Barrow WTW Upgrading & Securing Quality

utilising DAFRapide® technology

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Barrow WTW (120 MLD), owned by Bristol Water PLC, utilised microstrainers and slow sand filters (SSF) prior to conventional disinfection, using chlorine followed by the addition of phosphoric acid for plumbo solvency control. Historically, the works had suffered from algal blooms occasionally exceeding 7,500 cells/ml, which readily occurred in local source reservoirs Blagdon, Axbridge/Cheddar and Chew Valley Lake. The algae gave rise to rapid fouling of the SSFs. Bristol Water required a new pre-treatment works giving water quality to meet the latest Statutory Regulations.

Barrow WTW: New pre-treatment plant under construction — courtesy: Purac Ltd

In general, all the water sources are regarded as well buffered and of good quality with seasonal variation in residual metals such as iron, aluminium and manganese. Organoleptic parameters such as colour and turbidity are typically 5-15Hz and up to 50 NTU respectively.

Sand filters retained

The new pre-treatment plant was specified to produce water of potable quality at the full output of 120 Mld for the range of historic raw water qualities and algal loadings. The existing slow sand filters would be retained as a ‘second barrier’ in accordance with good water treatment practice. It was required that there was no increased risk of exceeding arsenic levels in the final water, either as a result of unusually high levels in the raw water or that, which might be added via the selected coagulant. An assessment was carried out during the design phase. (refer to Table 1.0 for more detail).

In accordance with Bristol Water’s requirements *Purac* proposed two process solutions. The first was based on ozone, coagulation and rapid gravity filters and the other with the process elements of the first but with an additional dissolved air flotation (DAF) stage.

The latter alternative offered more reliable compliance with the performance guarantees required by Bristol Water. The DAF stage considerably enhances the ability of the plant to remove the algae and can be switched off during low algae periods.

Both solutions required an effluent management plant. Furthermore, consideration had to be given to the impact of recovered water from the sand washing plant located at this works, which not only was used to clean contaminated sand from the onsite SSFs but also from other locations.

***Purac* solution chosen**

Bristol Water chose the Purac process solution that included the DAF stage. Post tender, a series of small-scale treatability tests were undertaken to confirm the proposals presented. Eventually, these discussions and tests resulted in a design approved for construction based on the use of DAF and RGF filtration using Polyaluminium Chloride (PaCl) as the primary coagulant.

The required water quality post pre treatment had to be of a standard that would meet the latest Statutory Regulations and in the context of the present plant are summarised as follows.

Table 1.0 Guaranteed Product Water Quality

Parameter	% ile	Value	Units
pH	N/A	>7.0	
Flow (product)	N/A	120	MLD
Turbidity	95	0.5	NTU
Aluminium	95	0.1	Al.mg/l
Iron	95	0.1	Fe.mg/l
Manganese	95	0.05	Mn.mg/l
Arsenic *	95	7*	As.µg/l
Algae Count	95	100	N/ml

* *It should be noted that an assessment of the raw water and selected coagulant indicated that there was little risk of the limits stipulated being exceeded and therefore no special provision was required as part of the design.*

Main process elements of the pre-treatment stage comprises:

Barrow WTW: One of the local feed reservoirs. courtesy: Purac Ltd

*** Pre-Ozone**
The unscreened and blended raw water will be dosed with up to 2 O_3.mg/l, produced from liquid oxygen, prior to splitting into two streams. Each stream will provide, via an appropriate contact tank, a mean hydraulic retention of up to 2 minutes when both streams are in service.

*** Flash Mixing Flocculation & DAF**
Flow from the pre-ozonation stage will be combined prior to the flash mixing stage with a nominal total retention of 60 seconds where the primary coagulant will be dosed.

Further flow splitting is provided such that six streams of flocculation and DAF are provided following flash mixing.

Each stream comprises two stages of flocculation, using propeller type mixers providing a nominal total retention time of 10 minutes. Each mixer has the capability to vary the input energy and hence velocity gradient provided. After flocculation the water will flow via a smooth transition stage to the dedicated flotation cell utilising DAFRapide® technology and rated at a nominal 20 m/h. Recycle injection will be delivered at a rate equivalent to 10% of the plant flow and at approximately 4.5 Barg using proprietary fixed orifice type nozzles.

The resulting sludge will be removed mechanically using a variable speed rotating "flipper" arrangement, which will ensure consistent sludge dry solid content of approximately 3-4%w/v.

The clarified subnatant from each stream will be collected via a common channel, where provision has been made, if required, to adjust the pH using sodium hydroxide, prior to flowing to the RGF stage.

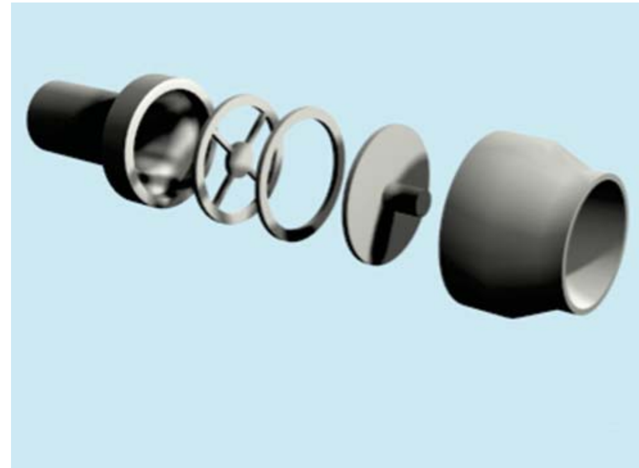
*** Rapid Gravity Filters (RGF)**
Ten concrete filters are provided, each rated at 6.5 - 8.1 m/h using a dual media arrangement, i.e. Grade 2 anthracite on 14/25 sand. In addition, due to the inherent difficulties normally associated with the removal of residual manganese, a small quantity of manganese dioxide will be blended with the sand.

Washing of these filters will be carried out using the principles of combined air and water, with an initial air scour at 50 m/h, followed by a combined phase using a "low" rate water flow at 12 m/h simultaneously with the air, finally followed by a separate high rate water rinse at 35 m/h which will ensure adequate removal of material from within and above the filter bed and ensure adequate restratification occurs before the filter is returned to service.

Washwater settling and sludge thickening via a conventionally designed WRC thickener are provided to maximise water recovery which is to be returned to the head of the works in a controlled fashion at a rate not exceeding 5% on a v/v basis of the feed to the plant. The returned water will also contain a proportion of recovered SSF sand washings.

The resulting product from the new pre-treatment plant will gravitate to a treated water chamber and then pass, via existing pipework, to the SSF.

Contract
The contract for this project valued at approximately £10.6 million was awarded to the consortium of *Purac-Costain* on September 25th 2002, with an agreed completion date 72 weeks from that date. As with any major contract such as this there are several parts to delivery and handover of a completed works. In general ***Costain*** were responsible for all the civil engineering aspects typically associated with such a project whilst *Purac Ltd* retained responsibility for the process, M & E and ICA elements of the contract. In addition, *Halcrow Group Ltd* provide the associated civil design for *Costain,* whilst the lead contractor throughout is *Purac Ltd*. The contract was based on the reimbursable IChemE 'Green Book', clauses 1-45 modified to include a target cost approach with a 'pain/gain' incentive.



During the civil engineering construction phase *Costain* were appointed Principal Contractor in compliance with CDM Regulations 1994, with this switching to Purac at a later stage. A Quality Manager was appointed for the preparation of a Quality Plan and production of an Environmental Management strategy. These were implemented from the outset. Value Engineering, HAZOP, HAZCON and associated risk analysis/assessments studies were undertaken early in the project. Actions arising from these were implemented during the detailed design phase.

The project was due for commission during early 2004 and into service by the middle of 2004.■

Notes on the authors: *Tony Amato, principal author, is Technology Manager at Purac Ltd; Keith Knight is Delivery Team Manager for Central & West regions of the UK and Project Manager for the Barrow Project at Purac Ltd; James Reckhouse is Engineering Manager for the Barrow Project at Bristol Water PLC.*