Water Injection Dredging in US Ports
North Carolina State Ports Authority, Wilmington & Morehead City, North Carolina
Port Tampa Bay, Tampa Florida

Each year, HDR's Ports and Maritime clients allocate a significant portion of their operating cost to maintaining existing channel and harbor depths through traditional dredging, which has meant removing sediments and debris from their harbors and berths by hydraulic or mechanical means. While the Port is generally only financially responsible for a portion of the maintenance costs of their authorized federal channel, with the US Army Corps of Engineers (USACE) bearing most of this expense, the Port is generally wholly responsible for maintaining its berths and auxiliary channels. To better understand the magnitude of this issue, the USACE annually dredges roughly 250 million cubic yards of sediments nationwide, at an estimated cost of $1.3 billion – the vast majority is maintenance dredging. For most of HDR's Ports and Maritime clients, this maintenance dredging obligation is a continuing and unrelenting multi-million dollar drain on their annual operating budgets.

Traditional hydraulic or mechanical dredging requires the entrainment of the dredged material in pipelines, dredge buckets, or hopper barges. The captured sediments are then transported to either an upland handling facility, a beneficial use site or a US Environmental Protection Agency (EPA) Offshore Dredged Material Disposal Sites (ODMDS). A significant portion of dredging costs are tied to securing the necessary acreage for an upland handling facility; planning, approval, and monitoring beneficial use sites; or the permitting and engineering ODMDS sites.

Water Injection Dredging (WID) is an innovative hydrodynamic dredging technique that is cost-effective, low-impact and environmentally sound. The WID injects large volumes of water at low pressure into the sediment layer, using pumps with a series of nozzles on a horizontal jet bar. The fluidized sediment is then carried with the water current horizontally along the waterway as bedload. The WID technique has specifically gained popularity for port authorities' maintenance dredging with continuous shoaling and siltation of access channels and berths.

This WID process occurs with a minimum of disturbance to the equilibrium of the ecosystem. In this way, instead of mechanical transportation, natural forces (currents, tides, and gravity) take care of the sediment transport, making WID under certain conditions a very cost-efficient dredging technique. Because a WID is highly maneuverable and because it does not dig into or excavate sediment as do traditional dredges, but instead applies water through jets to dilute the sediment layer, it can operate in places that other types of equipment cannot reach, for instance, underneath jetties and moored vessels. Additionally, the WID poses less risk of damaging underwater infrastructures, such as cables and pipelines, bulkheads, lock aprons, and dry-docks compared to traditional hydraulic and mechanical dredges.

Joe Wagner, PE, D.NE, BCEE worked closely with the ***North Carolina State Ports Authority*** (NCSPA) to design, plan, and purchase a custom-built WID for use at NCSPA two port facilities (Port of Wilmington and Morehead City). NCSPA originally budgeted $3,000,000 for the WID. Capitol cost came in well below this amount, and the project has a payback period of roughly 4 years. The WID, now in use by the NCSPA, is the first of its kind in the United States, and it is estimated that the dredge will save the NCSPA roughly $1,000,000 annually over a twenty-year life.

Image 1: NCSPA Port of Wilmington.

Image 2: NCSPA Port of Morehead City.

Material suspended in the water column by WID activities are finer-grained sediments that have been deposited above the authorized project depths. This technique utilizes water from the upper water column of the project site. High volumes of low-pressure water are pumped through a series of nozzles on a horizontal jet bar to disrupt the sediment's internal friction and cohesive properties to create a fluidized soil layer (density current). This fluidized sediment layer remains close to the bottom and moves out of the project area into a higher energy system allowing for natural deposition downstream. In the case of NCSPA, those forces include strong river currents and tidal fetch.

Please note that NCSPA will not remove any sediment from the waterbody using the WID methodology. Instead, all sediment will be carried laterally along the water-sediment interface via river currents or during an ebb tide cycle.

While the NCSPA was initially open to purchasing a standardized model WID, if the vessel and its appurtenances met the specific needs of the facilities served by the NCSPA, due to a non-existent US WID market, the NCSPA was obligated to purchase a custom-built vessel. The *Osprey* fully satisfies both ports' dredging needs while leveraging local markets and marine design expertise.

For the NCSPA, the primary benefit of the WID methodology is the reduction or elimination of several typical costs associated with the NCSPA's dredging, transporting, dewatering, handling, and dredged material storage. The amount of material relocated from the wharves depends on the duration between maintenance dredging events. NCSPA anticipates that it will use this dredging method to supplement the annual dredging performed by the USACE and the WID is expected to be used between 10 to 15 times annually during the prescribed environmental dredging windows for both port facilities. The NCSPA has regulatory authorizations in hand for maintenance dredging, including dredging via a WID as a primary maintenance dredging technique. These regulatory authorizations allow for dredging during the environmental window of October 1st to January 31st in the Port of Morehead City and the Port of Wilmington.

Image 3: Bow View of the NCSPA WID the Osprey.

Image 4: Stern View showing the Jet Bar Nozzle System.

The *Osprey* WID is designed for storage at the NCSPA's Wilmington facility during the off-season. Logistics of procurement, transportation, and demonstration are all part of the NCSPA criteria for manufacturer selection. Ease of operation, training requirements and onboard software integration with existing NCSPA data analysis capabilities were also considered in the *Osprey* WID procurement. Of specific importance to NCSPA, the *Osprey* WID can be efficiently transported between the Port of Wilmington and the Port of Morehead City (approximately 100 miles by land and 100 miles by sea) to work within seasonal dredging limitations. The NCSPA's final choice in dredge designer/manufacturer was weighted based on technical criteria, utility, and economy.

The ***Port Tampa Bay*** (PTB) currently spends more than $3 million annually on maintenance dredging of its ship channels, turning basins, and docking slips along its bulkheads. This dredging is necessary to keep sediment deposition and shoaling from accumulating to a point where it may damage vessels or prevent access to docking facilities. The dredging is supplemental to the periodic dredging performed by the USACE, which is limited to the federal navigation channels. PTB is focused on revisions that could be made to optimize the current program's dredging components and innovative technology and appropriate approaches currently available that PTB could implement.

Regarding the PTB's existing program's dredging components, PTB is primarily interested in evaluating the efficiency of its ongoing federal navigation program, which currently includes mechanically removing sandy sediments from the channel and side-casting that sediment just outside the channel template, and removing fine-grained sediments from its berths.

PTB is preliminarily concentrating on evaluating at least two dredging techniques. The first is the aforementioned state-of-the-art WID, while the second is using standard series hydraulic dredges. PTB wants to assess if the WID technique or the standard series hydraulic dredges can be used economically in Tampa Bay to supplement conventional dredging and potentially alleviate the sediment accumulation issues, at least temporarily, until the scheduled dredging by the USACE. Among the items of concern are each dredge's effectiveness, the likelihood of receiving the necessary permits from the responsible state and local regulatory agencies, the ability of PTB to quickly mobilize the dredge on-site and remove a shoal or sediment accumulation, and of course, the overall cost of such an operation.

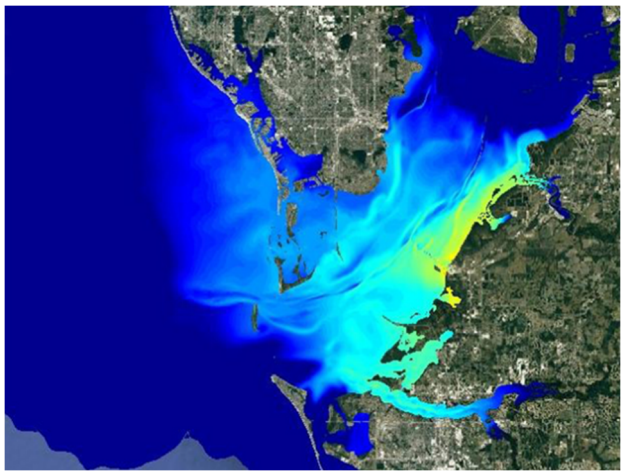

Image 5: USF Model showing Trajectory of Contaminants from a Recent Wastewater Release into Tampa Bay.

HDR will access a computer model initially developed by the University of South Florida (USF) College of Marine Science to track red tide and ocean currents to support the efforts to understand the transport, transformation and fate of dredged material fluidized by the WID in Tampa Bay. This ocean circulation model and the larger scale West Florida Coastal Ocean Model will simulate currents driven by winds, tides, and deeper ocean forcing. Based on the tidal and net current information obtained from the USF model, HDR will evaluate different areas of Tampa Bay and the sediment characteristics to complete a preliminary screening of the potential effectiveness of the WID application. HDR anticipates that preliminary screening results will demonstrate that suspended sediments can be effectively transported away from the WID activity to locations where the potential return to the dredged area is limited.

Please note that this feasibility study is presently relatively limited in scope. It is not intended to be a detailed dredging market analysis, a review of all innovative dredging techniques, or other large-scale reviews of the industry. Neither is this feasibility study an analysis of the effectiveness of PTB owning its dredges, a study of bidding, contracting, or project management techniques currently in use by PTB, or other operations and control measures.

Instead, the feasibility study is focused on identifying cost-inefficient elements of the current dredging program to help provide PTB with the justification to adopt innovative changes. Secondly, the feasibility study will review the efficacy of several proposed and available innovative changes. However, we anticipate that several of these elements and issues will be evaluated to better understand the WID technique's effectiveness and the standard series hydraulic dredge.

Finally, HDR is available to provide a presentation, including several short video clips that demonstrate the WID technique, the hydrodynamic modeling involved in evaluating the process, proposed modeling of a demonstration project's effectiveness, and detailed cost-benefit evaluations. The objective of any presentation would be flexible, but it would likely include:

1) Understand the need for cost-effective dredging techniques that take advantage of natural processes and forces to remove sedimentation within the nation's vital marine infrastructure. Recognize the difference between mechanical, hydraulic, and hydrodynamic dredging. WID is a hydrodynamic dredging technique.
2) Explain the WID technique.
3) Learn about the author's successful effort to bring the first WID to the US for the North Carolina State Ports Authority (NCSPA). The dredge is anticipated to save the NCSPA $1,000,000 per year over the 20-year life of the dredge. Learn about HDR's continuing efforts to bring a WID to our long-term client Port Tampa Bay.
4) Promote a dialog with the Port on how this technology could be evaluated for use in its waterways.