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A R92 million bulk pipeline stretching 5,7 km has been laid to boost the water supply from Pietermaritzburg to Durban by 1 024 litres per second. Umgeni Water, the bulk water provider, needed to improve the water supply to both eThekweni and Msunduzi Municipalities and commissioned Jeffares & Green to design a pipeline to boost the connection from the Midmar Water Treatment Works to World's View Reservoir. The previous system supplied water at a rate of 130 Ml/d but the ultimate design called for a total of 330 Ml/d

VARIOUS OPTIONS FOR the route of the pipeline were looked at from technical, geotechnical, risk, economic, land ownership and environmental points of view. The final route takes the new pipeline from a bulk supply line near Ferncliffe, a natural reserve adjacent to the DV Harris Water Treatment Works, through the Queen Elizabeth Park which is home to the headquarters of Ezemvelo KZN Wildlife, and across the newly established Victoria Country Club Estate, under the N3 highway as it snakes down Town Hill, from Hilton to Pietermaritzburg, and finally, along the Hilton mist-belt grassland biome up to the existing Clarendon Reservoir.

Bulk pipeline installation in KZN

From this point the existing 787 mm diameter and new 900 mm diameter pipelines were conjoined and the new 1 200 mm diameter pipeline was laid over 1 km and connected to the inlet at World's View reservoir. The 1 200 mm outlet followed the same route as the incoming line for 500 m and then deviated to link up with the existing supply lines to Umlaas Road which delivers water to eThekweni Municipality in Durban.

THE CONTRACT COMPRISED THE FOLLOWING

- Laying of 3 835 m of continuously welded 900 mm nominal diameter (ND) steel pipe, supplied by the employer, from a connection near DV Harris WTW to Clarendon Reservoir. Wall thickness varies from 6,35 to 8,4 mm
- Laying of 1 040 m of continuously welded 1 200 mm ND steel pipe, wall thickness 8,1 mm, from Clarendon Reservoir to World's View inlet
- Laying of 800 m of continuously welded 1 200 mm ND steel pipe, wall thickness 8,1 mm, from World's View Reservoir to the Umlaas system tie-in point
- Six tie-in points to the existing bulk water systems – two at DV Harris, one at Clarendon Reservoir, two at World's View and one at the beginning of the Umlaas supply system
- A confluence chamber and four meter chambers

- Laying of 900 mm diameter pipe through two 1 680 mm concrete sleeves under the N3 and R103 of 76 m and 20 m length respectively
- Restricted excavation and pipe laying along 800 m of Mistbelt Grassland on one side and the existing 787 mm diameter '60 pipeline on the other
- 30 air valves, 8 scour valves and 7 isolating valves
- Road crossings – 3 gravel road crossings and 3 crossings of brick-paved roads
- One 30 m long pipe bridge and two river crossings
- Pipeline sundries including environmental management
- Environmental rehabilitation (by selected specialist sub-contractor)
- Cathodic protection system (by selected specialist sub-contractor)

The project implementation was started in March 2009 and will be completed in June 2010. Apart from the pipeline, associated works such as pipe jacking under the N3 and R103, and additional environmental works were conducted. Jeffares & Green were responsible for all design, contract administration and construction supervision elements of the project and Icon Construction was the contractor.

ENVIRONMENTAL SENSITIVITIES

The environmental rehabilitation of the works is being done section by section, and

currently the first 1,4 km section between Ferncliffe and the Victoria Country Club Estate has been top-soiled and revegetated. The balance of the pipeline servitude will be brought back to natural ground level but the grassing and the replanting of rescued plant species will only take place at the beginning of the next growing season, September 2010, as any attempt to get the endemic grass seed to germinate will not be successful before spring. The intention was to have the area shaped, topsoiled and seeded earlier, but construction was

held up by an unusually wet summer in Pietermaritzburg. All rehabilitation measures will be completed by December 2010.

A particularly environmentally sensitive section on the project was the 800 m stretch that falls within the Hilton mist-belt grassland biome – one of seven such remaining areas in the region. Ezumvelo KZN Wildlife, a key role-player, was very specific about the need to reduce the working width of this section to minimise the disruption to the environment.

Prior to construction Umgeni Water appointed botanists to undertake a detailed vegetation survey and remove and relocate all threatened or endangered flora to a safe area within the biome, but outside the area

affected by construction. The botanists were followed by a plant rescue team who dug up sufficient quantities of the naturally occurring plant species and stored them at the Pietermaritzburg Botanical Gardens, where they are being maintained under controlled conditions until they can be planted out. The objective is to replace the plants, shrubs and grasses to replicate the biome environment that had existed prior to construction.

Umgeni Water has also agreed to assist the Msunduzi Municipality with the care of the Kettlefontein grassland by allowing a team of specialist to clear the alien vegetation in the grassland, carry out a maintenance program for the next growing season, assist with burning the brush and carry out the survey to allow the area to be declared a conservation area.

Once the plants had been removed, the topsoil was stripped and stockpiled in a specially demarcated area to keep it separate from the generic topsoil generated off the rest of the pipeline route. Again, the intention is to replace the mist-belt grassland topsoil as it contains a mixture of bulbs and seeds unique to the area.

The rehabilitation of the pipeline servitude through a gum tree plantation owned by NCT Forestry Co-Operative Limited was thoroughly discussed with NCT management. Since harvesting of the timber needs to occur over the next few months it has been agreed that the topsoil replacement and seeding will be held over until after the timber has been cut. This also means that rehabilitation will fall into the next growing season, thus giving the rehabilitated areas a better chance of full recovery.

PIPE JACKING UNDER THE N3

Since the pipeline route goes under the N3, the main highway between Johannesburg and Durban, as well as under the R103 which is 200 m to the west of the N3 crossing, an unconventional approach to pipeline installation needed to be adopted. The conventional approach is to dig an open trench, place the pipeline and then bury it, and although this method does not pose much of a problem in rural or sparsely populated areas where vehicle traffic is light it would have caused havoc to traffic on the busy N3 freeway.

Umgeni Water commissioned Jeffares & Green to undertake the design of the N3 pipe jacking as a separate project, to be implemented in advance of the

- 1 Heavy rains made pipe laying difficult
- 2 Cut-in and welding at the tie-in at World's View Reservoir





bulk pipeline so that there would be no hold-up to construction when the contractors reached that site.

Geotechnical investigations undertaken by Terratest, a firm of geotechnical and environmental specialists, revealed that the N3 was on unstable talus in this area. The crossing point opposite the Ezemvelo KZN Wildlife head office on Town Hill was identified as being the least unstable and selected as the most suitable area to lay the pipeline. This choice was strengthened by the fact that the existing 787 mm steel Clarendon pipeline had been laid within 30 m of the proposed crossing and that there had been no problems at the crossing in the past 25 years. Trial pits were excavated at each end of the pipe jacks and confirmed the expectation that the subsoil comprised dolerite boulders in a weak and compressible clayey matrix.

Jacking the N3 crossing became more challenging as the jacking progressed. Initially the expectation was that the jacked pipes would be far enough below the road layer works for the arching effect over the jacked pipe to be sufficient to support the road surface. Traffic management was initially not considered to be a problem.

The pipe jacking construction, by Esor Construction, started on 28 January 2009 and was completed on 26 June of the same year. The construction of the jack under the R103 went relatively smoothly with no major setbacks. Rocks were broken up using pneumatic tools or were hauled out of the sleeve using slings and chains. The N3 jack was a totally different scenario. The initial work went well with the establishment of the jacking pit and the insertion of the lead cutting shield.

Ten metres into the jack, road layer works were intersected at approximately 3 m below the N3 surface. This was probably the original surfaced slip road onto the N3 during construction in the mid-sixties. The bitumen was still tacky after being underground for 40 years. This made excavation difficult, and paving breakers had to be used to break up the road formation. This extended for a distance of 12,7 m.

Immediately following this, the shield entered rubble fill that had been used

to raise the level of the N3. Boulders of up to 1,3 m had to be dragged out or blasted into smaller pieces. Inevitably a void started to form above the sleeve as boulders fell in to replace those removed. The excavation was under the northbound fast lane and, as haulage trucks tend to use this lane at night, the additional load and vibration caused further rock movement and it was decided to seal the void with sandbags and to grout behind these. Unfortunately, one rogue boulder was dislodged above the sleeve and demolished the sandbag wall.

The eventual answer was to close the fast lane for safety reasons and excavate around the clock to reach the median and break through to daylight. This would allow soft material to be backfilled into the shield from the top so that large volumes of grout (35 m³) could be pumped into the voids without running back into the sleeve. The SANRAL maintenance team did a sterling job in arranging this lane closure at short notice.

Twenty metres further along, the excavation struck a block of reinforced concrete. Three days and nights of intensive drilling, cutting of reinforcement and blasting resulted in the removal of the concrete, which, on reconstruction outside, proved to have been a New Jersey barrier which had been incorporated into the N3 fill. The removal of the concrete caused an increase in water infiltration from the sides and the top of the face, with concomitant loss of support of the rubble-fill boulders. The shield was bricked up and a further 15 m³ of grout was pumped through the lifting holes in the lead sleeve to stabilise the excavation.

Five metres further (and 5 m below the N3) the night shift struck an abandoned Armco drain that had filled with water over the years. Two days of pumping allowed access to the working face once more. The ground was totally saturated and grouting the surrounding area was impractical because of the ruptured drain. The solution was to excavate and push the sleeve forward rapidly and simultaneously excavate through the N3 side fill to meet the shield. The open excavation was used to replace the saturated mud with dry material which, in turn, would provide support to the sleeve.

Despite all these problems the project was completed within budget and without affecting the programme of the main pipe-laying contractor. □

3 Inlet and outlet pipes towards World's View Reservoir

4 Removal of boulders from the pipe jack sleeve

5 Plant rescue at Kettlefontein mist-belt grassland in Hilton

(Photos: Annalè van Schijndel APSSA)