

Derwent Valley Aqueduct

improving resilience of the Severn Trent Water strategic supply grid

by Andy Dawe and Bob Taylor

The Derwent Valley aqueduct (DVA) is a spectacular piece of Victorian/Edwardian engineering, and is one of Severn Trent Water's (STW) most important assets, forming part of its strategic water grid. Treated water flows by gravity alone, and the aqueduct conveys 200MI/d of drinking water from Bamford Water Treatment Works (WTW) in North Derbyshire to Hallgates Service Reservoir near Leicester, serving more than 590,000 customers in Nottinghamshire, Derbyshire and Leicestershire. The aqueduct consists of 180km of large diameter pipeline (cast iron and steel pipes), 16km in 6 (No.) sections of single 6' 3" diameter tunnel. It includes 1,000 (No.) valves, 14 (No.) bridges and culverts, and 307 (No.) other structures and chambers.



33" & 36" DVA on a typical pipe bridge

Courtesy of Atkins

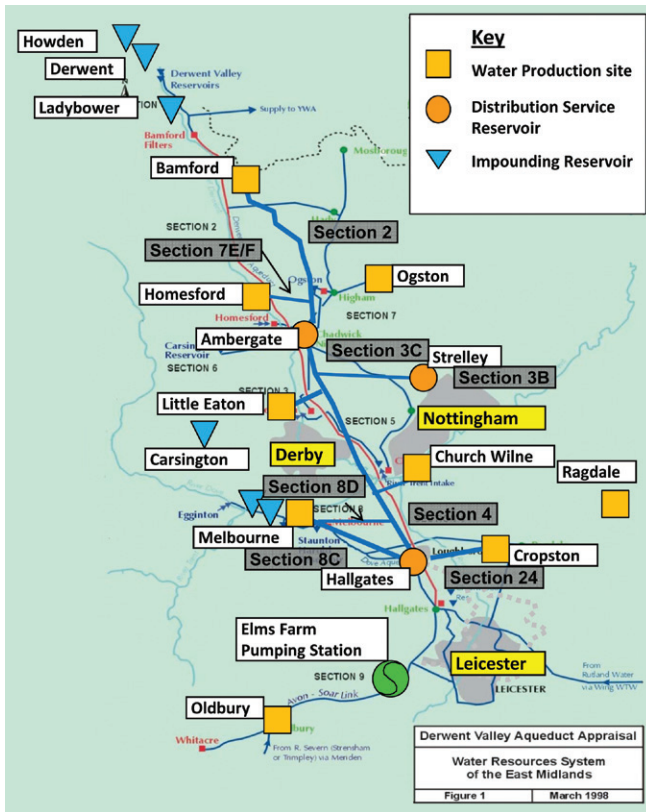
The aqueduct has needed little attention over its 100+ year life. Understandably, it is now beginning to show some wear and tear, and Severn Trent Water needs to fully understand its condition in order to prioritise its current AMP5 programme and develop a series of projects for AMP6 and beyond.

Severn Trent Water commissioned Atkins to undertake a feasibility design of the DVA to provide resilience of the potable water supply for the STW strategic grid. This included detailed hydraulic analysis of the aqueduct to develop a clear understanding of existing performance and hence ensure effective definition and integration of proposed upgrades. The upgrades will enhance performance of the aqueduct to ensure security of supply into and beyond the 30-year planning horizon.

Atkins was engaged by Severn Trent Water to deliver AMP5 specific schemes to provide resilience to the DVA and to the entire STW strategic grid. The team's extensive investigative and optimisation

work identified innovations to maximise the existing assets. The works included:

- Detailed hydraulic modelling
- Strategic grid modelling integrated with water resource management
- Review of strategic storage
- Innovative solution review assessing the initial final business plan projects, which engaged internal stakeholders to develop more cost-effective solutions
- Optioneered and optimised designs for use of existing assets and upgrades where necessary
- An Asset Management Plan incorporating 30 years maintenance and a resilience upgrade plan
- Reviewing and proposing rehabilitation and re-zoning solutions for the city of Leicester network
- Emergency planning with repair planning and strategic grid supply diversions for supply resilience



*Proposed reconfiguration of the existing Leicester supply main avoids the need for new trunk mains construction across sensitive rural areas
Courtesy of Atkins*

Modelling methodology

The hydraulic modelling was carried out in the following stages:

- Initial model construction
- Detailed field testing
- Model calibration
- Conceptual design of upgrades

The scale and nature of the aqueduct demanded innovative approaches and techniques, including the use of Infoworks CS software – traditionally used for sewer modelling - to represent open-channel flow sections of the aqueduct.

These models are now being used for a range of purposes, including support to emergency planning teams to establish suitable repair and maintenance plans for key elements of the aqueduct.

Atkins also reviewed strategic storage requirements within the grid to outline alternative solutions for a 128ML storage reservoir with future storage development into AMP6 and beyond.

Asset management planning

Through investigative work, Atkins developed an Asset Management Plan (AMPlan) for the DVA working with STW to meet their requirements at each stage. The AMPlan:

- Identified and developed a centralised asset knowledge base
- Provided an asset inventory
- Developed a maintenance planning framework and high level cost table to enable the development of an asset maintenance plan, including annual and a 30 year maintenance planning
- Current and future resilience planning needs
- Condition grading and monitoring of operational feedback reporting
- Provision of a risk quantification and methodology to enable a risk based programme to be developed

Atkins developed the AMPlan and Asset Maintenance Plan and integrated these with the client's own GIS platform. This information

was linked with emergency planning protocols and strategic grid modelled scenarios, allowing the client's GIS to be a powerful tool for use in an incident to access data and for a resilience management system.

Scope optioneering and cost-benefit analysis

Over the course of the project, the level of technical expertise provided, reinforced by continuous timely delivery, value for money and a clear understanding of the client's needs through effective stakeholder management and affordability, allowed Atkins to provide robust and innovative solutions for the DVA to future-proof its life beyond the next 30 years.

Supported by the latest software and techniques, Atkins has been able to develop a deep understanding of the DVA and surrounding water networks. Notably, Atkins have included detailed engagement with a wide range of stakeholders throughout the feasibility process. Investment in detailed feasibility assessment has enabled completion of a holistic review of the proposed capital schemes, adding value through identification of existing hydraulic constraints and development of cheaper and more effective solutions.

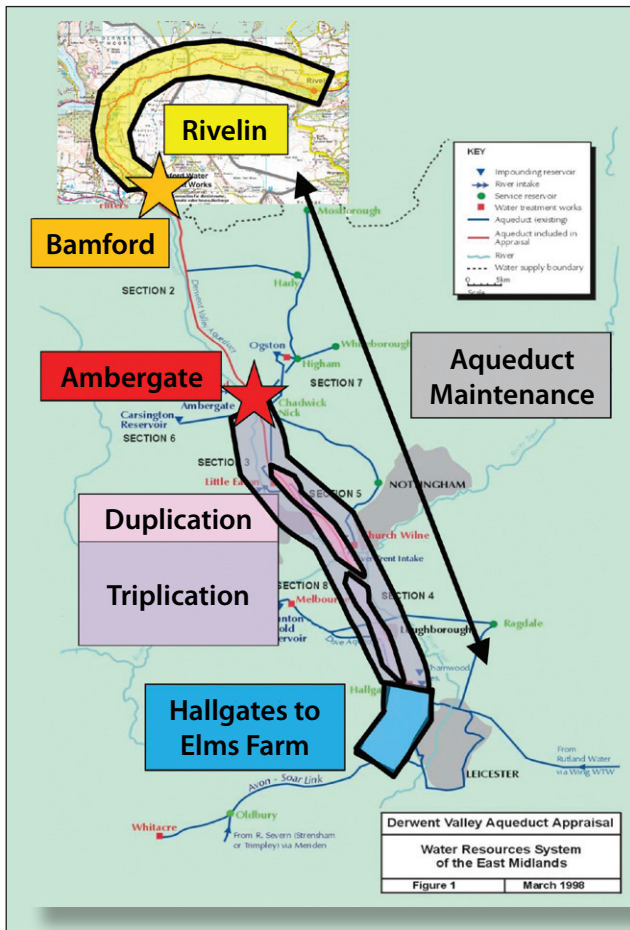
To date, the work has identified an estimated 22% saving on out-turn cost of the proposed upgrades.

The projects

The DVA project is a programme of several named projects within STW's business plan. Notional solutions were included. The Atkins team was encouraged by STW to challenge the solutions to meet the best interests for the wider STW businesses, their strategic vision of the supply grid, and to meet the aspirations of the future 25-year business planning objectives. Feasibility is virtually complete with single solutions identified and recommendations being finalised.

Project 1: Bamford WTW/DVA (Driver: Resilience/Maintenance)

This project was to improve the resilience in the northern part of the DVA. The notional solution was to introduce a supply from Rivelin works in the Yorkshire Water area via a 13km 1,000mm pipeline. However, this did not address the problem of losing the DVA. The



OVERVIEW OF DVA PROGRAMME

Bamford (Driver: Resilience/Maintenance)
Renewal of Bamford WTW with two process streams reducing the likelihood of works failure.

1. Rivelin (Driver: Resilience)
Reduce the likelihood of supply interruption due to Bamford WTW failing

2. Duplication/Triplication (Driver: Resilience)
Raw Water main re-commissioning and increased ability to supply Hallgates failing.

3. Ambergate Service Reservoir (Driver: Maintenance)
Rebuild of Ambergate DSR and potential refurbishment of existing reservoir

4. Hallgates to Elms Farm (Driver: Resilience)
Build a new main between Hallgates and Elms Farm or a network reconfiguration option.

5. Aqueeduct Maintenance (Driver: Maintenance)
Provide an Asset Management Plan to identify the DVA capital maintenance projects for AMP5 and 25 year programme instance the Riber Tunnel inspection and condition assessment.

chosen solution was to provide 9 (No.) network enhancement schemes, which would allow water from Homesford and Ogston WTW to be introduced into the affected areas. This would not totally address the loss of Bamford, but work currently taking place at the facility will also increase the resilience of that supply. STW decided that this offered the most cost effective solution. In order to totally secure the supply it was decided to investigate a supply from STW's Tittesworth works for the next AMP period.

Project 2: Duplication/Triplication (Driver: Resilience)

This project sought to increase the resilience of the supply to Leicestershire and intrinsically linked to other projects for the resilience to Birmingham. The notional scheme was to increase the capacity of the DVA between Kings Corner and Hallgates via 10km of new 1,100mm diameter main duplicating the DVA between Kings Corner and Sawley and 25km of 1,000mm new main between Sawley and Hallgates providing triplication of this section of the DVA.

Optioneering identified opportunities for cost-saving and risk-reduction through re-commissioning a 10km section of 39" raw water main in parallel with other trunk supply reconfiguration work rather than the construction of the new 10km section. The 10km section of main being considered for re-commissioning is the alternative River Derwent raw water supply into the Church Wilne bankside storage reservoir. Due to improved river quality in the Derwent, this main had not actually been used since 2004. Assessment of the main is currently ongoing but it is likely to require a non-structural liner to ensure the main will remain in service for the next 50 years.

Triplication of the DVA identified a potential water quality problem in low demand periods. Modelling the system showed that, by making better use of the hydraulic gradient and the introduction of a Break Pressure Tank (BPT) and 120Ml/d pumping station, the main laying is reduced to dual 2.5km of 900mm main replacing the DVA around a high spot. Other cost savings have been made

by utilising the site of derelict filters at Hallgates for the BPT. The pumps selected are dry-well installed single-stage end-suction submersible type pumps. This is a non-standard application for the pumps because of the reduced pump efficiency. However, the pumps will only be used infrequently and the lower efficiency is more than compensated by significantly reduced civils cost, relatively low capital cost of the pumps and by containing the motor control centre in an existing building.

Project 3: Ambergate Service Reservoir (Driver: Maintenance)

While this Victorian reservoir has stood the test of time in terms of size, it is now a 100 years old and has reached the end of its asset life. The solution here is to construct an 80Ml tank adjacent to the existing reservoir and then using the old tank walls as a back shutter to construct the remaining storage capacity. Due to the size and location of the development an environmental impact assessment is required and this is currently being prepared.

Project 4: Hallgates to Elms Farm (Driver: Resilience)

This project will allow 120Ml/d of water to be transferred to increase the resilience of supply to Birmingham. The notional solution was to lay 15km of 1,000mm main. However, re-configuring the Leicester supply zone and making use of the new BPT at Hallgates will allow the existing main between Hallgates and Elms Farm to be dedicated to this purpose with no intermediate takeoffs. Mainlaying will be reduced to 4km.

Currently the savings on the projects are £15m or 22% against Severn Trent's final business plan.

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