



## INTERLOCAL AGREEMENT

Between

**BROWARD COUNTY**

and

**City of Fort Lauderdale**

for

### **COST SHARING SUPPORT OF USGS PROJECT FOR "EVALUATION OF CHANGES TO THE SALINITY DISTRIBUTION WITHIN THE SURFICIAL AQUIFER UNDER PROJECTED FUTURE HYDROLOGIC CONDITIONS, BROWARD COUNTY, FLORIDA"**

This Interlocal Agreement (the "Agreement") is entered into between Broward County, a political subdivision of the State of Florida ("County"), and the City of Fort Lauderdale ("Partner"), a municipal corporation of the State of Florida. County and/or Partner will be referred to as the "Party" or "Parties."

#### **RECITALS**

- A. County, on behalf of its Resilient Environment Department (previously called Environmental Planning and Community Resilience Department), intends to enter into a separate agreement with the United States Geological Survey ("USGS") for a cooperative study that will evaluate the changes to the spatial distribution of salinity within the surficial aquifer of the urbanized areas of Broward County resulting from projected future hydrologic conditions ("USGS Agreement").
- B. Saltwater intrusion into the coastal part of the surficial aquifer of Southeast Florida is a major concern for water-supply managers in Broward County, Florida. The location and width of the saltwater front, or the mixing zone formed at the interface between fresh and saline groundwater, is heavily influenced by the local hydrology and responds to changes to the hydrologic conditions. Accordingly, increases in mean sea level, coastal wellfield pumping, or decreases in groundwater recharge would likely lead to a westward intrusion of the saltwater front, also known as saltwater intrusion. Conversely, decreases in coastal wellfield pumping and increases in groundwater recharge (e.g., wet season, wet years) can result in the seaward movement of the saltwater front.
- C. Saltwater intrusion into the coastal wellfields poses a threat to the fresh drinking water supplies in coastal areas.
- D. A variable density, numerical groundwater model capable of simulating the three-dimensional distribution of salinity within the surficial aquifer could be used to simulate

the encroachment of the saltwater front further into the County under various projections of future hydrologic conditions.

E. Some models have been completed and the next step in the evolution of the variable density models within Broward County is to further develop a merged model by incorporating improved input datasets, expanding the historical simulation period, improving the calibration of the model, and testing future scenarios with more recent sea-level and climate projections.

F. The primary objective of the study is to develop a tool to simulate the distribution of salinity within the surficial aquifer for the urban areas of Broward County under historical and/or projected conditions and to assess the projected changes to the saltwater front due to expected or proposed changes to the hydrologic conditions (e.g., sea level, wellfield pumping rates, recharge).

G. The results from the study will help inform Broward County water-supply managers on the current, historical, and projected future spatial distributions of salinity within the surficial aquifer and help identify the primary influences on the advancement of the saltwater front. The variable density numerical model developed during the study will provide the County with a tool capable of simulating projected future conditions and evaluating the effects of various changes to the hydrologic conditions on the salinity distribution.

H. County is seeking partner funding for the study to be performed pursuant to the USGS Agreement.

I. Partner agrees to contribute funds towards the study to be performed pursuant to the USGS Agreement.

Now, therefore, for good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the Parties agree as follows:

#### **ARTICLE 1. DEFINITIONS**

- 1.1. Board. The Board of County Commissioners of Broward County, Florida.
- 1.2. Contract Administrator. The Deputy Director of the Broward County Resilient Environment Department or such person as designated by County.
- 1.3. County Administrator. The administrative head of County pursuant to Sections 3.02 and 3.03 of the Broward County Charter.
- 1.4. Project. The project or projects for the "Evaluation of Changes to the Salinity Distribution within the Surficial Aquifer under Projected Future Hydrologic Conditions, Broward County, Florida", set forth in the USGS Agreement, and Exhibit A.

## ARTICLE 2. EXHIBITS

<b>Exhibit A</b>	<b>Scope of Services for USGS Agreement</b>
<b>Exhibit B</b>	<b>Partner Payment Schedule</b>

## ARTICLE 3. SCOPE OF SERVICES

- 3.1. Partner shall provide cost sharing for the Project, payable to the County as outlined in Article 4 and Exhibit B.
- 3.2. It is understood and agreed that County intends to enter into the USGS Agreement for the performance of the Project, the Scope of Services of which is attached hereto as Exhibit A, and that changes to the Scope of Services of the USGS Agreement may be made without affecting this agreement. The Parties agree that the Scope of Services for the Project is a description of all work to be performed under the USGS Agreement and includes preliminary considerations and prerequisites and all labor, materials, equipment, and tasks.
- 3.3. Partner shall not be responsible for any additional costs or expenses associated with the USGS Agreement beyond the cost sharing support as agreed to herein.

## ARTICLE 4. FINANCIAL CONTRIBUTION

- 4.1. Partner shall provide County a cost share participation in the amount of Eighty-seven Thousand Four Hundred Thirty-six Dollars (\$87,436).
- 4.2. Pursuant to the USGS Agreement, the Project is being funded by the USGS at the level of fifty percent (50%) of the total cost of the Project, or Five Hundred Twenty-four Thousand Six Hundred Sixteen Dollars (\$524,616), with the remaining costs being shared by the County at the level of twenty-five percent (25%), or Two Hundred Sixty-two Thousand Three Hundred Eight Dollars (\$262,308), and the cities of Hollywood, Fort Lauderdale, and Pompano Beach each contributing eight and thirty-three hundredths percent (8.33%), or Eighty-seven Thousand Four Hundred Thirty-six Dollars (\$87,436), for a total of Two Hundred Sixty-two Thousand Three Hundred Eight Dollars (\$262,308) in municipal cost sharing.
- 4.3. Partner agrees to pay County, in the manner specified in Section 4.4, Method of Billing and Payment, the total of Eighty-seven Thousand Four Hundred Thirty-six Dollars (\$87,436) for cost sharing support of the Project as set forth in Exhibit A, which amount shall be accepted by County as full satisfaction of cost share participation. It is acknowledged and accepted by County that this amount is the maximum payable and constitutes a limitation upon Partner's obligation to County.

4.4. Method of Billing and Payment.

- 4.2.1. County may submit annual invoices for cost share participation related to services completed under the USGS Agreement. Invoices must be in the form of one (1) original invoice plus one (1) copy. Invoices shall designate the nature of the services performed and/or expenses incurred under the cost share Project.
- 4.2.2. The invoice(s) submitted for this Interlocal Agreement shall be for a scheduled annual amount as agreed to by both Parties and delineated in the table of Exhibit B.
- 4.2.3. Partner shall pay County within thirty (30) days after receipt of County's invoice.
- 4.2.4. Payment shall be made to County at:

Broward County Board of County Commissioners  
Dr. Jennifer Jurado, Deputy Director  
Resilient Environment Department  
115 South Andrews Avenue, RM 329  
Fort Lauderdale, Florida 33301  
Email address: [jjurado@broward.org](mailto:jjurado@broward.org)

**ARTICLE 5. TERM AND TIME OF AGREEMENT**

- 5.1. Term. The term of this Agreement shall begin upon recordation (the "Effective Date"). The term of the Agreement shall be for a period of three (3) years from the Effective Date.
- 5.2. Extensions. The 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.
- 5.3. Fiscal Year. The continuation of this Agreement beyond the end of any Party's fiscal year shall be subject to both the appropriation and the availability of funds, in accordance with Chapters 129 and 166, Florida Statutes.
- 5.4. Force and Effect. All duties, obligations, and responsibilities of the Parties required by this Interlocal Agreement shall remain in full force and effect throughout the term of this Interlocal Agreement, as set forth above, unless written notice of termination by County or Partner is provided pursuant to the Notices provision.
- 5.5. Time of the Essence. Time is of the essence for all performance required under this Interlocal Agreement.

**ARTICLE 6. TERMINATION**

- 6.1. The Parties agree that, upon the USGS Agreement becoming effective, and unless the USGS Agreement is terminated, neither Party shall be entitled to terminate this Interlocal Agreement.

#### **ARTICLE 7. GOVERNMENTAL IMMUNITY AND LIABILITY PROTECTION**

- 7.1. Nothing herein is intended to serve as a waiver of sovereign immunity by any Party nor shall any term included herein be construed as consent to be sued by third parties in any matter arising out of this Agreement or any other contract. County and Partner, to the extent that they are state agencies or political subdivisions as defined in Chapter 768.28, Florida Statutes, agree to be fully responsible for the acts and omissions of their agents or employees to the extent permitted by law.
- 7.2. Partner is an entity subject to Section 768.28, Florida Statutes, and Partner shall furnish Contract Administrator with written verification of liability protection in accordance with state law prior to final execution of said Agreement.

#### **ARTICLE 8. MISCELLANEOUS**

- 8.1. Contract Administrator Authority. The Contract Administrator is authorized to coordinate and communicate with Partner and USGS to manage and supervise the performance of this Interlocal Agreement and the USGS Agreement. Unless expressly stated otherwise in this Agreement or otherwise set forth in an applicable provision of the Broward County Procurement Code, Broward County Code of Ordinances, or Broward County Administrative Code, the Contract Administrator may exercise any ministerial authority in connection with the day-to-day management of this Interlocal Agreement.
- 8.2. Ownership of Documents. Any and all reports, photographs, surveys, and other data and documents provided or created in connection with this Interlocal Agreement are and shall remain the property of County. To the extent permitted by law, the Partner and County shall retain joint ownership of any intellectual property, models, or new technology that result from the execution of this Interlocal Agreement.
- 8.3. Assignment. Neither this Agreement nor any interest herein shall be assigned, transferred, or encumbered by either Party. If Partner violates this provision, County shall have the right to immediately terminate this Agreement. County's participation in the USGS Agreement shall not be deemed an assignment.
- 8.4. Public Records. To the extent either Party is acting on behalf of the other as stated in Section 119.0701, Florida Statutes, each Party shall:
  - 8.4.1. Keep and maintain public records related to this Interlocal Agreement;
  - 8.4.2. Upon request, provide the other Party with a copy of the requested records or allow the records to be inspected or copied within a reasonable time and at a cost

that does not exceed that provided in Chapter 119, Florida Statutes, or as otherwise provided by law;

- 8.4.3. Ensure that public records that are exempt or confidential and exempt from public record requirements are not disclosed except as authorized by law for the duration of this Interlocal Agreement and following completion or termination of this Interlocal Agreement; and
- 8.4.4. Upon completion or termination of this Interlocal Agreement, each Party shall keep and maintain all public records related to this Interlocal Agreement and shall destroy any duplicate public records that are exempt or confidential and exempt. All records stored electronically must be provided to County upon request in a format that is compatible with the information technology systems of County.

Any material a Party contends constitutes or contains trade secrets or is otherwise exempt from production under Florida public records laws (including Chapter 119, Florida Statutes) ("Trade Secret Materials") must be separately submitted and conspicuously labeled "EXEMPT FROM PUBLIC RECORD PRODUCTION – TRADE SECRET." In addition, the Party providing the material must, simultaneous with the submission of any Trade Secret Materials, provide a sworn affidavit from a person with personal knowledge attesting that the Trade Secret Materials constitute trade secrets under Section 812.081, Florida Statutes, and stating the factual basis for same. If a third party submits a request to either Party for records designated as Trade Secret Materials, that Party shall refrain from disclosing the Trade Secret Materials, unless otherwise ordered by a court of competent jurisdiction or authorized in writing by the Party claiming the exemption. Neither Party waives any defense of sovereign immunity or increases the limits of its liability by entering into this Agreement, and each Party shall be liable for its own negligence and does not assume any liability for the other Party's negligence relating to the nondisclosure of any Trade Secret Materials in response to a records request by a third party.

**IF PARTNER HAS QUESTIONS REGARDING THE APPLICATION OF CHAPTER 119, FLORIDA STATUTES, TO PARTNER'S DUTY TO PROVIDE PUBLIC RECORDS RELATING TO THIS AGREEMENT, CONTACT THE CUSTODIAN OF PUBLIC RECORDS AT (954) 357-6613, JKLADERMAN@BROWARD.ORG, 115 S. ANDREWS AVE., SUITE 329H, FORT LAUDERDALE, FLORIDA 33301.**

- 8.5. Materiality and Waiver of Breach. Each requirement, duty, and obligation set forth in this Interlocal Agreement was bargained for at arm's-length and is agreed to by the Parties. Each requirement, duty, and obligation set forth in this Interlocal Agreement is substantial and important to the formation of this Interlocal Agreement, and each is, therefore, a material term of this Interlocal Agreement. Neither Party's failure to enforce any provision of this Interlocal Agreement shall be deemed a waiver of such provision or modification of this Interlocal Agreement. A waiver of any breach of a provision of this Interlocal 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 Interlocal Agreement. To be effective, any waiver must be in writing signed by an authorized signatory of the Party granting the waiver.

- 8.6. Notices. In order for notice to a Party to be effective under this Interlocal 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.

NOTICE TO COUNTY:

Broward County Resilient Environment Department  
115 South Andrews Avenue, Room 329  
Fort Lauderdale, Florida 33301  
Email address: jjurado@broward.org

With copy to:

Broward County Administrator  
115 South Andrews Avenue, Suite 409  
Fort Lauderdale, Florida 33301  
Email Address: mcepero@broward.org

NOTICE TO PARTNER:

City of Fort Lauderdale  
City Manager  
100 North Andrews Avenue  
Fort Lauderdale, FL 33301

With a copy to:

City Attorney  
100 North Andrews Avenue  
Fort Lauderdale, FL 33301  
Email address: rhasan@fortlauderdale.gov

- 8.7. Compliance with Laws. Each Party shall comply with all federal, state, and local laws, codes, ordinances, rules, and regulations in performing its duties, responsibilities, and obligations under this Interlocal Agreement.
- 8.8. Third Party Beneficiaries. The Parties acknowledge that there are no third party beneficiaries under this Interlocal Agreement.
- 8.9. Severability. In the event any part of this Interlocal Agreement is found to be unenforceable by any court of competent jurisdiction, that part shall be deemed severed from this Interlocal Agreement and the balance of this Interlocal Agreement shall remain in full force and effect.

- 8.10. Joint Preparation. This Interlocal Agreement has been jointly prepared by the Parties hereto, and shall not be construed more strictly against either Party.
- 8.11. 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 Interlocal Agreement by reference and a term, statement, requirement, or provision of Articles 1 through 8 of this Agreement, the term, statement, requirement, or provision contained in Articles 1 through 8 shall prevail and be given effect.
- 8.12. Headings and Interpretation. The headings contained in this Interlocal Agreement are for reference purposes only and shall not in any way affect the meaning or interpretation of this Agreement. All personal pronouns used in this Interlocal 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 Interlocal Agreement as a whole and not to any particular sentence, paragraph, or section where they appear, unless the context otherwise requires.
- 8.13. Governing Law, Venue and Waiver of Jury Trial. This Interlocal Agreement shall be interpreted and construed in accordance with, and governed by, the laws of the state of Florida. The Parties agree that the exclusive venue for any lawsuit arising from, related to, or in connection with this Interlocal Agreement shall be in the state courts of the Seventeenth Judicial Circuit in and for Broward County, Florida. If any claim arising from, related to, or in connection with this Agreement must be litigated in federal court, the Parties agree that the exclusive venue for any such lawsuit shall be in the United States District Court or United States Bankruptcy Court for the Southern District of Florida. **BY ENTERING INTO THIS AGREEMENT, PARTNER AND COUNTY HEREBY EXPRESSLY WAIVE ANY AND ALL RIGHTS EITHER PARTY MAY HAVE TO A TRIAL BY JURY OF ANY CIVIL LITIGATION RELATED TO THIS AGREEMENT.**
- 8.14. Amendments. Except as provided in Section 5.2, no modification, amendment, or alteration in the terms or conditions contained herein shall be effective unless contained in a written document prepared with the same or similar formality as this Interlocal Agreement and executed by duly authorized representatives of County and Partner.
- 8.15. Prior Agreements. This Interlocal Agreement represents the final and complete understanding of the Parties regarding the subject matter hereof and supersedes all prior and contemporaneous negotiations and discussions regarding that subject matter. There is no commitment, agreement, or understanding concerning the subject matter of this Interlocal Agreement that is not contained in this written document.
- 8.16. Incorporation by Reference. The truth and accuracy of each “Recital” clause set forth above is acknowledged by the Parties. The attached Exhibits are incorporated into and made a part of this Agreement.



- 8.17. Representation of Authority. Each individual executing this Interlocal Agreement on behalf of a Party hereto does hereby represent and warrant that he or she is, on the date he or she signs this Interlocal Agreement, duly authorized by all necessary and appropriate action to execute this Interlocal Agreement on behalf of such Party.
- 8.18. Counterparts and Multiple Originals. This Interlocal Agreement may be executed in multiple originals, and may be executed in counterparts, each of which shall be deemed to be an original, but all of which, taken together, shall constitute one and the same agreement.
- 8.19. Use of County or Partner Logos. The Parties agree that either Party's name or logo shall not be used in any marketing or publicity materials related to this Interlocal Agreement without the prior written consent of that Party.
- 8.20. Independent Contractors. The Parties are independent contractors, and nothing in this Interlocal Agreement shall constitute or create a legal entity, partnership, joint venture, or any other relationship between the Parties. Neither Party nor their agents shall act as officers, employees, or agents of the other. Neither Party shall have the right to bind the other Party to any obligation not expressly undertaken by this Interlocal Agreement.
- 8.21. Regulatory Capacity. Notwithstanding the fact that County is a political subdivision with certain regulatory authority, County's performance under this Interlocal Agreement is as a Party to this Interlocal Agreement and not in its regulatory capacity. If County exercises its regulatory authority, the exercise of such authority and the enforcement of any rules, regulations, laws, and ordinances shall have occurred pursuant to County's regulatory authority as a governmental body separate and apart from this Interlocal Agreement and shall not be attributable in any manner to County as a Party to this Interlocal Agreement.

(The remainder of this page is intentionally left blank.)

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 County Administrator, authorized to execute same by Board action on the \_\_\_\_ day of \_\_\_\_\_, 20\_\_, and Partner, signing by and through its \_\_\_\_\_, duly authorized to execute same.

COUNTY

<p>ATTEST:</p>  <p>_____</p> <p>Broward County Administrator, as ex officio Clerk of the Broward County Board of County Commissioners</p>	<p>BROWARD COUNTY, by and through its Board of County Commissioners</p> <p>By: _____</p> <p>_____ day of _____, 20__</p> <p>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</p> <p>By: _____ Deanna Kalil (Date) Assistant County Attorney</p> <p>By: _____ Michael C. Owens (Date) Senior County Attorney</p>
---	---

INTERLOCAL AGREEMENT BETWEEN BROWARD COUNTY AND PARTNER FOR COST SHARING SUPPORT OF USGS PROJECT FOR "EVALUATION OF CHANGES TO THE SALINITY DISTRIBUTION WITHIN THE SURFICIAL AQUIFER UNDER PROJECTED FUTURE HYDROLOGIC CONDITIONS, BROWARD COUNTY, FLORIDA"

City of Fort Lauderdale

Attest:

\_\_\_\_\_  
David R. Soloman, City Clerk

By \_\_\_\_\_  
Mayor Dean Trantalis

\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_

By \_\_\_\_\_  
Greg Chavarria, City Manager

\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_

APPROVED AS TO FORM AND CORRECTNESS:

\_\_\_\_\_  
Rhonda Montoya Hasan  
Assistant City Attorney

**EXHIBIT A**  
**SCOPE OF SERVICES FOR USGS PROJECT FOR “EVALUATION OF CHANGES TO THE SALINITY DISTRIBUTION WITHIN THE SURFICIAL AQUIFER UNDER PROJECTED FUTURE HYDROLOGIC CONDITIONS, BROWARD COUNTY, FLORIDA”**

**Title:** Evaluation of Changes to the Salinity Distribution within the Surficial Aquifer under Projected Future Hydrologic Conditions, Broward County, Florida

**Cooperator:** Broward County Resilient Environment Department

**1. Executive Summary:**

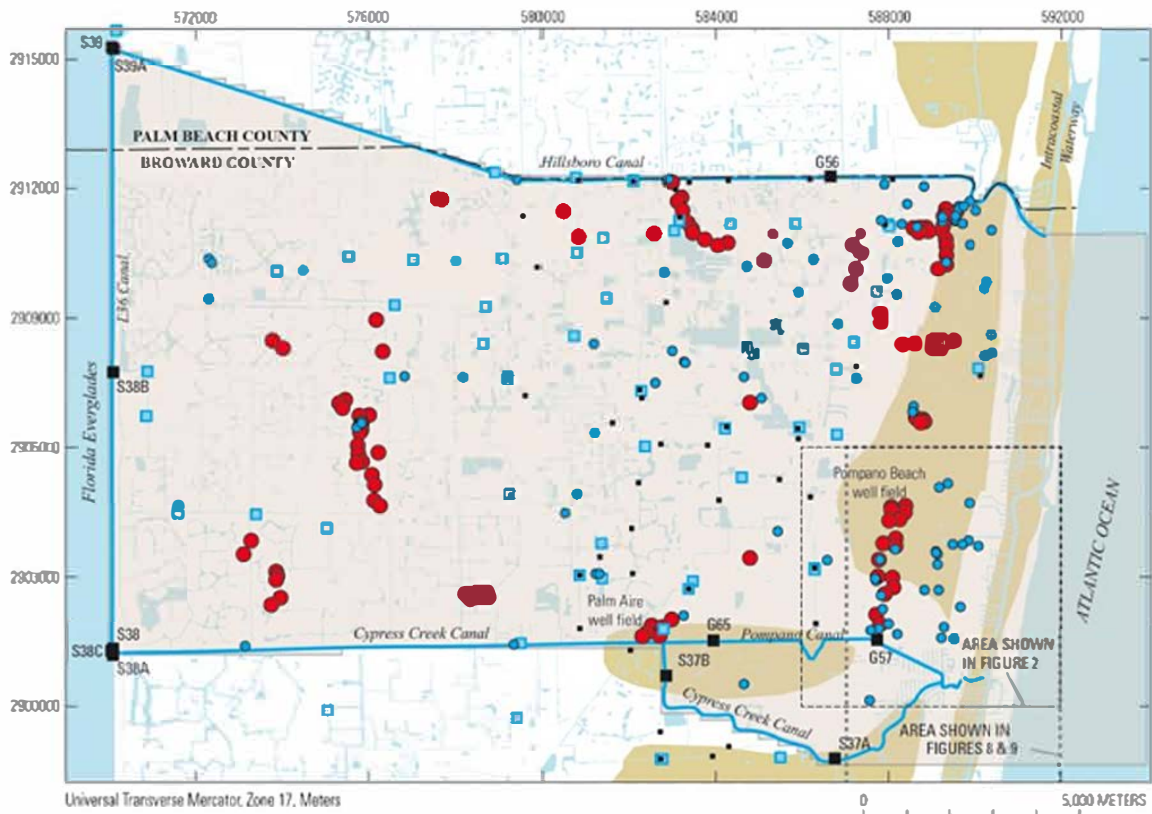
This proposal describes a proposed cooperative study between the U.S. Geological Survey and the Resilient Environment Department of Broward County, Florida. The primary objective of this study would be to evaluate the changes to the spatial distribution of salinity within the surficial aquifer for the urbanized areas of Broward County resulting from projected future hydrologic conditions. A variable density groundwater flow and transport model will be developed based on existing models and will incorporate improvements to input data, simulation tools, and parameter estimation techniques.

Future scenarios will be developed using projected sea-level estimates and changes to climate. Model output (e.g., water levels, system flows, and salinity distribution) will be used to evaluate the groundwater system’s response to projected future hydrologic conditions. Simulations may incorporate possible adaptation or mitigation strategies such as reallocation of well-field pumping rates or changes to the surface-water controls. A USGS report documenting the development of the flow and transport model and study results will be produced. Additionally, the flow and transport model and model archive will be released to the cooperator and the public as a USGS Data Release.

**2. Background and Problem Statement:**

Saltwater intrusion into the coastal part of the surficial aquifer of southeast Florida is a major concern for water-supply managers in Broward County, Florida. The general west-to-east decrease in the height of the potentiometric surface causes flow of fresh groundwater eastward and towards the saline groundwater that intrudes along the coastline. The result is a dynamic mixing zone that forms the interface between the two fluids, which is often called the saltwater front. The location of the saltwater front and the width of this mixing zone is heavily influenced by the local hydrology and responds to changes to the hydrologic conditions. Increases in mean sea level would likely lead to decreased west-to-east groundwater level gradients resulting in a reduced seaward fresh-groundwater flux and westward intrusion of the saltwater front. Increases in coastal wellfield pumping or decreases in groundwater recharge (e.g., dry season, periods of drought) can also lead to saltwater intrusion. Conversely, decreases in coastal wellfield pumping and increases in groundwater recharge (e.g., wet season, wet years) can result in the seaward movement of the saltwater front. Saltwater intrusion into the coastal wellfields poses a threat to the fresh drinking water supplies in coastal areas. A variable density, numerical groundwater model capable of simulating the three-dimensional distribution of salinity within the surficial aquifer could be used to simulate the encroachment of the saltwater front further into the county under various projections of future hydrologic conditions.

The U.S. Geological Survey has developed three (3) variable-density numerical models for Broward County in recent years. Dausman and Langevin (2005) developed a variable density model of a hypothetical area patterned after west-central Broward County using the SEAWAT (Langevin and others, 2008) modeling code. The study focused on the causes of saltwater intrusion and was used to determine the feasibility of developing a calibrated saltwater intrusion model for the coastal well fields within the county. The model was able to simulate long-term saltwater intrusion patterns and led to the development of two (2) additional studies. Langevin and Zygnerski (2013) developed a SEAWAT model for the northern portion of Broward County to evaluate the sensitivity of well-field water quality to sea-level rise and changes to well-field pumping rates (fig. 1). The “northern model” was calibrated using Parameter ESTimation (PEST) software (Doherty, 2010) and sea-level rise was simulated using four (4) different rates over a 100-year period. Hughes and others (2016) used the techniques from these previous two (2) models to develop a saltwater-intrusion model for the central and southern parts of Broward County. The “central/southern model” was calibrated using PEST and simulated historical conditions from 1950 to 2012 (fig. 2). The model was used to evaluate the sensitivity of the salinity distribution to sea-level rise and changes to well-field pumping rates. Since the release of the northern and central/southern saltwater intrusion models, Broward County has worked to combine the model inputs into one (1) “merged model” encompassing all the urban areas within the county. The county has also worked to extend the historical simulation period and further refine the model input datasets.



Universal Transverse Mercator, Zone 17, Meters

0 5,000 METERS



**EXPLANATION**

- Atlantic coastal ridge
- Active model domain
- Primary canal
- Primary structure
- Monitoring well
- Secondary structure
- Surface water gauge
- Municipal well

Figure 1. Map of study area showing active model domain, surface-water control structures, municipal wells, and surface water gauges used for the variable-density saltwater intrusion model developed for northern Broward County (Langevin and Zygnerski, 2013).



Related modeling efforts include two (2) studies within Broward County to evaluate the likelihood for increased inundation under various future mean sea levels and a study conducted in neighboring Miami-Dade County to simulate the salinity intrusion under future sea level and well-field pumping scenarios. The studies conducted in Broward County (referred to as the “inundation models”) used the calibrated aquifer parameters from the central/southern saltwater intrusion model but were not variable density and did not include solute transport (Decker and others, 2018; Decker, 2021). The inundation models were focused on the simulation of the surface-water control structures under future projections of sea level and the effects on groundwater. The study conducted in Miami-Dade also did not include solute transport but did use the SeaWater Intrusion (SWI) package in MODFLOW to simulate the saltwater interface and its movement due to changes in sea level and pumping rates (Hughes and White, 2014). Additionally, the USGS developed a solute transport model known as BISECT that covered the southern end of Florida, which included Miami-Dade County as well as Everglades National Park (Swain and others, 2019). The BISECT model was used to study the effects of sea-level increases as well as changes in other parameters and forcings on the distribution salinity within the surface-water and groundwater systems.

The next step in the evolution of the variable density models within Broward County is to further develop the merged model by incorporating improved input datasets, expanding the historical simulation period, improve the calibration of the model, and test future scenarios with more recent sea-level and climate projections.

### **3. Objectives and Scope:**

The primary objective of the proposed study is to develop a tool to simulate the distribution of salinity within the surficial aquifer for the urban areas of Broward County under historical and/or projected conditions and to assess the projected changes to the saltwater front due to expected or proposed changes to the hydrologic conditions (e.g., sea level, wellfield pumping rates, recharge). The approximate active model domain is represented by the combined northern and central/southern models (figs. 1 & 2) which constitute the merged model that Broward County and the USGS have developed. The project’s primary objective can be further divided into five specific objectives:

1. Accurately simulate the historical (approximately fifty (50) year) saltwater distribution and the patterns of change detected within the salinity data observed at the monitoring stations throughout the county.
2. Simulate the potential changes to salinity distribution in the coastal areas due to projected increases in mean sea level (approximately fifty (50) year).
3. Evaluate the influence of coastal well-field pumping on the location and advancement of the saltwater front for historical and future sea level simulations.
4. Evaluate the influence of aquifer recharge estimates (that acknowledge climate model-simulated changes in precipitation) on the salinity distribution within the surficial aquifer under projected future mean sea levels.



5. Develop a hydrologic budget for the modeling domain that accounts for recharge, evapotranspiration, surface-water/groundwater exchange, changes in aquifer storage, and groundwater flux to and from the surficial aquifer along the boundaries.

#### **4. Relevance and Benefits:**

The results from the proposed study will help inform Broward County managers on the current, historical, and projected future spatial distributions of salinity within the surficial aquifer and help identify the primary influences on the advancement of the saltwater front. The variable density numerical model developed during the study will provide the county with a tool capable of simulating projected future conditions and evaluate the effects of various changes to the hydrologic conditions on the salinity distribution. Additionally, during the project it would be desirable to communicate the importance and improve the understanding of the effects of future sea level and water use on salinity intrusion within the region to a broader audience. These beneficial outreach activities could include presentations at local colleges and universities, regional utilities, or local chapter meetings of environmental groups.

This study aligns with the goals, objectives, and actions outlined in USGS circular 1383-G (Evenson and others, 2013) by providing/aiding in the (1) advancement of the understanding of processes that determine water availability and effects from human interactions (Goal 2, Objective 4, Strategic Action 12); (2) development and application of models to predict the potential effects of changes in population, land-use, climate, and management practices upon future water availability considering human and ecological needs (Goal 3, Objective 1, Strategic Action 14, 15, 16, 17); and (3) identifying the current and future threats to communities from water-related hazards (Goal 4, Objective 1, Strategic Actions 19, 20). The proposed project also aligns with the Caribbean-Florida Water Science Center Strategic Science Plan (Stamm and others, 2017) by evaluating water availability, water quality, and the risk of further saltwater intrusion in response to increased sea level and providing tools to assess the uncertainty of future conditions and the effect on the hydrologic system.

#### **5. Approach**

To achieve the projects objectives, a three-dimensional, variable-density groundwater flow and transport model will be further developed from existing groundwater models and will incorporate expanded input datasets, new modeling tools, and will undergo additional parameter estimation with the objective of improving model fit to observed trends. The proposed model will build on the efforts made by Broward County in combining the northern and central/southern variable density models into a single merged model encompassing the urban areas within the county. The proposed model will be constructed using MODFLOW 6 (Hughes and others, 2017), which incorporates the capabilities of MODFLOW-2005, SEAWAT, and MODFLOW-USG allowing for the simulation of variable density groundwater flow using an unstructured grid. The ability to simulate using an unstructured grid permits the use of a refined grid in areas of particular interest such as coastal well fields without the computational burden of grid refinement throughout the study area or the use of submodeling.

The first task will be to identify, gather, and organize expanded or improved input datasets for the entire modeling domain. This includes updating observations and stress inputs such as historical groundwater levels, groundwater and surface-water salinity measurements, historical canal stages, and historical recharge/precipitation rates. Improvements to state-wide estimated historical evapotranspiration (ET) have been made in recent years and will be incorporated into the model input dataset. Additionally, improved information about the surface-water canal system is now available from the ongoing inundation model project and can provide expanded canal coverage and improved knowledge concerning the surface-water/groundwater interactions (Decker, in preparation).

The second task will be to transfer the existing and improved datasets from the merged variable density model into the MODFLOW 6 framework. This task will include the identification of areas where it would be desired to use the grid refinement capabilities of MODFLOW 6. The result from this second task will be a single, variable-density groundwater flow model (“historical model”) of the urban area of Broward County capable of completing an historical simulation of approximately fifty (50) years using the estimated model parameters from the previous studies.

The third task will involve the recalibration of the single model using the model-independent Parameter ESTimation (PEST) software. PEST was previously used for the estimation of the groundwater flow parameters for the northern and central/southern models as separate studies. The groundwater flow model parameters will be estimated using observed historical groundwater levels and salinity values. The fit to the observed salinity distribution will emphasize historical trends and the timing of the movement of the saltwater front as evidenced in the salinity observations. The newly estimated model input parameters will then be incorporated into the historical model and the simulated results from the historical period will be used as a baseline for the evaluation of the effects of the projected changes to the future hydrologic conditions.

The fourth task will be to define and simulate several future conditions scenarios to evaluate the effects on the salinity distribution and movement of the saltwater front. The scenarios should incorporate projected sea-level rise and possible changes to precipitation. Changes in pumping rate and the reallocation of pumping between well fields could also be evaluated to assess the effects on the saltwater front. At this point, additional mitigation/adaptation strategies could be identified and evaluated with input from Broward County managers.

The fifth task will be to document the model development, results, and analysis. A U.S. Geological Survey Scientific Investigations Report will be prepared and published at the conclusion of the study. Additionally, a U.S. Geological Survey data release will be prepared and will contain all the necessary executables and model input files to reproduce the historical and future scenario modeling results. The data release will also contain any pre- or post-processing executables required for simulation analysis.

Throughout the model development, testing and documentation the U.S. Geological Survey will work with officials at Broward County to facilitate the transfer of knowledge to prepare them for future modifications and scenario development. This collaboration would include the development of pre-processing tools that create new stress inputs or change model parameters and post-processing tools to examine model results. A guided workshop will be arranged near the completion of the project to further explain the model components and convey the necessary steps in reproducing the simulation results and creating new scenarios to test.

## **6. QA/QC and Data Management**

No new hydrologic data will be collected for this project; all data being used are pre-existing, and furnished by the cooperator or relevant entities, or are served from publicly available data bases, for example, DBHYDRO, or NWIS. Data analyzed for or presented in the project deliverables, that are provided by the cooperator, and are neither proprietary nor publicly available, will be released according to USGS Instructional Memoranda IM OSQI 2015-01 regarding scientific data management, metadata, review and approval, publication and sharing, and preservation. (<http://www.usgs.gov/usgs-manual/im/IM-OSQI-2015-01.html>; <http://www.usgs.gov/datamanagement/policyreferences.php>). A Data Management Plan (DMP) has been developed for the proposal and included for Center and OQA review. Deep technical reviews will be conducted around the 10%, 40%, and 70% completion dates. Project personnel will work with supervisor and technical leads to identify appropriate reviewers for the internal technical reviews.

The USGS will calibrate the models it develops to generally match observed groundwater levels, surface water stages, salinity, or other derived observations. The USGS will investigate model sensitivity and articulate model limitations. The model will be documented and archived according to:

- 1) USGS Office of Groundwater Technical Memorandum 2015.02/Office of Surface Water Technical Memorandum 2015.01/Office of Water Quality Technical Memorandum 2015.01: "Policy and guidelines for archival for surface-water, groundwater, and water-quality model applications" (available at <http://water.usgs.gov/admin/memo/GW/gw2015.02.pdf>).
- 2) USGS Office of Groundwater Technical Memorandum 2016.02: "Policy for Documenting, Archiving, and Public Release of Numerical Groundwater Flow and Transport Models" (available at <https://water.usgs.gov/admin/memo/GW/gw2016.02.pdf>).
- 3) "Instructions for Documenting, Archiving, and Public Release of Numerical Groundwater Flow and Transport Models" <https://water.usgs.gov/ogw/policy/gw-model/>.

All report(s) and/or journal article(s) authored by USGS personnel will conform to USGS Fundamental Science Practices (<http://www.usgs.gov/fsp/>), which include quality assurance and quality control elements.

## **7. Information Products**

- 1) U.S. Geological Survey Scientific Investigations Report documenting the variable density flow model and results
- 2) U.S. Geological Survey Data Release containing the variable density flow model and archive

## 8. References

- Dausman, Alyssa, and Langevin, C.D., 2005, Movement of the Saltwater Interface in the Surficial Aquifer System in Response to Hydrologic Stresses and Water-Management Practices, Broward County, Florida: U.S. Geological Survey Scientific Investigations Report 2004-5256, 73p.
- Decker, J.D. in preparation, Drainage infrastructure and Groundwater System Response to Changes in Sea-Level and Precipitation, Broward County, Florida: U.S. Geological Survey Scientific Investigations Report.
- Decker, J.D., Hughes, J.D., and Swain, E.D., 2019, Potential for increased inundation in flood-prone regions of southeast Florida in response to climate and sea-level changes in Broward County, Florida, 2060–69: U.S. Geological Survey Scientific Investigations Report 2018–5125, 106 p., accessed November 3, 2021, at <https://doi.org/10.3133/sir20185125>.
- Doherty, J.E., 2010, PEST, model-independent parameter estimation—User manual (5th ed.): Brisbane, Australia, Watermark Numerical Computing, 336 p.
- Evenson, E.J., Orndorff, R.C., Blome, C.D., Böhlke, J.K., Hershberger, P.K., Langenheim, V.E., McCabe, G.J., Morlock, S.E., Reeves, H.W., Verdin, J.P., Weyers, H.S., and Wood, T.M., 2013, U.S. Geological Survey water science strategy—Observing, understanding, predicting, and delivering water science to the Nation: U.S. Geological Survey Circular 1383–G, 49 p. (Also available at <https://pubs.usgs.gov/circ/1383g/circ1383-G.pdf>)
- Hughes, J.D., Langevin, C.D., and Banta, E.R., 2017, Documentation for the MODFLOW 6 framework: U.S. Geological Survey Techniques and Methods, book 6, chap. A57, 40 p., <https://doi.org/10.3133/tm6A57>
- Hughes, J.D., Sifuentes, D.F., and White, J.T., 2016, Simulated effects of alterations to the hydrologic system on the distribution of salinity in the Biscayne aquifer in Broward County, Florida: U.S. Geological Survey Scientific Investigations Report 2016–5022, 114 p., accessed November 3, 2021, <https://doi.org/10.3133/sir20165022>.
- Hughes, J.D., and White, J.T., 2014, Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow: U.S. Geological Scientific Investigations Report 2014–5162, 175 p., accessed August 1, 2018, at <http://dx.doi.org/10.3133/sir20145162>.
- Langevin, C.D., and Zygnerski, M., 2013, Effect of sea-level rise on saltwater intrusion near a coastal well field in south-eastern Florida: Ground Water, v. 51, no. 5, p. 781–803.
- Renken, R.A., Dixon, J., Koehmstedt, J., Ishman, S., Lietz, A.C., Marella, R.L., Telis, P., Rogers, J., and Memberg, S., 2005, Impact of anthropogenic development on coastal ground-water hydrology in southeastern Florida, 1900–2000: U.S. Geological Survey Circular 1275, 77 p.
- Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group, 2020, Unified sea level rise projection southeast Florida: Southeast Florida Regional Climate Change Compact Climate Leadership Committee, 36 p., accessed November 3, 2021, at <https://southeastfloridaclimatecompact.org/unified-sea-level-rise-projections/>

- Stamm, J.F., Rodríguez, J.M., Sifuentes, D.F., Sumner, D.M., and Grimsley, K.J. with contributions from Bogeajis, N., Torres-González, S., McBride, W.S., Parks, J., and Decker, J., 2017, **The USGS Caribbean-Florida Water Science Center Strategic Science Plan 2017-2027: A blueprint for USGS contributions to water resource science in Florida, Puerto Rico, and the US Virgin Islands**: available at [https://www.usgs.gov/centers/car-fl-water/science/cfwsestrategic-science-plan?qt-science\\_center\\_objects=0#qt-science\\_center\\_objects](https://www.usgs.gov/centers/car-fl-water/science/cfwsestrategic-science-plan?qt-science_center_objects=0#qt-science_center_objects)
- Swain, E.D., Lohmann, M.A., and Goodwin, C.R., 2019, The hydrologic system of the south Florida peninsula—Development and application of the Biscayne and Southern Everglades Coastal Transport (BISECT) model: U.S. Geological Survey Scientific Investigations Report 2019–5045, 114 p., <https://doi.org/10.3133/sir20195045>

**EXHIBIT B  
PAYMENT SCHEDULE  
Partner**

Total consideration for this Agreement is subject to multi-year funding allocations, and funding for each applicable fiscal year of this Agreement will be subject to County and Partner budgetary appropriations. In the event County or Partner does not approve funding for any subsequent fiscal year, this Agreement shall terminate upon expenditure of the current funding, notwithstanding other provisions in this Agreement to the contrary. Invoices may be sent either annually, or for a lump sum payment in the first fiscal year of the Interlocal Agreement, as determined in agreement with both Parties. Invoices shall be issued with payment to be received no later than thirty (30) days after receipt.

	<b>Project Fiscal Year 1</b>	<b>Project Fiscal Year 2</b>	<b>Project Fiscal Year 3</b>	<b>Project Fiscal Year 4</b>	<b>Project Total</b>
<b>Total Project Costs</b>	<b>\$ 170,912</b>	<b>\$ 340,488</b>	<b>\$ 355,938</b>	<b>\$ 181,894</b>	<b>\$ 1,049,232</b>
USGS Cooperator Funding	\$ 85,456	\$ 170,244	\$ 177,969	\$ 90,947	\$ 524,616
County Share	\$ 42,728	\$ 85,122	\$ 88,984.50	\$ 45,473.50	\$ 262,308
Partner Share Fort Lauderdale	\$ 14,243.67	\$ 28,374	\$ 29,661.50	\$ 15,157.83	\$ 87,437
Partner Share Hollywood	\$ 14,243.67	\$ 28,374	\$ 29,661.50	\$ 15,157.83	\$ 87,437
Partner Share Pompano Beach	\$ 14,243.67	\$ 28,374	\$ 29,661.50	\$ 15,157.83	\$ 87,437

The schedule above will be modified to account for the chosen payment schedule; lump sum or annual.