Blackburn WwTW

major works at Nabs Head Inlet and Smithfold Main Works

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Major project work was carried out between July 2007 and July 2009 at two United Utilities Wastewater Treatment sites in Blackburn, Lancashire namely 'Nabs Head Inlet' and 'Smithfold Main Works' with a combined capital value of £20m. The project at Nabs Head was to provide an improved quality of crude sewage from the inlet works, reduce the amount of maintenance and operator attendance on the existing screens and the storm tank scrapers, and to prevent solid residues remaining within the storm tanks. The projects at Smithfold were to provide a new tertiary treatment facility, increase and improve the reliability of sludge cake production and refurbish the existing brewery pre-treatment plant.

BAFF Structure during construction *Courtesy of DCT Civil Engineering Ltd*

IA+ Northern Delivery

At the commencement of the AMP4 programme United Utilities vision was clear - for all parties to collaborate and act as one, in partnership, to deliver the capital investment programme at minimum whole life cost at acceptable risk to the UU business.

United Utilities, MWH and Kier, Murphy, Interserve and Mouchel Parkman - (KMI+ JV) form the Northern Delivery for IA+ to ensure timely delivery of United Utilities' framework programme. MWH as Solution Services Provider were to take projects through the Solutions Identification and Development phases culminating in project solutions and scope book - pricing, detailed design and construction being carried out by the process partner KMI+.

Solution for Nabs Head

New Inlet Screens and Storm Tank cleaning - Nabs Head is a preliminary treatment plant to the main Blackburn Smithfold WwTW although located on a separate site approximately 1 mile from the main works. It comprises formula A overflow direct to river, inlet screening, detritors and off-line storm storage with a storm return pumping station.

The existing 4 screens were replaced with 4 new Longwood escalator type screens and associated screenings handling equipment comprising launder trough, screenings stone trap and dual tank Washpactor.

Storm Tank cleaning improvements consisted of Removal and disposal off site of existing Storm Tank Bridge Scrapers and all associated mechanical and electrical equipment and cabling from Storm Tanks 5 to 12.

New 'Swing-jet' mixers (2 per tank) were installed together with new actuated valve outlets to each storm tank outlet to facilitate automation of storm tanks emptying.

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Ariel views of Nab Head Inlet Works (left) and Smithfold STW (right) *Courtesy of MWH*

Inlet Screens **-** The ageing inlet screens failed regularly causing the raw sewage influent to frequently pass through the unscreened bypass channel and cause blockages and maintenance problems throughout the works. In addition the existing screens were automatic raked vertical 12mm bar screens which allowed the passage of solids of an unacceptable size and quantity to the main process stream.

The screens were to be decommissioned and replaced sequentially to retain an acceptable sewage screening capacity during the refurbishment. The solids captured by the raked bar screens were deposited on a belt conveyor where they were passed directly to a skip for removal from site. This existing belt conveyor had to be completely removed with the first conveyor to enable the installation of the launder channel section serving the first new conveyor. For this reason the screens were replaced sequentially starting from the screenings collection bay. Before the belt conveyor was taken out of service, temporary belt conveyors were installed to serve the existing screens that would remain in service. The screenings collection skip was relocated as the new washpactor would be installed in the existing skip bay. The new washpactor was installed simultaneously with the first screen and both were commissioned together prior to the removal of the next screen. The second screen was decommissioned and removed. The temporary conveyors were rearranged and the screens launder trough from the first new conveyor was extended across to the position of the second screen and the second screen was installed and commissioned. This process continued until all 4 screens were replaced. The new screening system required the installation of a new MCC serving existing and new equipment with new control software interfacing with the existing flow control penstocks.

Concurrently a new wash water system was installed to serve the new screens and the washpactor. Due to difficulties in upgrading the existing potable water supply to site and in the absence of a final effluent washwater system on site, it was proposed that screened final effluent would be used to serve the new screening equipment. Crude sewage would be drawn off the main process channel into an existing off-line wet well from where it would be passed through a fine screens and set of plenty filters before passing to the spray bars in the new screens. The existing pumping station required a new inlet penstock where the invert of the aperture was level with the floor of the main process channel. In order to gain access to install the new penstock, the whole works needed to be over pumped to create a dry working area within the main channel and the wet well.

Storm Tanks **-** The existing storm tanks posed maintenance issues in that the existing scraper bridges in tanks 5 to 12 broke down frequently causing a large quantity of solid to settle and solidify on the tank floors. United Utilities previously had the scraper bridges in tanks 1 to 4 replaced with KSB Swing Jet mixers which proved to be reliable and effective for cleaning the tank floors upon storm return. Part of the contract on the Nabs Head Storm tanks was to remove the scraper bridges from tanks 5-12 and replace them the Swing Jet mixers as per tanks 1-4. In addition, the outlets from each of the tanks to the storm return pumping station would be fitted with actuated valves to provide a controlled emptying regime. In early consultations with the Environment Agency, it was only permissible to have 4 storm tanks out of service at any one time so not to seriously affect the storm storage capacity and hence the frequency of spills to the watercourse. The new installation involved removal of the existing scrapers and associated control equipment, the extension of the existing Swing Jet MCC and interfacing with existing control systems.

Projects at Smithfold WwTW

Smithfold receives flows from several sources. The majority of the influent is crude sewage from Nabs Head Inlet, the other sources being raw unscreened sewage from surrounding businesses and residential properties and industrial effluent from a nearby brewery.

The project comprised:

- Refurbishment of the Tishy Well pumping station delivering raw sewage from local businesses and properties.
- Replace and refurbish the brewery pre-treatment plant inlet screens and divert Tishy Well pumped flows to it
- Installation of auto de-sludge pumping on the brewery pre-treatment clarifiers
- Introduction of a Tertiary treatment plant
- Increasing Sludge Dewatering Capacity and Replacement of existing sludge plate press with two centrifuges
- Upgrade of the site power supply and a new HV ring main around site with associated HV switchgear and new transformers supplying new MCC's

Solution for Smithfold

Tertiary Treatment Selection **-** A Tertiary treatment process was required in order to remove Ammonium and particulate BOD.

A gravity feed Biological Aerated Flooded Filter (BAFF) plant was the preferred solution. This would treat a maximum of 85 ML/Day equating to 50% of flow to full treatment (FTFT).

Flow from the 16 rectangular humus tanks was diverted to a new BAFF flow control chamber where the flows were distributed between the BAFF feed pipeline and the existing works outfall pipeline. Treated water from the BAFF was then returned to the main outfall pipeline where it blended with the BAFF bypass flows before passing to the works outfall.

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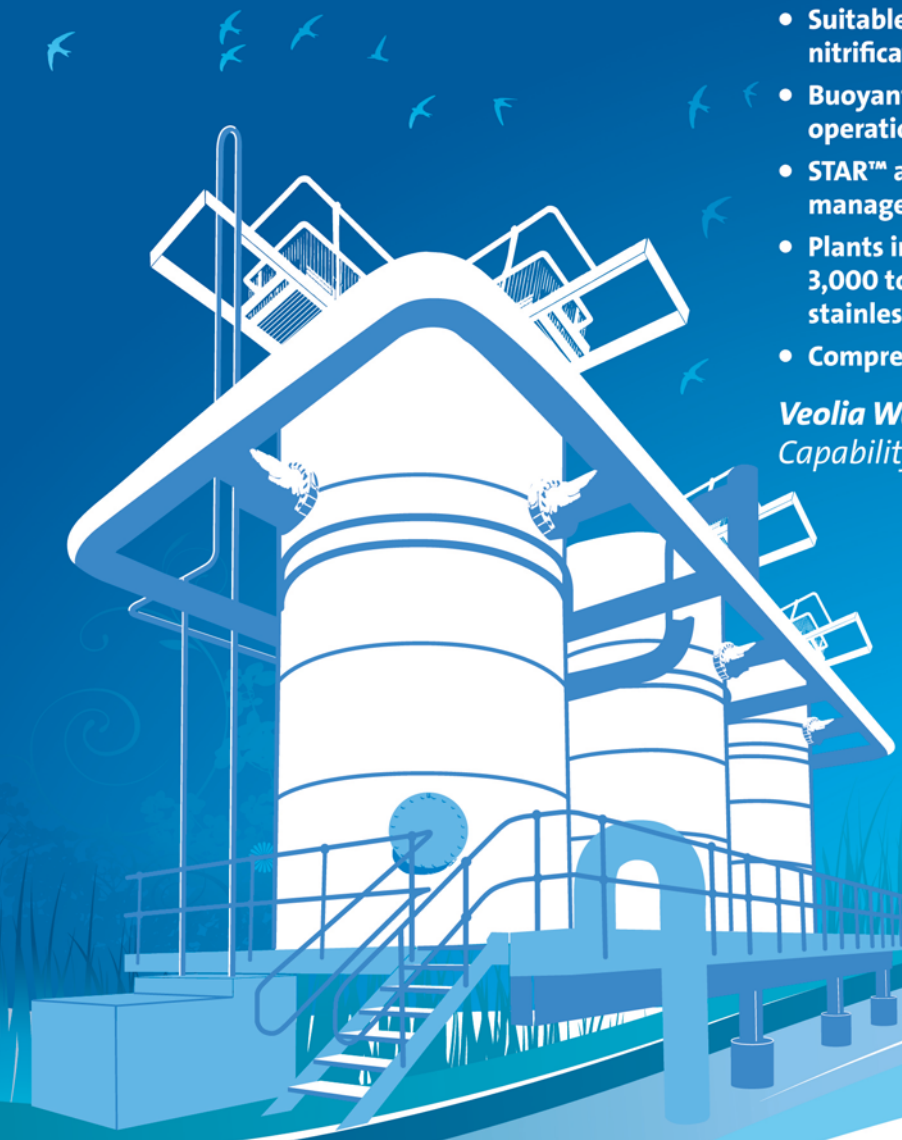

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3rd BAFF feed pipe jack in progress (left) and TBM arriving at upstream reception pit (right) *Courtesy of KMI+*

The BAFF plant comprises 6 cells of 84m^2 each. The Biostyr is a highly compact process, which in a single structure allows for the biodegradation of all carbonaceous and nitrogenous pollution together with clarification of the effluent by filtration through the compact 3m deep buoyant Biostyrene media bed. Through the introduction of compressed air at the base of each cell the media bed sustains the ideal environment for biological nitrification. Each cell is periodically backwashed to remove trapped solids and excess biological growth. This is carried out by gravity using the head of treated water above the filter nozzle floor. This eliminates the requirement for separate clean backwash storage and pumping facilities.

BAFF Feed Pipeline **-** The original proposal for the BAFF feed pipeline was an open cut pipe lay from the BAFF flow control chamber crossing through the site some 140m to the inlet of the new BAFF structure. Knowledge of the site and existing underground services attained from previous work on this site during AMP3 steered the solution towards pipe jacking to avoid the need for extensive service diversions. This removed the safety risks during construction from working around live services and resulted in substantial savings in programme, cost and disruption to the existing treatment process.

The pipeline was 1500mm diameter and 140m long. The launch pit was excavated at approximately mid point in the pipeline, firstly jacking downstream towards the BAFF inlet, then upstream towards the location of the new BAFF flow control chamber. Ground conditions were ideal for the pipe jacking operation. The pipe was driven through moderately firm clay, eased by the injection of bentonite to reduce skin friction and no groundwater was encountered. Upon completion of both drives, a new flow meter chamber was constructed in the launch pit and the area reinstated, leaving little trace of the works.

BAFF Flow Control Chamber **-** The location of the BAFF flow control chamber was dictated by the hydraulic model. Difficulties were encountered in this location buried cabling and the humus tank outlet pipeline which crossed the footprint of this new chamber. This pipeline would ultimately be intercepted to provide the feed to the BAFF. Many months of service diversions followed which were aided by a close working relationship with the United Utilities operators on site prior to commencing the diversion works. Construction began on 4 flow interception chambers to enable over pumping works to divert the final effluent pipeline away from the chamber footprint and to enable the final connection of feed and discharge pipe work to the new chamber. The enabling works for the pipeline interceptions involved 3 phases of over pumping at 1000 litres/sec for a total duration of 12 weeks.

BAFF Structure **-** The BAFF structure is a standard reinforced concrete design comprising 6 Biostyr cells with a common adjoining low level pipe gallery and high level outlet channel, located in a tight space adjacent to the works outfall structure between existing sludge tanks and the site boundary fence. Outside the site boundary fence, the land falls away sharply to a nearby brook. This was the only feasible position for the structure from a hydraulic and whole life cost perspective.

Originally the structure was proposed with a piled foundation, imposed by the process designers Veolia Water Solutions & Technologies (VWS) who specified a stringent tolerance on the flatness of the Biostyr cell nozzle floors. The value engineered

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solution was a ground bearing slab with a perimeter toe. The settlement of the structure was monitored as construction progressed up to the final water test and the flatness of the floors was found to be within acceptable limits.

A tower crane was erected on site to service the BAFF structure and backwash tank. The backwash tank was designed to incorporate the tower crane base. The wall design and sequence of pours was planned to allow for an early M&E start in the pipe gallery to generate programme and cost savings. The main gallery walls and overhead soffit were poured early in the programme to allow for the installation of an overhead gantry crane for the installation of large bore process pipework.

BAFF Backwash Tank - The backwash tank was constructed to the south west of the BAFF structure. The position was dictated by the available working area around the BAFF structure allowing access for construction plant down the temporary haul road and maintaining sufficient space for storing materials and prefabricating reinforcement mats and shuttering. Originally the tank base was designed with a perimeter toe to resist hydrostatic uplift, but would have been impractical logistically due to the close proximity to the sludge tanks. The foundation design was value engineered to eliminate the perimeter toe, proposing a stringent backfilling regime to the backwash tank in that the physical properties of the backfill once placed must mimic that of the surrounding clay subsoil in terms of water content and bulk density. This would exclude groundwater from the vicinity of the tank, therefore hydrostatic uplift pressure would never develop below the base slab. The water content of the clay backfill was controlled using lime stabilisation against a stringent sampling and testing regime.

Centrifuge Selection - Digested sludge was originally dewatered by a plate press which was nearing the end of its operational life.

Additional sludge de-watering capacity was required arising from two main sources, On-site increased production due to tertiary treatment and an Import increase due to the effect of Phosphorous removal at satellite sites.

On the basis of Whole Life Costs and a sludge cake requirement of at least 25% Dry Solids the plate press was replaced with 2 centrifuges.

Two 45m^3/h centrifuges provided a duty /stand-by capacity with the facility for duty assist operation giving additional capacity for "catch-up" in the event of down time, and potential up-rating of an existing Enhanced Enzymic Hydrolyser Plant.

Centrifuge Plant - The plate press was decommissioned and a temporary centrifuge plant was brought to site in the interim whilst the plate press was removed and the centrifuge plant installed. The steel platform which supported the plate press inside the sludge dewatering building was strengthened by the addition of secondary support members and a composite Ribdeck mezzanine floor was constructed to support duty/assist Alfa Laval centrifuges, each treating up to 45 m^3/hr of digested thickened sludge.

Other periphery equipment installed included new centrifuge feed pumps, dedicated sludge cake screw conveyors, a new polyelectrolyte batching and dosing system, a centrate return pumping station with anti-foam dosing and a new wash water booster set.

The control panels for the new equipment were located in a separate kiosk outside the dewatering building.

Brewery Pre-treatment Plant - The works receives industrial effluent from a nearby brewery in the order of 10Ml/day. This effluent requires preliminary biological treatment prior to being passed to the

main works. Due to the aggressive nature of this effluent, the pre-treatment works are experiencing premature degradation of existing assets.

The brewery screens break down on a regular basis causing maintenance issues within the pre-treatment plant from the passing forward of solids to the receiving process tanks. The screening plant refurbishment scope included the replacement of the isolation penstocks, replacement of the screens themselves and the addition of a new washpactor and filtrate return pumping facility. The replacement of the isolation penstocks proved the biggest challenge in this part of the works. The screens structure required to be entirely bypassed to allow access into the channels for this work to be carried out. An optioneering exercise selected a temporary bypass from the buried incoming pumped main direct from the brewery to the screened influent balancing tanks. With the assistance from the brewery utilities manager, the scheme was designed and hydraulically analysed in accordance with the pumping requirements to ensure there was no disruption to the trade effluent discharge capability from the brewery. The bypass was enabled through the valuable assistance given by the United Utilities process operators and the bypass was in operation for a period of 3 weeks to enable the penstocks to be replaced. Following replacement of the penstocks the screens channels were isolated to allow the replacement of the screens and the installation of the new washpactor.

Tishy Well, a small raw sewage pumping station serving local properties was also refurbished as part of the contract. Originally this pumping station passed unscreened sewage directly to the primary tanks, contributing to the cause of blockages throughout the works. Not only were the pumps and control system to be replaced, but a new rising main was to be installed to pass this raw sewage to the brewery inlet screens for solids removal. Whilst the wet well was under refurbishment, the incoming flows were intercepted and over pumped to the main works inlet channel to allow the well to be modified and new pumps installed.

The screened effluent is pumped to 2 biological filters prior to passing to two clarifiers at the end of the pre-treatment process. The desludge regime from these clarifiers was by actuated bellmouths discharging settled sludge to a below ground desludge chamber. The bellmouths, actuators, supporting platform and the concrete chamber have experienced significant decay from H_2S attack. The solution was to replace the bellmouths with dedicated dry well desludge pumps providing a reliable desludge facility and removing the risk of further H_2S corrosion to the concrete structure by fully containing the sludge within the pipework. The enabling works involved interception the sludge draw-off pipework by carrying out modifications inside the adjacent valve chambers to connect suction lines to temporary desludge pumps. The new pumps were successfully installed owing to close client liaison and valuable assistance given by the UU operators in facilitating the necessary plant isolations to facilitate the intricate interfacing.

Conclusion

Through the hard work, dedication and commitment shown by the staff working under KMI+, our subcontractors, suppliers and the Client, the projects were delivered successfully, on time and achieved in excess of 200,000 man hours on site with no reportable accidents. Mutual cooperation between the site team and the Client's operators was the major contributing factor to the successful and smooth interfacing of the new assets into the existing treatment process, particularly on a project of this scale and complexity.

Note: ***The Editor & Publishers thank Will Taylor Engineering Delivery Manager with MWH and Eleanor McFarlane, Assistant Site Manager with KMI+, for preparing the above article.***■