Horizontal directional drilling in the

This paper seeks to outline the various aspects of horizontal directional drilling in South Africa, contextualised by three case studies: Berg River duct installation, Diep River water pipeline installation and the bulk water main installation under various roadways for the Mossel Bay Desalination Plant project.

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Case study 1: Berg River duct pipeline installation

Location: Berg River, Velddrift (approximately 145 km north of Cape Town)
Diameter of pipeline installed: Multi-duct – 4 x 160 mm diameter HDPE ducts (installed in two parts)
Length of installations: 168 m and 164 m
Obstruction traversed: Berg River – approximately 140 m wide and 9 m deep (approximate measurement taken along the bore path)
Client: Local power utility
Main contractor: Racec Electrification
Drilling contractor: TT Innovations

The installation of the duct pipelines under the Berg River formed part of an initiative to upgrade the existing power supply to the Velddrift area. Two existing power feeder cables, suspended below the Carinus Bridge, served as the main power supply to the town and local fish factories. As this section of road (including the bridge) was scheduled for future upgrading, it was decided to install the new power supply cables beneath the river instead, using horizontal directional drilling (HDD).

Apart from the obvious construction constraints with regard to trenching across a river of this magnitude, the importance of this water body to the local fishing industry, tourism and its ecology played a major role in the decision-making process regarding the method of construction.

Any diversion of the river course or activities which could cause flooding of the river banks would result in dire consequences for both the natural habitat and human inhabitants along the river.

As part of the project planning, incremental measurements of the river invert were taken using a boat and survey equipment. The depth of the river was determined to be approximately 9 m at the deepest point. A bore plan was derived using this data with a maximum pilot bore depth reaching 3 m below river invert level. The initial pilot bore (150 m) proceeded without incident, apart from intermittent navigational signal losses and after various steering corrections, reached the target. Reaming commenced immediately thereafter.

The drill rods were attached to the rear of the reamer, trailing it during reaming. During one of these reaming stages, the spindle of the reamer detached due to a suspected bearing failure, causing metal fragments to be left behind in the bored tunnel. The tunnel was consequently abandoned and a new pilot bore installed adjacent to the previous tunnel. With the new tunnel successfully bored and all the reaming stages completed, the original three-pipe, 160 mm diameter HDPE duct configuration was attached to the reamer and inserted. The installation, however, ground to a halt just as the reamer and product pipe passed the pivot point along the final incline of the curved bore bath. The rapidly increasing forces had exceeded the rig’s pulling capacity.

Later investigation revealed that this was largely due to the bentonite being degraded by the high salt water content of the insitu soil. The drilling fluid (water and bentonite mixture) could therefore not perform its primary function of transporting the soil cuttings to the surface. The resultant soil build-up in the tunnel (increasing the friction along the pipe), in conjunction to the steep final incline, ultimately led to the rapid increase in pulling force. The salinity

FIGURE 1 View of the drill rig positioned alongside the Berg River and opposite perspective of the Carinus Bridge
of the ground-water was never considered as the Berg River is a freshwater river. A nearby freshwater lake also seemed to support this notion. It was however later learned that the river becomes salty at high tide and fresh again during the low tide due to the close proximity to the sea.

After numerous unsuccessful attempts at getting the pipe unstuck, the only apparent solution was to free the product pipe from the reamer. To do this, the contractor manufactured a device that attached to the end of the drill rods, which extended a set of cutting blades when forced outward by the drilling fluid pressure. The drill rods and cutting head were then inserted from the rear of the HDPE pipe. With the blades extended, the drill rods were rotated, severing the HDPE pipe and releasing it from the reamer. This option rendered the HDPE pipe unusable as any attempts to remove the partially installed pipes resulted in over-stretching, which deformed and restricted the useable cross-sectional area of the pipe. The reamer was retrieved and reused.

Despite these trying circumstances and set-backs, the contractor persisted. Salt water compatible bentonite was used for this attempt and the bore path lengthened to 168 m to allow for a flattened incline curve. It was also decided to increase the tunnel size and change the pipe arrangement from a three-pipe to a two-pipe configuration. The client duly elected to also install a fourth duct for future use. These measures were successful and culminated in two successful installations measuring 168 m and 164 m each.

### Case study 2: Diep River water pipeline installation

- **Location:** Adjacent to Gie Road, Table View – Cape Town
- **Diameter of pipeline installed:** 315 mm diameter HDPE PN12
- **Length of installation:** 200 m
- **Obstruction traversed:** Diep River – seasonal river and wetland ecosystem
- **Client:** City of Cape Town – Water and Sanitation Department

A **250 MM diameter asbestos cement pipeline** formed part of the distribution network emanating from an upstream reservoir which fed the residential area of Table View. Technicians traced a major leak to a section of this pipeline situated within the river stream. Due to the high groundwater table, wetland area, location and depth of the deteriorated pipeline, the local authority decided to replace this pipeline section using pipe bursting. This option was however discarded due to various bends along this section of the pipeline, its depth and the associated dewatering required. HDD was proposed as an alternative installation method and subsequently met the client’s objectives from an environmental, technical, financial and project-duration perspective.

With the contractor appointed, the first task was to determine the actual alignment of the existing AC pipeline to ensure that the new pipeline was installed as close as possible to the existing line. The drill rig was set up on the residential side of the river embankment, alongside a communal swimming pool. The actual water stream was minimal and enabled the pilot bore to be tracked by conventional walk-over methods. Due to the urgent nature of the project, extensive geotechnical investigations were not performed but the in-situ soil conditions were largely considered to be argillaceous. The actual tracking of the pilot bore proved to be the most challenging aspect of this project. Major interference was encountered along sections of the bore path, leading to an erratic signal and improper drill head location. A large portion of the pilot bore was installed ‘blindly’ as the rig operator lost signal as well as navigation visuals on the drill rig on-board instrumentation. Being closer to the signal source (sonde located within the drill head), the field operator was able to receive the signal and view the visual display on the hand-held navigation instrument. This enabled the field operator to relay vital information, such as the drill head position, inclination and location, to the drill rig operator via two-way radio. After much correction and adjustment, the pilot bore eventually exited on target at the pre-constructed exit pit. At this point, the 315 mm diameter class 12 HDPE pipe was already welded, pressure tested and in position for the installation. The pipeline itself was also filled with water to counteract buoyancy – in an effort to reduce frictional resistance. A suitably oversized tunnel was bored and the pipeline installed without any further complication. The pipeline was then re-connected to the existing network and the water re-routed through the newly installed pipeline.

### Case study 3: Mossel Bay Desalination Plant pipeline installations

- **Location:** Mossel Bay, Southern Cape (approximately 392 km from Cape Town when heading east along the coast)
- **Diameter of pipelines installed:** 800 mm diameter

![Main contractor: TT Innovations
Drilling contractor: TT Innovations](image)
TRENCHLESS TECHNOLOGY

Length of installations: 46 m and 50 m
Obstruction traversed: Two main roads – Louis Fourie Road and Alwyndal Road
Client: Mossel Bay Municipality and PetroSA
Main contractor: Entsha Henra
Drilling contractor: TT Innovations

Owing to a spate of droughts in the Southern Cape area, the local municipality of Mossel Bay and private sector stakeholders financed and approved the construction of a desalination plant along the nearby coastline. This consequently necessitated new bulk water pipeline installations (greenfields) – which also crossed two main roads.

The local roads authority, however, insisted on the use of trenchless technology for the main road crossings. HDD was decided on as the trenchless solution to be employed and various contractors were invited to submit bids for the installation of these works.

The project consulting engineers selected the approved drilling contractor on the basis of its technical ability and previous project experience. The pilot bore under Alwyndal Road commenced without incident and was completed on schedule. Operations, however, ground to a halt during the early hours of the morning when the effluent water supply valve failed, causing a disruption to the supply. Without an alternative water source, work was halted until the supply could be restored.

By midday the following day, the water supply was restored and drilling re-commenced. Reaming proceeded at a slow but steady pace, with the reaming rate of progress slowing as the reamer size increased. A temporary holding ‘pond’ was created adjacent to the drill site to house the drilling mud spoil and a TLB was utilised to remove the drilling mud from the drilling pits.

Owing to the large diameter of the pipe which needed to be installed, the frictional force caused by buoyancy had to be countered. Instead of the conventional closed front end, where the pulling head connects to the pipe, it was decided to leave this front end open – thereby creating an open-ended pipe and cancelling any buoyant forces. After installation, any drilling mud or spoil which collected within the pipe could be removed by conventional pipe cleaning methods. Further to this, the shallow cover over the pipe also increased the risk of drilling fluid escaping to the surface through the above soil layers due to excessive fluid pressures within the tunnel (frac-out). Once all the reaming stages were successfully completed, the 800 mm diameter HDPE pipeline was installed.

The actual installation duration of the pipe was minimal compared to the various reaming stages. Using the drill rig, the 630 mm diameter HDPE product pipe was inserted within the 800 mm pipe. The product pipe simply displaced the drilling mud and no additional pipe cleaning was required. The Louis Fourie installation proceeded in a similar fashion, without any complications.

FIGURE 3 View of the final reamer size and 800 mm diameter HDPE sleeve