Development of a flood risk visualization tool (ACUNE-CC) for Charlotte County, FLORIDA

1.INTRODUCTION

FDEP GRANT TO CHARLOTTE COUNTY

Charlotte County, Florida has been awarded a 6-year (7/1/2025-5/31/2031) grant from Florida Department of Environmental Protection (see DEP Agreement No. L0162) to develop Charlotte County Flood Monitoring and Response Network. Due to historic rainfall and tidal surges during Hurricanes Ian, Helene, and Milton, low-lying areas of Charlotte County experienced extensive flooding and significant damage. The county currently lacks the means to monitor flooding during major storm events. This project seeks to remedy those gaps by initiating a monitoring network for flooding events, developing modeling products to help predict potential flood impacts, and mitigation strategies for communities known to be at risk for frequent flooding events. In addition, data will be used to assist in water quality improvement through the development of load-based monitoring for discharges that enter the impaired waters of Charlotte Harbor and Lemon Bay. The project includes two major tasks and four major activities:

Task 1: Elevation Gauge Network Installation: (a) Installation of approximately 30 telemetry capable water elevation gauges for tracking of water levels in county canals and coastal waters; (b) Analysis of tide and freshwater conveyance trends and current stormwater management systems response to storm events.

Task 2: Flood and Surge Models and Visualization Tool Development: (a) Development of a compound flood model for the western portion of Charlotte County. (b) Development of a flood-risk visualization tool and a flood-impact visualization tool for the public to track water elevation rates and potential flood risk from active or prospective storms. Models developed under this program will be used to assist in the development and revision of stormwater master planning, watershed management plans, and pollutant loading estimation tools (such as SIMPLE).

Charlotte County, Florida is seeking expert assistance with the ACES (Advanced Coastal Environment Simulations) Laboratory of the University of Florida (UF), a leading coastal and compound flood risk and impact modeling team, to carry out the work described Task 2 of the FDEP grant. The ACES Laboratory, led by Dr. Peter Sheng, who is an internationally renowned coastal engineer and flood modeler, will conduct the required task. Dr. Sheng's team, consisting of coastal modeling experts, Dr. Vladimir Paramygin, and inland flood modeling expert, Dr. Aditia Rojali, along with graduate students, have completed several multiple research studies on flood forecasting and mapping with funding from several National Oceanic and Atmospheric Administration (NOAA) laboratories, EPA (Environmental Protection Agency), Florida DEP, Southeastern Universities Research Association (SURA), South Florida Water Management District (SFWMD), Southwest Florida Water Management District (SWFWMD), City of Naples, and KOPEC (Korea Power and Electricity Company) in various coasts of the world and the U.S., including New Jersey, New York, North Carolina, Texas, Southeast Florida, Northeast Florida, Pinella County, the Big Bend, Collier County, Charlotte and Lee Counties, and United Arab Emirates.

THE UF TEAM

The UF Team will be led by Dr. Peter Sheng (PI), Dr. Vladimir Paramygin (Co-PI), and other members of the Advanced Coastal Environment Simulations (ACES) Laboratory, including Dr. Aditia Rojali and Ph.D. students, in the Civil and Coastal Engineering Department of the Engineering Scholl of Sustainable Infrastructure and Environment (ESSIE) of University of Florida, with the assistance of Dr. Eban Bean in the Agricultural and Biological Engineering Department and Dr. John Sansalone in the Environmental Engineering Department of ESSIE.

Led by Drs. Sheng and Paramygin, the Advanced Coastal Environment Simulations (ACES) Laboratory has developed a comprehensive coastal flood modeling system ACMS (Advanced Coastal Modeling System) which consists of a robust three-dimensional vegetation-resolving coupled CH3D-SWAN hydrodynamic-wave models with coupling to ADCIRC and other two-dimensional hydraulic and hydrologic models. The modeling system has been applied worldwide and has been used to simulate all major hurricanes along the Gulf and Atlantic coasts. With funding from NOAA Restore Science Program and Effects of Sea-Level Rise Program, Dr. Sheng's team developed a visualization tool ACUNE (Adaptation of Coastal Urban and Natural Ecosystems) for use by Naples, Everglades City, RBNERR, Ten Thousand Island National Wildlife Refuge, and Collier County. See https://aces.coastal.ufl.edu/ACUNE_public.In 2022, ACUNE-SWFL was developed using the two-dimensional version of CH3D-SWAN for Charlotte County with limited funds from FDEP. The maps have been used by WSP as part of the state-mandated Charlotte County vulnerability assessment. These earlier maps will be significantly updated by the work to be conducted within this project. The ACES Lab has also developed preliminary compound flood maps for the Charlotte Harbor region, based on the methodology used to produce vulnerability analyses for the Big Bend region (which has since been accepted by the Resilient Florida Program). Previously, Dr. Sheng's team modeled the water quality in the Charlotte Harbor and Caloosahatchee estuarine systems while forecasting the circulation of the upper Charlotte Harbor, with funding from SWFWMD and SFWMD.

In addition, Dr. Eban Bean and his students have been studying the impact of development on the downstream water and mangrove system in the Meadows and Villas area of Charlotte County, using the ICPR model while incorporating stormwater infrastructure. This work is part of the FWC-managed juvenile sportfish habitat assessment program, funded by NOAA with the support of Charlotte County. Dr. Sansalone is an expert on stormwater system modeling with the EPA-SWMM model. Their participation will greatly enhance the capabilities of the UF Team.

The UF Team will perform necessary work listed below to complete the required Task 2 of the FDEP Grant listed on Page 1 of this document, for a not to exceed cost of $2,000,000.

2. UF TASKS TO COMPLETE FDEP GRANT TASK 2

Task 1. Develop a flood risk visualization for historical events.

a. Review available data and identify data gaps
    - Gather and review DEM, bathymetry, infrastructure, buildings, NFIP data –
        i. Via consultation with county staff, determine availability of stormwater infrastructure: location, slope and other parameters, condition, especially impaction. Priority will be given to high-risk areas defined by county
        ii. Evaluate elevation data resolution and age to determine updated DEM/LiDAR needs
        iii. Delineate preliminary basins and major conveyance systems based on available data.
    - Gather and review major historical flooding events
    - Gather and review time series of rainfall, hurricane, surge, wave, river flow, watershed flow
    - Review 1998 Master Stormwater Plan
    - With assistance from the county, acquire data for existing stormwater modeling efforts to evaluate the suitability for inclusion into this updated modeling effort.
    - Establish empirical data needed for calibration/verification of models.
b. Review coastal, hydraulic, and hydrologic models
    - Review coastal model – CH3D-SWAN

    - Review hydraulic and hydrologic models – ICPR, HEC-RAS, PRIMo, SWMM.

c. Test selected models within 1-2 basins modeled under previous projects, as agreed upon by vendor and county.
    - Test coastal model with varying model parameters
    - Test hydraulic and hydrologic models with varying model parameters
    - Test coupling of coastal and hydraulic/hydrologic models
    - Add stormwater infrastructure into selected models

d. Simulate selected historical events with selected models
    - Simulate major historical hurricane events
    - Simulate major historical rainfall events

e. Information gaps impact analysis and model approach review-prior to proceeding with Task 2:
    - Based on information acquired through Task 1a, consult with county on current data gaps.
    - Based on outcome of Tasks 1b-c, outline modeling approach for subsequent tasks, (e.g. describing methods for determining infiltration, stage-storage relationships, confirmation of conveyance features to be incorporated).
    - Coordinate with the Peer Review team to review the approach, including (but not limited to):
        - Proposed water level gauge locations;
        - Available data gathered by ACES UF (reviewed for reference when reviewing other deliverables);
        - Delineated preliminary basins and major conveyance systems;
        - The selected hydraulic and hydrologic (H&H) test models with varying model parameters (GIS and software files to be provided by ACES UF);
        - Results of the coupled coastal and H&H test models;
        - Results of adding the stormwater infrastructure into the selected models.
        - Proposed outline of the model approach
    - Assist the county in ensuring scientific robustness and compatibility of storm scenario methodology with future county-developed products which require external agency review, i.e. watershed management plans.

Task 2. Develop 2-dimensional probabilistic compound flood maps for Charlotte County.

a. Produce updated coastal tide and storms surge inundation maps (ACUNE) to meet immediate regulatory reporting requirements:
    i. Existing conditions as well as planning horizons of 2030, 2050, and 2080 SLR predictions at intermediate and intermediate-low;
    ii. Updated 3m resolution DEMs as approved by county
    iii. Minimum 1% flood event.
b. Produce pluvial/fluvial flood maps focusing on the inland part of the study area - Model domains: Portion of County MS4 service area as depicted in Figure 1. Optional regions as depicted in Figure 2 will be considered based on available resources. Consider Wet and Dry season conditions, incorporating variability in subsurface storage availability that occurs throughout the year. Produce Annual chance probability (ACP) 10%, 4%, 1%, and 0.2% flood (modeled storm scenarios should be compared to current required level of service as well as max event the system can mitigate, to identify areas that might underperform in the selected scenarios). Model two conditions, one assuming stormwater conveyance system operates at 50% capacity, the other assuming conveyance system operates at 100% capacity.
c. Produce compound flood maps based on low-resolution (30-50m for coastal and 10-30m for inland) modeling for the County domain using HEC-RAS/ICPR/SWMM with limited stormwater system. Consider Wet and Dry season conditions, incorporating variability in subsurface storage availability that occurs throughout the year. The low-resolution model domain would only include some major features of the stormwater system, because low-resolution would likely not allow us to properly add/resolve small scale stormwater features. Focus would be on target features that are expected to have significant impact (large channels, etc.). Small scale features will have very limited/localized impact on results.
d. Produce compound flood maps based on high-resolution (10-30m for coastal and 1-10m for inland) modeling for 3-4 selected neighborhoods (names of these neighborhoods?) shown in Figure 3 with full stormwater system, incorporating remaining stormwater features that are deemed to be too small for the low-resolution model for areas of primary concern to the County. Consider Wet and Dry season conditions, incorporating variability in subsurface storage availability that occurs throughout the year. To accomplish this, County will assess the need for additional surveying (with additional funding from other sources) for:
    i. Drainage pipe/culvert location, elevation and slope
    ii. Conveyance capacity/ level of impaction

    iii. Resolution of system to exclude drainage features limited to individual property parcels (e.g. driveway culverts)
e. Compare 3 evolutions of the models:
    i. Low-resolution with limited (major) stormwater infrastructures including bridges, ponds, canals and wall structures, if available.
    ii. High-resolution with limited stormwater infrastructures.
    iii. High-resolution with “full” stormwater system.
f. Finalize the high-resolution model with “full” stormwater system for 4 selected neighborhoods (Figure 3).
g. Produce integrated flood maps with limited stormwater system.
h. Produce high-resolution integrated flood maps with full stormwater system for selected neighborhoods.
i. Assess the effect of elevation changes in selected neighborhoods on the flood maps.

Task 3. Set up a flood risk visualization tool ACUNE-CC (Charlotte County).

a. Set up a preliminary visualization tool with probabilistic coastal flood maps
b. Add probabilistic coastal flood maps with stormwater infrastructures
c. Add probabilistic compound flood maps without and with stormwater infrastructures
d. Produce high-resolution compound flood maps for 2030, 2050, 2080 with stormwater systems.
e. Combine coastal and compound flood maps to produce high-resolution integrated flood maps for 2030, 2050, 2080 with stormwater systems.
f. Assess the effect of land use changes in selected areas on the coastal, compound, integrated maps.

Task 4. Communicate and provide training on the use of ACUNE-CC.

a. Conduct semi-annual TEAMS meeting to review progress on the project
b. Write annual progress reports
c. Complete Version One of ACUNE-CC
d. Gather feedback and enhance ACUNE-CC
e. Finalize ACUNE-CC and provide training to County staff
f. Produce a final summary report and all deliverables listed below

Task Peer Review

Upon completion of each task, a peer review process will be conducted in consultation with UF ACES to assist the county in evaluating progress to date and confirm outputs are compatible with state/federal planning instruments (watershed management/master plans, SIMPLE pollutant loading model).

Deliverables:

- Low-resolution modeling and limited stormwater infrastructure integrated flood maps for years 2030, 2050, 2080 and 10%, 4%, 1%, and 0.2% annual chance probability as georeferenced rasters (1m horizontal resolution) to be used within the county GIS systems.
- High-resolution modeling and full stormwater infrastructure integrated flood maps for years 2030, 2050, 2080 and 10%, 4%, 1%, and 0.2% annual chance probability as georeferenced rasters (1m horizontal resolution) to be used within the county GIS systems.
- Flood risk visualization tool ACUNE-CC. Provide hosted visualization for the duration of the project at no additional cost and, at the end of the contract, continue hosting the visualization system via an additional maintenance contract or assist the county in setting up the system in-house or moving the service to an external provider such as ArcGIS online (cost would be determined depending on the level of effort required).
- Final summary report on completed products and ongoing data gaps, information needs, and summary of uncertainties/assumptions in current products
- Input files used for final pluvial/fluvial models used in the study

3. KEY PERSONNEL

The project will be led by Dr. Peter Sheng, Principal Investigator, and Dr. Paramygin, Co-Principal Investigator, with the assistance of Dr. Aditia Rojali, as well as Dr. Eban Bean and Dr. John Sansalone, plus graduate students.

4. BUDGET AND SCHEDULE

The total budget for the study is a not-to-exceed of $2,000,000 from the date of execution of this PO through 4/31/2031. The schedule of the project is listed below. During the project period, the University of Florida will submit an invoice every three months with a brief description on % completion on various tasks.

Tasks	Year 1	Year 2	Year 3	Year 4	Year 5
1.a	X	X			
1.b	X	X			
1.c	X	X			
1.d	X	X			
2.a	X				
2.b	X	X			
2.c	X	X	X		
2.d	X	X	X		
2.e	X	X	X	X	X

2.f				X	X
2.g				X	X
2.h				X	X
2.i				X	X
3.a	X	X	X		
3.b	X	X	X		
3.c	X	X	X	X	
3.d	X	X	X	X	
3.e			X	X	
3.f			X	X	
4.a	X	X	X	X	X
4.b	X	X	X	X	
4.c				X	X
4.d				X	X
4.e					X
4.f					X

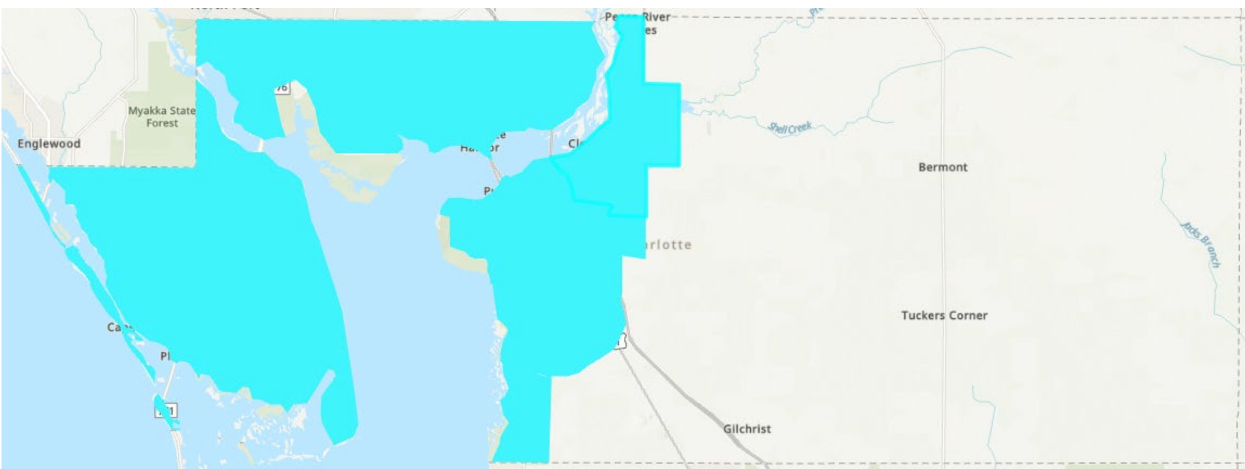

Figure 1. Model domains for Task 2A, component 1

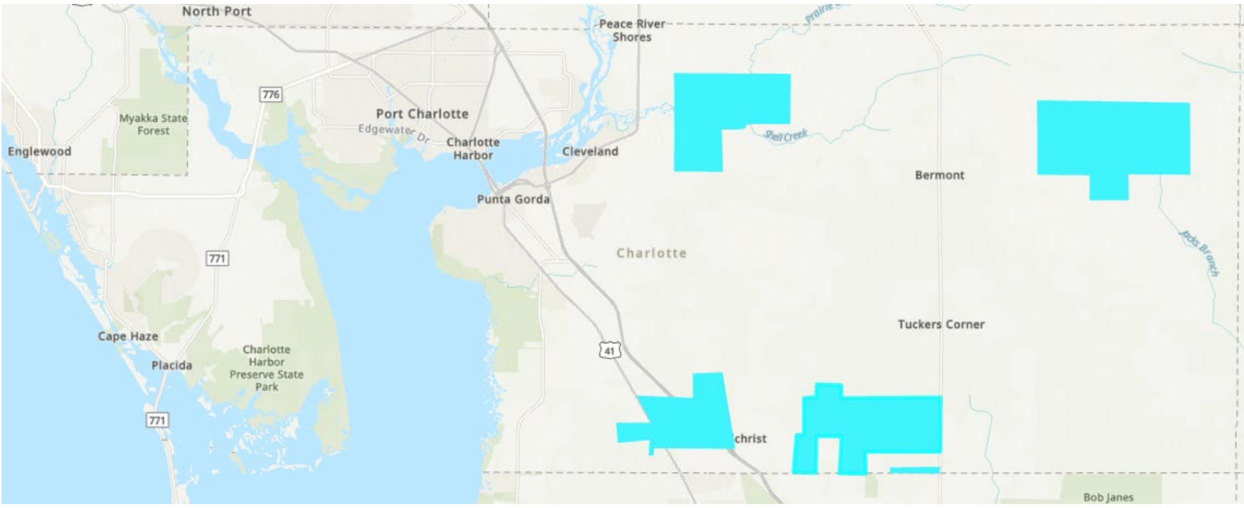

Figure 2. Model domains for Task 2A, component 2

Figure 3. Priority drainage areas for Task 2C