Christchurch STW

growth scheme - additional treatment capacity for existing sewage treatment works

by Jonathan Rayers MEng CEng MICE

Christchurch Sewage Treatment Works (STW) is located on the north western fringes of Christchurch, near Bournemouth on the south coast. The works serves a population equivalent of 57,551 and is required to pass a flow to full treatment of around 490l/s (42,500m^3/day). The activated sludge treatment process at Christchurch STW is at the limit of its hydraulic and biological capacity, and the works have recently struggled to achieve its Ammonia-N consent. Past growth and anticipated future growth mean additional treatment capacity is required.

Working area for FST8 and distribution chamber (existing sludge tanks being tunneled under in foreground) - Courtesy of WECS Civils

Scheme overview

Christchurch STW principally comprises an inlet works, 4 (No.) primary settlement tanks, 2 (No.) activated sludge plants (ASPs) each with 2 (No.) lanes with 4 (No.) surface aerators in each lane, 7 (No.) final settlement tanks, as well as UV disinfection of the final effluent and storm and sludge handling facilities.

To improve the site's treatment capabilities, the scope of works includes:

- Additional activated sludge plant (ASP3).
- Refurbishment of existing ASPs (ASP1 & ASP2).
- Additional final settlement tank (FST8).
- Associated ancillaries, including power and control system upgrades.

Delivery method

The scheme was delivered through Wessex Water's internal construction and engineering business, Wessex Engineering and Construction Services (WECS) under the AMP5 Framework Agreement, operating under the NEC3 Contract, with the inclusion of Option X12 for working in a partnership. In this specific AMP5 workstream there were 4 partners:

- WECS: Programme management.
- Grontmij: Design consultant.
- WECS Civils: Civil contractor.
- Trant Engineering Ltd : Mechanical & electrical contractor.

All partners have been involved during the outline design, detailed design and construction/commissioning phases of the project. Early

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Site Layout with ASPs 1 & 2 on the left and the new ASP3 being built on the right - Courtesy of WECS


Reinforcement being installed for FST8 - Courtesy of WECS Civils


Micro tunnel boring machine emerging into the reception pit Courtesy of WECS Civils


Diffuser feed pipework with zonal air flow monitoring and control Courtesy of Trant

contractor involvement has been a key element to the successful delivery of the scheme whilst maintaining site compliance. Further specialist contractors were used for various RC works, micro-tunnelling and process modifications.

Scope of works

The scope of work at Christchurch STW comprised hydraulic principles, structures, pipework and chambers, mechanical works, electrical works and capital maintenance.

Hydraulic principles:
The tight hydraulics of the existing site meant that it was not practical within the space available to split the flows between ASPs 1, 2 and 3 in the proportion required by the process by means of freely discharging weirs. The diversion and correct flow proportion to ASP3 was achieved by an actuated eccentric plug control valve controlled using flow measurements from an in line magnetic flow meter.

To avoid the need for interstage pumping, it was necessary to design the plant hydraulics around low pipe velocities to minimise headlosses along the new treatment stream. Experience and engineering judgement indicated that these low velocities would not promote excessive solids deposition from settled sewage or mixed liquors.

Structures:
Due to the sandy gravel ground conditions together with a high water table the permanent and temporary works designs needed careful consideration. The ASP and FST dimensions and levels were dictated by the process and hydraulic requirements.

A toe arrangement was developed for the ASP to resist flotation forces whilst remaining within the acceptable temporary works envelope, and anti-flotation 'Platipus' ground anchors were used in the base of FST8 to avoid using excessive amounts of mass concrete. This anchor arrangement was the same as the approach that had been adopted in the construction of FST7.

The preferred temporary works option was to install cantilever cofferdams for the larger structures; the ASP included a drainage system at formation level and deep reinforced blinding and was completed in four sections removing the bracing system once the structural blinding had met its required strength, leaving the excavation completely open to complete the structure.

The cofferdam measured approximately 70m long x 15m wide x 5m deep and the sheet piles used for this area were 12m long.

The FST was also installed with a cantilever cofferdam; however one section had to be completed under high voltage cables. A system was devised using a small hydraulic crane and welding the piles in small sections that allowed the works to be carried out within the safe limits of HSE's GS6 '*Avoiding danger from overhead power lines*' guidance note.

The piles were installed with a bitumen seal between each pile and internal well pointing was installed within the pan of the piles that managed the water during construction.

Both the dewatering and the piles were subject to strict monitoring during the construction period to ensure conformance to the designed criteria. Groundwater proved to be challenging at times; however the dewatering well points worked well during the construction period without any breakdowns or issues.

Pipework & chambers:
The majority of the buried pipework and chambers were installed using conventional open cut excavations; however the ASP feed pipe (connecting the existing works with the new ASP) and the

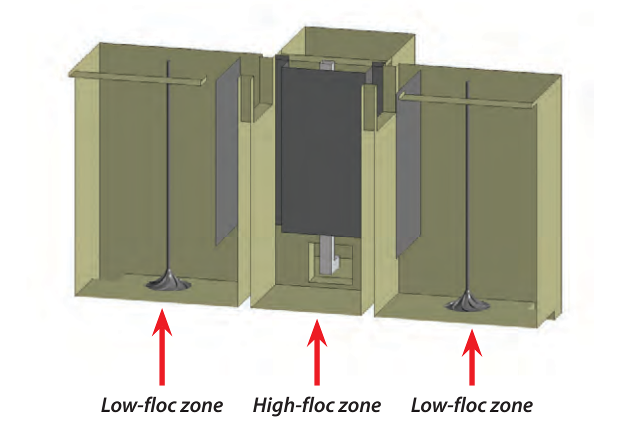

Figure 1: Layout of anoxic selectors - Courtesy of MMI Engineering

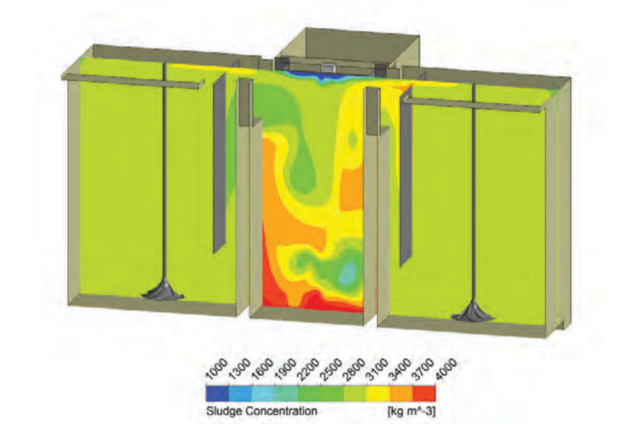

Figure 2: RAS distribution - Courtesy of MMI Engineering

effluent pipe (connecting the new ASP3 with the new FST8) crossed numerous existing services and their routes were constrained by existing structures, including sludge storage tanks between the ASP and FST.

The selected solution for these two pipe runs (20m and 45m respectively), in consultation with WECS Civils and specialist contractors, was to use a micro-tunnelling technique to install the pipe below the services. This minimised the need to deal with the running sand and existing services. The tunnel liner was used as the finished pipe.

The feed pipe was driven away from the ASP, and on completion the launch pit (by ASP3) became a future diversion chamber and the reception pit was turned into the upstream control valve chamber. The effluent pipe was driven towards the ASP underneath the sludge storage tanks, and on completion the launch pit became the FST distribution chamber (serving FSTs 7 & 8) and the reception pit (by ASP3) would become a future diversion chamber. The pits were constructed using caisson shafts with the reinforced concrete bases installed under water.

Mechanical works:
An assessment and optimisation study of the anoxic selectors was undertaken by MMI Engineering using computational fluid dynamics. The layout of the selectors is presented in Figure 1 - see above.

Settled sewage is received in to a compartment upstream of a high-floc loading zone. Return activated sludge (RAS) is received in the high-floc zone and here the two fluid streams mix. From the high-floc zone the flow is split to two low-floc loading zones located immediately upstream of the aeration lanes. Each low-floc zone is mixed by a hyperboloid mixer which was resolved in the model.

CFD modelling was undertaken to calculate the degree of mixing, the RAS split to the two aeration lanes and to also replicate a dye trace study to assess the residence time distribution and identify if short circuiting takes place.

Figure 2 (previous page) presents a contour plot showing the distribution of RAS. This shows the result of the optimisation work undertaken by MMI Engineering in collaboration with Wessex Water and Grontmij. The mixing that takes place in the selectors distributes RAS evenly to each of the aeration lanes, therefore preventing either lane from being overloaded.

The anoxic selector zones of the new ASP3 were designed to provide an initial common high-floc loading zone to preferentially select floc forming microorganisms. This also allows some degree of denitrification of the returned activated sludge.

Anoxic conditions are maintained and settlement prevented by low-speed Invent HyperClassic mixers provided by Corgin. The selectors were separated into zones by baffles configured to allow a continuous surface flow to minimise scum accumulation whilst minimising short-circuiting of flows.

Two process options were considered for ASP3:

- Integrated fixed film activated sludge (IFAS).
- A conventional ASP.

An options study concluded that a conventional ASP with a volume of 3,000m^3 using fine bubble diffusion aeration (FBDA) would more suitably satisfy the process requirements.

Different blower technologies for the FBDA were compared. Broadly speaking there was a choice between less efficient positive displacement blowers at lower CAPEX costs or more efficient high speed turbo centrifugal blowers with magnetic/air bearings at higher CAPEX costs.

A whole life cost (WLC) analysis was undertaken to compare the options available, looking at different operational scenarios requiring low, minimum and peak oxygen demands. The conclusion was that high speed turbo blowers (with air bearing) were the most cost effective for the each of the scenarios envisaged.

Corgin was chosen to provide the FBDA and blower package, and they in turn sourced the blowers from APG Neuros.

FBDA was provided using diffusers arranged in a tapered fashion with the density decreasing along the tank profile. Air flow was controlled via actuated eccentric plug valves for the diffusers serving each aeration zone.

ASP3 utilises real time ammonia control alongside conventional dissolved oxygen control to direct the zonal valve operation. The air pressure in the common main is monitored by a pressure transducer; blower speed adjusts to maintain a set point pressure.

Electrical works:
The existing site transformer and standby generator were found to not be suitable for the upgraded site's power requirements. As part of the scheme, a new 800kVA transformer and 1,000kVA standby generator were installed, complete with bunded fuel delivery area.

The generator was brought in from another Wessex Water site, with the former 800kVA generator being taken away for refurbishment and use elsewhere, as part of a wider rationalisation project of generators around the business.

Significant electrical assessments were undertaken to identify deficiencies in the existing motor control centres (MCCs) and to

ASP3 FBDA diffuser arrangement
Courtesy of WECS Civils

High speed turbo blowers being installed in dedicated kiosk
Courtesy of Trant

ASP3 structure being water tested - Courtesy of WECS Civils

ASP3 being commissioned - Courtesy of Grontmij

assess the impact of any modifications needed from the process and capital maintenance works. The conclusion was that a new combined MCC was the most economical solution.

The MCC replacement was undertaken in a phased approach given the need to keep the site operational throughout the upgrade works.

Capital maintenance:
Two options for replacement of the existing surface aerators in ASP2 were considered:

- New, more efficient, low speed surface aerators (LSSA).
- Retrofitting with FBDA.

A WLC analysis was undertaken, which concluded that ASP2 should be converted to receive FBDA. Corgin was again chosen to provide the FBDA and blower package.

Retrofitting FBDA was considered as an option for ASP1, however due to its tank geometry and small base footprint it was not deemed suitable for FBDA to ensure adequate mixing and aeration.

The whole life cost analysis of retaining the existing aerators has been compared to replacement with low speed surface aerators with a positive benefit for replacement.

On this basis the option selected for ASP1 was replacement of the existing surface aerators with low speed surface aerators by Corgin.

Future expansion

Options for the future potential change of process to accommodate a total nitrogen (TN) consent were considered. The current selected option is for one of the four tanks within the existing ASPs 1 & 2 lanes to be converted into an anoxic tank. The remaining tanks within the lanes will be aerobic.

Allowance for space for construction was made for a new anoxic tank to be built upstream of ASP3 (treating the remaining flows and loads). A new aeration tank (ASP4) will be constructed to compensate the loss of aeration volume caused by the partial conversion of ASPs 1 & 2 into anoxic tanks. Another FST (FST9) will be built identical to FSTs 7 & 8, and will be fed from a spare cell constructed in the new FST distribution chamber.

Furthermore certain pipes built under this scheme (generally those buried) and the aeration headers were sized to accommodate future higher flows being diverted to ASPs 3 and 4.

Completion

At the time of writing this paper (May 2015) the new treatment stream (ASP3 and FSTs 7 & 8) at Christchurch STW are in the final stages of commissioning before being handed over to Wessex Water Operations.

With the new stream handling flows, ASPs 1 & 2 can then be taken offline in a phased approach for their modifications, without disrupting or restricting the treatment capabilities of the site.

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