£11m Banwell & Rowberrow WTW's

30Ml/d works using submerged membranes & UV disinfection

by

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Weston -super-Mare and the surrounding area in the Mendip Hills, Somerset, is principally supplied by two potable water treatment works at Banwell and Rowberrow, constructed in 1958 and 1931. The treatment process at both sites currently takes the form of rapid gravity filtration (RGF) followed by Slow Sand Filtration (SSF) and final chlorination. Other potable sources can also feed into the area. The presence of algal blooms substantially reduces RGF run times and SSF throughput. When there is a high ambient temperature and reduced SSF throughput, the filters tend towards anaerobiosis and there is a risk of PCV failure for a number of water quality determinants. Robust compliance of the manganese standard, operational need for the works to operate reliably during the algae period, and the desire to maximise use of the local spring source at Banwell has driven a project to replace the existing treatment processes with a more robust arrangement and with a capacity that could be augmented in step with the growth in the Weston-super-Mare area.

Banwell & Rowberrow WTW: Membrane Units *courtesy Bristol Water*

Background

The treatment capacity of the Banwell works is 16.5Mld and Rowberrow 9.0Mld. They can be fed with raw water from two impounding reservoirs, Blagdon Lake and Cheddar Reservoir. Additionally, Banwell can be fed from a local spring with a maximum licensed yield of 15Mld; but this is subject to substantial turbidity swings and has a high risk of cryptosporidium. Blagdon Lake has substantial algae growth and high soluble manganese levels during the summer period of maximum demand, although this is controlled to some extent by destratification.

Blagdon Lake water quality

Blagdon Lake is relatively benign and stable in water quality terms, although the phosphate load is high enough to support significant algal blooms in the summer months. These algal blooms impact upon water quality and throughput at Banwell TW and Rowberrow TW.

Turbidity & Colour

The average lake turbidity over an 8 year sampling period has been 4.09 NTU with a 95%ile of 11.3 NTU. This should not present a treatment problem for any likely treatment option. However, the average colour over this period is 9.3 Hz, with a 95%ile of 14.2 Hz. This level of colour will have to be addressed in the chosen treatment option, a coagulation option will satisfy the required colour removal, but an unenhanced membrane treatment option may not.

Metals

The average iron content is 91.38 µg/l with a 95%ile of 208.8 µg/l - this should not present a treatment problem. However, the average manganese concentration is 100.1µg/l with a 95%ile of 419.05 µg/l; the potable PCV for manganese is 50 µg/l such that manganese removal will have to be specifically addressed in the chosen treatment option, indeed the issue of manganese, in sludge handling will also have to be specifically addressed.

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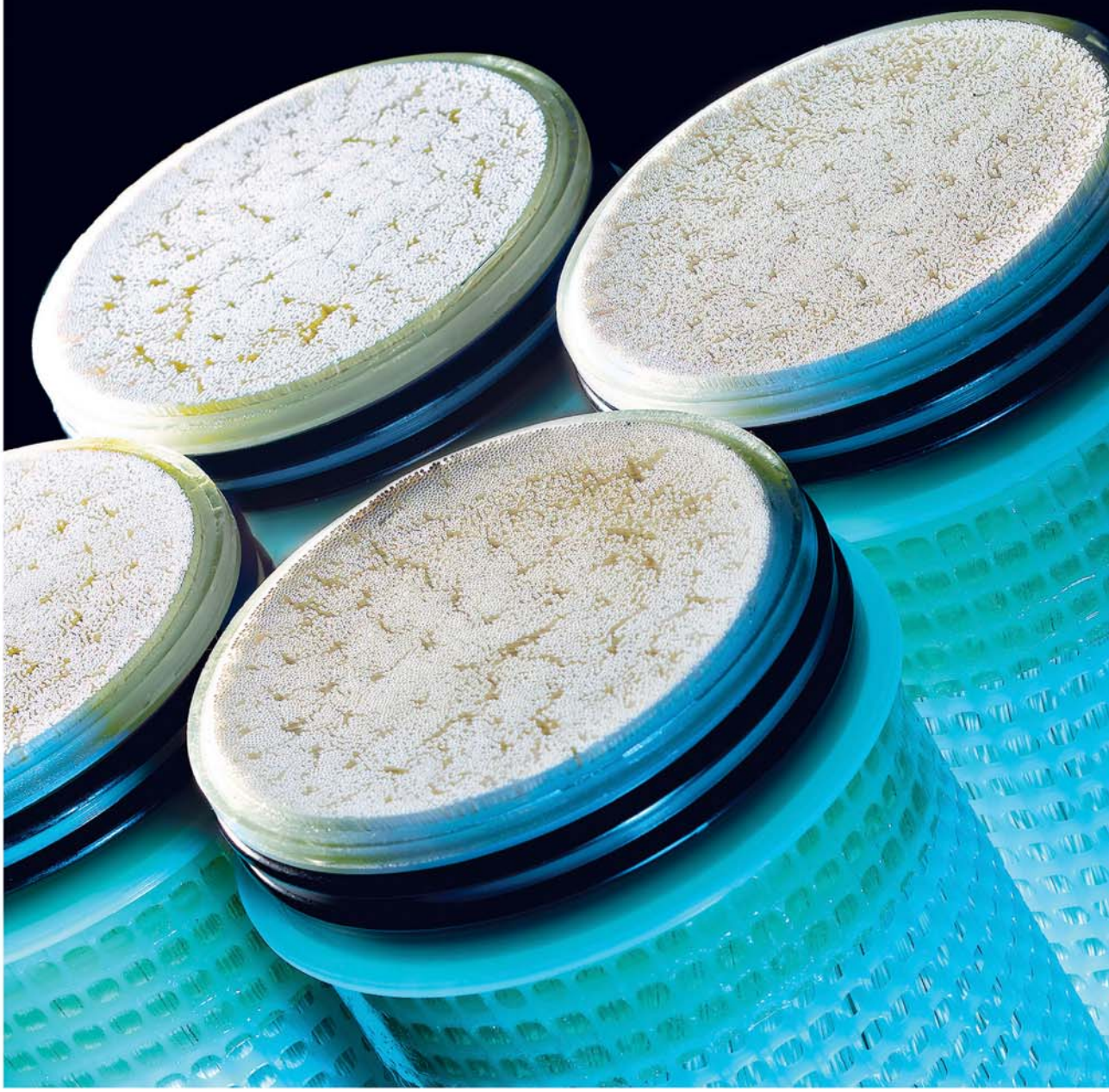

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pH
The average year round pH is 8.3; the average summer pH (April - October) is 8.5, with a winter average of 8.1. If a coagulation treatment option is chosen on this water, then pH correction will be required.

Algae
The average algal load for the summer months (March to October inclusive from 1995 - 2003 is 2964 cells/ml The predominant algal genus in Blagdon Lake is Fragillaria and this genus causes filter head loss (on both RGFs and SSFs) at above about 3000 cells/ml.Given that the average load is close to 3000 cells/ml, by implication the load will exceed this level for 50 per cent of the time. The peak algal load encountered was 34977 cells/ml on 23/05/1995 with a summer 95%ile value of 13642 cells/ml. Particularly in summer, the chosen treatment option must address the high algal load.

Nutrients
The level of **Nitrate** averages 17.5mg/l, with a peak of 32 mg/l (only encountered on rapid refill of lake). The average **phosphate** load is 146.9mg/l, although there are seasonal peaks associated with fertiliser use in the lake catchment. Blagdon Lake is relatively consistent and benign in terms of treatment challenge for other parameters; average alkalinity is 183 mg/l as Ca CO_3 (with a range of 148-284 mg/l), average conductivity is 402 µs/cm (with a range of 282-532 µs/cm). The level of pesticide in Blagdon Lake has never tended towards the potable PCV. The turbidity and colour in **Cheddar Reservoir** remains consistently very low. The overall manganese load in the reservoir is markedly lower than that in Blagdon and should not present a treatment challenge.

Treatment Options
The options for algae removal at Blagdon are complex, in that the colour and manganese load also have to be accommodated and the water treated to potable standard. Three process options were considered before the following choice was made:- **Detailed cost and operational benefit analysis determined that the optimum choice of process was submerged membranes. The analysis accounted for chemical, electricity and operational staff cost.**

Location
In addition to treatment type, there were a number of options as to the location of the new plant(s) - One of the advantages in locating the new pre-treatment plant at Banwell was that the fully licensed output from the spring feeding the site could also be processed. Further, an enhanced Banwell TW could then supply the adjacent Rowberrow zone, **such that the presently separate treatment works could be removed from service. A new pumping station and some main laying would be required but, whilst essentially cost neutral, there was operational advantage in constructing a single plant at Banwell and decommissioning the existing Rowberrow works.**

The submerged membrane plant
Tenders were requested from, membrane suppliers via Bristol Water's framework contractor, *Memcor* submitted a successful proposal for six primary membrane units (each 291m^3/hr, two secondary units (each 63.3 m^3/hr and a single tertiary unit (63.3 m^3/hr). The primary units receive raw water from the raw water contact tank, pre-dosed with a coagulant ((PACL) and potassium permanganate. The filtrate is passed onto three slow sand filters, then disinfected and to supply via a clear water tank. The backwash water from the primary units pass through the secondary membrane units with the filtrate combining with the raw feed to the primary units. The backwash water from the secondary units is passed to settlement tanks. The supernatant passes through the tertiary membrane before being discharged to the water course. The control of pH is achieved by dosing sulphuric acid before the membrane and sodium hydroxide at the inlet to the SSF's.

Disinfection
The existing chlorine contact tank has insufficient capacity to give adequate contact time at 30 Mld. An alternative solution was to install ultra violet reactors. These would enable the present superchlorination/dechlorination system to be discontinued in place of marginal chlorination - a cost saving. Additionally, ultraviolet disinfection provides a further safeguard against Cryptosporidia.In order that the UV reactors can be mounted at ground level existing low lift pumps originally used to pump from the RGFs to the SSFs will be re-used to maintain the hydraulic gradient. The installation of ozone disinfection was not viable because the 20-year NPV exceeded that of all other options

Challenges
Use of submerged membranes to treat algae laden, high manganese content water to DWI standards is a new application for the technology with relatively few similar reference sites. A small scale pilot plant set up adjacent to Blagdon Lake **demonstrated that the proposed solution will reliably treat the Blagdon Lake Water to the required potable standard**

The pilot plant has been particularly useful determining a cleaning regime and optimising the control algorithm for the manganese oxidising agent. The effluent produced by the pilot plant has been more difficult to settle than originally envisaged. Modifications were necessary to the benching of the settlement tanks at the Banwell Works and the addition of a polymer dosing system.The biggest challenge has been to determine a reliable system to control the dose of the manganese oxidising agent. Two agents were considered. chlorine dioxide and potassium permanganate. Potassium permanganate will be used. The plant is unmanned and the dosing system will rely on on-line monitors and electronic controlled algorithms which will take into account manganese content, pH, temperature and turbidity. Too little dose and the manganese standard will be breached. Too great a dose and pink water will result. Close working with the manganese monitor manufacturers has been essential in getting a workable automatic manganese oxidisation system.

Design & Construction
The construction project consists of three parts:-

* construction of the new 30Mld treatment plant at Banwell using submerged membrane and ultra-violet technology;
* laying of 600mm raw and 300mm potable HDTP pipelines between Rowberrow and Banwell, a distance of 2.4km. - both laid in the same trench.
* construction of a 9Mld pumping station to transfer treated water between Banwell & Rowberrow.

As always when constructing a new treatment system on an operational site with restricted space, great care has been necessary to avoid compromising the existing treatment and supply system. Clear demarcation of areas of responsibility between contractor and works operator and daily communication between them on current/future activities has been essential.

Key members of the design and construction team are:
Bristol Water; Costain Ltd; Black & Veatch and Memcor Ltd. Costain are Bristol Water's capital works framework contractor and are responsible for delivery of the works in accordance with a brief prepared by Bristol Water. Black & Veatch and Memcor Ltd are the principal subcontractors managed directly by Costain.

Work began on site in February 2006 and the plant is on programme to be in service in September 2007.■
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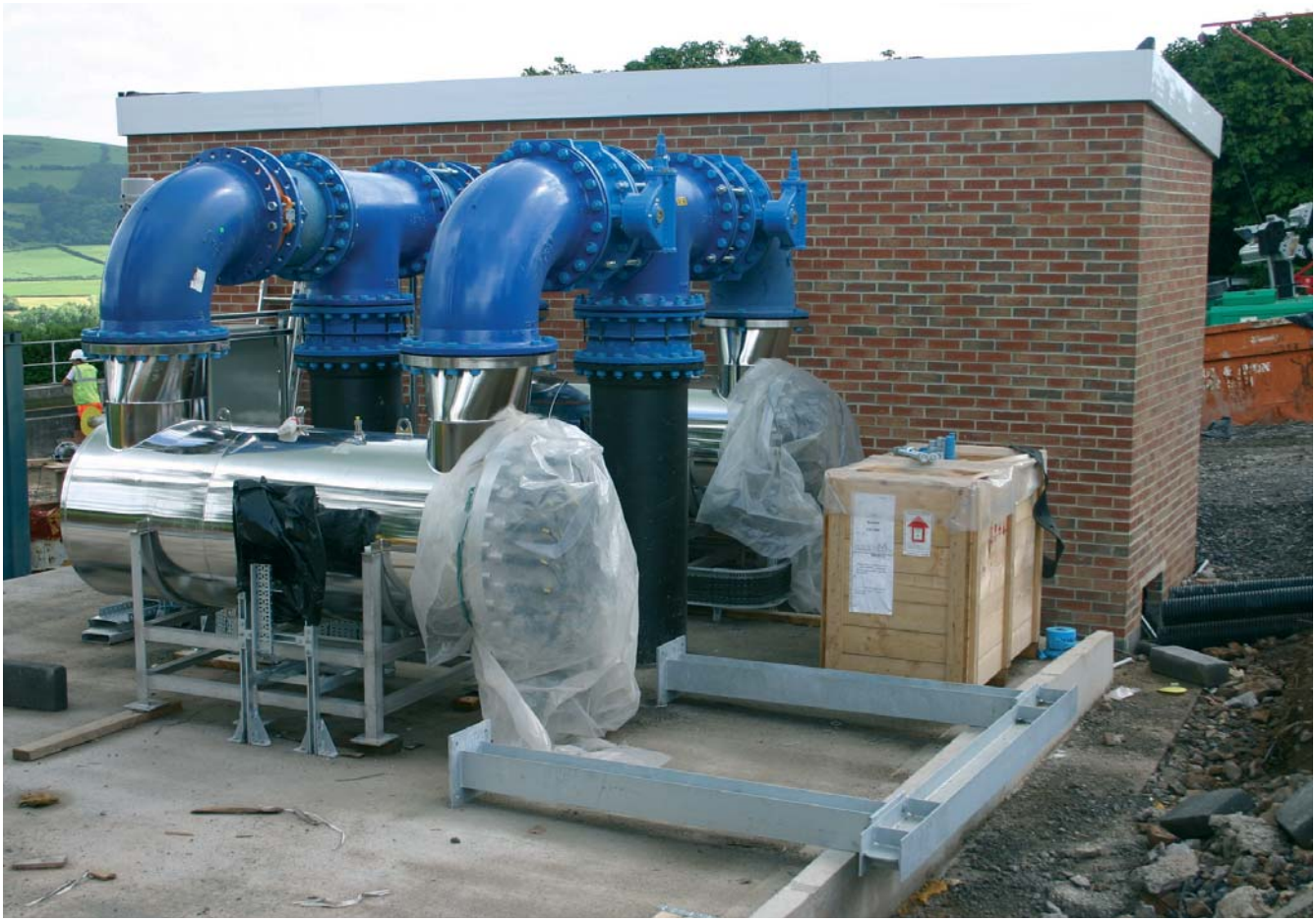

Photograph showing the UV reactors *courtesy Bristol Water*