Crai WTW

upgrade with CoCoDAFF® and existing works refurbishment

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Crai WTW is situated in the Brecon Beacons National Park, 20 miles north east of Swansea, and supplies drinking water to 20,000 customers in the Swansea Valley. Dŵr Cymru Welsh Water (DCWW), as part of their AMP4 Quality Investment Plan, has upgraded the works to meet the requirements of the Drinking Water Inspectorate (DWI). The scheme addresses the treated water quality manganese driver and increases the capacity of the Water Treatment Works, facilitating supply to the adjacent water network with more cost efficient water. The new process has been sized to double the existing capacity from 15Mld to 30Mld. The combination of a robust Counter Current Dissolved Air Flotation and Filtration (CoCoDAFF®) first stage treatment, and the refurbishment of the existing pressure filters, will provide a plant capable of producing high quality water well into the future.

Crai WTW *Courtesy of Black & Veatch Ltd*

Existing works

The original process incorporated pressure filters for direct filtration, with chemical dosing for coagulation and disinfection, before distribution into the local supply network. Over recent years, there have been a number of occasions when treated water in the supply zone, and at the WTW, has failed to comply with the Water Supply Regulations 2001 with respect to manganese, iron and turbidity. In order to achieve compliance with the prescribed concentration values (PCVs), Crai WTW had to be operated at the reduced output. This was typically 50% of the original design throughput.

Part of the reason for inadequate treatment was poor performance of the existing filters, and the solution for the WTW was required to address this problem.

The selected option

Black & Veatch, Dŵr Cymru Welsh Water's Process Partners for AMP4, investigated a number of options, which included 2 (No.) stage pressure filtration, as well as CoCoDAFF® and secondary filtration. Their feasibility assessment led to the decision to implement the smaller footprint and robust CoCoDAFF® solution combined with refurbishment of the existing pressure filters as secondary filters.

The existing filters were to be a key to the removal of oxidised manganese. The refurbishment included improving the filter lateral system redesign, and retrofitting an air scour system.

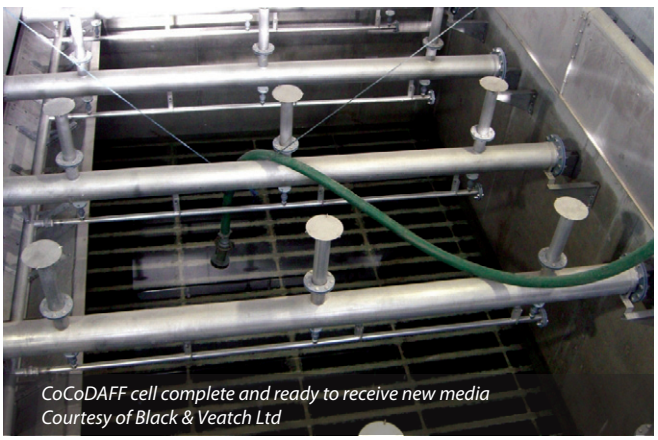
The site is located within the Brecon Beacons National Park and early consultation with the planning authority was followed by dialogue with other key stakeholders. Their feedback was taken into account when designing the enhanced exterior building finishes and site landscaping features.

The selected option utilised the existing feed to the works from the Crai Reservoir, breaking the head to enter the works at the hydraulic flocculation tanks and relifting with pumps after the CoCoDAFF®

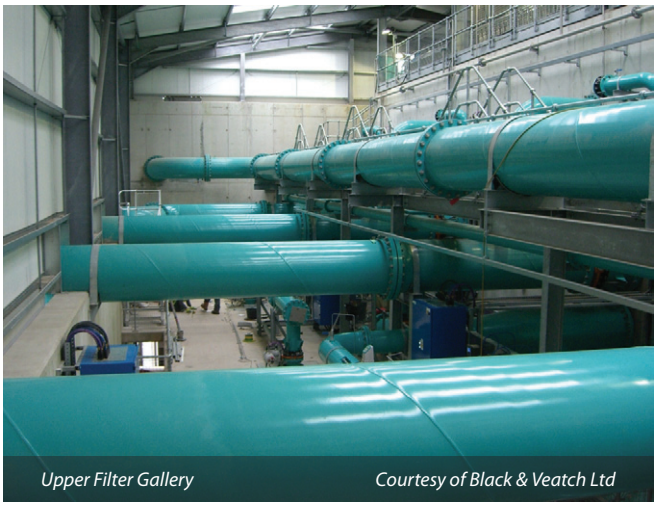
stage. A hydroturbine scheme is currently progressing to recover approximately 50% of the energy lost in breaking the head from the source. Provision was made in the main scheme to facilitate this.

The small area of land available provided challenges to the design and construction team. The land was located on the other side of a local tributary to the River Tawe (Nant Tywynni) and presented constraints on the footprint of the new plant in that construction could not encroach within 7m of the tributary. The CoCoDAFF® was an ideal solution as, unlike conventional treatment units, the CoCoDAFF® dissolved air flotation and filter stages are integrated together, so reducing the footprint required for the treatment units.

An additional constraint of the tributary running between the existing works and the new plant was overcome by transferring polyelectrolyte, lime slurry, and ferric chloride underneath the adjacent tributary through an existing 450mm diameter disused pipe. Triple contained pipework was utilised following consultation with the Environment Agency.



CoCoDAFF cell complete and ready to receive new media
Courtesy of Black & Veatch Ltd



Upper Filter Gallery *Courtesy of Black & Veatch Ltd*

The existing MCC and PLC control system for the existing works was replaced in a phased manner, ensuring that the WTW was kept operational at all times. All the work was completed whilst Dŵr Cymru Welsh Water continued to provide potable water to the network without disruption.

Construction

The small site presented a problem for the operation of crawler cranes and it was decided that a fixed tower crane would be employed. The tower crane was shared with other installation contractors during the construction period, including the mechanical installation contractor and steel building contractor. An adjacent field was leased from a local farmer to provide the site establishment for the main contractor and subcontractors.

Because of the site gradient, the relift sump and the clean wash water sump were able to be constructed under the CoCoDAFF® units. This minimised excavation of rock and effectively created a three-tier process unit on the smallest possible footprint without raising the eaves level of the building.

During the construction there were several openings on the upper floors, in particular under the motor control centre, which presented a working at height hazard. In these cases, some of the reinforcing bars were left in as a coarse mesh to temporarily cover the opening and provide full protection.

A similar approach to safety was adopted with the design of reinforced concrete platforms above the pump gallery on the ground floor. The original design incorporated steel platforms. However, this would have restricted access to the unprotected construction area below because of continued activities above. By utilising concrete floors instead, two separate working areas were created protecting the lower work area and allowing concurrent working activities.

Dirty Wash Water Tank
Courtesy of Black & Veatch Ltd

Upper Filter Galley *Courtesy of Black & Veatch Ltd*

The backwash duct for the CoCoDAFF® cell had a baffle wall which needed to be cast before the duct was closed off from above. The baffle wall was made up in precast modules fitted into a slot in the floor, grouted in and mechanically restrained at the top of the wall. This removed the requirement for shuttering in the 200mm wide space between two walls within the backwash duct.

Innovative methods used during design and construction

The design of the inlet pipework to the CoCoDAFF® is critical to good performance, and even distribution between CoCoDAFF® units is within +/- 10% . The distribution between the 18 (No.) inlet cones of the CoCoDAFF® units is within +/- 5% and feature a venturi insert in each of the inlet cones. The inlet distribution pipework to the 4 (No.) CoCoDAFF® units was carefully designed using CFD (computational fluid dynamics). Care was taken to ensure an even distribution of inlet flow across a 30MLD to 10MLd range. A baffle plate on the inlet cone outlet is designed to minimise disturbance of the sludge blanket.

Part of the CoCoDAFF® backwash cycle is a high flow water-only regrade wash to partition sand and anthracite, which is undertaken prior to the CoCoDAFF® filter being put back into service. The dirty wash water weir is designed to retain lighter particles of anthracite, which would otherwise carry over into the dirty wash water system. A media retention plate was specifically designed for this purpose using CFD methods.

Another innovative part of the design was the way in which de-alkalised water was used in the preparation of lime slurry, and in the periodic flushing of the lime transfer lines between the existing building and the new installation. The de-alkalised water was prepared on the new site in a CO_2 stripper, utilising a small proportion of the sulphuric acid principally used in conjunction with the coagulant. The de-alkalised water was transferred via the lime slurry transfer pipe to the existing lime plant to produce the slurry. The same pipe was then used to transfer slurry to a lime slurry day tank on the new site. In this way, the long transfer pipe under the tributary is kept clear of any build up of calcium carbonate deposits, which would otherwise have caused regular blockages and interruption of the pH control.

The existing filter refurbishment presented some design challenges. The existing filter lateral system was an old design and did not have an air scour feature. A separate air scour system was installed utilising the old surface water flush connection to the pressure filter. A network of air laterals was designed to fit between the water nozzles and to provide the necessary air scour for efficient backwashing of the refurbished filter. The water nozzles and laterals were cast into the base of the filter with polypropylene strands mixed into the concrete to prevent the filter base cracking in service.

Teamwork

Working closely with Dŵr Cymru Welsh Water operators at the design, construction and commissioning stages, was key to meeting the challenges in the programme and meeting the DWI output date.

The installation contractors, all Alliance Tier 1 Partners, were another important part of the team having worked previously with Black & Veatch on other clean water projects in Wales. The Black & Veatch process designer, and DCWW process scientists, became part of the commissioning team to ensure a controlled change over from operating the old works and introducing the new process units and reliable process control. The plant has been operating well since it went into service in April 2010.

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