

Boughton STW

improving effluent quality to meet Water Frame Directive standards whilst reducing operational budget and extending asset life

by Christopher Griffiths

Boughton STW is a medium sized sewage treatment works serving a population equivalent of approximately 13,000 located about 8 miles south-east of Worksop in Nottinghamshire. As part of Severn Trent's commitment to the Water Framework Directive (WFD) to improve the quality of waterbodies in the region within AMP6, Boughton STW was highlighted to accept a permit tightening to achieve an effluent standard of 1.2 mg/l ammonia and 0.2 mg/l total-phosphorus or better. Meeting this standard will improve the quality of the Bevercotes Beck (a tributary of the River Maun) to a 'good' status.



A view of the two new MBBR alternating bioreactors - Courtesy of Severn Trent

Options and solution

The existing process stream at Boughton STW consisted of screening and grit removal, 2 (No.) radial primary settlement tanks, 4 (No.) percolating filter beds, 2 (No.) radial humus settlement tanks as well as coagulant dosing and a tertiary polishing sandfilter. Boughton STW has also historically relied on 3 (No.) temporary submerged aerated filter (SAF) units and periods of removing final effluent off site by tanker to maintain compliance with its permit during seasonal sloughing periods.

The project was originally promoted for a complete works renewal, with the construction of a new activated sludge plant for ammonia treatment and a new tertiary solids plant for phosphorus removal. This option was discounted in favour of retaining and expanding the existing works, offering the best operational and capital cost solution, as well as a shorter programme duration.

The key elements of the project consisted of two phases:

- **Phase 1: Ammonia treatment:** Increasing nitrification capacity through refurbishment of the percolating filter beds and installation of a new tertiary ammonia removal plant, an alkalinity correction rig and an enhanced filter recirculation pump station.
- **Phase 2: Phosphorus treatment:** Increasing phosphorus removal capacity through installation of a new coagulant dosing rig with multipoint dosing and replacement of the existing tertiary sand filters with the installation of a new tertiary solids removal plant.

Ammonia treatment stream

In order to facilitate the incoming 1.2 mg/l ammonia permit, the site's nitrification capacity required expansion. The percolating

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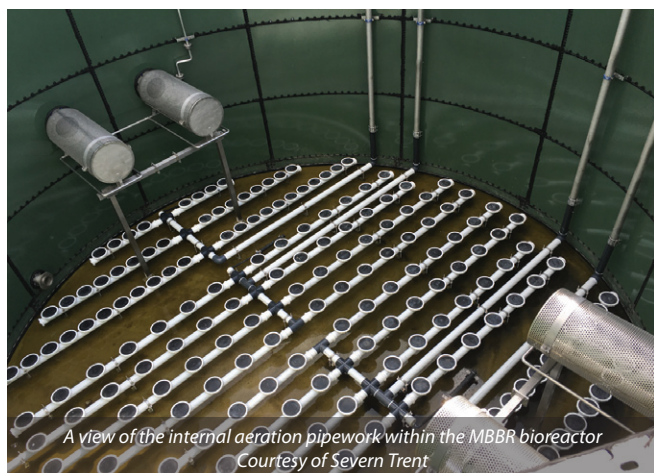




A view of the inside of the MBBR bioreactors, filled with specially designed plastic media - Courtesy of Severn Trent



A view of the external MBBR bioreactor pipework under construction - Courtesy of Severn Trent



A view of the internal aeration pipework within the MBBR bioreactor - Courtesy of Severn Trent



A view of the externals of the Mecana cloth filter assembly under construction - Courtesy of Severn Trent

filters were already well established and nitrify incoming loads well enough to meet the previous 5 mg/l ammonia standard but struggled to offer consistent performance at high flows. The performance of the percolating filters was also poor during and following the spring slough, a phenomenon where biofilms would shed from the filter media and the overall treatment capacity of the works would reduce significantly whilst the biofilms underwent a period of regrowth.

To overcome these issues a new moving bed biofilm reactor (MBBR) was installed downstream of the existing site assets as a method of tertiary ammonia removal. Supplied by Veolia, the MBBR technology consists of two aerated tanks in series filled with a plastic media substrate. The media is specially designed to provide a large surface area to encourage biofilm growth but is also designed to be self-shearing to prevent excessively thick biofilms from forming on the substrate.

The design of the media allows for a very dense level of nitrification treatment per reactor volume. At Boughton, current performance tests have indicated that the MBBR can treat in excess of 12 mg/l of ammonia from the upstream process to levels that are undetectable in the final effluent.

The MBBR process is also resilient when the plant is in a low-load condition. When flows and weather conditions are favourable at Boughton, loads on the MBBR can be as little as 1 mg/l ammonia. In traditional nitrification systems, prolonged periods of low loading would cause populations of the nitrifying bacteria to die, resulting in significant performance issues if the loading were to increase again quickly.

Veolia combatted this issue by implementing a pair of reactors which alternate the 'lead' and 'lag' duty. This control ensures the biofilms in both tanks are kept constantly fed and resilient to fluctuating loads from the upstream process.

To further improve the resilience of the treatment process, the existing media within the percolating filters was converted from plastic to blast furnace slag as the effects of sloughing have been observed to be less pronounced on sites with similar percolating filter loadings.

Electrically driven arms with automated scour cycles were also installed and the percolating filter recirculation system was upgraded to allow for more accurate flow balancing across the filters. The pumping main was modified to allow the delivery location of the recirculation flow to be moved from the settled sewage to the crude sewage if required in the future.

To ensure sufficient alkalinity for the nitrification process, a new alkalinity dosing rig was installed to dose sodium hydroxide. The dose is intelligently configured to compliment peak loads throughout the day and has pH trim correction to increase or reduce dosing as required.

Phosphorus treatment stream

The design of the phosphorus removal process stream followed extensive trials of solids removal technologies carried out at Severn Trent's Packington Sewage Treatment Works. The research trials appraised a selection of coagulant dosed and un-dosed technologies to determine how to reliably meet unprecedentedly low levels of final effluent total phosphorus. It was determined that for the flows and loads typical of those observed at Boughton STW, both pre-primary and pre-humus dosing would be required, as well as dosing ahead of the new Eliquo Hydrok Mecana cloth filter technology.

The Mecana filter, which comes with flash mixing, flocculation mixing and the filter units themselves, are simple in their design.

The dosed solids are encouraged to form large flocculated solids in which the phosphorus is bound through chemical coagulation. As the solids pass into the filter units, they are caught by the fine cloth filters, allowing fully treated effluent to pass through. As the cloths begin to become saturated with solids, differential pressure measurements trigger a backwashing cycle to clean and rejuvenate the cloths. Excess backwash solids are sent to the primary settlement tanks for co-settling with the primary sludge.

In order to optimise the coagulation of the phosphorus, three points of chemical dosing have been installed across Boughton STW. Dosing points are located at the pre-primary and pre-humus locations and are controlled on a timed diurnal profile. The dose that is injected directly into the pre-Mecana static mixer is controlled on a feed-forward algorithm which incorporates the values of flow and concentration of phosphorus ahead of the Mecana, as well as a feedback control based on the turbidity of the Mecana effluent.

A valuable additional outcome of the Mecana filter is the compliance protection offered throughout the spring sloughing of the percolating filters. Where in previous years proportions of the final effluent has had to be removed off site by means of tanker for treatment at other Severn Trent Sewage Treatment Works, the Mecana filter has consistently produced an effluent with less than 5 mg/l BOD-ATU and less than 10mg/l suspended solids. Its confirmed performance throughout the 2019 sloughing season will indicatively save Severn Trent approximately £250k per year in unplanned emergency operations.

Summary

The implementation of the MBBR and cloth filter technologies is now enabling site to achieve higher quality effluent standards than ever before whilst also reducing operational spend on site related to unplanned emergency operations as a result of the spring sloughing season. Both technologies were new and innovative to both Severn

Supply Chain	Company
Client	Severn Trent
Principal designer & contractor	nmcn PLC
Tertiary ammonia removal plant	Veolia Water Technologies
Tertiary solids removal plant	Eliquo Hydrok

Trent and nmcn PLC, but have prevented the requirement for the much greater capital installation of a new activated sludge plant and the associated ancillary equipment.

It is anticipated that following the success of the Boughton STW project, many other percolating filter works that require improvement will be enhanced by tertiary ammonia removal technologies such as the MBBR and benefit from large cost and programme savings. The Mecana technology is now widely used throughout Severn Trent alongside similar tertiary solids removal technologies with great success within the company's AMP6 low phosphorus programme.

The Boughton STW project was one of the earliest Severn Trent projects delivered in AMP6 with such tight effluent standards. Its success was in part due to being batched with 25 other projects with similar incoming permit requirements to collaboratively develop new technologies and exploit existing technologies to deliver TOTEX solutions for Severn Trent.

The £5.8m project is now (June 2019) fully commissioned and is currently being optimised to meet the new permit criteria as efficiently as possible.

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A view of the two Mecana cloth filters - Courtesy of Severn Trent