TECHNICAL MEMORANDUM

Coastal Vulnerability and Resiliency Assessment

TO:	City of Atlantic Beach
FROM:	Karen Liang, PE, CFM; Justin Gregory, PE; Brett Cunningham, PE
DATE:	March 15, 2019
SUBJECT:	Sea Level Task Authorization #09 – Resiliency Support – Task 1 Jones Edmunds Project No. 95239-057-19

1 INTRODUCTION

The City of Atlantic Beach selected Jones Edmunds and Applied Technology & Management, Inc. (ATM) to perform an analysis of future flood risk under projected sea level rise scenarios to support the City's resiliency plan. As part of this project the City asked Jones Edmunds to review sea level rise projections and tidal data for the City and to provide a description of the approach that would be used to analyze future flood risk. This memo provides a summary of this task.

2 SEA-LEVEL-RISE REVIEW

Jones Edmunds performed a comparison review regarding the projected local sea level rise at the proximity of the project site. The projected local sea-level-rise estimates we examined were for years 2044, 2069, and 2119 (i.e., the 25-, 50-, and 100-year scenarios).

The nearby gauge that Jones Edmunds selected was National Oceanic and Aeronautic Administration (NOAA) Gauge 8720218. This tidal gauge is at Mayport Bar Pilots Dock (1995 to present), approximately 3 miles northwest of the City and is the closest applicable long-term gauge to the City. The gauge datum is 1983 – 2001 epoch.

Several studies have published projected sea-level-rise estimates at the gauge. Using the US Army Corps of Engineers (USACE) web-based Sea-Level Change Curve Calculator tool (USACE, 2017), Jones Edmunds compared the published estimates from the following:

- USACE Engineer Regulation (ER) 1100-2-8162 – *Incorporating Sea Level Changes in Civil Works Programs* (USACE, 2013).
- NOAA Technical Report OAR CPO-1 titled *Global Sea Level Rise Scenarios for the United States National Climate Assessment* (NOAA, 2012).
- Coastal Assessment Regional Scenario Working Group (CARSWG) Regional Sea Level Scenarios for Coastal Risk Management Report 2016 (CARSWG, 2016).
- NOAA Technical Report NOS CO-OPS 083 titled *Global and Regional Sea Level Rise Scenarios for The United States* (NOAA, 2017).

In addition to the estimates from these four studies, Jones Edmunds also compared estimates from Intergovernmental Panel on Climate Change (IPCC) AR5 RCP8.5 using information from the following:

- IPCC *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC, 2014).
- Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact) 2015 Unified Sea Level Rise Projection for Southeast Florida (Compact, 2015).

The sea level change equation used to calculate the IPCC 2014 estimates is:

$$E(t) = a\,t + b\,t^2$$

where *E(t)* is the sea level change, *a* is the rate of sea level change, *b* is the acceleration of sea level change, and *t* is the number of years since 1992. For *a*, the NOAA regional rate of 0.002289 meters per year (m/yr) (or 0.00751 feet per year [ft/yr]) was used. For *b,* we used the same IPCC AR5 RCP8.5 value of 4.684499×10^{-5} meters per year squared (m/yr^2) (or 0.000154 feet per year squared [ft/yr^2]) as the Compact report. For *t*, we subtracted 1992 from the scenario year.

3 DATUM CONVERSION

The estimates from NOAA 2017 and IPCC AR5 RCP8.5 are in the form of relative sea level (RSL) change in feet with reference to the 1991 – 2009 datum epoch and the 1983 – 2001 datum epoch, respectively. The estimates from the other three studies are presented with reference to North American Vertical Datum of 1988 (NAVD88). The gauge is on a 1983 – 2001 datum epoch. For uniform comparison, Jones Edmunds adjusted the NOAA 2017 and IPCC AR5 RCP8.5 estimates to reference the NAVD88 datum.

3.1 Datum Conversion for the NOAA 2017 Study

Using the recommended method described in the NOAA 2017 technical report, the adjustment value to convert from a 1983 – 2001 datum epoch to a 1983 – 2009 epoch for the gauge was calculated by combining 8 years of non-climatic background RSL changes with 8 years of global mean sea level (GMSL) change. Based on Figure 12a in the NOAA 2017 technical report, the non-climatic background RSL change is 1 millimeter per year (mm/yr) for this region, which is 8 mm or 0.026 feet over 8 years. The GMSL over 8 years was estimated to be 3.0 centimeters (cm) or 0.098 feet by Nerem et al. (2010) and 1.8 cm or 0.059 feet by Hay et al. (2015). Due to the nature of the project goal, Jones Edmunds used the more conservative value from Nerem et al. (2010). The sum of the non-climatic background RSL change and the GMSL change (0.12 feet) was subtracted from the RSL change estimates to convert them to a 1983 – 2001 datum epoch. Then, we applied an offset of -0.65 feet to convert the RSL change in the 1983 – 2001 datum epoch to NAVD88. This conversion value was based on the difference between the mean sea Level and NAVD88 datums listed for the station on the NOAA station webpage.

3.2 Datum Conversion for IPCC AR5 RCP8.5 Study

The IPCC AR5 RCP8.5 estimates and the gauge are both referenced to the 1983 – 2001 datum epoch. To convert to NAVD88, an offset of -0.53 was applied to the RSL change estimates. This is the same 1983 – 2001 datum epoch-to-NAVD88 conversion value from the NOAA station webpage that was used to adjust the NOAA 2017 study estimates.

4 SEA LEVEL RISE ESTIMATE COMPARISONS

Table 1 summarizes the projected mean sea levels by the five studies at the Mayport gauge. Each study includes scenarios of different severity. Jones Edmunds examined intermediate and more severe scenarios. The projected elevation range is 0.1 to 1.83 feet NAVD88 for 2044, 0.58 to 4.63 feet NAVD88 for 2069, and 1.86 to 13.62 feet NAVD88 for 2119. Overall, the NOAA 2017 estimates are consistently the highest. Jones Edmunds recommends using the intermediate-high values from NOAA 2017. Figure 1 presents a graphical comparison.

Figure 1 Comparison of the Projected Sea Levels

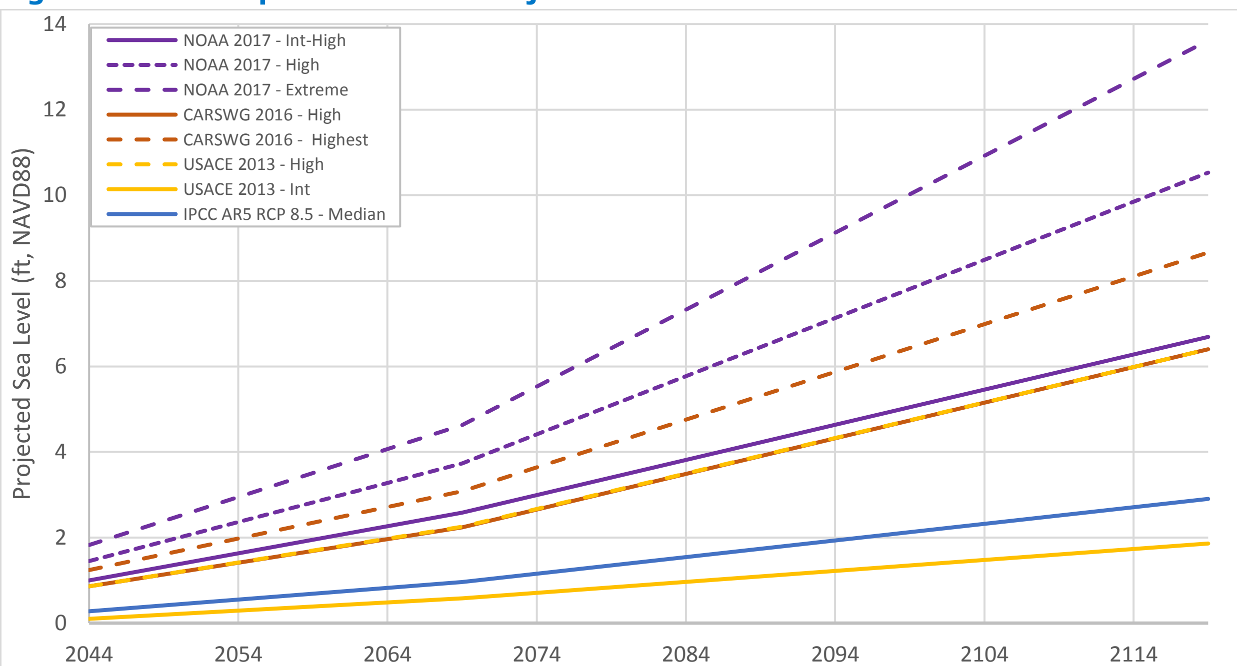


Table 1. Summary of Projected Mean Sea Levels at the Mayport Gauge (Feet – NAVD88)

Year	USACE 2013		NOAA 2012		CARSWG 2016			NOAA 2017				IPCC AR5 RCP 8.5
	Int	High	Int-High	High	Medium	High	Highest	Int	Int-High	High	Extreme	Median
2044	0.1	0.86	0.63	1.24	0.48	0.86	1.24	0.54	**1.00**	1.45	1.83	0.28
2069	0.58	2.25	1.74	3.08	1.41	2.24	3.08	1.53	**2.58**	3.73	4.63	0.96
2119	1.86	6.4	5.03	8.66	4.13	6.4	8.66	3.77	**6.69**	10.53	13.62	2.90

Note: Int = Intermediate.
Bolded numbers indicate the recommended values to be used for the resiliency study.

5 TIDAL GAUGE DATA REVIEW

Jones Edmunds also compared the projected elevations to two major hurricane events in recent years. The two events are Hurricane Matthew in October 2016 and Hurricane Irma in September 2017. Jones Edmunds used gauge data recorded by the Mayport gauge. The highest tide was 5.23 feet NAVD88 during Hurricane Matthew, and 5.58 feet NAVD88 during Hurricane Irma. Figures 2 and 3 present the water levels during the peaks of those events. Figure 4 compares the projected sea levels with the highest tides from the two hurricane events.

Figure 2 Water Level During Hurricane Matthew in October 2016 at Mayport Gauge

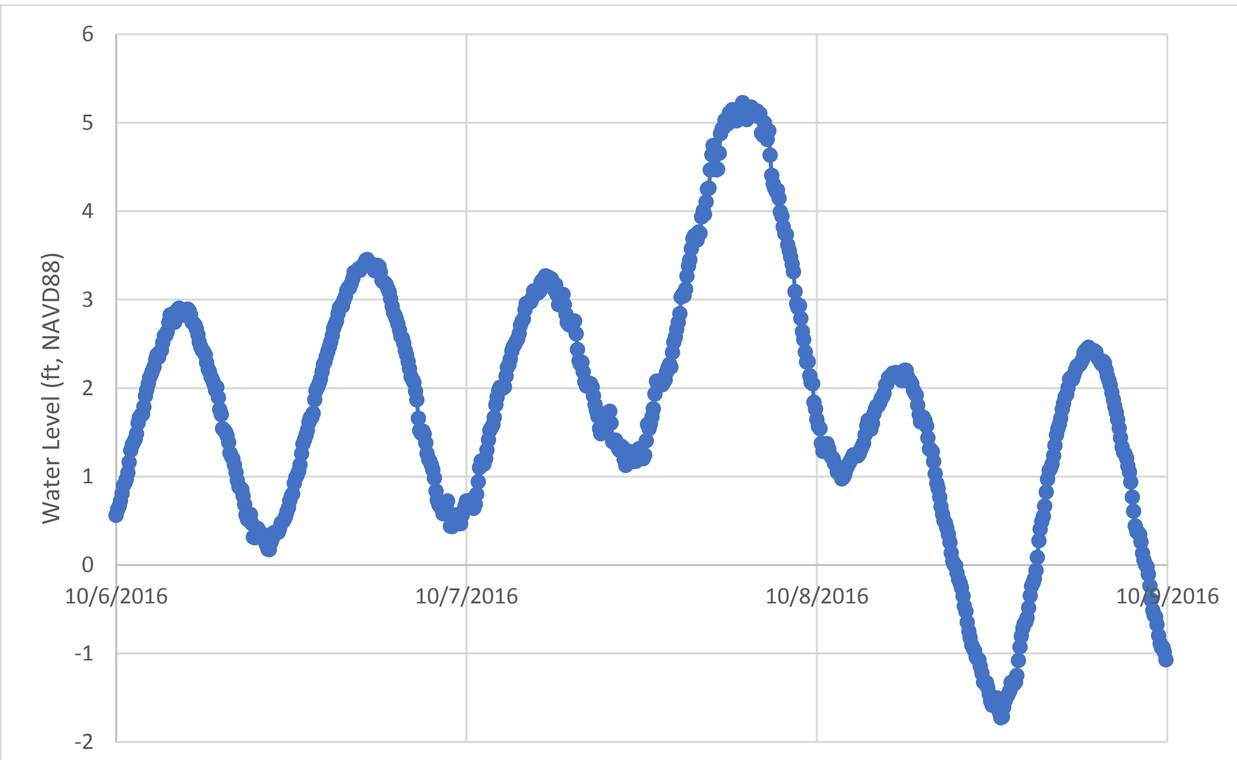


Figure 3 Water Level During Hurricane Irma in September 2017 at Mayport Gauge

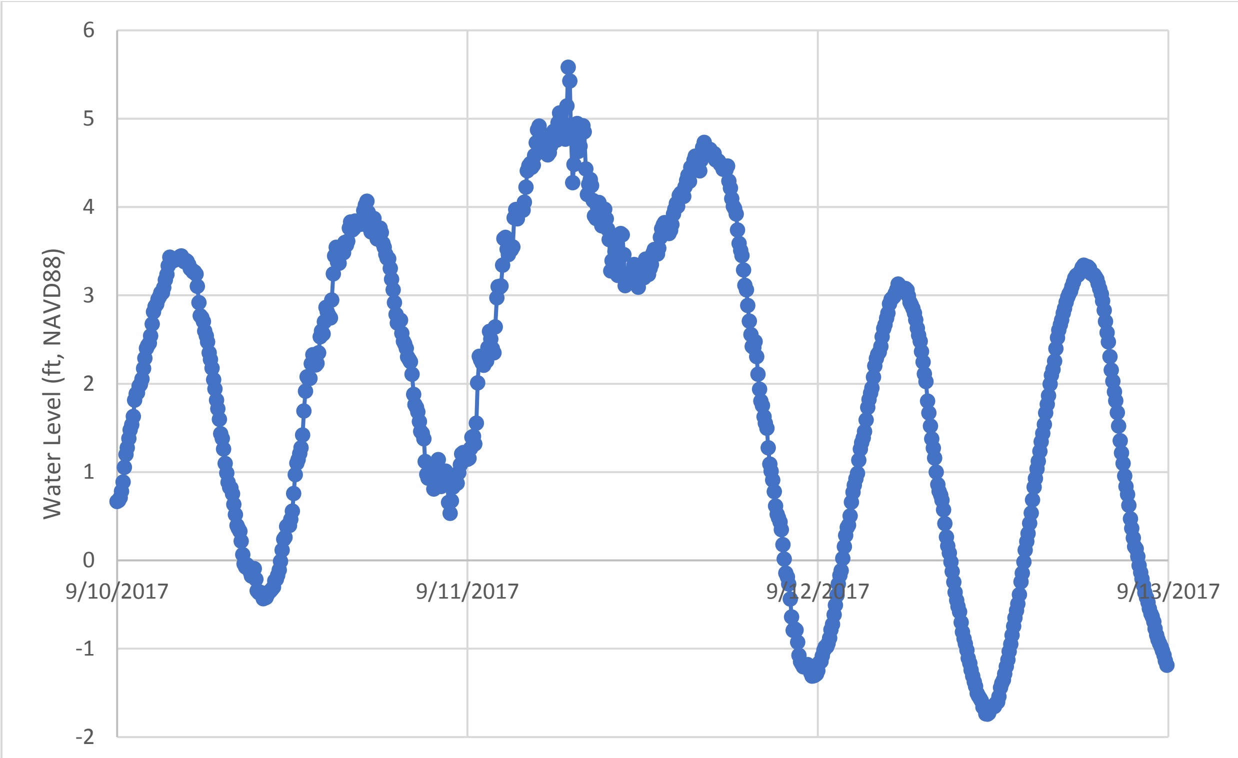
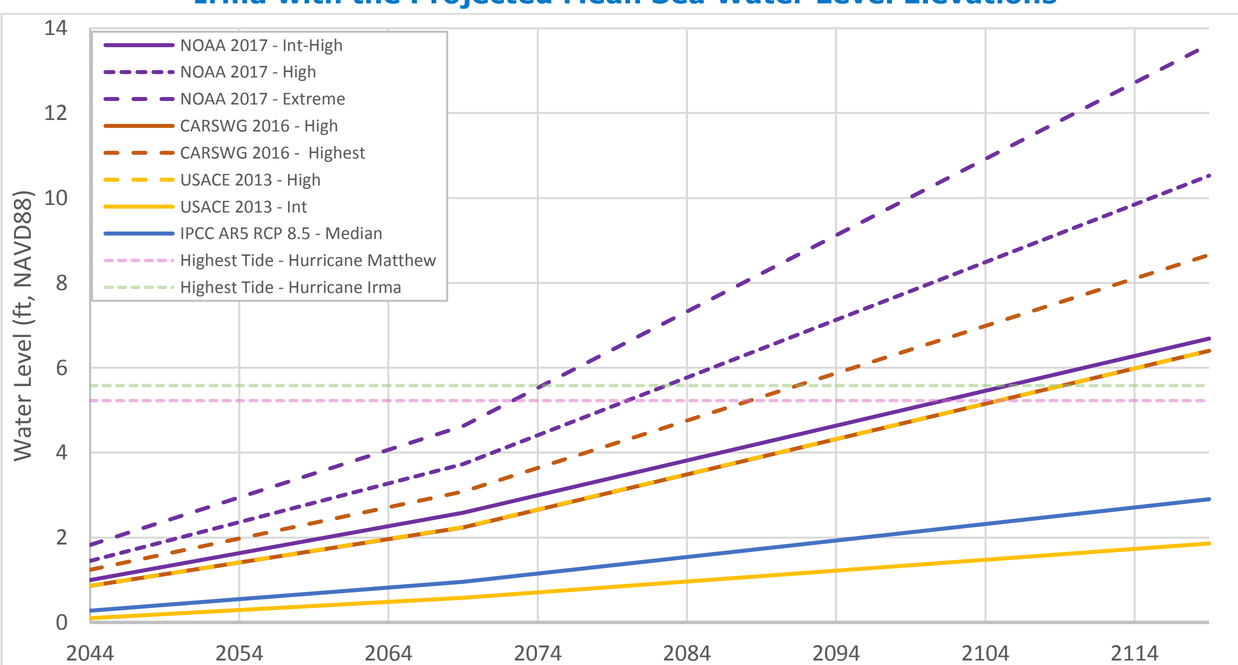


Figure 4 Comparison of the Highest Tides During Hurricanes Matthew and Irma with the Projected Mean Sea Water Level Elevations



6 APPROACH TO EVALUATING SEA LEVEL RISE EFFECTS ON FLOODING

Both coastal and rainfall induced flooding are likely to change in the future. Understanding how both forms of flooding may change under future conditions will be an important part of developing a resiliency plan. The following is a summary of the approach that will be used to evaluate flood risk in the future.

6.1 FLOOD RISK – STORM SURGE

Rising sea level will result in increased storm surge levels and wave heights as well as exacerbate nuisance flooding from extreme high tides. The combination of a higher sea level with a storm surge can result in larger storm impacts and coastal vulnerability from a flooding perspective than are currently experienced. To understand potential flooding from storm surge ATM will use the intermediate-high values from the NOAA 2017 SLR projections combined with the FEMA Flood Insurance Rate Maps (FIRMs) and Flood Insurance Study (FIS) for Duval County, which are deemed the best available data, to ascertain projected extreme storm tide water levels and predicted wind-wave heights. To refine wave impact predictions the existing FEMA Wave Height Analysis for Flood Insurance Studies (WHAFIS) model will be updated for typical transects under 100-year storm conditions to evaluate SLR scenarios.

As part of the task ATM will:

a) Review the coastal FEMA FIRM and FIS for the City. ATM will rely on and use FEMA's projected extreme storm tide water levels (no storm surge modeling will be completed) as a representation of current coastal flood risk.

b) As an approximation, ATM will add the SLR projection values to the FEMA 100-year (i.e. 1% annual chance) flood hazard zones, where base flood elevation (BFE) information is provided on the FEMA coastal flood maps (i.e., AE and VE flood zones). Three SLR scenarios, 25-,50- and 100-year, will be evaluated to determine "future" 100-year BFEs for the following years 2044, 2069, and 2119.

c) To check potential "future" increases in BFEs at the study location due to increased wave heights from SLR, ATM will develop the FEMA WHAFIS model for overland wave propagation along two representative transects under 100-year storm conditions. One transect will represent the Atlantic coast and the other will represent the Atlantic Intracoastal Waterway. If necessary/applicable for the coastal transect, wave runup will also be assessed using FEMA methodology to investigate potential increases in runup elevations because of SLR. The same SLR scenarios utilized above will be evaluated for this analysis. If needed, ATM will update the approximate projected 100-year flood risk developed in Item b.

d) ATM will map extents of the future 100-year coastal flood risk under the three SLR projection scenarios for 2044, 2069, and 2119.

6.2 Flood Risk – Rainfall Induced

Jones Edmunds will develop 2044, 2069, and 2119 drainage conditions models to see what future drainage conditions within the City may be and determine how rainfall induced flooding may be impacted by sea level rise and new development within the City. To develop these models, Jones Edmunds will adjust hydrologic and hydraulic parameters to reflect projected increases in impervious area from future development, increased boundary conditions and node initial conditions from rising sea levels, and reduction in soil storage from rising sea levels. The following is a summary of how these changes will be considered:

- Future Impervious Area Updates – Jones Edmunds will use the rates of future development that were used in the City's 2018 stormwater master plan to estimate the impervious area in the City in 2044,2069, and 2119. This estimated future impervious values will be applied to the modeled stormwater drainage basins so that modeled runoff accurately reflects future conditions.
- Boundary Condition Updates from Sea-Level-Rise – Jones Edmunds will use the intermediate-high values from the NOAA 2017 SLR projections to estimate the change in tidal boundary conditions for the future drainage condition models. Tidal boundary conditions are usually established based on the mean higher high tide.
- Changes in Runoff Due to Reduction in Soil Storage – Jones Edmunds will adjust basin NRCS Curve Number parameters to reflect hydrologic conditions with decreased soil storage from higher groundwater tables created by rising sea levels. We expect that surficial groundwater levels will be higher because of consistently higher tides. This increase in groundwater levels will reduce the amount of soil storage available for rainfall to infiltrate into and will increase the volume of runoff during storm events. The decrease in soil storage will be more marked in areas directly adjacent to the coastline and will be reduced farther inland. Jones Edmunds will use an estimate of the reduction in soil storage.

Results from the future drainage conditions models will be used to map rainfall induced flood risk in the City.

6.3 Flood Risk – Combined

Jones Edmunds will combine the mapped storm surge flood risk and mapped rainfall induced flood risk maps to develop a predictive flood risk map for 2044, 2069, and 2119. Where there is overlap between the flood risk mapping we will select the higher estimate. These maps will be used to provide the City with a spatial estimate of future flood risk that can be used in resiliency planning.

7 REFERENCES

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