Focus on Water Engineering
ON THE COVER
The DWS contracted SSIS Pipeline Services (Pty) Ltd, who represents Pure Technologies Ltd in South Africa, to provide comprehensive inspection, risk assessment and engineering analysis services on the Rietspruit–Davel–Kriel pipeline. The successful completion of the project highlights the value of using cutting-edge technology for comprehensive and proactive pipeline condition assessment.

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BACKGROUND
The Usutu Water Scheme in the Mpumalanga Province of South Africa supplies raw water to various coal-fired power stations and towns. The DN1300 mm, pre-stressed concrete non-cylinder pipe (PCP) between the Rietspruit and Davel Reservoirs (36.5 km), and between the Davel and Kriel Reservoirs (54.4 km) was completed in the late 1970s and forms a strategic link in the scheme.

PROJECT SCOPE AND EXECUTION
The Department of Water and Sanitation (DWS) contracted SSIS Pipeline Services (Pty) Ltd, who represents Pure Technologies Ltd in South Africa, to provide comprehensive inspection, risk assessment and engineering analysis services, including the following:
- Pipe specification development and material testing
- SmartBall™ and Sahara™ leak and gas pocket detection survey
- PipeDiver™ electromagnetic survey
- Steady-state and transient hydraulic assessment
- Cathodic protection and soil corrosivity survey
- Flown LiDAR survey
- Structural analysis
- Risk assessment and engineering analysis.

Pipe specification development and material testing
Due to a lack of records regarding the pipe specifications and design, pipes that had been removed from the pipeline, and spare pipes provided by the DWS, were destructively evaluated to determine the design specifications and calibrate the electromagnetic signal to accurately detect wire breaks. Laboratory and in-field tests and measurements were completed on the individual pipe components (i.e., mortar coating, pre-stressing wire and concrete core) to determine the integrity of the materials and develop design drawings and specifications.

Leak detection survey
The SmartBall™ leak and gas pocket detection surveys covered the entire pipe length. Follow-up Sahara audio-video surveys were performed to gain a better understanding of the leak locations. A total of ten leaks were detected and accurately located.

PipeDiver™ electromagnetic survey
An electromagnetic (EM) inspection provides a non-destructive method of evaluating the existing condition of the pre-stressing wires. EM inspections collect a magnetic signature for each pipe section to identify anomalies that are produced by zones of wire break damage. This inspection method is the best available technology to quantify the number of wire breaks to determine the baseline condition of a pipeline.

PipeDiver™ is a revolutionary free-swimming inspection platform that can be used to inspect pressurised pipelines, including PCP. The modular tool is articulated and has collapsible fins allowing it to pass through sharp bends, diameter reductions and butterfly valves. PipeDiver™ is neutrally buoyant and is carried by the flow of water. It was inserted and extracted under depressurised conditions. The survey was, however, performed while the pipeline was operational. The entire 90 km of pipeline was inspected in three runs. PipeDiver™ offers a major advantage compared to earlier man-entry inspections that required extensive periods of shutdowns and non-supply.

The electromagnetic inspections found that the vast majority of pipes did not have any wire break damage (Figure 1).
Transient pressure monitoring and hydraulic monitoring

Field verification data was used to compile a calibrated hydraulic model that accurately mimed the steady state and transient behaviour of the pipelines. The analysis found that the DWS’s current standard operating procedures effectively control the flow, and prevent excessive pressure surges. The calibrated model was also used during the engineering analysis to determine the pressure in each PCP section.

Cathodic protection and soil corrosivity survey

Various surveys were performed to confirm the current status of the cathodic protection and monitoring system, and to determine the corrosivity of the environment around the pipeline. The findings were compared with other survey findings to identify possible inter-relationships.

Flown LiDAR

The flown LiDAR survey provided high-resolution aerial imagery that assisted in developing detailed aerial maps of the pipeline. The LiDAR survey provided an up-to-date overview assessment of the depth of cover over the pipeline and indicated that the DWS generally maintains the pipelines’ servitudes well.

Structural analysis and risk assessment

Pure Technologies completed three-dimensional, nonlinear finite element analysis (FEA) to quantify the structural ramifications of the broken pre-stressing wire wraps detected by the electromagnetic inspection. The FEA provided performance curves unique to each PCP class that evaluate the structural integrity of a PCP with a given number of broken pre-stressing wire wraps and internal pressure. These curves were used in conjunction with the electromagnetic inspection results during the risk assessment.

The DWS’s risk exposure to pipeline failure was evaluated on a pipe-by-pipe basis, and was defined as the product of the pipe’s Likelihood of Failure (LoF) rating and Consequence of Failure (CoF) rating. The LoF rating incorporates the inspection results and structural evaluation, and is representative of the condition of the pipe. The CoF rating quantifies the social, environmental, and financial ramifications of a pipe failure, and is representative of the total impact...
of a failure. The risk rating of each pipe barrel is used to guide proactive intervention and management.

**FINDINGS**

The inspection and condition assessment determined that the majority of both transmission mains are still in a reliable and manageable condition. However, some individual PCPs have a higher risk rating and need to be attended to. The distress in both transmission mains can, however, be economically and effectively managed with targeted remediation and an appropriate long-term management strategy. A number of specific intervention actions were recommended to the DWS.

This project highlights the value of implementing a comprehensive and proactive pipeline condition assessment programme using international best practice and expertise, and cutting-edge technology. The DWS originally faced an unknown and ill-defined risk, or even worse, full infrastructure replacement at significant capital cost based on pipe age, failure history and perceived risk as its only indicators. This investigation, however, confirmed that the asset life can be extended while managing the DWS’s exposure to risk. Further action will be required, but with the baseline set, the DWS can now implement a proactive approach to the management of this valuable asset, setting an example for other utilities faced with similar challenges in South Africa.

**INFO**

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**PROJECT TEAM**

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Contact: Leonardo Manus  
Pipelines: Usutu Water Scheme, Rietspruit–Davel–Kriel Pipeline  
Service Provider: SSIS Pipeline Services and Pure Technologies Limited

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**Figure 1: Electromagnetic inspection findings**

- Number of pipes with no suspected wire breaks: 13,212 (92.3%)
- Number of pipes with 0–10 suspected wire breaks: 1,013 (7.1%)
- Number of pipes with 11–20 suspected wire breaks: 57 (0.4%)
- Number of pipes with > 20 suspected wire breaks: 35 (0.2%)

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