

**INTERLOCAL AGREEMENT BETWEEN BROWARD COUNTY, FLORIDA AND THE CITY OF OAKLAND, FLORIDA, FOR SHARING THE COST OF THE 100-YEAR FLOOD ELEVATION MAP AND ASSOCIATED MODELING**

This is an Interlocal Agreement ("Interlocal Agreement" or "Agreement"), made and entered into by and between Broward County, a political subdivision of the State of Florida ("County"), and the City of Oakland, a municipal corporation ("City") (collectively referred to as the "Parties").

**RECITALS**

- A. In 2016, County adopted the updated Unified Sea Level Rise Projection for Southeast Florida Regional Climate Compact and directed staff to apply this projection as the basis for regional sea level rise adaptation planning.
- B. In 2017, County also directed its Environmental Protection and Growth Management Department ("EPGMD") to create and maintain a future conditions map series to include average wet season groundwater elevations and 100-year flood elevations to account for predicted changes in water levels and ensure the resiliency of current and future infrastructure investments.
- C. In 2018, County entered into an agreement with Geosyntec Consultants Inc. ("Consultant"), an Engineering Consulting Company, to develop a County-wide 100-Year Flood Elevation Map and Associate Modeling, at a total cost not to exceed \$717,894 (the "100-Year Flood Agreement") in response to Request for Proposals # R2114367P1. The scope of the 100-Year Flood Agreement is attached as Exhibit A.
- D. County has identified ten (10) local government partners willing to collectively cost share fifty percent (50%) of the 100-Year Flood Agreement costs, as provided in the Cost Sharing Schedule attached as Exhibit B. NOW, THEREFORE,

IN CONSIDERATION of the mutual terms, conditions, promises, covenants, and payments hereinafter set forth, the Parties agree as follows:

**ARTICLE 1. DEFINITIONS**

- 1.1 **Board.** The Board of County Commissioners of Broward County, Florida.
- 1.2 **Contract Administrator.** Director of County's Environmental Planning and Community Resilience Division.

- 1.3 **County Administrator**. The administrative head of County appointed by the Board.

## **ARTICLE 2. SCOPE OF SERVICES**

- 2.1 County shall share with City materials, information, and data received from Consultant pursuant to the work more fully described in Exhibit A within a reasonable time following County's receipt of that information from Consultant.
- 2.2 It is understood and agreed that County may enter into separate agreements with Consultant; however, City shall not be responsible for any additional costs or expenses associated with said separate agreement with Consultant unless City otherwise agrees in writing to such responsibility. Furthermore, the 100-Year Flood Agreement is understood to be solely between the County and the Consultant, and City shall have no right or responsibility to administer the 100-Year Flood Agreement.

## **Article 3. COST SHARING**

- 3.1 Upon completion of the project described in Exhibit A, City agrees to pay County, in the manner specified in Section 3.2, Method of Billing and Payment, its "Cost Share" of the 100-Year Flood cost as set forth in the schedule attached as Exhibit B. The failure of any city or government entity to provide County payment or to enter into a separate interlocal agreement shall not increase City's obligation or relieve City of its own obligation to pay County. County may enter into additional cost sharing agreements with other cities or government entities not listed in Exhibit B. The entering into any such additional agreements shall not alter City's cost share.

### **3.2 METHOD OF BILLING AND PAYMENT**

- 3.2.1 County may submit an invoice for services completed under this Agreement in the amount set forth as City's "Cost Share" in Exhibit B. Invoice must be in the form of one original invoice plus one copy. Invoice shall designate the nature of the services performed and/or the expenses incurred.
- 3.2.3 City shall pay County within thirty (30) calendar days after receipt of County's invoice.

- 3.3 Payment of the County invoice shall be made as follows:

Jennifer Jurado  
Director and Chief Resilience Officer  
Environmental Planning and Community Resilience Division  
Government Center, Room 329H  
115 South Andrews Avenue  
Fort Lauderdale, FL

#### **ARTICLE 4. TERM AND TIME OF PERFORMANCE OF AGREEMENT**

- 4.1 This Interlocal Agreement shall become effective upon execution by County (following prior execution by City) and shall continue in full force and effect until midnight, twenty-four (24) months following final execution of the Agreement. In addition, County Administrator is authorized to execute any amendments extending the term of this Interlocal Agreement with the appropriate amendment prepared with the same or similar formality, provided that any such amendment does not decrease the compensation due to County.
- 4.2 All duties, obligations, and responsibilities of County and City required by this Interlocal Agreement shall remain in full force and effect through the termination date or any extended termination date, as set forth above, unless written notice of termination by County or City is provided pursuant to Section 7.7, Notices. Time shall be deemed to be of the essence in performing the duties, obligations, and responsibilities required by this Interlocal Agreement.

#### **ARTICLE 5. GOVERNMENTAL IMMUNITY**

- 5.1 Nothing herein is intended to serve as a waiver of sovereign immunity by any party nor shall anything included herein be construed as consent to be sued by third parties in any matter arising out of this Interlocal Agreement or any other contract. City and County are state agencies or political subdivisions as defined in Chapter 768.28, Florida Statutes, and agree to be fully responsible for the acts and omissions of their agents or employees to the extent permitted by law.

#### **ARTICLE 6. TERMINATION**

- 6.1 This Interlocal Agreement may be terminated for cause by the aggrieved party if the party in breach has not corrected the breach within ten (10) days after written notice from the aggrieved party identifying the breach, or for convenience by either Party upon not less than thirty (30) days' written notice. An erroneous termination for cause shall be considered a termination for convenience.
- 6.3 Notice of termination shall be provided in accordance with the "Notices" section of this Interlocal Agreement except that notice of termination by Contract Administrator which Contract Administrator deems necessary to protect the public health, safety, or welfare may be verbal notice which shall be promptly confirmed in writing in accordance with the "Notices" section of this Interlocal Agreement.

## ARTICLE 7. MISCELLANEOUS

- 7.1 Public Records. The Parties shall comply with all public records requirements of Chapter 119, Florida Statutes, as may be required by law.

**IF EITHER PARTY HAS QUESTIONS REGARDING THE APPLICATION OF CHAPTER 119, FLORIDA STATUTES, TO A PARTY'S DUTY TO PROVIDE PUBLIC RECORDS RELATING TO THIS CONTRACT, CONTACT THE BROWARD COUNTY CUSTODIAN OF PUBLIC RECORDS, NORMA ELLISON, AT (954) 519-1466, [nellison@broward.org](mailto:nellison@broward.org), 115 S. ANDREWS AVE., SUITE 329H, FORT LAUDERDALE, FLORIDA 33301, OR RENEE SHROUT, AT (954) 630-4298, [ReneeS@oaklandparkfl.gov](mailto:ReneeS@oaklandparkfl.gov), 3650 NE 12<sup>th</sup> AVE., OAKLAND PARK, FL 33334.**

- 7.2 Assignment and Performance. Neither this Agreement nor any interest herein shall be assigned, transferred, or encumbered without the written consent of the other party and any attempt to transfer or assign any interest in this Agreement without the written consent of the other party shall be void.
- 7.3 All Prior Agreements Superseded. This document incorporates and includes all prior negotiations, correspondence, conversations, agreements, or understandings applicable to the matters contained herein; and the Parties agree that there are no commitments, agreements or understandings concerning the subject matter of this Agreement that are not contained in this document. Accordingly, the Parties agree that no deviation from the terms hereof shall be predicated upon any prior representations or agreements whether oral or written.
- 7.4 Disclaimer of Warranties. COUNTY MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED, OF ANY KIND CONCERNING CONSULTANT'S WORK OR INFORMATION PROVIDED TO CITY.
- 7.5 Amendments. Except as provided in Section 4.1, no modification, amendment, or alteration in the terms or conditions contained herein shall be effective unless contained in a written document executed with the same formality and of equal dignity herewith.
- 7.6 Notices. In order for a notice to a party to be effective under this Agreement, notice must be sent via U.S. first-class mail with a contemporaneous copy via e-mail to the addresses listed below and shall be effective upon mailing. The addresses for notice shall remain as set forth herein unless and until changed by providing notice of such change in accordance with the provisions of this section.

FOR COUNTY:

Broward County Environmental Planning and Community Resilience Division  
Attn: Dr. Jennifer Jurado, Director and Chief Resilience Officer  
Governmental Center, Room 329H  
115 South Andrews Avenue  
Fort Lauderdale, Florida 33301  
Email address: [jjurado@broward.org](mailto:jjurado@broward.org)

FOR CITY:

Albert J. Carbon, III  
Public Works Director  
3801 NE 5<sup>th</sup> Avenue  
Oakland Park, FL 33334  
[albertc@oaklandparkfl.gov](mailto:albertc@oaklandparkfl.gov)

- 7.8 Interpretation. The language of this Agreement has been agreed to by both Parties to express their mutual intent and no rule of strict construction shall be applied against either party hereto. The headings contained in this Agreement are for reference purposes only and shall not affect in any way the meaning or interpretation of this Agreement. All personal pronouns used in this Agreement shall include the other gender, and the singular shall include the plural, and vice versa, unless the context otherwise requires. Terms such as "herein," "hereof," "hereunder," and "hereinafter" refer to this Agreement as a whole and not to any particular sentence, paragraph, or section where they appear, unless the context otherwise requires. Whenever reference is made to a section or article of this Agreement, such reference is to the section or article as a whole, including all of the subsections of such section, unless the reference is made to a particular subsection or subparagraph of such section or article.
- 7.9 Independent Contractor. Each Party is an independent contractor and not an agent, employee, partner, or joint venturer of the other Party. Neither Party has authority to undertake or accept any obligation, liability or expense on behalf of the other Party, nor act in any other manner on behalf of the other Party, nor in the name of the other Party.
- 7.10 Third Party Beneficiaries. The Parties do not intend to directly or substantially benefit a third party by this Agreement. Therefore, the Parties acknowledge that there are no third party beneficiaries to this Agreement and that no third party shall be entitled to assert a right or claim against either of them based upon this Agreement.
- 7.11 Materiality and Waiver of Breach. The Parties agree that each requirement, duty, and obligation set forth herein was bargained for at arms-length and is agreed to by the Parties in exchange for quid pro quo, that each is substantial and important to the formation of this Agreement, and that each is, therefore, a material term hereof. Either Party's failure to enforce any provision of this Agreement shall not be deemed a waiver of such provision or modification of this Agreement. A waiver of any breach of a provision

of this Agreement shall not be deemed a waiver of any subsequent breach and shall not be construed to be a modification of the terms of this Agreement.

- 7.12 Compliance with Laws. The parties shall comply with all federal, state, and local laws, codes, ordinances, rules, and regulations in performing their duties, responsibilities, and obligations related to this Agreement.
- 7.13 Severability. In the event any part of this Agreement is found to be unenforceable by any court of competent jurisdiction, that part shall be deemed severed from this Agreement and the balance of this Agreement shall remain in full force and effect.
- 7.14 Joint Preparation. This Agreement has been jointly prepared by the Parties hereto, and shall not be construed more strictly against either Party.
- 7.15 Priority of Provisions. If there is a conflict or inconsistency between any term, statement, requirement, or provision of any exhibit attached hereto, any document or events referred to herein, or any document incorporated into this Agreement by reference and a term, statement, requirement, or provision of this Agreement, the term, statement, requirement, or provision contained in Articles 1 through 7 of this Agreement shall prevail and be given effect.
- 7.16 Law, Jurisdiction, Venue, Waiver of Jury Trial. This Agreement shall be interpreted and construed in accordance with and governed by the laws of the state of Florida. All Parties acknowledge and accept that jurisdiction of any controversies or legal problems arising out of this Agreement, and any action involving the enforcement or interpretation of any rights hereunder, shall be exclusively in the state courts of the Seventeenth Judicial Circuit in Broward County, Florida, and venue for litigation arising out of this Agreement shall be exclusively in such state courts, forsaking any other jurisdiction which either party may claim by virtue of its residency or other jurisdictional device. **BY ENTERING INTO THIS AGREEMENT, THE PARTIES HEREBY EXPRESSLY WAIVE ANY RIGHTS EITHER PARTY MAY HAVE TO A TRIAL BY JURY OF ANY CIVIL LITIGATION RELATED TO THIS AGREEMENT.**
- 7.17 Incorporation by Reference. Any and all Recital clauses stated above are true and correct and are incorporated herein by reference. The attached Exhibits are incorporated into and made a part of this Agreement.
- 7.18 Representation of Authority. Each individual executing this Agreement on behalf of a party hereto hereby represents and warrants that he or she is, on the date he or she signs this Agreement, duly authorized by all necessary and appropriate action to execute this Agreement on behalf of such party and does so with full and legal authority.

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IN WITNESS WHEREOF, the Parties hereto have made and executed this Agreement: BROWARD COUNTY, through its BOARD OF COUNTY COMMISSIONERS, signing by and through its Mayor or Vice-Mayor, authorized to execute same by Board action on the \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_, and the City of Oakland, signing by and through its Mayor, duly authorized to execute same.

COUNTY

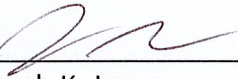
ATTEST:

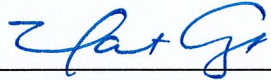
BROWARD COUNTY, by and through  
its Board of County Commissioners

\_\_\_\_\_  
Broward County Administrator, as  
Ex-officio Clerk of the Broward County  
Board of County Commissioners

By \_\_\_\_\_  
Mayor  
\_\_\_\_ day of \_\_\_\_\_, 20\_\_

Approved as to form by  
Andrew J. Meyers  
Broward County Attorney  
Governmental Center, Suite 423  
115 South Andrews Avenue  
Fort Lauderdale, Florida 33301  
Telephone: (954) 357-7600  
Telecopier: (954) 357-7641

By  10/09/2018  
Joseph K. Jarone (Date)  
Assistant County Attorney

By  10/9/18  
Maite Azcoitia (Date)  
Deputy County Attorney

INTERLOCAL AGREEMENT BETWEEN BROWARD COUNTY AND THE CITY OF OAKLAND, FLORIDA,  
FOR COST SHARE FOR 100-YEAR FLOOD ELEVATION MAP AND ASSOCIATED MODELING (RFP  
#R2114367P1)

FOR OAKLAND PARK:

City

City of Oakland Park

By: Albert J. Carbon  
Albert J. Carbon, III, Public Works Director

6<sup>th</sup> day of July, 2018



## **EXHIBIT A - SCOPE OF WORK**

### **Broward County 100-year Flood Elevation Map and Associated Modeling**

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#### **Project Request**

The objective of this project is to update the Broward County 100-year Flood Elevation Map with incorporation of future climatic conditions, including sea level rise, through the refinement and application of the latest Broward County-wide Integrated MIKE SHE/MIKE 11 Hydrologic-Hydraulic Model (referred below as "BCModel"), and in accordance with stakeholder inputs.

#### **Background**

In 1977, the Broward County Board of County Commissioners (Board) adopted a 100-year flood elevation map in order to mitigate flood risk in developed areas through regulation of minimum infrastructure design criteria, including base flood elevation. The map was based on estimated runoff across existing development at the time, the anticipated expansion of the urban area to its final bounds, historic extreme rainfall-driven flooding events and historic groundwater and sea levels. Although some Federal Emergency Management Agency (FEMA) flood insurance studies and flood insurance rate maps (FIRMs) had been completed for certain municipalities by 1977, county-wide information on flood depths or appropriate design criteria was not available until the adoption of the County map.

Since 1977, three county-wide FEMA flood insurance studies have been completed for Broward County. Each study released, updated, and typically increased base flood elevation requirements for buildings. County policy has required the most conservative design criteria shown on the FEMA FIRMs, or the County map, or as derived by basin-specific modeling to be applied in the construction design of new development. In areas where the County map was more conservative and was thus applied, property owners often realized subsequent cost savings in avoided flooding or flood insurance premiums as FEMA base flood elevations were adjusted in later years. In its most recent update, in 2014, FEMA revised flood hazard areas in Broward County utilizing the BCModel. The revised flood map revealed significant changes in base flood elevations and delineation of flood area boundaries in certain parts of the County, a combined result of increased development and changes in hydrologic conditions since the previous update, nearly 20-years prior. This study also revealed a substantial convergence in the flood elevations derived from the two map-based approaches, with the County's flood elevation map no longer predictably providing the higher, or more protective, standard. With substantial build-out already having taken place, changes in hydrologic processes resulting from development patterns have already been realized. As such, sea level rise and its influence on the groundwater table, regional storage, and the discharge capacity of stormwater systems not only constitutes the most significant influence

on future flood elevations, but is expected to substantially increase flood elevations in coastal and inland portions of the county in the coming decades. Additionally, downscaled climate models have predicted scenarios of future rainfall and extreme events. In order to mitigate for the increased potential for flooding with time, the County desires to update the 100-year Flood Elevation Map to account for flood conditions predicted with changes in climate and rising sea level to support planning, infrastructure investments, and development requirements.

In 2016, the Board adopted the updated Unified Sea Level Rise Projection for Southeast Florida (Compact, 2015) and directed staff to apply this projection as the basis for regional sea level rise adaptation planning. This action reflected the recognized vulnerability of both coastal and inland areas to the impacts of rising seas, including increased coastal flooding, changes in groundwater levels, and reduced capacity of gravity-dependent stormwater systems.

In February 2017, the Board approved a motion to Direct the Environmental Protection and Growth Management Department (EPGMD) to create and maintain a future conditions map series to include average wet season groundwater elevations and 100-year flood elevations to account for predicted changes in groundwater levels due to sea level rise and ensure the resiliency of current and future infrastructure investments.

Similar to the strategy employed in 1977, the County has again identified the need for progressive building requirements that will deliver flood protection for the duration of the investment, including under future climate conditions and changes in sea level. While the FEMA FIRMs will continue to reflect flood risk under current conditions, it is expected that as these maps are updated in ensuing years, the flood elevations will again begin to proximate those of the more forward-looking community flood map. As such, it is fully anticipated that the Broward County 100-year Flood Elevation Map may undergo future adjustments as trends in sea level and flood condition warrant.

This scope of work defines the data analysis, modeling and development of deliverables necessary to update the Broward County 100-year Flood Elevation Map to account for future climatic conditions.

#### **Project Overview**

The EPGMD is currently seeking professional consulting services to update the Broward County 100-year Flood Elevation Map to establish flood elevations under future climate conditions. The results of this analysis are expected to support the establishment of finished floor elevations necessary for mitigating flood risk under conditions of continued sea level rise and more intense rainfall events.

Following FEMA Guidelines and Standards (FEMA, 2017) and Broward County and SFWMD stormwater rules and regulations, the selected consultant shall use the most recent version of the BCMModel from the 2014 FEMA flood insurance study (FEMA, 2014) to generate flood depths for selected storm scenarios. The model is referenced to NAVD88 elevation datum and was updated to include surveyed cross sections of canals C-11, C-13, C-14, C-42 and North New River. Updates to drainage systems and control structures, including sediment information, may be required and identified through community stakeholder meetings and model review process. The selected consultant shall research and incorporate recent modeling efforts on water management systems made available by partner municipalities, utilities, control and drainage districts, including the City of Fort Lauderdale Stormwater Master Plan; as well as updated tidal information for downstream boundary conditions developed by the South Florida Water Management District (SFWMD) and tidal tailwater information to develop time-varying stage boundary conditions, expected land use changes and refined LiDAR information, where available. These efforts may include targeted collection and review of plans and as-built data from permits and municipal records, field reconnaissance to confirm drainage infrastructure, and topography survey. Potential future modifications, including planned infrastructure projects to surface water management systems should be discussed with the SFWMD and incorporated into the future conditions model, as applicable, and in accordance with the approach employed by SFWMD in the Big Cypress Basin Flood Protection Level of Service (FPLOS) Study, and including the analysis of simulated operating protocols of gravity-driven coastal structures. The consultant will review the soils and aquifer-based parameters in the BCMModel to ensure reasonable values for hydraulic conductivity in the surficial aquifer, as well as soil moisture characteristic curves. The consultant also needs to verify at time of commencement of current project if additional refinements had been made after August 2015, as part of current FEMA Coastal A zone remodeling. The selected consultant shall develop a user-friendly utility to easily reprocess the results of the FEMA Coastal A zone remodeling, once these results become available, and integrate into the inland flooding simulation using joint probabilistic analysis.

Upon the conclusion of the prioritized updates, the consultant shall demonstrate the modified (current conditions) BCMModel ability to improve peak stages and flows in response to extreme rainfall events, based on watershed evaluation. Future Conditions rainfall Intensity-Duration-Frequency curves and associated simulation time steps should be derived according to NOAA Atlas 14 and based on the results of adjusting the best set of downscaled data among three alternatives to be tested: 1) Statistical Downscaled Localized Constructed Analogs (LOCA); 2) Statistical Downscaled Center for Ocean-Atmospheric Prediction Studies (COAPS); and 3) Dynamically Downscaled World Climate Research Program Coordinated Regional Climate Downscaling Experiment (CORDEX). If results of the statistical analysis, determined according to the approach suggested by SFWMD, 2016, show large bias, a probabilistic approach to quantify potential changes to the 100-year floodplain, in response to non-stationary rainfall conditions, can be

performed in conjunction with the determination of associated risks, as suggested by Salas & Obeysekera, 2014.

The County will also provide future groundwater elevations to be used as boundary/antecedent conditions for the modified (future conditions) BCMModel based on output from recent applications of MODFLOW groundwater models developed by the United States Geological Survey (USGS). This input data will represent groundwater elevations under future sea level conditions (2060-2069) in accordance with the Unified Sea Level Rise Projection for South Florida (Compact, 2015) and estimated future rainfall average in accordance with the Center for Ocean-Atmospheric Prediction Studies (COAPS) downscaled Community Climate System Model (CCSM) global model. The consultant shall develop a user-friendly utility to easily convert updated MODFLOW output files to MIKE SHE/MIKE 11 input files to allow for future updates based on changes to the groundwater model or sea level rise projections.

Once future extreme rainfall conditions, sea level rise, tide and groundwater elevation, as well as future model configurations are determined, the consultant shall run the modified (future conditions) BCMModel for approved 10-, 25-, 50-, 100-, and 500-year storm events assuming nonstationary conditions. The model results will represent flood elevations under future conditions (2060-2069) and will serve as the basis of the updated Future Conditions 100-year Flood Elevation Map. Extreme rainfall events, combined with an agreed upon Sea Level Rise scenario should also be evaluated under nonstationary conditions to simulate flood elevations under 2100 future condition.

Once the simulations are complete and reasonable results are attested, the updated 100-year Flood Elevation Map (future conditions 2060-2069) should be developed in a similar format to the 1977 image map (Figure 1), and also a digital format grid and resulting flood zones, similar to the 2014 FEMA DFIRMs and to the 2017 Broward County Future Conditions Average Wet Season Groundwater Elevation Digital Map. The MIKE ZERO Toolbox will be used to export the gridded maximum depth of overland water, and the output grid will be converted into ESRI ArcGIS. The resulting feature class will then be transformed into a triangular integrated network and overlaid onto the detailed LiDAR data to develop 100-year future floodplain surface. From this surface, contours can be easily generated in ArcGIS or Surfer using standard tools. The consultant shall also develop a user-friendly utility to easily update the flood elevation digital map, as new simulated results become available.

All three developed utilities should allow the County to run the analysis on future updated datasets as well as evaluate the effect of changes to the factor scoring scheme on the analysis results with minimal effort required. Also, the tools should be nonproprietary and run as tools in the native ArcGIS environment (ArcGIS Toolbox), to provide flexibility to make updates to the tools in the future if needed due to major changes to the input data, calculation methodology, etc. All features represented in the modified BCMModel, especially drainage systems and water

control structures, should also be available in geodatabase format. Required coordinate system and datum are specified in Figure 2.

The consultant shall review the National Flood Insurance Program Community Rating System (CRS) and ensure that specific components of this project are undertaken in a manner that will maximize the potential for earning creditable criteria in accordance with the CRS program. It appears the public information and floodplain mapping tasks of this project may qualify for additional CRS Credit points. To maximize the CRS credit potential, it is recommended to review the County's and Partner Municipalities' current CRS Coordinator's Manual Activity Checklists and Documentation Checklists to identify current credit allocations. A list of current and recommended scope tasks would then be developed that if implemented would maximize the CRS credit points available and potential for improving the CRS classification. The CRS creditable project activities will be presented to the community stakeholders to ensure the stakeholders are aware that the project may be used to increase their communities CRS credit points and potentially CRS classification. Communicating the potential CRS benefits of the project to stakeholders early in the project schedule may enhance stakeholder participation in the project.

As part of the community outreach process, the selected consultant is also required to prepare and deliver presentations, as needed, before stakeholder and public groups as part of the map development process, and establish a methodology to organize and track stakeholder comments and questions, and follow up as necessary. Stakeholder communication efforts will begin at project onset and move forward in parallel with the technical model development tasks of the project. Key stakeholders that will be involved in the project and key individual(s) within each stakeholder organization should be identified. It is anticipated that this will involve communication with local representatives from 23 special districts, 25 water utilities, and 31 municipalities within the County; SFWMD and other regional, state and federal stakeholders involved in the Comprehensive Everglades Restoration Plan (CERP) and the Lower East Coast Water Supply Plan. The selected consultant should also facilitate effective stakeholder meetings, including the preparation of emails, mailers, social media posts, websites, and / or phone calls to ensure all stakeholders are well informed of meetings, as well as agendas, informational handouts, and comment forms are prepared for each meeting.

Finally, the consultant shall develop a summary report detailing the project methodology, stakeholder process, model improvements, technical assumptions, calibration parameters and results, production runs results, map development process, and the evaluation of potential CRS creditable criteria resulting from the project and through the stakeholder process.

## County Contributions

The County will provide the future conditions average wet season groundwater elevations in a grid format, 500x500ft, with centroids representing the NAVD88 groundwater elevation of discrete cells. The County will also provide the original updated version of the existing BCModel as delivered by FEMA in August 2015.

The County will schedule three stakeholder meetings to introduce the community to this project and gather information to refine the existing BCModel. Meetings will be held in the geographic areas associated with the north, central, and south portions of the County and may include residents, media, private sector, elected officials, subject matter experts, and other interested stakeholders. If substantial contentious issues are identified in any of the initial open houses, a follow up meeting would be scheduled to address revisions to initial assumptions of process.

## List of Detailed Tasks and Proposed Schedule

### **Task 1 - Project Kick off and Schedule Development**

This task will include a general project team introduction, establish communication protocols, define quality assurance / quality control (QA/QC) procedures, and upfront planning to move forward with the technical scope of work and stakeholder involvement.

#### Task 1.1 - Project Management Plan

Consultant will develop a generalized management plan for the project which addresses issues of project management, communication (internal and client), and quality assurance / quality control (QA/QC).

#### Task 1.2 - Develop MS Project Gantt Diagram

Consultant will develop a project schedule that outlines the tasks for completion. Included will be key milestones for deliverables, and identify contingent paths and tasks predecessors.

#### Task 1.3 - Attend Kick off Meeting

Consultant will coordinate with County staff to conduct a kick-off meeting with Consultant personnel. The meeting will be an opportunity to discuss the scope in detail, answer scope clarification questions, schedule constraints, and scope challenges. Initial data collection needs will be discussed as well as preliminary stakeholder coordination strategies.

#### Task 1.4 - Prepare Kick off Meeting Minutes and Update Schedule

Consultant shall prepare a meeting summary to capture the salient points of the kick-off meeting. This will include action items required of Consultant and/or County. County input will be solicited, and a revised version issued if necessary.

### **Task 2 - Initial Data Collection and Review**

This task will include efforts to gather all relevant, readily available data from various entities that will be required for the model updates and establishing future conditions.

Task 2.1 - Collect & Compile Broward County Model Files

Consultant will coordinate with County to obtain latest Broward County Model (BCModel) files and associated backup materials. This will include the latest version of the MIKE SHE / MIKE 11 model used during the County-wide FEMA Flood Mapping update (or more recent revisions if available). This also includes MODFLOW based groundwater input files (including future 2060 and 2100) that will be used as initial conditions for the MIKE SHE model.

Task 2.2 - Collect & Compile LiDAR data

Consultant will obtain the latest topographical data for County in LiDAR format from available sources. It is assumed that the LiDAR based topography will be available in both native LAS format as well as a derived digital elevation model (DEM) raster surface in a minimum 5'x5' grid cell size.

Task 2.3 - Collect & Compile Jurisdictional Data

Consultant will make requests to obtain the latest data from the various municipalities, water districts and major utilities that have relevance to surface water drainage and conveyance. This will include drainage feature inventories, map atlas data, hydrological & hydraulic reports, and modeling files. This will also include information on flood prone areas and flood complaint areas.

Task 2.4 - Collect & Compile Soils / Hydrogeology / Aquifer Characteristics

Consultant will obtain the latest available information from various government sources that describe subsurface conditions in Broward County. This includes the most recent shallow soils data from the USDA-NRCS soils web service, and hydrogeologic data representing deeper hydrogeological formations from County, SFWMD, and other relevant water district and municipal agencies.

Task 2.5 - Collect & Compile Current Land Use / Future Land Use

Consultant will obtain the latest GIS based existing land use data from County and the SFWMD in Florida Land Use Cover and Forms Classification Systems (FLUCFCS) format. Consultant will coordinate with County to obtain future land use coverages from planning based on comprehensive plans or other planning projections.

Task 2.6 - Collect & Compile FEMA Coastal Modeling

Consultant will obtain the latest costal modeling and associated data (when available) from the ongoing FEMA coastal modeling efforts.

Task 2.7 - Collect & Compile Gauge and Tidal Data

Consultant will obtain the latest available relevant flow and stage data sets from the SFWMD, County, water districts, municipalities (Including Pompano Beach and Ft. Lauderdale), and other agencies as appropriate. Particular focus will be getting data representing Hurricane Irma to be used for model validation purposes.

Task 2.8 - Collect & Compile Rainfall and Calibration Storm

Consultant will obtain the latest available relevant rainfall data sets from the SFWMD, NOAA, and other agencies as appropriate. This will include rain gauge data and available

radar based (NEXRAD) data. Particular focus will be getting data representing Hurricane Irma to be used for model validation purposes.

#### Task 2.9 - Collect & Compile Reference Climate Documentation

Consultant will obtain the latest relevant documentation from identified and other relevant sources. This will include relevant documentation associated with the Southeast Florida Regional Compact on Climate Change, NOAA Atlas 14 precipitation frequency estimates, Localized Constructed Analogs (LOCA) processes for statistical downscaling, Statistical Downscaled Center for Ocean-Atmospheric Prediction Studies (COAPS), and the Coordinated Regional Climate Downscaling Experiment (CORDEX). Also, specifically the following:

- *Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact). October 2015. Unified Sea Level Rise Projection for Southeast Florida. A document prepared for the Southeast Florida Regional Climate Change Compact Steering Committee. 35 p.*
- *South Florida Water Management District. Determination of Future Intensity-Duration-Frequency Curves for Level of Service Planning Projects – Extreme Rainfall Analysis in Climate Model Outputs to Determine Temporal Changes in Intensity-Duration-Frequency Curves. November 2016.*
- *Salas, J.; Obeysekera, J. (2014) Revisiting the Concepts of Return Period and Risk for Nonstationary Hydrologic Extreme Events. Journal of Hydrologic Engineering 19: 554-568p. ASCE.*

Additional reference documentation may be compiled as appropriate.

#### Task 2.10 - Collect & Compile Sedimentation Data

Consultant will obtain the latest available relevant sedimentation data sets from the SFWMD, County, water districts, municipalities, and other agencies as appropriate. Particular focus will be getting current data for existing conditions model validation purposes.

#### Task 2.11 - Conduct Data Gap Analysis

Based on the foregoing data items, Consultant will identify and significant data gaps that will need to be addressed as part of the existing model update process. An assessment of the degree of impact will be made.

#### Task 2.12 - Initial Model Data Needs Identification

Based on the foregoing data items and data gap analysis, Consultant will identify significant data needs that will need to be addressed as part of the existing model update process. A plan of action for obtaining the data will be developed, with identification of key stakeholders which may assist.

#### Task 2.13 - Task Summary Memorandum

A Task Summary Memorandum will be developed summarizing the above subtasks and provide the basis for addressing data gaps and model data needs. County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

### **Task 3 - Community Stakeholder Meeting Support**



This task includes planning and involvement in the stakeholder communication process.

Task 3.1 - Stakeholder Planning / Strategy Meeting with County

Consultant will coordinate with County to schedule a planning meeting to strategize on the best approach for stakeholder involvements. This will include initial discussion of appropriate stakeholders to be involved and sources of relevant input.

Task 3.2 - Key Stakeholder Identification

Consultant will work with County to develop listing of key stakeholders on which to focus primary communication efforts with during initial meetings.

Task 3.3 - Other Stakeholder Identification

Consultant will work with County to develop listing of other relevant stakeholders that may warrant secondary communication efforts with outside of initial meetings. This may include peripheral agencies or public interest entities which may have some information useful to the technical aspects of the project. A plan of action for contact with identified parties will be developed.

Task 3.4 - Develop Stakeholder Tracking Process

Consultant will develop a tracking process for effectively tracking stakeholder input, including consideration for tracking initial and follow up communications, data requests, and data transfers. This is expected to be a traditional database system with possible integration of geographic data if warranted.

Task 3.5 - Develop Notifications - emails, mailers, social media, websites, etc.

Consultant will support the communication efforts of County prior to the Stakeholder Meetings by preparing as appropriate email blasts, mailers, social media posts, website content, etc. as necessary to effectively communicate the logistics and intent of the meetings. It is assumed that the content will be prepared and transmitted to County for use by County's Public Information Office for dissemination.

Task 3.6 - Prepare agendas, informational handouts, comment forms, etc.

Consultant will support the communication efforts of County during the Stakeholder Meetings by preparing as appropriate agendas, informational handouts, comment forms, etc. as necessary to effectively communicate the purpose and intent of the meetings, and effectively solicit input from the stakeholders. It is assumed that the content will be prepared and transmitted to County for production prior to the meetings.

Task 3.7 - Attend North Stakeholder Meeting

Consultant will prepare for and attend the North Stakeholder Meeting, including assistance with presentations as appropriate.

Task 3.8 - Attend Central Stakeholder Meeting

Consultant will prepare for and attend the Central Stakeholder Meeting, including assistance with presentations as appropriate.

Task 3.9 - Attend South Stakeholder Meeting

Consultant will prepare for and attend the South Stakeholder Meeting, including assistance with presentations as appropriate.

Task 3.10 - Meeting Summaries

Consultant will compile information from each of the three Stakeholder Meetings and prepare a meeting summary. This will include attendance, capture of relevant comments, and data contact.

Task 3.11 - Model Data Needs Identification

Based on the meeting summaries, input relevant to updating the existing conditions modeling will be compiled and a prioritized listing of possible modifications developed. It is recognized that not all stakeholder requested model updates may be feasible or able to be addressed under the current scope of work. As such, the prioritization will distinguish between updates recommended to be covered by the current scope, a future scope, or that may not be appropriate given the overall goal of the model. It is also recognized that the model is regional in nature focused on primary and secondary infrastructures and conveyances, and requested updates related to tertiary infrastructure or local level issues will likely not be appropriate.

Task 3.12 - Follow Up Meetings with Selected Stakeholders

Consultant will communicate with County to identify any stakeholders that may warrant individualized meetings. This may either be "other" stakeholders identified in Task 3.3 or primary stakeholders identified through the three meetings as warranting follow up. For the purposes of the scope of work, it is assumed that up to four such meetings will be included.

Task 3.13 - Task Summary Memorandum

A Task Summary Memorandum will be developed summarizing the above subtasks and provide the basis for addressing supplemental data collection and completing acquisition of information for model updates. County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

**Task 4 - Supplemental Data Collection Based on Stakeholder Meetings**

This task includes efforts to follow up and obtain various relevant data based on contacts with stakeholders in the previous task.

Task 4.1 - Municipality Stormwater Plan and Model Acquisition

Consultant will coordinate with identified municipalities and water control districts to obtain relevant stormwater plan and model information which may be warranted for model update purposes.

Task 4.2 - Planned Major Infrastructure Projects

Consultant will coordinate with local water control districts and identified municipalities to obtain relevant plans for major water resource infrastructure projects which may be warranted for model update purposes.

Task 4.3 - SFWMD ERPs, As-built plans, etc.

Consultant will coordinate with SFWMD and identified municipalities as needed to obtain relevant stormwater plan and as-built plans information relevant to drainage infrastructure that warrants inclusion in the updated model.

Task 4.4 - SFWMD Future Water Control Projects

Consultant will coordinate with the SFWMD to identify significant future water control projects which may warrant inclusion in the future conditions model.

Task 4.5 - Field Reconnaissance

Consultant will make field visits to identified drainage infrastructure and projects to confirm conditions for model inclusion. For the purposes of the scope, this effort will be limited to up to 3 days of staff time.

Task 4.6 - Field Survey - Structures, Cross-sections, Sediments

Consultant will coordinate with surveying subconsultant to collect field survey data of features identified for inclusion in the model and/or for confirmation of current conditions of features already represented in the model as warranted. For the purpose of the scope of work, an allowance for surveying services is assumed as specific locations are not yet identified. The surveying may address the following types of features:

- Measure cross-section and profiles of major and secondary canals.
- Measure and collect as-built data of major water control structures associated with canals or primary piping systems.
- Measure and collect as-built details of bridges (span, deck, low chord, piers, opening cross-sections, channel cross-section upstream and downstream, etc.).
- Measure and collect as-built details of major storm water ponds and outfall structures.
- Measure and collect as-built detail of major pipe conveyance systems including culverts and drainage inlets.
- Measure sediment with probe depth surveys in major canals.
- Measure high water marks of water bodies and/or at bridges and significant culvert crossings.
- Provide verification of elevation data collected by previous LIDAR efforts.
- Prepare maps, cross-sections and reports as needed to accurately depict the features being surveyed.

All field survey work will be performed in accordance with the following:

- All survey work will be prepared in accordance with the Standards of Practice for surveying established by The Board of Professional Surveyors and Mappers within the State of Florida.
- Data to be collected by conventional survey measurements, GPS measurements, echo sounding and laser scanning.
- Project Horizontal control will be based on the Florida State Plane Coordinate System, East Zone, NAD 83.
- Project Vertical control will be based on NAVD 88 Vertical Datum.
- Establish vertical control networks (benchruns) as needed to support accurate vertical data for each site to be surveyed.
- Drawings will be delivered in AutoCAD (.dwg) file format. Raw data will be delivered in ASCII file format. Scan data will be delivered in RCP file format

Task 4.7 - Task Summary Memorandum

A Task Summary Memorandum will be developed summarizing the above subtasks and the supplemental data collected for model updates. County's comments in the Task

Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

#### **Task 5 - Develop ArcGIS Tool - MODFLOW Groundwater Output to MIKE-SHE Boundary Conditions**

This task includes effort to develop a utility tool to translate groundwater MODFLOW model output into a MIKE SHE model compatible input format.

##### Task 5.1 - Coordinate example datasets with County

Consultant will coordinate with County to obtain the appropriate MODFLOW model output datasets to be used for the project.

##### Task 5.2 - Utility Development

Consultant will develop a utility tool to translate grid based MODFLOW model output data into a MIKE-SHE model compatible input format. The tool will be developed as an ArcGIS toolbox compatible with County GIS systems. For the purposes of the project it is assumed the tool will be developed at the ArcGIS 10.5 version level.

##### Task 5.3 - Utility Delivery and Troubleshooting

The tool will be tested by Consultant with project data and then used for project model input purposes. The tool will also be tested on County's system to ensure compatibility.

##### Task 5.4 – Task Summary Memorandum

Consultant will prepare a Task Summary Memorandum documenting the tool development process and providing instructional information for use of the tool in the future by County. Also, will include electronic delivery of ArcGIS tool. County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

#### **Task 6 – Update Current Conditions MIKE SHE / MIKE-11 Model**

Consultant will update the most recent version of the BCModel from the 2014 FEMA flood insurance study to generate flood depths for selected storm scenarios. The updates will be identified through the outcomes of previous tasks including the Task 2 - Initial Data Collection and Review, Task 3 - Community Stakeholder Meetings, and Task 4 - Supplemental Data Collection including Field Survey. These may include updates to drainage systems, control structures, additional major conveyances, and channel cross sections to account for sedimentation. The updates to the model will be validated against a historical storm event (Hurricane Irma or other recent). The use of the model to predict flood depths shall be in general accordance with FEMA Guidelines and Specifications (FEMA, 2017). A description/justification of the selected model structure that will address the modeling objectives, will be agreed to among parties before model runs/all updates.

It is noted that this task will be accomplished using the current 2017 version of MIKE SHE / MIKE 11 and does not include updating the MIKE 11 model to its successor 1-D modeling package, MIKE Hydro River. MIKE Hydro River was introduced as part of the 2016 release of MIKE

SHE. While the 2016 and 2017 releases of MIKE SHE contains both MIKE 11 and MIKE Hydro River, the 2017 version is reportedly the last major release in which MIKE 11 is included as a product. MIKE Hydro River contains several computational method changes and other framework differences which would not facilitate a direct import. If desired for future compatibility, the existing MIKE 11 modeling data can be ported to MIKE Hydro River under a separate future scope of work.

#### 6.1 – Add Hydraulic Detail Based on Stakeholder Input

At the commencement of this Task, Consultant will coordinate with County to prioritize the updates identified in the initial model data needs identification, as well as updates requested by the stakeholders. Starting with the highest priority updates and working down the list of updates in order of decreasing priority, Consultant will incorporate the additional detail subject to the not-to-exceed budget for this task.

#### 6.2 –Reduce Model Grid Size

The current MIKE SHE model grid spacing in the BCModel is 500 feet x 500 feet. Because this spacing does not effectively capture fine details of topography and impervious coverage in urban areas, significant improvements in the accuracy of the 2-D overland flow component could be realized by reducing the grid spacing. Increasing the grid resolution will, however, increase run times. It is expected that grid spacing smaller than 250 feet x 250 feet may result in acceptable run times, while greatly improving the model's representation of runoff, storage, and overland flow. This task includes an initial test run with the finer grid resolution to determine the impact on model run times. If the test run results in acceptable run times, all components of the 2-D overland flow module will be re-parameterized using the source LiDAR data and detailed land use/land cover mapping. Because the objective of this task is to improve the overland flow representation, the groundwater and unsaturated zone parameters used for the 500-foot grid will be duplicated when adapting to the 250-foot or smaller grid.

#### 6.3 – Land Use Refinement

The current SFWMD FLUCFCS based land use and most recently available aerial photography will be compared with the land use in the current BCModel. Areas of recent development and other land use changes will be identified. Aerial mapping and construction drawings (where available from ERPs, etc.) will be used to update the land use in the MIKE SHE model. Additionally, overland flow roughness coefficients will be varied by land use throughout the model gridded area, as the current BCModel uses a single value for this parameter throughout the domain. Note the resolution and detail of this effort will be respective to the overall grid size of the model (i.e., localized changes in land use coverage significantly less than the grid resolution will not be addressed).

#### 6.4 – Storage Representation

The 2017 version of MIKE SHE includes a new ponded drainage routine that will be used in conjunction with land use dependent detention storage values to improve the representation of storage detention and routing in portions of the model domain where small (sub-grid scale) stormwater detention ponds or other significant storage features are not explicitly represented in the current BCModel. This task includes development

and implementation of this routine, model-wide. Storage representation will rely solely on the LiDAR based DEM, take-offs from plans or other source material will not be included. Focus will be applied to flood prone areas identified by County and municipalities as appropriate.

#### 6.5 – Hydrologic Parameterization Updates

Consultant will review the remaining MIKE SHE parameterization, including saturated zone drain levels and time constants, paved area roughness coefficients, soils parameters (specifically, the soil moisture retention curves), and hydraulic conductivities of the surficial aquifer, and update as necessary. The current model values will be retained unless sufficient justification is found for revision.

#### 6.6 – Groundwater Initial Conditions

Consultant will compare the initial groundwater elevations from the 2014 BCModel with groundwater well data (measurements) for the time period preceding the model validation event (i.e., Hurricane Irma). The initial groundwater elevations will be adjusted if necessary in preparation for the validation simulation.

#### 6.7 – Model Validation

The existing conditions model updates will be validated by simulating a single historic storm event (most likely Hurricane Irma or other recent storm events) and comparing the results with observed stage and flow hydrographs. NEXRAD radar-based rainfall data, with a 15-minute time step (previously collected in Task 2) will be formatted for input into the MIKE SHE model. Observed tidal data, where available, will be input as boundary conditions for the major coastal outfalls. Model inputs will be adjusted, within reasonable ranges, in an effort to achieve best acceptable agreement between simulated and observed flow volumes, peak flows, and peak stages at selected measurement stations. The goodness-of-fit of peak stages and flows will be compared in a spatially varied manner as appropriate to the previous BCModel calibration (to Hurricane Irene in 1999) to validate the improvements to the model, with the objective of obtaining an overall goodness-of-fit that is equal or better than the previous calibration.

#### 6.8 – Current Conditions Simulations

Current conditions model simulations will be run for the 10-, 25-, 50-, 100-, and 500-year design storm events, with distributions to be based on SWFWMD or NOAA 14. MIKE SHE model outputs, in the form of maximum depths of overland flow, will be compiled, mapped, and reviewed to ensure the results are reasonable and numerically stable. The MIKE 11 peak stage profiles will also be prepared using the MIKE standard post-processing tools and reviewed for reasonableness and stability. Any identified model instabilities will be addressed.

#### 6.9 – Compile Model Input Data into ArcGIS Geodatabase

Consultant will compile the current conditions MIKE SHE model input into an ArcGIS 10.5 geodatabase. The geodatabase will be populated with readily exportable data using the standard MIKE Zero toolbox.

#### 6.10 - Task Summary Memorandum

The approach, parameterization, and results of the current conditions model update will be documented in a Task Summary Memorandum and submitted to County for review.

County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

### **Task 7 – Develop Future Conditions MIKE SHE / MIKE 11 Model Input**

Under this task, the updated BCModel input will be modified to develop a version of the model to represent future conditions. Model inputs will be adjusted to represent projected future sea levels, future rainfall depths, major changes in future land use, and planned major future infrastructure improvements.

#### 7.1 – Develop Future Conditions Rainfall IDF Curves

The Future Conditions Rainfall Intensity Duration-Frequency (IDF) curves will be developed in accordance with the prescribed scope. In general, the process will be that the Future rainfall depths and IDF curves (and associated simulation time steps) will be derived according to NOAA Atlas 14 and based on the results of adjusting the best set of downscaled data among three alternatives to be tested:

- 1) Statistical Downscaled Localized Constructed Analogs (LOCA)
- 2) Dynamically Downscaled Center for Ocean-Atmospheric Prediction Studies (COAPS)
- 3) Dynamically Downscaled World Climate Research Program Coordinated Regional Climate Downscaling Experiment (CORDEX).

If it is determined that the results of the statistical analysis, determined according to the approach suggested by SFWMD, 2016, show large bias, a probabilistic approach to quantify potential changes to the 100-year floodplain, in response to non-stationary rainfall conditions, will be performed in conjunction with the determination of associated risks, for example by Salas & Obeysekera, 2014.

#### 7.2 – Future Sea Level Rise Scenarios

Two future sea level rise scenarios will be evaluated with the updated BCModel based on the unified projections from the Southeast Florida Climate Compact. The basis of the updated Future Conditions 100-year Flood Elevation Map (Task 10) will be model results representing flood elevations under 2060-2069 conditions. Flood elevations will also be evaluated under 2100 future conditions. In this subtask, projected sea level rise information for the year 2100 scenario will be identified, discussed and agreed upon between Consultant and County.

#### 7.3 – Future Groundwater Elevations from MODFLOW

County will provide future groundwater elevations (2060 and 2100) to be used as antecedent conditions for the future conditions MIKE SHE model based on output from recent applications of MODFLOW by the U.S. Geological Survey. This input data will represent groundwater elevations under future sea level conditions (2060-2069) in accordance with the Unified Sea Level Rise Projection for South Florida, and estimated future rainfall average in accordance with the Center for Ocean-Atmospheric Prediction Studies (COAPS) downscaled Community Climate System Model (CCSM) global model. Consultant will import these elevations, using the tool developed in Task 5, into a MIKE SHE grid file for use as initial water table elevations for the surficial aquifer.

#### 7.4 – Future Tidal Boundary Conditions

Surface water boundary conditions for the 1-D hydraulic model, the 2-D overland flow model, and surficial aquifer will be developed in consultation with SFWMD and County. Boundary conditions for projected tide and storm surge will be developed according to the C4/C7 FPLOS studies from the SFWMD. Because the FEMA Coastal Zone A modeling/mapping results will be integrated with the MIKE SHE / MIKE 11 model results, it is anticipated that it will not be necessary or appropriate for the MIKE SHE and MIKE 11 tidal boundary conditions to incorporate the effects of storm surge. Tidal boundary conditions will be based on an astronomical tide cycle (without atmospheric influences) adjusted upward to account for future sea level rise.

#### 7.5 – Future Land Use

Future land use mapping for the 2060 to 2069 scenario will be obtained from Broward County. For the purposes of the scope, up to 20 specific areas (each larger than approximately 100 contiguous acres to be targeted for development or redevelopment) that County and stakeholders will identify can be represented in the future conditions model. The land use categories for these areas will be aggregated into the subset of model-based (hydrologic) land use categories developed for MIKE SHE modeling purposes. The resulting future land use polygons will be used to parameterize the two future conditions MIKE SHE model scenarios. The approach to land-use based model parameterization will be identical to that used to update the current conditions model, and will account for storage and attenuation in the updated areas as appropriate. For the purposes of this study, it is assumed that the year 2100 land use will be unchanged from the 2060 to 2069 land use (e.g., same land use changes reflected in both model scenarios).

#### 7.6 – Future Operating Protocols of Gravity-Driven Structures

In consultation with SFWMD, any expected long-term changes to operating protocols of gravity-driven coastal structures (to adapt to future sea levels) will be incorporated into the 1-D (MIKE 11) model input. For the purposes of this study, it is assumed that the year 2100 operating protocols will be unchanged from those reflected in 2060 to 2069.

#### 7.7 – Planned Infrastructure Improvements

Potential future modifications, including planned surface water management infrastructure projects (e.g., the C-9 and C-11 Impoundments and C-51 reservoir) will be discussed with the SFWMD and incorporated into the future conditions model, as applicable, and in accordance with the approach employed by SFWMD in the Big Cypress Basin Flood Protection Level of Service (FPLOS) Study. Up to five (5) additional major water control/storage/conveyance projects identified by SFWMD and/or water control districts will be incorporated. For the purposes of this study, it is assumed that the year 2100 infrastructure improvements will be unchanged from those reflected in 2060 to 2069.

#### 7.8 – Compile Model Input Data into ArcGIS Geodatabases

Consultant will compile the future conditions MIKE SHE model input into an ArcGIS 10.5 geodatabase. The geodatabase will be populated with readily exportable data using the standard MIKE Zero toolbox.

#### 7.9 – Task Summary Memorandum



The approach and parameterization of the future conditions model scenarios will be documented in a Task Summary Memorandum and submitted to County for review. County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

## **Task 8 – Model Execution and Results Processing**

The model inputs developed and modified in the preceding tasks will be used to generate flood elevations for the selected future conditions scenarios. Model simulations will be conducted for the 10-, 25-, 50-, 100-, and 500-year storm events for the following scenarios.

### 8.1 – Future Conditions Simulations – 2060-2069

Future conditions (2060-2069) model simulations will be run for the 10-, 25-, 50-, 100-, and 500-year design storm events. MIKE SHE model outputs, in the form of maximum depths of overland flow, will be generated and reviewed to ensure the results are reasonable and numerically stable. The MIKE 11 peak stage profiles will also be prepared using the MIKE standard post-processing tools and reviewed for reasonableness and stability. Any identified model instabilities will be addressed.

### 8.2 – Future Conditions Simulations – 2100

Future conditions (2100) model simulations will be run for the 10-, 25-, 50-, 100-, and 500-year design storm events. MIKE SHE model outputs, in the form of maximum depths of overland flow, will be generated and reviewed to ensure the results are reasonable and numerically stable. The MIKE 11 or MIKE Hydro River peak stage profiles will also be prepared using the MIKE standard post-processing tools and reviewed for reasonableness and stability. Any identified model instabilities will be addressed.

### 8.3 – Model Results Post-Processing

Using the standard MIKE Zero toolbox, model results from the two future conditions simulations will be exported to ArcGIS grid files and shape files. Map projections files will be created for all feature classes.

- Maximum depth of overland flow (10-, 25-, 50-, 100-, 500-year)
- Maximum groundwater elevations in the Surficial Aquifer (10-, 25-, 50-, 100-, 500-year)

### 8.4 – Compile Model Output Data into ArcGIS Geodatabases

Consultant will compile the future conditions MIKE SHE model output into an ArcGIS 10.5 geodatabase. In addition to the feature classes generated in the preceding subtask, feature classes will be generated to represent the overland flood elevations by adding the maximum depths over overland flow to the topographic grid elevations.

### 8.5 – Task Summary Memorandum

The results of the future conditions model scenarios will be documented in a Task Summary Memorandum and submitted to County for review. County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

## **Task 9 – Develop ArcGIS Tool – Coastal Zone A Model Results Integration with MIKE SHE**

The development of flood hazards in Broward County incorporates upland (riverine, surficial) and coastal sources (storm surge including wave action). In its flood risk studies, Broward County assumes that flooding from upland and coastal sources is statistically independent. This task seeks to calculate the total or actual frequency flood curve at any desired point by statistically adding flood elevations from all sources, a calculation called combined rate of return (CRR).

#### 9.1 – Extract Results from Current Coastal Storm Scenarios

Consultant will develop a tool that will read model results, perform iterative calculation of a given flood frequency, and produce an output. Time allocated to Task 9.1 includes preparation of MIKE-SHE and coastal datasets to meet the needs of the CRR Tool. For example, we will convert datasets to a different format (e.g., raster, ESRI terrain, or shapefile), clip to County's boundary, or create necessary geodatabase fields.

#### 9.2 – Develop Toolbox

Consultant will develop a tool that will read model results, perform an iterative calculation to estimate a given frequency within the range of the flood frequency curve, and produce geospatial output for mapping.

We envision the CRR Tool operation as follows.

1. Using a template geodatabase, the CRR Tool will read coastal and upland flood elevations at user-specified point locations. These locations may include the center of a grid element, a cross section, or any other location specified by the user. The CRR Tool will populate the geodatabase with the specified frequency levels.
2. The CRR Tool will allow manual edits in case the user would like to edit flood elevations. For example, the user may want to include the effects of waves, not included in FEMA's stillwater elevation surfaces.
3. The CRR Tool will iteratively solve the combined rate of return equation.
4. The CRR Tool will store results in the same geodatabase.

The CRR tool will be delivered as an ArcGIS toolbox. Some tool functionality may change during its development to improve efficiency and accommodate Broward County's interests. Major changes to the design of the CRR Tool proposed in this scope of work, may require an additional fee.

#### 9.3 – Integrate Coastal Zone Results with Future MIKE SHE Model Results

Consultant will compute flood frequency results using the tool developed in Task 9.2. We will create a point shapefile with locations of interest in obtaining combined rate of return. Typically, these points will extend upstream along tidally-influenced canals. Staff will review results and recalculate combined rates, if necessary. The task includes the development of a geodatabase or shapefile with combined elevations that mappers can use to delineate flood risks.

#### 9.4 – Task Summary Memorandum

Consultant will prepare Task Summary Memorandum documenting the tool development process and providing instructional information for use of the tool in the future by County,

including documentation that will guide the user on how to operate the tool and describe input and output products for future reference. Also, will include electronic delivery of ArcGIS tool. County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

#### **Task 10 - Develop ArcGIS Tool - Generate Future 100-year Flood Contour Map**

This task will produce a utility tool that will convert MIKE SHE output flood stages into contours suitable for County flood mapping purposes.

##### Task 10.1 - Develop Toolbox

Consultant will develop a work flow process to generate 100-year flood contours from GIS based model output data. This work flow will rely on standard ArcGIS based processes which will be compiled into an ArcGIS toolbox for delivery to County. The tool box will be troubleshooted using project model output datasets to generate desired results. The generalized process will be to use rasterized flood stage results processed from the model output and DEM, then further process using contouring tools to produce desired results in vector format. Resulting contour elevation features will be attributed with results in both NGVD 1929 and NAVD 1988 vertical datums.

##### Task 10.2 - Generate Future 2060-2069 100-year Flood Contour Map

An ArcGIS map template (mxd) will generated in to facilitate depiction of the resulting 100-year flood contours in a format similar to the previous 1977 100-year flood map used by County.

##### Task 10.3 - Task Summary Memorandum

Consultant will prepare a Task Summary Memorandum providing details on the construction of the tool and providing instructions on usage, data format requirements, etc. Also, will include electronic delivery of ArcGIS tool and map template. County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

#### **Task 11 - CRS Evaluation and Recommendations**

This task will evaluate current Community Rating System (CRS) credits for Broward County and applicable municipalities, and recommend categories for improvement in the rating system based on this study. Consideration of FEMA Guidelines and Specifications shall be made when using the results of the flood modeling as a basis to evaluate CRS improvement measures.

##### Task 11.1 - Develop CRS Credit Information for Initial Stakeholder Meetings

Consultant will compile CRS data relevant to Broward County and its municipalities from reference sources and preliminarily identify applicable sections that may be influenced by the results of this project. This will be used to develop information to be shared with relevant stakeholders at the initial project coordination meetings.

Task 11.2 - Compile Current CRS Rating Data from County and Municipalities

Based on input from stakeholders, compile and summarize current CRS program data from participating municipalities. Comparison of current rating credit will be performed.

Task 11.3 - Evaluate Credit Opportunities Relevant to Flood Mapping Effort

Based on compiled data and evaluation, evaluate potential areas for additional credit opportunity for County and applicable municipalities based on the results of this 100-year flood map project. This will be evaluated in general County-wide and individually specific to applicable municipalities.

Task 11.4 - Prepare Potential CRS Credit Recommendations

Based on the results of the previous tasks, generate a matrix of specific potential CRS credit recommendations. It is noted that this will focus on recommendation for County and applicable municipalities (municipalities which are specifically identified during the initial stakeholder process as expressing interest in receiving recommendation and that actively engaged in a dialog regarding CRS under this effort).

Task 11.5 - Task Summary Memorandum

The results of the above referenced task will be provided in a Task Summary Memorandum for County's review and comment. County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

**Task 12 - Presentation of Results to County and Stakeholders**

This task includes effort to coordinate, attend, and disseminate information to identified stakeholders during the course of the project.

Task 12.1 - Meetings at Milestones (assume 2)

Consultant shall coordinate with County to prepare for and attend meetings at key project milestones to disseminate project results to interested stakeholders. For the purposes of the scope of work, it is assumed that up to two meetings will be included. It is assumed that Consultant shall prepare presentation materials to assist the County with the meeting.

Task 12.2 - Meetings During Map Adoption Process (assume 2)

Consultant shall coordinate with County to prepare for and attend meetings during the map adoption process to relevant stakeholders. For the purposes of the scope of work, it is assumed that up to two meetings will be included. It is assumed that Consultant shall prepare presentation materials to assist County with the meeting.

Task 12.3 - Task Summary Memorandum

A Task Summary Memorandum will be prepared capturing the results of the milestone and map adoption meetings and documenting any relevant decisions and supporting information. County's comments in the Task Summary Memorandum, if any, will be addressed in the draft Project Summary Report (Task 13).

**Task 13 - Prepare and Submit Draft Summary Report**

This task includes efforts to develop a comprehensive draft report of project activities for County review.

Task 13.1 - Prepare draft report narrative and supporting figures, tables, etc.

It is anticipated this will incorporate information from the various task summary memos into a combined report. In general, the organization will include an introduction, narrative sections corresponding to scope tasks, and supporting appendices. Relevant figures and table of data will be provided. The appendices will be focused on immediately supportive material to the report narrative. Volume reference information and model related data will be referenced but provided as part of the electronic deliverable (cataloged for future reference purposes).

Task 13.2 - Report QA/QC

The report will have senior review conducted by the project manager and a peer review by a qualified individual not directly associated with the project for QA/QC purposes.

Task 13.3 - Publish report

The draft report will be published in PDF format for delivery to County. Native files will be provided along with back up reference and model materials in a set of electronic deliverables.

**Task 14 - Prepare and Submit Final Summary Report**

Task 14.1 - Prepare final report

Based on County comments and those of other applicable stakeholders, Consultant will revise and finalize the report.

Task 14.2 - Report QA/QC

The report will have senior review conducted by the project manager and a peer review by a qualified individual not directly associated with the project for QA/QC purposes.

Task 14.3 - Publish report

The final report will be published in PDF format for delivery to County. Native files will be provided along with back up reference and model materials in a set of electronic deliverables. It is understood that the information developed during the project will be used to support technical publications and /or presentation to organizations.

**Task 15 - Project Management**

This task includes various administrative efforts necessary for execution of the project work.

Task 15.1 - Project setup & administration

Task 15.2 - Management of subconsultant efforts and QA/QC

Task 15.3 - Management of technical staff efforts and general project QA/QC

Task 15.4 - Project tracking, schedule updates, weekly status reports, etc.

**References**

Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact). October 2015. Unified Sea Level Rise Projection for Southeast Florida. A document prepared for the Southeast Florida Regional Climate Change Compact Steering Committee. 35 p.

Federal Emergency Management Agency. August 18, 2014. Federal Insurance Study Broward County, Florida and incorporated Areas. Flood Insurance Study Number 12011CV000A. 60 p.

Federal Emergency Management Agency. FEMA's Guidelines and Standards for Flood Risk Analysis and Mapping. Available at: <https://www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping> Access on April, 2017.

South Florida Water Management District. Determination of Future Intensity-Duration-Frequency Curves for Level of Service Planning Projects – Extreme Rainfall Analysis in Climate Model Outputs to Determine Temporal Changes in Intensity-Duration-Frequency Curves. November 2016.

Salas, J.; Obeysekera, J. (2014) Revisiting the Concepts of Return Period and Risk for Nonstationary Hydrologic Extreme Events. Journal of Hydrologic Engineering 19: 554-568p. ASCE.

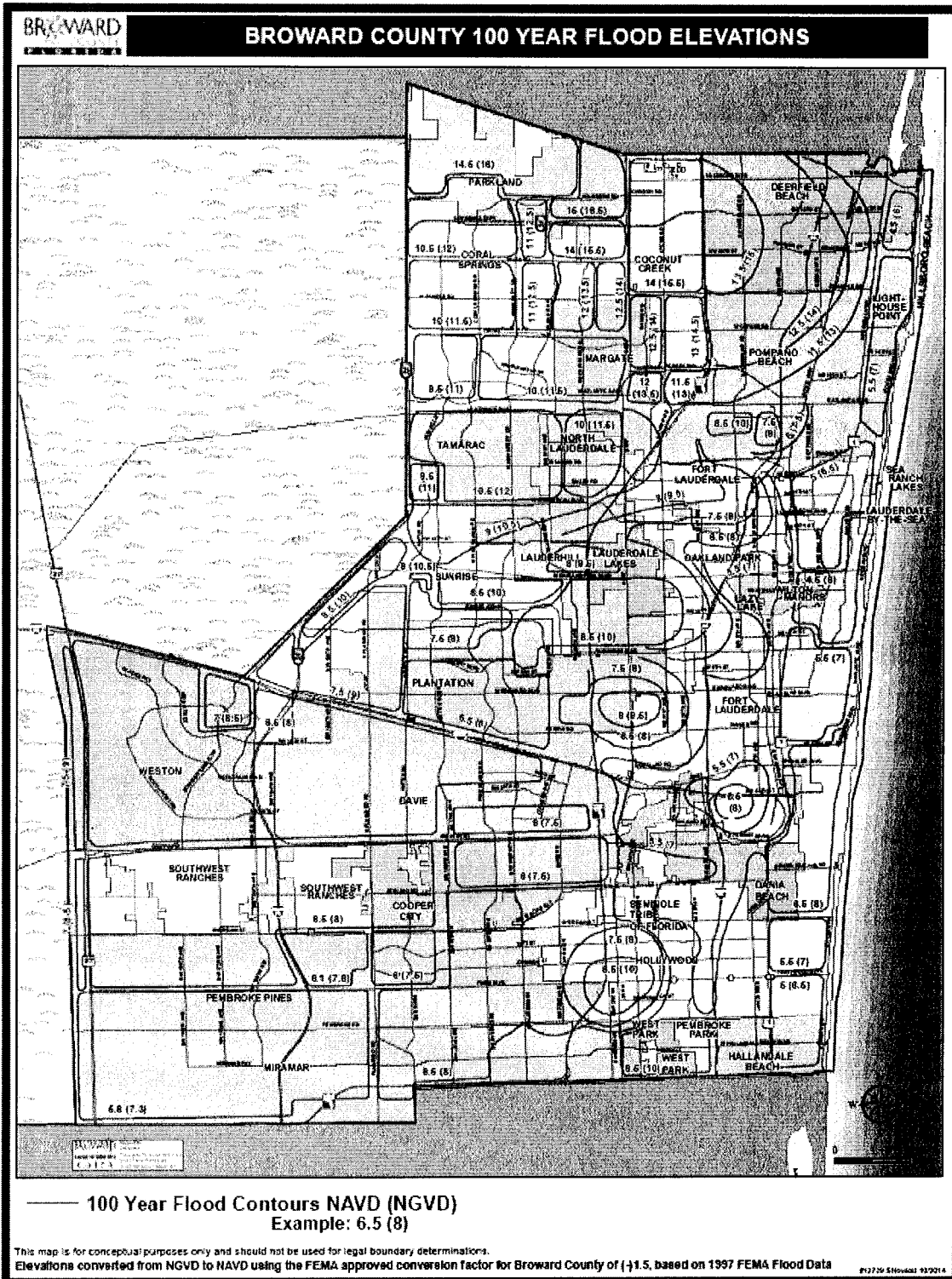


Figure 1. 1977 Broward County 100-year flood elevation map

NAD\_1983\_HARN\_StatePlane\_Florida\_East\_FIPS\_0901\_Feet  
WKID: 2881 Authority: EPSG

Projection: Transverse\_Mercator  
False\_Easting: 656166.6666666665  
False\_Northing: 0.0  
Central\_Meridian: -81.0  
Scale\_Factor: 0.9999411764705882  
Latitude\_Of\_Origin: 24.33333333333333  
Linear Unit: Foot\_US (0.3048006096012192)

Geographic Coordinate System: GCS\_North\_American\_1983\_HARN  
Angular Unit: Degree (0.0174532925199433)  
Prime Meridian: Greenwich (0.0)  
Datum: D\_North\_American\_1983\_HARN  
Spheroid: GRS\_1980  
Semimajor Axis: 6378137.0  
Semiminor Axis: 6356752.314140356  
Inverse Flattening: 298.257222101

Figure 2. Recommended GIS Coordinate System and Datum



**EXHIBIT B – Cost Sharing Schedule**

<b>Municipality</b>	<b>Population</b>	<b>Shares</b>	<b>Cost Share</b>
Coconut Creek	52000	2	\$ 32,000.00
Dania Beach	29639	1	\$ 16,000.00
Fort Lauderdale	165521	6	\$ 96,000.00
Hallandale Beach	37113	1	\$ 16,000.00
Hollywood	140768	5	\$ 80,000.00
Oakland Park	41363	1	\$ 16,000.00
Pompano Beach	99845	3	\$ 48,000.00
Wilton Manors	11932	1	\$ 16,000.00
<b>Subtotal</b>	<b>578181</b>	<b>20</b>	<b>\$ 320,000.00</b>
Hillsboro		NA	\$ 10,000.00
SBDD		NA	\$ 30,000.00
<b>Subtotal</b>		<b>NA</b>	<b>\$ 360,000.00</b>
County			\$ 360,000.00
<b>Total</b>			<b>\$ 720,000.00</b>