Construction of Offshore Stormwater Discharges using HDD Technologies

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1. ABSTRACT

Florida’s Gulf coast receives stormwater discharge through many types of outfalls crossing the beach dune over it’s low-lying, barrier islands. The beaches typically block discharge resulting in upstream flooding, interruption of alongshore sediment transport processes, and erosion. The use of horizontal directional drilling (HDD) technologies are crucial in successfully permitting and constructing stormwater outfalls seaward of areas where sediment transport processes are impacted. Two municipalities in Southwest Florida commissioned design, permitting and construction of pipelines to convey existing stormwater discharges offshore utilizing HDD technologies.

Offshore stormwater discharge pipelines are very limited in the Southeast US and Florida, creating unique permitting challenges and resulting in close coordination between permitting agencies. Successful design and permitting of such systems involve a team of design professionals with expertise in coastal processes, modeling, structural design, water quality treatment, geotechnical engineering, and HDD construction.

Applying new technologies to offshore disposal of stormwater can remedy current problems and efficiently dispose of runoff to alleviate frequent, seasonal flooding and eliminate water quality violations. ECE designed a stormwater system utilizing current HDD technologies, high capacity filtration, UV disinfection and a carefully designed diffuser system with no adverse impacts to the beach dune and marine environments.

This paper describes the project planning, design, engineering, construction and operational components, focusing on the unique application of materials and HDD technologies. The paper reviews a recently completed offshore stormwater pipeline in Sarasota in terms of the project’s purpose and objectives as well as design, permitting and construction challenges.

2. INTRODUCTION

On an eroding shoreline, stormwater discharge interferes with alongshore sediment transport processes causing increased erosion. On an accreting shoreline, the beach blocks the discharge, resulting in upstream flooding problems. Such outfalls typically pre-date current, regulatory oversight prohibiting such discharges.

Stormwater outfalls are commonly blocked by sand deposits allowing the growth of bacteria such as E-Coli and Enterococci in upstream standing water. Discharges to the ocean are frequently in the warm summer months when bacteria loads are at their peak resulting in beach closures. Several nationally ranked beaches and Gulf coast tourist destination have been affected.

Generally, there are two solutions to this problem:
1. re-route the discharges landward away from the beach/dune system; or
2. bypass the dune and marine littoral zone.

Solution 1 is often difficult as many of Florida’s low-lying barrier islands do not have the capacity to support increased stormwater flows landward of the dune system. Solution 2 provides the logical solution to addressing the problems associated
with existing ocean stormwater outfalls; regardless of whether you have an accreting shoreline or an eroding shoreline. The primary objective is to design for water quality treatment and installation methods that eliminate impacts to the dune and marine environments. Installing the pipeline using horizontal directional drilling (HDD) technologies eliminates the potential for impacts to sand movement, thereby easing the permitting and construction of a stormwater outfall.

To resolve problems with beach closures due to water quality violations and remedy upland flooding, ECE worked with two Gulfcoast municipalities to replace an existing ocean outfall gravity type stormwater with a state of the art water quality improvement and treatment system and offshore discharge directional drill line (DDL). Sarasota County commissioned ECE to plan, design, permit and conduct final engineering for the construction of a pipeline to collect, treat and convey existing stormwater discharges to nearshore outfalls.

The improved stormwater system discharge to nearshore Gulf waters utilized a subsurface pipeline installed using HDD technologies, with treatment incorporating a high capacity sediment filtration and UV disinfection system, pump station and a robust diffuser system. This outfall was constructed without impacts to the marine and beach environments. The stormwater treatment and management system was designed using existing materials and technologies to new applications allowing for the offshore disposal of treated stormwater to remedy current problems and efficiently dispose of runoff to alleviate flooding.

The system was recently installed in Sarasota County to alleviate beach closures at Siesta Key Public Beach and the resulting adverse impacts on tourism and beach use at a #1 nationally ranked beach in Florida. Stormwater system capacity and water quality were significantly improved without impacting the nearshore seabed, affecting sediment movement, or impacting hardbottom habitat.

3. PROJECT NEED AND PURPOSE

*The existing outfall was identified as a source of fecal coliform and cause of numerous beach closures.* Runoff from the adjacent Beach Road was collected via a storm sewer network that outfalls to the existing pond/wetland at the northeast end of the County property, with gravity flow to the beach via a heavily vegetated, tidally fed ditch. The ditch, due to its heavy vegetation, supported many small animals and avifauna. During rainfall events, animal excrement within the ditch would be flushed from the ditch across the beach to the nearshore Gulf waters.

*A significant loss of positive discharge due to dune accretion.* The shoreline at the Siesta Key Public Beach has accreted causing the existing vegetated ditch to stage to levels that overflow along its banks due to blockage from high beach-dune elevations which prevented positive discharge to the Gulf. See Figure 1. The seaward top of bank of the existing ditch bank is low at 3.5 ft (NAVD88) with seaward beach elevations at 4.5 to 6.0 ft thus blocking flows to the Gulf. Since 2009, the dune has continued to accrete with the ditch discharge point fronting a 300 ft wide beach at an elevation 2-4 ft higher than the ditch top of bank. These conditions are typical of “Nourished Beaches” along the east coast of the US, where sand is placed to widen the beach by 100-200 ft every 6-10 years.

The original ditch system, roadway drainage and the pond stage resulted in roadway flooding along Beach Road which is the primary roadway and hurricane evacuation route along a 3 mile length of high density tourism and residential development.

![Figure 1 – Original Stormwater Outfall (2009 Pre-Project)](image)
4. SITE CONDITIONS

Design and permitting of an offshore discharge line must consider the depth of closure, or the limiting depth of nearshore sand movement at approximately -18 ft, NAVD88 (see Figure 2) for this site, based on shoreline profiles and a 10 ft average annual accretion rate. Placement of the outfall at or beyond the depth of closure (-18 ft) prevents impacts to sediment transport and navigation. Further, no offshore hardbottom habitat was present that would require a pipeline route to avoid impacts; however such features are often a factor when siting an offshore discharge pipeline.

![Figure 2 – Historic Beach Profile Comparison](image)

5. PROJECT OBJECTIVES AND DESIGN

The improved stormwater system is designed for discharge to pump directly to the Gulf via an HDD placed offshore pipeline, eliminating discharges across the beach-dune system, preventing erosion and related impacts to the beach and littoral system. A mangrove lined ditch will remain to: (1) avoid impacts to wetland habitat; (2) route discharge during infrequent rainfall events that exceed the capacity of the pump system; and (3) route emergency overflow if the pump/treatment system fail.

A two stage treatment system was designed with stage one filtration removing particulate matter prior to discharge. Water is collected and stages in the stormwater pond and then discharges through a traditional, gravity-fed control structure to a filter vault where it flows through 40 siphon actuated, media-filled filter cartridges (designed by Contech Construction Products, Inc.) as shown in Figure 3. Following filtration, the water gravity flows to the pump station where it is pumped through the in-line UV disinfection unit (stage two), as shown in Figure 4. The Acquionics UV disinfection removes bacteria including fecal coliform reducing the discharge to safe levels prior to Gulf discharge. Further, water is diluted by the diffuser upon discharge to marine waters, which are denser than freshwater, and is further dispersed due to discharge velocities of 8-10 fps. The function of the system is significantly improved by direct discharge to the Gulf.

The diffuser system is replaceable and designed to withstand most types of vessel impacts from anchors and nets. A bottom anchored diffuser system was designed to be operated and maintained with replaceable sections and components. For example, if an individual diffuser unit becomes damaged by a vessel’s anchor, the diffuser can be replaced. Should large-scale damage to the system occur, the entire diffuser pipeline section (45 ft) can be disconnected from the main HDD pipeline at the mechanical joint and from anchor system and a new diffuser assembly section installed. The anchor and strapping system was designed to withstand the buoyancy load of the pipe and loads from anchors. The pipeline was placed using Horizontal Directional Drilling Techniques which eliminates most construction impacts to the beach dune thus protecting dune vegetation and nearshore marine-life. See Figures 5 and 6 for HDD equipment set-up.
Figure 3 – Contech Storm Filter

Figure 4 – Acquionics UV Disinfection System

Figure 5 – HDD Equipment and Set-Up

Figure 6 – HDD Equipment and Set-Up
6. DESIGN CONSIDERATIONS

The pipeline was sized to discharge the normal, seasonal rainfall events and as well as to allow for HDD placement and traversing small ditches and coastal dunes to the Gulf. HDD pipeline placement techniques were used to place the pipe under the Gulf seafloor with termination at the -18 ft (NAVD88) contour, preventing interaction with littoral processes and wave forces except under extreme storm events.

The pipe discharges through a diffuser head that is located approximately 2.5ft above the seabed and was designed so that water discharged in an upward direction. The depth of water and the relief of the pipe from the seabed addressed the USCG concerns and thus there were no objections with the velocity discharge through the diffusers designed at 8-10 fps to create sufficient mixing of the fresh and saline waters and resulting in a 100 ft mixing zone. See Figure 7 for the design plan and profile of the diffuser system.

As discussed above, the diffuser system was designed for diver assisted repairs and/or replacement, if necessary. Each component of the system (duckbill diffuser and tapping sleeve) is designed to be removed and replaced. Individual diffusers were designed to fail first providing for preservation of the overall assembly and the pipeline.

Figure 7– Plan and Profile of Diffuser System

7. CONSTRUCTION

The entry point was located on shore, landward of the vegetated dune. The exit point of the HDD was located offshore, at the diffuser connection point as shown in Figure 7, where two barges were anchored offshore to receive the drill. The entry angle of the drill and the drill rig setback distance were designed to avoid disturbing the vegetated dune. The minimum depth of the HDD was 35 feet based on geotechnical considerations to prevent frac-out of the drilling fluid during the HDD operation. See Figure 8 for the drilling contractors profile for their anticipated pipe installation using HDD. Drilling took approximately 5 days. Once the drill exited the seafloor, a reamer was attached to the drill at the offshore exit location and the contractor reamed back toward shore, carrying a cable that was also attached to the offshore barge. The reaming process took...
approximately 10 days. Once back on shore, the reamer was disconnected from the drill and attached to the pipe. The pipe was fused and pulled from land to the offshore exit point within 1 day.

The contractor was given the option of two pipe materials, HDPE and FPVC, for the pipeline. In this case, the contractor selected the FPVC option due to the strength of its fused joint and its ability to withstand anticipated forces during pullback. Figure 12 shows the pipe fusion and pullback set-up.

The anchoring system was preassembled offsite and designed for connection through a mechanical joint fitting (Figure 9). All components shown in Figures 10 and 11 were assembled by the contractor and examined by the Engineers prior to installation. Anchor strappings are 316 Stainless Steel to resist corrosion and are approximately 1 inch thick to support the pipeline from pulling forces and the weight of the pipeline in the event of seabed erosion.

Table 1 below provides information regarding the final constructed pipeline and the HDD process.

![Figure 8– HDD Emergence and MJ Adapter](image)

![Figure 9 – HDD Emergence and MJ Adapter](image)
Figure 10 – Anchor System with Strapping

Figure 11 – Tapping Saddle/Diffuser Assembly

Figure 12 – Pipeline Fusion and Pull Back Process
### Table 1 – Final Constructed HDD Pipeline

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Pipe Diameter (ID)</td>
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<tr>
<td>Pipe Material</td>
<td>FPVC</td>
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<tr>
<td>Pipe Specifications</td>
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<td>Hole Diameter</td>
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<tr>
<td>Entry and Exit Angles</td>
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<tr>
<td>Number of Horizontal and Vertical Curves in Path</td>
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<tr>
<td>Minimum/Maximum Radius</td>
<td>1,600 ft/2400 ft</td>
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<tr>
<td>Maximum Depth</td>
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<tr>
<td>Bore Length</td>
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<tr>
<td>Additional Length of Pipe for Handling &amp; Thermal Contraction</td>
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<tr>
<td>Horizontal Distance to Achieve Desired Depth and Rise to Surface</td>
<td>484 ft and 332 ft</td>
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<tr>
<td>Distance Traversed at Desired Depth</td>
<td>2,067 ft</td>
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<tr>
<td>Maximum Pullback Pressure on Pipe</td>
<td>53,570 lb</td>
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<tr>
<td>Published Safe Pulling Force for Pipe</td>
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</table>

8. **FLAMINGO BEACH DISCHARGE SITE**

A second site, located in Venice, FL, has gone through the planning and design phase. This primary differences between this project and the Beach Road project are that the Venice project has an eroding shoreline, nearby hardbottom and significantly larger existing discharges from the outfall. Figures 13 through 16 show the specifics of the Flamingo Beach Project.
As seen in Figure 15, this project utilized the existing discharge structure (shown in Figure 13) as the overflow during severe events. Figure 16 which shows the two parallel pipes with 16 diffusers on each pipe; 32 diffusers total.

Table 2 below provides the specific design information for the Venice Project.

<table>
<thead>
<tr>
<th>Table 2 – Venice Project Design Details</th>
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<tr>
<td><strong>Pipe Material</strong></td>
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<td><strong>Pipeline Length</strong></td>
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<td><strong>Pipeline Placement</strong></td>
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<td><strong>Discharge Capacity</strong></td>
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<td><strong>HDD Below Seabed</strong></td>
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<td><strong>Depth of Emergent Pipeline</strong></td>
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<td><strong>Anchoring System</strong></td>
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<td></td>
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<tr>
<td><strong>Diffuser System</strong></td>
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</table>
9. CONCLUSION

Stormwater discharge treatment with discharge offshore is an effective solution to addressing the problems associated with existing ocean stormwater outfalls; whether the shoreline is accreting or eroding.

The approach to existing shoreline stormwater disposal accomplished:
   a) Bacteria and fine sediment removal;
   b) Erosion abatement (nourished beaches); and
   c) Backshore flooding of low uplands resolved.

HDD construction techniques make projects such as this possible by significantly minimizing permitting concerns regarding impacts to environmentally sensitive areas during construction.

10. REFERENCES

3. Erickson Consulting Engineers, Inc. (2012) – Construction Drawings for Beach Road Drainage Improvements Gulf Discharge, Siesta Key, FL.