

# Restore Lagoon Inflow Research (Phase 3) Executive Summary



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October 2023



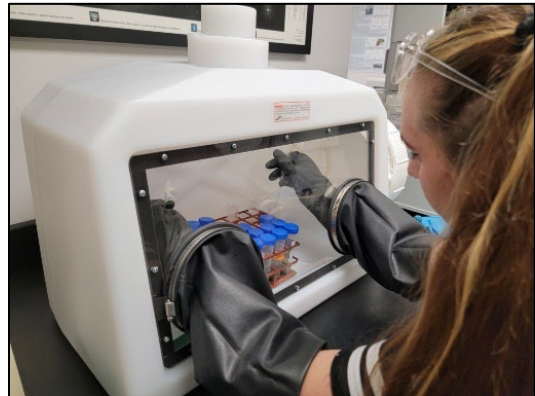
## Executive Summary

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More than 50 years of impacts from a growing human population have taken a tragic toll on the Indian River Lagoon (IRL) system. Excessive nutrients and all forms of pollution from human activity flow overland and through groundwater to the lagoon. The seagrasses, clams, and oysters are nearly gone from many regions of the lagoon, displaced by nutrient laden muck, polluted water, and algal blooms. With the loss of most seagrasses, manatees are dying in record numbers as they are unable to find food. Fish populations that survived the 2011 superbloom now struggle to adjust to rapidly changing conditions, and the once popular and economically important Redfish are now closed to harvest in the IRL. Algae that once unnoticeably cycled through the seasons in clear water now cloud the water, as blooms of one dominant species quickly die out only to be replaced by the next dominant species in an unbalanced, sometimes hypoxic or anoxic, high nutrient (eutrophic) system.

Water circulation in the lagoon is restricted on all sides, increasing risk of eutrophication and ecosystem collapse. Previous federal development activity supporting space and defense projects cut off the finger flows of Banana Creek, eliminating the northern connection of the Banana River Lagoon (BRL) to IRL. To the east, natural episodic connections between the coastal ocean and IRL system have been lost with the hardened development of the barrier islands, while the benefits of water circulation through the five maintained inlets are limited by the many causeways that restrict flow north and south. To the west, polluted water that historically largely drained to the St. Johns River now flows to the IRL system, with some improvements from ongoing water farming and wetland restoration projects.

Deliberate and timely restoration of lagoon hydrology can improve water quality and help restore the rapidly deteriorating lagoon ecosystem. Elected officials; local, state, and federal government agencies; and stakeholders in the IRL region are exploring a variety of approaches to help restore the lagoon. The Restore Lagoon Inflow Research project is providing data to help determine the viability of a permanent ocean inflow system as a potential additional tool to stabilize and restore the lagoon.



With funding from the Florida Legislature in fiscal year 2020, the Florida Institute of Technology (Florida Tech) completed Phase 1 of a multi-phase research project to explore water quality improvement within the IRL system by enhancing ocean inflows. This first phase gathered baseline data and conducted modeling and experiments on water quality, biological parameters, and hydrologic conditions at candidate locations for a temporary ocean inflow system. The Florida Legislature authorized funding for Phase 2 in fiscal year 2021, which built upon the lessons learned from Phase 1, and focused on planning for construction and implementation of a small-scale, temporary ocean inflow system and the studies required to evaluate its effectiveness. The efforts in Phase 2 included site selection, agency and stakeholder engagement, conceptual engineering and optimization, pre-permitting briefings, expanded ecosystem modeling, and baseline data collection. The Florida Legislature authorized funding for Phase 3 in fiscal year 2023, which included United States Army Corps of Engineers (USACE) Section 404 and Section 408 permits and Florida Environmental Resources Permit (ERP), as well as additional design of the pilot system. Biogeochemical research and modeling efforts proceeded in parallel with

permitting and design in advance of construction and operation of the proposed, temporary pilot inflow system by a state or federal agency.

Phase 1 through 3 results, when combined with findings from the temporary inflow pilot system, will allow for an informed determination of the feasibility and impacts of a potential permanent ocean inflow system.

For Phase 3, the multi-disciplined team of research professionals, supported by community partners, Florida Tech staff, students, and engineering professionals from Tetra Tech, Inc., was expanded to capture data gaps identified in the baseline investigations. The expanded Florida Tech research team included:

- Project Manager – Dr. Jeff Eble
- Engineering – Dr. Robert Weaver and Tetra Tech
- Modeling – Dr. Gary Zarillo
- Geochemistry – Dr. Austin Fox, Dr. Jane Caffrey (University of West Florida [UWF]), Dr. Wade Jeffrey (UWF), and Dr. Lisa Waidner (UWF)
- Biology – Olivia Escandell (Brevard Zoo), Dr. Richard Paperno (Florida Fish and Wildlife Conservation Commission [FWC]) Dr. Jesse Blanchard (Florida International University), Dr. Wendy Noke Durden (Hubbs Sea World Research Institute), and Dr. Edward Philips (University of Florida)



## Project Overview

The multi-phased Restore Lagoon Inflow Research project has included the baseline monitoring, design, permitting, and modeling of a system to provide temporary ocean inflow to IRL to help determine the viability of a permanent ocean inflow system. By improving understanding and management of the IRL system, the implementation of the pilot scale study results will also help to address several actions in the IRL National Estuary Program Comprehensive Conservation and Management Plan, including specifically addressing action Connected Waters-5, which calls for a pilot project to assess the benefits and risks of enhanced ocean exchange with the lagoon.

The pilot system final design was completed in Phase 3, and USACE and state permits were obtained. The permits are transferable to allow any agency to install, operate, and maintain the temporary pumping system. A license has also been prepared by USACE to access the Canaveral Lock property to complete the project. In the next phase, project bid documents will be created, the request for proposals drafted and sent out for bidding, and an award made for construction of the temporary inflow pilot system. The temporary inflow pilot system is expected to be constructed by an agency in accordance with the USACE and ERP permit requirements.

The temporary inflow pilot system is proposed to be operated by a state or federal agency for one year in parallel with continued focused research, monitoring, and modeling. This approach allows for data to be collected on changes due to small-scale ocean inflow at the study site compared to a reference site outside the influence of pumping, to directly assess impacts on focal biological communities and to validate dissolved oxygen (DO), temperature, nutrient, salinity, and chlorophyll-a (Chl-a) model predictions. The temporary pump system established for the project will be decommissioned at the end of the research period, with the piping and pump removed



from the site. The results of the full Restore Lagoon Inflow Research project will be summarized to provide information and analysis to stakeholders and decision-makers on the viability of a permanent ocean inflow system.

### Proposed Inflow Site

Based on data collected during Phase 1 and discussions with agencies and stakeholders, Phase 2 identified the northern BRL as the most feasible and cost-effective location of a temporary inflow research site, and design and permitting was completed in Phase 3. BRL is a sub-basin of IRL that lies between Cape Canaveral and Merritt Island and extends from the National Aeronautics and Space Administration (NASA) Kennedy Space Center to Dragon Point. It is poorly flushed with no direct connection to the ocean, which results in long water residence times and increased vulnerability to nutrient accumulation.

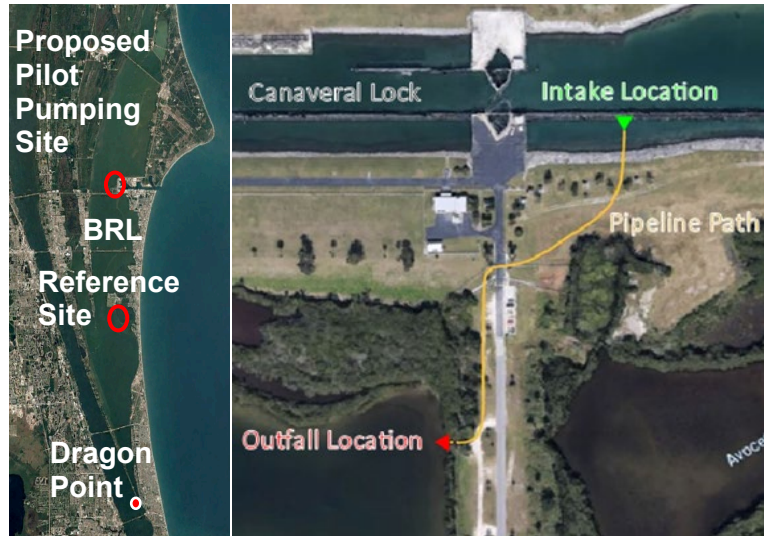


Figure ES-1. Map of the proposed inflow pilot system site

The proposed temporary inflow system installed by an agency would extract water from the ocean side of the Canaveral Lock system and discharge to BRL via the cove to the west of Avocet Lagoon (Figure ES-1). A pump station is proposed that pumps a relatively small volume of 0.5 cubic meters per second of seawater through a pipe system above ground to the lagoon. While offshore seawater would be better suited for inflow due to lower nutrient concentrations and more stable dissolved inorganic nitrogen and soluble reactive phosphorus ratio, the data-to-date support a limited test of inflow from Port Canaveral waters, providing a significant cost savings due to the proximity of the waters in Port Canaveral to the IRL. The cove configuration will restrict flow movement from the outfall location and provide a concentration gradient to evaluate changes on water quality, geochemistry, and biology. A reference site in the central BRL was proposed, which was identified through model evaluation and field sampling as comparable to the proposed inflow site and outside the influence of the pilot system. The proposed pilot system configuration was selected to preserve the reference site while minimizing cost and impacts to existing infrastructure, public access, and natural resources.

### Data Collection and Modeling

Florida Tech adapted the project approach based on data collected while addressing concerns/questions from stakeholders. Internal project meetings and stakeholder meetings were focused on providing the lowest cost and least invasive approach to implement the temporary inflow pilot system, without sacrificing the validity and quality of the pilot research project.

An IRL Environmental Fluid Dynamics Code model was updated to provide numerical predictions of hydrodynamics, flushing rate, water quality, and phytoplankton concentration with and without enhanced inflow. Model boundary conditions used data from St. Johns River Water Management District and Harbor Branch Oceanographic Institute IRL Observation Network, with watershed

inputs from the Spatial Watershed Iterative Loading model developed by Applied Ecology and internal nutrient loading and groundwater inflow predictions compiled by Florida Tech.

Acoustic Doppler Current Profiler units were deployed in BRL near the Barge Canal, Dragon Point, and Sykes Creek to improve modeling of current directions and velocities. Data on temperature, salinity, DO, and nutrients were also collected with a focus on the proposed temporary inflow pilot system site, internal and external reference sites, and Port Canaveral. Uptake and release (fluxes) of nutrients from sediments and water column were evaluated in the field and using laboratory bench tests of IRL sediments in simulated inflow conditions. During Phase 3, this work was conducted in parallel with sediment microbial assessments with the goal of investigating inflow potential to promote natural nutrient removal through improved bottom water circulation, lower water temperature, and higher and more stable DO concentrations.

In addition, biological data collection efforts for seagrass, drift algae, phytoplankton and harmful algae, benthic infauna, mammals, and fish community continued from Phases 1 and 2. These data improve understanding of the BRL ecosystem, providing biological baselines for comparison to conditions with the proposed temporary inflow pilot system in place to identify effects of enhanced inflow to key species, communities, and habitats. The project also included a comparison of biological and geochemical data near the Destin Harbor inflow site, which has been in operation since 1992.



## Highlighted Key Initial Findings

### **The Restore Lagoon Inflow system is designed, permitted, transferable, and shovel ready.**

Thoughtful consideration and design of the study and inflow system is the result of a collaborative approach of the study team and input from federal and state agencies and other stakeholders. A natural cove a short distance from ocean water was selected to confine inflows and allow development of measurable concentration gradients in water quality parameters at relatively low pumping volumes. A similar reference site outside the influence of pilot pumping has also been evaluated to test predicted impacts of inflow on lagoon water quality, nutrient removal, and biology using scientifically sound methods. The design allows for normal operations at the Canaveral Lock site to continue, eliminates the need for dredging, avoids impacts to wetlands, prevents impacts to manatees and other mammals and fish populations, and provides the lowest cost option to achieve the project goals. The design and permits may be transferred for temporary pump implementation by a state or federal agency to evaluate the efficacy of a permanent inflow system.

### **Inflow would help to buffer against extreme temperatures and salinities.**

One major predicted benefit of ocean inflow would be buffering against extreme temperature and salinities that have been attributed to mass mortality events and initiation of the regime shift from a seagrass to algal dominated system. Consistent with events in the IRL, initiation of the Laguna Madre, Texas seagrass to algal regime shift was attributed to extreme low temperatures and perpetuated by subsequent changes in internal nutrient cycling with increased occurrences of hypoxia.

**Stabilizing DO and reducing water temperature can improve natural nutrient removal.**

Under low oxygen conditions (hypoxia), sediments were found to be a source of dissolved nutrients to overlying water. Inflow is predicted to stabilize DO concentrations (as well as temperature and salinity) and mitigate occurrences of hypoxia, which would improve binding of orthophosphate by sediments, reduce total nitrogen (TN), and promote nutrient ratios that are less favorable for harmful algal bloom (HAB) species. Predicted lower temperatures resulting from the temporary small-scale inflow system are estimated to prevent 1.6 metric tons of TN and 0.7 metric tons of total phosphorus (TP) from entering the lagoon.

**Net nutrient reduction is predicted as a result of enhanced inflow.**

Models and field data suggest that measurable impacts of inflow rates from 0.5 to 10 cubic meters per second (m<sup>3</sup>/sec) will be limited to the northern compartments of the IRL system. This is supported in water quality projections for Sebastian Inlet, which indicate increased water discharge but no detectable change in nutrient concentrations in or near the inlet. The most apparent impact of prescribed pilot inflow rates (0.5 m<sup>3</sup>/sec) is in the bottom model water layer in the immediate vicinity of the BRL outfall site, where the DO concentration is predicted to increase. Pilot inflow nutrient improvements are expected to be small but measurable and no large changes in salinity, water temperature, or water quality constituent concentrations are predicted that could produce a significant negative impact during the pilot inflow project.

**Water quality determines fish distribution and local population size.**

Significant responses were shown to increased inflow by ecologically and recreationally valuable fishes. Model projections indicate local populations of five of eight species of interest would increase and three species would decrease with enhanced inflow. Significant positive and negative associations between local fish population size and Chl-a concentrations were detected and include a decline in nearly all species of interest following the 2011 “superbloom.” Species of Interest are likely to be relatively unaffected by net changes to salinity and temperature predicted with inflow; however, negative impacts are expected if rates of change exceed species’ response capacity.

**Biological baselines allow tracking system response to inflow.**

The biological assessments undertaken in Phase 3 and the prior phases provides a solid foundation for understanding the biological state of the BRL. Collaborative efforts between Florida Tech and five partner organizations resulted in diverse datasets, each addressing different biological aspects of the lagoon ecosystem. A significant component was the in-depth assessment of benthic habitats, focusing on the distribution and health of seagrass and other submerged aquatic vegetation. This developing baseline and fish habitat suitability model infrastructure will help ensure that any changes from inflow, positive or negative, can be accurately attributed to intervention and not mistakenly ascribed to pre-existing conditions.

**Improvements in the BRL study area were observed.**

During the Phase 3 study, minor recovery of seagrasses, reduced nutrient loads, more favorable nitrogen to phosphorus ratios, and stable phytoplankton communities were observed. While these improvements were small, they hold promise for a recovering IRL system, but this recovery is fragile. Estuaries by their nature are subject to changing conditions in nutrients, temperature, salinity, and DO. Long-term recovery relies on the system’s resilience at the extreme edges of (and beyond) normal ranges. These improvements in water quality and sea grasses observed in 2023 may be one cold spell, one hurricane, or other extreme event away from being stressed beyond the system resilience and return to severe instability. Ocean inflow may be proven to help regulate temperature, DO, and salinity, thereby reducing the stressors to the system.