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I. Background
Observed changes in sea levels along Florida’s coastline and research into the effects of climate change on rising sea levels have led to the establishment of vulnerability assessments at local and regional scales within the state of Florida. Such vulnerability assessments document the risks posed to community assets from potential sea level rise inundation and set a baseline for future policy and adaptation strategy development.

This vulnerability assessment was completed for the Space Coast Transportation Planning Organization (SCTPO) and covers the entirety of Brevard County, Florida. The assessment looks specifically at assets that contribute to transportation functionality within the County, including roadways, railroads, airports, transit and other critical facilities deemed important for countywide transit.

By taking a risk-based approach and identifying vulnerable facilities within Brevard County, the TPO can begin to implement adaptation actions, policies and practices that will address vulnerable facilities and minimize long-term impacts on countywide mobility.

Increased frequency and duration of flooding, along with a greater prevalence, can occur as a result of sea level rise, which can have impacts on vital infrastructure\(^1\). This can result in malfunctioning drainage systems, insufficient stormwater storage, loss of access to facilities and economic losses to properties and the overall community and region.

This assessment will also assist the Space Coast TPO and Brevard County in applying for money from Federal programs such as the Fixing America’s Surface Transportation (FAST) Act, which focuses on increasing the resiliency of coastal transportation and stormwater runoff systems\(^2\). Funding requires specific strategies to mitigate transportation infrastructure from the effects of natural disasters. Secondly, the Community Rating System (CRS) now identifies sea level rise as a natural hazard and rewards credits to communities that analyze the potential impacts of sea level rise\(^3\).

The data and maps in this assessment are for planning, educational, and awareness purposes only and should not be used for site-specific analysis, navigation, and flood rates or permitting. As with all data, all features should be verified with site visits and surveying. The data and maps in this report are provided “as is”. Please see the methodology portion of this report for more information.
II. Methodology

This study builds on a methodology developed by the East Central Florida Regional Planning Council (ECFRPC) that utilizes sea level rise data provided by the University of Florida GeoPlan Center. Previous studies completed for the City of Satellite Beach, the Florida Department of Economic Opportunity, the Florida Sea Grant Program and the River to Sea Transportation Planning Organization set baseline planning horizons (2040, 2070 and 2100) as well as consistent inundation projection rate curves (low, intermediate and high) from the U.S. Army Corps of Engineers (USACE). This study was developed in a manner to maintain regional consistency based upon the best available data.

Sea Level Scenario Sketch Planning Tool

The Sea Level Scenario Sketch Planning Tool was developed by the University of Florida GeoPlan Center for the Florida Department of Transportation (FDOT) to determine future sea level rise inundation areas utilizing U.S. Army Corps of Engineers (USACE) and National Oceanographic and Atmospheric Administration (NOAA) projection rate curves. The Guide to GIS Data SLR Models document developed by UF GeoPlan Center can be found in the appendix. More details concerning the methodology utilized by the University of Florida can be found at the following link: https://sls.geoplan.ufl.edu/documents-links/.

This analysis used the “modified bathtub model that applies a hydrologic connectivity filter to remove isolated inundated areas not connect to a major waterway”. The resulting inundation files represent the specific projection rate curve mapped on top of MHHW.

Inundation Projection Rate Curves

NOAA and the U.S. Army Corps of Engineers publish rate curves determined by global factors. Low sea level scenarios are based on historic rates of sea level change; intermediate level scenarios are based on projected ocean warming; and high curve scenarios factor in continued reductions in the growth rate of Arctic and Antarctic ice sheets and ice sheet loss. Calculations of projected sea level rise and inundation from the Atlantic and Indian River Lagoon (IRL) used the Daytona Beach Shores NOAA tide station’s sea level trend values, which incorporate local subsidence or uplift rates.
The specific projected sea level rise scenarios and associated rates of increase utilized in this report (USACE rates) are shown below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Low</th>
<th>Intermediate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>2040</td>
<td>4.38&quot;</td>
<td>6.84&quot;</td>
<td>14.63&quot;</td>
</tr>
<tr>
<td>2070</td>
<td>7.12&quot;</td>
<td>13.62&quot;</td>
<td>34.19&quot;</td>
</tr>
<tr>
<td>2100</td>
<td>9.86&quot;</td>
<td>22.31&quot;</td>
<td>61.76&quot;</td>
</tr>
</tbody>
</table>

Source: UF GeoPlan Sea Level Scenario Sketch Planning Tool

The projected sea level rise rates based upon the Daytona Beach Tidal Shores Gauge results in increasing levels of inundation across scenarios. The actual depth of inundation will vary depending upon the elevation of specific locales. The figure below shows the potential inundation, above mean sea level (MSL), during MHHW events under the specific planning horizons and rate curves. These data are important for vulnerability analysis.

While the analysis in this report focuses on all three rate curves and years, generally, the graphics provided focus on USACE High Projection Rate Curve due to the criteria of the 2017 Community Rating System (CRS) Manual which states that all future planning analysis must be, at a minimum, equivalent to the 2012 NOAA Intermediate High. USACE High is the only USACE curve that meets these criteria and is slightly higher (max. about 12 inches) than the NOAA Intermediate High curve. Therefore, this report meets the CRS criteria for projection rate curves.

It should be noted that this analysis does not take into account the impacts of increased storm surge due to sea level rise and does not include analysis of increases in the water table.

The 2017 CRS Manual can be found here: https://www.fema.gov/media-library-data/1493905477815-d79467aadeed5beb6a6304d8ba0b207/633300_2017_CRS_Coordinators_Manual_508.pdf
III. Vulnerability Analysis

Overview

The vulnerability analysis consists of maps and tables depicting inundated assets throughout the County. Summaries of inundation are provided within each section and outline the percentage of total inundation to network assets (such as roads and railroads) as well as the number of facilities projected to be inundated and approximate inundation timetables.

The following assets within Brevard County were analyzed for intermediate and long-term vulnerability to sea level rise inundation:

- Evacuation Routes
- Roadways by Classification
- Railroads
- SCAT Bus Stops and Routes
- Trails
- Fleet Storage Facilities
- Transportation Operations Facilities
- Public Service Facilities and other Critical Facilities
- Major Hospitals
- Regional Assets (Patrick Air Force Base and Multi Modal Facilities)

The map below depicts sea level rise inundation under the Army Corps of Engineers High Projection Rate Curve for year 2100. This curve depicts the maximum modeled inundation provided within this report. This and all other maps in this report depict areas of higher (deeper) inundation in darker shades of blue, while areas of shallow inundation are depicted in lighter shades of blue. In addition to the inundation analysis within this section, refer to the Atlas that has been completed as part of this report (Appendix II). The appendix also includes inundation maps of each scenario.

Key County Statistics

Lagoon Coastline: ~245 mi*
Atlantic Coastline: ~72 mi*
Total Coastline: ~317 mi*
Area: 1,016 mi²
Cities & Towns: 16

*Coastline mileage does not include islands
Map 3: Northern Brevard County Inundation Depth Map – 2100 High Curve

Source: University of Florida GeoPlan Center (2017)
General Findings
Brevard County has an area of approximately 1,016 square miles. The table below illustrates the area within the County that is projected to be inundated under MHHW conditions based upon the planning horizons and projection rate curve.

By 2100, under the USACE High Projection rate curve, approximately 12.2% of the County may be inundated during MHHW, almost double from the year 2070. However, between 2040 and 2070, there is expected to be a 318% increase in inundated areas. Interestingly, although the Intermediate Curve does not impact as much square mileage as the High Curve, the percent increase of inundated area is the highest between 2040 and 2070 under that curve (1993%).

While the largest area expected to be inundated is the Merritt Island National Wildlife Refuge area, comprised largely of natural lands, this is also home to NASA/Kennedy Space Center, Cape Canaveral Air Force Station, as well as developed areas of unincorporated Brevard County. This area is an economic hub for Brevard County due to its space industry as well as eco-tourism opportunities and eco-system services provided by the area.

| Table 2: Change in Inundation based on USACE Rate Curve & Year |

<table>
<thead>
<tr>
<th></th>
<th>Low Curve</th>
<th></th>
<th></th>
<th></th>
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<tr>
<td></td>
<td>2040</td>
<td>2070</td>
<td>2100</td>
<td>2040</td>
<td>2070</td>
<td>2100</td>
<td>2040</td>
</tr>
<tr>
<td>Total Area of Inundation</td>
<td>0.26</td>
<td>0.67</td>
<td>7.71</td>
<td>0.67</td>
<td>14.02</td>
<td>37.5</td>
<td>16.73</td>
</tr>
<tr>
<td>Percentage of County</td>
<td>0.0%</td>
<td>0.1%</td>
<td>0.8%</td>
<td>0.1%</td>
<td>1.4%</td>
<td>3.7%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Percentage Change</td>
<td>--</td>
<td>158%</td>
<td>1051%</td>
<td>--</td>
<td>1993%</td>
<td>167%</td>
<td>--</td>
</tr>
</tbody>
</table>

| Table 3: Change in Inundation (NOAA) |

<table>
<thead>
<tr>
<th>Total Area of Inundation (Square Miles)</th>
<th>1 Foot</th>
<th>2 Feet</th>
<th>3 Feet</th>
<th>4 Feet</th>
<th>5 Feet</th>
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<tr>
<td>25.7</td>
<td>64.02</td>
<td>104.1</td>
<td>124.7</td>
<td>144.2</td>
<td></td>
</tr>
<tr>
<td>Percentage of County</td>
<td>2.5%</td>
<td>6.3%</td>
<td>10.2%</td>
<td>12.3%</td>
<td>14.2%</td>
</tr>
<tr>
<td>Percentage Change</td>
<td>--</td>
<td>149%</td>
<td>63%</td>
<td>20%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Map 5: USACE Sea Level Rise Scenario Comparison over Brevard County
These data results, the projection rate curves and modeling derived from the NOAA Digital Coast Sea Level Rise Viewer Tool, indicate that Brevard County may experience a “tipping range” between approximately 1.5-2 feet (around 2045-2060) when considering the USACE High projection rate curve. These dates and ranges are estimates and as projections and rates change, so may the tipping ranges.

The figures below depict the changes in inundation extent at 2 feet and 3 feet of sea level rise in the NOAA Sea Level Rise Viewer.

Map 6: Sea Level Rise Viewer Maps (NOAA Digital Coast)
Vulnerability Analysis | *Evacuation Routes*

Evacuation routes are pivotal infrastructure assets that protect the safety of Brevard County residents and visitors. This section includes an analysis of designated County evacuation routes and potential inundation by sea level rise during the 2040, 2070 and 2100-time horizons. Table 4 depicts projected sea level rise inundation mileage along these routes and Map 7 shows the locations of these vulnerable facilities. It is important to note that the mileage shown in the table does not represent a consistent stretch of roadway but the total mileage of segment inundation for that specific roadway. Brevard County has a total of 651.8 miles of evacuation routes, of which 15.72 miles (or about 2.4% of countywide mileage) are projected to be inundated under the high curve, year 2100. No impacts are projected using the low and intermediate curves by the year 2100.

While most of the County’s evacuation routes are generally located on higher ground to avoid flooding, most of the vulnerable routes are located on the barrier islands or the causeway connecting to the mainland. US Highway 1, State Highway A1A, and SR 520, all high-volume roadways, are the most vulnerable and experience multiple sections of inundation throughout the County. A significant portion of SR A1A about (about 4 miles) from Cocoa Beach south to Patrick Air Force Base may be inundated during high tide by the year 2100. Also, by 2100 there is expected to be major impacts to the Merritt Island Area, with some of the only areas above inundation levels being the road infrastructure itself. The integrity of these systems such as SR 3, SR 528 and SR 520 need to be investigated as sea level rises, as erosion and over-wash may be issues, especially after storms as the increased flooding may take much longer to recede, thus impacting reentry to these areas and long-term functionality of the road.

Causeways, especially along SR 528 (Bennet Causeway), a highly traveled evacuation route and SR 520 (East Merritt Island Causeway) are expected to experience significant inundation by 2070 up to 23 inches during high-tide and up to nearly 50 inches by 2100. Pineda and Eau Gallie are expected to experience inundation by 2100. The run-ups to these bridges and the land that support the causeways will need to be more closely evaluated, as well as bridge spans. The data depicts that inundation will creep to the roadways edge and in some case take over areas of the roadway especially along the east side of the lagoon on SR 528 as it approaches Merritt Island, however other environmental factors such as increased erosion, over-wash from higher storm surges and potential increased “nuisance” flooding resulting from sea level rise could also impact the integrity of these evacuation routes, especially during high tide, and also impact re-entry along these causeways.

Google Earth Depictions of E. Merritt Island Causeway (SR 520) and Bennet Causeway (SR 528) areas expected to be impacted by sea level rise by 2070 under the USACE High Scenario. These causeways not only are major evacuation routes for the barrier islands of Brevard County, but also serve as major pieces of economic infrastructure for accessing jobs and tourism opportunities.
Also, it should be noted that while the sections of SR 46 vulnerable to inundation from rising levels of the St. Johns River is in Volusia and Seminole Counties, this corridor is a vital roadway for Brevard County for evacuation purposes, as well as daily commutes for employees who may live in Seminole County as well as visitors traveling from central Florida. Improvements, or lack thereof, along this vulnerable stretch of roadway, can have major impacts on Brevard County. The water levels around SR 46 and the St. Johns River were at extremely high levels after Hurricane Irma. This is a tell-tale sign of impacts to come as the extent of this flood will increase as sea levels rise.

The Sea Level Rise Atlas that is included as an appendix to this report depicts County sea level rise alongside evacuation routes and critical transportation facilities colorized by vulnerability to sea level rise. Please utilize this atlas as the primary source for graphic representation of the impacts of high projection rate curve sea level rise on evacuation routes within the County.

<table>
<thead>
<tr>
<th>Evacuation Route</th>
<th>Low Curve</th>
<th>Intermediate Curve</th>
<th>High Curve</th>
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<tbody>
<tr>
<td></td>
<td>2040</td>
<td>2070</td>
<td>2100</td>
</tr>
<tr>
<td>County Highway 509</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Interstate 95</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Micco Road</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Misc. Ramps</td>
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<td>None</td>
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<tr>
<td>Norwood Avenue</td>
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<td>None</td>
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<tr>
<td>Space Commerce Way</td>
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<td>None</td>
</tr>
<tr>
<td>State Road 3</td>
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</tr>
<tr>
<td>State Road 404</td>
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<td>None</td>
<td>None</td>
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<td>State Road 405</td>
<td>None</td>
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</tr>
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<td>State Road 406</td>
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</tr>
<tr>
<td>State Road 50</td>
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<td>State Road 507</td>
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<td>State Road 524</td>
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</tr>
<tr>
<td>State Road 528</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>State Road A1A</td>
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<tr>
<td>US Highway 1</td>
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<td>US Highway 192</td>
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<td>Wickham Road</td>
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</tr>
<tr>
<td>Totals</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
Map 7: Evacuation Route Inundation – High Curve

Hurricane Evacuation Routes
Projected Inundation
High Curve

Inundation projected by
2070 time horizon
Inundation projected by
2100 time horizon

2100 Inundation Extents

1. SR 406 & US Highway 1
   0.06 Miles & 0.38 Miles
2. SR 50 & US Highway 1
   0.09 Miles & 0.11 Miles
3. SR 528 (Beachline)
   0.15 Miles
4. SR A1A (Astronaut Blvd.)
   0.88 Miles
5. SR 520 (King Street)
   0.26 Miles
6. SR 520 (Merritt Isl. Causeway)
   4.53 Miles
7. SR A1A (N. Atlantic Ave)
   3.59 Miles
8. US Highway 1
   0.48 Miles
9. SR 404 (Pineda Causeway)
   0.02 Miles
10. SR 518 (Eau Gallie Cswy)
    0.19 Miles
11. US Highway 1
    0.07 Miles
12. US Highway 1
    3.11 Miles
13. SR A1A
    0.85 Miles
14. Interstate 95
    0.02 Miles

*Two false positives were removed from this map. Therefore, #3 and #4 are skipped.
Vulnerability Analysis | Roadways by Classification

The USACE high projection rate curve shows inundation for 46.34 miles of major roadway in the County by the year 2100. This represents approximately 6.2% of the County’s major roadway mileage. It is important to note that these miles are not consistent stretches of roadways but segments. Due to proximity or stretches of segments, larger miles of roadway may need to be mitigated.

Inundation Summary – Northern Brevard County
The western coastline of the lagoon system near Mims and Scottsmoor is projected to experience up to one mile of inundation inland under the high curve for year 2100, and approximately 0.62 miles of Huntington Avenue is projected to be inundated. Portions of Kennedy Parkway along Canaveral National Seashore property are also projected to be inundated by 2100, and inundation to South Hopkins Avenue (US Hwy. 1) in downtown Titusville is expected to be occur by year 2100 (high curve) in addition to a small portion of Cheney Highway (AADT 14,000) to the south at its intersection with US Highway 1. High-volume US Highway 1 has intermittent inundation projected throughout the County. In the initial analysis, it was determined that some potential LIDAR issues caused run-ups of the Max Brewer Bridge to be flagged as inundated. After additional analysis, most of the flagged segments are elevated and may be above inundation levels. However, it is strongly advised to assess the run ups of the Max Brewer Bridge to provide a site-specific analysis, rather than spatial and wave action and over-wash should also be considered along the runups of this and other bridges.

Inundation Summary – Central Brevard County
The southern portion of Merritt Island is projected to have large swaths of inundation under the high curve by year 2100. At this projection parameter, inundation is projected to State Road 520 (AADT 26,000) Banana River Drive (13,700), Sykes Creek Parkway (16,700), Fortenberry Road (4,000), Merritt Avenue (6,600), Newfound Harbor Drive (7,100), Plumosa Street (6,600), Courtenay Parkway (7,100), Plantation Road (9,900) and Cone Road (4,900). Inundation continues to

As shown in the graphic, by 2100 there is expected to be major impacts to the Merritt Island Area, with some of the only areas above inundation levels being the road infrastructure itself. The integrity of these systems such as SR 3, SR 528 and SR 520, as well as local roads, need to be investigated as sea level rises, as erosion and over-wash may be issues, especially after storms as the increased flooding may take much longer to recede, thus impacting long term functionality of the road and integrity of the community.
the southern tip of the island along 1.6 miles of South Tropical Trail (1,600). Across the lagoon in the Cocoa Beach area, inundation is projected along 1.29 miles of the Minutemen Causeway (AADT 5,400), 0.22 miles of Brevard Avenue (2,500), and 1.93 miles to the southbound lanes of A1A (14,000) under the high curve for year 2100.

On and off ramps for the Pineda Causeway and U.S. 1 should also be examined as inundation is expected to impact small segments of these facilities. While it would appear this would be minor impacts, flooding would prevent evacuees or in times of no storm, commuters, from accessing major thoroughfare, especially under higher flood/tide events (King Tides). New configurations of the NB on ramp and NB exit ramp may be necessary to ensure access in this area.

**Inundation Summary – Southern Brevard County**

US Highway 1 and State Highway A1A are projected to experience intermittent inundation in southern Brevard County under the high curve by year 2100. In addition to these roadways, a high degree of risk to transportation facilities is present in the Satellite Beach, Indian Harbour Beach and Indialantic communities. In this portion of the County, South Patrick Drive (AADT up to 16,600) is expected to experience approximately 3.73 miles of inundation under the high curve by year 2100. During this horizon and using this projection curve, inundation is also projected for 0.32 miles of Ocean Boulevard (AADT 3,700), 0.16 miles of Sea Park Boulevard (1,200), 0.11 miles of Shearwater Parkway (2,300), 0.52 miles of Jackson Avenue (3,800), 0.48 miles of Cassia Boulevard (1,950), 0.78 miles of Desoto Parkway (4,300), 0.22 miles of Pine Tree Drive (5,000) and 0.04 miles of Eau Gallie Boulevard (22,000).

**Table 5: Roadway by Classification Inundation Summary**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Low Curve</th>
<th>Intermediate Curve</th>
<th>High Curve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2040 2070 2100</td>
<td>2040 2070 2100</td>
<td>2040 2070 2100</td>
</tr>
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**Note:** The FDOT RCI files were used in this analysis, while data from the Statewide Regional Evacuation Study (Tele-atlas) was used to assess Evacuation Routes. When the east and west bound lanes, or north and south, are separated roadways, the evacuation routes indicate this allowing for more accurate analysis and result in additional mileage of roadway. This accounts for the variation of mileage of between same named evacuation routes and major roadways However, the RCI files work from one center line regardless of the separated roadways. Where evacuation routes showed further impacts of in an area versus the RCI files, staff worked to identify these areas and adjust tables and maps. However, it is recommended that both files are used in further analysis and prioritization. Additionally, the RCI file may provide alternate/local names for State and US Roadways which may be used in the table below. Additionally, it should be noted these files are lines on a map and do not represent the entire width of the roadway and in some cases, false negatives may appear, (ex. The inundation data and aerial shows roadway impacts along outer edges or lanes, but the analysis did not pick up the road data line.) Staff worked to identify and discuss some of these areas, especially where inundation is occurring on both sides of the facility. It is recommended to conduct a deeper analysis into critical facilities to further assess impacts in questionable areas.
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**Table 6: Roadway by Classification Detailed Summary**
Roadways by Classification

Projected Inundation High Curve

- Projected Inundation by 2070
- Projected Inundation by 2100

Source: Roadways by Classification (FDOT); Sea Level Rise (UF GeoPlan Center)
Vulnerability Analysis | *SCAT Bus Stops*

The only time horizon and inundation curve combination that is projected to impact Space Coast Area Transit (SCAT) bus stop locations is the high curve for year 2100, and all analysis in this section will reflect the inundation risk approximated from this curve.

A total of 30 of the more-than-850 bus stops in the County are projected to be inundated, accounting for approximately 3.52% of all SCAT bus stops. The vast majority of these facilities are located in a small number of communities, including Titusville, Merritt Island, Cape Canaveral, Cocoa Beach, Indian Harbour Beach and Melbourne.

**Inundation Summary – Northern Brevard County**

Titusville has three bus stops that are projected to be inundated, and two of the three are located downtown. They include the bus stop facility on US Highway 1 (Hopkins Avenue) at Marina Road and the facility on Indian River Avenue to the south of Space View Park. Further down US Highway 1, inundation is projected at the two bus stops south of Cheney Highway. The US Highway 1 and Cheney Highway intersection is highly traveled and is projected to be partially inundated by year 2100 using the high projection rate curve.

**Inundation Summary – Central Brevard County**

Central Brevard County has the majority of the bus stop projected to be inundated by year 2100 under the high rate curve. The communities primarily affected include Merritt Island, Port Canaveral and Cocoa Beach. In Merritt Island, six bus stops along State Road 520 are projected to be inundated. This includes the bus stops to the east and west of the Sykes Parkway intersection, the two facilities to the west of Banana River Drive and the two facilities at Milford Point. In addition, one bus stop on Sykes Creek Parkway south of the State Road 520 intersection and one bus stop south of Treasure Street on Banana River Drive are projected to be inundated by year 2100 under the high curve. In Cape Canaveral, three bus stops located on State Road A1A are projected for inundation, including the two bus stops near Central Boulevard and the bus stop at Columbia Drive. In Cocoa Beach, all eight of the bus stops that are projected to be inundated are also located along State Road A1A. This includes the bus stops north of North 2nd Street, south of Minutemen Parkway, south of South 2nd Street, and at the intersections of South 4th Street, South 6th Street, South 16th Street and South 35th Street. It is highly recommended that mitigating action occur along A1A in this portion of the County.

**Inundation Summary – Southern Brevard County**

Bus stop facilities in the southern portion of the County are largely untouched from the projected effects of sea level rise with the exception of two. The first is located in Indian Harbour Beach on Eau Gallie Boulevard at the intersection with Riverside Drive. The second facility is located in downtown Melbourne on East New Haven Avenue at the intersection with Front Street. In summary, the absence of bus stop facilities along South Patrick Drive and Riverside Drive reduces bus stop exposure in this portion of the County. It is recommended that bus stop facilities remain off of these roadways unless mitigating measures are taken.

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<td>0% 0% 3.52%</td>
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Vulnerability Analysis | Railroads

There are two railroad owners in Brevard County; the Florida East Coast (FEC) Railway and the United States Federal Government. The Florida East Coast line runs along the western coastline of the Indian River Lagoon, while the federal line runs eastward to the government facilities on Merritt Island. Portions of both owners’ railways are projected to be inundated by year 2070 under the high projection rate curve.

The Florida East Coast Railway is projected to experience 1.91 miles of direct linear inundation by year 2100 under the high curve. This number is not telling of the true scenario, however. To the north of Titusville, approximately 28 segments with an average segment length of 348 feet (a total of 1.85 miles) are projected to be inundated along a stretch of railway that extends more than 12 miles (2100, high curve). This area is marked in burgundy text in the map on the following page and, due to overall map scale, appears as a continuous segment. From a mitigation perspective, fixing this stretch of railway would likely include mitigation to the entire stretch, as elevations would need to remain relatively consistent for traveling goods to flow through.

The FEC line is much less impacted in the central and southern portions of the County. A total of 8 segments totaling 0.05 miles are projected to be inundated by year 2100 when utilizing the high projection rate curve. These railroad segments are located adjacent to the Eau Gallie River in Melbourne (2 segments), Crane Creek in Palm Bay (4), and Goat Creek to the south of Malabar (2), all of which are riverine systems that run inland from the Indian River Lagoon.

The federal government-owned railroad lines are located in the most vulnerable portion of the County from a sea level rise perspective: central and northern Merritt Island. Inundation is projected as soon as 2070 under the high curve along railroad segments, a combined 360 feet long, which is the approximate size of a football field. These segments are located to the northwest of the NASA landing facility and along the Atlantic coastline where the railway turns to the southeast. By 2100, inundation is projected to encompass 8.93 miles of this railway. The vast majority of this inundation is located along the segment that connects to the Cape Canaveral Air Force Station near the Atlantic coast. Inundation is also projected in three clusters near Banana Creek in central Merritt Island.

Both the FEC and federal railroad routes are critical from an economic perspective. The FEC line supplies goods to and from south Florida, while the federal line, while not currently in use, serves National Aeronautics and Space Administration (NASA) and Cape Canaveral Air Force Station. With the future of rail in Florida for freight and passenger transport, disruption of the FEC line could cause long-term economic impacts more than the cost of mitigation. Thus, it is recommended that the necessary stakeholders conduct a cost-benefit analysis concerning the mitigation of this infrastructure. NASA should include the future of the rail line in their adaptation decision making process and whether this rail corridor is necessary for the current and future aerospace industry.

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Table 8: Railroad Inundation Summary
Note: Highly segmented, not continuous

Source: Railroads (Space Coast TPO); Sea Level Rise (UF GeoPlan Center)
Vulnerability Analysis | Trails

The countywide trail system is the most vulnerable of all transportation assets in Brevard County due to a number of coastal segments that are located in very low-elevation areas. The most vulnerable trails in the County are expected to be subject to inundation by 2070 when utilizing the intermediate projection rate curve scenario. Below is a summary of countywide inundation to the trail system. The vast majority of trail segments with projected sea level rise inundation are located on the barrier islands and Merritt Island. The exceptions are the East Coast Greenway with projected inundation in the Titusville and Port St. John areas, the All-Aboard Florida Rail-Trail corridor with projected inundation near Melbourne and Palm Bay, and the St. Sebastian River Greenway corridor with projected inundation at the southern County boundary.

The areas to the north and south of the Kennedy Space Center have a number of vulnerable trail systems. The Space Coast Trail has numerous sections projected to experience of inundation by 2070 and 2100 under the high projection rate curve, with smaller segments with projected inundation in the 2040-time horizon as well. To the south of the Kennedy Space Center, the North Merritt Island Pioneer Trail is projected to experience 9.48 total miles of inundation, with the majority occurring by 2070 when utilizing the high curve. As this trail is yet to be built, mitigation and adaptation strategies to address frequent flooding and standing should be reviewed. The County and partners should make efforts to address these issues now in the design of the trail to ensure the longevity of the trail to gain the greatest economic return.

The State Road A1A Urban Trail has a number of segments in central Brevard County that are vulnerable to inundation. This trail system is the County’s most vulnerable, with projected inundation by year 2070 under the intermediate curve. The inundation on this system is primarily located in six areas, and while the segments are not lengthy, they are very low in elevation. Mitigating efforts to raise the elevation of these trail segments and provide green infrastructure along the trail to reduce flood impacts in the near term w is recommended.

The Pineda Causeway Corridor in Satellite Beach is also vulnerable to the high projection rate curve by time horizon 2100. This corridor is located in one of the lowest areas of elevation within Brevard County. Just to the south, the East Coast Greenway has two-thirds of a mile of projected inundation in the Indian Harbour Beach area (2100, high curve). Finally, in the far southern extent of the County near Sebastian Inlet, the East Coast Greenway has three segments totaling less than 0.1 miles that are projected to be inundated by year 2100 utilizing the high projection rate curve.

<table>
<thead>
<tr>
<th>Trail or Corridor Name</th>
<th>Low Curve</th>
<th>Intermediate Curve</th>
<th>High Curve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2040 2070 2100</td>
<td>2040 2070 2100</td>
<td>2040 2070 2100</td>
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<tr>
<td>All Aboard Florida Rail w/ Trail Corr.</td>
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<td>None 1.23 Mi 2.52 Mi</td>
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<td>0.14 Mi 4.27 Mi 17.39 Mi</td>
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<td>North Merritt Island Pioneer Trail</td>
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<td>None &lt;0.1 Mi &lt;0.1 Mi</td>
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<td>0.08 Mi 0.16 Mi 1.94 Mi</td>
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<td><strong>Totals</strong></td>
<td>None None None</td>
<td>None 0.08 Mi 2.30 Mi</td>
<td>0.22 Mi 9.02 Mi 33.28 Mi</td>
</tr>
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</table>
Map 12: Trail Systems

Trail Systems
High Curve

- Inundation Projected by 2040
- Inundation Projected by 2070
- Inundation Projected by 2100
- No Projected Inundation

Inundation Detail

1. Space Coast Trail
   0.37 Miles
2. Space Coast Trail
   1.70 Miles
3. Merritt Isl. to Atlantic Corridor
   2.21 Miles
4. Space Coast Trail
   0.55 Miles
   C2C Gap - Downtown Titusville
   Far West Segment - 0.12 Miles
5. Merritt Isl. to Atlantic Corridor
   6.50 Miles
6. East Coast Greenway
   0.04 Miles
7. Pioneer Trail
   0.22 Miles
8. Pioneer Trail
   1.26 Miles
9. East Coast Greenway
   1.76 Miles
10. State Road A1A Urban Trail
    1.40 Miles
11. State Road A1A Urban Trail
    0.51 Miles
12. Pineda Causeway Corridor
    0.39 Miles
13. East Coast Greenway
    0.67 Miles
    0.07 Miles
15. All Aboard Florida Rail/Trail Corr.
    0.26 Miles
16. East Coast Greenway
    0.05 Miles
    0.09 Miles

Source: Trails (Space Coast TPO); Sea Level Rise (UF GeoPlan Center)
Vulnerability Analysis | Critical Transportation Facilities

The facility analysis analyzes sea level rise risk posed to 152 buildings that contribute to transportation operations, administration, incident response and overall safety and evacuation needs within Brevard County. This includes airports, city halls, emergency operation centers, fire stations, fleet storage facilities, hospitals, police stations, transportation administration buildings, shelters, Port Canaveral and Federal Facilities (NASA/KSC, Patrick Air Force Base, and the Cape Canaveral Air Station). In total, 19 of these facilities are projected to be impacted, by varying degrees, by 2100 utilizing the high projection rate curve. The high projection rate curve is the only inundation curve that projects inundation to these facilities with the exception of Port Canaveral. Port Canaveral has projected inundation by year 2040. Note that there is a margin of error associated with the depth analysis of these facilities. Those areas with inundation of less than 3 inches should be assessed further. Additional analysis may be necessary on the facilities listed in the table as well as the facilities in the database indicated as not being vulnerable to determine if access to the facilities may be compromised. In most cases, the site may be at a higher elevation than the roadway, thus inundation may be likely surrounding the site, than on the site itself, or may be greater than the few expected inches of inundation on the site.

The table on the following page lists the 19 transportation-related facilities that are projected to be inundated by sea level rise by the year 2100. All values are measured in vertical inches of inundation and represent the deepest inundated portion of the building (or runway) footprints analyzed.

Airport runways are critical to the economic viability of the County, and four are projected to be inundated by year 2100 under the high curve, with only one of these serving as a public oriented airport, the Merritt Island Airport. The other airstrips include Cape Canaveral Air Force Station, the NASA landing facility runway, and Patrick Air Force Base. A cost-benefit analysis should be completed on these facilities to determine the appropriate mitigation or relocation strategy for long-term viability.

With the exception of Brevard County Fire Rescue #40, #42 and #43, all other facilities with projected inundation are located along the barrier islands. Communities directly impacted include Cape Canaveral, Cocoa Beach, Satellite Beach and Indian Harbour Beach. In Cape Canaveral, the fleet storage facility has projected inundation. In Cocoa Beach, fire rescue stations #50 and #51 are projected to be inundated by 2100 in addition to City Hall and the police department building. Satellite Beach shows projected inundation to City Hall, the police station and fire rescue #55, while Indian Harbour Beach shows inundation to City Hall and the police department.
Facility Vulnerability Overview

Year 2100 | ACOE High Curve | Vulnerable Assets Countywide

Airports: 4/8 impacted (50%)
City Halls: 3/15 impacted (20%)
EOC: 0/2 impacted (0%)
Fire Service: 6/73 impacted (8.2%)
Hospitals: 1/6 impacted (16.6%)
Police Stations: 3/32 impacted (9.4%)
Transportation Operations: 1/15 impacted (6.7%)

Table 10: Facility Inundation Summary (Inches of Inundation)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Type</th>
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<th>Intermediate Curve</th>
<th>High Curve</th>
</tr>
</thead>
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<td></td>
<td></td>
<td>2040</td>
<td>2070</td>
<td>2100</td>
</tr>
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<td>Cape Canaveral A.F.S Runway</td>
<td>Airport</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>Merritt Island Airport Runway</td>
<td>Airport</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NASA Landing Facility Runway</td>
<td>Airport</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Patrick Air Force Base Runway</td>
<td>Airport</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Indian Harbour Beach City Hall</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Satellite Beach City Hall</td>
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</tr>
<tr>
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<td>None</td>
</tr>
<tr>
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<tr>
<td>Satellite Beach Police Dept.</td>
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<td>None</td>
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<tr>
<td>Port Canaveral</td>
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<td>None</td>
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</tr>
</tbody>
</table>

Inundation Levels in Inches
Vulnerability Analysis | Special Infrastructure

Brevard County has unique infrastructure that – if impacted by sea level rise – would result in large scale economic hardship for the community. The following assets are included as part of this section:

- Port Canaveral
- Cape Canaveral Air Force Station
- Patrick Air Force Base
- NASA

Port Canaveral

Port Canaveral is a port of call for a number of ships and serves as one of the major economic hubs along the United States’ Atlantic Coast. As a man-made inlet, the port is susceptible to sea level rise as soon as 2040. The following map depicts sea level rise levels in 2040, 2070 and 2100 utilizing the Army Corps of Engineers high projection rate curve.

A number of the susceptible areas on Port property are retention areas that will likely fill up with water over time. However, some critical transportation infrastructure on site is susceptible to rising seas.

Mullet Road – a roadway near the southwestern corner of the property that is the only access point for a number of boat docks – is expected to be almost completely inundated by 2100. Cape Marina (which is also in this portion of the property) is expected to take in water by the same time frame.

Perhaps the direst situation occurs near the central portion of the inlet where the Port Canaveral Terminal and Royal Caribbean are located. In addition to the terminals, a number of restaurants are also located here. The parking area for Royal Caribbean customers is a large revenue-generator for the port but is also extremely susceptible to sea level rise.

It is recommended that officials at Port Canaveral fortify existing jetties to curb the impact of infringing sea level rise in the short term. This could be a cost-effective method of mitigation in the short to intermediate term to protect the many assets on property.
Cape Canaveral Air Force Station

The Cape Canaveral Air Force Station is located in one of the most lowly-elevated areas of the county and, thus, is susceptible to projected sea level rise. This facility is critical to national defense and provides a large volume of jobs to Brevard County.

The runway facility is located at a high-enough elevation to not be susceptible to sea level rise by the 2100 time frame. However, in the future, water is expected to infringe approximately 80 feet away from the northwestern portion of the runway and nearly adjacent to the southeastern corner of the runway facility. Raising this facility in the future would almost certainly be completed with federal military dollars and would not be a function of the TPO.

The administrative area of the Air Force Station (see the boundary in the map below) is located primarily on high ground and no buildings are expected to be infringed upon by sea level rise by the 2100 time frame. However, the southwestern corner of the administrative area could be susceptible in short order after the 2100 time frame has eclipsed. Nine buildings are projected to be within 200 feet of the inundated area by year 2100.

The most vulnerable portion of the Air Force Station is the launch pads, located near the Atlantic Coastline. Four of the launch pads – Launch Complexes 20, 34, 37 and 41 – are included in the Kennedy Space Center Vulnerability Analysis on page 30. Within view of the map below, inundation if projected for Launch Complex 14 (#1 in map) and SpaceX Landing Zone 1 (#2 in map).
Patrick Air Force Base

Patrick Air Force Base is located along the barrier island system to the north of the City of Satellite Beach. The base is projected to be highly susceptible to sea level rise.

The runway is projected to be inundated under the Army Corps of Engineers high projection rate curve by year 2100. This 280-foot-wide facility is projected to have a majority of its central and southern portions inundated by this time.

The administrative area of the Air Force Base is equally susceptible to sea level rise. The US Army Corps of Engineers office is projected to be completely inundated by year 2100 under the USACE high curve, while the personnel barracks, family housing, dining area, postal service building, seaside chapel, gym, fitness center and boat ramp are projected to be partially (or almost completely) inundated. Overall, few buildings in the administrative area are projected to be protected from sea level rise intrusion by year 2100.

While sea level rise intrusion is projected to be very severe by year 2100, the 2040 and 2070 time frames show minimal-to-no impact on the Air Force Base administrative buildings or runways. This will help to push back the time table to approve the funds needed to mitigate the runway and administrative area.

It will be important for staff at the Air Force Base to monitor new projections that include the effects of sea level rise and storm surge together.

As with the Cape Canaveral Air Force Station, mitigation to these facilities will likely be done at the federal level. It is recommended that the TPO remain engaged with all stakeholders despite the source of funding needed for mitigation.
Kennedy Space Center (NASA)

Kennedy Space Center is among the most important assets to the federal government and contains a number of critical exploratory transportation facilities. The map on the following page depicts the NASA property and 11 of its primary operation centers. The numbers in the map correspond to the eleven operation centers analyzed below.

**Primary Operation Centers | Inundation Summary**

**Area 1 – Shuttle Landing Facility:** The shuttle landing facility is located in a low-lying and is projected to be surrounded by water by year 2100 when utilizing the ACOE high projection rate curve. The facility is mostly out of the hazard zone with the exception of a small sliver of the runway near its northwestern corner. It is suggested that this facility and its surrounding area be raised further, perhaps with the use of an adjoining retention area.

**Area 2 – Vehicle Assembly Building:** The Vehicle Assembly Building is projected to experience slight inundation along its site perimeter by year 2100 under the ACOE high projection rate curve. However, this projected inundation is limited to open spaces and no buildings or roadways are projected to be even partially inundated.

**Area 3 – Launch Complex 39A:** A heavily-used asset, this launch complex is located near the Atlantic coastline and is projected to experience inundation by year 2070 when utilizing the ACOE high projection rate curve. By year 2100, inundation is projected to reach the far inner portion of the launch pad that houses rockets.

**Area 4 – Launch Complex 39B:** While currently inactive, this launch complex has a long history of heavy usage and is among the largest launch sites on Kennedy Space Center Property. This launch site is highly susceptible to sea level rise by year 2100 when utilizing the ACOE high projection rate curve, as more than 70% of the facility is projected to be inundated by that time. Despite this high degree of risk to almost the entire site, the high projections show no inundation in 2040 or 2070.

**Area 5 – Launch Complex 41 – CCAFS:** This launch site is highly protected from sea level rise inundation due to its high elevation. However, sea level rise is expected to intrude within the outer boundary (but not the circular boundary) of the launch site by year 2100 when utilizing the ACOE high curve.

**Area 6 – Launch Complex 40 – SpaceX:** This launch complex is located on high ground and is not susceptible to the impacts of sea level rise by year 2100 under current projections. All service roads leading to the facility are also safe from projected rising seas.

**Area 7 – Launch Complex 37 – CCAFS:** This launch complex is located on high ground and is not susceptible to the impacts of sea level rise by year 2100 under current projections. All service roads leading to the facility are also safe from projected rising seas.

**Area 8 – Launch Complex 34 - CCAFS:** One of the smaller launch facilities on site, the inner circle and operational area of this launch pad are not projected to be inundated by year 2100 under current projections. However, inundated is projected to occur within the site boundary by year 2100 when utilizing the ACOE high projection rate curve. The service roads leading to this facility are not projected to be inundated by year 2100.

**Area 9 – Launch Complex 20 - CCAFS:** This Air Force facility is located just to the south of Launch Complex 34 and has a similar degree of vulnerability to sea level rise. While the launch pad itself is not
projected to be inundated by 2100, its outer boundary is expected to be inundated when utilizing the ACOE high projection rate curve.

Area 10 – Administrative Area: The administrative area of the Kennedy Space Center is a large employment center that includes a number of high-tech laboratories. This site is located on high ground and is not susceptible to the impacts of sea level rise by year 2100 under current projections. All service roads leading to the facility are also safe from projected rising seas.

Area 11 – Visitor Center: While the Visitor Center building itself is not projected to be inundated by year 2100, the parking lot on the southern end of the site is projected to be completely inundated by year 2100 under the ACOE high projection rate curve. All roadways leading to the site are, however, left intact by year 2100 under current projections. Mitigating efforts to this site could include raising the elevation of the parking lot, or reinforcing the boundary with a sea wall.

Map 17: Kennedy Space Center Vulnerability (ACOE High Curve)
IV. Stormwater Management Analysis

Complete inundation is not the only issue facing Brevard County as sea level rises. As sea level rises, flooding risks increase along the coast especially during tidal events, the extent of flooding from storm surge will be expanded and will reach new depths, and flooding along the St. Johns River and various tributaries of the river and the lagoon will occur. Natural drainage as well as stormwater infrastructure may be compromised as the ability to discharge stormwater and overflow into waterbodies and retention ponds may be diminished as sea levels rise, stormwater capacity decreases and as salt water intrusion and excess rainfall raises the water table. The image below is an illustration of how rising sea levels can impact stormwater infrastructure causing salt water plugs and ultimately salt water back up.

The rate at which gravity can drain an area depends, in part, on the difference in elevation between the area being drained and the place to which the water flows. The greater the difference in elevation, the greater the “hydraulic head” and the faster the water can drain. Lower elevations, particularly populated areas proximate to the coast and the St. Johns River, will be more susceptible to tidal flooding with changes to sea levels. This combination can severely hinder natural drainage. Roadways that traverse lower areas or that approach bridges near rivers may be inundated.

High tides can decrease the difference in elevation and during rain events. Saturated soils will prevent permeation, resulting in more standing water. With high storm events, drainage systems can be ineffectual until water levels have subsided. Due to sea level rise, the failure of existing drainage systems will be more common and additional planning and engineering will be needed to ensure that systems work.

Nuisance flooding, or lesser type flood events that are not caused by major storms, are expected to increase as the rise in sea levels create higher tides. This type of flooding can occur on a sunny day because of the higher water levels and the inability of water to be discharged thus causing flooding. Unfortunately, these nuisance floods can have a cumulative impact over time as much of the infrastructure was not made to withstand salt water inundation to this extent. Additionally, as sewers and stormwater systems flood, health and economic impacts are also anticipated as these nuisance flood events can cause road and business closures, as well as overflowing storm pipes and sewer systems, damaging infrastructure and causing economic strain on the community. If a storm occurs in conjunction with a nuisance flood event, the impacts can be more severe (NOAA, 2017)5.

While in 2014, Florida only experience 0-5 days of nuisance flooding, NOAA anticipated that due to the El Nino in 2015/2016, the Jacksonville area may experience upward of 10 days of nuisance flooding with some areas of the U.S. experiencing a 25% increase in these flood events.
NOAA’s Digital Coast “Sea Level Rise Viewer” (Map 18) is an online visualization tool that allows users to look at resources and areas exposed to coastal flooding and sea level rise. The areas most susceptible to increases in flood frequency are those in lower elevations, where local sea level rise is higher or where extreme variability is less. Map 18 depicts, in red, the areas in the County that are vulnerable to shallow flood events that are normally a result of meteorological factors. A unique part of the tool allows users to look at “Flood Frequency” which according to NOAA is the “annual occurrences of tidal flooding that exceed local thresholds”. According to the graphic, as sea level rise increases upwards of 1.6 feet, it is anticipated that the area along the Brevard Coast will change from the current couple events/days per year of nuisance flooding, to 156 flood events/13 days per year to 657 events/123 days per year at 3.2 feet of sea level rise, making these events more of a norm than the once a year occurrence (NOAA, 2017 – Digital Coast). Also, King Tides, the highest high tide of the year, generally occurs in the October/November timeframe. The chart below from NOAA illustrates the rising water levels during the highest tide of the year (King Tides). As shown, the red trend line indicates an increase in water levels during king tides since 1994. The image shows flooding in October 2017 in the City of Cocoa as King Tides pushed waves over the embankments onto the roads. Due to the topography of Brevard County, these impacts can be realized on both sides of the Indian River Lagoon as well as along the beach side. Wind speed and direction, as well as storms, can make these conditions even worse.
According to the Journal of Water Resources Planning and Management, there are three general strategies to address these issues: enhanced gravity drainage, forced drainage and adaptation to increased flooding. Gravity drainage can be improved by using larger pipes or wider drainage channels. Communities with drainage systems in place can either install supplemental pipe systems or replace old pipes with larger pipes that can handle future flows. Planning and engineering staff may investigate the increase of setbacks from canals and waterways to prevent loss of or impacts to infrastructure and development from flooding. Enlarging channels, canals or detention basins to allow for storing increase volumes may be feasible in some areas and will require additional analysis. Locks and flap gates may useful to allow drainage during low tides and prevent back flow during surges or high tide events. Some critical areas may need to install forced pumping systems in lieu of gravity systems. Other techniques can be implemented in urban areas to increase infiltration directly in the ground instead of through pipes and run off. Some of these include infiltration trenches, porous pavement, rooftop detention, storage in playgrounds and parking areas, and other natural based solutions. Additional detention basins higher in the drainage basin may help deter the accumulation of water in lower areas and reduce the peak discharge.

The County and municipalities should work with the SJRWMD to assess critical areas vulnerable to excessive flooding as well as prime areas to direct flow or to focus groundwater storage to aid in stormwater management. It will also be vital for transportation planning to focus on these issues when determining the location and capacity of stormwater ponds and discharge. Practices and calculations of the past will not be sufficient in some areas to mitigate stormwater or nuisance flooding episodes of the future.
V. Next Steps

With this assessment, the Space Coast TPO, Brevard County, and all 16 jurisdictions within Brevard County can begin to take the steps necessary to discuss next steps to mitigate the potential impacts of sea level rise on their transportation facilities. The ECFRPC recommends that the Space Coast TPO consider the following actions in order to fulfill federal directives such as the FAST Act. These recommendations are consistent with a regional strategy, but are tailored to be specific to the needs of Brevard County.

**Compile Case Studies from other TPO’s:** Compile case studies showing how other TPO’s have taken steps to mitigate the effect of sea level rise on their facilities. Pertinent case studies do not necessarily have to be from areas with sea level rise risk equal to Brevard County.

**Recommend County-wide Standards:** Recommend County-wide standards for planning for further analysis of sea level rise and strategies. This can include time horizon and projection rate curves as well as policies to require assessment prior to funding or prioritization. This will allow for a uniform prioritization of asset mitigation and adaptation processes throughout the County. This study continues the framework set by Satellite Beach (in terms of horizons and rate curves used) and it is recommended that these parameters remain unchanged in future studies. Based upon the direction of the updated 2017 Community Rating System Manual, the ECFRPC recommends that in order to maintain consistency across the region with already completed work, and to assist in the opportunities for communities and the County to obtain CRS credits for assessing future conditions, the SCTPO adopt the USACE High Projection Rate curve as a minimum for assessing future projects. The time frame set by any project for assessing impacts should be based on the “life-span” span of the project (50 years vs. 100 years), its use (i.e. a recreational facility versus bridge), and its capacity to withstand increased certain degrees of flooding (ground level parking area vs. transformer area).

**Review Plans and Programs for Consistency:** Review the TPO’s Long Term Transportation Plan (LRTP), Bicycle Pedestrian and Trails Mobility Plan, and the Intelligent Transportation System (ITS) Master Plan to ensure that sea level rise vulnerability is addressed. For example: Projects identified in the LRTP could also include an assessment of vulnerability to sea level rise and flooding in matrix format. Review the TPO’s Unified Planning Work Program, Transportation Improvement Program (TIP), Safety Program and Trails Program to ensure that sea level rise vulnerability is addressed. For example: Roadways with vulnerability to sea level rise could potentially be given higher priority on the TIP project listing to assess mitigation options, conduct cost-benefit analysis and determine future actions.

**Conduct Site Specific Analysis for Priority Assets:** Conduct ground-level analysis of highly vulnerable or vital assets to determine site specific inundation depth potential of project areas as the depth analysis conducted for this project is not site specific and should not be used for planning purposes. In the initial analysis, it was determined that some potential LIDAR issues caused run-ups of the Max Brewer Bridge to be flagged as inundated. After additional analysis, most of the flagged segments are elevated and may be above inundation levels. However, it is strongly advised to assess the run ups of the Max Brewer Bridge to provide a site-specific analysis, rather than spatial and wave action and overwash should also be considered along the runups of this and other bridges.
**Determine Cost/Benefit Analysis Scenarios:** Quantify the cost/benefit of proposed strategies to transportation systems and other assets and compare to potential impacts without action. For example: Quantify the potential economic losses if FEC railroad inundation prohibits the flow goods and passengers along its corridor. Also, assess the consequence cost of the vulnerable asset by looking at the severity of the flood over different time periods and the cost of various strategies to help determine appropriate strategy. The agency can partner with the ECFRPC to conduct various economic analyses of strategies using the REMI Model.

**Further Analyze Potential Storm Surge Impacts:** Assess transportation system integrity resulting from impacts of future 100-year storm and hurricane storm surge combined with sea level rise. This analysis should identify facilities that may not be vulnerable to full inundation from sea level rise but will be vulnerable to increased flood levels and erosion from storm events. This assessment should be required of current and new projects seeking funding if they are in the vulnerable areas. Any areas that were vulnerable to excessive flooding after Hurricane Irma should be a priority as the extent of this storm flooding will increase as sea levels rise.

**Work with Cities on Comprehensive Plan Updates:** Policy updates can have an effect on the location of future development and overall community resiliency to sea level rise and increased nuisance flooding. Continue to advocate for policy language that steers development away from floodplains and sea level rise zones.

**Build on the Precedent Set in Satellite Beach:** The City of Satellite Beach continues to set an example for cities and towns within the State of Florida on how to deal with the potential effects of sea level rise. Use Satellite Beach as an example for other at-risk communities that are just getting started on sea level rise vulnerability analysis plans.

**Continue Data Collection and Maintenance of Data:** Continue to collect and properly maintain data to ensure that vulnerability is known with the addition of new transportation facilities. In addition, collect data outlining the effects of mitigating efforts on a cost/benefit basis. As new sea level rise data and flood data becomes available or updated, conduct additional assessments as climate science is ever changing.

**Work with Floodplain Managers on CRS-Related Issues:** Work with jurisdiction-based floodplain managers to incorporate sea level rise components that have been added to the CRS manual. This can reduce flood insurance payments for residents.

**Analyze Green Infrastructure Techniques:** Continue to analyze the use of green streets and green infrastructure to protect transportation infrastructure from increased flooding. These facilities can improve resiliency, sense of place and safety. It is recommended that any LRTP project that is anticipated to be vulnerable to increased flooding, especially long-term flooding, be required to include a green infrastructure plan that utilizes new techniques to improve stormwater drainage and uses natural areas to mitigate flood hazards.

**Consider Turning A1A into a “Green Street”:** A1A is among the most vulnerable roads in the County from a sea level rise perspective. Consider turning this roadway into a ‘green street’ with stormwater mitigation swales as well as improved safety features.

**Stakeholder Engagement:** Whenever possible, engage residents in conversation regarding the science behind sea level rise projections utilizing easy-to-understand data and graphics. An example of this could include the Mean Sea Level Trend graphics available from the early 20th century onward for multiple buoy locations across the state of Florida. Engage citizenry in discussions on solutions.
Appendix
Appendix 1: Florida Sea Level Scenario Sketch Planning Tool

The UF GeoPlan Sea Level Scenario Sketch Planning Tool provides the opportunity to assess roadway impacts to sea level rise directly in the viewer. The data utilized is FDOT RCI files. However, the web-based tool selects the entire segment of roadway as dictated by the FDOT base data resulting in a larger stretch of roadway appearing as selected, whereas the analysis conducted as part of this report reported only the segments of roadway impacted, thus the lower miles of segments noted in this report compared to the outputs in the web-tool. The viewer provides a breakdown of the percentage of that particular segment of roadway that is vulnerable to inundation. The web-based viewer is useful for non-GIS personnel looking at extent of impacts and different scenarios. The data provided in the viewer can be downloaded for further analysis. The maps on the following pages represent the US ACE scenarios and impacted roadways as shown in the web-tool in order to illustrated the difference in the selection and analysis of the impacts. The viewer does not show 2070, therefore, the maps depicted below show 2080 and 2100.

The web-tool also allows users to see the roadways that are affected by the 100 and the 500-year floodplain as well as the Category 1-5 Storm Surge. These maps have been exported via the tool and included in this appendix.
Roadways Affected by Cat. 5 Storm Surge

November 28, 2017

% Roadway in Cat 5 Storm Surge

- < 10%
- 10% - 24%
- 25% - 49%
- 50% - 100%

Sources: Esri, HERE, DeLorme, Intermap, iCorporated, GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Appendix 2: Source Documentation

1. Vitousek, Barnard, Fletcher, Frazer, Erikson, Storlazzi
   Doubling of Coastal Flooding Frequency within Decades Due to Sea Level Rise (2016)
   Retrieved from: https://www.nature.com/articles/s41598-017-01362-7

2. United States Federal Highway Administration
   FAST Act (2015)

3. State of Florida
   Florida Statute 163.3178 (2017)

4. The University of Florida GeoPlan Center
   Sea Level Scenario Sketch Planning Tool (2017)
   Retrieved from: https://sls.geoplan.ufl.edu/documents-links/

5. Marra, Sweet
   National Oceanic and Atmospheric Administration (2017)

6. NOAA
   NOAA Digital Coast
   Retrieved From: https://coast.noaa.gov/digitalcoast/
Appendix 3: Vulnerability Atlas

To view the Sea Level Rise Vulnerability Atlas, click here for the online version or contact the Space Coast TPO if you are reading a printed copy of this report.
Appendix 4: Planning Team Contacts

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