Liverpool WwTW

construction nears completion with the project moving smoothly into fit out and commissioning phases

The decks are rising as the construction of the sequencing batch reactor (SBR) in the old Wellington Dock heritage site, moves into its third year of build. In UK Water Projects 2012 we reported the start of construction when the planning permission was granted. In 2013 we highlighted the various parts of the project whilst the construction of the main structure foundations was completed and SBR lower deck walls were underway. This year the project has moved on in many areas, including upgrading of the existing treatment plant and replacing assets making the plant better and more efficient whilst the SBR rises to new heights.

Liverpool WwTW SBR under construction - November 2013 - Courtesy of United Utilities

Building information modelling (BIM)

GCA (Galliford Try-Costain-Atkins) Joint Venture is the main contractor for the SBR project in Wellington Dock and the refurbishment of the existing works in Sandon Dock. GCA JV has employed the 3D model as part of the overall BIM implementation plan as the hub of the design and collaboration tool.

Value engineering exercises have been easily communicated to United Utilities' engineering and operations teams to demonstrate improved design leading to quicker delivery, reduced materials and improved safety and operational benefits.

The 3D model has been created from the outset as a construction and operational model, with all components as separate entities and individual concrete pours defined as objects, enabling changes to be made quickly. This process, if done using 2D drawings, would typically have taken several times longer resulting in a timeframe incompatible with the requirements of the programme.

Inlet pumps

The existing Inlet pumps were installed as part of the original MEPAS (Mersey Estuary Pollution Alleviation Scheme) when Liverpool WwTW was first built in the late 1980s. The original centrifugal pumps have since suffered blockages due to large debris and rags and on several occasions have had to be unblocked and repaired.

The pumps have now come to the end of their useful life and so new, more robust pumps with larger solids handling capacity have been chosen. The inlet from the MEPAS sewer is 18m deep and is split into north and south approach channels each feeding 4 (No.) of 8 (No.) pumps each of which in turn have a capacity of 1,571l/s to meet maximum inlet flow 11,000l/s.

The change of all 8 (No.) inlet pumps to the new Hidrostal single vane impeller type makes them capable of handling larger solids. The work also includes the associated equipment valves, variable speed drives, suction bends and discharge pipe work. This work


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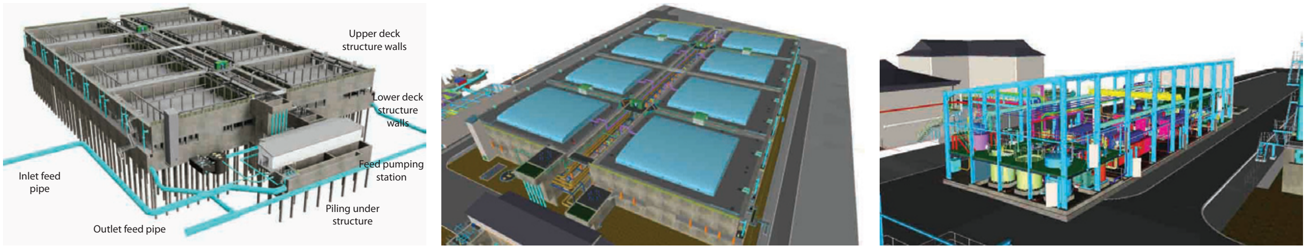


Building information modelling - BIM: (left) SBR structure overview (centre) SBR with covers showing and (right) sludge building- Courtesy of United Utilities

requires two major 40 day shutdowns; Phase 1: South channel works, and Phase 2: North.

During the shutdown it limits the inlet pumping capacity by half of high flow conditions. The reduced capacity of the pumped flows causes back up in the MEPAS sewer and therefore the levels have to be managed during storm conditions. The shutdowns had to be agreed with the Environment Agency before worked commenced.

A working safely protocol was adopted as the approach channels are 18m deep with a restricted access NC4 confined space. Additionally, there is a risk of flooding and it was necessary to work closely with the operators to continuously monitor the sewer. A high priority maintenance call out regime was also put in place.

The main challenges faced by the team were:

- Lifting large components 18m up/down the shaft.
- Changing existing pump suction isolation valves in the difficult confined space.
- Fixing the existing worn suction pipes.
- Maintaining an operational live site safely and without service or operational disruption.
- Weather.

Primary settlement tanks

The 10 (No.) rectangular primary settlement tanks (PSTs) were built as part of the original works in the late 1980s and have regular mechanical problems. In the 1990s the plant was modified leaving only 6 (No.) primary tanks remaining. The tanks contain a chain and boom type scraper mechanism providing both sludge and scum removal.

An analysis of the regular problems encountered proved it was fact that the equipment had come to the end of its useful asset life and the project needed to find a way forward to ensure the plant could be reliable for another 10-15yrs.

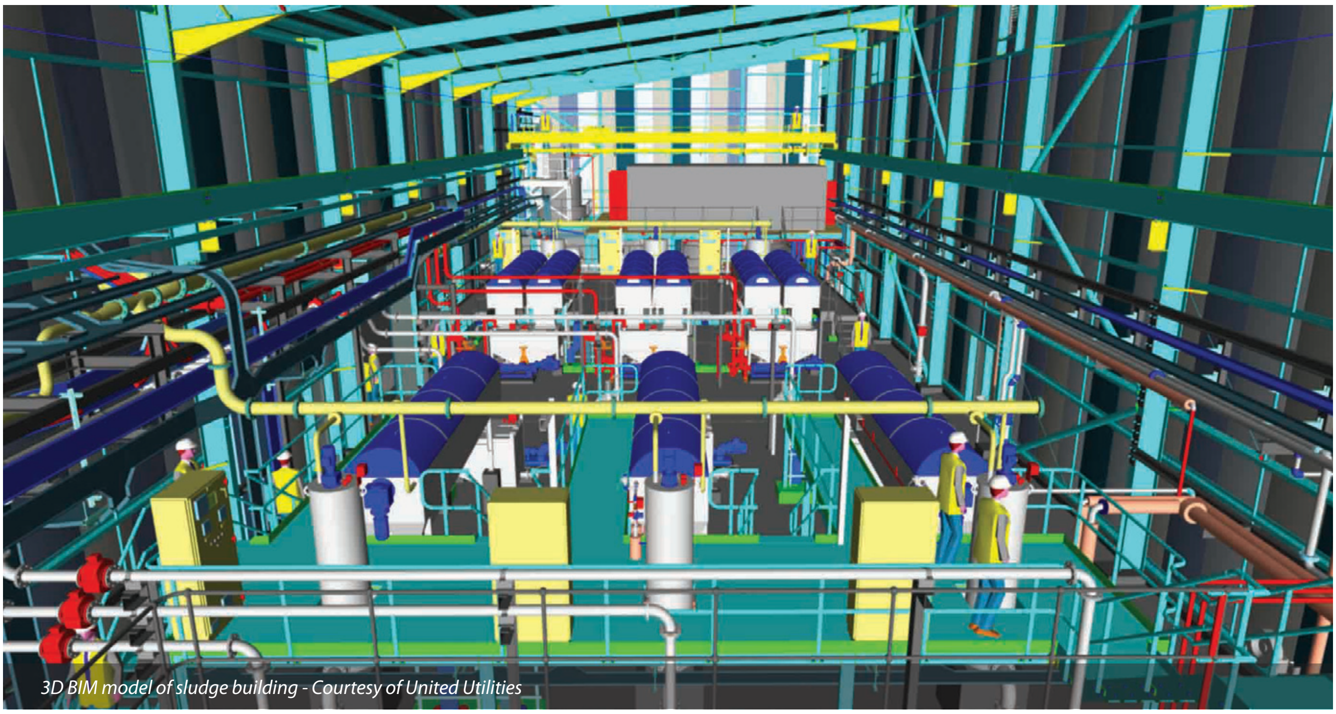
The boom operates via a chain drive and is designed to scrape sludge from the bottom of the tank and skim any floating debris from the surface of the effluent and as such operates at two levels. The chain drive and guide both suffered abrasive corrosive wear and are being replaced with new more reliable components.

One of the main issues is the chain failure and by careful alignment of the sprockets to ensure correct chain engagement. A duplex chain monitoring device was installed counting the link movements and arranged to trip the drive should there be a problem.

SBR construction

The sequence batch reactor (SBR) construction commenced early September 2012 with the main base slab requiring 20 (No.) 600m^3 concrete pours. The upper and lower walls are 6.7m high x 600mm thick and were completed in 20-40m long sections. Each of the 8 (No.) upper deck cells are supported by 68 (No.) 500mm x 500mm columns spaced on a 5m square grid.

The upper deck construction commenced March 2013. A new falsework support system (layer) was chosen for its versatility and ease of installation/dismantling. One value engineering initiative using the decanter support plinths (4 (No.) per cell) enabled the wall sections to be slimmed down whilst acting as strengthening abutments. Phased civil completion and handover of the cells allowed the M&E installation to commence in July 2013 enabling the earliest possible start for erecting the aeration and decanter



3D BIM model of sludge building - Courtesy of United Utilities pipework, hand railing and metalwork flooring. The collaboration of all trades ensured the work interfaces were managed efficiently and safely.

A significant amount of precast concrete elements were incorporated into the final design and provided cost benefits, minimised interface issues and shortened the programme.

Due to the highly restrictive nature of the site a 'just in time' delivery schedule and night-shift working was adopted to install the majority of the precast elements. Along with modularisation, this accelerated the construction of the upper cells. Modular design and build was also utilised to provide programme and cost saving benefits for the main SBR gallery pipework, staircases and platforms.

Refurbishment of existing primary settlement tank assets: chain and boom - Courtesy of United Utilities

Upper distribution chamber under construction Courtesy of United Utilities

Typical cell decanter and aeration pipework - Courtesy of United Utilities

SBR distribution chambers

Incoming flows from the existing works will be diverted to the new SBR feed pumping station where they will be pumped to the distribution chambers. Gravity flow will then feed the SBR cells for treatment.

The chambers are significant structures and presented a challenge to the site team due to their complexity and tight working restrictions in a very congested area.

Night time working was employed to ensure safety and allow the adjacent feed pump station superstructure to be progressed and gain valuable programme time.

The upper distribution chamber is supported on substantial cruciform precast support legs, which dramatically saved construction time for these simple platforms. In addition, the 1,800mm diameter duckfoot bends to each chamber were held in position with complex temporary works supports whilst the structure was constructed around them.

Sludge thickening building

The new sludge thickening building is a facility for both primary and secondary (SBR) sludge and was designed to be constructed off-line minimising disruption to the existing operating process.

The building is a cladded steel frame housing both the primary and secondary drum thickeners, polymer make up systems, tanks, pipework and associated MCC and control equipment. The two systems are independent of each other as per the different sludge requirements.

The primary drum thickeners are Alfa Laval ALDRUM Mega x 3 for the primary and MegaDuo x 3 for the SBR secondary. The average primary sludge volume is 901m^3/day and the secondary 5,600m^3/day. Each plant is designed with two units operating to cater for the daily sludge load with a third unit for standby and ability to run when there is a backlog.

Blower building

The blower building (48m long x 14m wide x 18m high cladded steel frame) is designed to house the SBR aeration blowers and associated MCCs and control equipment. The building was designed with a raft foundation to avoid the need to pile the foundations unlike virtually all other structures on site.

A mezzanine floor has been designed to house the MCCs which will provide power and control for the 14 (No.) blower units feeding air to the SBR. The blower building is a complex steel structure which, due to the heat generated has been designed to be partially exposed thus avoiding costly cooling and ventilation systems.

Lean construction

The site team employed lean construction techniques from early on in the project in order to manage and constantly improve the construction process. The lean strategy was to use collaborative planning sessions with key subcontractors helping the team focus on coordinated activities thus:

- Removing wasted time hence improving programme times.
- Ensuring realistic planning thus raising quality levels.
- Overall reducing costs.
- Coordinated activities which assist in improving safety.

Outfall extension

December 2013 saw the successful completion of a new 285m long large diameter polyethylene outfall extension pipe used to improve dispersion of the final effluent from the treatment works into the River Mersey and ensure compliance with the Habitats Directive. The installation, carried out by Van Oord required meticulous planning by a team of marine experts working directly for United Utilities.

The existing outfall from the treatment works is located adjacent to the river wall and has reduced dispersion and dilution resulting in a visual plume in the river which exceeds EA standards. Water quality dispersion modelling undertaken in conjunction with the Environment Agency identified a new discharge location for the outfall 285m from the river wall. This location was in the deeper main channel of the Mersey where the tidal currents would provide the necessary dispersion.

Hydraulic analysis of the new outfall over a range of discharge flows and tidal conditions was undertaken. To satisfy the requirement for the outfall a minimum internal diameter of 2m was required.

To combat floatation, the design proposed that the polyethylene pipe be stabilised using a combination of continuous concrete weight collars to reduce buoyancy and enable controlled installation. Rock armour backfill to the trench provided additional stability and protection from storms and the strong tidal currents in the Mersey.

The outfall utilised marine design and construction techniques with an emphasis on limiting the amount of diving required. Below is a list of innovations utilised on the outfall element of the programme:

- The first use of solid wall PE100 pipe at 2100mm in the UK. The pipe was extruded directly into a fjord in Norway by PipeLife Norge AS and then using tug boats delivered to the construction site in Liverpool.
- A single long string with flange connections reduced installation times and minimised underwater jointing and the need for diving work in the River Mersey.
- The use of a long single string reduces the frequency the pipe is mechanically handled which minimises the risk of pipe damage, maximising installation efficiencies and improving overall safety.
- The first use of a specialist rock ripping tool to excavate the marine trench of this scale within the UK. This tool minimised noise and vibration in close proximity to the historical river wall and within an environmentally sensitive location. This enabled optimisation of the dredged material and a reduction in the overall carbon footprint for the scheme.
- The first single pipe string installation using the float and flood technique in one of the most extreme tidal estuaries in the UK with currents up to 8 knots. This significantly reduced the diving operations required in these challenging conditions.
- The first use of a 2.1m diameter Nova Siria Multi Grip end restraint within UK with beneficial manufacture, delivery and installation timescales.
- To protect the integrity of the historical river wall it was necessary to design, fabricate and install a bespoke connection to the existing works. This connection provided a unique solution for connecting new to old.

The innovation demonstrated on this outfall pipeline project has ensured successful completion and allowed other similar or larger projects to be developed into the AMP6 programme.

Summary

The final connection to the existing treatment works outlet was undertaken in December 2013, 15 months ahead of the Regulatory Date whilst achieving cost efficiencies totalling over 10%. The success of the project so far bears testament to the collaborative working ethos of the project team and suppliers. Combined with other investment undertaken by United Utilities, environmental and water quality benefits to the River Mersey will continue.

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Outfall pipe installation in Mersey - Courtesy of United Utilities