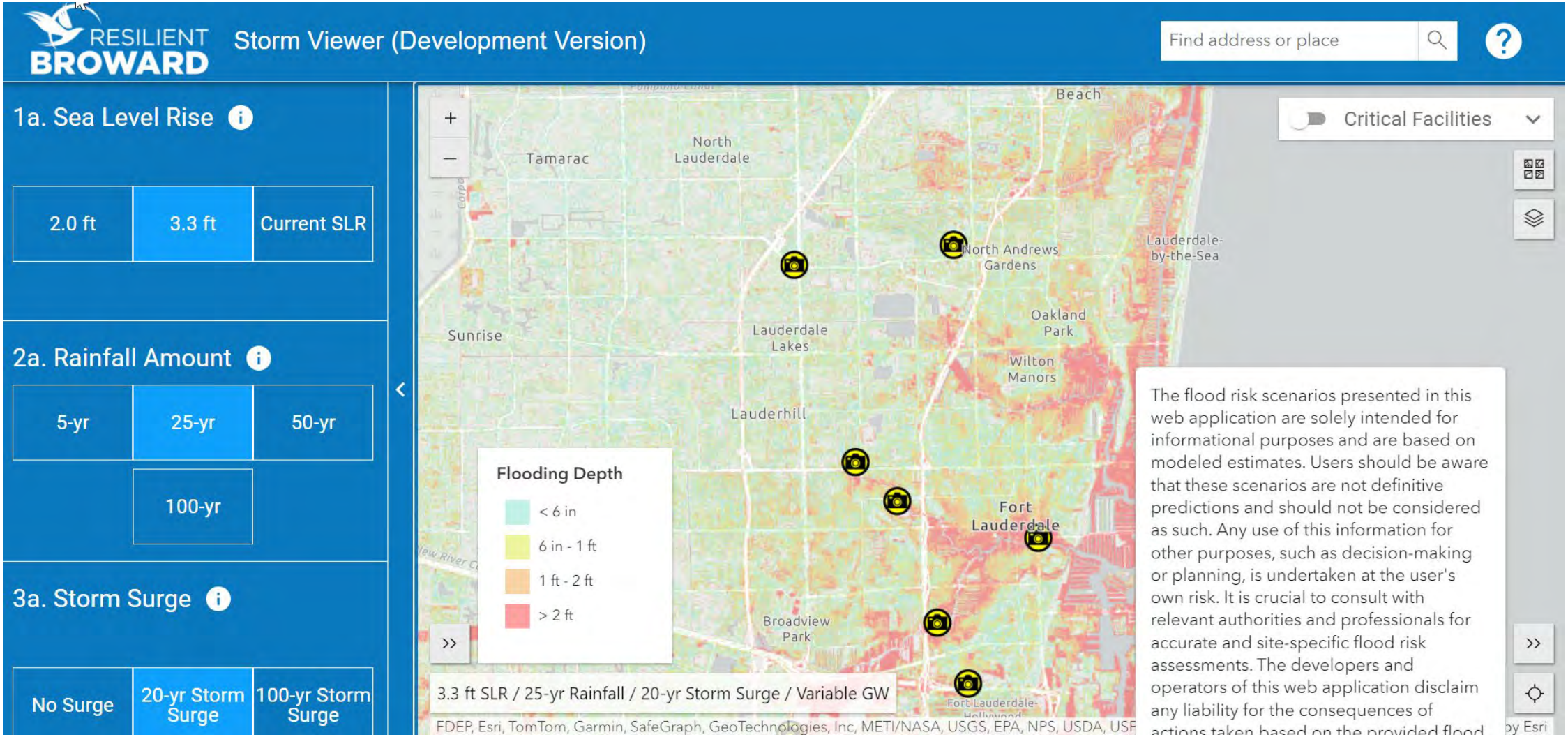


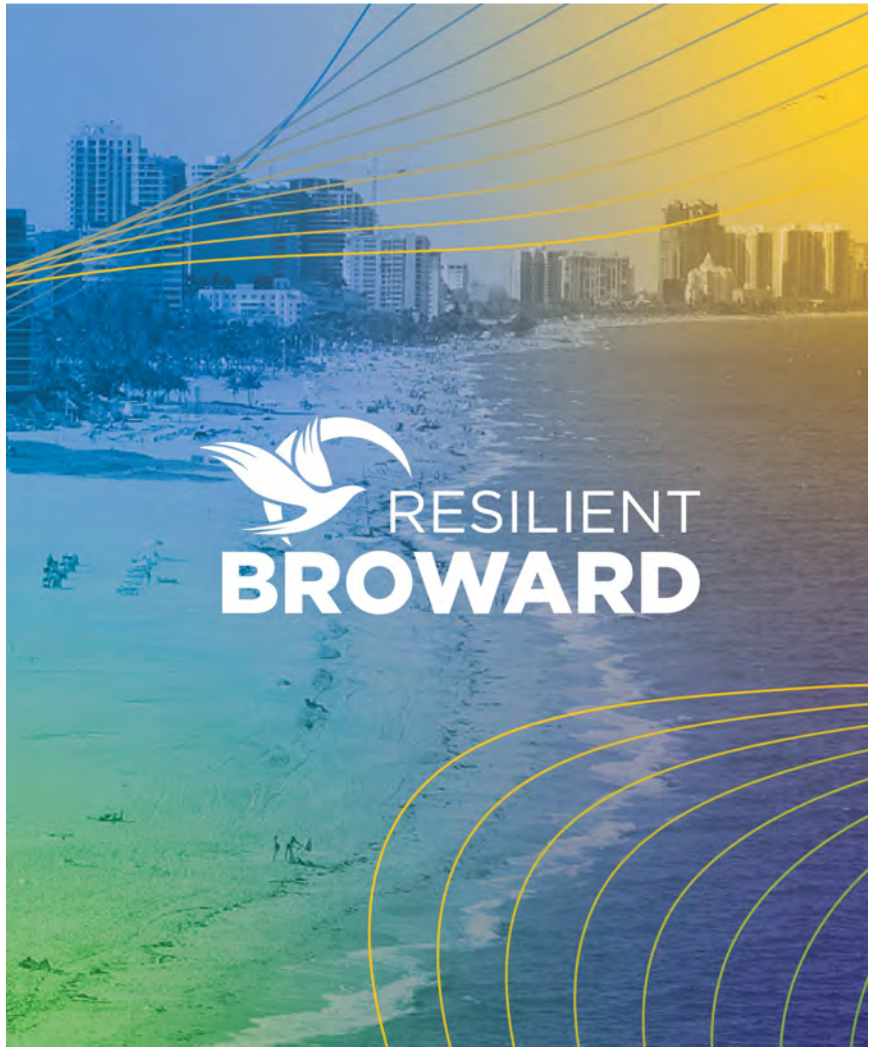
5

Flood Viewer

Hazen

Interactive Flood Viewer Allows Performance Comparison of Adaptation Strategies





6

Conceptual Site Representations

Hazen

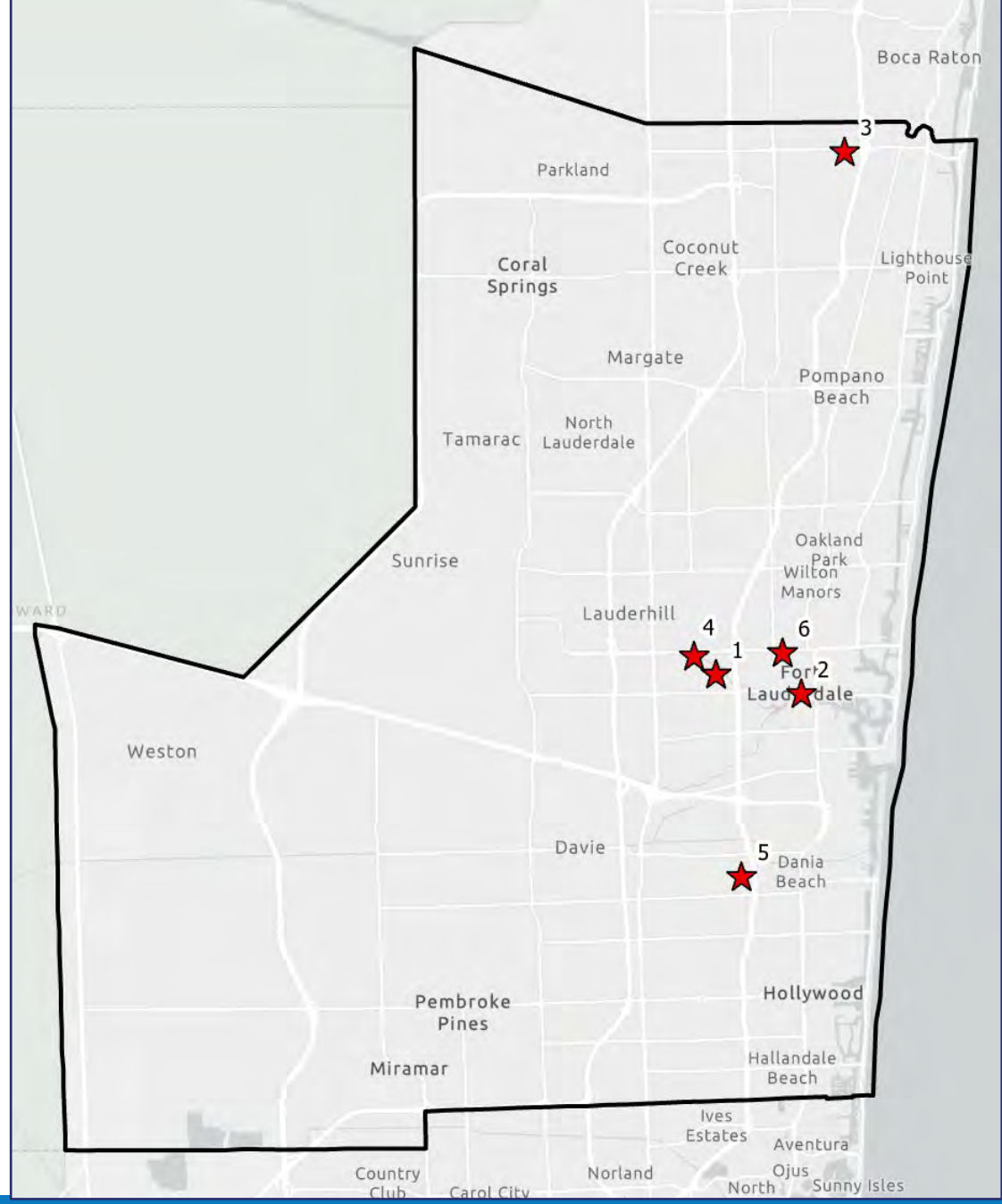
Broward County Asset Sites Conceptual Representations

PURPOSE

- **Develop tailored adaptation concepts** for county-owned assets, focusing on reducing flood risk, managing heat, and ensuring service continuity through optimized green infrastructure and the use of open spaces for water storage and treatment.
- Serve as a **toolbox for adaptable solutions** applicable to similar county properties.

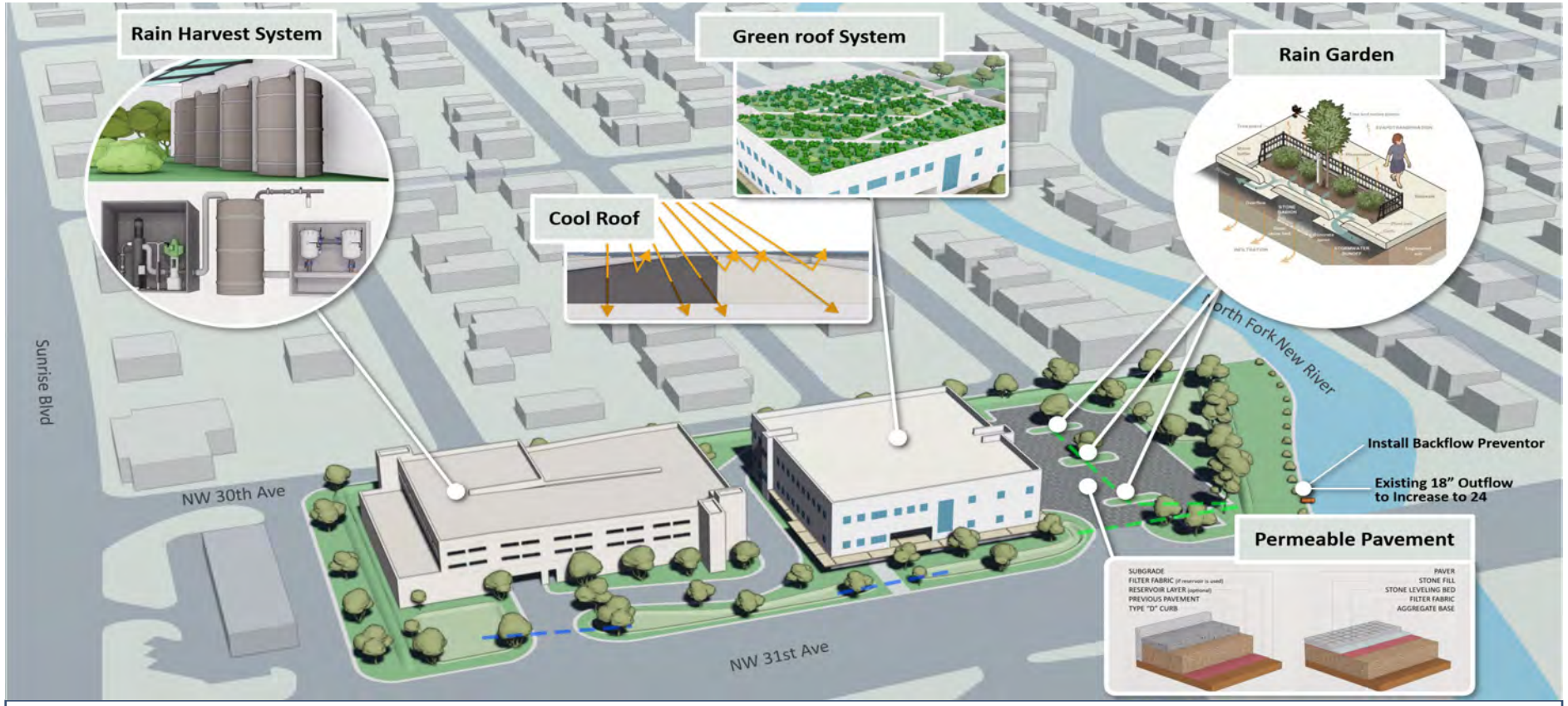
SELECTED SITES

1. African-American Research Library & Cultural Center
2. Main Library
3. North Regional Courthouse
4. Edgar P. Mills Center
5. South Mass Transit
6. Central Homeless Assistance Center



Edgar Mills Multi-Purpose Center

Concept Overview Example



Conceptual Solution

The proposed concept design integrates a multi-faceted approach to enhance both flood and heat resiliency. A cool or green roof system mitigates heat and absorbs rainwater, while a rainwater harvesting system captures and stores water for reuse, reducing runoff. Permeable pavement facilitates ground infiltration, easing stormwater management. Interconnecting existing ponds balances water levels to prevent flooding, and the installation of backflow preventers and larger outfall pipes ensures effective drainage during heavy rainfall and North Fork New River. Together, these solutions create a robust, resilient urban environment.

Site Size: 3.2 Acres
SLR: 2 ft
Rain: 25 yr. and 100 yr
Assumed FFE: 8.2 ft (NAVD)
BFE (FIRM): 8 ft

Site Characteristics:
- 68% impervious
- Existing berm around property
- Outfall to water body
- Multi-level- Parking Structure

Target Site Volume
- 25 yr Rainfall: 0.80 MGal
- 100 yr Rainfall: 1.1 MGal

Concept Elements
- Rain harvesting system
- Green Roof/Cool Roof
- Permeable Pavement
- Backflow Preventor
- Bioretention
- Drainage resize

Countywide Risk Assessment and Resilience Plan (DRAFT)

BROWARD COUNTY FLORIDA

Hazen

August 2024

Conceptual Design – Not for Construction

Proposed Solution Details – Edgar Mills Multi-Purpose Center

Stormwater Management

Rainwater harvesting system

- **Total Area**: 0.50 Acres
- **Stormwater Management**: Manage up to 100,000 gal. runoff volume. Concept Design of 40,000 gal.

- **Pervious Pavement**
- **Total Area**: 0.57 Acres
- **Stormwater Management**: Designed to manage up to 10% of the 25-year, 72-hour storm volume

- **Storage Interconnectivity and Collection**
- **Stormwater Management**: Interconnect existing pond system for storage balance.
- Backflow preventor valve on outfall
- Increase outfall pipe size

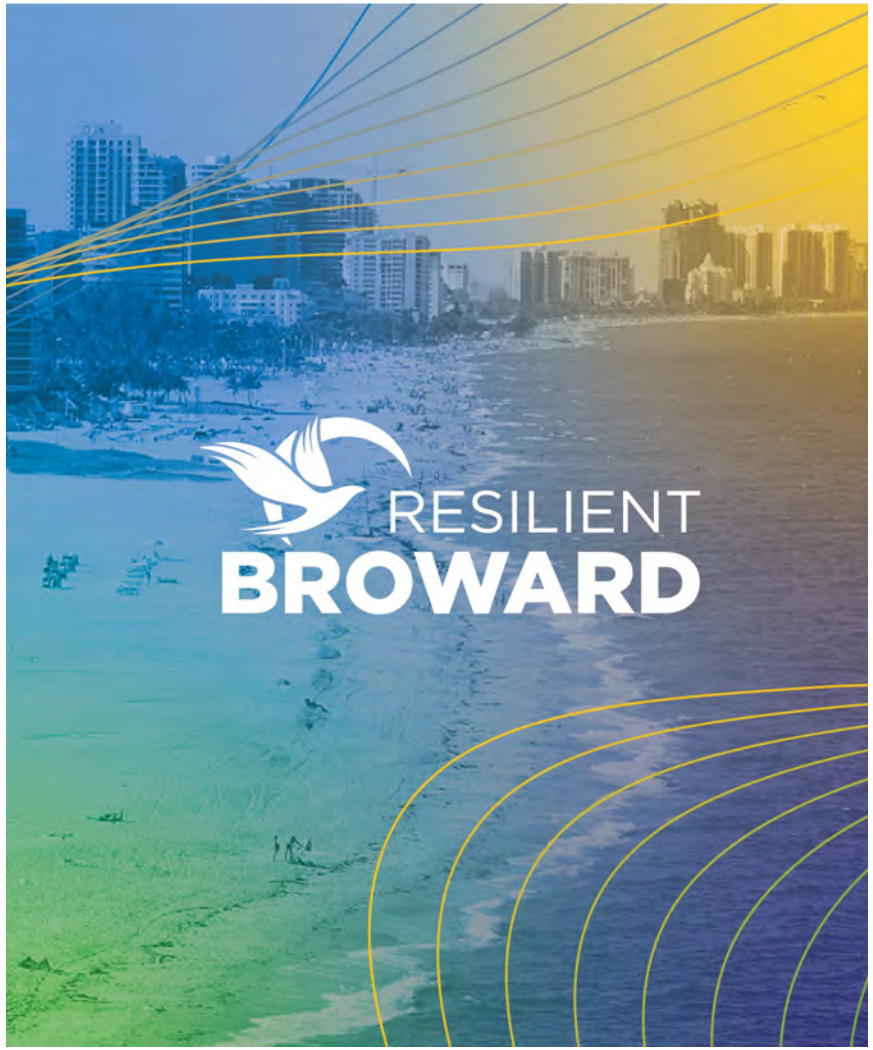
Solutions for reducing heat impact
Area: 0.43 Acres

	Green Roofs	Cool Roofs
Cooling Impact	Reduces heat through insulation and vegetation	Reflects solar radiation to lower roof temperature
Energy Savings	Long-term energy efficiency (natural insulation)	Immediate energy cost reduction
Environmental Impact	Manages stormwater, creates habitats	Limited to reducing heat island effect
Maintenance	Requires regular maintenance (watering, weeding)	Low maintenance (occasional cleaning)
Structural Constraints	Heavier, may require additional structural support	Lighter, easier to implement

$ Concept Cost Estimate

	Qty	Unit Price	Total
Pervious Pavement	24,829 sq-ft	$30 (sq-ft)	$744,870
Rainwater System	1 - 40,000 gal.	$200,000	$200,000
Green Roof	18,730 sq-ft	$ 30.00	$561,900
Cool Roof	18,730 sq-ft	$10.00	$187,300
Pipes and trenches	100 LF	$300.00	$ 30,000
Backflow preventor	1	$20,000	$20,000
Bio-retention	600 ft^2	$25.00	$15,000

Conceptual cost estimate is variable depending on site conditions



7

Property Scale Proposals

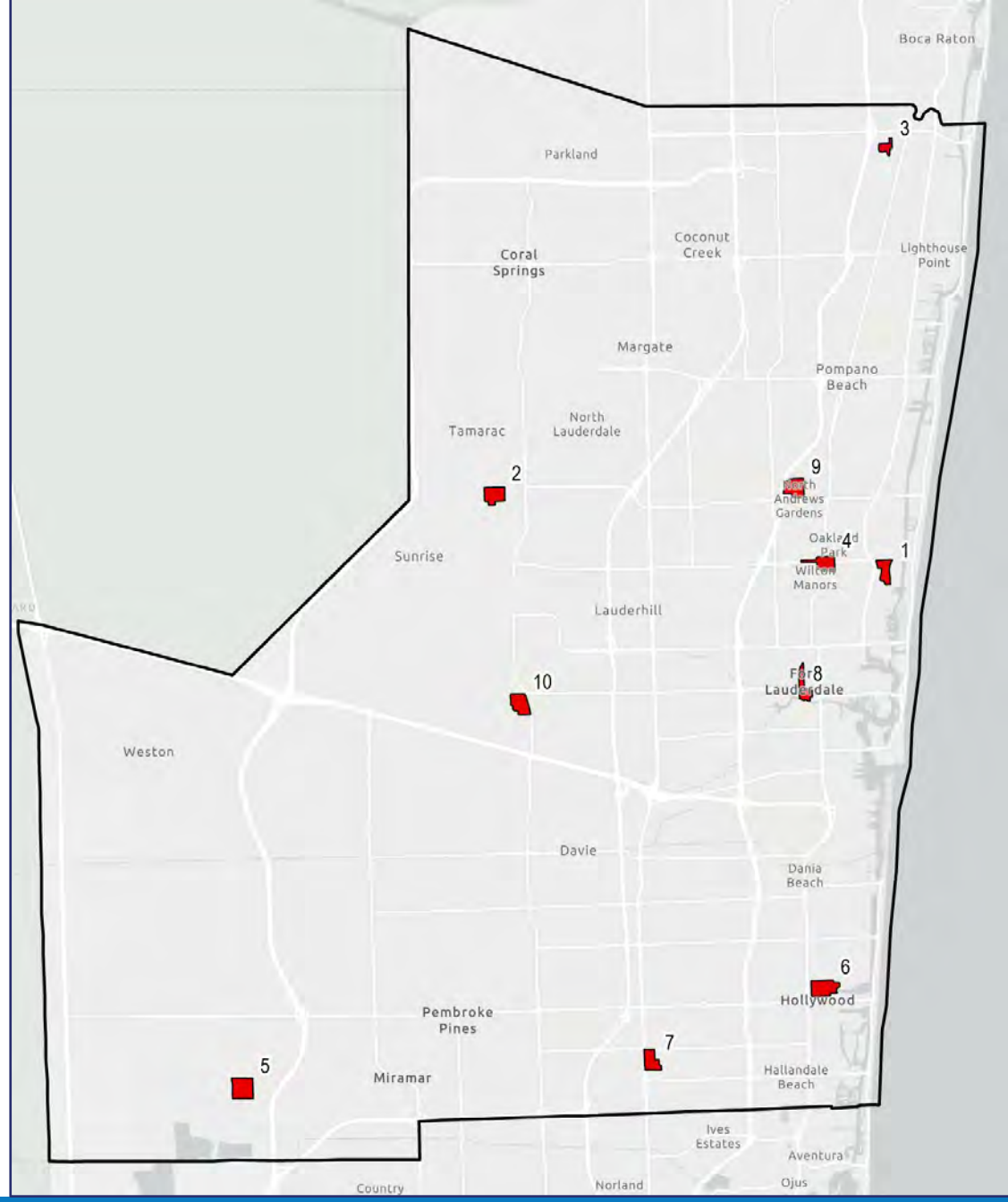
Hazen

Broward County Property Scale Proposals

PURPOSE

- **Provides examples of infrastructure improvements** for municipalities, developers, etc. to consider when evaluating redevelopment
- **Encourages incorporation of green infrastructure** first
- **Delineates conceptual costs** of improvements

Reminder: Property scale proposals are examples for reference for other similar locations and are <u>not intended</u> to be specific recommendations for any particular site.



Ten Sub-basin (“Property Scale”) Proposals were identified to capture representative concepts for adaptation implementation

1 - East of coastal control structure (Fort Lauderdale)

2 - West of the coastal control structure (Lauderhill)

3 - Exhibits extreme flooding and within LMI/FEMA (Deerfield Beach)

4 - LMI/FEMA/highly developed (Oakland Park)

5 - Highly pervious (Miramar Regional Park)

6 - Near Beach/Intracoastal (Hollywood)

7 - Conversion of large impervious to pervious (West Park)

8 - Highly urbanized downtown (Fort Lauderdale)

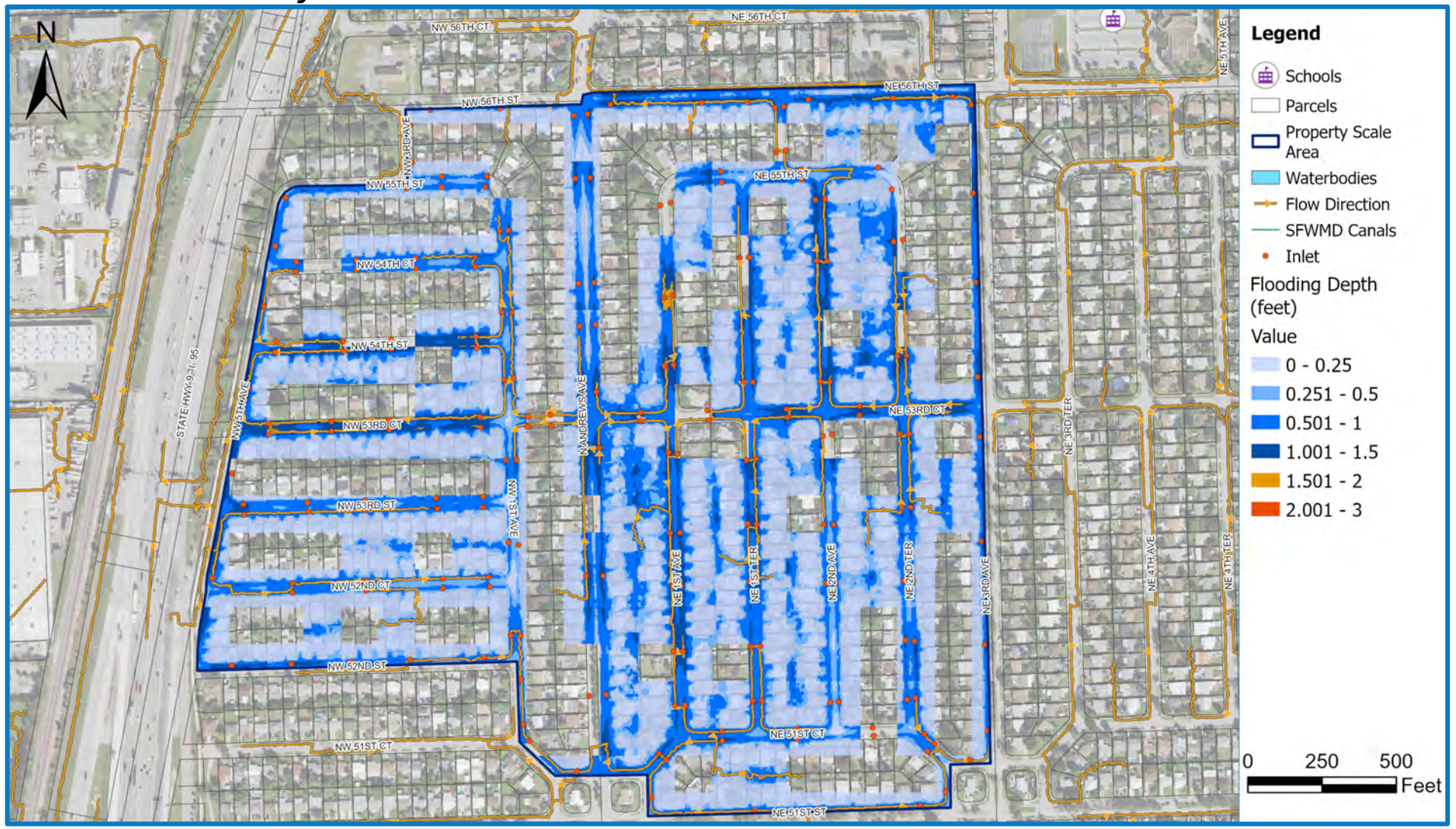
9 - Older residential development (Oakland Park)

10 - Large commercial re-development (Plantation - Broward Mall)

Example #9 – Older Residential Development

Property Scale Proposal #9 – Older Residential Developments (Oakland Park)

Medium Density Residential



Municipality
Oakland Park, North Andrews
Area
123 acres

Percent Impervious	Groundwater Depth
65%	3.5 ft
Target Design Storm Volume*	
23.3 million gallons	
Average Flooding Depth*	**Max Flooding Depth***
0.4 ft	2.1 ft

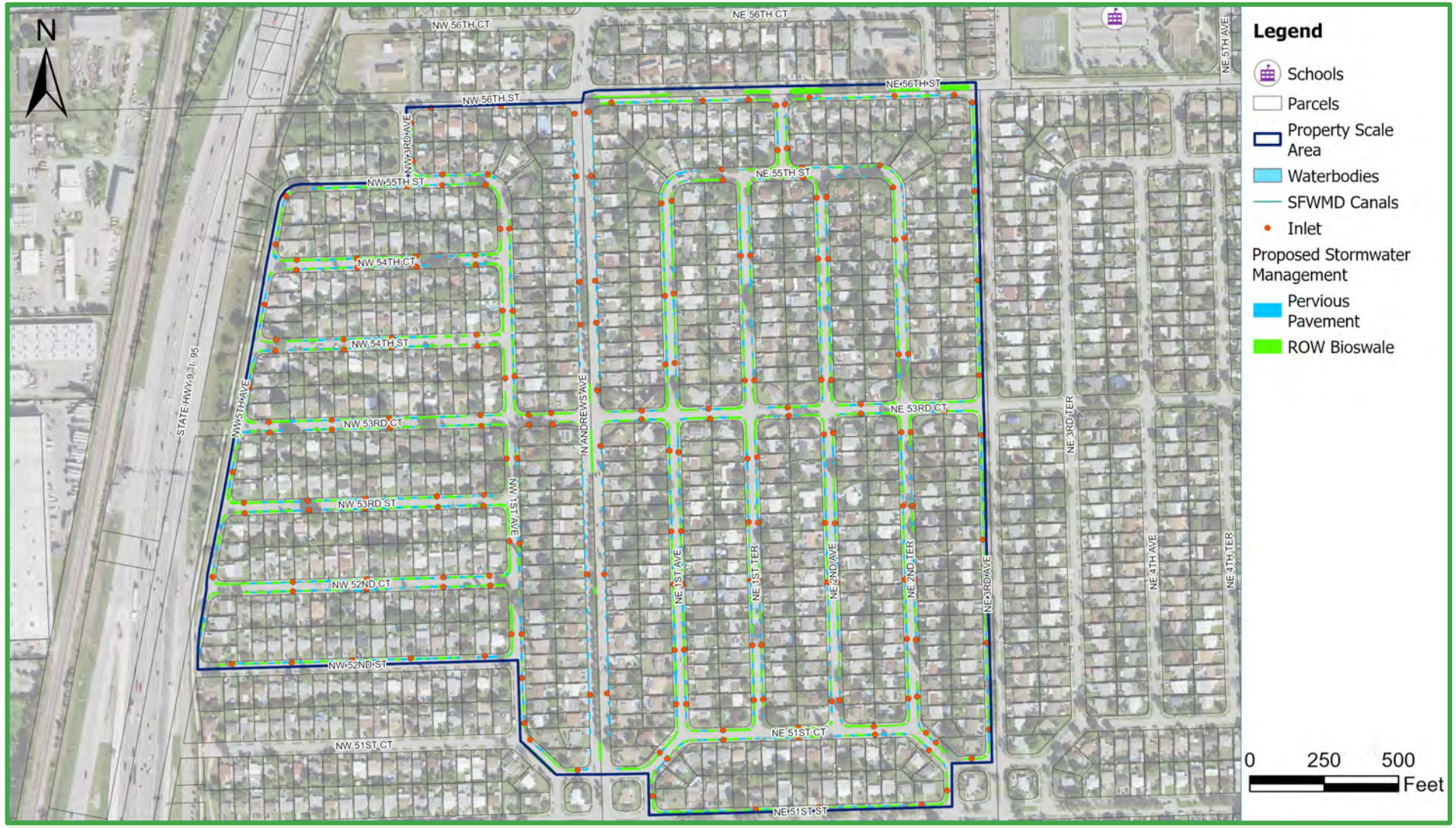
*Based on target design storm scenario 10-yr, 72-hr, 2ft SLR, no surge

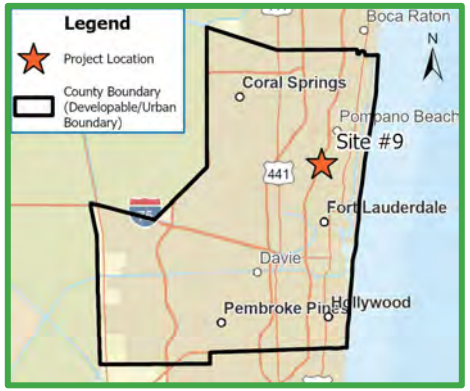
Existing Conditions

This medium density residential neighborhood is primarily older, single-family homes with residential streets. N. Andrews Avenue is a local thoroughfare road with a bus route intersecting the neighborhood. This community experiences frequent shallow flooding, and topography and drainage typically flows to the southwest. Critical infrastructure in the vicinity includes two nearby schools, North Andrews Garden Elementary school to the north of NE 56th and Northeast High School to the east of NE 6th Avenue. The 10-year, 72-hour storm event with a 2-foot level sea level rise condition creates wide-spread flooding through the neighborhood. Parcels typically experience <6 in of flooding while streets experience up to 2 feet of flooding in some pockets throughout the neighborhood.

Property Solution Overview – Property Scale Proposal #9

Short-Term Solution: Right-of-Way Green Infrastructure





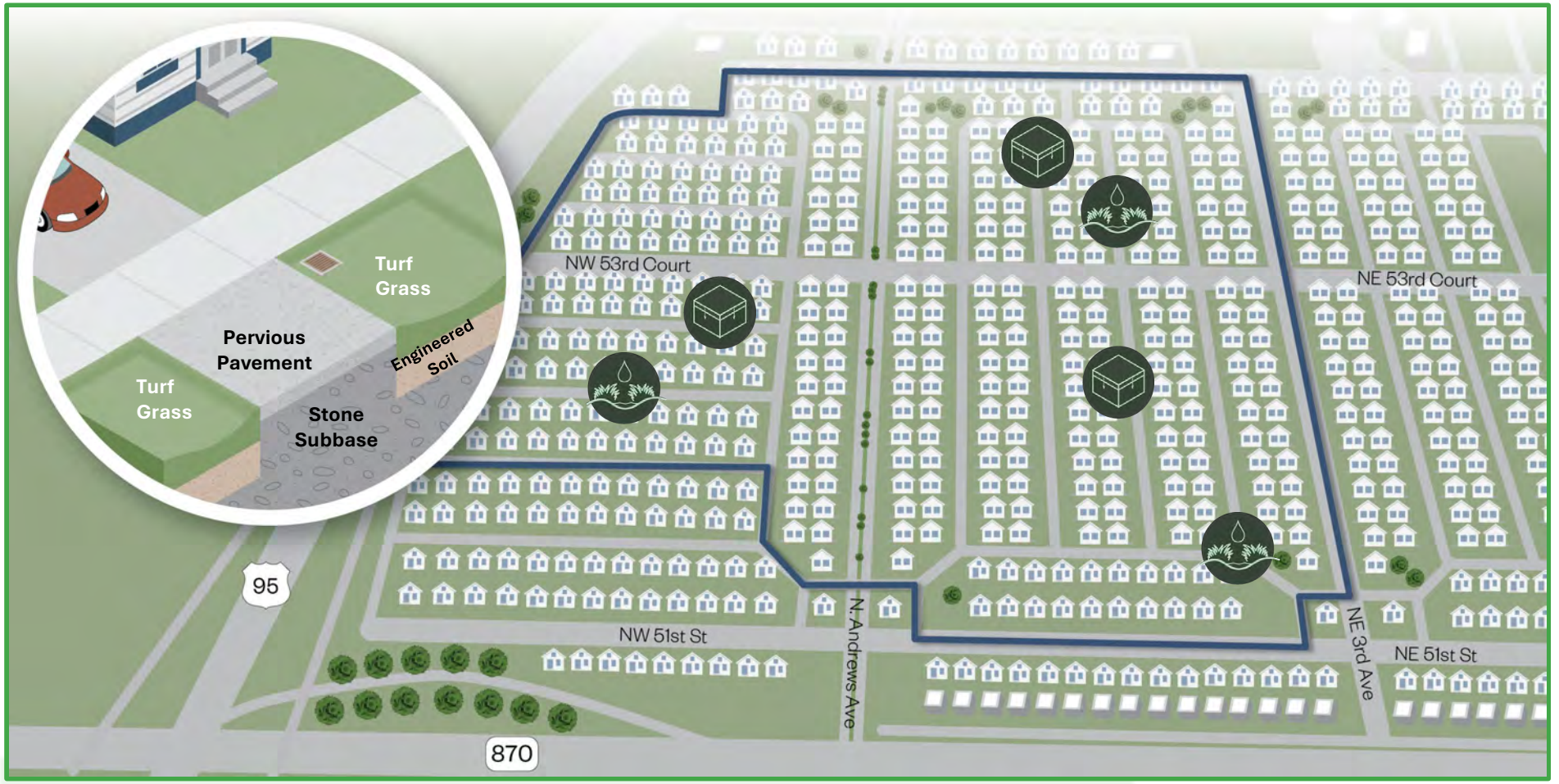
Stormwater Volume Managed	
2.5 million gallons	
% Volume Reduction 10-yr, 72-hr	**% Volume Reduction 10-yr, 24-hr**
11%	13%
% Volume Reduction 5-yr, 24-hr	**% Volume Reduction 2-yr, 2-hr**
16%	37%
Conceptual Cost Estimate	
$6,730,000	

Proposed Solution Description

The proposed near-term solution involves transforming current right-of-way green space between the street and the sidewalk into shallow bioswales with a turf grass surface. Bioswales were sited to avoid major structures within the right-of-way (i.e. mailboxes, above ground utility boxes, etc). Bioswales would have a shallow 3" depression in the middle to allow for short-term ponding. Driveways in-between the grassed bioswales are proposed as pervious pavement with opportunities to hydraulically connect systems with the underlying stone base and underdrains. Underground stone areas can be expanded within the street to accommodate shallow ground water while maximizing volume capture. Shallow subsurface chambers or perforated pipes can be included within the stone layers to increase void space.

Property Solution Details – Property Scale Proposal #9

Short-Term Solution: Right-of-Way Green Infrastructure



Existing Driveways

Existing Grass Strip

Proposed Short-Term Solution

Residential solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking and neighborhood use. These concepts can be used in other parts of the County with similar right-of-way configurations and particularly in residential areas where impacts should be minimal in the short-term.

Right-of-Way Bioswales

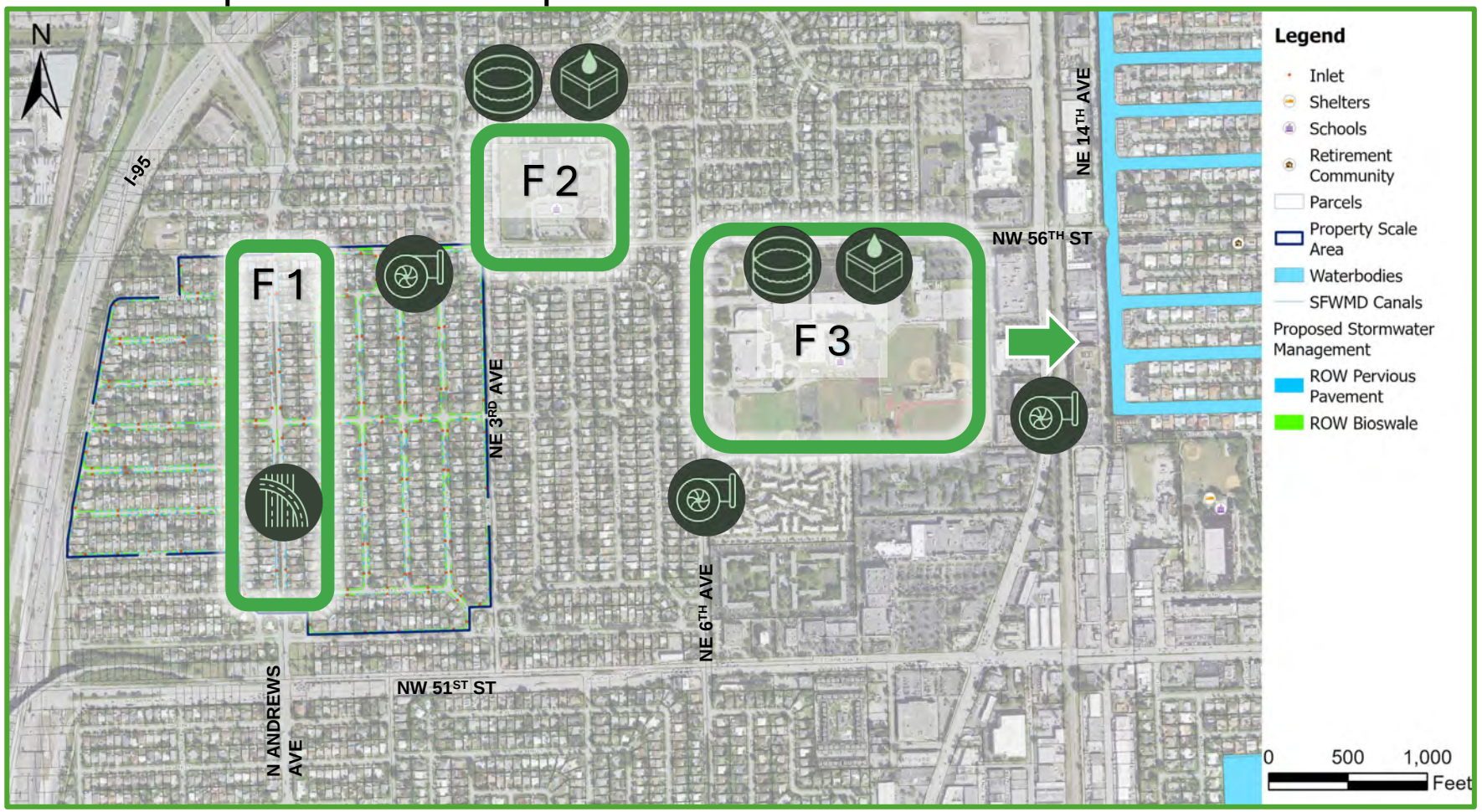
Pervious Pavement

Co-benefits

- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

Proposed Solution Details – Property Scale Proposal #9

Future Implementation Options



- Roadway Modification
- Above-ground Water Storage
- Large Subsurface Storage
- Pump Station

Potential Additional Volume Managed

- ✓ F 1 – 1,205,000 gal
- ✓ F 2 – 1,770,000 gal
- ✓ F 3 – 2,650,000 gal

Key Considerations

- ✓ Stakeholder Support
- ✓ Utility Relocation

Proposed Solution Details – Property Scale Proposal #9

Metric Summary

Rainfall and Coastal Conditions

Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.

Scenario	Rainfall Depth (in)	Storm Volume (gal)
2-year, 2-hour	3.19	6,875,971
5-year, 24-hour	7.42	15,993,638
10-year, 24-hour	9.07	19,550,175
10-year, 72-hour	10.8	23,279,149

Short-Term Solution Cost Estimate

	Quantity	Unit Cost	Subtotal
Exfiltration/Bioswale	158,223 SF	$ 25.00	$ 3,960,000
Porous Pavement	92,194 SF	$ 30.00	$ 2,770,000
			$ 6,730,000

Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.

Summary of Design

Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.

Drainage Area 123 ac
Percentage Impervious 65%

		System	*% of Tv Managed by Full Vol.**			
			2yr - 2hr	*5yr - 24hr*	*10yr-24hr*	*10yr - 72hr*
Exfiltration/Bioswale	158,223 ft²	1,676,863 gal	24%	10%	9%	7%
F 1 (North Andrews Ave)	70,000 ft²	1,204,441 gal	18%	8%	6%	5%
F 2 (North Gardens Elementary School)	91,000 ft²	1,767,551 gal	26%	11%	9%	8%
SubTotal	***381,000 ft²***	***5,625,253 gal***	***82%***	***35%***	***29%***	***24%***

**Tv = Storm Depth * % Impervious * Drainage Area*

Green Infrastructure Sizing Assumptions

Exfiltration/Bioswale Systems

Surface Volume Provided

Ponding Depth	3"
ROW System Floor Area	158,223 ft²
Area at Ponding Elevation	158,223 ft²
Surface Ponding Volume	39,556 ft³

Full Storage Volume Provided

Soil Depth	1.0'
Soil Porosity	30%
Stone Depth	2.17'
Stone Porosity	40%
Surface Volume	39,556 ft³
Soil Volume	47,467 ft³
Stone Volume	137,127 ft³
Total Storage Volume	224,150 ft³
Total Storage Volume (gal)	1,676,863 gal

Porous Pavement Systems

Surface Volume Provided

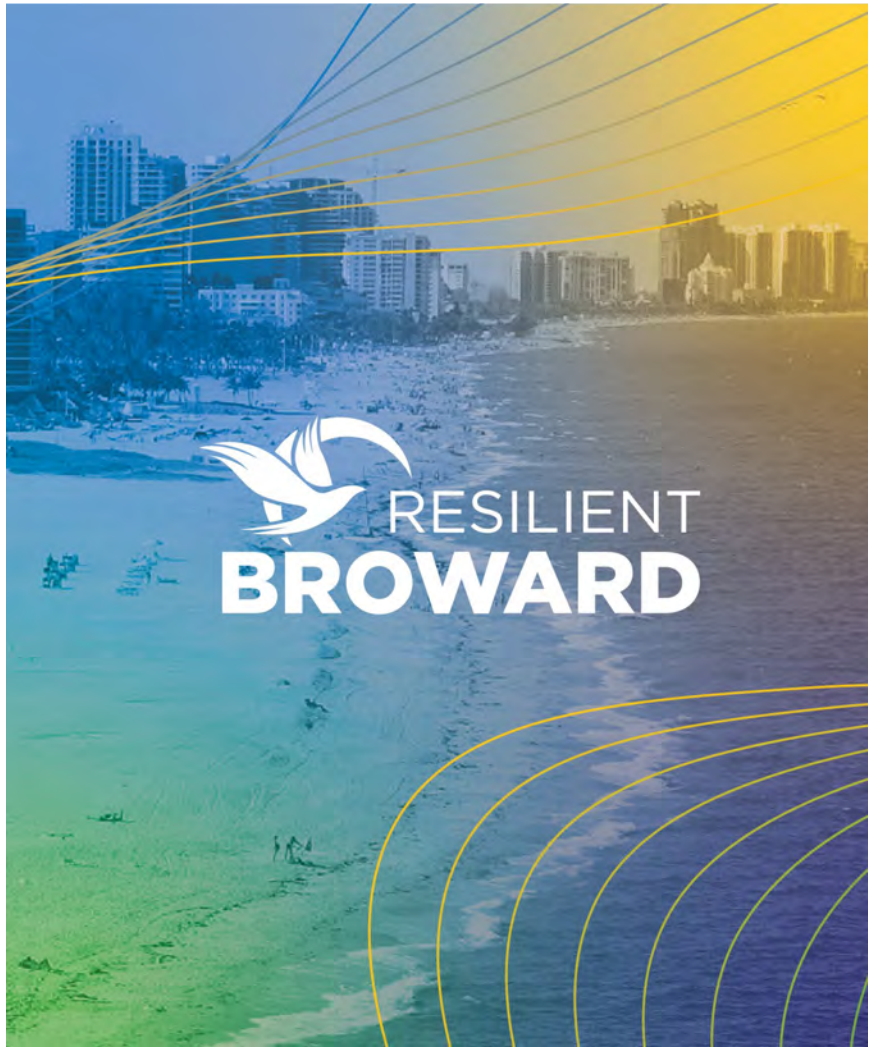
	-
ROW System Floor Area	92,194 ft²
	-
	-

Full Storage Volume Provided

	-
	-
Stone Depth	3.17'
Stone Porosity	40%
	-
	-
Stone Volume	116,779 ft³
Total Storage Volume	116,779 ft³
Total Storage Volume (gal)	873,626 gal

Summary of Property Scale Proposal Benefits for Retrofit of Older Residential Neighborhood

- Potential to manage up to 2.5 million gallons of stormwater with right-of-way green infrastructure; additional improvements could increase managed volume to 8 million gallons
- Grassed surface bioswales and pervious pavement allow for minimal disruption in a residential neighborhood
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach
- Driving lane removal for stormwater management or raising roads within the neighborhood could provide additional flood relief
- Pumping to available storage areas and/or canals provides opportunities for greater stormwater management



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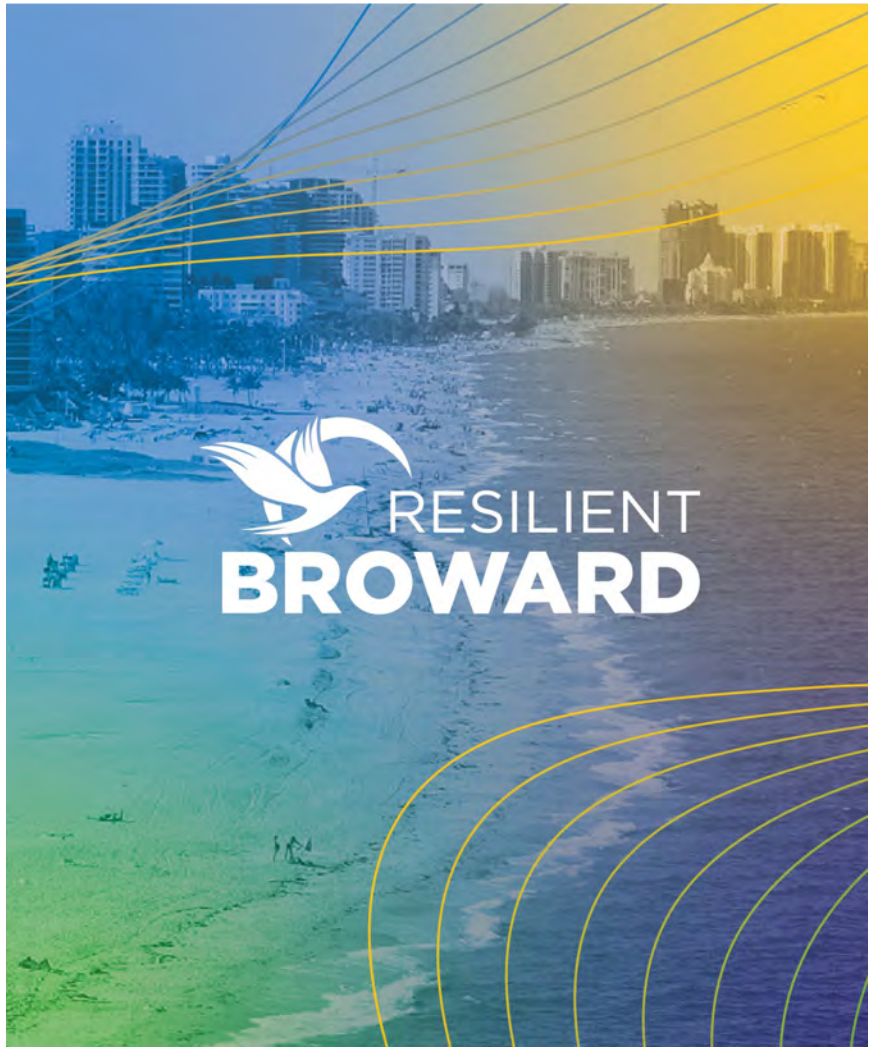
Adjournment – Thank You!

Hazen



BULLPEN

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