TECHNICAL MEMORANDUM

JonesEdmunds

Alachua County Vulnerability Analysis

TO: Shane Williams, PE; Alachua County

FROM: Justin Gregory, PE; Alyssa Guariniello, EI

DATE: June 13, 2023

SUBJECT: Countywide Inundation Modeling (Task 2)
Jones Edmunds Project No. 01560-157-01

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This item has been digitally signed and sealed by Justin Haig Gregory on the date indicated here.

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1 BACKGROUND

Alachua County is concerned about the impact of climate change on its critical infrastructure and natural resources and the well-being of its citizens and their property. To help evaluate these impacts, the County is completing a critical infrastructure and land use climate vulnerability analysis. One of the primary climate impacts in the County will most likely be altered flooding conditions due to changing rainfall volume, frequency, and intensity.

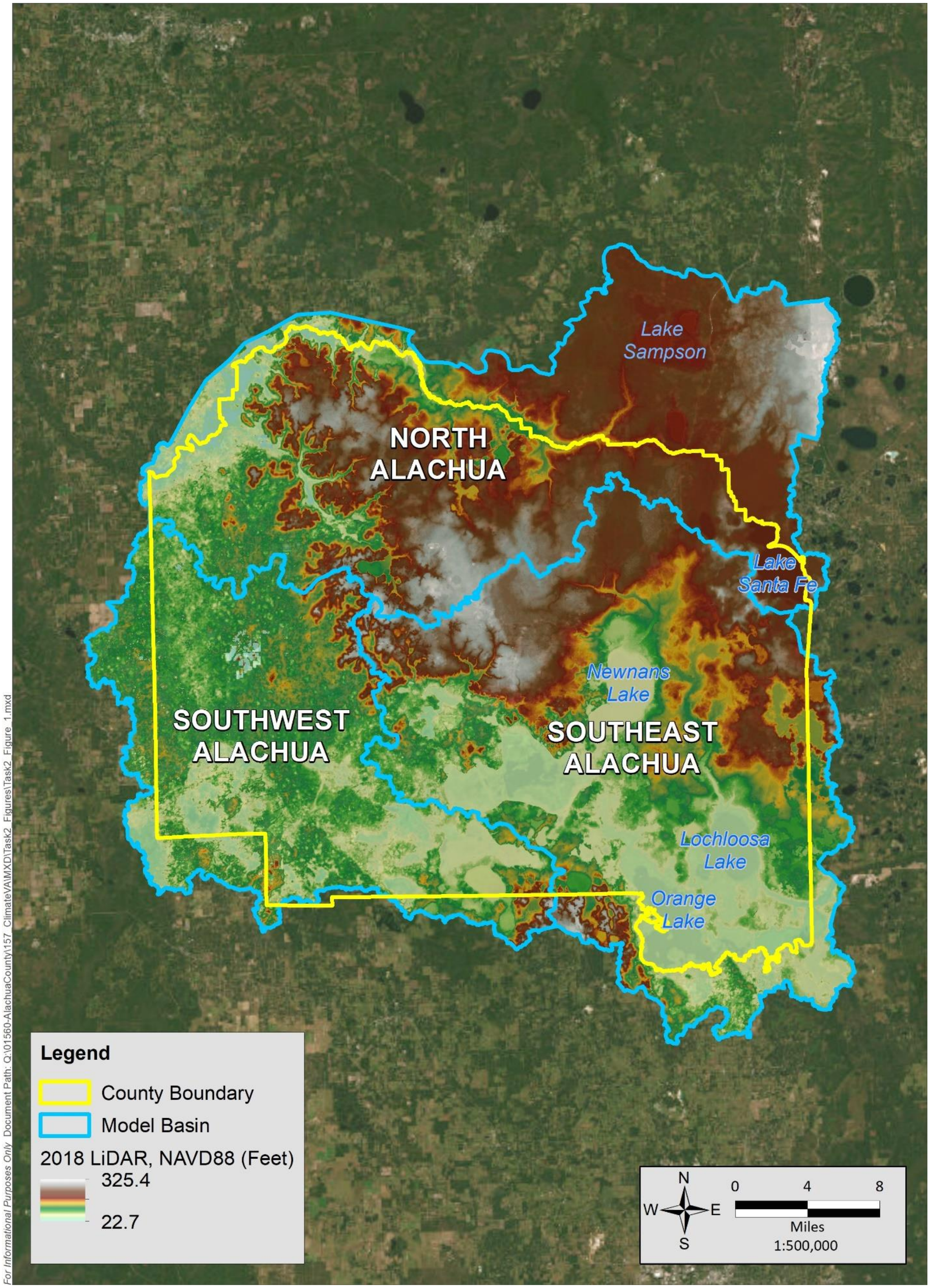
Rainfall-driven flooding occurs throughout Alachua County, but not all flooded areas are presented in flood risk maps or represented in existing flood models. The Federal Emergency Management Agency (FEMA) has not studied large portions of the County. FEMA mapping studies typically focus on riverine or lake flooding with occurrence intervals of 100 or 500 years and generally with a drainage area of at least 100 acres. These studies also focus on current rainfall conditions and do not consider the future probability of extreme rainfall events.

Predicting inundation areas that result from various current and projected future storm depths, including ones greater than those modeled by FEMA, is particularly important for understanding flood vulnerability.

2 COUNTYWIDE MODELING APPROACH

Jones Edmunds developed a two-dimensional (2D) inundation model for Alachua County within TUFLOW HPC (Release 2020-10-AF). The model covers approximately 1,300 square miles and includes all of the County and portions of adjacent counties that drain into Alachua County. The model is referred to herein as the *countywide model* and uses a rapid-flood modeling approach to predict inundation areas for rainfall events. Figure 1 shows the countywide model broken into three planning regions to reduce model run times.

Figure 1 Planning Region Extents



The countywide model employs grid-based hydraulic and hydrologic methods with a variable grid resolution. The grid resolution varies from 80 feet to 20 feet. The surface hydraulics are defined based on surface roughness and the 2.5-foot 2019 light detection and ranging (LiDAR) digital elevation model (DEM) obtained from the US Geological Service (USGS). The model uses sub-grid sampling that allows each model cell to account for ground elevation every 5 feet when determining conveyance between cells and storage within cells.

3 COMPARISON TO TRADITIONAL MODELING APPROACHES

Jones Edmunds developed the countywide model using a modeling approach that is inherently different from a traditional single-dimensional (1D) stormwater model, such as those used for conventional flood studies performed to generate and update FEMA Flood Risk Maps. When compared to a traditional modeling approach, the strength of the countywide model is twofold:

1. The countywide model uses a disaggregated hydrologic and hydraulic approach that generates flood inundation predictions at a high resolution for the entire modeled watershed.
2. The countywide model uses a 2D approach for overland flow predictions, allowing more accurate flow predictions outside managed stormwater conveyance systems.

Since the grid-based approach is more inclusive of local landscape features typically not included in more traditional node-link approaches with lumped basins, we expect the countywide model predictions to provide more information regarding potential inundation areas within the County than a conventional flood study. The relative accuracy of the countywide model predictions compared to conventional flood studies will vary depending on the modeled 1D basins and 1D node density to characterize the rainfall-runoff response and flood levels in the conventional study. Due to a traditional flood study's model input parameter requirements, producing accurate flood predictions at a similar scale and coverage is cost prohibitive.

Instead, traditional flood studies often sacrifice scale or coverage, producing accurate results limited to focus areas such as a channel reach within a larger watershed or limiting the model coverage to a smaller subwatershed. Generally, given the limitations of this study, the countywide model predictions are expected to be slightly less accurate than a traditional flood study within the focus areas of previous studies since traditional flood studies are built on more robust data-collection efforts including local survey data. However, the countywide model’s accuracy could be improved under future efforts with the additional characterization of hydraulic structures, channels, other model inputs, and additional model calibration.

4 COUNTYWIDE MODEL DEVELOPMENT

The following is an overview of the countywide model development. The inputs to the TUFLOW model are stored within a combination of open-source geographic information system (GIS) files (shapefiles and rasters) and text files.

4.1 Computational Mesh

Jones Edmunds developed the countywide model using a variable-grid resolution. We set up the computational mesh to enable sub-grid sampling of elevations at least every 5 feet. The sub-grid sampling enabled the model to sample elevations every 5 feet along the cell edges to characterize the flow between the grid cells. The model also represented storage within each cell based on the sub-grid sampling resolution of 5 feet within each grid cell. The sub-grid sampling allowed the model to take advantage of the 2019 high-resolution LiDAR obtained from USGS. We initially ran the countywide model at a grid resolution of 40 feet. We then increased the maximum grid size to 80 feet in rural areas to reduce model runtime. When we compared the water surface elevation (WSE) between the model with a maximum grid size of 40 feet to the model with a maximum grid size of 80 feet, we found that the modeled WSE was within 0.5 foot for 93 percent of the cells and within 1.0 foot at 99 percent of the cells. In some areas, we reduced the model resolution to 20 feet to ensure we represented complex channel hydraulics appropriately.

4.2 DEM

Jones Edmunds obtained a copy of the 2019 LiDAR data from USGS. The USGS LiDAR vendor collected the 2019 LiDAR data at a 1-foot nominal pulse spacing (ANPS) between December 5, 2018, and December 3, 2019. The data coordinate reference system is as follows:

- The horizontal datum is the North American Datum of 1983 with the 2011 Adjustment (NAD83 [2011]).
- The vertical datum is the North American Vertical Datum of 1988 (NAVD88).
- The coordinate system is NAD83 (2011) State Plane Florida North (US Survey Feet).
- The geoid model is Geoid12B.

The LiDAR vendor reported the vertical accuracy of the 2019 LiDAR as having a root-mean-square-error (RMSE) relative to 62 non-vegetated checkpoints of 0.26 foot at the 95-percent confidence interval.

4.3 Green-Ampt Soil Parameters

Jones Edmunds used the US Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS) Soil Survey Geographic (SSURGO) Database for classifying soils within each planning region. NRCS last updated the SSURGO data we downloaded in September 2019. Jones Edmunds used the SSURGO soil characteristic data combined with the *Characterization of Florida Soil* (University of Florida/Institute of Food and Agricultural Sciences [UF/IFAS], 2006) and other standard soil characterization references to develop the Green-Ampt infiltration parameters for the model. As part of the model calibration, we adjusted the soil parameters. Table A-1 in Attachment A outlines the soil parameters used for the countywide model following calibration.

4.4 LANDCOVER AND IMPERVIOUS MAPPING

Jones Edmunds used the following sources to generate a landcover map over the model domain:

- 2013–2014 Suwannee River Water Management District (SRWMD) landcover mapping.
- 2014 St. Johns River Water Management District (SJRWMD) landcover mapping.
- 2018 USGS National Hydrography Dataset (NHD).
- 2022 Microsoft statewide building footprints.
- 2022 OpenStreetMap (OSM) roads and railways.
- Jones Edmunds' impervious mapping (2019 LiDAR and 2022 Florida Department of Transportation [FDOT] aerial imagery).

SRWMD based their landcover mapping on 2013 or 2014 True-Color photography, and SJRWMD based their mapping on 2013 to 2016 digital orthoimagery. The USGS NHDPlus dataset uses the 10-meter Three-Dimensional Elevation Program Digital Elevation Model (3DEP DEM) and the National Watershed Boundary Dataset (WBD) to map stream networks and waterbodies across the County. We supplemented our impervious mapping with 2022 Microsoft building footprints and the OSM roads and railways feature classes.

High-resolution impervious mapping is particularly useful in urban areas where existing landcover classification is insufficient for the model. Jones Edmunds used a combination of 2019 LiDAR data and 2022 FDOT color infrared aerial imagery to create a 5-foot binary raster identifying impervious surfaces across the County. To categorize each 5-foot cell, we used the C5.0 decision tree algorithm. We created various input rasters to train the algorithm by modifying the existing LiDAR data and aerial imagery. The algorithm was then able to identify imperviousness across the County with an accuracy of 98 percent compared to 2,000 random training points that we did not include in the original training algorithm. We generated over 115,000 polygons from the resulting raster, which were manually reviewed and adjusted as needed. This impervious mapping helped improve the model's accuracy, especially in high-density urban areas.

The countywide landcover classification generated by Jones Edmunds consists of approximately 630,000 unique polygons. We aggregated the previous sources to create a 5-foot countywide landcover raster categorized into eight classes. Table 1 lists the eight classes. We then assigned each class a constant or depth-varying Manning's *n* value. We classified the classes as being impervious or pervious. Impervious landcover classes do not allow infiltration to take place. In a traditional, lumped-parameter model, impervious areas are generally classified as being made of directly connected or unconnected areas. The connectedness of the impervious areas is not defined in a high-resolution distributed model such as TUFLOW because the model simulates the infiltration downstream of the mapped impervious areas.

Table 1 Modeled Landcover Parameters

Landcover	Roughness				Pervious/ Impervious
	Depth 1		Depth 2		
	Depth (inch)	Manning n	Depth (inch)	Manning n	
Building	0.1	0.02	0.3	3	Impervious
Compacted Dirt	0.1	0.022	0.3	0.022	Impervious
Forest	0.1	0.192	0.3	0.192	Pervious
Grassed	0.1	0.1	0.3	0.04	Pervious
Paved	0.1	0.011	0.3	0.011	Impervious
Water	0.1	0.03	0.3	0.03	Impervious
Wetland	0.1	0.1	0.3	0.1	Impervious
Open Space	0.1	0.06	0.3	0.06	Pervious

We based buildings on the 2022 Microsoft building footprints, which are represented explicitly in the landcover mapping. We defined buildings as having a low roughness at low-flow depths (0.1 inch) and a very high roughness at higher depths (0.3 inch). This representation allows the models to represent rainfall-induced runoff from building roofs with minimal attenuation while reducing overland flow velocity over areas defined as buildings within the landcover. Alternatives for modeling buildings included blocking buildings out of the 2D domain, which would prevent runoff from roofs or raising the DEM elevations over buildings, creating discontinuities in the DEM surface that can result in model instabilities.

4.5 1D Hydraulic Features

The City of Gainesville provided Jones Edmunds with a copy of the joint City-County stormwater asset database in 2022. This is a joint database for the City of Gainesville and Alachua County and is currently managed by the City of Gainesville. Jones Edmunds reviewed the database and found that most pipe elevations and sizes were populated. We compared the invert elevations to the LiDAR DEM and confirmed that the calculated pipe cover for most pipes was reasonable. We updated invert elevations where these elevations were missing or appeared unreasonable. We assigned these new elevations based on surrounding structure inverts or by setting a fixed cover relative to the LiDAR DEM. Jones Edmunds also reviewed stormwater features identified in the 2010 Alachua County Stormwater Master Plan.

Jones Edmunds then used the City and County data and a desktop review to identify stormwater culverts, pipes, and weirs to include in the countywide model. We selected structures based on our estimate of the structure's impact on the inundation mapping, especially for the simulated extreme rainfall events. We considered the intended planning-level accuracy of the final mapping when selecting these features. Most subsurface stormwater systems within the County are designed for more frequently occurring storms and do not significantly impact inundation during extreme, infrequent storms. However, the model included 14,300 pipes, culverts, or weirs. In some cases, we made assumptions for the invert elevations or pipe dimensions based on the LiDAR DEM, assumed pipe cover, and drainage area upstream of the structure. Attachment B shows the structures included in the countywide model.

Although not a part of this effort, Jones Edmunds recommends that future refinements and enhancements to the countywide model include adding more 1D structures to the countywide model to reflect subsurface conveyance better, allowing the model to simulate higher-frequency storms more accurately. In addition, many of the structures used assumed pipe sizes and inverts. To improve the accuracy of the model results, we recommend that the County survey these features as part of future model updates.

4.6 Boundary Stages

Jones Edmunds generally extended the model domain to a point where the model was no longer sensitive to boundary conditions. Two primary boundaries for the model were:

- Orange Creek – Jones Edmunds set the boundary condition approximately 1.8 miles east of the County line. We set the boundary downstream of a historical river crossing likely to control water levels during extreme storms.
- Santa Fe River – Jones Edmunds generally treated the Santa Fe River as a boundary condition. The Santa Fe River watershed extends well beyond Alachua County, and modeling all of the watersheds was not feasible for this study.

4.7 Starting Water Levels

Jones Edmunds set the starting water levels in the countywide model based on the water levels at the time of the 2019 LiDAR collection. Water levels were generally higher than normal after Hurricane Irma, and the 2019 LiDAR seems to represent that condition.

Although not a part of this effort, we recommend reviewing these starting levels as part of future updates to the countywide model since model results were sensitive to starting water levels in some locations.

4.8 Model Calibration and Verification

Hurricane Irma caused flooding in Alachua County in September 2017. The County received approximately 12 inches of rainfall near the Gainesville Regional Airport and over 10 inches at multiple other locations. Attachment C shows the distribution of rainfall based on the SJRWMD radar rainfall measurements. Jones Edmunds calibrated the countywide model to record high-water marks and water-level gauge data provided by the County, City of Gainesville, USGS, and SJRWMD for Hurricane Irma.

When reviewing the high-water marks, we identified several instances where multiple high-water marks were recorded for the same level-pool flooding. We found that the reported difference in high-water elevation for the same instance of flooding exceeded 2 feet in some locations. Given this variability, our general conclusion was that the accuracy of the documented high-water marks was approximately 1 to 2 feet. When comparing modeling flood elevations to the high-water marks, we excluded 14 high-water marks because the stated flood elevations were highly unlikely given the topography and the extent of infrastructure that would have been impacted at that elevation.

Jones Edmunds reviewed the high-water marks provided by the City of Gainesville and the County. We compared model results to the surveyed water levels and peak gauge stages at 82 locations. We found that the mean absolute difference between Hurricane Irma's modeled water surface elevations and the recorded high-water marks was 1.3 feet. This difference was within this planning-level model's expected accuracy (approximately 2 feet). Attachment D provides a table comparing high-water marks to Hurricane Irma's modeled peak WSEs.

Jones Edmunds also compared recorded water-level data from the SJRWMD, USGS, City of Gainesville, and County gauges for Hurricane Irma. This comparison showed that the hydrographs produced by the planning-level model were generally similar to the gauge recordings. Attachment E shows these comparisons.

Hurricane Elsa caused some flooding in Alachua County in July 2021. Attachment F shows the recorded rainfall depths associated with Elsa varied from approximately 2.5 to 8 inches. To verify the countywide model, Jones Edmunds used the countywide model to simulate flooding from Hurricane Elsa. SJRWMD provided hourly radar rainfall for the event. We compared hydrographs recorded at gauges in the County to model water levels for Hurricane Elsa. Attachment G shows these comparisons.

4.9 Design-Storm Rainfall and Inundation Mapping

Jones Edmunds used the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall totals to simulate flood risk in the County for the following storms:

- 100-year/1-day.
- 100-year/10-day.
- 500-year/1-day.
- 500-year/10-day.

A 1-day storm is a typical critical duration where positive drainage occurs, and a 10-day storm is a typical critical duration for closed basins. By running both durations, we were able to predict appropriate flood stages throughout the County regardless of the drainage conditions. We assigned rainfall by averaging the NOAA Atlas 14 rainfall depths across a 2-kilometer (km)-by-2-km grid that aligns with the SJRWMD radar rainfall grid. Table 2 provides the range in Atlas 14 rainfall depths for each design storm.

We used the maximum of the modeled inundation depth for the 100-year/1-day and 100-year/10-day storms to identify the potential 100-year flood risk. Similarly, we based the 500-year flood risk on the maximum 500-year/1-day and 500-year/10-day storms. The 1-day storm generally characterizes the flood risk in flowing streams and other conveyances, and the 10-day storm characterizes the flood risk in closed basins. We used the NRCS FL-Modified rainfall distribution for the 1-day storm and the FDOT 10-day distribution for the 10-day storm. We mapped inundation for the 100-year and 500-year return period at a 5-foot resolution across the County using the high-resolution flood-mapping routine available within the modeling platform. We excluded areas with flooding less than 0.2 foot deep or flooding extent less than 1,600 square feet from the flood mapping.

Table 2 Countywide Inundation Model – Simulated Design Storm Depth (NOAA Atlas 14)

Design Storm	Maximum Rainfall Depth (inches)	Minimum Rainfall Depth (inches)
100-year/1-day	11.7	9.4
100-year/10-day	17.7	14.6
500-year/1-day	17.0	12.8
500-year/10-day	24.3	19.3

5 2040 AND 2070 FLOOD MODELING

Jones Edmunds developed future condition models to represent flooding in Alachua County in 2040 and 2070. We based these models on the TUFLOW HPC model of existing conditions described in this document. The following summarizes the updates that we considered or made to the model:

- Tidal conditions – The lowest elevation in the County is 23 feet NAVD88, which is well above the 2018 sea-level rise projections for Cedar Key. We did not change boundary conditions to reflect the proposed level rise projections for 2040 or 2070.

- Model boundary conditions – We established model boundary conditions where the modeled WSE in Alachua County was not sensitive to the boundary condition. We did not change the model boundary conditions.

- Rainfall – We used the change factors developed by the Florida International University (FIU) for North Florida to adjust the NOAA Altas 14 rainfall depths to evaluate future flood risk in Alachua County. These change factors are described in the FIU report *Updating the Statewide Extreme Rainfall Projections* (Obeysekera et al., 2021). Table 3 provides the change factors that we used. We made the following assumptions when adjusting these data:

  - The FIU 2030–2069 condition represents 2040.
  - The FIU 2070–2099 condition represents 2070.
  - After discussions with the County, we used the maximum 50th percentile extreme precipitation change factors.
  - We used the change factors based on the Multivariate Adaptive Constructed Analogs (MACA) data that were used in Obeysekera et al. (2021).
  - We assumed the change factors for the 200-year events applied to the 500-year events since the FIU study did not evaluate the 500-year storms.

- Landcover – Alachua County, SJRWMD, and SRWMD require that new developments include sufficient stormwater retention or detention to offset potential increases in off-site flows and stages. Therefore, we expect future growth to have a minimal impact on flood risk in the County since on-site stormwater controls will mitigate these land use changes.

Jones Edmunds applied the change factors in Table 3 and reran the 100-year and 500-year 1-day and 10-day storms for 2040 and 2070. We used the maximum of the modeled inundation depth for the 100-year/1-day and 100-year/10-day storms to identify the potential 100-year flood risk. We mapped the 2040 and 2070 inundation for the 100-year and 500-year return period at a 5-foot resolution across the County using the high-resolution flood-mapping routine available within the modeling platform. We excluded areas with flooding less than 0.2 foot deep or less than 1,600 square feet from the flood mapping.

Appendix H shows the mapped flood extents for the 100-year and 500-year return periods for current, 2040, and 2070 flooding.

Table 3 Countywide Inundation Model – Rainfall Change Factors

Design Storm	Rainfall Change Factor	
	2040	2070
100-year/1-day	1.35	1.47
100-year/10-day	1.21	1.38
500-year/1-day	1.49	1.52
500-year/10-day	1.49	1.47

6 SUMMARY

Jones Edmunds developed a rapid 2D inundation model for the County within TUFLOW HPC referred to as the *countywide model*. The countywide model operates using a model grid mesh that varies from 80 to 20 feet. We based the model on the 2019 USGS DEM and used a Green-Ampt approach to predict a rainfall-runoff response. Each model grid cell generated an expected runoff response, which was routed to other grid cells using a 2D approach defined by landcover data and topography. We supplemented the overland routing with over 14,000 1D hydraulic elements based on the City of Gainesville and Alachua County asset inventories. The countywide model was calibrated to recorded water levels from Hurricane Irma (September 2017) and verified to water levels from Hurricane Elsa (July 2021). The model generated predictions of acceptable accuracy for a planning-level tool. The model was used to map 100-year and 500-year flood risks.

Jones Edmunds noted a few areas where the countywide model results could be improved as part of future efforts:

- Starting water levels should be reviewed as part of future updates to the countywide model since model results were sensitive to starting water levels in some locations.
- Additional 1D structures should be added, and structures with assumed dimensions and elevations should be surveyed to better reflect subsurface conveyance to allow the model to simulate more frequent storms more accurately.

7 REFERENCES

Obeysekera, J; Sukop, M; Troxler, T; and John, A. 2021. *Updating the Statewide Extreme Rainfall Projections.* Sea Level Solutions Center (SLSC), Institute of Environment, Florida International University. Retrieved from https://environment.fiu.edu/slsc/resources/_assets/fbc_fiu_finalreport.pdf.

University of Florida/Institute of Food and Agricultural Sciences [UF/IFAS]. 2006. *Characterization of Florida Soil.*

Attachment A

Modeled Green-Ampt Soil Parameters

Table A-1 Modeled Green-Ampt Soil Parameters

MUKEY	Soil Name	Ksat (in/hr)	Suction Head (inches)	Porosity	Initial Moisture
1414061	Adamsville fine sand, 0- to 5-percent slopes	13.14	1.95	0.4	0.06
132799	Albany fine sand, 0- to 5-percent slopes	2.34	3.46	0.4	0.2
132801	Allanton and Rutlege mucky fine sands, depressional	7.05	2.08	0.41	0.23
1712887	Anclote sand, frequently ponded, 0- to 1-percent slopes	0.02	1.95	0.41	0.21
1712888	Anclote-Tomoka complex, depressional	16.57	2	0.59	0.42
320759	Apopka sand, 0- to 5-percent slopes	3.24	1.95	0.4	0.11
1712889	Apopka sand, 0- to 5-percent slopes	13.25	4.17	0.41	0.14
1712891	Arredondo sand, 0- to 5-percent slopes	4.13	4.87	0.39	0.23
320727	Arredondo-Urban land complex, 0- to 5-percent slopes	11.43	1.95	0.42	0.08
1414119	Astatula fine sand, 1- to 8-percent slopes	11.64	1.95	0.47	0.05
797486	Bigbee fine sand	3.08	2.1	0.46	0.19
320708	Bivans sand, 2- to 5-percent slopes	0.01	7.05	0.36	0.32
132810	Blanton fine sand, 0- to 5-percent slopes	15.06	3.28	0.46	0.13
797430	Blanton-Bonneau-Ichetucknee complex, 2- to 5-percent slopes	10.87	1.95	0.43	0.13
1712899	Blichton sand, 0- to 2-percent slopes	0.29	5.35	0.37	0.24
1712901	Blichton-Urban land complex, 0- to 5-percent slopes	7.01	1.95	0.42	0.18
1712902	Bluff sandy clay, frequently flooded	3.12	9.14	0.51	0.34
1712903	Boardman loamy sand, 5- to 8-percent slopes	0.37	7.01	0.44	0.25
1414605	Bonneau fine sand, 6- to 10-percent slopes	0.11	5.67	0.36	0.24
797434	Bonneau-Blanton complex, 2- to 5-percent slopes	10.77	1.95	0.43	0.12
1414050	Candler fine sand, 1- to 5-percent slopes	6.71	1.95	0.42	0.07
1712905	Candler sand, 0- to 5-percent slopes	3.31	1.95	0.43	0.1
1414051	Candler-Apopka complex, 1- to 5-percent slopes	16.90	1.95	0.41	0.04
2771248	Cassia fine sand	5.90	1.95	0.44	0.11
132852	Centenary fine sand, 0- to 5-percent slopes	8.97	1.95	0.42	0.07
1414587	Chipley fine sand, 0- to 5-percent slopes	19.26	1.95	0.43	0.09

MUKEY	Soil Name	Ksat (in/hr)	Suction Head (inches)	Porosity	Initial Moisture
320694	Chipley sand	3.05	1.95	0.39	0.16
631640	Dorovan muck, frequently flooded	1.82	1.95	0.83	0.87
1712908	Eaton loamy sand	0.31	6.94	0.42	0.25
323375	Electra fine sand	8.52	2.29	0.39	0.14
1712909	Electra sand, 0- to 5-percent slopes	3.14	2.48	0.4	0.16
797442	Electra variant fine sand, 0- to 5-percent slopes	1.86	2.48	0.4	0.2
320749	Emeralda fine sandy loam	6.05	4.33	0.43	0.22
1712910	Eureka loamy fine sand, 0- to 2-percent slopes	1.89	6.65	0.48	0.23
1712912	Fellowship loamy sand, 2- to 5-percent slopes	1.42	12.5	0.46	0.28
323414	Florahome sand	12.00	1.95	0.46	0.13
320687	Floridana sand, frequently ponded, 0- to 2-percent slopes	1.02	2.43	0.57	0.27
320743	Fort Meade fine sand, 0- to 5-percent slopes	6.35	1.95	0.52	0.21
1414581	Foxworth fine sand, 0- to 5-percent slopes	5.37	1.95	0.43	0.1
1414094	Ft. Green-Bivans complex, 2- to 5-percent slopes	0.14	5.21	0.36	0.26
1712918	Gainesville loamy sand, 0- to 5-percent slopes	16.17	2.41	0.44	0.06
1414600	Goldhead fine sand	0.58	3.57	0.42	0.32
797445	Goldsboro loamy fine sand, 2- to 5-percent slopes	2.95	1.95	0.46	0.23
1414586	Grifton and Elloree soils, frequently flooded	0.36	4.81	0.41	0.29
1712920	Hague sand, 2- to 5-percent slopes	4.45	2.4	0.42	0.1
1414113	Hallandale-Boca-Holopaw complex	5.54	3.44	0.69	0.08
1414092	Hicoria fine sand	0.21	5.39	0.37	0.27
1414065	Holopaw fine sand	0.67	3.14	0.42	0.22
1712924	Hontoon muck, frequently ponded, 0- to 1-percent slopes	2.06	1.95	0.97	0.88
132820	Hurricane fine sand, 0- -to 5-percent slopes	6.27	1.95	0.44	0.09
1414049	Immokalee fine sand	0.00	1.95	0.58	0.28
1414074	Jonesville-Otela-Seaboard complex, 1- to 5-percent slopes	0.13	1.95	0.53	0.11
1712925	Jumper fine sand, 0- to 5-percent slopes	2.90	5.75	0.4	0.16

MUKEY	Soil Name	Ksat (in/hr)	Suction Head (inches)	Porosity	Initial Moisture
1712926	Kanapaha-Kanapaha, wet, fine sand, 0- to 5-percent slopes	2.18	5.41	0.37	0.26
1712927	Kendrick loamy sand, 0- to 5-percent slopes	3.30	1.95	0.4	0.16
320701	Kendrick sand, 2- to 5-percent slopes	0.83	5.55	0.39	0.29
132842	Kershaw sand, 0- to 8-percent slopes	11.35	1.95	0.56	0.04
320750	Lake sand, 0- to 5-percent slopes	16.83	1.95	0.47	0.08
1414583	Lakeland fine sand, 0- to 5-percent slopes	6.22	2.29	0.58	0.09
631630	Lakeland sand, 0- to 5-percent slopes	4.95	1.95	0.42	0.08
320747	Ledwith muck	0.18	6.62	0.53	0.35
797452	Leefield fine sand	0.66	3.93	0.38	0.23
132838	Leon fine sand, frequently flooded	1.90	1.95	0.43	0.18
631631	Leon sand, 0- to 2-percent slopes	2.30	2.1	0.38	0.21
1414109	Levyville-Shadeville complex, 2- to 5-percent slopes	5.43	1.95	0.4	0.18
1712929	Lochloosa fine sand, 0- to 5-percent slopes	0.64	3.34	0.39	0.26
323381	Lochloosa sand, 0- to 5-percent slopes	0.69	4.26	0.37	0.23
797455	Lucy loamy fine sand, 2- to 5-percent slopes	1.87	4.2	0.39	0.18
1414091	Lutterloh-Moriah complex, 0- to 5-percent slopes	4.27	4.3	0.38	0.18
132844	Lynn Haven fine sand	0.45	1.95	0.43	0.17
132845	Mandarin fine sand, 0- to 2-percent slopes	4.88	2.02	0.44	0.18
1712932	Martel sandy clay loam, 0- to 2-percent slopes	0.07	11	0.45	0.32
1414604	Mascotte sand, 0- to 2-percent slopes	1.43	3.97	0.4	0.19
320786	Mascotte, Wesconnett, and Surrency soils, flooded	7.04	8.6	0.42	0.13
132816	Maurepas muck, frequently flooded	15.06	1.95	0.82	0.72
631650	Meadowbrook and Allanton soils, frequently flooded	2.40	2.9	0.35	0.2
1712933	Micanopy fine sand, 2- to 5-percent slopes	0.42	7.22	0.42	0.28
1414048	Millhopper fine sand, 1- to 5-percent slopes	7.74	2.9	0.44	0.11
1414105	Millhopper-Bonneau complex, 1- to 5-percent slopes	7.95	3.14	0.36	0.2
320680	Monteocha loamy sand	2.50	2.6	0.41	0.23

MUKEY	Soil Name	Ksat (in/hr)	Suction Head (inches)	Porosity	Initial Moisture
1414099	Moriah-Bushnell-Mabel, limestone substratum, complex, 0- to 5-percent slopes	7.49	1.95	0.42	0.21
320688	Mulat sand	0.15	2.37	0.38	0.22
1414080	Myakka muck, occasionally flooded	0.32	2.02	0.47	0.22
1414081	Myakka sand	3.30	1.95	0.41	0.11
323389	Narcoossee fine sand, 0- to 2-percent slopes	6.25	1.95	0.49	0.1
132848	Neilhurst fine sand, undulating	45.56	1.95	0.41	0.05
323429	Newnan fine sand	2.95	2.78	0.44	0.22
320685	Newnan sand	5.24	3	0.46	0.13
320712	Norfolk loamy fine sand, 2- to 5-percent slopes	0.01	8.32	0.49	0.43
1414595	Ocilla fine sand, 0- to 5-percent slopes	0.04	4.02	0.4	0.29
320790	Ocilla, Alapaha, and Mandarin soils, occasionally flooded	9.96	1.95	0.42	0.11
320765	Okeechobee, frequently ponded, 0- to 1-percent slopes	17.61	1.95	0.89	0.87
320761	Oleno clay, occasionally flooded	0.82	9.32	0.48	0.23
132850	Ona fine sand	2.16	1.95	0.42	0.15
797465	Orangeburg loamy fine sand, 2- to 5-percent slopes	0.91	7.31	0.39	0.29
1414116	Orlando fine sand, 1- to 5-percent slopes	18.03	1.95	0.44	0.05
132800	Ortega fine sand, 0- to 5-percent slopes	6.78	1.95	0.46	0.06
132804	Ortega-Urban land complex, 0- to 5-percent slopes	17.60	1.95	0.44	0.05
1414576	Osier sand	8.02	1.95	0.39	0.08
1414056	Otela-Candler complex, 1- to 5-percent slopes	3.42	4.17	0.35	0.15
1712936	Paisley loamy fine sand	0.13	4.32	0.4	0.25
323387	Palmetto fine sand	1.97	2.35	0.41	0.09
132817	Pamlico muck	5.77	1.95	0.68	0.05
1414098	Pedro-Jonesville-Shadeville complex, 0- to 5-percent slopes	6.79	1.95	0.64	0.08
1414588	Pelham complex, 0- to 2-percent slopes	0.87	3.21	0.46	0.17
797470	Pelham fine sand, 0- to 2-percent slopes	0.36	4.19	0.39	0.28
320669	Pelham sand	0.11	5.87	0.37	0.28
132824	Penney fine sand, 5- to 8-percent slopes	4.89	1.95	0.46	0.07
320789	Pickney sand, frequently flooded	10.10	1.95	0.84	0.06

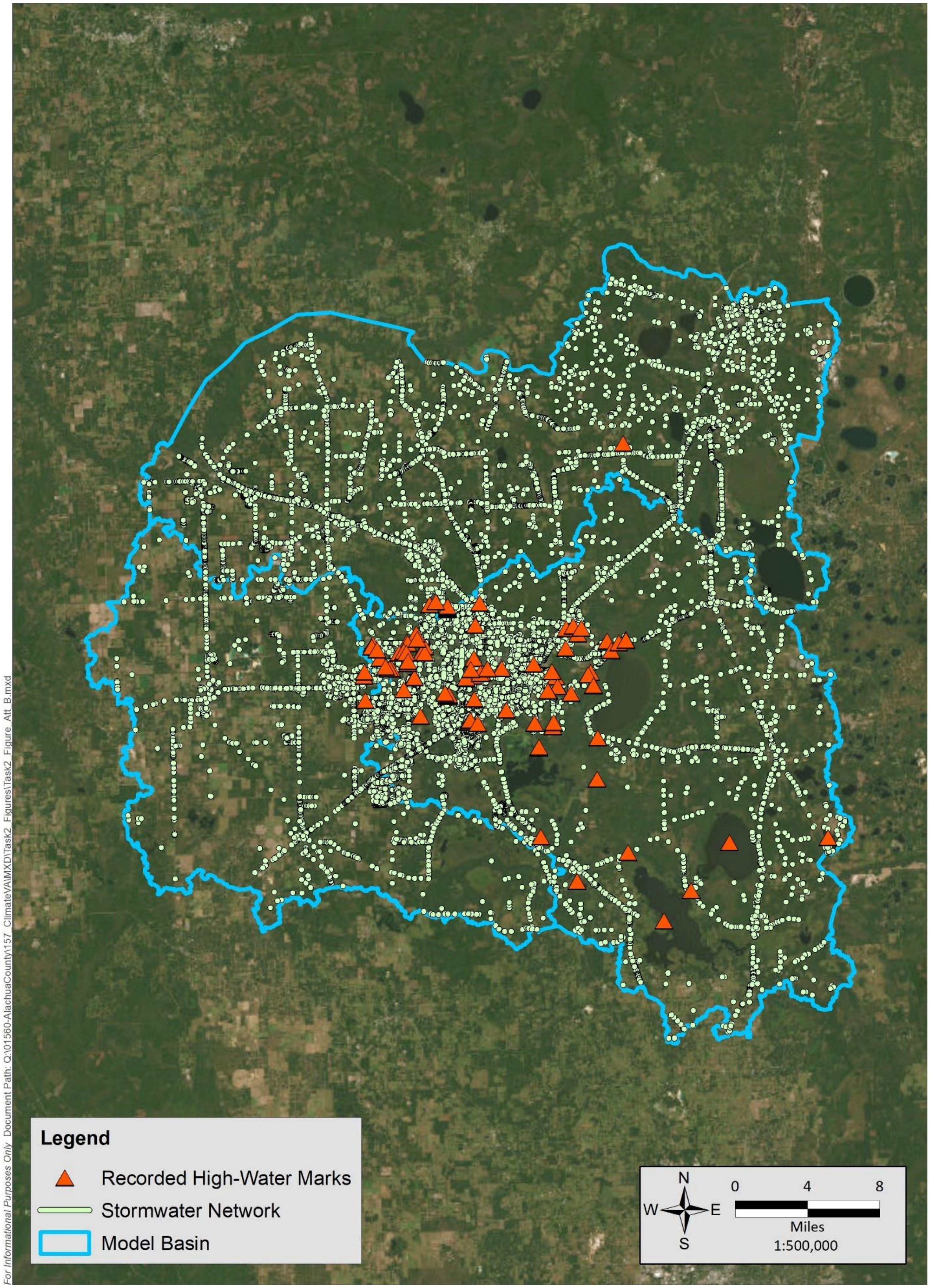
MUKEY	Soil Name	Ksat (in/hr)	Suction Head (inches)	Porosity	Initial Moisture
1414070	Placid and Popash soils, depressional	3.11	1.95	0.42	0.25
1414054	Placid fine sand	1.54	1.95	0.42	0.2
1414611	Plummer-Plummer wet, sands	0.93	4.07	0.38	0.26
1414053	Pomona fine sand	3.06	3.61	0.43	0.21
1713202	Pomona sand	3.66	3.09	0.47	0.15
1414064	Pompano fine sand	0.23	1.95	0.55	0.09
1713210	Pompano sand	9.61	1.95	0.41	0.04
132822	Pottsburg fine sand	6.15	1.95	0.4	0.15
132805	Quartzipsaments, excavated	0.00	2	0.5	0.25
132846	Ridgeland fine sand	13.78	1.95	0.43	0.07
132808	Ridgewood fine sand, 0- to 5-percent slopes	6.70	1.95	0.42	0.07
323393	Riviera fine sand, frequently flooded	5.10	3.37	0.38	0.15
320667	Riviera sand	0.18	3.38	0.71	0.06
132819	Rutlege-Osier complex, frequently flooded	0.10	1.95	0.47	0.18
320692	Samsula muck	8.29	2.43	0.61	0.22
1713204	Samsula-Martel complex, depressional	8.78	1.95	0.66	0.07
132853	Sapelo fine sand	2.16	3.03	0.4	0.24
1414058	Shadeville-Otela complex, 1- to 5-percent slopes	1.31	1.95	0.47	0.15
320748	Shenks muck	0.45	9.3	0.64	0.42
1414052	Smyrna fine sand, 0- to 2-percent slopes	1.49	2	0.43	0.15
132849	Solite fine sand	21.11	1.95	0.44	0.08
1414063	Sparr fine sand	11.01	2.36	0.41	0.13
1414108	Sparr-Lochloosa complex, 1- to 5-percent slopes	2.35	3.98	0.39	0.2
323376	St. Johns fine sand, depressional	0.38	1.95	0.5	0.25
1414589	Starke mucky fine sand, depressional	9.79	8.6	0.43	0.15
132802	Surrency fine sand, depressional	0.30	5.94	0.39	0.3
1414046	Tavares fine sand, 1- to 5-percent slopes	5.33	1.95	0.45	0.07
1713212	Terra Ceia muck, frequently ponded, 0- to 1-percent slopes	8.11	2.58	0.68	0.2
1713213	Tomoka muck, frequently ponded, 0- to 1-percent slopes	10.56	2	0.67	0.56
132841	Troup sand, 0- to 5-percent slopes	2.64	4.56	0.4	0.2
323417	Wabasso-Wabasso, wet, fine sand, 0- to 2-percent slopes	0.29	4.23	0.52	0.22

MUKEY	Soil Name	Ksat (in/hr)	Suction Head (inches)	Porosity	Initial Moisture
1713216	Wacahoota loamy sand, 5- to 8-percent slopes	0.13	6.29	0.41	0.18
321796	Wadley fine sand, 0- to 5-percent slopes	2.56	4.56	0.38	0.22
1414601	Wampee loamy fine sand, 5- to 12-percent slopes	0.20	5.66	0.41	0.29
320752	Wauberg sand	0.02	5.76	0.42	0.22
320677	Wauchula sand	0.72	4.44	0.38	0.21
132847	Wesconnett fine sand, frequently flooded	1.68	1.95	0.41	0.19
320721	Zolfo sand	6.33	1.95	0.63	0.06
1713220	Zuber loamy sand, 2- to 5-percent slopes	0.91	6.95	0.42	0.27

Note: in/hr = inches per hour; Ksat = saturated hydraulic conductivity.

Attachment B

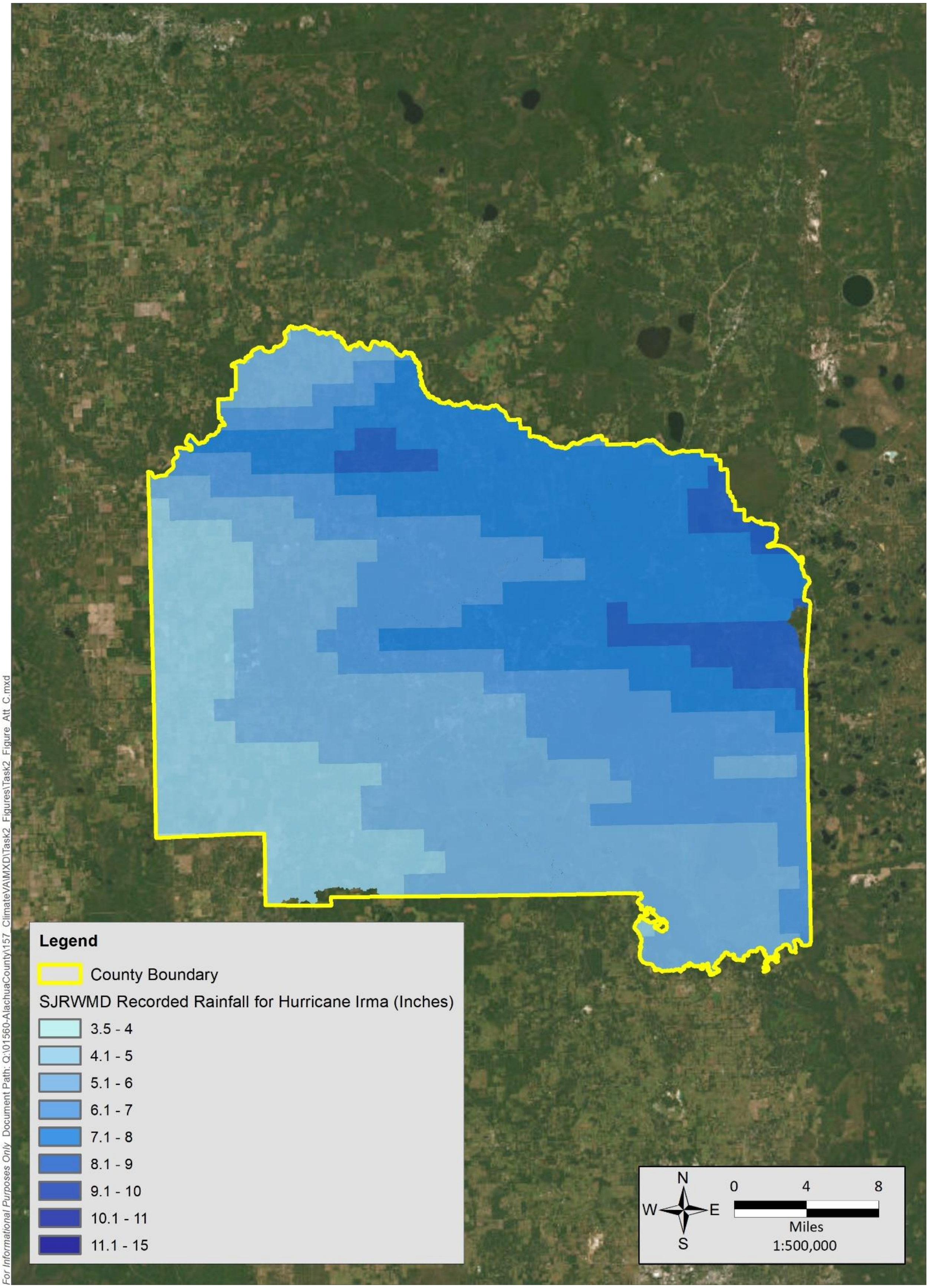
Modeled Structures and Recorded High-Water Marks



For Informational Purposes Only Document Path: Q:\01560-AlachuaCounty\157_ClimateVA\MXD\Task2_Figures\Task2_Figure_Att_B.mxd
Legend
Recorded High-Water Marks
Stormwater Network
Model Basin
N
W
E
S
0
4
8
Miles
1:500,000

Attachment C

SJRWMD Recorded Rainfall Distribution for Hurricane Irma (September 2017)



For Informational Purposes Only Document Path: Q:\01560-AlachuaCounty\157_ClimateVA\MXD\Task2_Figures\Task2_Figure_Att_C.mxd

Attachment D

Comparison of High-Water Marks and Countywide Model Results for Hurricane Irma

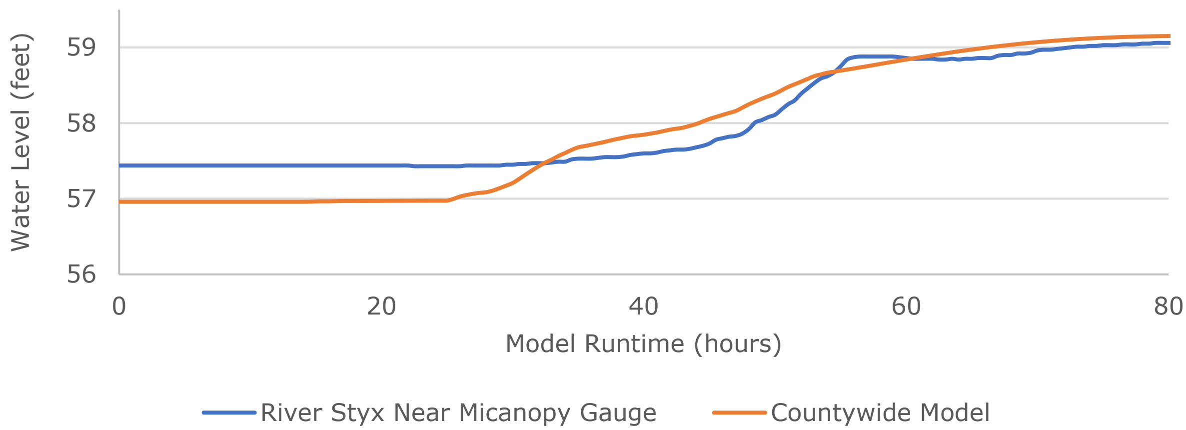
No.	Source	Type	High-Water (feet-NAVD88)	TUFLOW Peak Stage (feet-NAVD88)	Difference (feet)
1	County	Survey	102.0	106.5	4.5
2	County	Survey	58.8	62.5	3.7
3	SJRWMD	Gauge	78.1	81.7	3.6
4	County	Survey	85.0	87.8	2.8
5	County	Survey	94.5	97.3	2.8
6	City	Survey	84.7	87.3	2.6
7	County	Survey	111.4	113.8	2.4
8	County	Survey	111.4	113.8	2.4
9	County	Survey	150.5	152.8	2.3
10	County	Survey	96.4	98.5	2.1
11	County	Survey	89.8	91.8	2.0
12	County	Survey	92.9	94.8	1.9
13	City	Survey	80.5	82.4	1.9
14	County	Survey	93.1	94.8	1.7
15	County	Survey	85.0	86.8	1.6
16	County	Survey	93.2	94.8	1.6
17	County	Survey	61.2	62.7	1.5
18	County	Survey	61.2	62.7	1.5
19	County	Survey	102.3	103.8	1.5
20	City	Survey	78.7	80.1	1.4
21	City	Survey	78.7	80.1	1.4
22	County	Survey	187.0	188.4	1.4
23	County	Survey	126.6	128.0	1.4
24	City	Survey	70.5	71.8	1.3
25	County	Survey	139.9	141.2	1.3
26	City	Survey	78.9	80.2	1.3
27	City	Survey	81.1	82.3	1.2
28	City	Survey	83.3	84.5	1.2
29	City	Survey	134.3	135.4	1.1
30	County	Survey	90.7	91.8	1.1
31	County	Survey	93.7	94.8	1.1
32	SJRWMD	Gauge	67.2	68.3	1.1
33	City	Survey	176.8	177.8	0.9
34	City	Survey	182.7	183.6	0.9
35	City	Survey	149.9	150.7	0.8
36	County	Survey	108.7	109.5	0.8
37	County	Survey	106.3	107.0	0.7
38	UF Study	ICPR Model	71.4	72.1	0.7
39	SJRWMD	Gauge	71.2	71.8	0.6
40	SJRWMD	Gauge	64.9	64.3	0.6
41	City	Survey	176.8	177.4	0.6
42	SJRWMD	Gauge	60.7	61.1	0.5
43	City	Survey	62.3	62.7	0.4
44	County	Survey	71.7	72.1	0.4

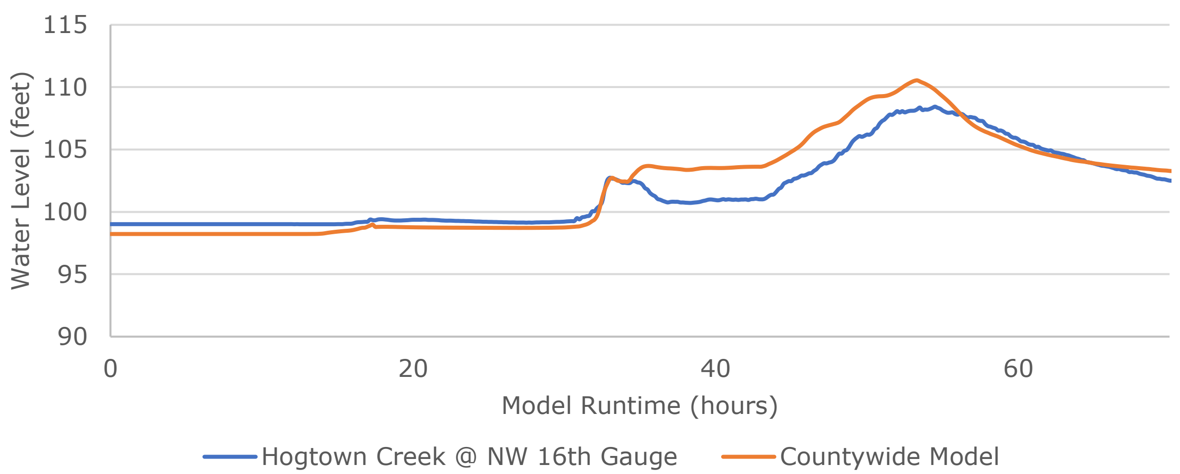
No.	Source	Type	High-Water (feet-NAVD88)	TUFLOW Peak Stage (feet-NAVD88)	Difference (feet)
45	County	Survey	158.8	159.2	0.4
46	City	Survey	131.6	131.9	0.4
47	City	Survey	73.1	73.3	0.3
48	City	Survey	83.3	83.6	0.3
49	City	Survey	160.7	160.9	0.2
50	SJRWMD	Gauge	91.8	91.7	0.0
51	SJRWMD	Gauge	67.2	67.1	-0.1
52	City	Survey	186.2	186.1	-0.1
53	City	Survey	160.7	160.6	-0.2
54	City	Survey	176.4	176.3	-0.2
55	SJRWMD	Gauge	59.7	59.4	-0.3
56	County	Survey	73.1	72.7	-0.3
57	City	Survey	83.3	82.9	-0.4
58	SJRWMD	Gauge	58.5	58.1	-0.4
59	SJRWMD	Gauge	78.4	78.0	-0.4
60	City	Survey	72.9	72.4	-0.5
61	City	Survey	176.8	176.3	-0.5
62	City	Survey	63.3	62.7	-0.6
63	County	Survey	139.5	138.8	-0.7
64	City	Survey	176.9	176.2	-0.7
65	SJRWMD	Gauge	59.3	58.6	-0.7
66	County	Survey	75.3	74.5	-0.8
67	County	Survey	75.2	74.3	-0.9
68	SJRWMD	Gauge	60.0	59.0	-1.0
69	County	Survey	102.3	101.3	-1.0
70	City	Survey	121.0	119.9	-1.1
71	City	Survey	177.6	176.4	-1.2
72	SJRWMD	Gauge	60.4	59.1	-1.3
73	SJRWMD	Gauge	60.4	59.1	-1.3
74	County	Survey	135.8	134.4	-1.4
75	City	Survey	120.6	119.0	-1.6
76	USGS	Gauge	119.9	118.2	-1.7
77	City	Survey	110.0	108.1	-1.8
78	County	Survey	73.1	70.9	-2.2
79	City	Survey	122.4	119.6	-2.8
80	County	Survey	115.3	112.5	-2.8
81	City	Survey	143.8	139.0	-4.8
82	County	Survey	141.1	135.2	-5.9

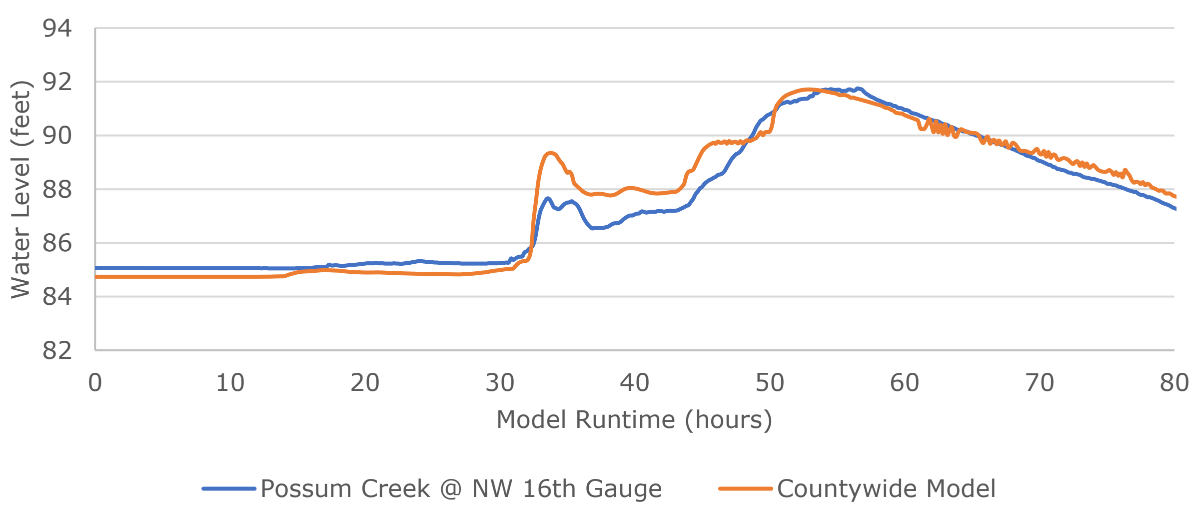
Attachment E

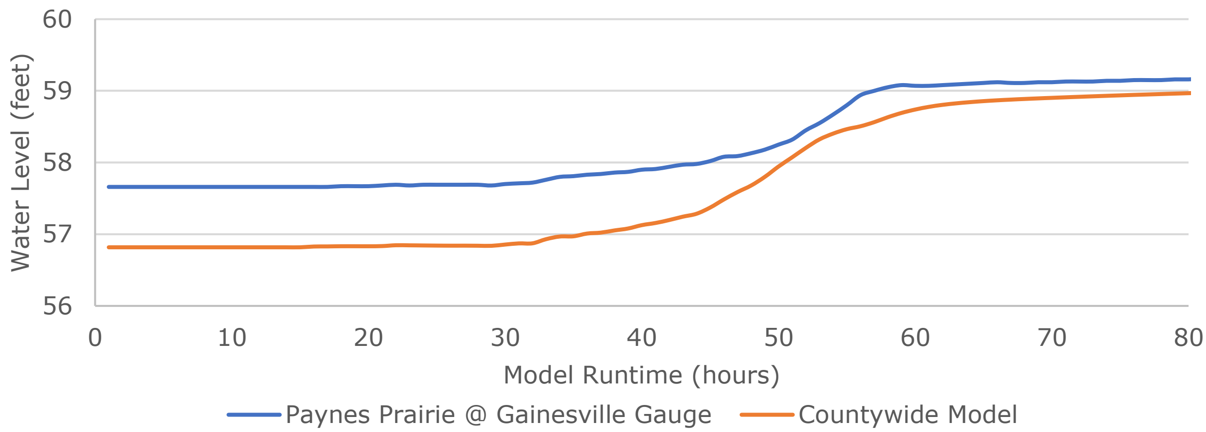
Hurricane Irma Model Hydrograph Comparisons

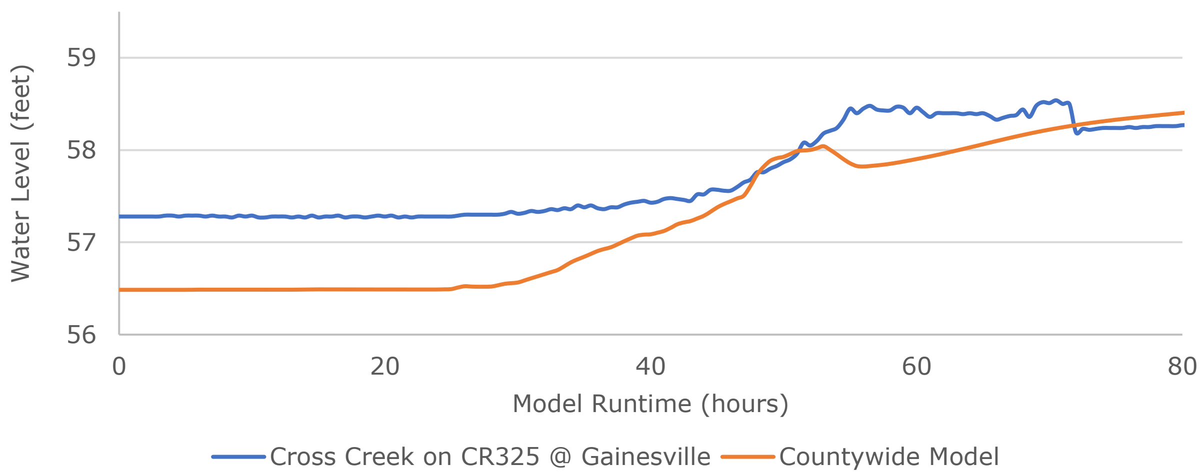
Hurricane Irma Hydrograph Comparisons

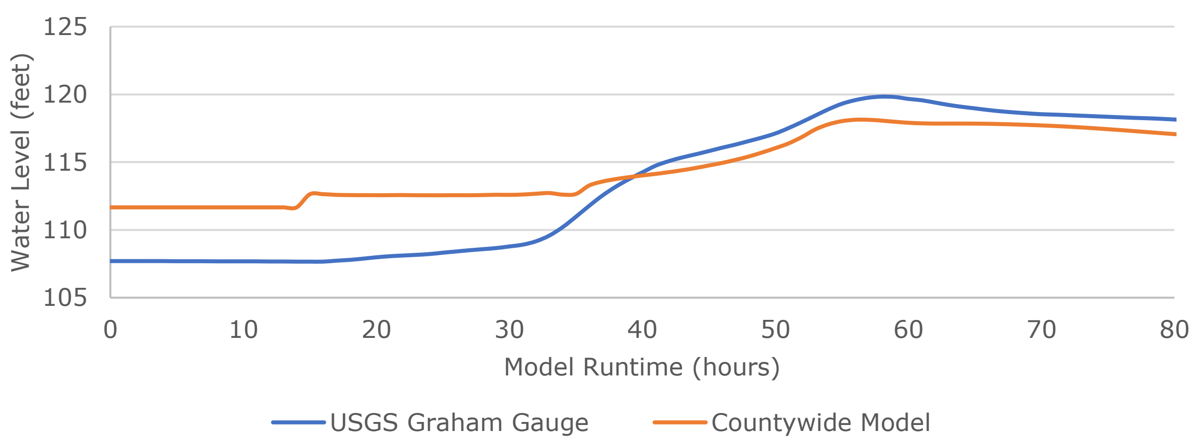


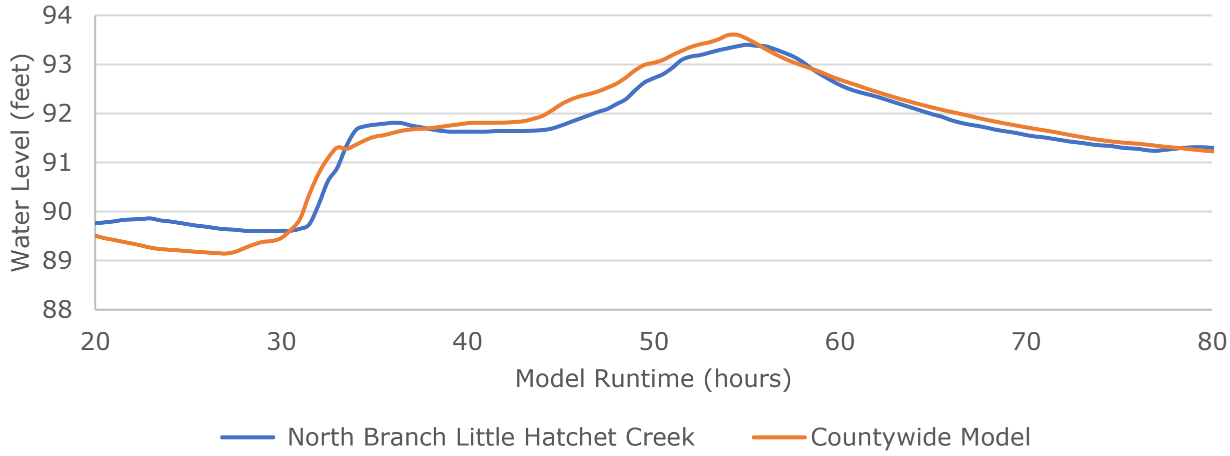




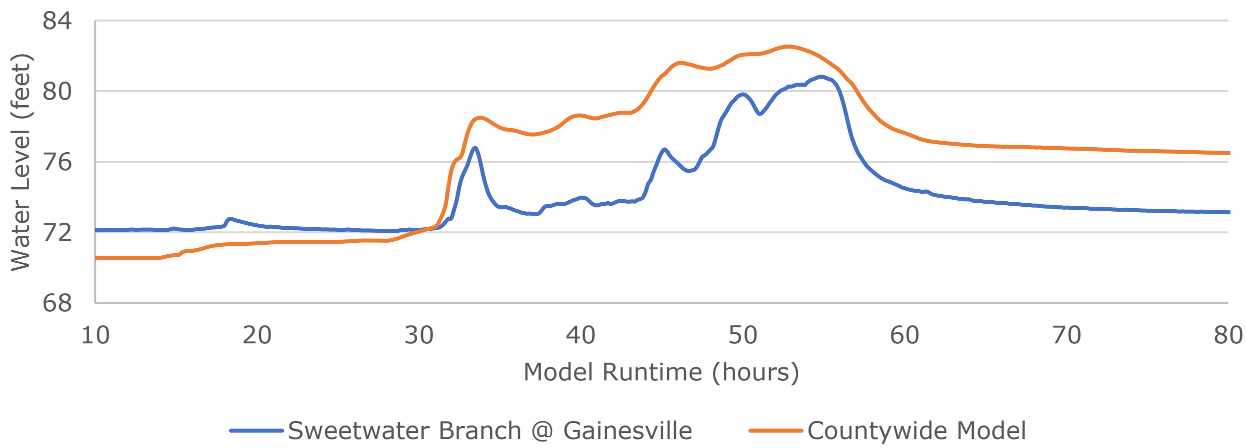

60
59
58
57
56
Water Level (feet)
0
10
20
30
40
50
60
70
80
Model Runtime (hours)
Paynes Prairie @ Gainesville Gauge
Countywide Model


59
58
57
56
Water Level (feet)
0
20
40
60
80
Model Runtime (hours)
Cross Creek on CR325 @ Gainesville
Countywide Model

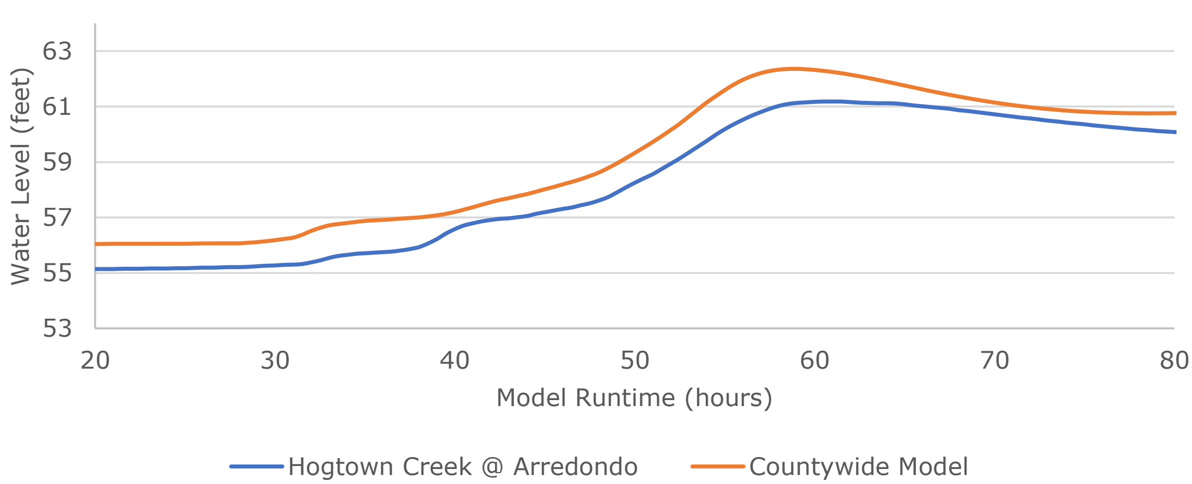

125
120
115
110
105
Water Level (feet)
0
10
20
30
40
50
60
70
80
Model Runtime (hours)
USGS Graham Gauge
Countywide Model



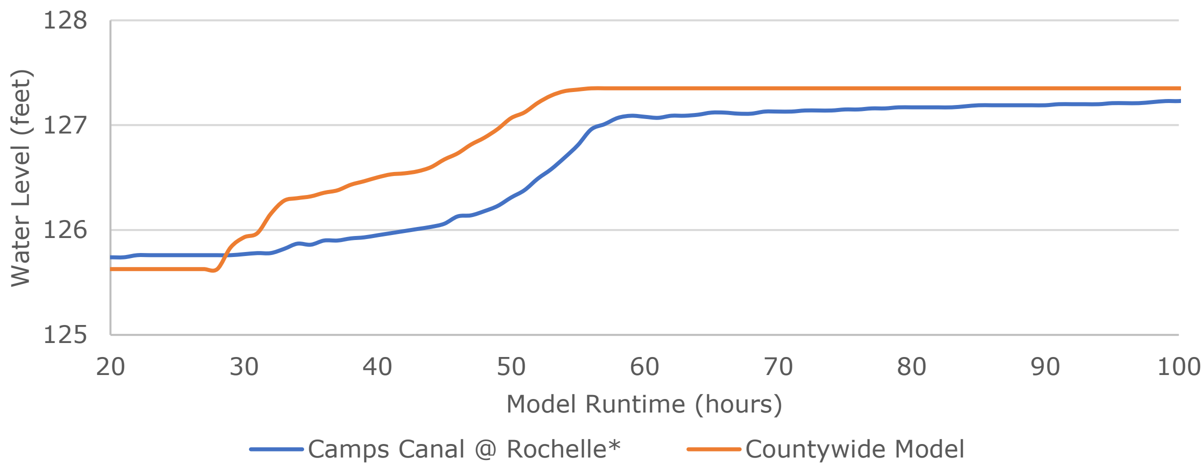
94
93
92
91
90
89
88
Water Level (feet)
20
30
40
50
60
70
80
Model Runtime (hours)
North Branch Little Hatchet Creek
Countywide Model



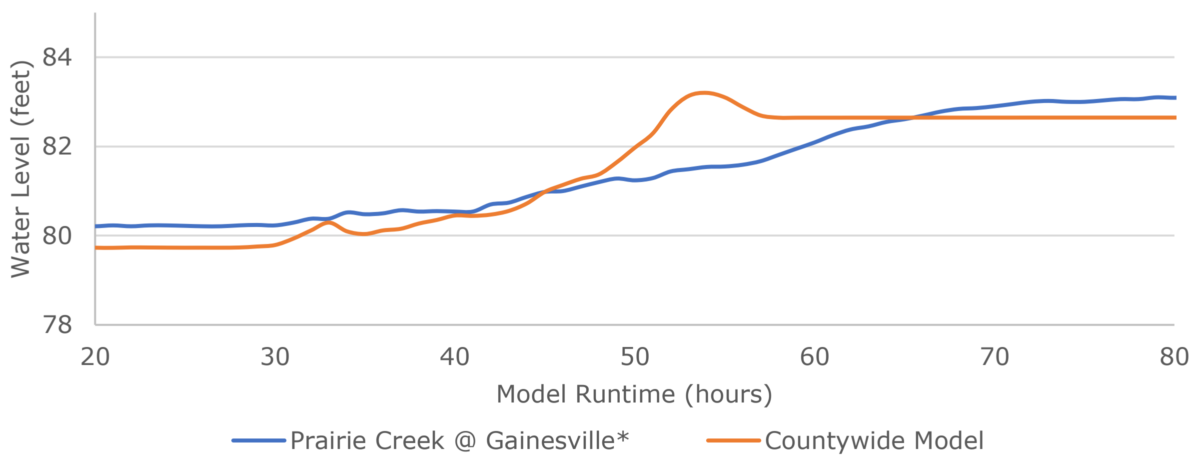
84
80
76
72
68
Water Level (feet)
10
20
30
40
50
60
70
80
Model Runtime (hours)
Sweetwater Branch @ Gainesville
Countywide Model



63
61
59
57
55
53
Water Level (feet)
20
30
40
50
60
70
80
Model Runtime (hours)
Hogtown Creek @ Arredondo
Countywide Model



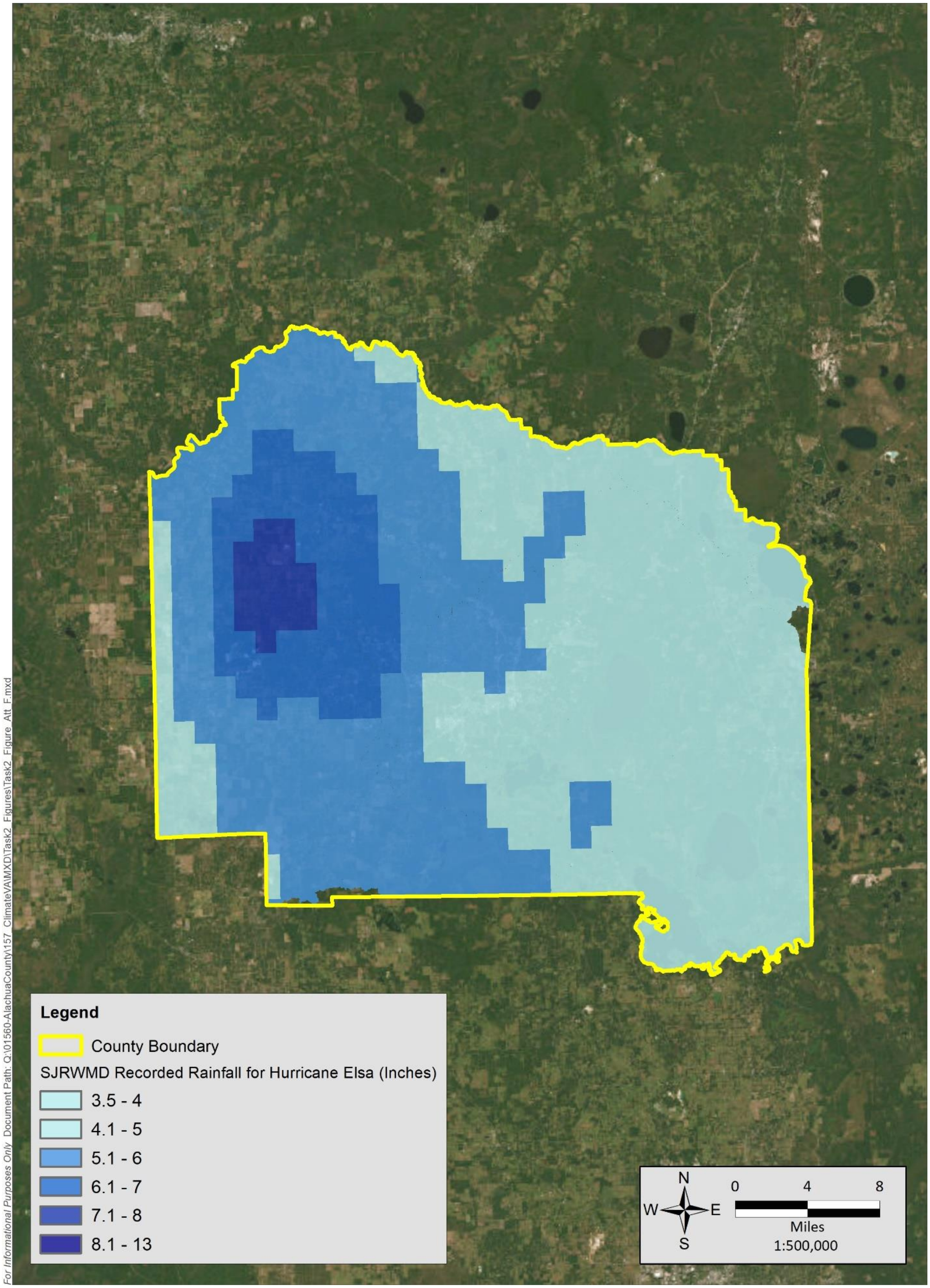
*Note: Based on nearby model node, not exact gauge location.



*Note: Based on nearby node, not exact gauge location.

Attachment F

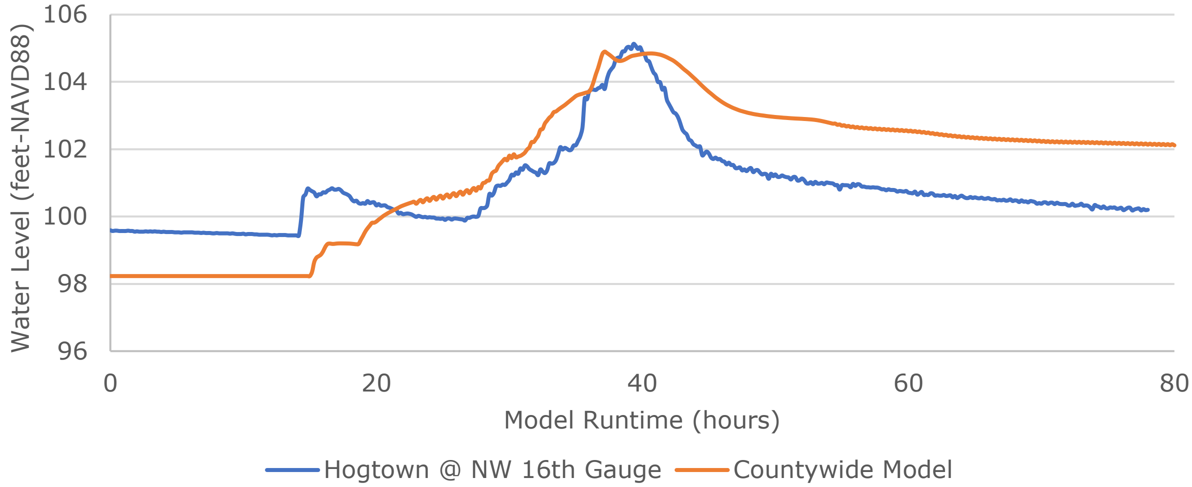
SJRWMD Recorded Rainfall Distribution for Hurricane Elsa (July 2021)

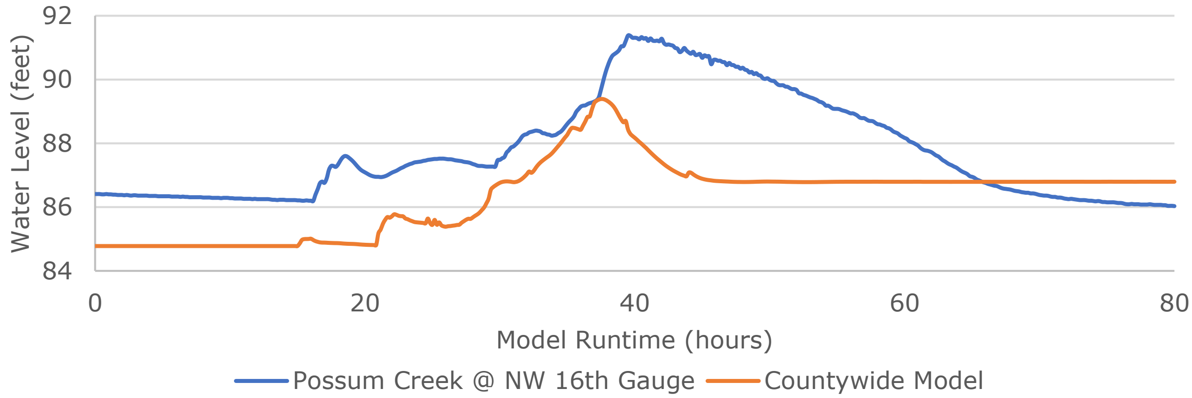

Legend
County Boundary
SJRWMD Recorded Rainfall for Hurricane Elsa (Inches)
3.5 - 4
4.1 - 5
5.1 - 6
6.1 - 7
7.1 - 8
8.1 - 13
N
W
E
S
0
4
8
Miles
1:500,000
For Informational Purposes Only Document Path: Q:\01560-AlachuaCounty\157_ClimateVA\MXD\Task2_Figures\Task2_Figure_Att_F.mxd

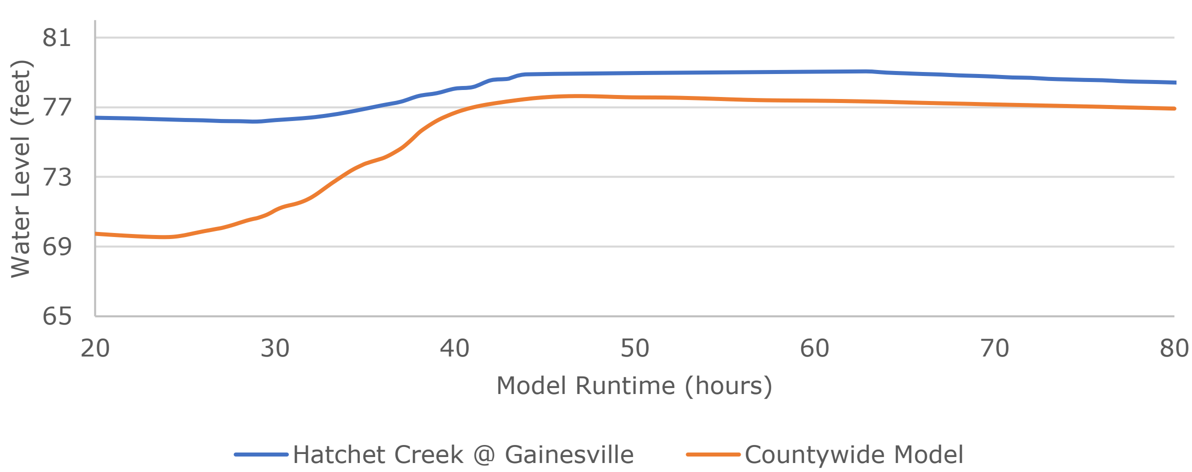
Attachment G

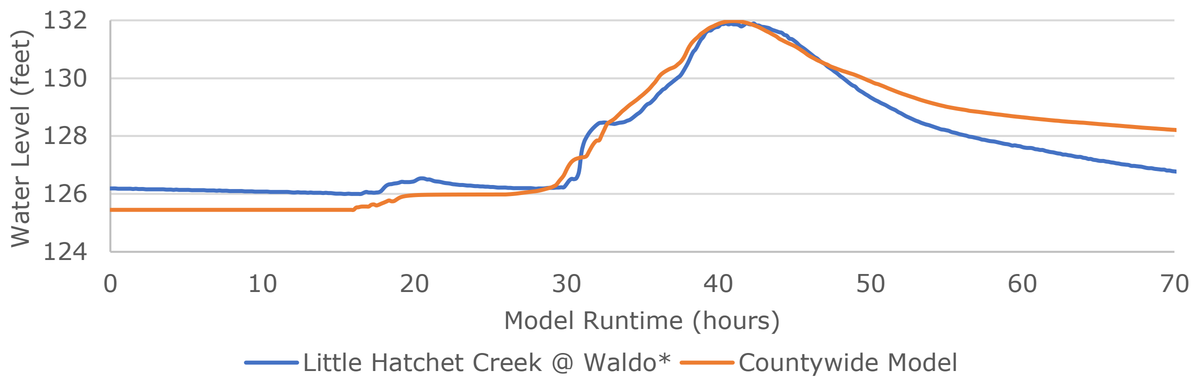
Hurricane Elsa Model Hydrograph Comparisons

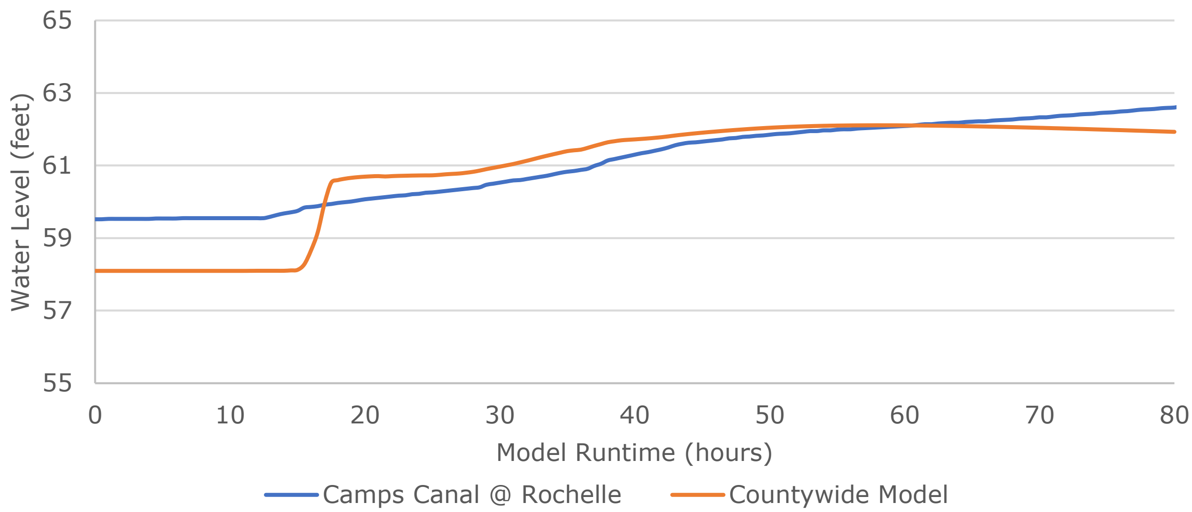
Hurricane Elsa Hydrograph Comparisons

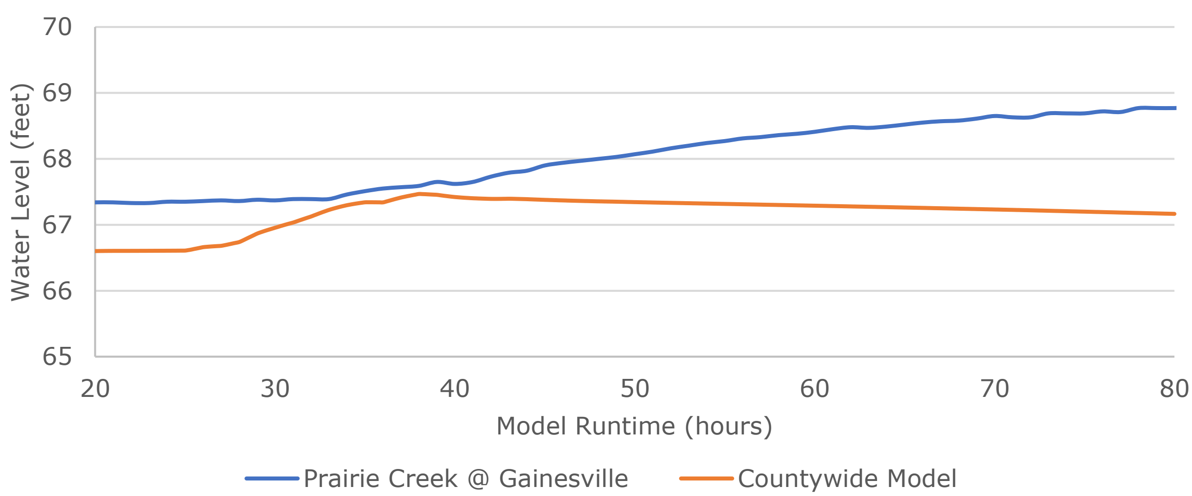


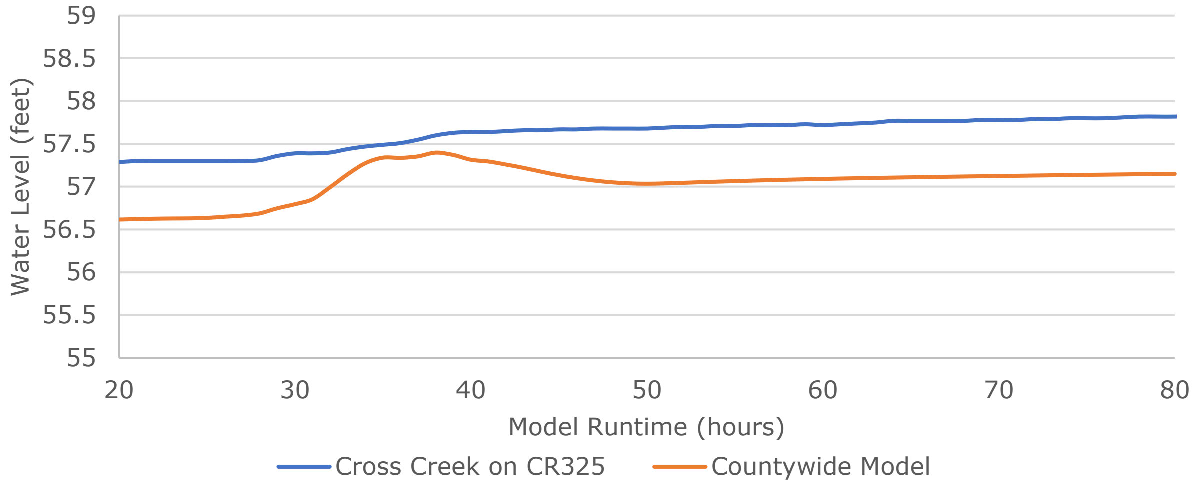





132
130
128
126
124
Water Level (feet)
0
10
20
30
40
50
60
70
Model Runtime (hours)
Little Hatchet Creek @ Waldo*
Countywide Model


65
63
61
59
57
55
Water Level (feet)
0
10
20
30
40
50
60
70
80
Model Runtime (hours)
Camps Canal @ Rochelle
Countywide Model

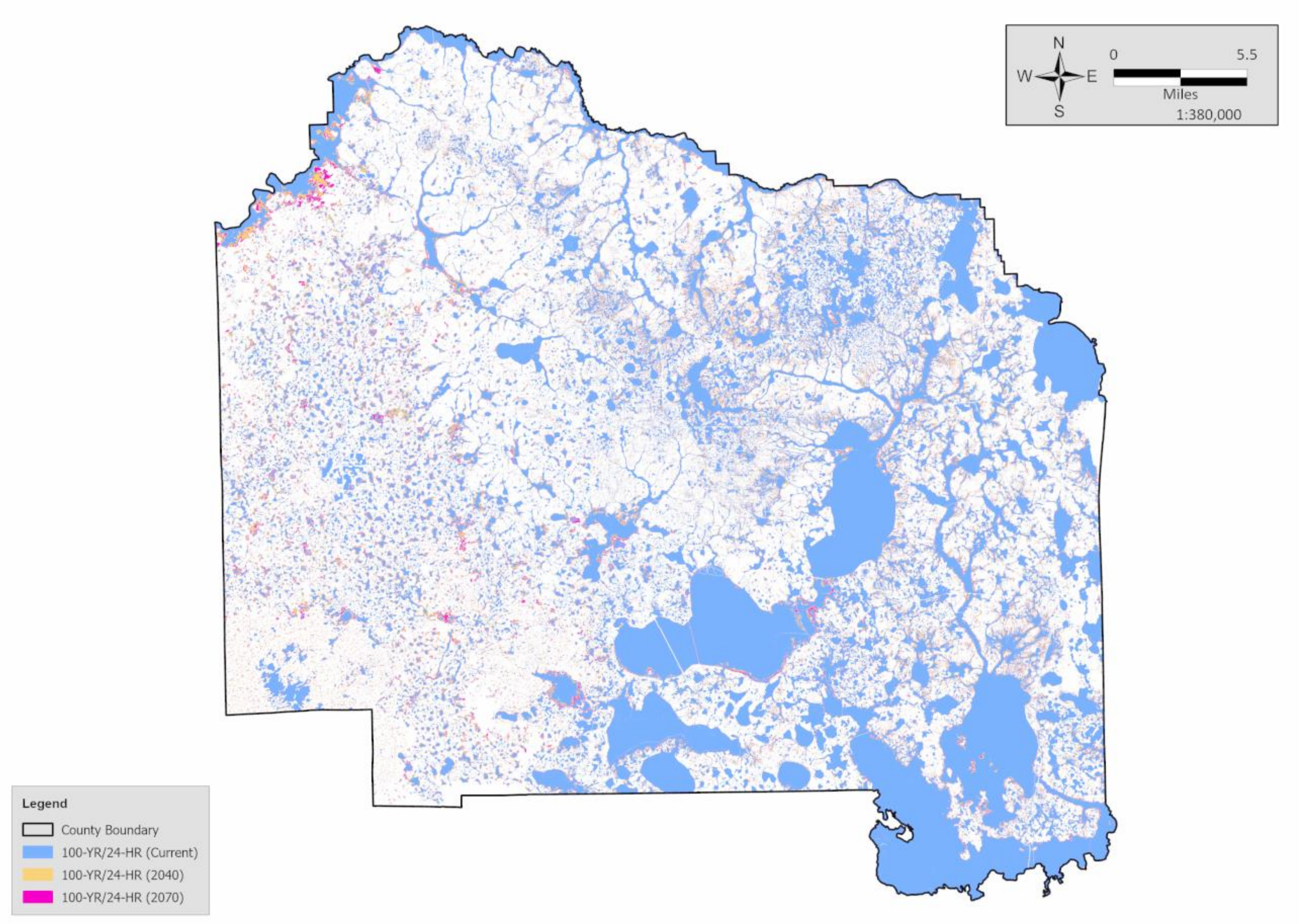

70
69
68
67
66
65
Water Level (feet)
20
30
40
50
60
70
80
Model Runtime (hours)
Prairie Creek @ Gainesville
Countywide Model

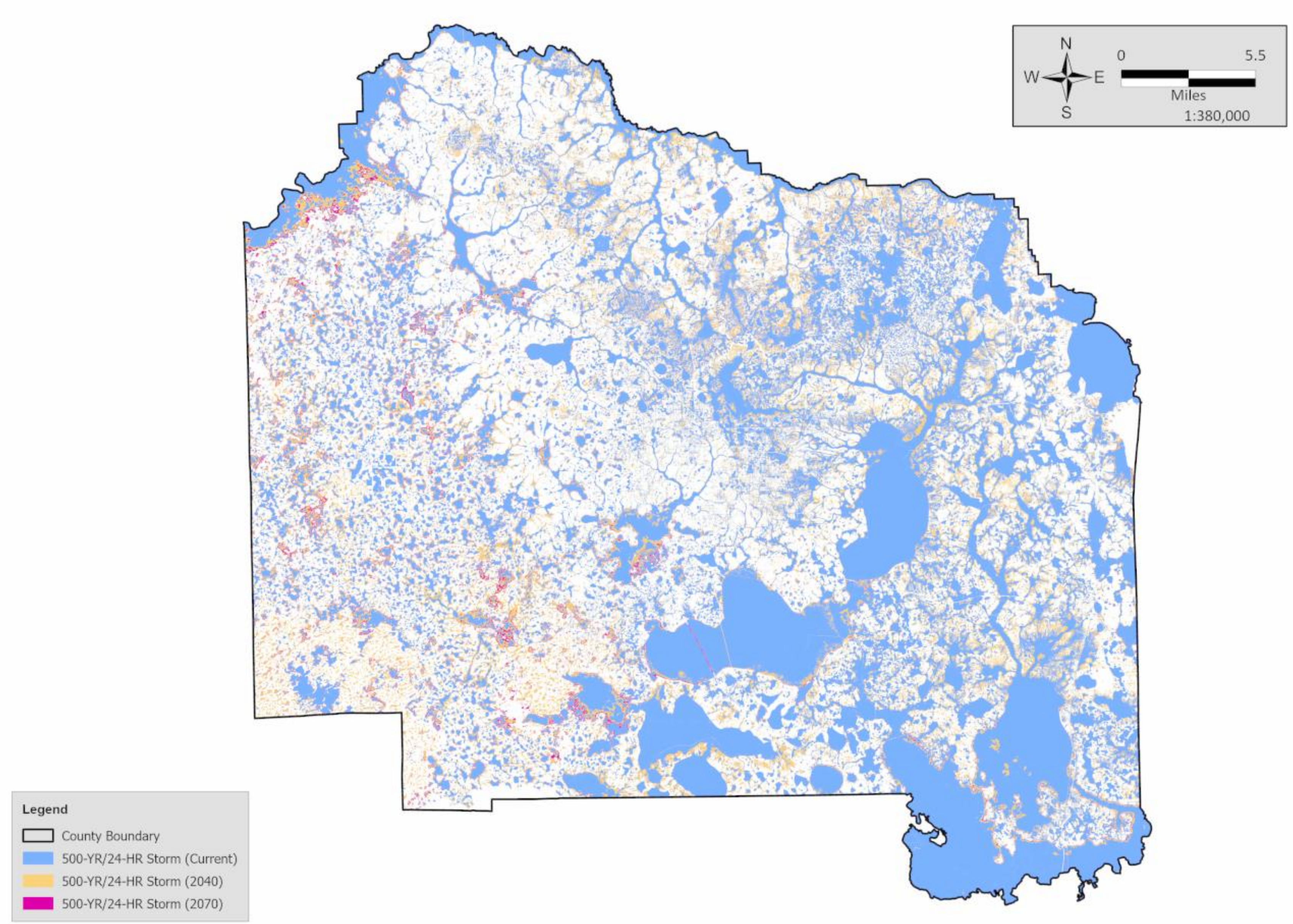


*Original gauge heights were not relative to a datum. Jones Edmunds adjusted these heights based on observation of normal stream depth.

Attachment H

100-Year and 500-Year Mapped Inundation Extents


N
W
E
S
0
5.5
Miles
1:380,000
Legend
County Boundary
100-YR/24-HR (Current)
100-YR/24-HR (2040)
100-YR/24-HR (2070)


N
W
E
S
0
5.5
Miles
1:380,000
Legend
County Boundary
500-YR/24-HR Storm (Current)
500-YR/24-HR Storm (2040)
500-YR/24-HR Storm (2070)