

# Yorkshire Derwent Aqueduct Duplication Main Elvington WTW to Riccall Pumping Station

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**D**esigned to augment potable water supplies from Pennine sources, Stage One of the 60km Yorkshire Derwent Aqueduct (YDA) was commissioned by Sheffield Waterworks in late 1964. The aqueduct was constructed to pump treated water from Elvington Water Treatment Works (WTW) near York, to the urban areas of Sheffield and Rotherham. Further links provided pumped flows into Leeds and Barnsley. Initially designed to provide 68 thousand cubic metres of water a day (tcmd), the system was subsequently modified (Stage 2) to supply 113 tcmd. Further works followed in 1975 (Stage 3) increasing treatment capacity at Elvington WTW to 182 tcmd and installing additional 'on line' pumping facilities on the aqueduct. In more recent years, modifications to the treatment process at Elvington WTW has increased the plant capacity to 264 tcmd and the YDA has become a strategic part of the Yorkshire Water grid system.



900mm ductile iron pipes; elongated sockets ready for installation (courtesy Yorkshire Water Services Ltd)

The original YDA comprises 42", 38" and 36" diameter butt welded, steel pipelines. In 1985 the 38km leg of the aqueduct between Brayton Barff service reservoir (SR) and Hooper SR was duplicated with a 1,200mm diameter welded steel pipeline to increase capacity, reduce pumping costs and enhance security of supply. When mining operations in the Selby coalfield threatened the integrity of the YDA, the 8km Riccall Pumping Station (PS) to Brayton Barff SR section was duplicated. The aqueduct has, therefore, been totally duplicated apart from the section between Elvington WTW and Riccall Pumping Station (PS).

## The problem

This section is approximately 14km in length and passes through the Selby Coalfield. Mining has already affected the existing pipeline to some extent but further mining will have a greater

impact on the integrity of the pipeline within the next five years. The original length of pipeline was designed and constructed before the Selby Coalfield was developed and as such requires continual monitoring and remedial work to mitigate the effects of mining subsidence.

Past experience has dictated that duplication will provide 'security of supply' against the effects of mining subsidence. This is not strictly accurate because certain mining patterns can affect both pipelines in nearly equal measures. However, originally developed by Transco, the use of 'Stress Measurement' has been adopted by Yorkshire Water (YW) on the YDA. This provides advance notification of problems requiring pipeline shutdown, or in the case of the new duplicate pipeline, predicts the maximum current and future values of ground movement resulting from the mining activity.

Ongoing dialogue with UK Coal plc has indicated that mining plans are extremely fluid, depending on market conditions. At the moment rising energy prices are making the price of coal, from the Selby Coalfield, more competitive. This could increase demand and planned coal extraction could increase within the '5 year plan' of UK Coal plc. This activity places a greater risk to 4.5 million customers on the single length of pipeline with respect to security of supply.

**Stress measurement**

Stress measurement combines analytical techniques with field measurement, It uses a computer model to predict the location and magnitude of stresses affecting an operational pipeline. Ground movement predictions have been made for the YDA duplication pipeline, taking into account the local factors associated with the mining geology of the Selby coalfield.

The following ground movements are the maximum predicted values occurring after completion of all mining at Selby.

- \* subsidence 820mm
- \* Axial +136/ - 139mm
- \* Perpendicular +107/ - 115mm

The mechanism by which these movements are transferred to the pipeline is best described by considering the surrounding soil acting as a spring in the direction of movement. The pipeline will generally follow the subsidence profile as a consequence of the overburden load. This normally results in vertical bending stress. Axial movements are transferred to the pipeline by virtue of the shear resistance between the soil and pipe interface. The type of joint has a significant influence on this parameter, a socket and spigot joint will facilitate greater movement and will have less ability to slip.

Any pipeline design must accommodate this magnitude of movement either by its structural strength or by the incorporation of flexibility at each pipe joint. A further measurement, the ground strain, should also be considered, although its use does not correctly reflect the transfer of ground movement to a pipeline.

Based on the maximum subsidence value of 820mm and using the appropriate ratios in the Subsidence Engineers Handbook, the ground strains at mining completion will be +0.7mm/m and - 2.1mm/m. It is almost certain that as a consequence of changing magnitude and direction of ground movements during mining, these values will be exceeded at some stage.

Consequently it was recommended that a factor of safety be used to accommodate this variation. It was recommended that the YDA duplication pipeline be based on ground strains of 3mm/m tensile and 4mm/m compression.

**Solution**

Duplication of the remaining single section of the existing YDA (14km) between Elvington WTW and Riccall PS is being constructed using 900mm dia ductile iron pipe incorporating extended sockets (19mm longer than standard joints) where the pipe is laid through active mining areas. This will allow the pipeline to accommodate 4.3mm/m axial strain in compression and 4.1mm/m in tension (3.3mm/m compression and 2.8mm/m tension for standard joints). Two cross connections will be provided between the new duplicate pipeline and the existing steel main to facilitate operational 'shut down' and to maintain a maximum flow of 227 tcmd along the YDA when one section of main is isolated.



Excavating across A19 (York - Selby road) for new 900mm ductile iron pipeline (courtesy Yorkshire Water Services Ltd)



900mm ductile iron pipe with elongated socket ready for installing (courtesy Yorkshire Water Services Ltd)

Pipeline Stress Measurement has allowed Yorkshire Water to consult with pipeline suppliers and identify a suitable material that will cope with the predicted current and future pipeline stresses, notably ductile iron.

This has allowed the company to confidently move away from a 'traditional' welded steel pipeline, that requires continual monitoring and remedial work in the active mining area.

Construction work recently commenced on the new duplicate pipeline at Riccall PS and the full 14km mainlaying to Elvington WTW is expected to be completed by the end of December 2002. ■

**Note:** The author of this article, Paul Robins, is Capital Solutions Manager, Yorkshire Water.