Scope of Work, Schedule, and Cost Proposal for
Loxahatchee River Salinity Modeling and Analysis Services

The Loxahatchee River is a tidally influenced system where freshwater inflows, tidal exchange through Jupiter Inlet, and meteorological forcing collectively control salinity distribution within the estuary and floodplain. Changes in freshwater delivery, sea level rise, and inlet dynamics have contributed to saltwater intrusion and ecological stress, particularly in the Northwest Fork (NW) floodplain.

The Jupiter Inlet District (JID) is currently evaluating alternatives for a navigation channel through the Jupiter Inlet ebb shoal. The proposed channel, depending on its depth and width, has the potential to substantially increase saltwater conveyance through the inlet and possibly alter salinity regimes in select portions of the Loxahatchee River system. The effect on salinity intrusion of the navigation channel is expected to be in varying degrees depending on the distance from the inlet and the ambient salinity in the river system.

Since January 2004, the Loxahatchee River District (LRD), in partnership with the South Florida Water Management District (SFWMD) and the Loxahatchee River Preservation Initiative (LRPI), has monitored the physical water quality parameters (e.g., temperature, salinity, pH, dissolved oxygen, depth) within the Loxahatchee River Watershed. The partnership used datasondes, automatic recording, and multi-parameter water quality monitoring instruments to monitor physical water quality conditions at eight stations (see Figure 1). Table 1 presents the average, minimum, and maximum of the recorded temperature and salinity at these stations.

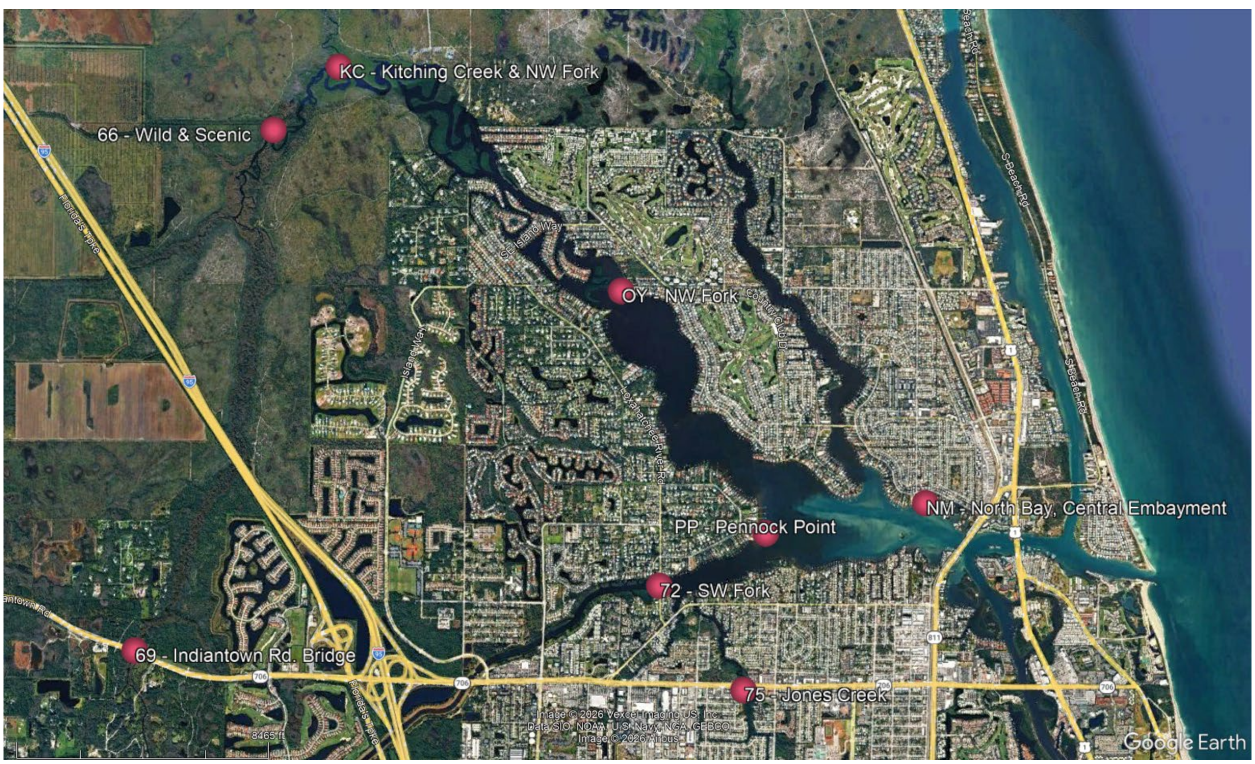

Figure 1 Loxahatchee River System Water Quality Monitoring Stations

Table 1. Statistics of Measured Temperature and Salinity at the Loxahatchee River System Water Quality Stations (Source: Howard et al., 2010)

Station	Start Date	End Date	Number of Samples	Temperature (°F)			Salinity (Practical Salinity Unit, ppt)			Salinity Classification
				Average	Minimum	Maximum	Average	Minimum	Maximum	
66	5/1/1999	5/24/2009	50,381	76.6	56.8	88.7	1.2	0.1	16.8	Oligohaline
69	1/19/1995	9/30/2009	84,477	77.7	57.2	91.9	0.3	0.1	0.8	Freshwater (below oligohaline)
72	8/29/2006	9/30/2009	50,455	79.9	57.0	94.8	26.7	0.2	35.5	Polyhaline
75	6/30/2008	9/30/2009	35,718	77.5	54.3	92.8	19.8	0.3	33.7	Polyhaline
Kitching Creek Surface	1/1/2005	9/30/2009	141,679	77.0	56.1	91.0	1.6	0.0	23.0	Oligohaline
Kitching Creek Bottom	1/9/2003	9/30/2009	174,617	77.2	58.3	91.0	5.7	0.0	25.1	Mesohaline
NB	5/1/2004	9/30/2009	168,976	78.6	58.5	95.7	32.8	1.3	37.9	Polyhaline (Euhaline)
OY	2/13/2007	9/30/2009	74,763	78.1	53.8	93.2	19.3	0.1	36.5	Polyhaline
PP	5/1/2004	9/30/2009	168,868	78.4	58.1	93.7	31.8	0.2	38.1	Polyhaline (Euhaline)
Total Samples			**949,934**							

Notes: 1. Oligohaline – freshwater-dominated systems or upstream tidal reaches (0.5 – 5.0 ppt)

2. Mesohaline – transitional mixing zones (5.0 – 18.0 ppt)

3. Polyhaline – marine-dominated estuary regions (18.0 – 30.0 ppt)

4. Euhaline – high salinity comparable to a salinity level similar to that of the open ocean (> 30 ppt).

Table 1 provides the salinity classification of the waters near each station based on the recorded average salinity up to 2009. Table 1 indicates that the stratified salinity transition zone can extend along the Northwest Fork from Station PP to Station Kitching Creek and move upstream and downstream depending on the saltwater conveyance through the inlet. As such, the JID requested Taylor Engineering to use a numerical model to analyze the effect on salinity intrusion of the construction of a navigation channel through the Jupiter Inlet ebb shoal. A three-dimensional (3D) hydrodynamic and salinity transport model provides the means to simulate the stratified salinity transport.

Existing MIKE21 Flexible Mesh (FM) hydrodynamic (HD) models (see Figure 2), developed by Taylor Engineering originally for the Florida Inland Navigation District's (FIND) Dredging Efficiencies Program (Taylor Engineering, 2025) and then updated for the evaluation of shoaling in alternatives for ebb shoal navigation channel (Taylor Engineering, 2026), already cover most of the Loxahatchee River reaches shown in Figure 1. The FIND program created the numerical modeling framework to evaluate alternatives that reduce shoaling in the Intracoastal Waterway (IWW) and decrease the frequency of maintenance dredging near Jupiter Inlet. Taylor Engineering (2026) evaluated the shoaling performances of various ebbs shoal navigation channel designs. Because the Taylor Engineering (2026) model domain includes Jupiter Inlet, its ebb shoal, portions of the Loxahatchee River system (Southwest [SW] Fork, NW Fork, and North [N] Fork), and the adjacent waterways, it can provide, when extended upstream to the NW Fork, an effective platform for assessing salinity intrusion behavior associated with proposed ebb shoal navigation channel construction.

Based on the 2025 MIKE21 HD model, the existing 2026 MIKE21 HD model developed for the Jupiter Inlet system provides a calibrated representation of:

- Tides and water levels
- Depth-averaged currents
- Nearshore, inlet, estuary, and riverine circulation processes
- Large-scale hydraulics across the inlet, nearshore, and connected waterways

Therefore, this effort will leverage the existing 2026 MIKE21 HD model to develop a MIKE3 3D hydrodynamic and salinity transport model to simulate:

- Vertical salinity stratification
- Salt wedge dynamics
- Freshwater inflow impacts
- Estuarine salinity response under baseline (without ebb shoal navigation channel) and with ebb shoal navigation channel flow scenarios

The following tasks describe (1) data collection and analysis; (2) baseline model development and refinement; (3) baseline model development and calibration under dry, average, and wet flow conditions; (4) evaluation of navigation channel effects on salinity intrusion and recommendations; and (5) preparation of the evaluation study report.

TASK 1 Data Collection and Analysis

The objective of this task is to compile and review available data required to support MIKE3 model development, calibration, and verification. A key component in evaluating potential changes in the salinity intrusion along the Loxahatchee River is understanding the dominant hydraulic processes that influence stratified salinity transport within the inlet, river, and adjacent waterways. To enhance our understanding of the salinity transport process, we will collect and review relevant existing literature and data on the Loxahatchee River system. This review will provide historical context on the historical salinity in the river, including salinity during the opening and closing of natural channels through the ebb shoal from 1996 to 2025.

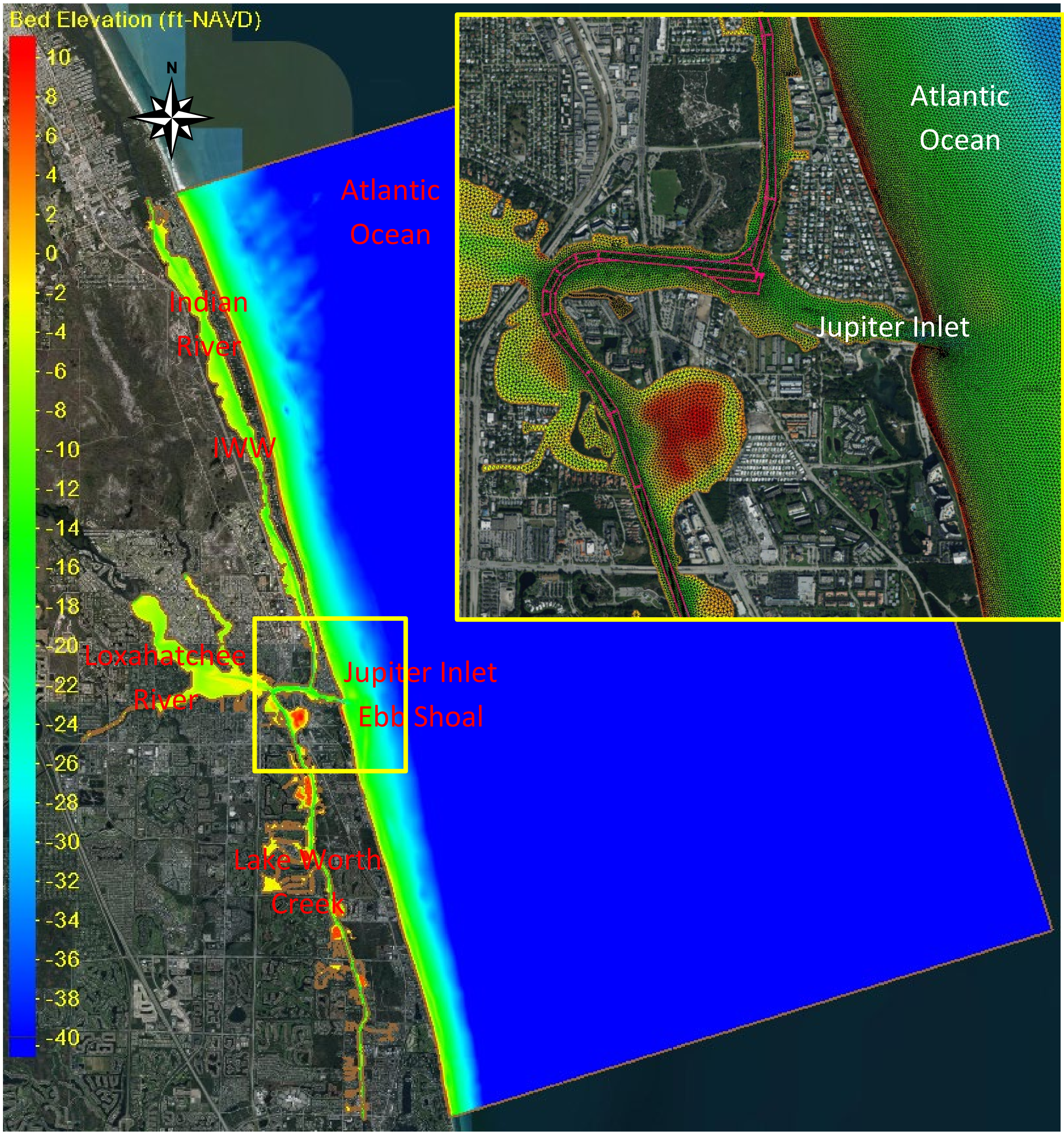

Figure 2 MIKE21 Model Domain, Bed Elevations, and Model Mesh (Inset) at Jupiter Inlet

We will collect and evaluate existing datasets relevant to the Loxahatchee River system and the Taylor Engineering (2026) model. Examples of data sources include water surface elevations (tides), dam outflow records at S-46 and Lainhart Dam, precipitation records, salinity and temperature observations (long-term monitoring at stations listed in Table 1), and bathymetric surveys. Our review will also focus exclusively on hydraulic and salinity studies conducted in the Loxahatchee River area.

Potential sources of information include

- U.S. Army Corps of Engineers (USACE) Jacksonville District
- Florida Department of Environmental Protection (FDEP)
- Florida Inland Navigation District (FIND)
- National Oceanic and Atmospheric Administration (NOAA)
- U.S. Geological Survey (USGS)
- Palm Beach County (PBC)
- South Florida Water Management District (SFWMD)

Key Activities will include

- Review MIKE21 model setup, calibration, and limitations
- Evaluation of salinity and temperature datasets for calibration targets
- Identification of temporal periods for simulation (e.g., dry/wet year or season, representative year)

We will evaluate the salinity and temperature data for completeness, remove anomalous readings, and align observations with the model time step. We will pair salinity with corresponding temperature data to correctly represent density-driven processes and seasonal stratification patterns within the estuary. We will then classify the data into representative **dry, average, and wet hydrological years** based on regional rainfall, freshwater inflows, and water management conditions. This classification will allow the capture of the full range of hydrologic variability that controls salinity dynamics in the system.

TASK 2 Baseline 3D Model Development

Task 2 will focus on extending the Taylor Engineering (2026) model along the NW Fork (possibly up to Station 66 and Kitching Creek) and refining the model to achieve high resolution in areas of interest in the Loxahatchee River system; and to simulate, in detail, the baseline hydraulics and salinity transport without the ebb shoal navigation channel. This refinement will also enable evaluation of a proposed ebb shoal navigation channel design in Task 3.

Building on the Taylor Engineering (2026) integrated MIKE21 model, we will construct baseline versions of the MIKE3 3D hydrodynamic (HD) and salinity transport (TR) models with enhanced resolution in the areas of interest in the Loxahatchee River system. These refinements will improve the representation of hydraulics and salinity transport processes in the area. The MIKE3 TR model will be used to estimate salinity movement through the proposed navigation channel, IWW, and river system, incorporating advection-dispersion computations to predict salinity concentration and duration in offshore and interior adjacent waterways.

Model forcing will include temporally and spatially varying predicted tides (derived from MIKE21 global tide model data) at the offshore, ocean north, and ocean south boundaries, as well as NOAA-predicted tides at the inshore water level boundaries. If necessary, a regional model will provide eastward (u) and northward (v) velocity components along ocean boundaries to represent Florida Current conditions during select periods. Ocean and river salinity characteristics will be defined using available data from the literature and already measured data from the water quality stations shown in Figure 1.

TASK 3 3D Model Calibration and Verification

Task 3 aims to ensure that the MIKE3 model accurately reproduces observed water levels and salinity distributions at select locations in the river system.

HD Model Calibration and Verification

The Taylor Engineering (2026) MIKE21 HD model parameter values guide the MIKE3 HD model calibration. We will calibrate the MIKE3 HD model to predicted tide conditions by adjusting relevant model parameters for a month-long calibration period. Next, we will perform a MIKE3 HD model month-long verification period run to confirm the modeling approach and test the applicability of the calibrated model's ability to simulate events outside the calibration period. Model calibration and verification will use predicted tides offshore and inshore as model boundary conditions.

Model calibration iterates the model parameters (e.g., bottom roughness and eddy viscosity) to achieve a good comparison of modeled and predicted water levels, tidal phases, and tidal amplitudes at the following NOAA tide prediction stations (see Figure 3). NOAA's Vdatum provides supplementary information on station tidal datums.

- Jupiter Inlet, South Jetty (NOAA 8722495
- Jupiter Sound, South End (NOAA 8722491)
- Conch Bar, Jupiter Sound (NOAA 8722471)
- Jupiter, Lake Worth Creek, IWW (NOAA 8722499)
- Lake Worth Creek, Day Beacon 19, IWW (NOAA 8722512)
- A1A highway bridge (NOAA 8722492)
- Tequesta (TEC3787)
- Southwest Fork, 0.5 mile above entrance (NOAA 8722494)
- Tequesta, North Fork (NOAA 8722486)
- Three miles above A1A highway bridge (NOAA 8722481)
- Boy Scout Dock (NOAA 8722472)

Model verification ensures that the model parameters set to achieve good model performance during the calibration period also apply to simulations outside the calibration period. Thus, model verification will apply the model parameters as adjusted in model calibration. We will compare the modeled and predicted tides at the NOAA tide prediction stations shown in Figure 3 to verify that the MIKE3 HD model can estimate the water levels, tidal phase, and tidal magnitudes well for another month-long period.

We will perform HD model sensitivity analysis to evaluate the sensitivity of the HD model to changes in bottom roughness. We will perform two HD model simulations for the HD model sensitivity analysis

TR Model Calibration and Verification

We will develop the salinity transport model for the Loxahatchee River system and nearby waterways by systematically calibrating and verifying the TR model outputs against measured salinity and temperature data collected at selected stations among those shown in Figure 1. We will use selected station records representing spatial gradients from freshwater reaches to marine-influenced segments to check if the model reproduces both longitudinal and temporal salinity variability.

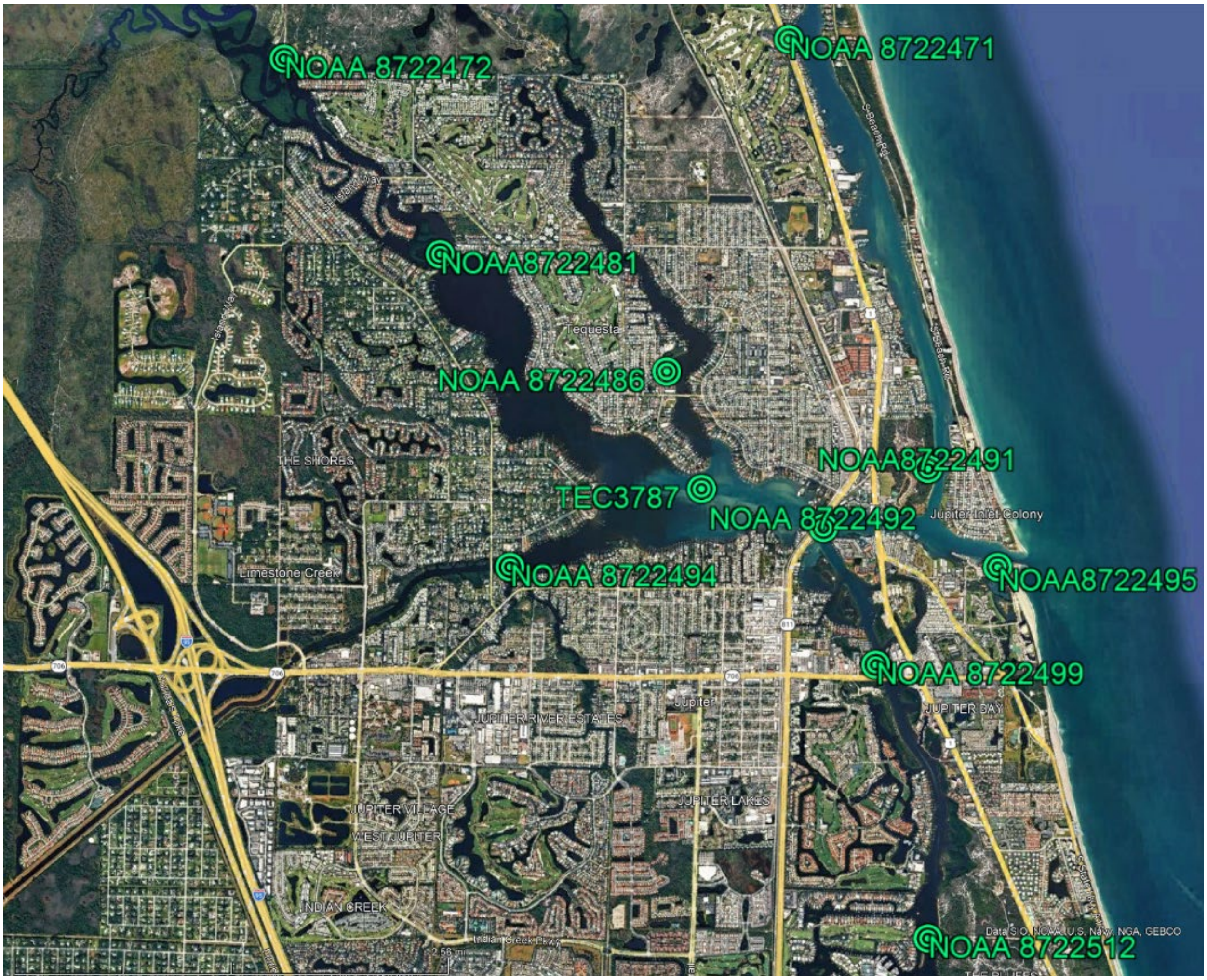

Figure 2 MIKE3 Water Level Calibration and Verification Stations

We will use each hydrologic condition strategically:

- **Dry Year Conditions** – We will use dry conditions to calibrate the model under low freshwater inflow conditions, when marine influence dominates. These conditions helped us adjust parameters governing tidal exchange, salinity intrusion, and dispersion processes. We will check that the model predicts upstream salinity intrusion and higher salinity persistence during reduced flows.

- **Wet Year Conditions** – We will use wet-year datasets to evaluate and refine the model's response to high freshwater inflows. These datasets will allow us to calibrate flow-salinity relationships, plume dynamics, and flushing rates. We will check that the model simulates salinity reduction, stratification breakdown, and enhanced mixing under high-flow conditions.

- **Average Year Conditions** – We will use average-year datasets to fine-tune the model for typical system behavior. These data will provide a balanced representation of tidal forcing and freshwater inflow, ensuring that the model performs well under commonly occurring conditions.

By incorporating all three hydrologic conditions, we can evaluate if the TR model will remain robust across the full spectrum of environmental scenarios relevant to the Loxahatchee River system and nearby waterways.

TR Model Calibration Procedure

We will calibrate the TR model iteratively by comparing simulated salinity and temperature outputs with measured data at selected stations among those shown in Figure 1. We will adjust key model parameters, including:

- Dispersion and mixing coefficients
- Turbulence parameters
- Boundary salinity conditions at ocean interfaces
- Freshwater inflow distributions and timing

At each iteration, we will evaluate how well the model reproduces observed salinity patterns in time and space. We will focus on matching:

- Tidal salinity fluctuations
- Seasonal salinity trends
- Longitudinal salinity gradients
- Salinity responses to freshwater inflow events

We will prioritize achieving consistency across selected stations rather than optimizing performance at a single location. We will deem the TR model adequately calibrated when it:

- Reproduces observed salinity within acceptable error ranges across selected stations
- Accurately captures timing and magnitude of salinity fluctuations
- Demonstrates minimal bias across hydrologic conditions

TR Model Verification Procedure

After completing the TR model calibration, we will perform TR model verification using an independent dataset that was not used during TR model calibration. We will select verification periods that include different hydrologic conditions (dry, average, or wet years) to confirm the model's predictive capability. We will run the model without further TR model parameter adjustment and compare the simulated outputs to measured salinity and temperature data. The TR model verification will confirm that the TR model's calibrated parameters are generally well applicable across independent conditions.

We will also evaluate the TR model skill during critical events, such as high discharge periods and extended droughts, to check if the model reproduces system responses under extreme conditions.

By integrating measured salinity and temperature data from multiple stations and systematically applying dry, average, and wet hydrologic datasets, we can calibrate and verify a salinity model that reliably simulates estuarine conditions in the Loxahatchee River system and nearby waterways. This structured approach ensures that the TR model provides accurate estimations across a wide range of environmental conditions and supports robust water resources decision-making.

TASK 4 Analysis of the Effect of the Ebb Shoal Navigation Channel Design

In Task 4, we will apply the calibrated and verified MIKE3 HD and TR models to evaluate how constructing and maintaining a navigation channel through the Jupiter Inlet ebb shoal would influence salinity dynamics within the Loxahatchee River system and nearby waterways. We will use the models to simulate hydrodynamic and salinity responses under the preferred channel configuration (with-project scenario), allowing us to isolate and quantify project-related effects.

We will explicitly incorporate the preferred navigation channel design into the Task 3 baseline model grid by modifying bathymetry, channel geometry, and hydraulic connectivity across the ebb shoal. We will represent the navigation channel depth, width, and alignment consistent with the preferred channel design specifications. This modification will allow the model to capture changes in tidal prism, exchange efficiency, and flow conveyance between the Atlantic Ocean and the estuary.

We will evaluate the ebb shoal navigation channel effects in two phases. In Phase 1, we will apply dry hydrological year conditions to represent worst-case salinity impacts. If Phase 1 shows substantial effects based on the evaluation metrics, we will proceed to Phase 2, where we will apply average and wet hydrological year conditions to fully characterize system response across the natural range of hydrological variability. If Phase 1 does not show substantial salinity effects of the preferred navigation channel design, we will not perform Phase 2.

- **Phase 1 Dry Year Simulation –** We will use a dry-year inflow and meteorological conditions to assess how the navigation channel may enhance saltwater intrusion during periods of reduced freshwater discharge. Under these conditions, the estuary becomes more sensitive to ocean forcing. We will specifically evaluate whether the channel increases the upstream extent, duration, and intensity of saline conditions, particularly in environmentally sensitive freshwater and oligohaline habitats.

- **Phase 2 Wet Year Simulation (if necessary) –** We will use wet-year conditions to evaluate system response under high freshwater inflow. We will assess whether the channel modifies flushing efficiency, alters plume dynamics, or accelerates the export of freshwater to the ocean. We will also examine whether the increased conveyance will dampen or amplify short-term salinity variability during high-discharge events.

- **Phase 2 Average Year Simulation (if necessary) –** We will use an average-year dataset to represent typical system behavior and to evaluate the most probable, long-term effects of the channel. These simulations provide a balanced assessment of tidal exchange and freshwater inflow interactions and support general conclusions about day-to-day system response.

By simulating all three hydrologic conditions, we can ensure that the evaluation captures both routine and extreme scenarios, which is critical for assessing potential risks and benefits.

Evaluation Approach

We will evaluate by running the MIKE3 HD and TR models for two primary scenarios:

1. **Baseline Condition (Existing Ebb Shoal) –** We will simulate current bathymetric and hydraulic conditions without the navigation channel. This scenario establishes reference baseline salinity patterns and variability throughout the estuary.

2. **With-Project Condition (Navigation Channel Constructed) –** We will simulate the modified geometry with the ebb shoal navigation channel in place. All other model inputs, including boundary conditions and freshwater inflows, remain identical to the baseline to ensure a controlled comparison.

3. **Historic Conditions (2004 Ebb Shoal Bathymetry) –** We will simulate the hydraulics and salinity transport for the 2004 inland hydrology, offshore conditions, and bathymetries of inshore, inlet, and ebb shoal areas to evaluate the salinity regime for such conditions. If available, we will compare modeled salinity with salinity data from selected stations among those shown in Figure

We will then compare results from the two scenarios under Phase 1 evaluation and, if necessary, under Phase 2 evaluation.

Evaluation Metrics and Analysis

We will evaluate the effects of the ebb shoal navigation channel using a combination of spatial and temporal analyses:

- **Salinity Time Series Comparisons –** We will compare modeled salinity at each monitoring station under baseline and with-project conditions to identify changes in magnitude, duration, and timing of salinity fluctuations.

- **Longitudinal Salinity Gradients –** We will examine how the channel altered salinity distribution along the river-estuary continuum, particularly the upstream migration of key isohalines (e.g., 0.5 ppt, 5 ppt).

- **Salinity Duration Curves –** We will compute exceedance statistics to quantify how often salinity thresholds important for ecological resources are exceeded under each scenario. If shifts in the salinity duration curves are substantial, we will identify potential species that may be affected, given the salinity tolerances of species in the affected portions of the Loxahatchee River system.

- **Spatial Difference Mapping –** We will map differences in salinity between baseline and with-project conditions to visualize areas of increased or decreased salinity influence.

- **Event-Based Analysis –** We will evaluate model response during critical hydrologic events, such as sustained droughts or large discharge pulses, to determine how the ebb shoal navigation channel will affect system resilience and recovery.

Interpretation of Results

We will interpret the results by identifying consistent patterns across hydrologic conditions:

- Under **dry conditions**, we will focus on whether the ebb shoal navigation channel will increase saltwater intrusion and reduce freshwater habitat availability.

- Under **wet conditions**, we will evaluate whether the ebb shoal channel will alter flushing rates or affect the system's ability to maintain low salinity conditions.

- Under **average conditions**, we will assess overall system stability and long-term salinity regime shifts.

We will also examine whether observed impacts will be localized near the inlet or propagated upstream into critical ecological zones. We will specify the mechanism that creates changes in salinity.

Decision Support and Adaptive Considerations

We will use the model results to inform engineering design and environmental management decisions by:

- Identifying potential adverse salinity impacts associated with the ebb shoal navigation channel construction
- Evaluating whether design modifications (e.g., channel depth or alignment adjustments) could reduce impacts
- Supporting regulatory review by demonstrating quantitative effects on salinity regimes

If needed, we will iteratively refine the channel design within the model and re-evaluate outcomes to minimize negative impacts while maintaining navigational objectives.

By applying the salinity model under dry, average, and wet hydrologic conditions and comparing baseline and with-project scenarios, we can rigorously evaluate how a navigation channel through the Jupiter Inlet ebb shoal influences salinity dynamics in the Loxahatchee River system. This approach provides a scientifically defensible basis for assessing potential impacts and optimizing project design.

Task 5 Report Preparation and Presentation

We will prepare a feasibility report summarizing the results of Tasks 1–4. The report will include model documentation, featuring a written summary of the modeling approach and key findings, along with supporting graphics. Additionally, the report will present hydraulic model results in tabular format for both the baseline condition (without the ebb shoal navigation channel) and the preferred alternative design incorporating the ebb shoal navigation channel.

SUMMARY

We will perform these services for a lump-sum fixed price of $64,936 if Task 4 Phase 2 is unnecessary, or $79,820 if Tasks 4 Phases 1 and 2 are included. Table 1 provides a detailed cost breakdown, and Table 2 outlines the proposed task schedule. The model update and refinements for Tasks 2 and 3 will require multiple iterations and simulations, which we estimate will take approximately five months to complete. Based on these requirements, we anticipate that completion of Tasks 1–5 will take approximately eight months.

ASSUMPTIONS

We have made several key assumptions in developing this scope of work and the associated fees for the project. These assumptions, outlined below, influence the proposed level of effort and corresponding costs. <u>If any of these assumptions prove to be incorrect, we will provide a revised proposal to adjust the scope and fees accordingly.</u> The scope of work has been developed based on the following assumptions and background information:

i. No field measurements are included in this scope of work.
ii. The digitized salinity and temperature data from the stations shown in Figure 1 are adequate to characterize dry, wet, and average hydrological years or conditions.
iii. There will be a single preferred ebb shoal navigation channel design for the analysis in Task 4.
iv. Engineering design and permit application services are excluded from this scope of work.

As channels shoal and sediments accumulate, the channel flow conveyance and salinity transport also decrease. Therefore, long-term average salinity transport may differ from that presented in Task 4. Additionally, future hydraulic conditions—such as tides and waves—may vary from those characterized in the Task 4 analysis, which was based on representative hydrological year conditions. Extreme episodic events, such as storm surges and high-wave conditions and/or extreme upstream drought or rainfall, can also cause significant changes in salinity intrusion.

REFERENCES

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Taylor Engineering. 2026. Jupiter Inlet Jupiter Inlet Ebb Shoal Navigation Channel Modeling and Analysis, Draft Letter Report, 28 p.

Table 1 Estimated Task Cost

Task	Task Name	Fee
1	Data Collection and Analysis	$9,506
2	Baseline 3D Model Development	$8,484
3	3D Model Calibration and Verification	$22,536
4	Analysis of the Effect of the Ebb Shoal Navigation Channel Design (if Task 4 Phase 2 analysis becomes unnecessary)	$29,250 (14,366)
5	Report Preparation and Presentation	$10,044
	Total (if Task 4 Phase 2 analysis becomes unnecessary)	**$79,820** **($64,936)**

Table 2 Estimated Schedule for the Jupiter Inlet Ebb Shoal Navigation Channel Modeling and Analysis

Task No.	Task Description	Months from Notice-to-Proceed							
		1	2	3	4	5	6	7	8
1	Data Collection and Analysis	■							
2	Baseline 3D Model Development		■	■					
3	3D Model Calibration and Verification			■	■	■			
4	Analysis of the Effect of the Ebb Shoal Navigation Channel Design					■	■	■	■
5	Report Preparation and Presentation							■	■