North American Society for Trenchless Technology (NASTT)
2024 No-Dig Show
Providence, Rhode Island
April 14-18, 2024

WM-T2-03

Highlights of the High Life – Miami Beach's Horizontal Directional Drill Case Study

Shari Ramirez PE, Wade Trim, Coral Gables, Florida
Freddy Betancourt PE, Wade Trim, Orlando, Florida
Omar Mendoza, PE, City of Miami Beach, Florida

1.0 ABSTRACT

The City of Miami Beach required replacement of a 16-inch water main crossing the Intracoastal Waterway along 41st Street between Pine Tree Drive and Collins Avenue. A portion of the existing water main is attached to the 41st Street bridge. Approximately 1,020 linear feet of this pipe is replaced by a 20-inch large diameter distribution water main with most of the replacement pipe installed via horizontal directional drill (HDD) under the Florida Department of Transportation (FDOT) bridge and Intracoastal Waterway. Key challenges include a compound curve alignment due to right-of-way limitations and congested utility corridor. Additionally, the HDD profile navigates the geotechnical challenges including a soil-rock interface, while simultaneously aligning with the bridge and avoiding existing bridge substructure and pilings. Extensive coordination was done with FDOT and two adjacent projects. Since the project is in a coastal community area of heavy traffic and major tourism, public outreach is essential during construction to maintain access to residents, tourists, and emergency vehicles through the maintenance-of-traffic (MOT) zones. Further, multiple residential buildings in the work zones have their only parking entrance within the MOT limits. Construction requires closing an intersection of two state roads during the pipeline pullback operation located within 200 feet of the beach. This paper provides pictures and exhibits of how all these elements came together during design and construction of a very challenging project for the City.

2.0 INTRODUCTION

The existing aerial water main that runs across the 41st Street bridge between Pine Tree Drive and Collins Avenue was in need of replacement. This water main was categorized with high probability and consequence of failure under the City's Water Master Plan and prioritized as part of the City's Capital Improvements Plan. In addition, FDOT had planned a bridge rehabilitation project that required the removal of the existing aerial water main. As a result, the City, in coordination with FDOT, determined the importance of providing reliable water service to the customers, as well as the importance of preventing leaks into the Indian Creek Canal (protected water of the Biscayne Bay Preserve), and prioritized this project in advance of FDOT's other construction projects.

The replacement of approximately 1,020 linear feet of a 16-inch cast iron water main along 41st Street spans across the Intracoastal Waterway suspended from the 41st Street Bridge, which is an FDOT structure. As part of the project, a portion of the existing water main is to be upsized to a 20-inch diameter distribution water main. Most of the replacement pipe will be installed via horizontal directional drill (HDD) under the FDOT bridge and Intracoastal Waterway. The remainder includes open-cut portions in FDOT right-of-way which will provide temporary connections to existing water mains and will provide a configuration that allows for quick transfers to proposed replacement water mains on adjacent corridors that are being designed and constructed as separate contracts.

Key challenges for the HDD design include a compound curve alignment due to right-of-way limitations and a congested utility corridor, limiting the availability of entry and exit pit locations. Additionally, the HDD profile navigates a challenging soil-rock interface while simultaneously aligning with the bridge and avoiding the existing bridge substructure and pilings. These pilings run in series across the full width of the bridge to a depth of 25 feet below mean low water (MLW). Extensive coordination was done with FDOT for upcoming adjacent projects to have them commence after this one to eliminate conflict and rework. A detailed sequence of construction also allows for grouting and removing portions of the existing water main within the corridor, while allowing the portion of pipe suspending from the bridge structure to remain in place temporarily. The removal of this segment of pipe was coordinated with an FDOT bridge improvement project that would soon follow the completion of this water main replacement.

Since the project is in a coastal community area with heavy traffic and major tourism, public outreach is essential during construction to maintain access to residents, tourists, and emergency vehicles. Further, multiple residential buildings in the work zones have their only parking entrance within the project limits. Construction requires closing an intersection of two state roads, located within 200 feet of the beach, during the pipeline pull-back operation. The proposed placement of the drilling machine on the west side of 41st Street was strategically planned to avoid closing access to the beach through Indian Creek Drive. Public outreach needs for this project will be closely coordinated between the Contractor and the City of Miami Beach, leveraging the City's Public Engagement Toolbox.

3.0 PROJECT LOCATION

The water main replacement project is in the City of Miami Beach, Florida along 41st Street between Pine Tree Drive and Collins Avenue within a state-owned road right-of-way. See Figure 1.

Figure 1. Project Location Map

4.0 PROJECT OVERVIEW, PIPE MATERIALS, AND PIPE INSTALLATION

The project consists of the installation of about 1,200 linear feet (LF) of 20-inch water main; 320 LF are to be installed via open cut and 820 LF are to be installed via subaqueous horizontal directional drill (HDD) across the Indian Creek Waterway. The project includes the installation of four 20-inch butterfly

valves, two air release valves, three sampling points, and one 6-inch fire service reconnection. The option of replacing the water main along the bridge structure was discarded by the City and FDOT. The constant exposure to seawater and the inability to access the water main for inspection or repair were two of the major reasons the City did not want to consider another bridge-attached crossing. FDOT has a major bridge improvement project planned and preferred the water main not be attached to the structure to allow the restoration activities to occur without interference.

4.1 High Density Polyethylene Pipe

The proposed pipe to be installed via HDD is a 20-inch diameter High Density Polyethylene (HDPE) DR-11 Ductile Iron Pipe Size (DIPS) pipe material with a pressure rating of 200 psi. The inside diameter of the 20-inch HDPE pipe with a dimension ratio (DR) of DR-11 is roughly 17 inches.

4.2 Ductile Iron Pipe

The portion of installation via open cut trench is 20-inch Ductile Iron Pipe (DIP) with an inside diameter of roughly 20 inches and class 51 in accordance with AWWA C151. To prolong and protect against corrosion of the ductile iron material exposed to coastal areas with saline groundwater, the following protective measures were specified:

1. Polyethylene Encasement
2. Zinc Coating
3. Cement Lining

4.2.1 Polyethylene Encasement

V-Bio Polyethylene Enhanced Encasement was specified for the DIP and fittings in accordance with AWWA C600 and AWWA C105 for corrosion protection against aggressive soil conditions. Polyethylene encasement for use with DIP systems consists of three layers of co-extruded linear low-density polyethylene (LLDPE) fused into a single thickness of not less than 8 mils. The inside layer of the polyethylene wrap to be in contact with the pipe exterior is infused with a corrosion inhibitor and antimicrobial biocide to control galvanic corrosion.

4.2.2 Zinc Coating

Zinc protective coating was specified for the ductile iron pipe and fittings to be factory-applied. The exterior of the ductile iron pipe and fitting was coated with a layer of arc-sprayed zinc per ISO 8179. The zinc coating provides for corrosion resistance of ductile iron material in aggressive soils. The zinc coating acts as a passive anode prolonging the useful life of the asset. The use of zinc coating is relatively new in the industry but is predominantly used and specified in the coastal areas of South Florida where elevated salinity in the groundwater is prevalent.

4.2.3 Cement Lining

Cement lining was specified for the ductile iron pipe in accordance with AWWA C104. Cement lining is NSF 61 approved and consistent with potable water applications.

4.3 PIPE INSTALLATION AND TIE-IN CONNECTIONS

The proposed pipe is to be installed via open-cut trench and HDD methods. The open cut takes place at both ends of the project at Pine Tree Drive and at Collins Avenue with the crossing of Indian Creek Waterway performed via HDD. Refer to Figure 2 to Figure 4 for photos of these areas. There are three tie-in points to the existing water main with the intent to allow for additional water main replacement.

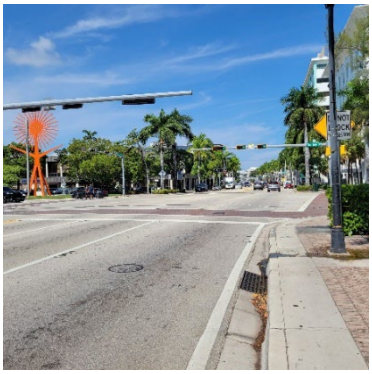

Figure 2. East Open-Cut Installation Pine Tree Drive

Figure 3. Middle HDD Installation Indian Creek

Figure 4. West Open-Cut Installation Collins Avenue

5.0 DESIGN CHALLENGES

The project faced design challenges that required engineering evaluation and alternative solutions to provide a constructible project.

5.1 HDD UNDER 41ST STREET BRIDGE

The existing 41st Street roadway has limited right-of-way in an urban corridor with nearby high-rise buildings. In addition to FDOT's preference to not attach the new pipeline to the bridge, aerial crossings are no longer allowed across the Indian Creek Waterway. Given this restriction, a trenchless method was required under the existing 41st Street Bridge. The project team elected to design the pipeline as an HDD.

The existing bridge length is approximately 280 feet as shown in Figure 5. Obtaining the best available bridge as-builts to identify the depth of the piles was critical to the design of the proposed water main crossing the Indian Creek Waterway. The as-builts showed the depth of the piles at 25 feet below mean low water (MLW) from datum 0.00 to the rock interface as shown in Figure 6. To clear the zone of influence of the bridge piles, the HDD was designed at a depth of 45 feet below datum 0.00. The HDD was designed with reduced radius to maintain clearance between the piles and to stay within the intersections of Pine Tree Drive on one end and Collins Avenue on the other end .

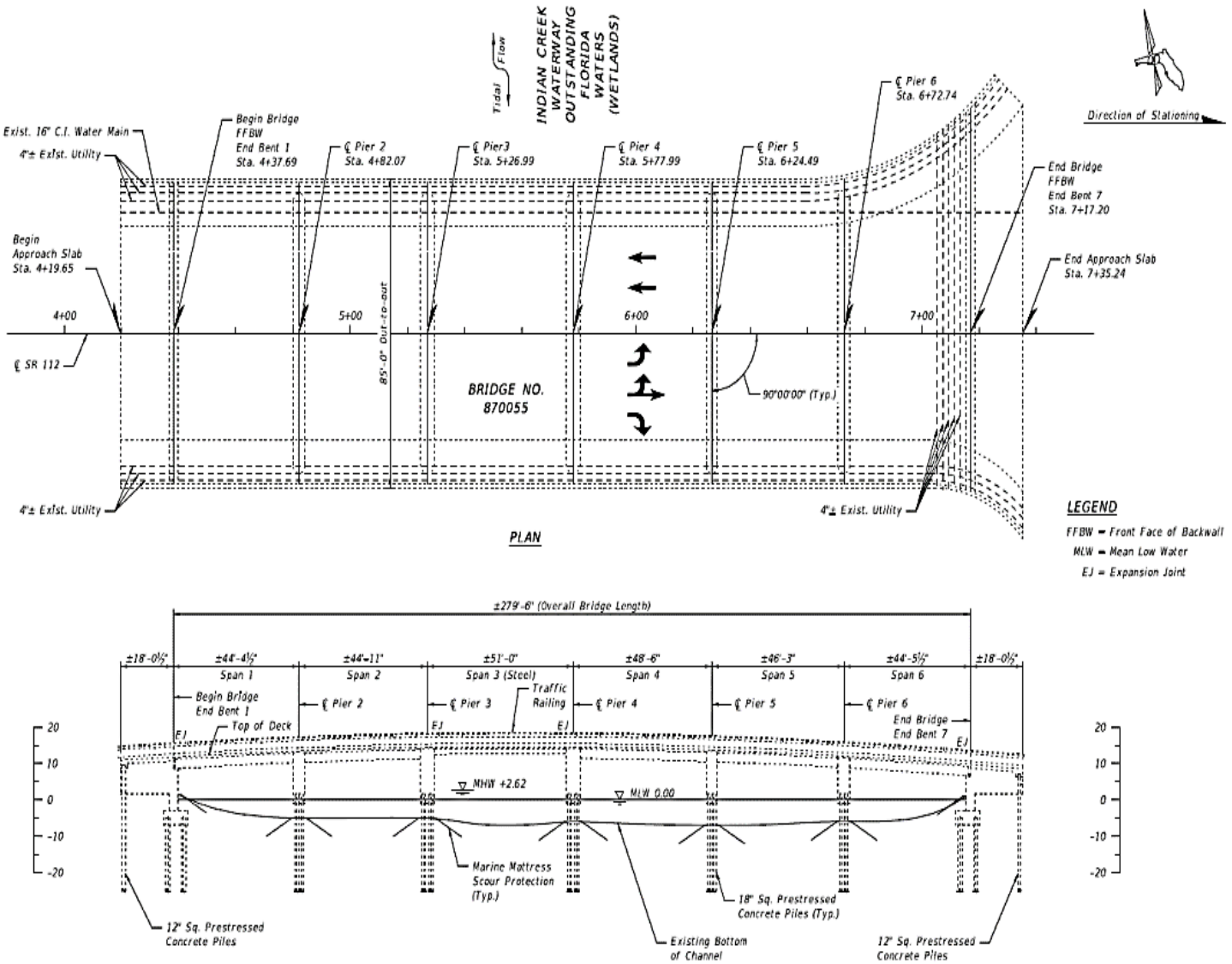

Figure 5. 41st Street Bridge Rehabilitation Plan

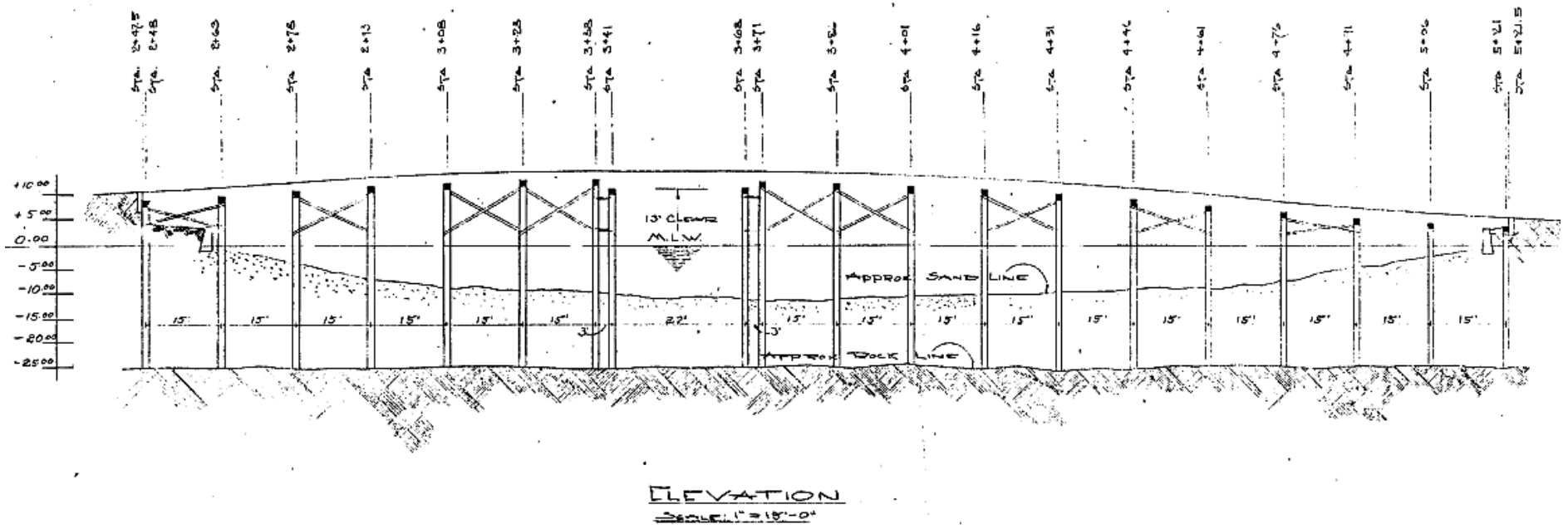

Figure 6. 41st Street Bridge Piling Plan As-Built

5.2 HDD Compound Curve Alignment

The HDD had to be designed as a compound curve alignment due to the existing 41st Street roadway corridor geometry and the presence of existing utilities limiting the location of the proposed water main. On the west end of Pine Tree Drive, the HDD runs parallel to an existing 3-foot by 2-foot storm culvert as it exits the pit. Through the bridge run, the HDD was kept in between the piers. On the east side, the HDD runs south of the north sidewalk to allow for dual pipe installation and tie-in to existing water mains. Refer to the overall horizontal alignment of the proposed water main shown in Figure 7 for the complete pipe layout.

Figure 7. Proposed Water Main Horizontal Alignment

5.3 SOIL-ROCK INTERFACE

The soils within the first 33 feet below the existing ground elevation are mostly classified as sand. Because the HDD is deeper than 33 feet, it will be drilling through the limestone/soil interface. This layer consists of light gray limestone with interbedded sand layers and sandy zones found between depths of 33 to 80 feet below grade (see Figure 8).

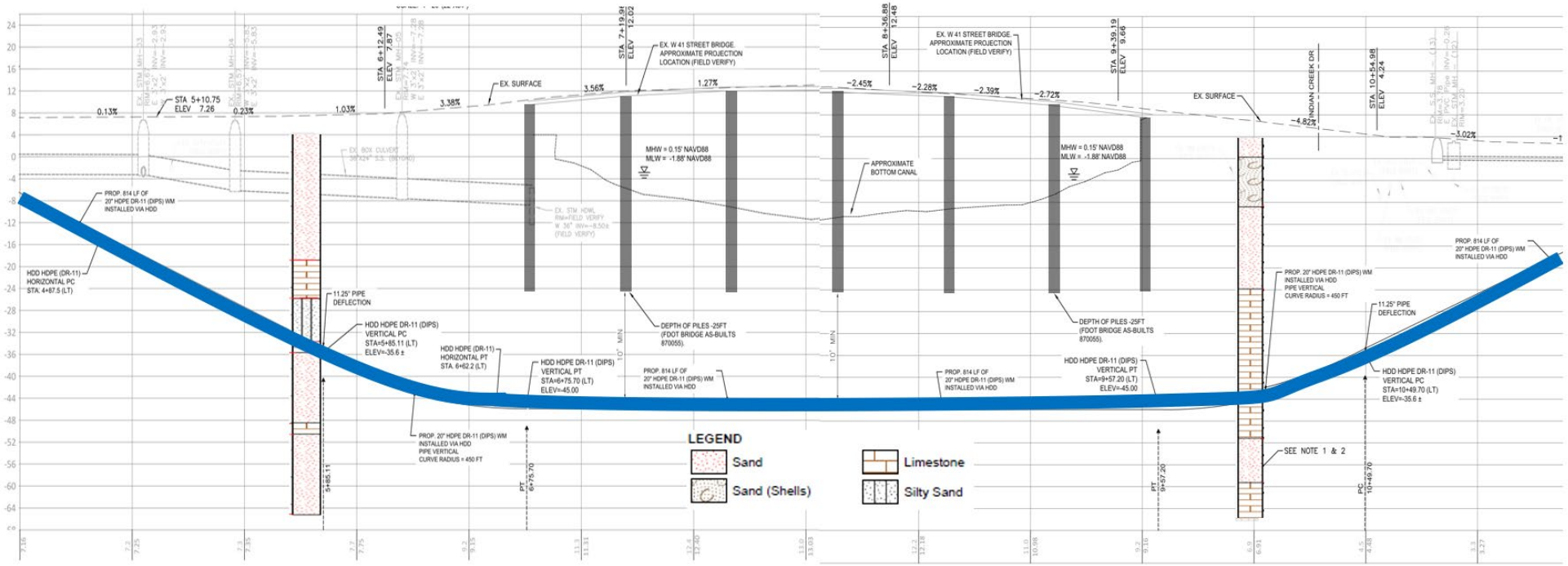

Figure 8. Proposed Water Main Vertical Alignment

5.4 Stakeholder and Permitting Coordination

Multiple FDOT and City projects had to be coordinated to avoid schedule conflicts and work overlaps. The water main replacement was arranged to commence ahead of the following projects:

1. 41st Street Bridge Rehabilitation Project – It is critical for the water main attached to the bridge to be decommissioned to allow for the removal of the pipe.
2. Resurfacing, Restoration, and Rehabilitation of Collins Avenue from 44th Street to 4700 Block and Indian Creek from 41st Street to 44th Street Project – The proposed water main will need to be installed before resurfacing the streets.
3. Proposed 20-inch and 12-inch Ductile Iron Water Main Replacement within Collins Avenue from 44th Street to 4700 Block and Indian Creek from 41st Street to 44th Street Project – The proposed water main must be installed to allow for the continuation of the water main replacement.
4. 41st Street Beautification Project – All pipeline work must be completed to allow the landscaping and other hardscape improvements to be completed without disrupting or damaging new work.

In addition to City project coordination, other state agencies required extensive communication to obtain the required permits including Miami-Dade Water and Sewer Department (WASD) Approvals, City Fire Department Approvals, Regulatory and Economic Resources (RER) Approvals, Florida Department of Health (FDOH) and Florida Department of Environmental Protection (FDEP) Notice of Intent to Use the General Permit for Construction of Water Main Extension for PWSs Permit, South Florida Water Management District (SFWMD) and FDEP Individual Environmental Resource Permit, US Army Corps of Engineers (USACE) Permit, and Florida Department of Transportation (FDOT) Utility Permit, with two Utility Work Schedule and Design and Construction agreements.

5.5 Automatic Air Release Valve/ Inflow Preventer

During the process of applying for permitting through the FDEP and filling out the permit application, there were two criteria identified for Automatic Air Release Valves (AARVs) that needed to be met. These criteria were the following regulations:

> *"At high points where air can accumulate in new or altered water mains included in this project, provisions will be made to remove the air by means of air relief valves, and automatic air relief valves will not be used in situations where flooding of the valve manhole or chamber may occur."*
>
> *"The open end of the air relief pipe from all automatic air relief valves installed under this project will be extended to at least one foot above grade and will be provided with a screened, downward-facing elbow."*

The Federal Emergency Management Agency (FEMA) flood map was obtained and reviewed to determine the flood level risk of the project area. The 100-year flood elevation for this area is at elevation 7.0 feet NAVD (Figure 9**)**. The existing ground elevations surveyed along 41st Street ranged between 2.4 feet to 6.5 feet NAVD.

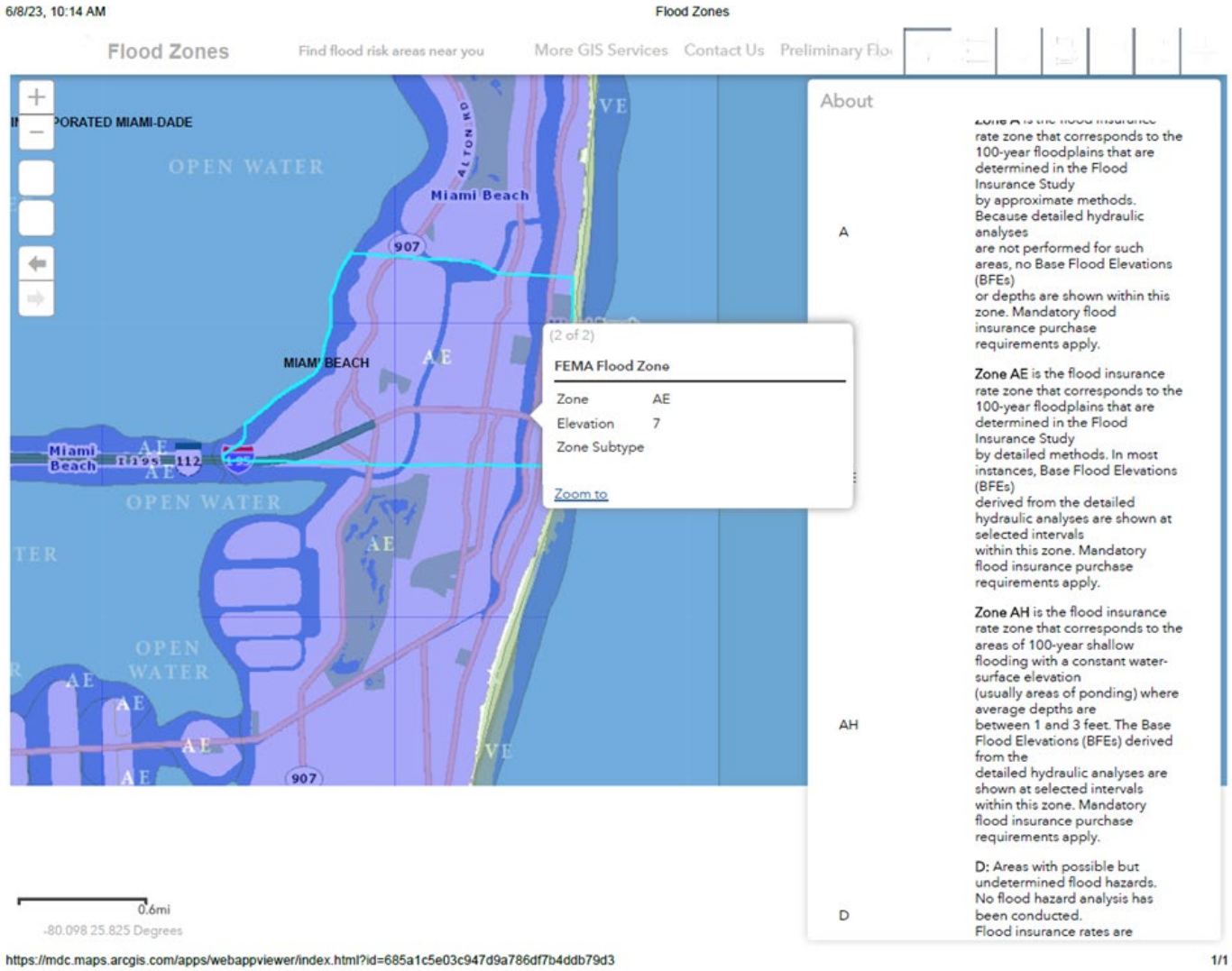

Figure 9. FEMA Flood Map

The criteria listed above to extend the proposed AARV to at least one foot above the existing grade was not feasible because the AARV on the west side had to be placed on the road due to conflict with utilities and the AARV on the east side was placed on the sidewalk but would have had to be raised 5.5 feet above grade to meet criteria.

Alternatively, to avoid contamination in the water main system in case of a flooding scenario, the City detail was modified to keep the AARV underground but include an inflow preventer to meet the FDEP requirement. Details shown in Figure 10 and Figure 11 below were prepared and provided by Hazen and Sawyer to the City for the utilization in the design of this project. Type 1 was used for typical AARV and Type 2 was used where sampling of the pipeline was also required.

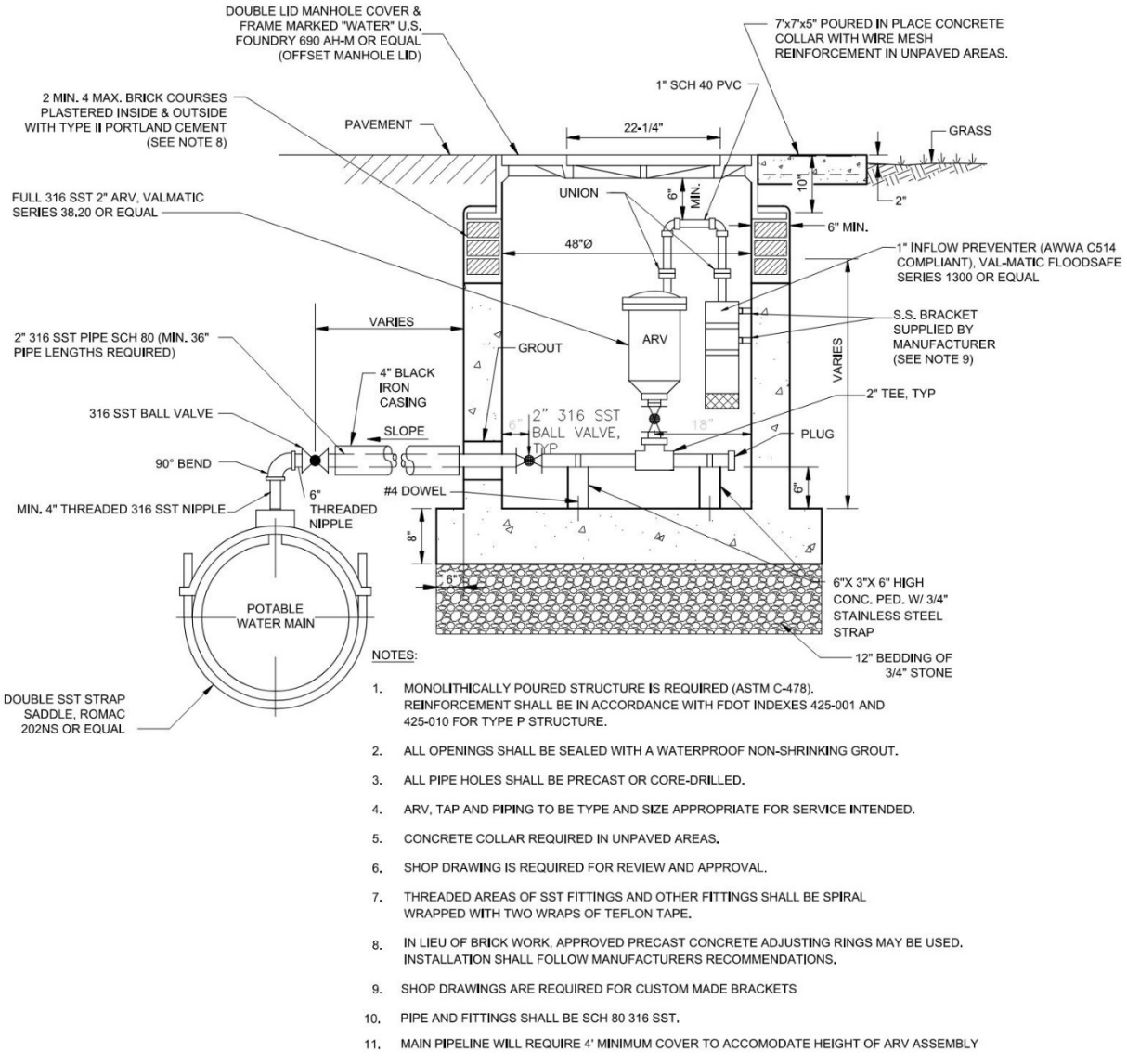

Figure 10. Air Release Vault – Type 1

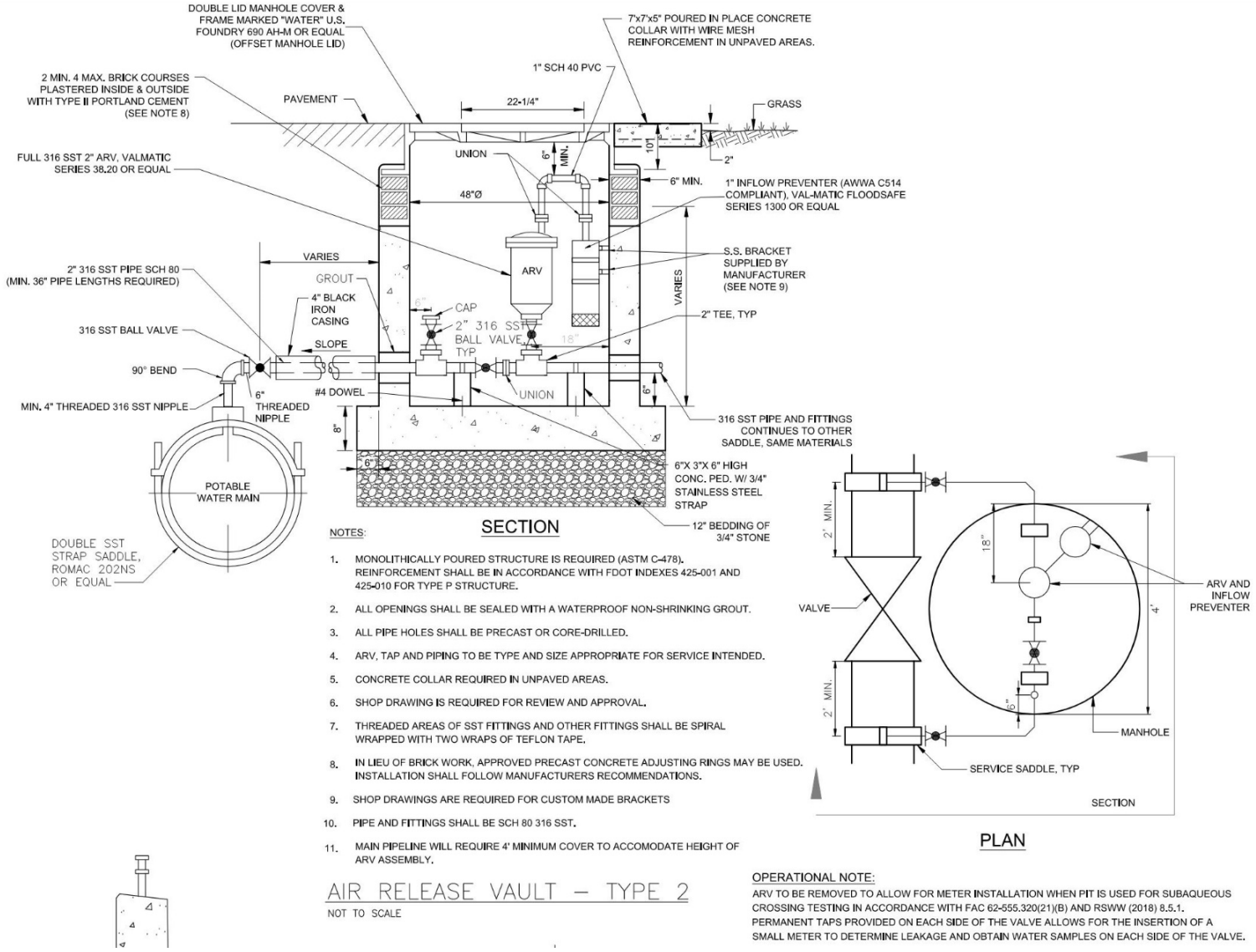

Figure 11. Air Release Vault – Type 2

6.0 CONSTRUCTION CHALLENGES

The following construction challenges and mitigation options are anticipated.

6.1 PUBLIC OUTREACH

Miami Beach is a world tourist destination, attracting millions of visitors per year to its world-famous shores. The project is located in the Mid-Beach Section which spans between 24th Street and 60th Street. This area of Miami Beach has a diverse combination of hotels, residential buildings, an art district, stylish restaurants, and much more. As seen in Figure 12 below, the project construction and staging area is immediately adjacent to four hotels and at least six residential buildings, a major public parking structure, and some commercial frontage.

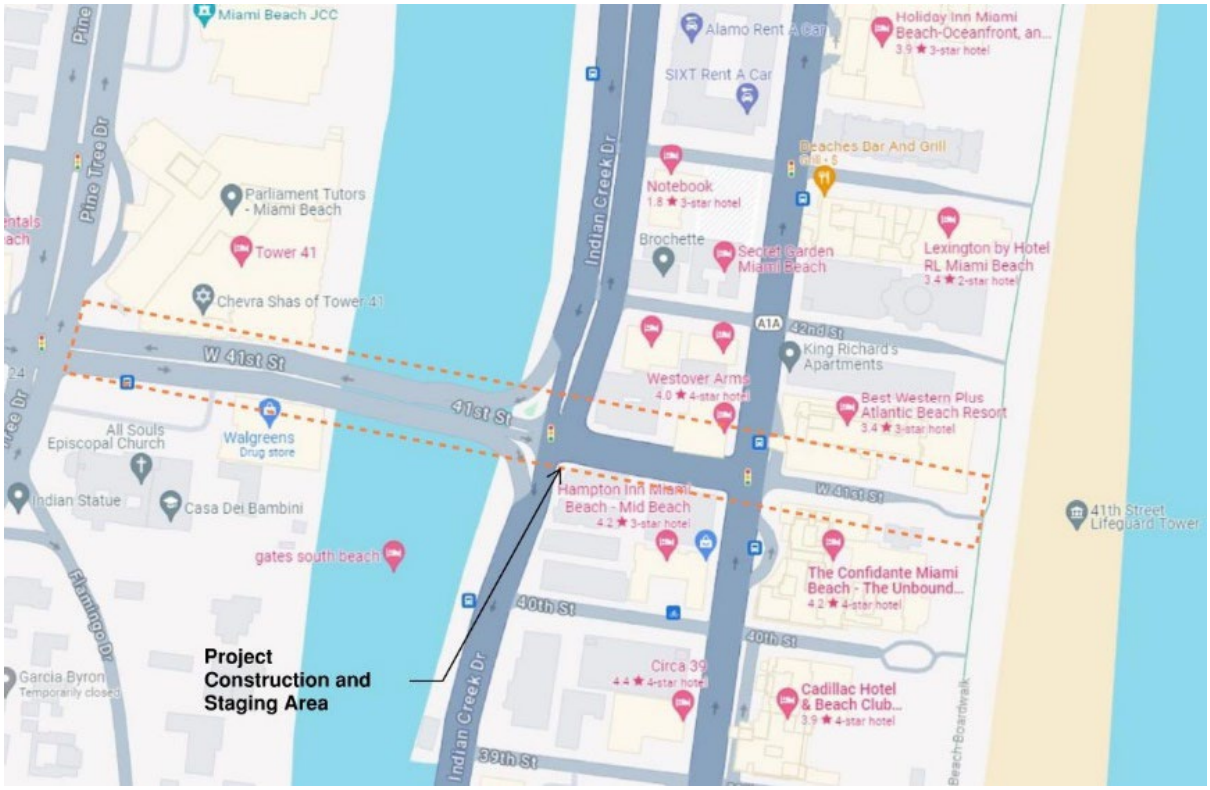

Figure 12. Project Construction and Staging Area

This project has the potential to be very disruptive, albeit only for a short duration, to a significant number of local residents and visitors to the area, and thus a proactive communication plan is imperative for the success of the project. In addition to advanced warning signs for local and passersby drivers, upfront and diligent communication will be made with hotel managers, residential condominium associations, commercial properties in the project area, and the Fire Department for coordination of access for emergency services vehicles. Usual door hangers and direct communications from the Contractor or City designated staff will provide advance notice of any access impediment to private parking lots or residential access, or any planned water service disruption during the change-over of water services. All public parking along the street will be rented out by the Contractor to minimize public parking and maximize available layout and access.

The City of Miami Beach will keep the general public appraised of activities and local impacts through its website and engagement toolbox, which include e-newsletters, text alerts, MB Resident Connect, mobile app, and others. Figure 13 below shows the City's engagement options to support Contractor communication activities.

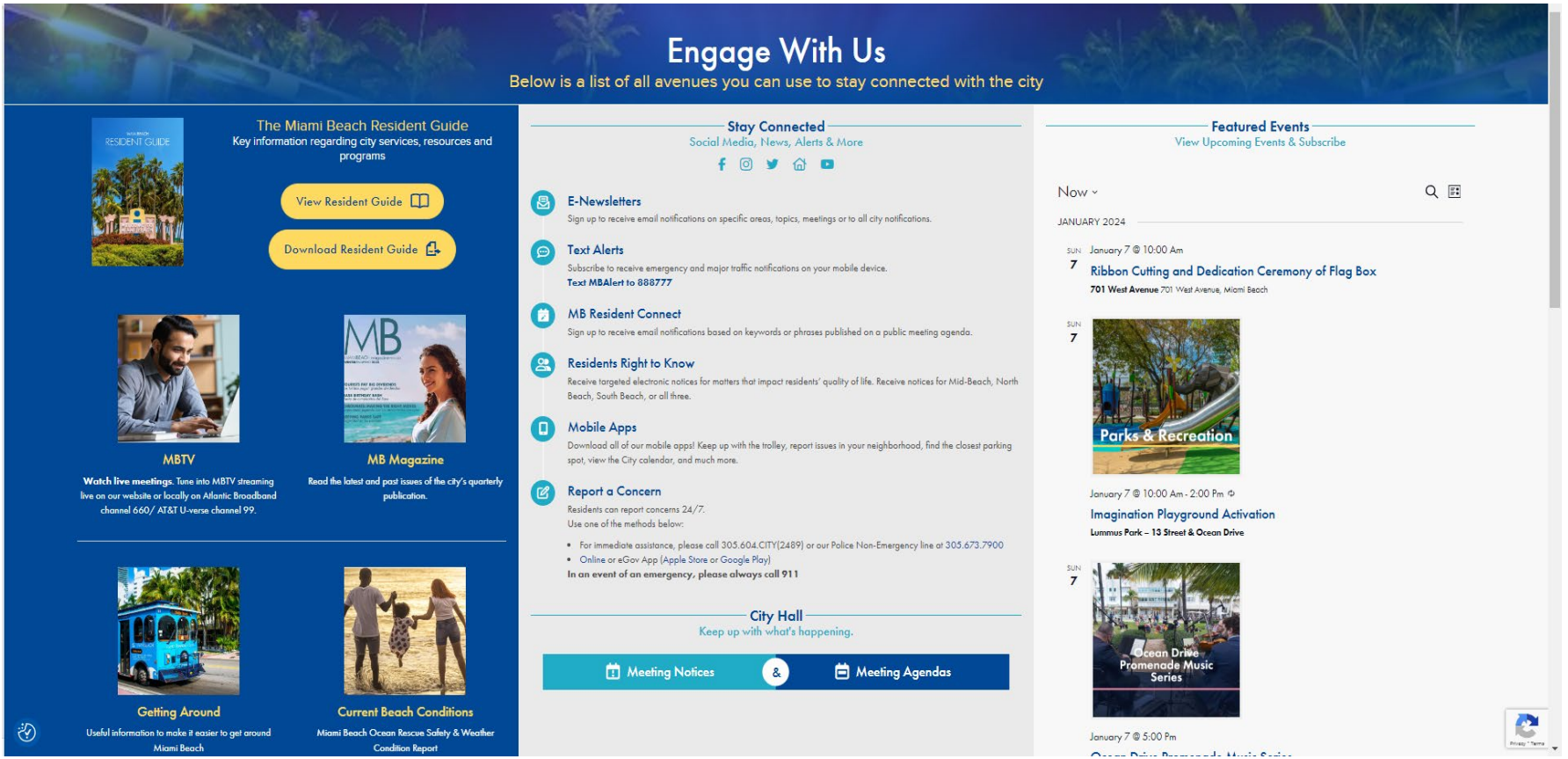

Figure 13. City of Miami Beach Engagement Toolbox

6.2 MAINTENANCE-OF-TRAFFIC (MOT)

The project is in a high-traffic corridor, and the 41st Street roadway is one of the main accesses to the beach, one of the few intracoastal bridges to the barrier island. This corridor also serves as a public transportation corridor, including multiple Miami-Dade Metrobus Routes (Routes 14, 36, and 150 along 41st Street, and Routes 79 and 100 at the intersection of 41st Street with Collins Avenue). MOT for the project was broken into three phases based on the nature of the work: HDD Setup, HDD Pulling and Open Cut. The MOT detours extend north up to 63rd Street and south up to 23rd Street. See Figure 14.

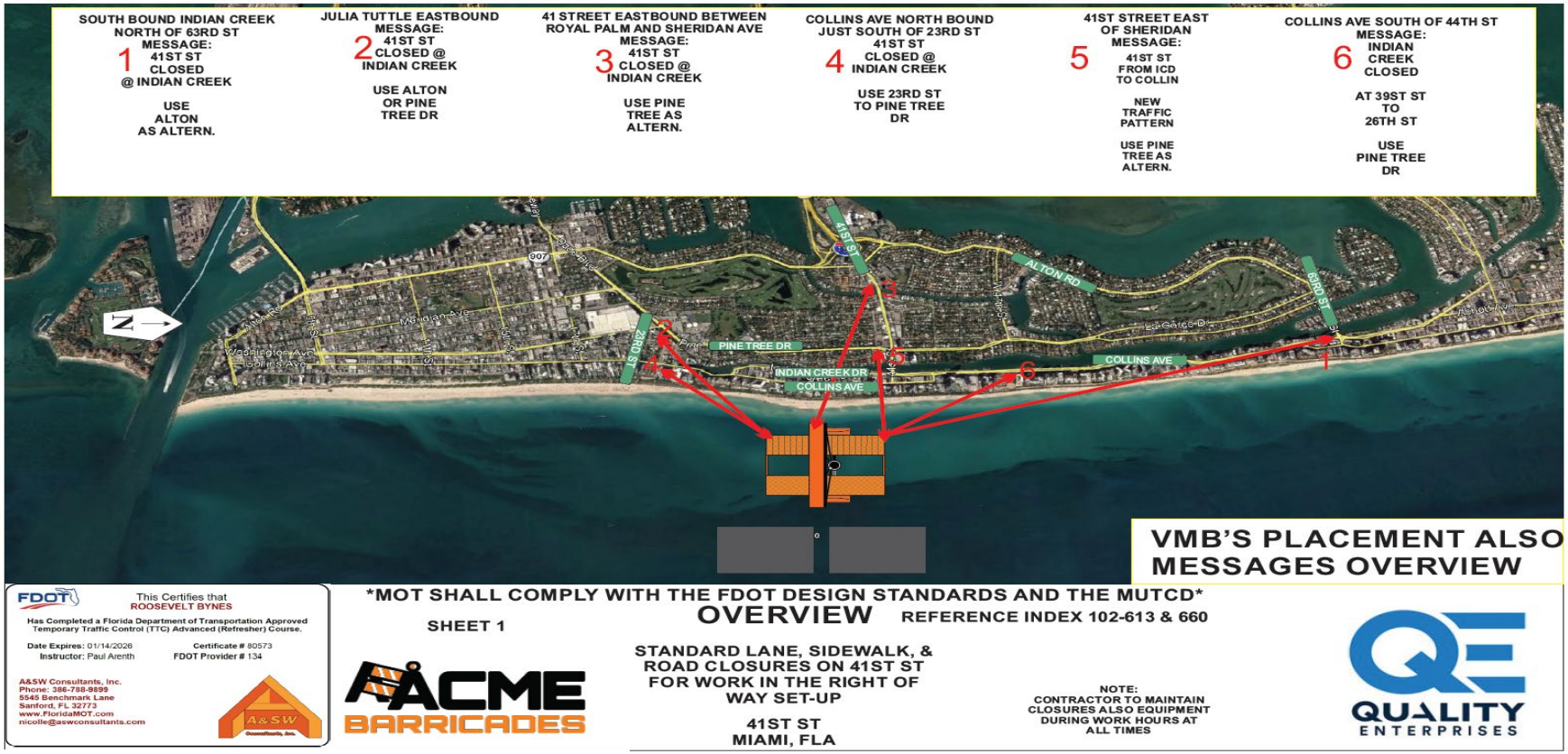

Figure 14. MOT Overview Detour

6.2.1 MOT Phase 1 – HDD Setup

Phase 1 includes the MOT setup to mobilize and bring the HDD Drilling Rig and HDPE pipe for fusing. The pipe storage and fusing operation is planned to be staged at the end of 41st Street approximately 200 feet away from the beach. This work involves drilling the pilot hole, reaming the pilot hole, and fusing the pipe. The position and location of the entry and exit pits were strategically planned to avoid closure of access to the beach. The fusing of the pipe at the end of the street eliminates the obstruction to intersections. The anticipated work duration is two to three weeks. See Figure 15.

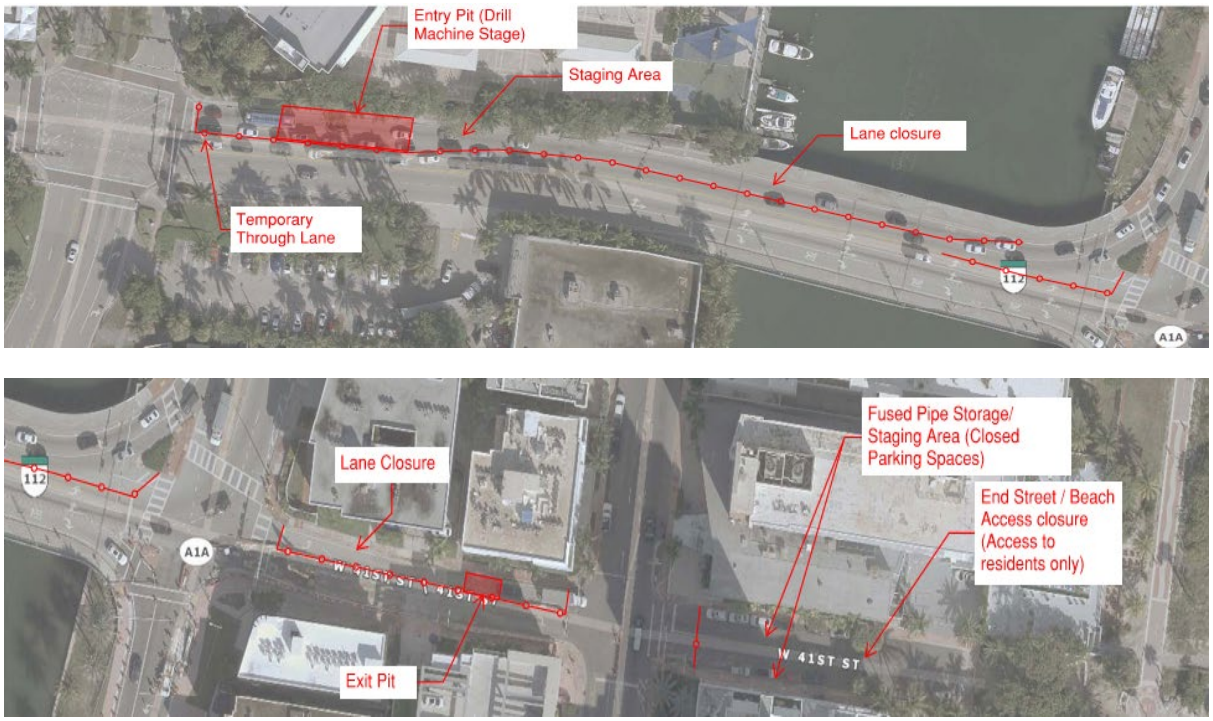

Figure 15. MOT Phase 1 – HDD Setup

6.2.2 MOT Phase 2 – HDD Pulling

Phase 2 includes the MOT to close the intersection of Collins Avenue and 41st Street to perform the pulling of the HDD at night. Detour of vehicle and pedestrian traffic is important due to the high volume of tourism in the area. Within the closure area, only residents will be granted access. The anticipated work duration is one to two days. See Figure 16.

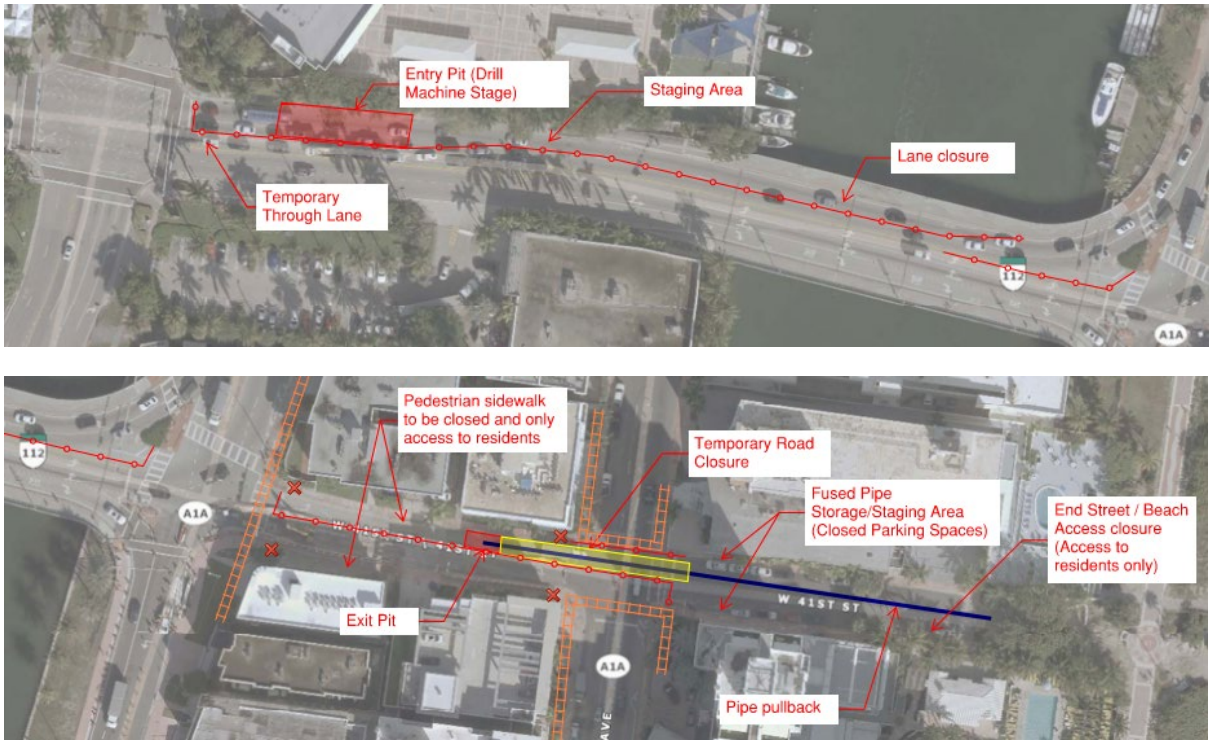

Figure 16. MOT Phase 2 – HDD Pulling

6.2.3 MOT Phase 3 – Open Cut

Phase 3 includes the MOT for the open-cut pipe installation and testing, milling, resurfacing, and pavement markings to complete the project. Proposed water main disinfection and pressure testing acceptance will be obtained prior to the abandonment and grout-filling of the existing water main that is to be decommissioned. The roadway restoration will be done to FDOT standards and match the existing pavement design. The work duration is about two months. See Figure 17.

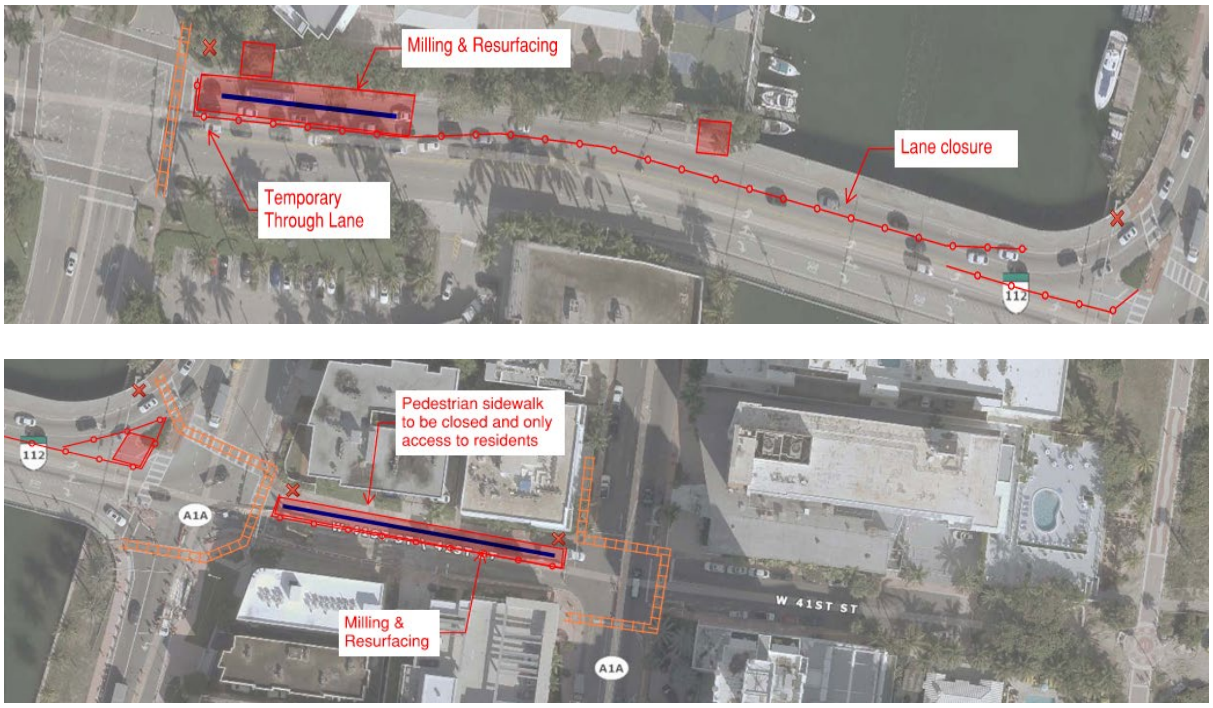

Figure 17. MOT Phase 3 – Open Cut

6.3 BRIDGE PILES VERTICAL CLEARANCE

The HDD is to clear 20 feet beneath the bridge piles. The existing bridge piles showed piles to extend up to the bedrock interface. Figure 18 shows the modified HDD drill path with smooth curves but maintaining the depth of HDD.

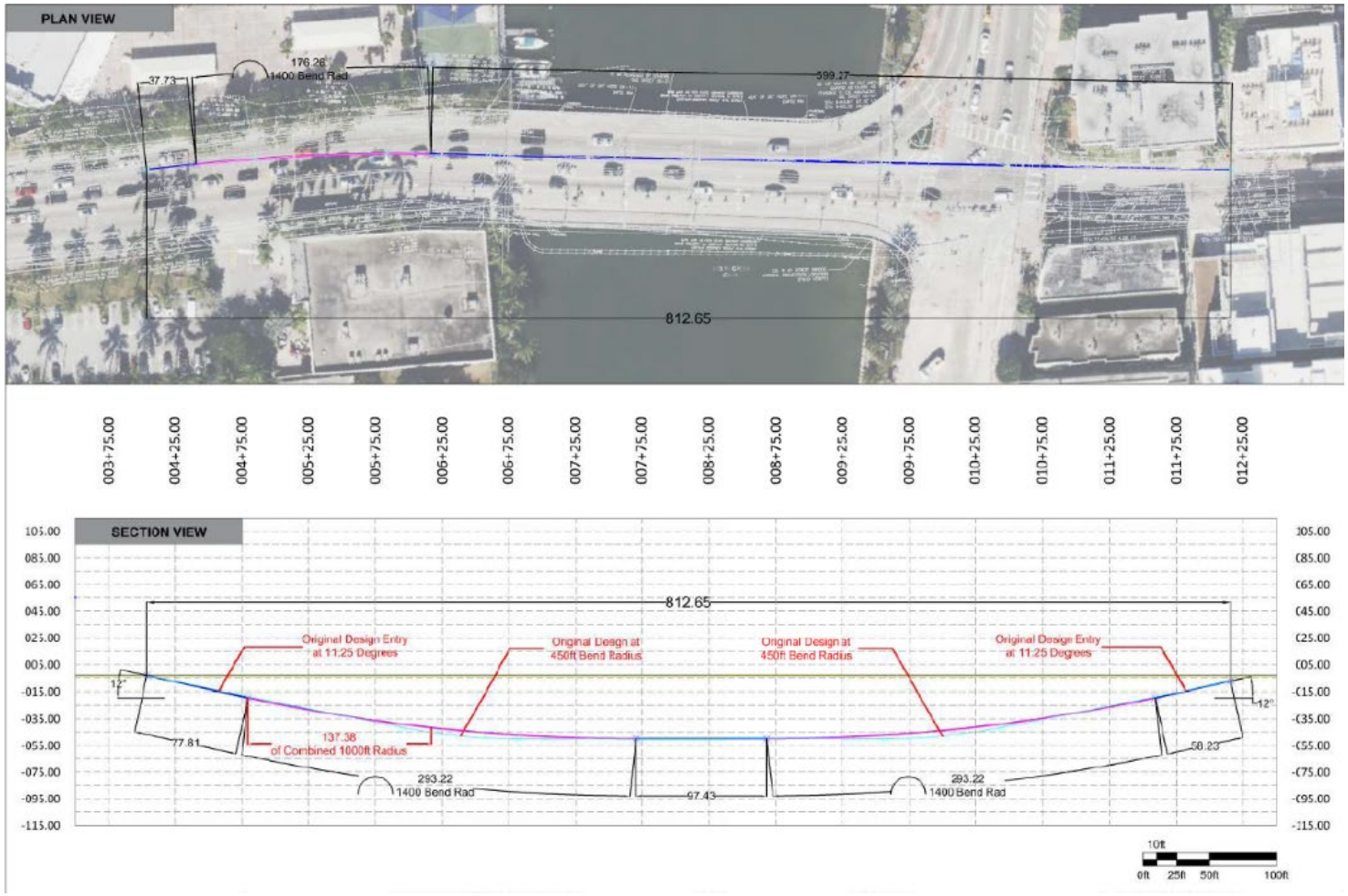

Figure 18. Modified Drill Path

6.4 HDD Pulling Operation at Night

The HDD pulling of the pipe operation is to be performed at night to reduce inconvenience to residents, businesses, and visitors. Off-duty police officers will control traffic during closure of Collins Avenue intersection. A noise ordinance waiver will need to be approved by the City for the night work.

6.5 Tie-In Connections

The connection on the west end of Pine Tree Drive will require a line stop valve to allow for the tie-in to the existing water main since there is no isolation valve in the area. The connection is close to a storm culvert where the pipe will be crossing above the existing storm line. On the east end of Collins Avenue, making the tie-in connection point outside of the Collins Avenue intersection will reduce extended road closure and pedestrian detours.

7.0 CONCLUSION

The purpose of this paper was to provide pictures and exhibits of how all the elements of the water main HDD installation came together during the design and construction of a very challenging project for the City. The project was awarded to Quality Enterprises USA, Inc., and pre-construction administration activities began on January 15, 2024. During the design phase, challenges were addressed by strategically placing the water main pipe alignment beneath the bridge and transition curvilinear between pipe ends within the road right-of-way (ROW) limits to limit intersection closures. The automatic air release valves were provided with an inflow preventer for flood protection due to low roadway elevations, potential for tidal flooding and storm surge. In the construction phase, the City addressed public outreach in-house and initiated early notifications to the residents and businesses ahead of the Contractor mobilizing on April 15, 2024. The Contractor will follow the proposed sequence of construction and MOT setup with slight modifications. MOT plans are to be approved by the City and FDOT. The proposed water main tie-ins are temporary connections in anticipation for future water main replacements happening after this project. The installation of this water main was critical for the City to service their residents and businesses with uninterrupted potable water and to allow for FDOT work to be coordinated to commence afterward without conflicts. The project is expected to be completed by September 1, 2024.

8.0 REFERENCE

Federal Emergency Management Agency (FEMA) (last accessed 2024). Flood Zone Maps. https://www.miamidade.gov/environment/flood-maps.asp