North American Society for Trenchless Technology
2008 No-Dig Conference & Exhibition

Dallas, Texas
April 27 – May 2, 2008

DRILLING INSTEAD OF DIGGING – SEPARATING THE SCRIPPS INSTITUTION OF OCEANOGRAPHY'S COMBINED OUTFALL SYSTEM

Anka Fabian, P.E.[1]

[1] Facilities Design and Construction, University of California, San Diego, CA

ABSTRACT: The Scripps Institution of Oceanography (SIO) at the University of California, San Diego (UCSD) is one of the oldest and largest centers for marine research in the world. SIO has maintained a seawater system since 1910 that currently uses 1 MGD of seawater, and, until recently, discharged all commingled seawater and stormwater back into the Pacific Ocean. State regulators recently issued discharge permit requirements for SIO's effluent which requires the separating of the seawater and stormwater system by 2008.

SIO has steep hillsides, site constraints like facility buildings and roads, is congested with many utilities, and is heavily traveled by researchers and staff during the day with their work equipment. The design originally was going to be PVC pipe installed by microtunneling, but this was expanded to allow horizontal directional drilling (HDD) as well. The project was awarded based on HDD and High-Density Polyethylene (HDPE) pipe was submitted in lieu of PVC. SIO's concern was the restricted flow area due to the smaller inner diameter of the HDPE, and wall thickness. The successful contractor, Newest Construction, suggested that SIO consider fusible polyvinylchloride (FPVC™) pipe instead, since it has the same dimensions as the specified PVC pipe and makes reconnection to identically sized standard bell and spigot PVC simple.

The HDD installations avoided the site concerns and the project was completed in May, 2007. This was the first time that SIO used HDD techniques and FPVC piping material, and given the congested nature of the campus, as well as various environmental, aesthetic, archaeological, and cultural concerns; HDD and FPVC is now considered the ideal alternative.

1. INTRODUCTION

SIO was founded in 1903 as an independent biological research laboratory and became part of the University of California in 1912. Research at SIO includes physical, chemical, biological, geological and geophysical studies of the oceans. SIO has maintained a seawater system to support its research and teaching mission since 1910. This high quality filtered seawater is a critical resource in numerous marine biology and oceanography research and teaching activities. The return seawater is co-mingled with storm water and urban runoff and discharged onto the beach. SIO has also maintained a public museum and aquarium for the past 30 years to elevate awareness and educate the public about the marine environment.

2. PROJECT BACKGROUND

The discharge of seawater from the aquariums is allowed under Order No.R9-2005-0008, NPDES Permit No. CA0107239, Water Discharge Requirements for Order No. 99-83/ Waste Discharge for the UCSD, SIO. This order (permit) was adopted on February 9, 2005. A report was submitted based on Section C.4.b of this permit to the Regional Water Quality Control Board evaluating the seawater systems which discharge into the San Diego Marine Life Refuge Area of Special Biological Significance (ASBS). Although the California Ocean Plan prohibits waste discharges into ASBSs, the State Water Board adopted a resolution that grants the institution an exception if it complies with all of its National Pollutant Discharge Elimination System (NPDES) permit requirements. The goal was to ensure that the seawater system's effluent would not alter ASBS 31's natural water quality.

SIO had six months to submit a report to the regional board to propose solutions to the discharge permit requirements. The report included an evaluation of the costs and feasibility of potential solutions, as well as partial or complete diversion of flows to the municipal sewer system, alternate treatment techniques, and pollutant minimization and source control. The project team considered four alternatives:

- Separating the seawater and stormwater discharge system into two separate systems
- Diverting flow to the municipal sanitary sewer system
- Extending the pier (and discharge pipe) beyond ASBS 31
- Constructing an ocean outfall

Team members determined that only sewer separation was feasible. The other options proved to be impractical, were more expensive or would take too long to complete. Sewer separation would meet the board's requirements by:

- Segregating seawater flows from stormwater flows
- Minimizing the use of chemical additives
- Eliminating the discharge of copper and other treatment chemicals by diverting them to the municipal sewer system

Numerical effluent limits for seawater discharges into the ASBS were set forth in the permit which essentially required the seawater and stormwater be in separate systems so that the discharges could be monitored. The permit also prohibited discharge of non-stormwater to a stormwater collection system, beginning on January 1, 2007. Separating seawater and stormwater flows was deemed essential, but reconfiguring the 80-year-old system was an arduous engineering task. Also, proposed modifications to the open-flow system had to be carefully evaluated to ensure that they would not jeopardize the marine life used in research and public exhibits.

Information was compiled on the existing commingled seawater and stormwater piping system, as well as the seawater delivery system. This included available record drawings, field investigations, and interviews with maintenance and operations personnel.

The seawater delivery system evaluation showed that the existing water system supplied about 0.5 to 1.25 MGD of seawater to seven buildings, three storage tank locations, and a filtration facility. The seawater is pumped from the end of Scripps Pier, through a flume on the pier, then through sand filters and into a settling tank. The water is then pumped to three lower storage tanks near La Jolla Shores Drive and Naga Way. Pumps located near the tanks pump the water to the seven buildings, and two supply upper storage tanks located above Birch Aquarium, and one storage tank above South West Fisheries building. After distribution, the seawater from the aquariums and the overflow from the seawater storage tanks were directly connected to the existing nearby stormwater system and were eventually discharged to two separate pipe outfalls onto the beach.

SIO land has steep hillside slopes. The area for the project is occupied by paved winding narrow roads, parking lots, landscaped areas, and has many site constraints like facility buildings and is congested with many underground utilities. It has heavy pedestrian and service vehicle traffic during the day with minimal sidewalk facilities. See Figure 1 below for an example portion of the project site.

Figure 1 – Typical Street Layout on SIO Campus

3. DESIGN AND PROJECT APPROACH

Once the existing commingled seawater discharge and stormwater collection pipelines were identified by reviewing 'as-constructed' plans, it was determined that it would be much easier to put in a new seawater discharge system, due to the very finite nature of the system. The project team decided to reserve the existing piping for stormwater and install a new pipeline to handle seawater from the existing aquarium and research tank sites. Possible alignments were sketched out, and a topographic survey was obtained along the alignments. Utilities were marked out on the ground by a utility locating company and the horizontal survey also included existing manhole flowline information, wherever it could be obtained. The civil engineering consultant for this project, JC Heden and Nasland Consultant Engineers, determined the existing utility location and depths. Many pipelines such as sewer, storm drain, gas, seawater supply lines, water, electrical and telecom were identified including crossing and service laterals. The following Figure 1 shows a general overview of the alignments selected (shown in blue) for the new seawater discharge system.

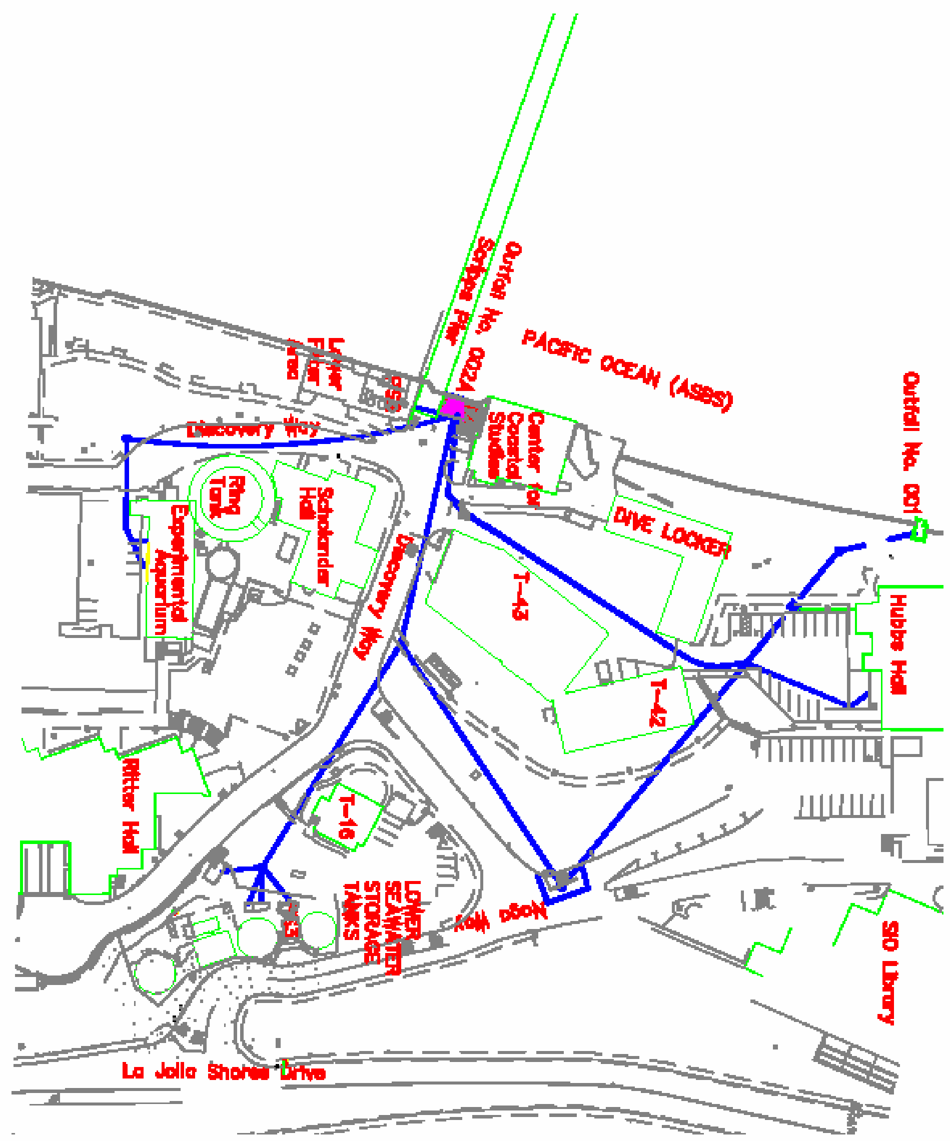

Figure 2 – Seawater Discharge Pipeline Alignments

The soils were tested by Geocon Geotechnical Consultants and the pipeline encountered undocumented fill soils and soils of Scripps Formations. Scripps formation is medium dense to very dense soils and there were localized lenses of concretion, gravel, cobble, and cohesionless sand layers. Moreover, its soils also consisted of sedimentary rock, including pockets of large cobblestones, cemented sandstone and moist sandstone These various layers would prove to be difficult during the construction phase of the project.

Finally the grades for the seawater line were set below all existing utilities varying from 6 feet to 42 feet deep. The seawater line required was primarily 8 inch diameter and increased to 12 inch near the shore where the grades were flatter and the velocities needed to be slowed down. The conceptual plan called for 2,500 feet of 8-inch, inside-diameter pipe to be installed near the existing storm drain lines.

.

The bid documents allowed pipe installation with or without trenches, and for the trenchless option allowed the use of solvent cemented PVC pipe installed by micro-tunneling. The lowest bid was awarded to Newest Construction, with Inland Valley Engineering Inc. as a drilling subcontractor, and was based on HDD and High-Density Polyethylene (HDPE) pipe, submitted in lieu of the solvent cemented PVC.

Upon review, the institute became concerned that the 8-inch HDPE pipe would only have an inner diameter of 6.6 inches, which would not be able to handle the required flow rate. The contractor, Newest Construction Co. Inc., suggested that the institute consider Fusible PVC™ pipes instead. This pipe has the same 8-inch inner diameter as the original specified PVC pipe, thereby meeting design flows, but was stronger than HDPE, resulting in a reduced outside diameter and a smaller bore hole. The institute also had a long history with the installation of PVC pipe and was most comfortable with this material. The contracting team proposed installing the pipes via horizontal directional drilling (HDD), which was less expensive than micro-tunneling. In the HDD method, a directional drill bores a path for the pipe, which is pulled through afterward. Typically, the bore path originates at the surface and has little impact on the surrounding area. This method often is used when trenching or excavating is impractical, or when minimal environmental disruption is preferred.

After inspecting the shop drawings to confirm that this approach was feasible, institute staff accepted this team's proposal. Although slightly more expensive than the traditional trench-based installation method, the HDD installation with Fusible PVC™ was deemed likely to be less intrusive at the campus.

4. CONSTRUCTION

Construction began in August, 2006. In addition to the contracting team, project staff included an archeologist, who monitored the soils for native artifacts, and a biologist, who ensured that the pits and staging areas remained within previously established boundaries to minimize environmental effects.

The contractor first constructed pits at strategic locations next to roads or in parking lots (See Figure 3 and 4). Due to the depths of the lines (20 to 25 feet), they used a custom pit-launched directional drill to bore paths below the surface for the new pipeline.

Figure 3 – Installing Trench Shoring at a Pit Location

Figure 4 – Pit B at Biological Grade

Each time, the contractors set the drill to a pre-established pipe grade (angle) and directionally drilled a pilot hole from entry pit to exit pit. They then step-reamed each hole with aggregate hole openers to facilitate a smooth pull.

The restricted workspace was a challenge. The project team initially underestimated the staging and space required to fuse 40-foot pipe lengths together and pull them through each hole, as well as the space requirements for the associated equipment needed to excavate and shore up each pit. However, after determination of the requirements for the initial pull, the team became adept at determining the construction areas required. The installation method proved so beneficial that the team was able to expand the project so telecommunications lines could also be installed for a small additional cost.

The pipe was surprisingly flexible – although not as flexible as HDPE – so that the contractors did not need as large a trench as originally designed to maneuver the pipe so deep underground. This flexibility was useful when the pipe had to be threaded through existing utilities at some sites. The new pipe is expected to handle seawater with fewer maintenance requirements than the concrete pipe that formerly housed such flows. Seawater is highly corrosive and contains living organisms, such as algae, crabs, and Zebra mussels, that tend to inhabit concrete pipelines.

Overall, the installation went very well. There were two cases where the drill rod connecting bolts on the swivel were sheared due to difficult pull-back conditions in high-cobble areas and the resultant forces required. The pipe was not damaged and simply pulled back through the entrance hole (with a backhoe), and new swivel bolts were installed and reconnected. The contractors installed more than 4,360 feet of 8-inch inside diameter fusible-PVC C-900 pipe in about eight months. The project involved 12 pulls and was completed in early May 2007.

The amount of pipe installed was 4,360 ft of 8" PVC and 120 ft of 12" PVC which required 8 drilling pits and ending up with 12 manholes in the system. At the same time, some HDPE 4" pipe was installed for telecom purposes. The pits were located in the road and often there were utility conflicts which needed to be highlined or relocated. The most challenging aspect was installing the pipe from the ocean side. The contractor needed to drill downhill and then pull uphill. This was done with large equipment as seen in Figures 5, 6, and 7.

Figure 5 – Installing the Pipe from the SIO Pier

Figure 6 - Pulling the Fusible PVC™ Pipe String Through the Seawall

Figure 7 - Pulling the Fusible PVC™ Pipe String Through the Seawall

The HDD installations avoided the site concerns of digging up the roads which allowed traffic for the most part to continue to use the road throughout construction. The project was completed in May, 2007.

Figure 8 – Base of a Seawater Discharge Manhole

5. CONCLUSION

Of the $8 million the institute budgeted to address 13 discharge issues, this project cost $2.5 million. Material costs were lower than originally planned, because the pipe was about 30-percent less expensive than a comparable HDPE pipe for the project, and resulted in a smaller bore hole. However, total project costs were somewhat higher because the drilling went so well that the institute added more work (telecommunications line installations) via change orders.

This was the first time that SIO used HDD techniques and FPVC piping material, and given the congested nature of the campus, various environmental, aesthetic, archaeological, and cultural concerns, HDD and FPVC is now considered the ideal alternative for other UCSD projects. American Public Works Association gave this project an honor award, 2007, because of its contribution to improving and protecting the environment.

6. REFERENCES

1. UCSD/SIO Seawater Systems Evaluation, PBS&J, August 9, 2005
2. UCSD Seawater Pipeline, UCSD, Geotechnical Investigation. April 21, 2006

Figure 6 – Installing welded pipe on top of a high embankment

Figure 7 – South view of pulling pipe