Town of Palm Beach

Coastal Flood Resilience Implementation Plan

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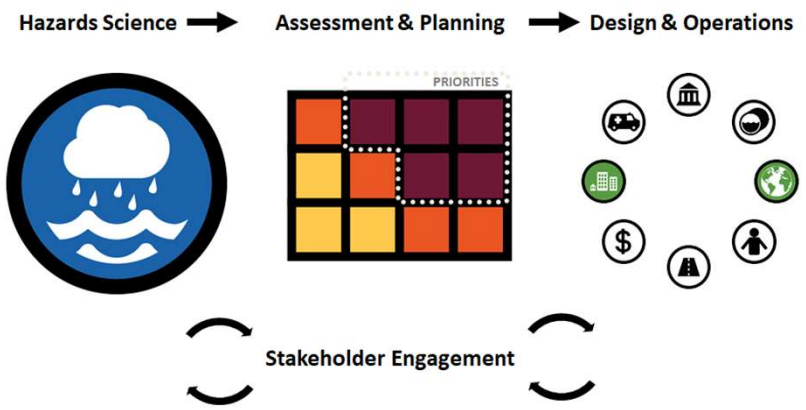
Take Home Messaging

1. Climate Change Vulnerability Assessments must Result in Affordable Actions
   - Not another plan on the shelf
2. Utilize Better Technical Basis
   - Physics and dynamics of flood risk – Not a bathtub or insurance map
   - Consider *probability* of flooding – Not just that an asset migl get wet
3. Implementation Plan
   - Clear decision points
   - Actions within capital improvement plan (CIP) and timelines
4. Creative Designs
   - Regional solutions
   - Nature-based; Hybrid



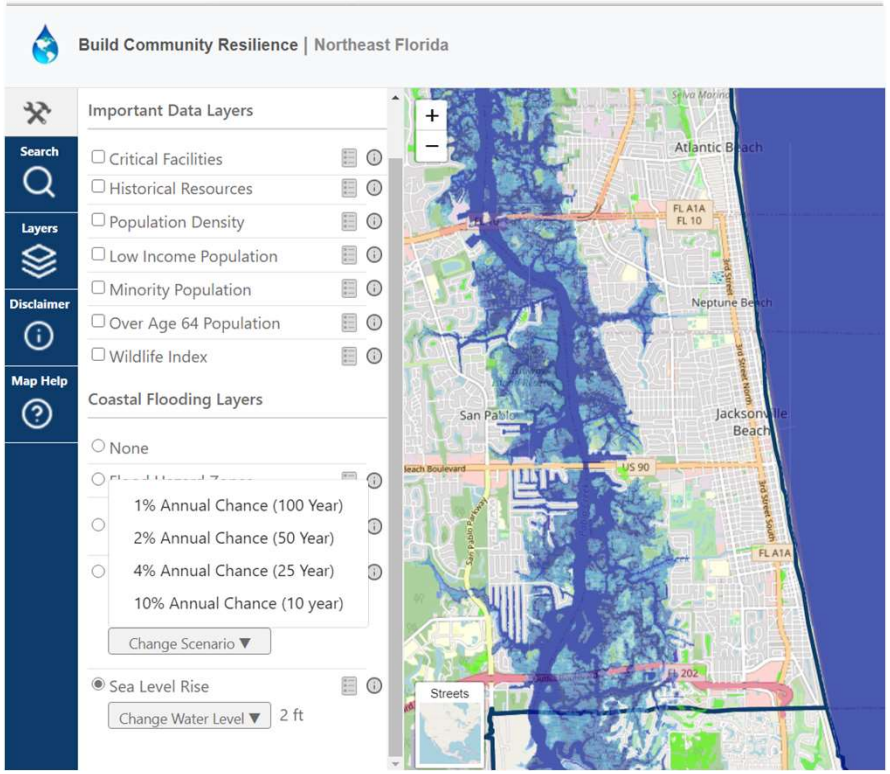
Limitations of Existing Flood Risk Modeling Approaches

Coastal communities are at risk today, increasing in the future
Not affordable or reasonable to plan for all this possible risk

Existing methods are not sufficient to characterize risk or provide what planners and engineers need

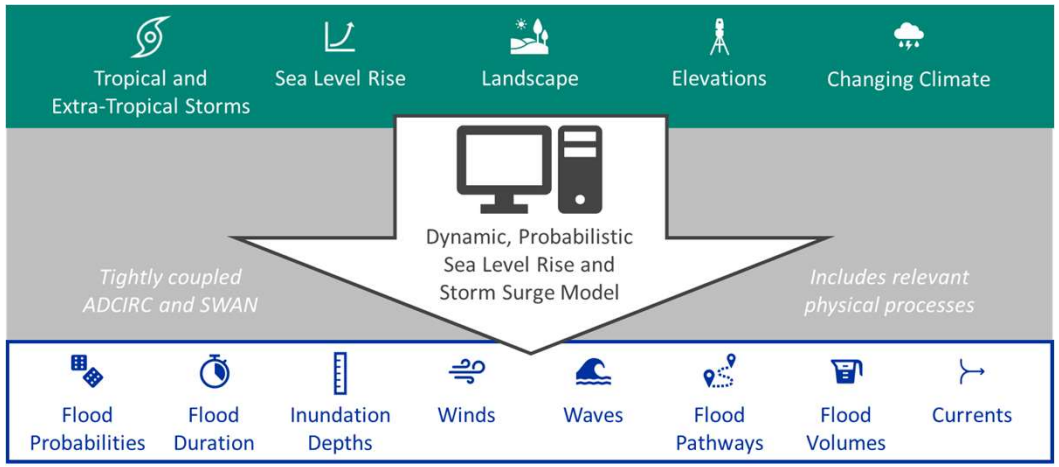
FEMA in only backward-looking and is for insurance purposes

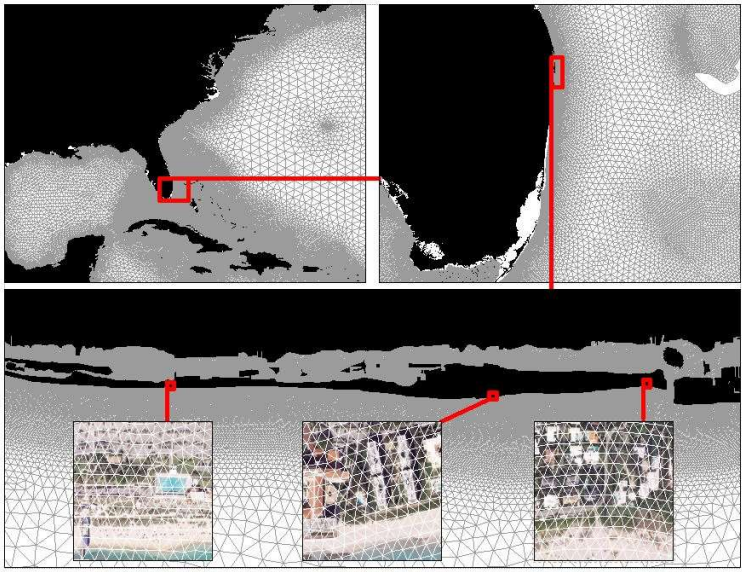
Bathtub methods do not account for important dynamics



A Better Tool for Resilience Planning and Design

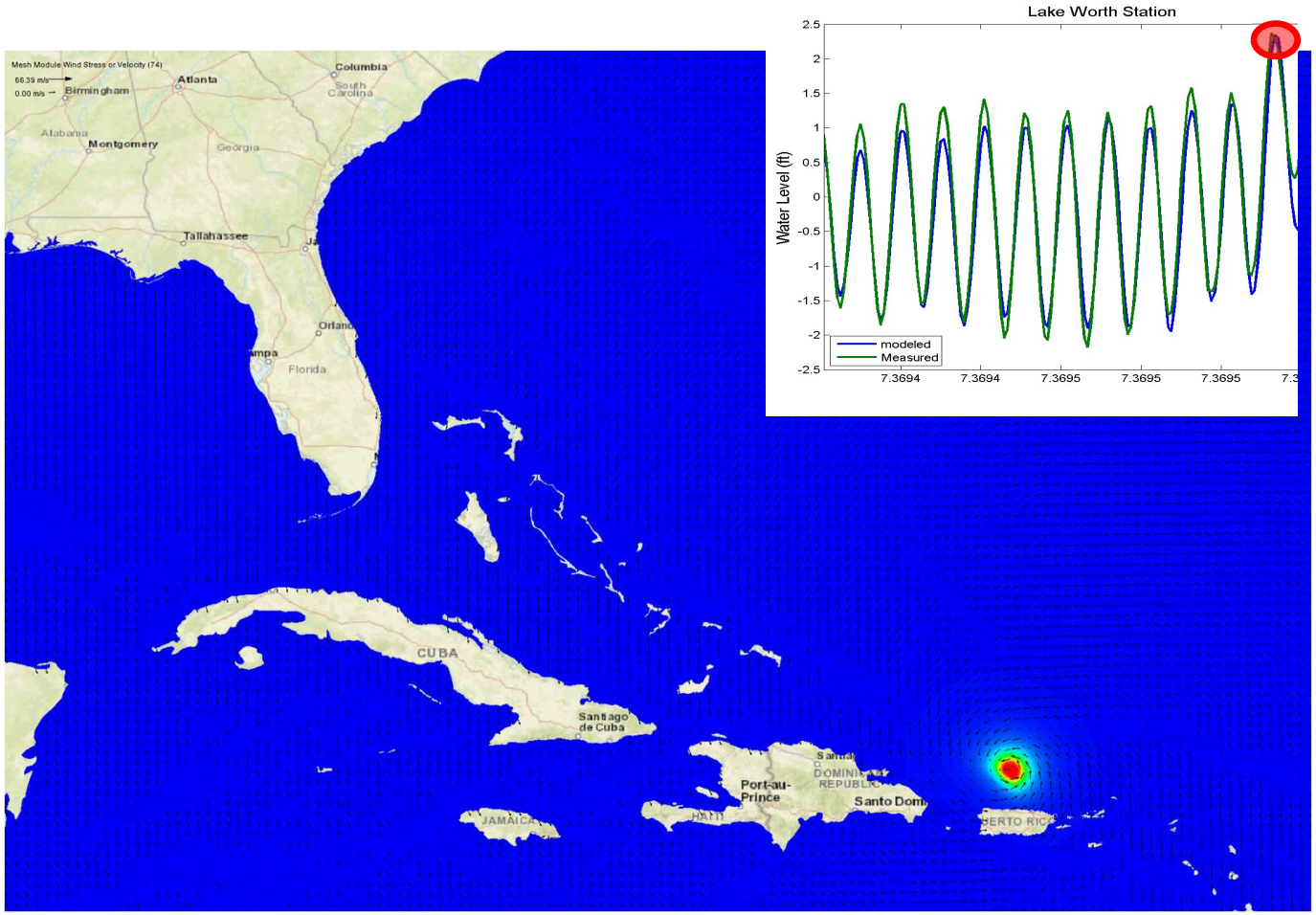
- Advanced, national award-winning modeling approach
  (*2017 Federal Highway Administration Environmental Excellence Award*)
- Town of Palm Beach is the state leader applying this approach to build resilience
  (Palm Beach – Flood Risk Model)
- Town of Palm Beach can cost-effectively prioritize protective adaptations and approaches



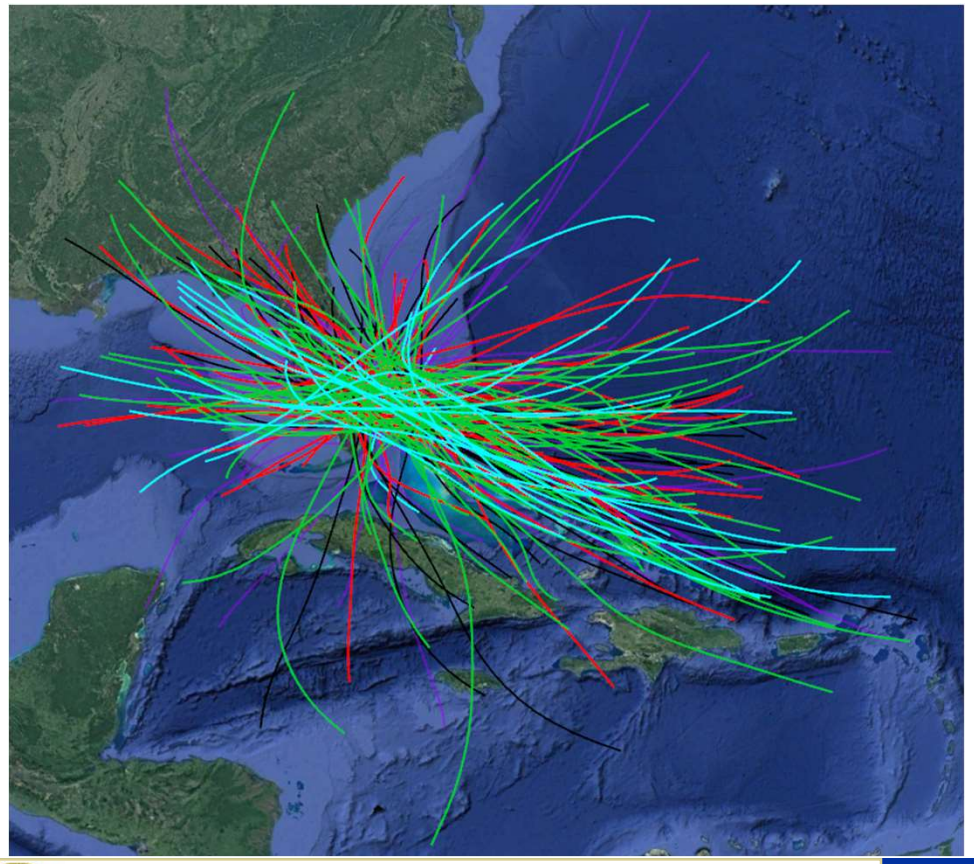


Model Verification

IRMA

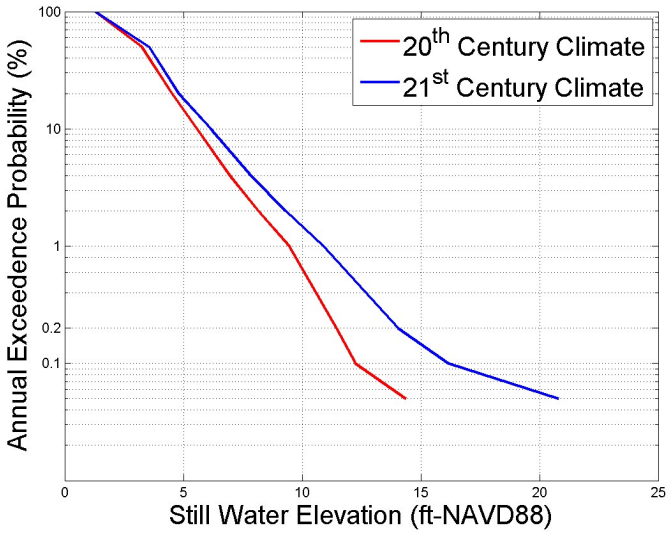


Storm Climatology – Monte Carlo Approach

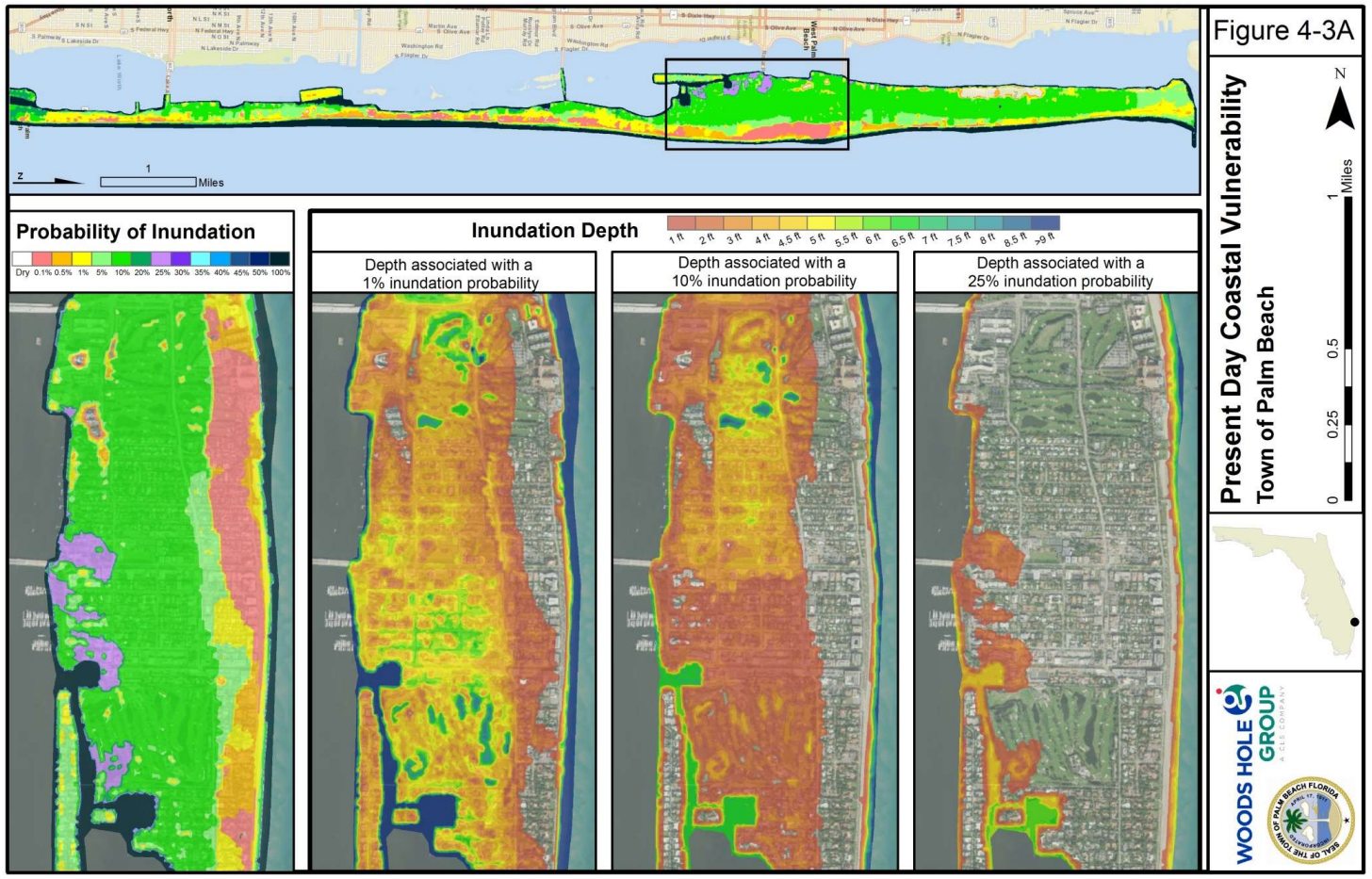


Monte Carlo simulations, using a large statistically robust set of storms (Emanuel, et al., 2006) and a physics-based approach

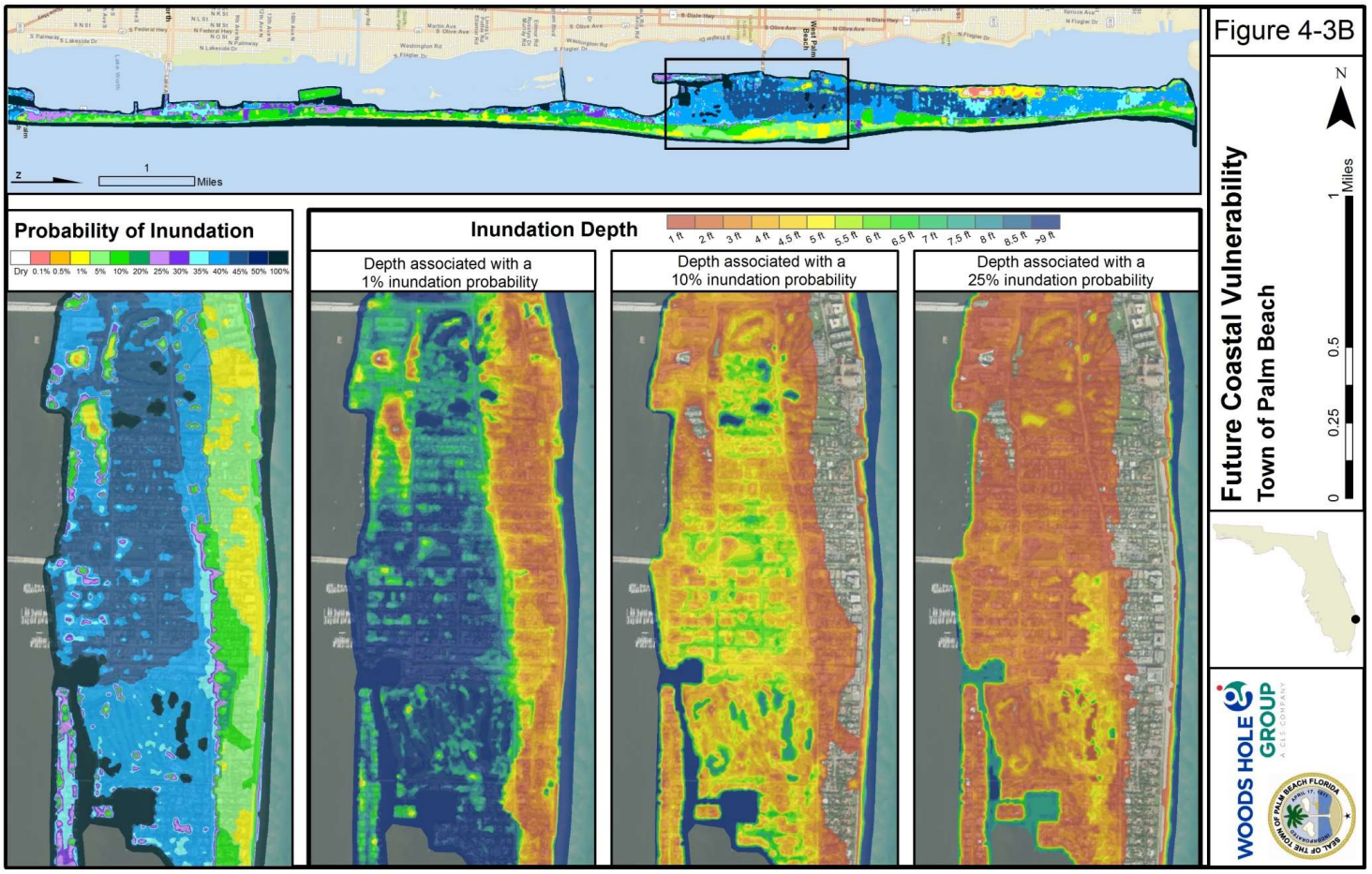
Present and future storm conditions



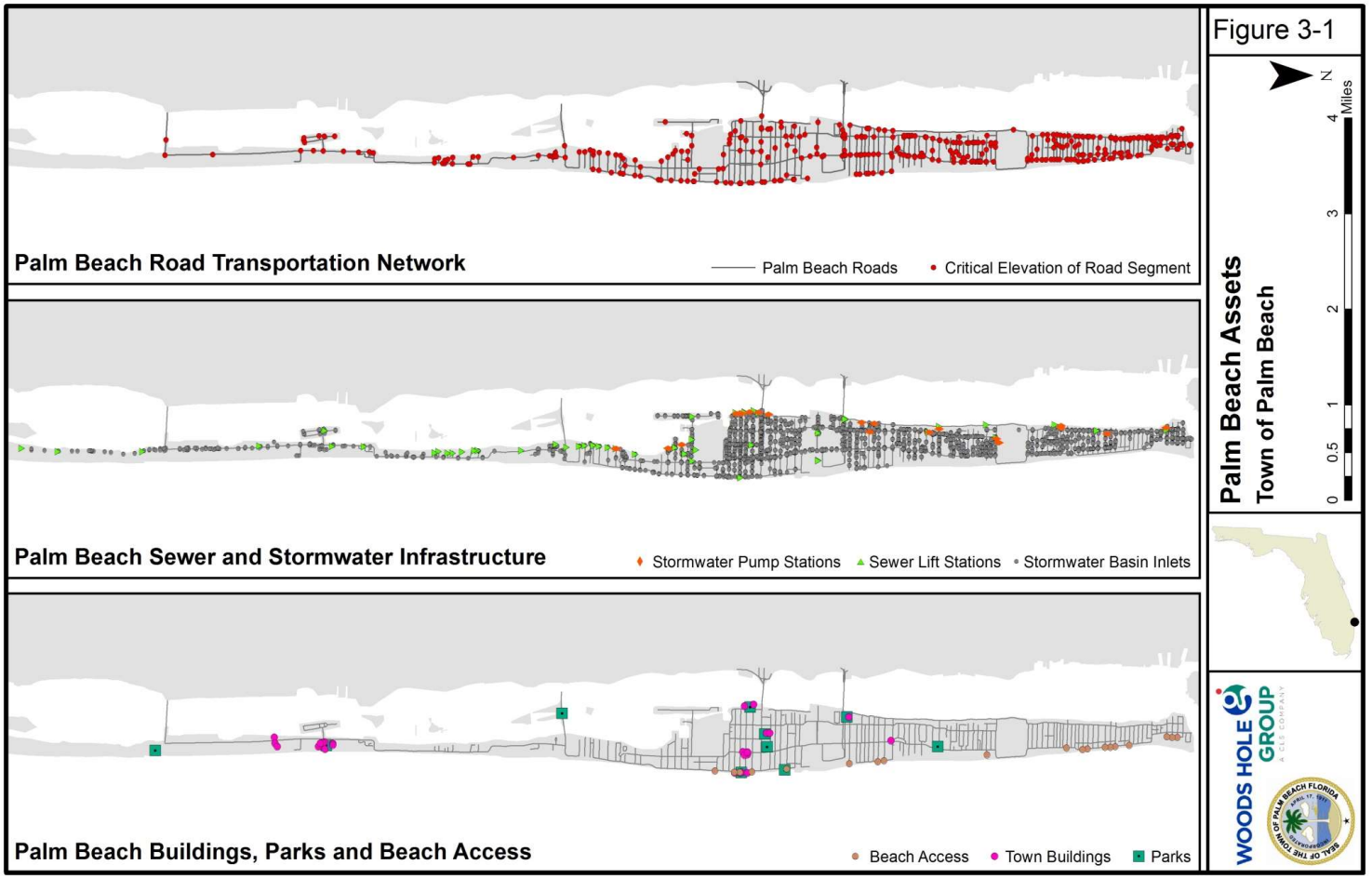
Inundation Probability & Depth (Present)



Inundation Probability & Depth (2050)



Town Assets


Palm Beach Road Transportation Network
Palm Beach Roads
Critical Elevation of Road Segment
Palm Beach Sewer and Stormwater Infrastructure
Stormwater Pump Stations
Sewer Lift Stations
Stormwater Basin Inlets
Palm Beach Buildings, Parks and Beach Access
Beach Access
Town Buildings
Parks
Figure 3-1
Palm Beach Assets
Town of Palm Beach
N
Miles
0
0.5
1
2
3
4
WOODS HOLE GROUP

Risk = Probability × Consequence

Master Sewer Pump Station

- Probability of flooding exceeding critical elevation (First Floor, FF)
  - Present: 5% (20-year recurrence)
  - Future: 20% (5-year recurrence)
- Consequences
  - High
    - Impacts to Public Health & Environment
    - Cost of Damage
    - Impacts to Economic Activities
    - Impacts to Public Safety Services
    - Area of Service Loss
  - Medium/Low
    - Duration of Service Loss
  - Score: 90/100

Risk-Informed Prioritization

Asset-by-Asset Approaches

Risk Score: *mitigate most likely impacts*

Asset	Present Probability (Recurrence)	Consequence	Present Risk Score
Sewer Pump Station E-13	20% (5-yr)	60	**12.0**
Sewer Pump Station E-15	20% (5-yr)	60	**12.0**
Stormwater Pump Station D-16	20% (5-yr)	60	**12.0**
Stormwater Pump Station D-17	20% (5-yr)	57	**11.3**
Stormwater Pump Station D-CC	20% (5-yr)	57	**11.3**
Sewer Pump Station E-1	10% (10-yr)	63	**6.3**
Sewer Pump Station E-50	10% (10-yr)	63	**6.3**
Sewer Pump Station SANA	10% (10-yr)	60	**6.0**
Sewer Pump Station G-7	10% (10-yr)	60	**6.0**

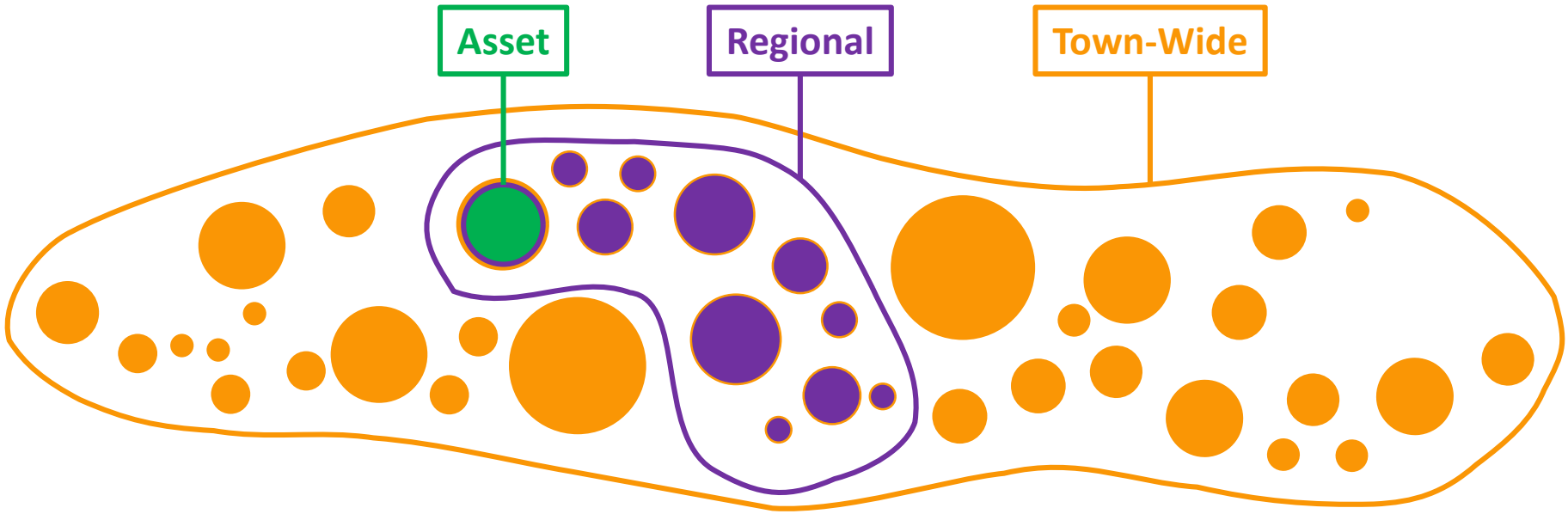
- <10-year recurrence of damage/service disruption:
  - Neighborhood sewer pump stations
  - Neighborhood stormwater pump stations

Consequence Tiers: *mitigate unacceptable impacts*

Asset	Present Probability (Recurrence)	Consequence	Present Risk Score
Master Sewer Pump Station S-2	**5% (20-yr)**	**90**	4.5
Police Station	**5% (20-yr)**	**80**	4.0
Sewer Pump Station E-6	**5% (20-yr)**	**70**	3.5
Stormwater Pump Station D-12	**5% (20-yr)**	**70**	3.5
Town Hall	**2% (50-yr)**	**73**	1.5
Sewer Pump Station A-39	**2% (50-yr)**	**70**	1.4
Stormwater Pump Station D-4	**2% (50-yr)**	**70**	1.4
Sewer Pump Station A-7	**1% (100-yr)**	**70**	0.7
Central Fire	**1% (100-yr)**	**73**	0.7
North Fire	**0.5% (200-yr)**	**70**	0.4

- <100-year recurrence of critical service disruption:
  - Conveyance of Town-wide sewer across Lake Worth
  - Town's only police station
  - Pumping for largest stormwater catchment area

Resilience Strategies at Three Scales



Asset Specific - Police Station

- Critical building systems in underground garage, exposed in Present 20yr
- First floor ~3 ft above grade, exposed in Present >100yr

Install Flood Barrier at Garage Ramp

Regional Risk-Informed Prioritization

Multi-Asset Approaches

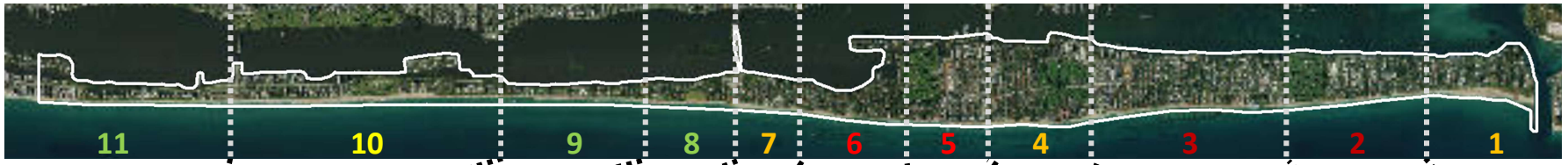
Sectors and Systems: *strengthen system core…*

Asset	Present Probability	Consequence	Present Risk Score
Master Sewer Pump Station S-2	**5%**	**90**	4.5
Sewer Pump Station E-6	**5%**	**70**	3.5
Sewer Pump Station A-6	**5%**	**67**	3.4
Sewer Pump Station A-39	**2%**	**70**	1.4
Sewer Pump Station E-3	**2%**	**67**	1.3
Sewer Pump Station A-7	**1%**	**70**	0.7

…and periphery

Asset	Present Probability	Consequence	Present Risk Score
Sewer Pump Station E-13	20%	60	**12.0**
Sewer Pump Station E-15	20%	60	**12.0**
Sewer Pump Station E-1	10%	63	**6.3**
Sewer Pump Station E-50	10%	63	**6.3**
Sewer Pump Station SANA	10%	60	**6.0**
Sewer Pump Station G-7	10%	60	**6.0**

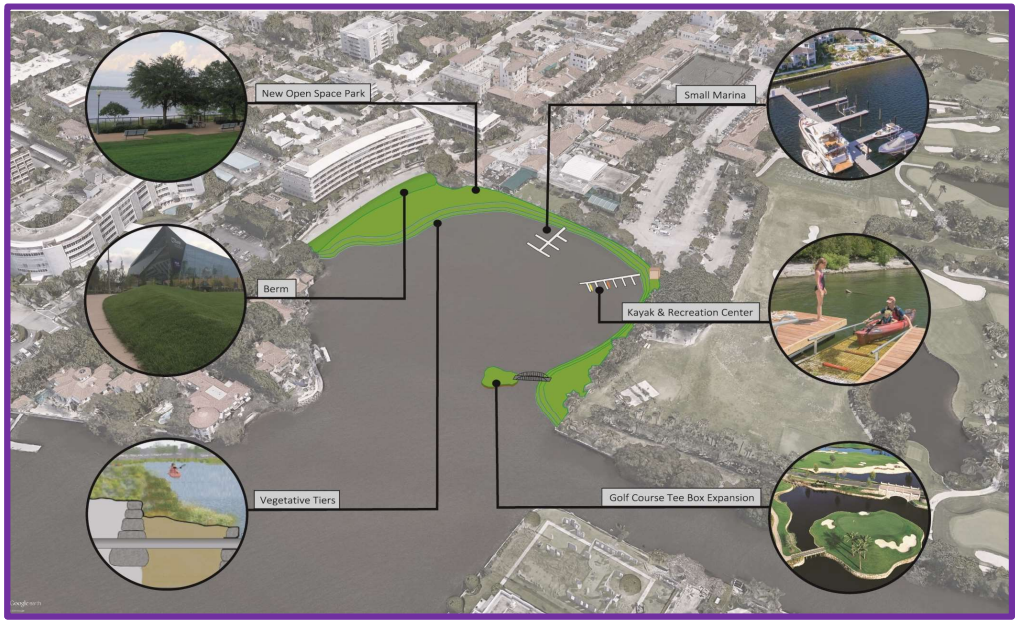
Regions: *prioritize independently-effective, area-wide risk mitigation strategies*



	11		10		9		8		7		6		5		4		3		2		1	
	Town Line to Lake Ave		Lake Ave to Sloans Curve		Sloans Curve to 1500 S Ocean Blvd		1500 S Ocean Blvd to Southern Blvd		Southern Blvd to Clarendon		Clarendon to EverG Club		EverG Club to Royal Palm		Royal Palm to Royal Poinciana		Royal Poinciana to PBCC		PBCC to Palmo Way		Palmo Way to Channel	
	Assets	Risk Sum	Assets	Risk Sum	Assets	Risk Sum	Assets	Risk Sum	Assets	Risk Sum	Assets	Risk Sum	Assets	Risk Sum	Assets	Risk Sum	Assets	Risk Sum	Assets	Risk Sum	Assets	Risk Sum
Facilities	2	5	14	9	7	7	2	4	6	32	11	75	18	49	6	6	11	29	8	25	2	8
Road Segments	0	0	10	40	13	5	8	47	12	46	24	88	24	91	36	227	106	743	57	415	58	262
Parks	1	33	1	52	0	0	0	0	0	0	0	0	2	58	3	22	2	35	0	0	0	0
Total	3	38	25	101	20	12	10	52	18	78	35	163	44	198	45	255	119	807	65	439	60	270

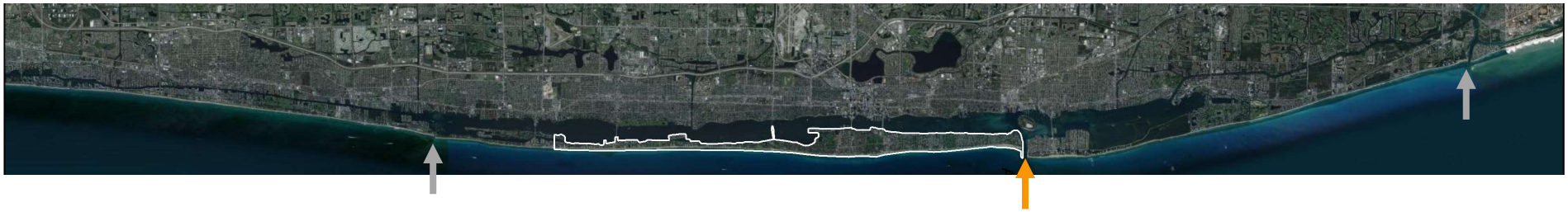
Regional Flood Pathways

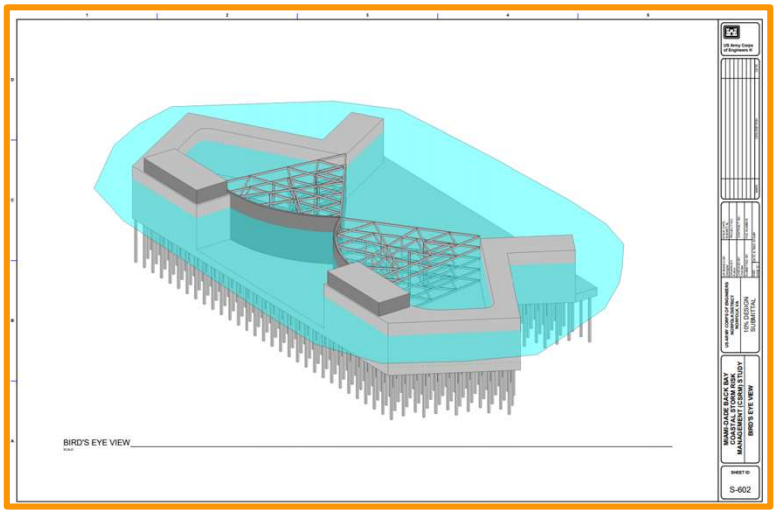
Regional Strategies



Raised Bulkhead at Town Marina (2020)

Town-Wide Strategies





Construct Surge Barrier at Palm Beach Inlet

Sector Gate Rendering

Source: USACE 2020, Miami-Dade Back Bay Coastal Storm Risk Management, Draft Structural Sub-Appendix

Adaptation Planning

Falmouth MA, Coastal Resiliency Planning

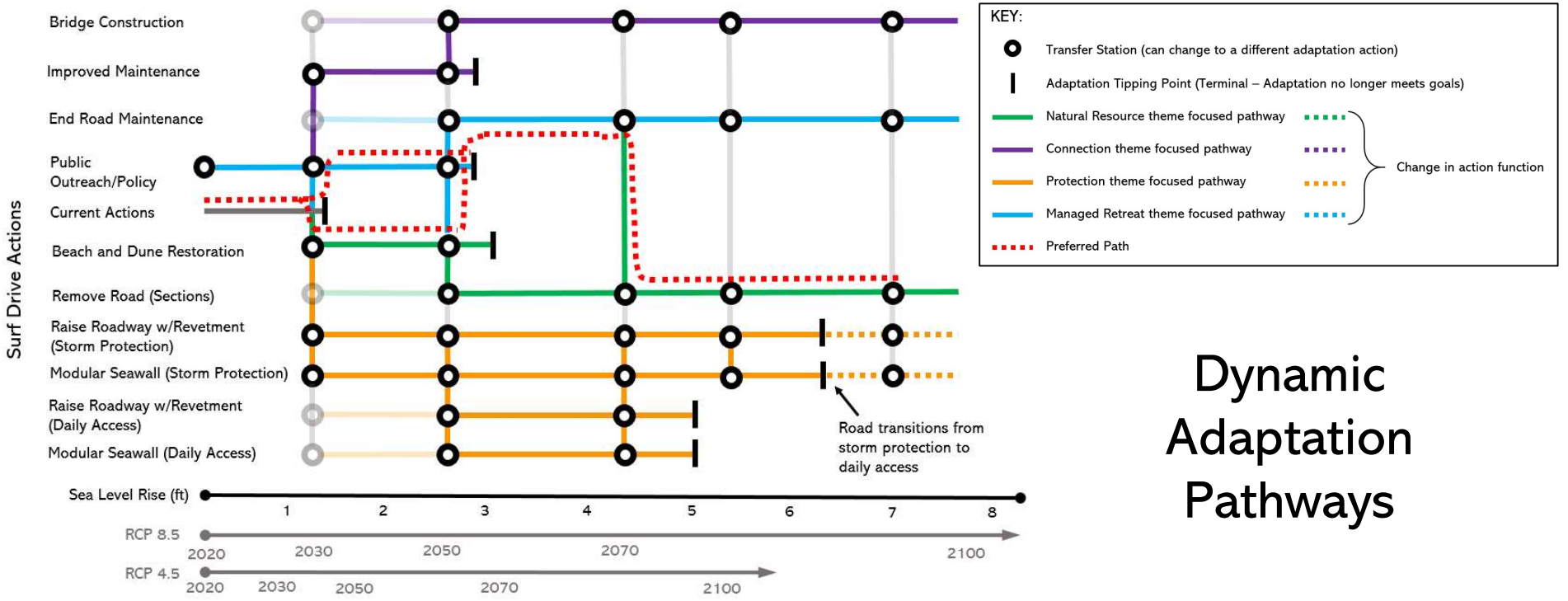
Identify problem and assets at risk:

1. Daily High Tide Flooding
2. Storm Surge Inundation
3. Coastal Erosion

GOALS	SCENARIOS & STRATEGIES (THEMES)	ADAPTATION ACTION EXAMPLES
Preserve, restore and enhance coastal and marine ecosystems to improve coastal resiliency and promote healthy ecosystem functions.	NATURAL RESOURCES Emphasize ecosystem health and resilience	• Beach/dune nourishment • Culvert widening; enhanced fish passage/tidal exchange; reduce dredging needs • Protect residential neighborhoods with living shorelines • Provide salt marsh migration corridors to adapt to SLR
Improve resiliency of infrastructure along the Surf Drive coastline to protect operational capacity.	PROTECTION Emphasize protection and maintenance of infrastructure	• Armor Surf Drive • Elevate roadway • Protect/elevate homes • Floodproof and/or elevate Surf Drive sewer lift station • Floodproof Mitchell Bathhouse • Protect/maintain Woods Hole sewer line in place
Maintain important public access, transportation corridor, and utility line connections.*	CONNECTION Emphasize maintenance of vital access, transportation and utility corridors	• Maintain access to beach† • Maintain transportation connections† • Maintain (redundant) utility lines† • Maintain bikeway to W.H.† †*Could be shifted in location*
Balance the use, access, and enjoyment of coastal resources, while accounting for geologic and ecosystem shifts in response to sea level rise, and encouraging community wide adaptability.	MANAGED RETREAT Emphasize a balance of uses now with increased costs and risks in the future through a multi phased retreat plan	• Identify thresholds for abandoning sections of Surf Dr. • Shift bikeway landward (potential boardwalk sections) • Shift sewer main landward • Remove Mitchell Bathhouse; convert to portable restrooms • Adopt bylaws that limit future development

Implementation Plan

Falmouth MA, Coastal Resiliency Planning for the Surf Drive Area

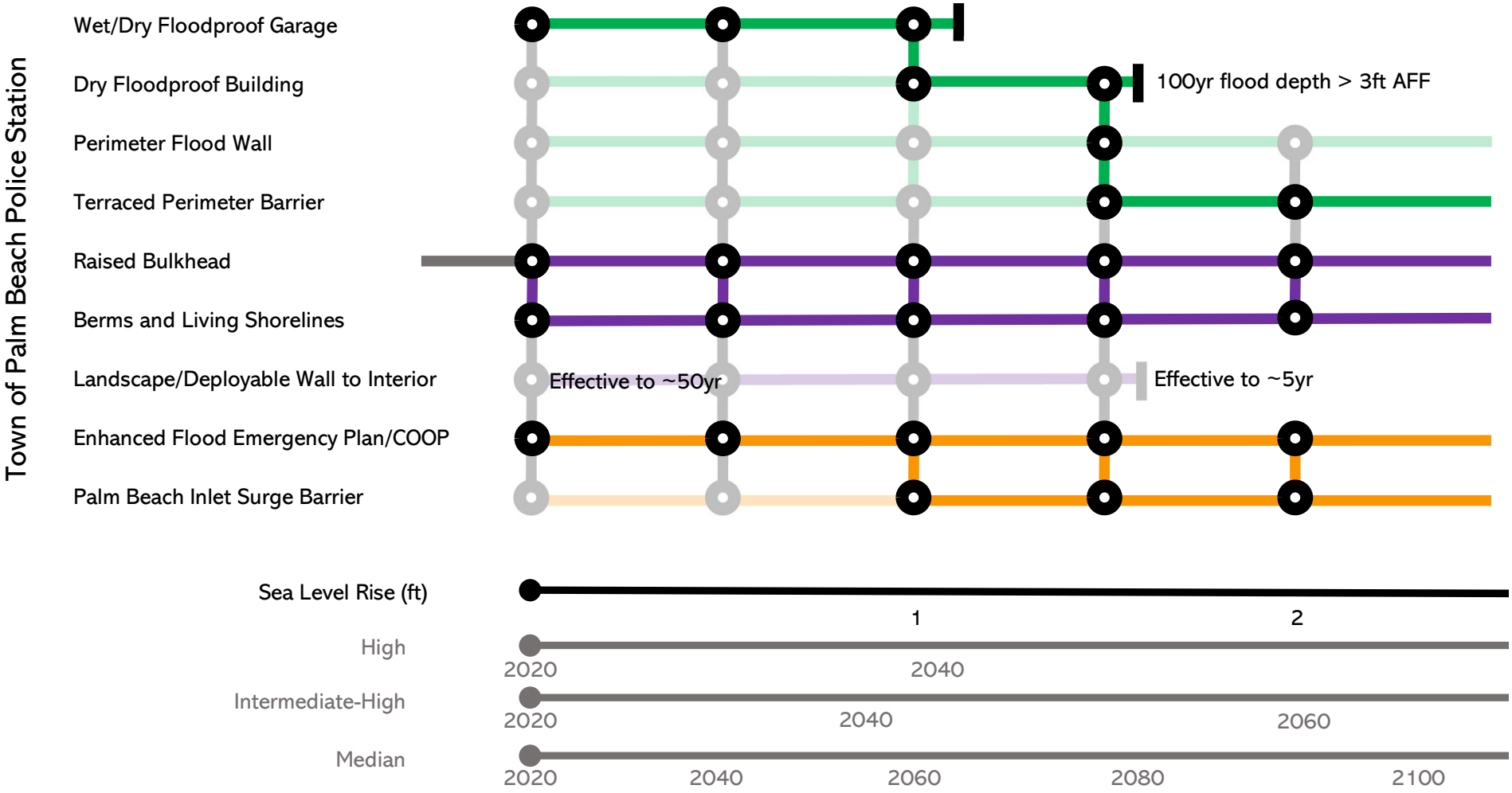


Dynamic Adaptation Pathways

DYNAMIC ADAPTION PATHWAYS FOR SURF DRIVE FALMOUTH, MA

Pathway Scorecard

	Path Actions	Relative Costs	Target Effects	Side Effects
1.	Managed Retreat	+	Balances present uses with increased costs and risks in the future through a multi-phase retreat plan	Loss of Homes No Connection via Surf Drive Loss of Accessible Beach
2.	Protection	+++++	Protects operational capacity of existing Infrastructure and features	Loss of Accessible Beach Aesthetics/Visuals
3.	Natural Resources	+++	Preserves and enhances coastal and marine ecosystem functions	Loss of Homes No Connection via Surf Drive
4.	Connection	++++++	Maintains important public access, utility Connections and transportation corridors	Loss of Homes
5.	Preferred	+++	Balances present uses w/increased costs and risks in the future through a multi-phase retreat plan, while enhancing ecosystems	Loss of Homes No Connection via Surf Drive
6.		+++	Improved maintenance for short-term uses w/a long-term focus on ecosystem restoration	Loss of Homes No Connection via Surf Drive
7.		+++++	Coastal habitat restoration in the short term, w/protection of existing infrastructure in the long-term	Loss of Accessible Beach Aesthetics/Visuals


Town of Palm Beach Police Station
Wet/Dry Floodproof Garage
Dry Floodproof Building
Perimeter Flood Wall
Terraced Perimeter Barrier
Raised Bulkhead
Berms and Living Shorelines
Landscape/Deployable Wall to Interior
Enhanced Flood Emergency Plan/COOP
Palm Beach Inlet Surge Barrier
100yr flood depth > 3ft AFF
Effective to ~50yr
Effective to ~5yr
Sea Level Rise (ft)
1
2
High
2020
2040
Intermediate-High
2020
2040
2060
Median
2020
2040
2060
2080
2100

Town Perspective & Next Steps

- Support from highest government officials
- Town staff actively engaged / contributing
- Extends beyond traditional coastal plan
- Already refining projects already in the CIP
- Identifying new projects
  - Specific assets vulnerable now
  - Plan ahead for creative cost-effective regional solutions
- Extend uses for general public and private property
- Reveals strengths & redundancies already in-place
  - Not all doom and gloom
  - Methodical approach for managing future uncertainty

Questions / Discussion