Transportation Network Resiliency Study

Martin County Metropolitan Planning Organization (MPO)

December 2022

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EXECUTIVE SUMMARY

The Martin MPO is the primary agency responsible for coordinating transportation planning activities in Martin County. The MPO requested to utilize the services of their General Planning Consultant (GPC) firm Kimley-Horn and Associates, Inc. to provide professional transportation planning services for this Study in December of 2021.

The purpose of this Study is to provide professional assistance to MPO staff to produce the Transportation Network Resiliency Study, which will provide a mechanism/methodology on how to consider resiliency/climate change in the transportation planning process.

The three tasks consisted of the following: forming a Project Advisory Committee (PAC) to gather feedback from stakeholders on the types of threats to be considered, assets currently exposed, and the criteria for prioritizing projects to mitigate risk and reduce vulnerability of these assets; developing a methodology to assess exposure of transportation assets in present-day conditions and two future planning horizons (2040 and 2070); and developing a set of prioritization criteria to utilize the exposure analysis results in ranking future projects, based on the resiliency components they include.

The Resilient Florida Program (see § 380.093, Fla. Stat.) was used as a guideline for the methodology and criteria tasks, to parallel the requirements of the critical asset vulnerability studies and project scoring criteria for ease in future funding proposal efforts. The eight critical transporation assets evaluated in the study are roads with a Federal Functional Classification, highways, evacuation routes, bridges, railroads, airports, fleet storage facilities, and regional trails. The exposure analysis evaluated four flooding threats (Tidal flooding and sea level rise, storm surge, rainfall-induced, and compound flooding), and vulnerability to excessive heat. In addition, the Social Vulnerability Index (SVI) as defined by the Centers for Disease Control and Prevention (CDC) was mapped for inclusion in prioritization.

ArcGIS software was used to create dedicated map series per asset, for exposure to each threat in each scenario**.** In addition, all GIS data used to build the maps is provided as a separate digital attachment in the form of an ArcPro Map Package file.

1 INTRODUCTION

MARTIN COUNTY METROPOLITAN PLANNING ORGANIZATION RESILIENCY PLANNING

The Martin MPO is the primary agency responsible for coordinating transportation planning activities in Martin County. The MPO requested to utilize the services of General Planning Consultant (GPC) firm Kimley-Horn and Associates, Inc. to provide professional transportation planning services for this Study in December of 2021.

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The three tasks consisted of the following:

- Form a Project Advisory Committee (PAC) to gather feedback from stakeholders on the types of threats to be considered, assets currently exposed, and the criteria for prioritizing projects to mitigate risk and reduce vulnerability of these assets
- Develop a methodology to assess exposure of transportation assets in present-day conditions and two future planning horizons (2040 and 2070)
- Develop a set of prioritization criteria to utilize the exposure analysis results in ranking future projects with respect to resiliency

The Resilient Florida Program (see § 380.093, Fla. Stat.) was used as a guideline for the methodology and criteria tasks. This decision was made to parallel the requirements of the critical asset vulnerability studies and project scoring criteria for ease in future funding proposal efforts. The eight critical transporation assets evaluated in the study are listed below:

- Roads with a Federal Functional Classification
- Highways
- Evacuation routes
- Bridges
- Railroads
- Airports
- Fleet storage facilities
- Regional trails

The exposure analysis evaluated four flooding threats: tidal flooding and sea level rise, storm surge-induced flooding, rainfall-induced flooding, and compound flooding. The

exposure analysis also considered vulnerability to excessive heat. In addition, the Social Vulnerability Index (SVI) as defined by the Centers for Disease Control and Prevention (CDC) was mapped for inclusion in future prioritization efforts.

ArcGIS was used to create and analyze the data associated with this Study. Dedicated map series were created for each asset classification and for exposure to each threat in each scenario**.** All digital GIS data used in this study has been provided digitally for incorporation into the MPO's GIS data framework.

PURPOSE OF THE TRANSPORTATION NETWORK RESILIENCY STUDY

As part of the MPO's resiliency planning, Kimley-Horn and Associates, Inc. was selected to provide a mechanism/methodology on how to consider resiliency/climate change in the transportation planning process through RFQ 2019-3099 Task Order No. 10 Transportation Network Resiliency Study (Study).

The goals of the study are presented below:

- Identify critical assets of the MPO's transportation network
- Provide a methodology to measure asset vulnerability to existing and future flooding and excessive heat
- Utilize the methodology to develop a map series presenting which assets are vulnerable to which hazard, under specific planning horizons
- Present examples of adaptation strategies applied to three vulnerable transportation asset case studies
- Develop a recommended project prioritization process to rank and prioritize mitigation projects to address vulnerable transportation infrastructure assets

A Project Advisory Committee (PAC) was formed to incorporate stakeholder input into the development of all aspects and products of the study. Members include staff from the Martin MPO, Martin County Public Works, Planning, and CRA departments, Village of Indiantown, City of Stuart, Town of Sewall's Point, and Florida Department of Transportation (FDOT) District IV.

RESILIENT FLORIDA PROGRAM

On May 12, 2021 Senate Bill 1954 was signed into law as the legislative start to a coordinated approach to Florida's coastal and inland resiliency, entitled the Resilient Florida Program (see § 380.093, Fla. Stat.).[1] A significant part of developing the program is the creation of a grant mechanism that will fund county, municipal, water management

[1] (Florida Statute § 380.093 (2021))

district, and other entity projects that address flooding and sea level rise impacts. The funding is also applicable to vulnerability assessments completed by the same entities.

The FDEP developed rule chapter 62S-8 to implement F.S. § 380.093, and establish project scoring critera to be used by FDEP when incorporating grant proposals into the Statewide Flooding and Sea Level Rise Resilience Plan. The final rule language defined in August 2022 is used in this Study as the basis for the vulnerability assessment and the drafting of project prioritization criteria to provide a parallel evalution of potential projects and remain in line with future state funding requirements and opportunities.

2 TRANSPORTATION NETWORK ASSETS

§ 380.093(2)(a), Fla. Stat. includes the following definition of a critical transportation asset:

Transportation assets and evacuation routes, including airports, bridges, bus terminals, ports, major roadways, marinas, rail facilities, and railroad bridges.

Based on input from the PAC and the agreed upon scope of work, the Study evaluated the following assets:

- Airports
- Bridges
- Railroads and railroad bridges
- Fleet storage facilities
- Regional trails
- All roadways included in the Federal Functional Classification (FFC).
    - County Evacuation routes and highways will be identified as a subset of roadways.

3 VULNERABILITY ASSESSMENT METHODOLOGY

All elevations in this Study are presented according to the North American Vertical Datum of 1988 (NAVD88) vertical datum in feet unless otherwise noted.

Vulnerability is defined in the Study as the degree of exposure of transportation assets to hazards that will degrade functionality, cause physical damage, or require implementation of adaptive strategies to mitigate consequences of an existing or potential threat. The degree of exposure determines the level of vulnerability to that specific hazard. See the Methodology Section for further detail on how the levels of vulnerability are differentiated by hazard.

An asset's vulnerability was measured for two hazards as part of this assessment – flooding and excessive heat. Flooding was further categorized into five subtypes: Tidal,

storm surge, sea level rise, rainfall-induced, and compound. Both flooding and excessive heat hazards were evaluated for the planning horizons established by F.S. § 380.093 as shown below in Table 1.

Table 1. Transportation Resiliency Study Hazards and Planning Horizons

Hazard	2022 (current)	Planning Horizon	
		2040	2070
Tidal flooding	✓	✓	✓
Storm surge flooding	✓	✓	✓
Sea level rise flooding	✓	✓	✓
Rainfall-induced flooding	✓		
Compound flooding	✓	✓	✓
Excessive heat	✓	✓	✓

The vulnerability assessment considered risks associated with flooding, excessive heat, and socioeconomic vulnerabilities. Flood risk vulnerability methodology is consistent with the required hazards and scenarios of Section 380.093(3)(c) of the Florida Statutes. Excessive heat was evaluated using the NOAA National Integrated Heat Health Information System. Socioeconomic vulnerability was evaluated using the Social Vulnerability Index (SVI) published by the Centers for Disease Control and Prevention (CDC).

Planning horizons for 2040 and 2070 were included per Section 380.093(3)(c) for all flooding scenarios below. However, there is more than one publicly available source for sea level rise projections. From email correspondence with FDOT and DEP, NOAA 2017 projections were used in vulnerability assessment development to ensure eligibility for funding per Section 380.093. The County's robust digital elevation model was used for mapping flood depths.

The subsections below describe the approach used for evaluating exposure to each threat listed in Table 1 and the incorporation of the SVI.

FLOODING THREATS

1) **Depth of tidal flooding, including future high tide flooding, and number of tidal flood days expected for each scenario and planning horizon**

Description - Tidal flooding (also known as nuisance, sunny day and recurrent tidal flooding) refers to temporary and local sea level rise above an identified threshold, in the absence of storm surge or other sources of flooding[2]

Methodology - Statistical analysis of historical high tide elevations to evaluate current flooding conditions, augmentation in future conditions using sea level rise projections, and evaluation of output against the Martin County DEM

Degree of Vulnerability - Flooding depth and total number of flood days per year

Planning Horizon - Current, 2040, 2070

Tidal flooding refers to temporary and local sea level rise above an identified threshold, in the absence of storm surge or other sources of flooding. Like all instances of flooding, tidal flooding affects commuter access, impacts critical networks, and may damage roadway surfaces. Saltwater, especially, may deteriorate roadway surfaces and vehicles that are periodically flooded.

NOAA has published High Tide Minor Flood Thresholds which define a specific depth above mean-higher-high water (MHHW) that represent high tide flooding.[3] The Virginia Key gauge threshold was used as a reference. To evaluate transportation asset vulnerability to tidal flooding, the annual average of total days with high tide elevations above the threshold were derived from historical data (2010-2022) of the closest National Oceanic and Atmospheric Administration (NOAA) tidal gauge to Martin County located in Lake Worth Pier.[4] Note that tidal elevations influenced by tropical cyclones were excluded from the analysis. Tidal flooding days in future conditions were evaluated using published NOAA projections. The flood elevation output for both scenarios was evaluated against the Martin County DEM.

2) Depth of current and future storm surge flooding

Description - Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide[5]

Methodology - Analysis of SLOSH (Sea, Lake and Overland Surges from Hurricanes) data output against the Martin County DEM for current conditions and an overlay of SLOSH and sea level rise projections for future conditions

[2] (U.S. Climate Resilience Toolkit 2021)
[3] (National Oceanic and Atmospheric Administration 2022)
[4] (National Oceanic and Atmospheric Administration 2022)
[5] (National Oceanic and Atmospheric Administration (NOAA) n.d.)

Degree of Vulnerability - Flooding depth and risk level compared to hurricane category 1 and 3 storm surges

Planning Horizon - Current, 2040, 2070

Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide. The intensity of storm surge depends on speed, size, angle of approach, and the topography/bathymetry of the shoreline. Damage to transportation infrastructure occurs from rapid flooding and direct wave action that can erode bridge piers, transport debris, and cripple essential and low-lying causeways.

NOAA's SLOSH dataset provided the information for current storm surge flooding in Martin County (note that it does not include wave propagation or wind speed effects). Flood depths in each storm surge condition analyzed were derived by evaluating the SLOSH output against the Martin County DEM. The NOAA sea level rise projections were overlayed on the SLOSH data to identify future storm surge flooding depths.

To differentiate between risk levels, the results were evaluated for hurricane categories 1 and 3.

3) **Rainfall-induced flooding using spatiotemporal analysis or existing hydrologic and hydraulic modeling results. Future boundary conditions should be modified to consider sea level rise and high tide conditions.**

Description - Rainfall-induced flooding occurs when moderate precipitation accumulates over several days or intense precipitation falls over a short period[6]

Methodology - Analysis of FEMA Flood Insurance Study maps against the Martin County DEM for current conditions

Degree of Vulnerability - Flooding depth

Planning Horizon - Current

Rainfall-induced flooding occurs when moderate precipitation accumulates over several days or intense precipitation falls over a short period. Potential consequences of this type of flooding are damage of roadway subgrade, debris accumulation and hindrance to stormwater infrastructure and networks. In addition, the most recent South Florida Water Management District Extreme Rainfall Projections Workshop (April 2022) emphasized that the 200+ global climate models analyzed show increases in the magnitude of extreme rainfall events 50 years from now, represented

[6] (National Oceanic and Atmospheric Administration (NOAA) National Severe Storms Laboratory n.d.)

by a change factor larger than one. Awareness of increasing rainfall can inform the replacement and design of aging infrastructure.

Martin County's June 2020 Resilience and Watershed Management Plan included a comprehensive vulnerability analysis of various critical assets to sea level rise, regular tidal flooding, and a combination of sea level rise and 100-year storm surge event. However, it did not address rainfall-induced flooding, as the development of a contiguous county-wide hydrology and hydraulic model is not yet available. Model development is also outside the scope of this study. Therefore, the analysis of current rainfall-induced flooding was based on the FEMA Flood Insurance Study of the County.

In addition, the City of Stuart Stormwater Master Plan: Capital Improvement Project list includes identification of flood-prone areas, to be captured in the study if not included in the mapped results of the other hazards in this study.

4) **Depth of compound flooding or combination of tidal, storm surge and rainfall-induced flooding**

Description - Compound flooding refers to the effect on an area vulnerable to many flood-inducing factors

Methodology - Overlay of all flooding hazards for current and future scenarios, evaluated against the Martin County DEM

Degree of Vulnerability - Flooding depth

Planning Horizon - Current, 2040, 2070

From draft language of Rule 62S-8, the definition of compound flooding refers to flooding caused by complex interactions between two or more oceanographic, hydrological, or meteorological processes, such as the combination of rainfall-induced, riverine, coastal floods, or groundwater flooding. In this case, tidal, storm surge, and rainfall-induced flooding assessments discussed above can be overlayed to determine compound flooding depths for areas vulnerable to more than one hazard. Future conditions can utilize an overlay of the datasets that consider sea level rise projections.

EXCESSIVE HEAT

Description - Excessive heat for this region and study is defined as temperatures above 95 degrees Fahrenheit. In addition, the urban heat island effect will be evaluated which compares temperatures within cities to surrounding, less urban areas.

Methodology - The NOAA National Integrated Heat Health Information System will be used to compare the total number of heat events (days with temperatures above 95 degrees) in 2020 versus 2040, and 2070.

Degree of Vulnerability - Total number of heat events per year

Planning Horizon - Current, 2040, 2070

Similar to increases in sea level due to changing climatic conditions, extreme or excessive heat events are projected to increase in severity, frequency, and duration in eastern Florida.[7] The definition and thresholds of excessive heat are based on multiple factors including temperature, location, humidity, and cloud cover. In addition, the urban heat island effect is known to result in higher temperatures within cities, especially during the summer, when dense clusters of unshaded roads and buildings absorb heat that is then radiated off to ambient air. The consequences include negative effects on human health and increased energy consumption.[8]

Excessive heat arose as a threat to transportation assets with significant influence on future transit planning, amongst the PAC working group. Therefore, excessive heat is included in the vulnerability assessment as an additional hazard to be evaluated.

Current vulnerability to excessive heat was assessed by quantifying how many days a year an area experiences a heat event, defined as a day with temperatures over 95 degrees Fahrenheit. The NOAA National Integrated Heat Health Information System was used to compare the total number of heat events in 2020 versus 2070.

SOCIOECONOMIC VULNERABILITY

Future incorporation of socioeconomic vulnerability into resilience planning is a main outcome of Martin County's Resilience and Watershed Management Plan. The following are excerpts of some of the recommendations included in the plan.

> *Economic analysis. Conduct a countywide property damage assessment aligning inundation depths and property values for future sea level rise …* ***Incorporate demographic and socioeconomic data into this analysis to address project priorities based on equity considerations.***
>
> *Agency or stakeholder coordination.* ***Identify socially and economically vulnerable populations and neighborhoods and develop strategies to ensure equitable distribution of improvements and inclusive communication and***

[7] (Centers for Disease Control and Prevention (CDC) 2016)
[8] (National Integrated Heat Health Information System n.d.)

***outreach to those communities**. Identify resources particularly suited for vulnerable communities and businesses for climate change preparedness.*

The PAC also emphasized the need to consider socioeconomic factors when planning for future transportation network improvements.

Description Social vulnerability, as defined by the CDC, refers to the resilience of communities (the ability to survive and thrive) when confronted by external stresses on human health, stresses such as natural or human-caused disasters, or disease outbreaks.

Methodology The SVI considers four groups of factors: Socioeconomic status, household composition and disability, minority status and language, and housing and transportation. An overlay of SVI by Census Districts will be incorporated into the vulnerability assessment maps.[9]

Degree of Vulnerability The SVI is itself a relative score by which to compare vulnerability by area (census tract).

Planning Horizon Current

The South Atlantic Coast Study by the Army Corps of Engineers (USACE) is a recent comprehensive analysis that identifies risks and vulnerabilities of the southeastern coastal United States to hurricane and storm damage due to sea level rise. Within the study, the Social Vulnerability Index (SVI) published by the CDC is used as a percentage of an overall composite risk index (CRI) to storm damage. Although the CRI is not used in this Martin County MPO study due to different hazards integrated into the score, the SVI index was used as the socioeconomic criterion of vulnerability.

4 ASSET EXPOSURE ANALYSIS

The Vulnerability Assessment Methodology discussed in Section 3 was implemented using ArcGIS software to map the spatial extent and depth of flooding for each current and future planning horizon scenario. Each category of asset has a dedicated map series for exposure to each threat and scenario included in **Appendices A through E.** In addition, all GIS data used to build the maps is provided as a separate digital attachment in the form of an ArcPro Map Package file. Each asset shapefile has an attribute table with maximum flood depths per threat, scenario and planning horizon as applicable.

[9] (United States Army Corps of Engineers (USACE) 2021)

The NOAA 2017 sea level rise projection scenarios of Intermediate-Low (IL) and Intermediate-High (IH) used in the analysis are consistent with requirements of F.S. § 380.093 and with the Southeast Florida Climate Compact recommendation below:[10]

> *Application of the NOAA Intermediate-High Curve*
>
> *"Projects in need of a greater factor of safety related to potential inundation should consider designing for the NOAA Intermediate High Curve. Examples of such projects may include evacuation routes planned for reconstruction, communications and energy infrastructure, and critical government and financial facilities or infrastructure that may stay in place beyond a design life of 50 years."*

TIDAL FLOODING AND SEA LEVEL RISE

Projected SLR for Martin County is shown in Table 2. The data is published by NOAA per county but based on a limited number of tidal gauges. Martin County's SLR is based on projections for Miami Beach, Florida.[11]

Table 2. Martin County Projected Sea Level Rise

Planning Horizon	2020		2040		2070	
NOAA 2017 Projection	IL	IH	IL	IH	IL	IH
Sea Level Rise (feet) based on a baseline value of 0' in 2000	0.39	0.69	0.75	1.48	1.31	3.35

IL = Intermediate-Low Scenario
IH= Intermediate-High Scenario

Current tidal datums for the closest gauge to Martin County, located at Lake Worth Pier, are published by NOAA on its Tides and Currents website. The Mean Higher-High Water (MHHW) datum is defined as the average of the higher high-water height of each tidal day observed over the National Tidal Datum Epoch.

High-tide flooding elevations are determined by adding a local threshold to the MHHW elevation, and these local thresholds are defined by a 2018 report by NOAA titled "Patterns and Projections of High Tide Flooding Along the U.S. Coastline Using a Common Impact Threshold" that showed existing NOAA coastal flood thresholds for minor, moderate or major flooding "share a common pattern based upon the local tide range". The report found that minor flooding, also referred to as *high-tide flooding* and

[10] (Southeast Florida Regional Climate Compact 2019)
[11] (National Oceanic and Atmospheric Administration 2022)

used in this Study typically begins at about 0.5 meters above the MHHW. NOAA found that based upon the pattern and statistical analysis of minor flooding in coastal areas around the country, a “derived set of flood threshold proxies for minor impacts are permissible for almost any location along the U.S. coastline”.

Therefore, the closest tidal gauge with a corresponding local threshold was used to define high-tide flooding elevation for Martin County. The Virginia Key gauge is the closest and its high-tide flooding threshold is 0.53 meters (1.74 feet) above the MHHW. This value was applied to the Lake worth Pier MHHW elevation of 0.55 ft NAVD88 to reach a high-tide flooding elevation of 2.29 feet for Martin County.

A map series for the County was developed showing the spatial extent and depth of flooding at a sea level elevation of 2.29 feet. An excerpt is shown below, and the complete map series is included in **Appendix A Tidal Flooding and SLR Map Series**.

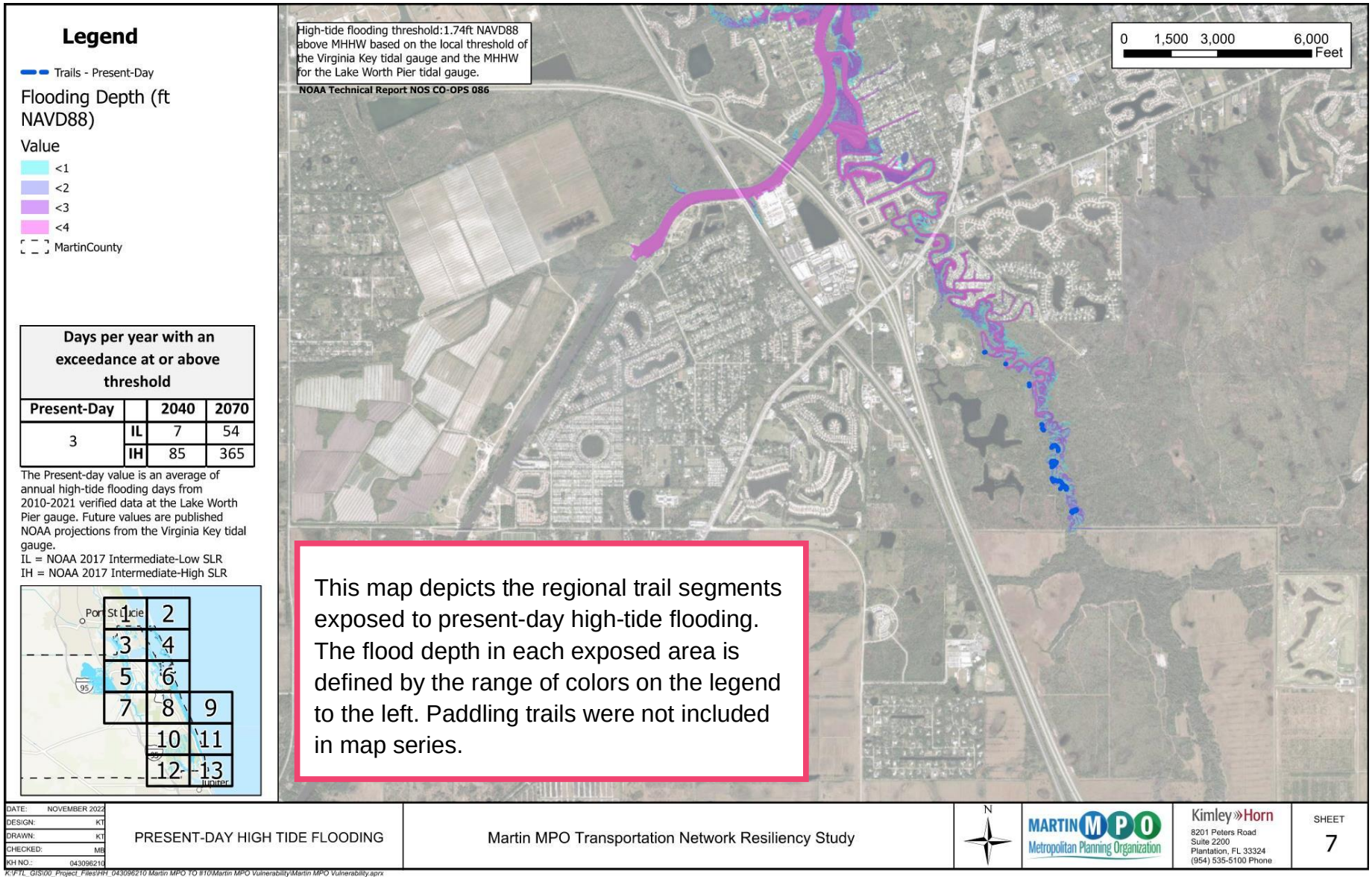
The number of present-day, annual flooding days was determined by finding the annual average of high-tide flooding days, as defined by the local threshold of 2.29 feet, from 2010-2021 daily data at the Lake Worth Pier gauge. Days with storm surge influence were removed from the data set. Future high-tide flooding days were taken from published NOAA projections available from the Virginia Key gauge.[12] Table 3 below summarizes the findings per planning horizon and scenario.

Table 3. Days per Year of High-Tide Flooding

Present-Day		2040	2070
3	Intermediate-Low	7	54
	Intermediate-High	85	365

[12] (National Oceanic and Atmospheric Administration n.d.)

Figure 1. Present-Day High-Tide Flooding Map Series Excerpt



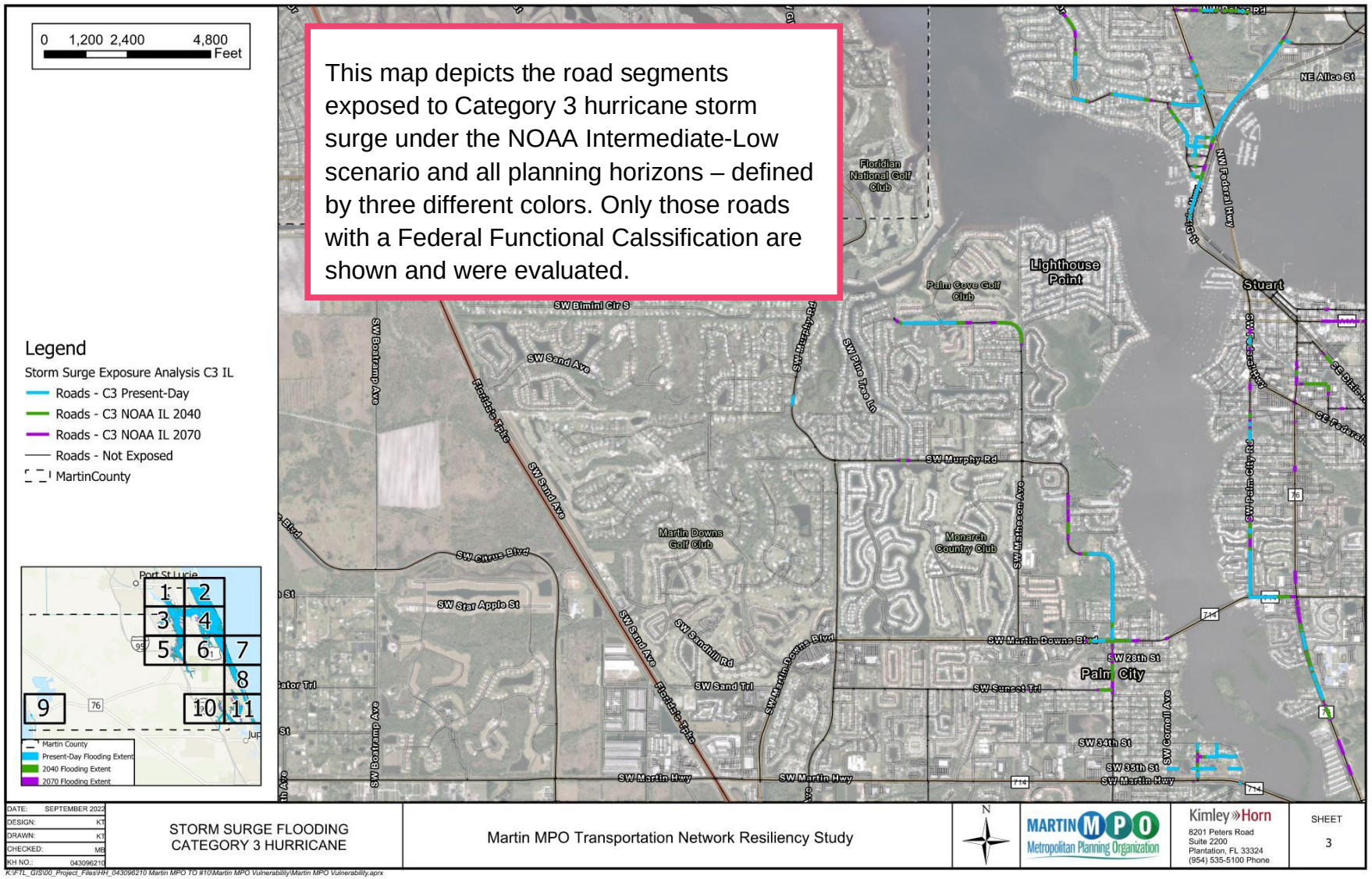
STORM SURGE FLOODING

As discussed in Section 3, NOAA SLOSH data from storm surge impact on the eastern coast of the County was used to generate a water surface elevation raster for category 1 and 3 hurricanes. The storm surge water surface elevation raster was then subtracted from the County DEM to identify positive flood depths. Subsequently, the sea level rise shown in Table 2 was added to the original water surface elevation of each category storm for all scenarios and time horizons to create a map series of each combination. An excerpt is shown below, and the complete map series is included in **Appendix B Storm Surge Flooding Map Series.**

Martin County and its transportation assets are also subject to the effects of storm surge induced flooding via Lake Okeechobee. Data available through the University of Florida Sea Level Scenario Sketch Planning Tool was used to model present-day storm surge impacts from the Lake .[13] The purpose of the tool parallels that of this study as it depicts current and future flood risk to Florida transportation assets using various SLR scenarios. However, documentation for the Tool does not define which lake level scenario is used for the output of storm surge water surface elevations. In addition, data from the Tool was only available for present-day storm surge.[14]

[14] (National Oceanic and Atmospheric Administration n.d.)

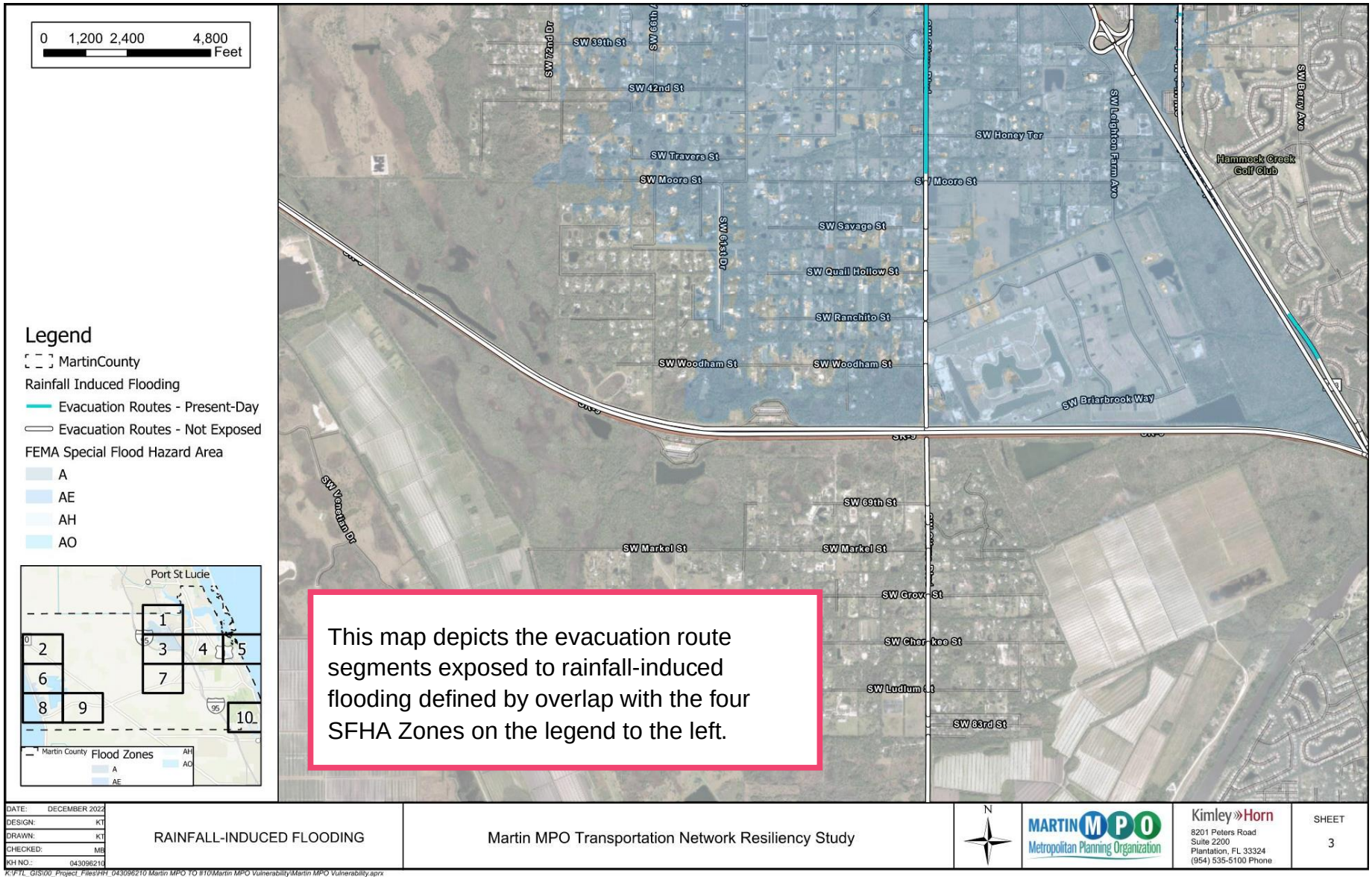
Figure 2. Storm Surge Flooding Map Series Excerpt



RAINFALL-INDUCED FLOODING

Special Flood Hazard Areas (SFHA) are defined by FEMA as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. GIS layers of FEMA SFHA were used in the development of the map series for rainfall-induced flooding. To eliminate the effect of storm surge and sea level rise addressed in previous analyses, SFHA zones representing risk in coastal areas influenced by wave action (Zones V and VE) were removed from the data set. All other Zones were intersected with the asset categories to determine the exposure of each. Note that only present-day conditions are represented by FEMA. An excerpt is shown below, and the complete map series is included in **Appendix C Rainfall-Induced Flooding Map series.**

Figure 3 Rainfall-Induced Flooding Map Series Excerpt



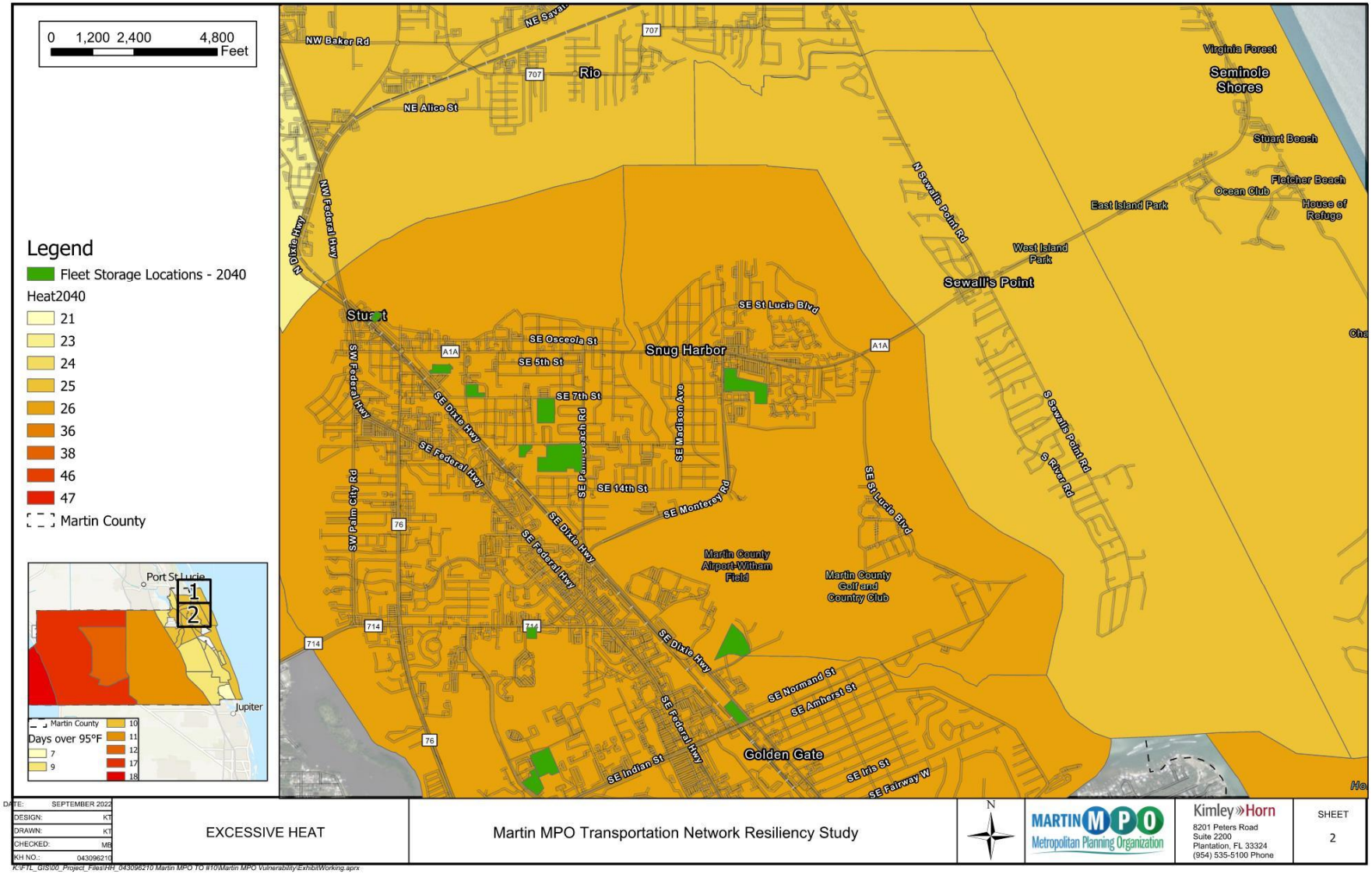
COMPOUND FLOODING

The creation of separate GIS layers as discussed in previous sections allows for the superposition of the three flooding threats to identify assets vulnerable to more than one. In addition to a visual analysis of areas affected by compound flooding, the data within each GIS asset layer is reviewable for a comparison of the flood depths arising from each threat.

EXCESSIVE HEAT

Census tracts containing heat event information, as defined in Section 3 (the number of days with temperatures over 95 degrees Fahrenheit) were intersected with each asset to identify current and future exposure to excessive heat. Present-day conditions and each of the two planning horizons were presented in separate map series as shown in the excerpt below. Refer to **Appendix D Excessive Heat Map Series** for the complete map series.

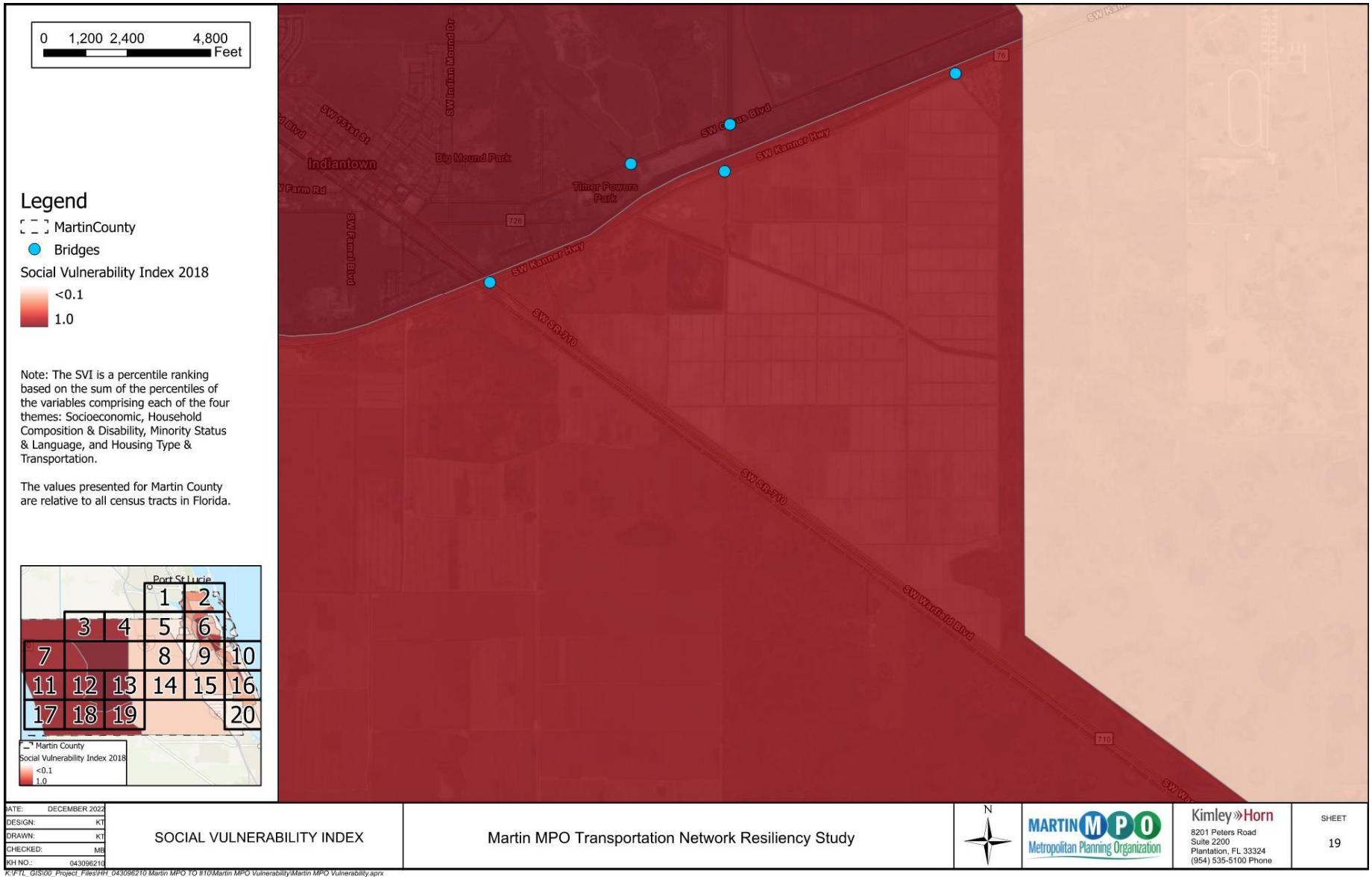
Figure 4. Excessive Heat Map Series Excerpt



SOCIAL VULNERABILITY INDEX

The SVI is not considered a threat as part of this analysis but is presented as an additional characteristic that impacts the planning of future resilient transportation network projects. SVI information is presented by census tract. Similar to excessive heat, SVI data was intersected with each asset to identify exposure to excessive heat. Only present-day condition information was available, as shown in the map series excerpt below. Refer to **Appendix E Social Vulnerability Index Map Series** for the complete map series.

Figure 5. SVI Map Series Excerpt



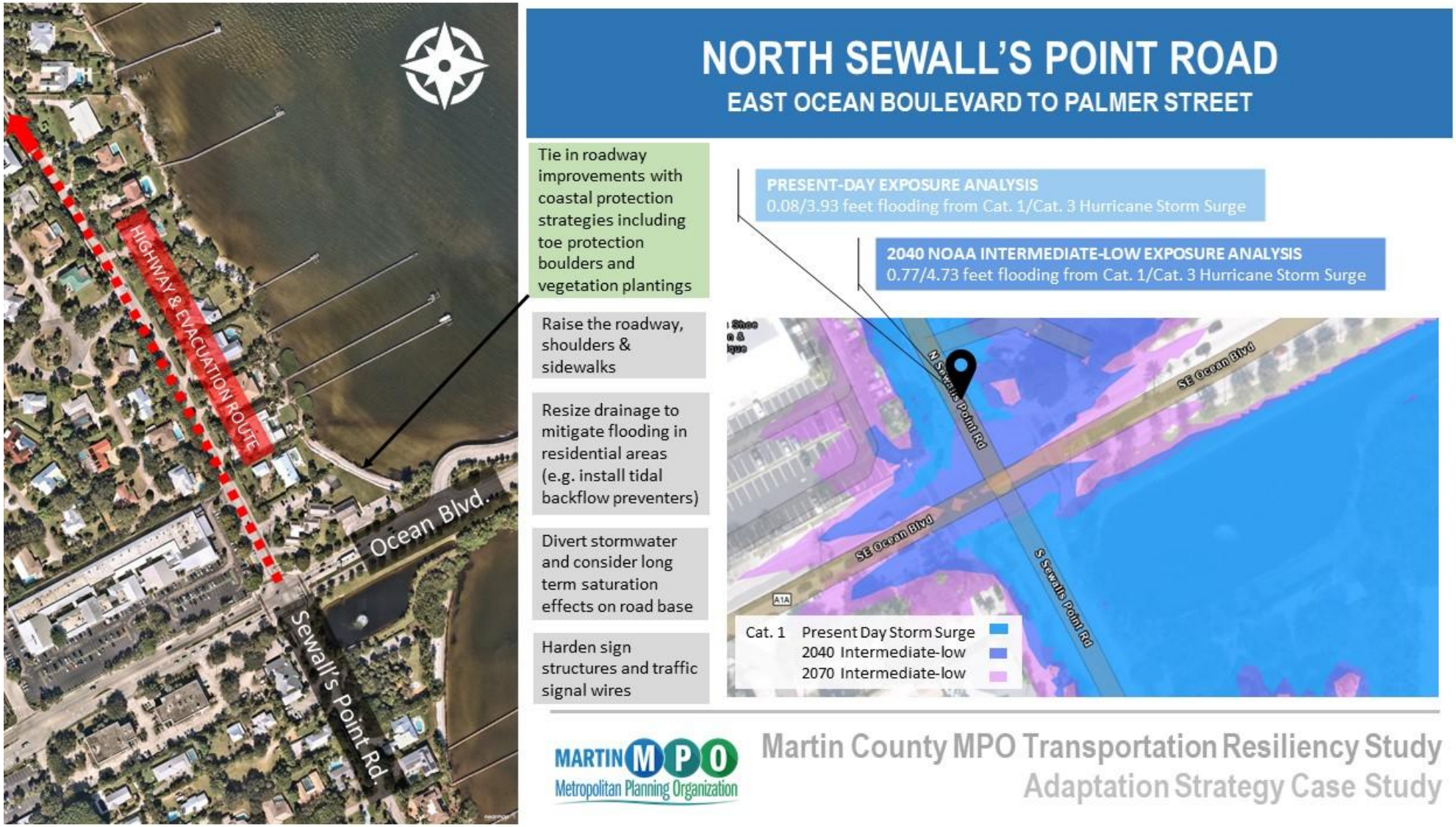
5 EXAMPLE ADAPTATION STRATEGIES

An individual adaptation strategy case study was developed to represent each of three types of assets identified as vulnerable through the exposure analysis task, exposed to a varying number and degree of threats. The purpose is to present example solutions for small-scale areas that could be implemented in the future as independent resiliency projects or in conjunction with other planned roadway projects in the same area or along the same segment. Two forms of structural solutions are included: green boxes represent nature-based solutions and grey boxes represent human-made infrastructure.

EXAMPLE 1

North Sewall's Point Road was identified in the Martin MPO TIP List of Project Priorities based on mitigation for sea level rise impact. The exposure analysis completed as part of this Study shows that the road is vulnerable to flooding from all three analyzed threats and is currently impacted in present-day conditions. The case study presented below highlights the classification of the road as an evacuation route and highway and focuses on adaptation strategies for mitigating storm surge impacts.

Figure 6. Adaptation Strategy Example 1



EXAMPLE 2

Dixie Highway traverses Martin County along the coast. The section from Cove Road to Jefferson Street was identified in the Martin MPO TIP List of Priority Projects for resurfacing and complete street improvements.[15] The exposure analysis completed as part of this Study shows that a bridge on this segment is vulnerable to flooding and is in an area with a high SVI. The case study presented below highlights the classification of the road as an evacuation route and highway and focuses on adaptation strategies for mitigating storm surge impacts.

[15] (Martin County Metropolitan Planning Organization 2022)

Figure 7. Adaptation Strategy Example 2

DIXIE HIGHWAY

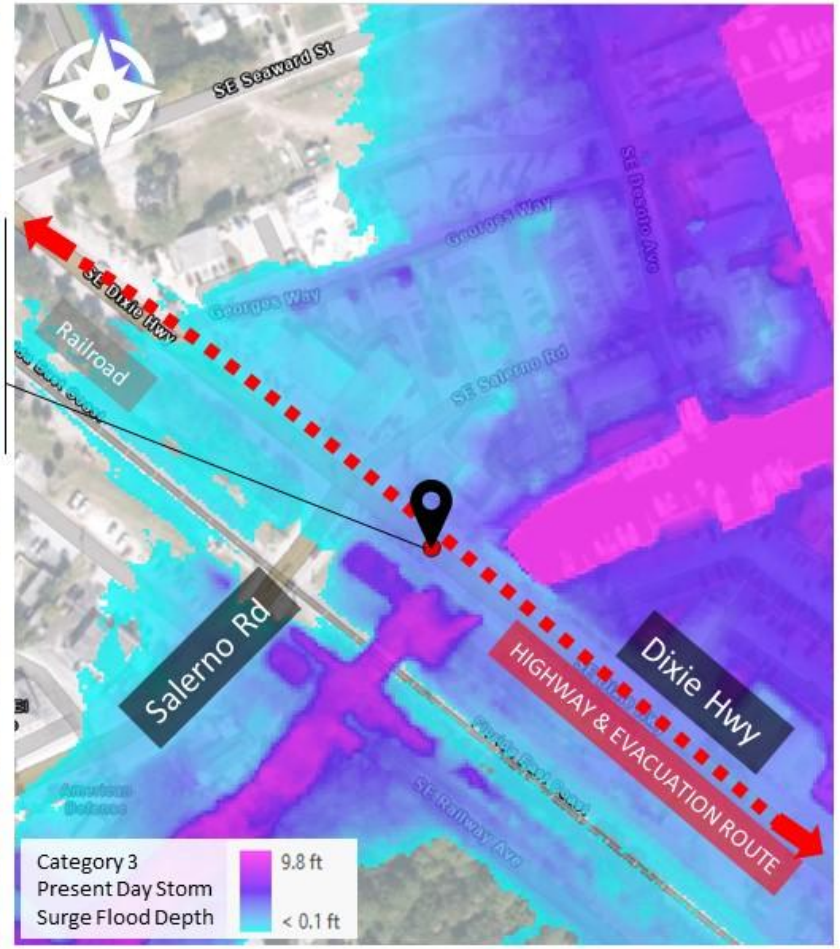
COVE ROAD TO JEFFERSON STREET

Elevate the bridge to avoid damaging wave loads near bridge deck

Bank protection to prevent shoreline recession and protect bridge approaches and foundation

PRESENT-DAY EXPOSURE ANALYSIS
0.0/3.62 feet flooding from Cat.1 /Cat.3 Hurricane Storm Surge
10 days with temperatures over 95 degrees F
High SVI

2040 NOAA INTERMEDIATE-LOW EXPOSURE ANALYSIS
0.82/4.37 feet flooding from Cat.1 /Cat.3 Hurricane Storm Surge
26 days with temperatures over 95 degrees F



Examine foundation of bridge and evaluate need for substructure rehabilitation due to both tidal influence and storm surge

Investigate nature-based alternatives to protect the upstream side, similar to living shoreline and revetment protection on downstream side

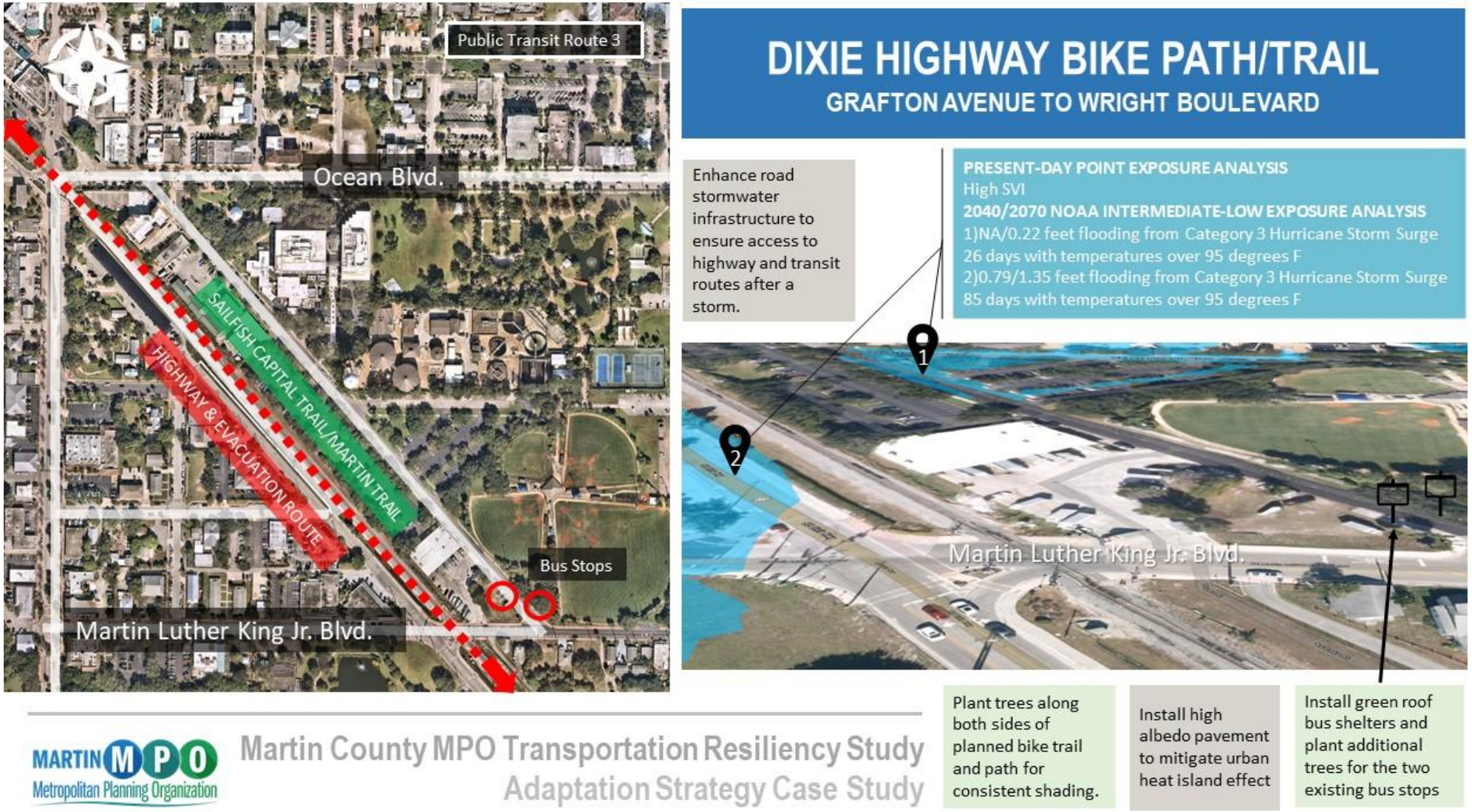
MARTIN MPO Metropolitan Planning Organization

Martin County MPO Transportation Resiliency Study
Adaptation Strategy Case Study

EXAMPLE 3

Dixie Highway is identified in the MPO's 2017 Bicycle, Pedestrian and Trails Master Plan as part of the East Coast Greenway, a priority project of the Florida Greenways and Trails System. The exposure analysis completed as part of this Study highlights the following considerations for local planning: present-day and future storm surge flooding that would affect access to a main bridge crossing the St. Lucie River, excessive heat that should be considered in the planning and design of the regional trail and of existing transit routes and bus shelter upgrades, and the benefit of prioritizing these types of projects in a high SVI area.

Figure 8. Adaptation Strategy Example 3



6 PRIORITIZATION CRITERIA DEVELOPMENT AND LANGUAGE

Task 3 of the Study consisted of developing criteria that could evaluate the level of resiliency considered in the design of a transportation network project. The goal is for the criteria to be used by the MPO as well as any municipality, to enhance existing criteria for ranking projects.

The first step was to determine how the quantified flood depths could be grouped into defined levels of vulnerability with a qualitative impact. The table below shows how flood depth was converted to an impact level based on the type of asset exposed.

Table 4. Impact Levels of Flood Depth

Flooding	**Applicable to**	**Roads, Highways, Evacuation Routes, Bridges & Railroads**	
	Impact	**Description**	**Reasoning**
	Low	0-0.5 ft flood depth	Emergency vehicle passage is not hindered
	Medium	0.5-1 ft flood depth	Emergency vehicle passage is somewhat hindered
	High	> 1 ft flood depth	Emergency vehicle passage is hindered
	Applicable to	**Fleet storage facilities and Airports**	
	Impact	**Description**	**Reasoning**
	Low	0-0.25 ft flood depth	Minimal flooding
	Medium	0.25-0.5 ft flood depth	Access is somewhat hindered
	High	> 0.5 ft flood depth	Access is hindered
	Applicable to	**Trails**	
	Impact	**Description**	**Reasoning**
	Low	Portions of area and access route are impacted	minimal loss of access and does not pose a health or safety risk and repair costs are relatively low
	Medium	Entire area and access route are impacted	loss in access but does not pose a health or safety risk and repair costs are relatively low

The second step was to develop the language to incorporate flooding, excessive heat, and SVI into project prioritization. The basis of the criteria was taken from the Resilient Florida Program discussed in Section 1. Specifically, rule chapter 62S-8 was referenced, which establishes project scoring critera to be used by FDEP when incorporating grant proposals into the Statewide Flooding and Sea Level Rise Resilience Plan. Modifications were made to include only criteria relevant to transportation network assets and additional lanaguage was included to incorporate the impact levels in the table above.

PAC feedback was significant in this Task and vital to ensuring that the criteria could used by local governments as well as the MPO. Final criteria is shown in Table 5.

Table 5. Project Prioritization Criteria

No	Martin MPO Transportation Network Project Prioritization Criteria	Maximum Points Awarded
1	Degree to which the project addresses the risks posed by flooding and sea-level rise	10
	Project will reduce flood exposure impact from high to medium, medium to low, or low to none/minimal	
	Project will reduce flood exposure in present-day conditions, modeled 2040, and modeled 2070 conditions	
2	Project reduces one or more risks to a critical transportation asset, as defined in paragraph 380.093(2)(d) or the project adapts a critical transportation asset to help avoid such risk (adaptation of a significant asset to avoid risk may include relocation of the asset outside the area(s) of flooding risk)	12.5
	Project addresses threats posed by excessive heat in present-day or future conditions	
	Project addresses more than one flooding threat (e.g. storm surge, sea level rise, rainfall-induced flooding)	
3	Project provides risk reduction in areas with a higher percentage of vulnerable critical assets as demonstrated in the local vulnerability assessments (a vulnerable critical asset is a critical asset identified in a comprehensive vulnerability assessment as having one or more risks due to flooding or sea level rise)	10
	Project is in area with high number of projects identified in the local stormwater master plan/Martin County Vulnerability Assessment	
4	Project contributes to existing flood mitigation projects that reduce upland damage costs	10
5	Degree to which flooding and erosion currently affect the condition of the project area. Justification for methods used to estimate or determine extent and frequency of flooding or erosion must be provided	7.5
	Analysis shows that asset impact exposure is high	
	Analysis shows that asset impact exposure is medium	
	Analysis shows that asset impact exposure is low	
6	Readiness of the project to proceed in a timely manner	7.5
7	Project incorporates environmental habitat enhancement or nature-based solutions for resilience	8
8	Project provides reasonable analysis that demonstrates the project is cost-effective. The basis for cost-effectiveness shall be provided by the applicant within the submitted statement.**	5
9	Project provides documentation that demonstrates 50% cost share is available or that the community is a financially disadvantaged small community.	7.5
10	Verification of funding previously awarded to the project is provided. Verification must include previously funded phases, amount of prior funding, and previous partial appropriations, and must be submitted in a format that is verifiable by the agency or agencies having awarded the previous funding.	7.5
11	Project exceeds the flood-resistant requirements in the Florida Building Codes Act or local floodplain management regulations or documentation is provided that demonstrates no Florida Building Code flood-resistant requirements or local floodplain management regulations apply to the project	2.5
12	Project incorporates innovative technologies designed to reduce project costs	5
13	The impact area of the proposed project is wholly or partially located in a community with a high social vulnerability index	7
	TOTAL	**100**

7 RECOMMENDATIONS

The Martin MPO's existing methodology for prioritization is described in the Cost Feasible Chapter of its 2045 Long-Range Transportation Plan. The criteria used in the 2045 LRTP varied based on the type of asset being evaluated. For example, roadway projects that do not fall into the Strategic Intermodal System (SIS) and are therefore not prioritized by the state, are evaluated using 15 performance measures related to safety, level of service, funding and others.

In the 2045 LRTP, resiliency is only considered through two broad criteria: whether the project is an area vulnerable to flooding, and whether the segment is classified as an evacuation route. This Study seeks to enhance the methodology the Martin MPO uses to determine the level to which prospective projects consider resiliency.

It is Kimley-Horn's recommendation to use the data and information in this Study to continue the implementation of the MPO's resiliency goals, by incorporating the prioritization criteria into the next planning session. In addition, municipalities within the County may adopt similar criteria to support their own planning and funding needs.

The Study as a whole can be used to support larger funding and grant proposals. Even though limited to transportation network assets, the exposure analysis is consistent with the vulnerability assessment requirements of F.S. § 380.093, and the prioritization criteria parallels the requirements of project scoring criteria of 62S-8 – both prerequisite guidelines for consideration of inclusion in state-wide project prioritization.

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9 APPENDICES

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APPENDIX A TIDAL FLOODING AND SLR MAP SERIES

The map series shows the spatial extent and flood depth for present-day high-tide flooding only. Also, each sheet of the map series and its corresponding legend show only those assets exposed to present-day high-tide flooding in the extent covered by that sheet.

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APPENDIX B STORM SURGE FLOODING MAP SERIES

Each asset has its own map series for each combination of category 1 or 3 hurricane and the two SLR scenarios. The three planning horizons are included within each map series. There is no map series for the Railroad asset category under the category 1 Intermediate-Low scenario due to minimal or no exposure to this threat.

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APPENDIX C RAINFALL-INDUCED FLOODING MAP SERIES

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APPENDIX D EXCESSIVE HEAT MAP SERIES

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APPENDIX E SOCIAL VULNERABILITY INDEX MAP SERIES

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