Deephams STW

creating a cleaner, healthier River Lee - Thames Water's £250m flagship project in London is currently one of the largest water projects in the UK

by Alex Robbins

The Deephams STW upgrade project will ensure compliance with the new quality consent set by the Environment Agency (EA) for 1st March 2017 and storm consent by 31 March 2017. The new consent also allows for future growth, taking the capacity of the plant from a population equivalent of 885,000 to 989,000 by 2031. The need for the project is included in the National Policy Statement for Wastewater and has gone through the normal planning process and received planning approval in February 2015, subject to some planning conditions. The new works will consist primarily of replacement effluent streams, including new flow to full treatment pumping station, primary settlement, activated sludge plant (incorporating IFAS), final settlement, tertiary treatment, CHP engines, and new high voltage network.

Creating a cleaner, healthier River Lee. The AMK JV has begun works on the £250m Thames water project at Deephams, London - Courtesy of AMK

Creating a cleaner, healthier River Lee

The Deephams STW upgrade will significantly improve the quality of treated effluent from the sewage works that flows into Salmons Brook, meeting the standards in the environmental permit. In addition to delivering water quality improvements, the upgrade will cater for population growth within the area already served by the works, and improve the infrastructure at the sewage works, much of which is now over 50 years old. It will provide sewage treatment for North London that is sustainable and is able to respond to the challenges of climate change, as well as delivering significant odour reductions from the sewage works.

The project will deliver financial benefits through energy generation by the installation of new CHP engines that eliminate the OPEX need for fuel oil.

These objectives will be achieved by close collaboration between Thames Water (TW) and AECOM Murphy Kier (AMK Joint Venture) working together as one team, with completion of all works expected by the end of August 2018.

Keeping existing works operational

The existing works consists of three sewage treatment streams; A, B and C. Each stream comprises primary settlement tanks (PST), activated sludge plant (ASP) and final settlement tanks (FST). The works upgrade will be phased to maintain treatment and overall compliance during the construction of the new streams. The phasing includes taking individual streams out of service to be decommissioned. The treatment capacity of in-service streams will be enhanced by incorporation of IFAS media, supplied by Hydrok, supporting sessile biomass within each stream.

During the temporary phase, the existing stream A will be taken out of service and treatment will be maintained by existing streams B and C. Initially, Integrated Fixed film Activated Sludge (IFAS) units, will be installed in the existing streams B and C. The installation will be carried out before taking stream A out of service. This will allow the sessile biomass to establish and provide additional treatment capacity. Stream A will continue to be in service while the effluent quality from all streams is monitored.

The performance of two streams (B and C) will be demonstrated over a 28 day period after stream A is taken out of service with operations agreement. The transition to two stream operation will be carried out gradually and an early indication of two stream operation will be achieved by operating Stream B at 50% load. This process will allow decommissioning of stream A and construction of the first phase of the new works.

Following construction and commissioning of the new stream A, and during the intermediate phase, the existing stream B will be taken out of service with treatment being maintained by the new treatment works and existing stream C. Initially, the new element of the treatment works will be commissioned as a conventional activated sludge plant and brought into service. IFAS units with their associated biomass will be gradually transferred from the existing stream B to the new stream A. The existing stream B will remain in service until after all the IFAS units have been transferred.

Sufficient time will be allowed to ensure the biomass has established and acclimatised in the new aeration lanes. Existing Stream B will then be taken out of service, decommissioned and demolished to allow construction of the next phase of the new works.

In the permanent phase, overall treatment will be provided as a single stream replacing existing streams A and B, with new process units comprising fourteen PSTs, 6 (No.) ASPs and 10 (No.) FSTs. Existing Stream C will only be taken out of service after the performance of the new works has been confirmed. The transition to the permanent phase of operation will again be carried out gradually transferring the remaining IFAS. Existing stream C will then be decommissioned and demolished. The existing stream C PSTs will be converted to storm tanks.

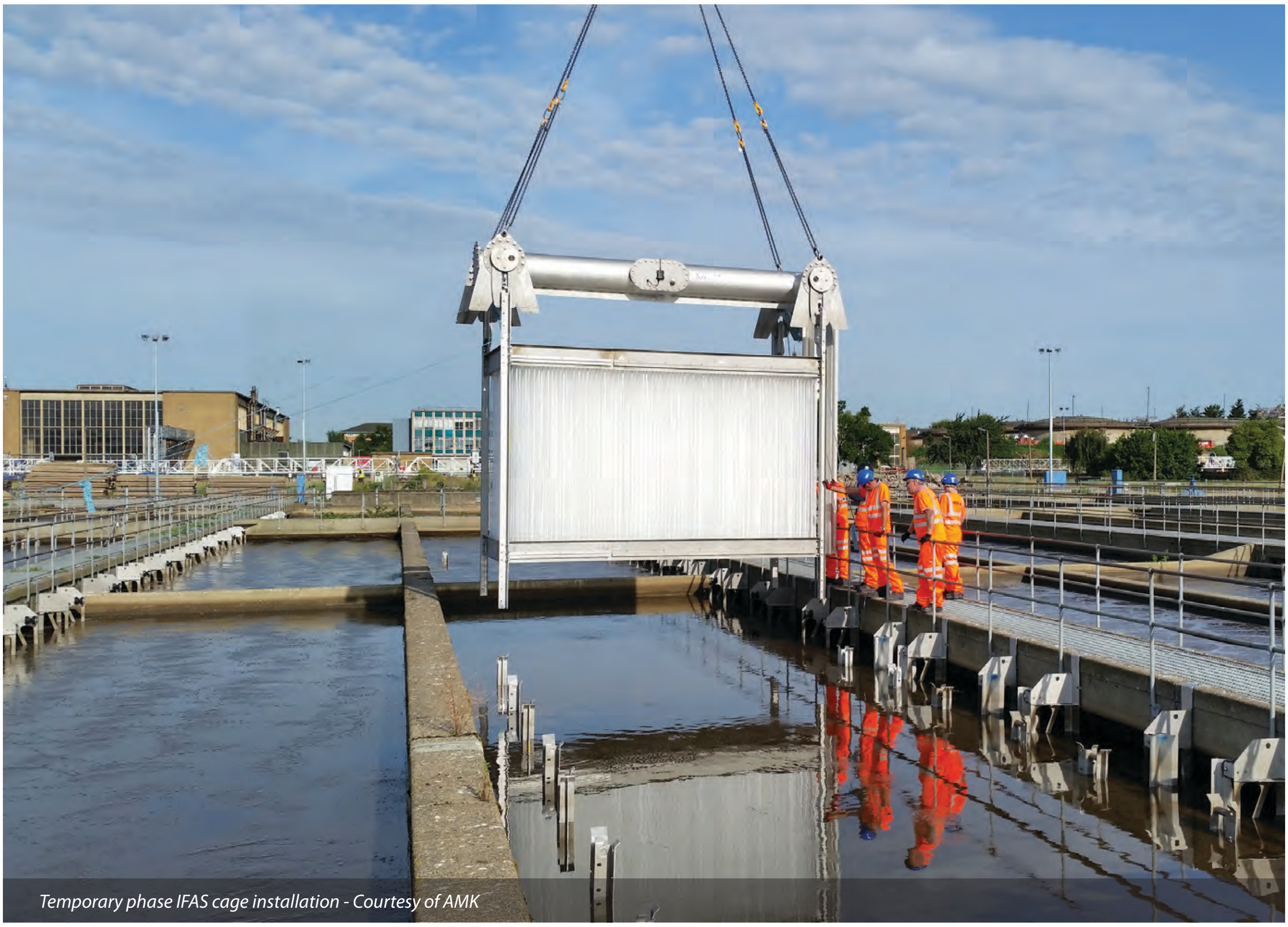
Wastewater characterisation was carried out in May 2014 on the crude sewage, the internal process streams and the final effluent. This information was used in the process modelling of the design at the temporary, intermediate and permanent phases of the project.

Self-cleaning FTFT pumping station

In the permanent works design, after passing through preliminary screening, grit removal and fine screening, sewage will gravitate to a new flow to full treatment (FTFT) pumping station via an existing twin culvert on site, which links the inlet works to the primary settlement tanks. The sewage will pass into a new self-cleaning trench style wet well FTFT pumping station, housing 6 (No.) conventional axial flow pumps in canisters with the flow to full treatment capacity of 6,240l/s.

Two of the six pumps will draw from a sump level during the cleaning operation. The pumps are removed vertically through the canister, which is a quick and non-intrusive procedure. Entry into the wet well will not be necessary, giving health and safety benefits and providing optimum efficiency to minimise whole life cost.

Pumps will discharge via individual bellmouths to a high level concrete chamber and outlet channel above ground, gravitate through a rapid mixing chamber and split two ways to the primary tanks. An elevated channel is necessary to suit the new hydraulic profile through the works to suit final river levels. This type of trench wet well has been adopted from existing AECOM wastewater pumping designs in the USA.



Temporary phase IFAS cage installation - Courtesy of AMK

The wet well is designed to be generally self-cleansing in normal operation and semi-buoyant or non-buoyant debris will be drawn out by the duty pumps. Flow through the trench will promote transfer of debris to the furthest end and heavier particles will settle in a sump where dedicated pumps can be used periodically to remove this debris from the wet well.

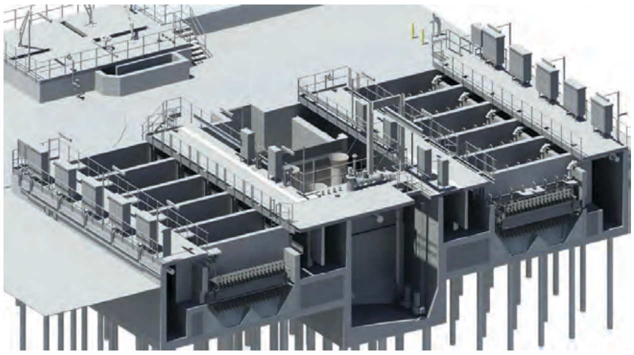
The pumping station will be constructed using in situ reinforced concrete substantially inside an existing primary settlement tank. Some demolition of the existing PST wall and temporary support of adjacent ground will be required. Use of the existing tank will minimise excavation volumes, and also reduce the depth of working in excavations. Part of the well will be excavated below the existing primary settlement tank base and a bearing slab formed in the London Clay.

The wet well will be designed to resist flotation for water level to ground level, but additionally will be constructed using lightweight aggregate in order to limit settlement.

Improved primary settlement to increase biogas yield

After the rapid mixing chamber, ferric sulphate will be added using existing dosing pumps and system and mixed with the sewage before the flow is divided evenly between two banks of 7 (No.) PSTs operating in parallel. Flows will be split evenly between all tanks and will first enter two-stage flocculation chambers fitted with slow-speed vertical mixers to enhance the action of the ferric coagulant. Flow will then travel evenly down the length of the tank and solids will settle to the floors of the tank.

Each tank will be fitted with dual chain and flight combined sludge scraper/scum removal mechanisms. Settled solids will be moved by the scrapers to inlet sludge hoppers. Sludge accumulation will be pumped from the hoppers to the existing primary sludge storage facility via the existing pressure sludge screens.

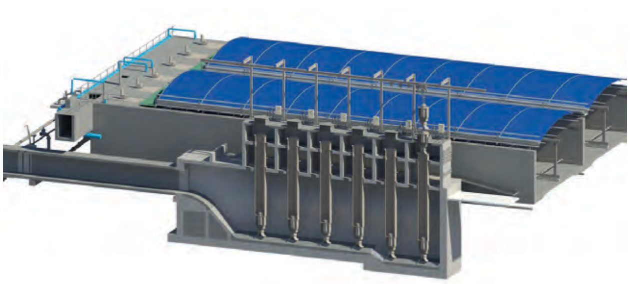


3D model of tertiary treatment plant - Courtesy of AMK

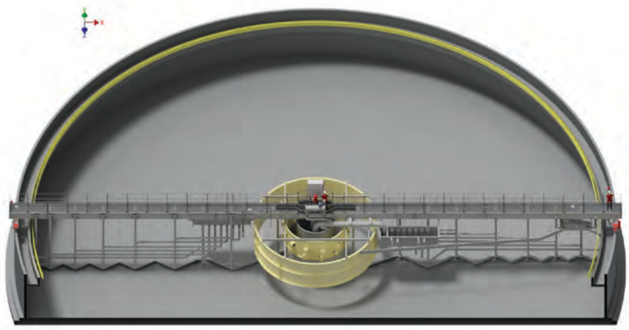
Scum will be removed from the surface of the PSTs by rotary scum tubes and will flow by gravity to a scum buffer tank for each bank of 7 (No.) PSTs.

Scum will then be pumped to the existing primary sludge storage facility via the existing pressure sludge screens. The proposed design accounts for provision of two additional pressure sludge screen units in order to be able to accommodate the anticipated primary sludge production volume of the design.

The two banks of new tanks will be constructed using in situ reinforced concrete. The walls and base will be a monolithic construction. They will be designed to accommodate water to coping level and to resist flotation by the use of self weight with up to two tanks per bank to be empty at any time for maintenance. These walls will have openings in their base to prevent hydrostatic pressure being built up on one side.



3D model cross section of the flow to full treatment (FTFT) pumping station - Courtesy of AMK



A&J Water suction lift final settlement tank scraper Courtesy of AMK

Existing aeration lane demolition - Courtesy of AMK

Deephams STW - Contractors and Process Plant Suppliers	
Main Contractors	AMK (AECOM Murphy Kier) JV
IFAS & Tertiary Treatment Plant	Hydrok UK Ltd
PST Scrapers & FST Scrapers	A&J Water Treatment
CHP	Edina Ltd
Diffusers	Suprafilt
Odour Control Covers	Power Plastics Ltd
MCCs & System Integration	Blackburn Starling & Company Ltd
HV Switchgear	Hawker Siddeley
Capital Maintenance Work	GEL Engineering
Inlet Screens	Ham Baker Ltd
Air Blowers	ABB Sulzer
Canister Pumps	Bedford Pumps Ltd
Submersible Mixers	Xylem Water Solutions
HV Transformers	Winder Power

The inlets to the PSTs were modelled and it was deemed that the variation of flow to each PST will be within ±5% for medium to high flows.

The method for sludge and scum removal from the primary settlement tanks is a chain and flight system. This is to be supplied by FinnChain who have incorporated various new innovations to overcome historical chain and flight issues. Each tank will be served by 2 (No.) 6.5m wide scrapers. The scraper blades are GRP spaced at 5m centres, with rubber blades. The chain mechanism is a non-metallic notched-link chain, and the driving sprocket wheel will be 316 stainless steel. This is fitted with a patented monitoring system on both drive wheels to prevent skipping.

8 (No.) de-sludge pumps will be provided per bank of settlement tanks. These will be rotary lobe type positive displacement pumps,designed to remove up to 1.5% sludge. Inverters will be provided so the pumps can be operated at lower speeds to pump thick sludge of up to 7%.

The construction of new, well-designed, primary settlement tanks installed with reliable sludge and scum collection and removal systems will increase the mass of primary sludge removed at Deephams. Settled sludge will also be removed more swiftly and will arrive at subsequent treatment processes in a much 'fresher' state. Additionally, the implementation of improved chemical dosing to remove phosphorus will further enhance the removal of SS and BOD.

Currently, the sludge remains within the PSTs for prolonged periods because of operational difficulties in removing sludge from the existing tanks. Reduction in sludge storage time before digestion means that methanogenesis is not reached and the maximum amount of volatile organic matter will be available for digestion, thus maximising the generation of biogas. It is expected that the amount of secondary sludge from the new integrated fixed film activated sludge process (IFAS) will be significantly lower than currently produced from the existing activated sludge process.

This is mainly as a result of higher BOD removal in the PSTs so the organic load for biological treatment is lower yielding less waste activated sludge (SAS) but also contributing to the longer sludge age in the new plant which also will produce less SAS. Primary sludge yields more biogas than SAS, and thus the upgraded plant should produce more biogas even at current loadings.

Activated sludge process incorporating IFAS

The new secondary treatment aeration lanes will be constructed within the area currently occupied by aeration lanes for existing Streams A and B, occupying six of the existing eight lanes. The equipment in the redundant half of existing Stream B will be removed.

Each new lane will have a three pass anoxic zone, with each pass fitted with a submersible mixer. Each aeration lane will have 4 (No.) aeration zones. IFAS will be transferred from the temporary phase and positioned in each lane to optimise treatment.

A new blower building will be constructed to house high efficiency high speed turbo blowers to supply air to the new aeration system. Settled sewage from PSTs 1–14 will be mixed with RAS at the outlet of their collective channels. Flow distribution chamber No.1 will distribute flow in equal proportions to the 6 (No.) aeration lanes. Each lane is approximately 106m long x 25m wide x 7m deep. Flow will enter a three pass anoxic zone from the flow distribution chamber FS1. Flow will pass over baffles in the tank before discharging at the outlet end via a full width submerged orifice.

The diffuser density varies down each aeration lane to provide the required amount of air based on oxygen demand per zone with good oxygen transfer efficiency. CFD has been carried out to demonstrate that there is adequate distribution of flow from the anoxic zone into the first aerobic zone. Aeration design is to achieve a sufficient DO in each of the 4 (No.) zones to allow full nitrification. The outlet of the ASP is monitored for ammonia and mixed liquors. Ammonia monitoring will be used to determine a variable DO setpoint to maximise energy savings.

Precast final settlement

All 32 (No.) existing tanks and foundations within Streams A and B will be removed. 10 (No.) circular 45mØ flat bottom tanks will be provided, constructed with precast walls on an in situ reinforced concrete base slab, with incoming mixed liquor and outgoing RAS pipes at the centre. Flow into the tank will be discharged through an energy dissipating inlet (EDI). The new tank walls will be partly above ground and so will be partially backfilled and partially visible.

Final effluent will be collected via an integral inner concrete launder arrangement. The launder will have an adjustable v-notch weir plate. The final effluent launder from each tank will connect via a drop shaft and new pipe to the new FST culvert to the new gravity tertiary treatment plant. Each tank will include a sump and drain connection for pumping out and redistribution to other tanks via the RAS system. RAS will be removed from the FST using a siphon lift full bridge scraper system.

The RAS will gravitate into a central outlet arrangement to a chamber located externally to the FST where the removal rate will be controlled via an actuated bellmouth & flow meter. Scum will be collected by a Pelican arrangement and will be returned with the RAS.

Each tank requires a grid of piles primarily to limit settlement and also resist flotation if a tank is empty. The existing FST tank bases will be largely demolished to facilitate the installation of new piles. The tanks will have an in situ cast reinforced concrete base tied to the grid of piles. The tanks will have a flat base (tank depth 4.3m base to TWL). Precast panels utilising interlocking joints and gaskets with post tensioning tendons will be used for the wall construction.

Returned activated sludge from the final settlement tanks will be drawn off through bellmouth chambers and gravitate to the RAS PS, where it will be pumped to the PST outlet drop shafts of PST Tanks 1-7 and 8-14.

The RAS PS structure will comprise of a common inlet channel feeding into 2 (No.) in situ concrete wet wells. Canister pumps will pump from these wells to high level discharge bellmouths. Flow from these will be collected in a channel where it will pass into a drop shaft and then into a gravity pipe going to the PSTs. Surplus sludge will be pumped to the sludge storage area via a ductile iron pumping main with submersible pumps drawing from both wet wells.

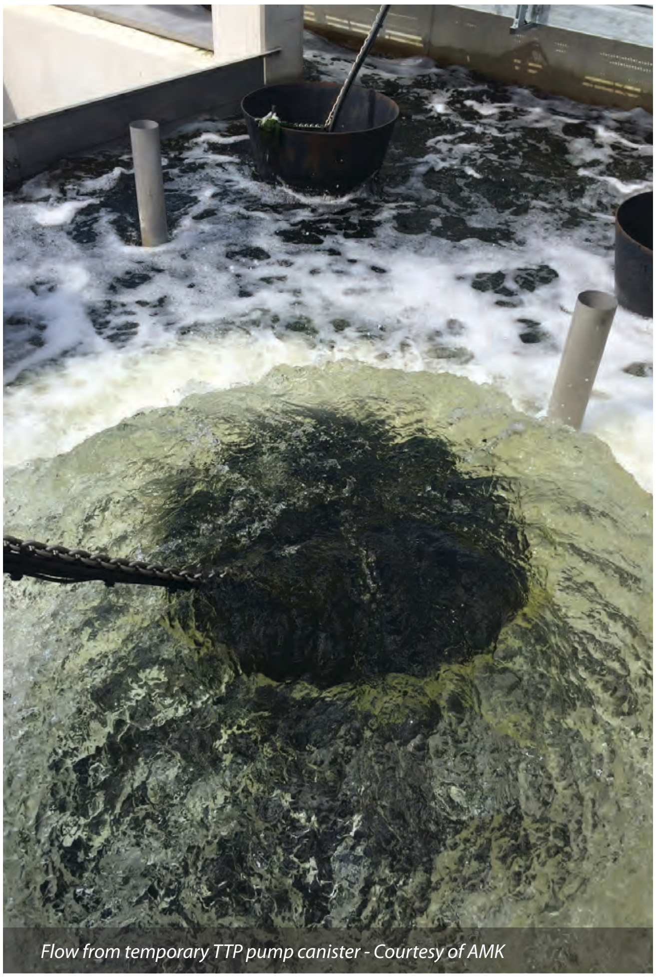
The structure has been designed against flotation. It is intended to construct the entire wet well structure during the phase when stream A is demolished.

Largest Mecana tertiary treatment plant in the UK

The existing works is served by an existing tertiary treatment plant (TTP) which was sized to treat a proportion of the secondary effluent. Up to 50% of FTFT is pumped into the TTP, screened and filtered before being returned to the final effluent culvert and blended with non-treated effluent. New TTP will be constructed in parallel to the existing one to allow all treated flows to receive tertiary filtration before discharge.

The new TTP will form part of the early of works for the scheme to act as mitigation against potential solids carry-over from the existing final settlement tanks during the temporary phase.

One of four TTP pump canister installations - Courtesy of AMK



Flow from temporary TTP pump canister - Courtesy of AMK

The addition of the new TTP will operate together with the existing tertiary treatment plant to provide the capacity to ensure consent is not breached.

The new tertiary treatment plant (TTP), a new 12-unit Mecana pile cloth disc filter plant installation, will be a standalone structure comprising of a low level inlet channel and temporary lift pumping station, and a raised upper level including a distribution chamber, various inlet and outlet flow channels, 2 banks of pile cloth type disc filters (each bank containing 6 (No.) disc filters), overflow chamber, and a dirty back wash tank.

The structure will comprise a reinforced concrete structure base and an inlet weir structure with overflow facility fed from the final settlement tanks. Concrete weirs and a baffle wall will be constructed for even flow distribution.

A physical model has been implemented to study the hydraulic operation of the structure and the results obtained have confirmed that the proposed arrangement will adequately distribute the flow among the filters.

The Mecana disc filters use cloth media filtration (CMF). Cloth media is a deep pile fabric, similar in nature to carpet, with long fibres retained on a solid semi-rigid framing backing material. The fibres in the pile are mircons thick and act independently similar to a granular media filter media, creating a very large surface area for interception of particles as well as having a sieving mechanism.

In contrast to micro-screens which have no depth filtration capability, granular media filters use the pore space for efficient solids capture and interception, similar to the pile cloth fibres, which are cylindrical instead of discrete semi-spherical grains. CMF behaves like a rapid gravity sand filter, in that the initial phase of filtration has a ripening period, a filtering period and then a possible breakthrough. Backwash is controlled to clean the filter cloth before breakthrough occurs.

Flood preventing storm pumping station

The existing storm system has insufficient hydraulic head to discharge the works storm flow (9.98m^3/s) against the design brook flood level of 1 in 100 and climate change. In order to overcome these problems, a stormwater pumping station will be built, with a penstock isolation facility to safeguard the tank capacity.

The existing storm tanks supply and overflow weirs will be raised in order to increase storm storage capacity. The stormwater pumping station will comprise a reinforced concrete culvert type structure, constructed in the existing trapezoidal channel. The main structure will allow free flow of storm tank overflow to the brook, if the outfall channel level is below the storm tank overflow weir level.

As the river level rises, penstocks will close to protect the storm tanks from backflow. Pumps will initiate based on flow and level, to discharge the storm overflow up to a higher level discharge chamber to concrete channels on both sides of the main culvert, which will discharge to the outfall channel beyond the closed penstocks and hence against the design river flood level.

This will be a concrete in situ construction. Silt or soft ground will be excavated for the new pumping station to achieve the necessary bearing capacity. A diversion pipeline will be constructed in advance, in order to provide an alternative route for storm outflow and enable the pumping station to be built in situ without affecting the operation of the works.

The weight of the structure will be sufficient to eliminate flotation with the highest design water level. The footprint fits within the outlet channel and has minimal volume. This eliminates the chance of deposition of debris within the structure.

Energy generation through CHP

The existing CHP units will be replaced with 2 (No.) new CHP generators rated at 1.56MWe and generating at 11kV. They will be connected to the new 11kV switchboard. Each CHP generator will be provided with a waste heat recovery system and the heat generated will be used to generate hot water for existing digester heating circuits.

The design is based on average biogas production of 25,428Nm^3/d. The installation takes into account future expansion for thermal hydrolysis by the addition of third identical CHP engine.

Electrical distribution

The high voltage (HV) distribution network will be substantially revamped to cater for the new process and plant areas. Power will be distributed at 11kV mainly, via local step down transformers, to existing/ retained areas, which operate at 415V. Some parts of the existing 3.3kV distribution network will be retained.

The new HV network will comprise:

- New Main 11kV distribution switchboard.
- CHP 11kV switchboard.
- Local Step-down transformers.

Transformers will be of the MIDEL filled KNAN type. They will be installed outside in purpose-built and bunded transformer pens. The pens will be surrounded by palisade fencing and a double security gate. Where 2 (No.) transformers are installed in twin pens a blast-proof wall will fully separate them.

A total of 4 (No.) new 2.5MVA 11kV diesel powered standby generators will be provided to supplement the 2 (No.) existing 2.5MVA 3.3kV diesel powered standby generators supplied under previous works.

A new PMS system will be provided, designed and configured to monitor and control the HV switchgear associated with both new and retained power generation and distribution plant.

The system will be based on distributed I/O connected via a fibre optic ring. This will provide a more flexible system suitable for future expansion. The system will be monitored and controlled via the new PMS SCADA system with large screen LCD display.

Progress on site

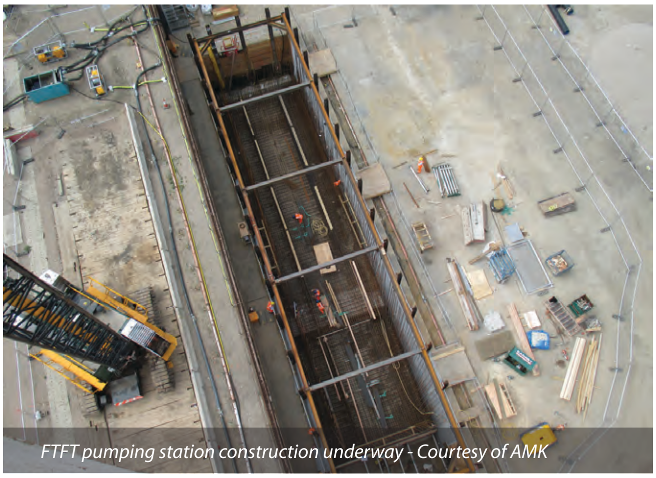
In order to facilitate decommissioning of Stream A and transfer of flows to Streams B & C, AMK undertook a programme of bolstering works to improve the operation of the existing plant, due to the age and state of the existing assets. These works were planned after numerous surveys of the existing assets with ongoing coordination with the Thames Water Operations team.

A full deep clean of the existing assets was undertaken first to remove settled grit and rag which had made its way from the inlet works. These works were coordinated so as not to affect the throughput of sewage, with the project team only having a single asset at a time to work on.

All FSTs were isolated and fully drained then cleaned. Once they were cleaned new weir plates were installed on all 32 (No.) tanks as over time these had suffered differential settlement which ultimately affect the hydraulics of the works. Originally the installation of weirs was to take place from a full birdcage type scaffold as the tanks have a conical bottom. During this process AMK's site supervisors along with their subcontractor A&J Water developed a method of installing the weirs from a pontoon. This resulted in a significant programme reduction for these works as the tanks could be isolated and partially drained and removed the requirement of installing a scaffold. As well as the programme benefits this method also removed numerous health and safety risks.

FTFT pumping station temporary works inside existing PST - Courtesy of AMK

A&J Water installing replacement FST weirs using pontoon Courtesy of AMK



FTFT pumping station construction underway - Courtesy of AMK

Construction nearing completion on the tertiary treatment plant\ Courtesy of AMK

Deephams is a project with world class safety. Above, safety engagement day - Courtesy of AMK

The full scope of works for bolstering were undertaken by AMK and their mechanical subcontractor Gel Engineering who worked from an on-site fabrication shop enabling them to improve production and bring innovative solutions to a number of process related issues; essentially this enabled AMK to return assets to Thames Water Operations in full working order.

These works are now complete and flows have been transferred from Stream A to Streams B & C. This is considered a significant milestone in the project and has been completed on programme.

In addition to the bolstering works AMK has undertaken a considerable amount of site investigation works to enable the construction and design teams to fully plan and coordinate isolation of Stream A and its subsequent decommissioning and demolition. Due to the age of the plant there exists a number of uncharted, redundant and temporary assets in situ. Understanding the complexity of the operational plant and how to remove it from service is paramount to the successful completion of the works.

As part of site establishment works AMK undertook cleaning and demolition of twelve existing digesters to form a site office and storage compound. The scope of works was to isolate and enter each digester, which had been redundant since 1998 and clean them of all contents which consisted of compacted rag and grit.

Once these works were complete the digesters were then demolished and the area built up to 6m above existing ground level, utilising the material gained during demolition works. The work was completed in 30 weeks with 28,000m^3 of material being removed from the digesters and 4,000 tonnes of material being crushed for reuse on site.

The new 12-filter TTP has been constructed and at the time of time writing (July 2015) is currently in its 28 day reliability testing period. In order for the TTP to operate in its temporary phase culvert connections and a pumping chamber were constructed with a series of weirs used to transfer the water from the final effluent culvert to the plant with the remainder of the flow to the existing TTP. The connection works involved complex concrete cutting and confined space entries into the culvert at a series of locations along with innovative temporary works solutions.

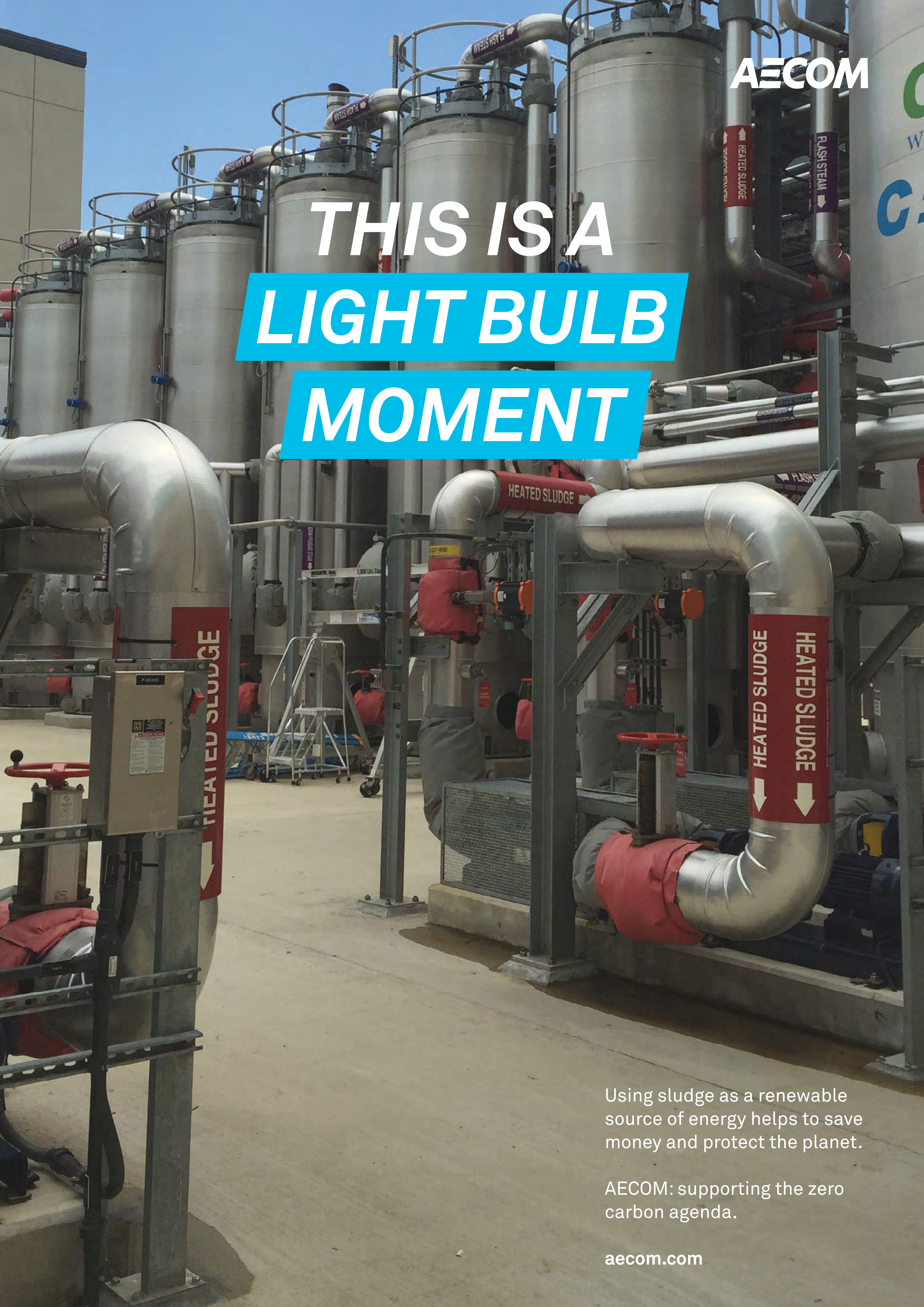
As part of early works AMK has been given opportunity to remove an existing PST from service to start construction of the FTFT pumping station. The early commencement of these works will mitigate programme risk. Once the existing tank was isolated and removed from service AMK was able to demolish part of the East wall to enable full access into the tank.

Once safe access was gained AMK, in conjunction with a ground dewatering specialist design, installed a series of wells to reduce groundwater levels. Once installed temporary works comprising of kingposts were driven 8m into the London Clay.

Excavation works are currently underway with timber lagging being placed within the kingposts. This form of temporary works allows groundwater to enter the excavation into a guttering system to then be pumped out.

Due to the complicated nature of the interfaces on this project it was paramount that Thames Water and AMK work collaboratively to ensure the existing plant remains fully operational throughout the upgrade. Through this integrated method of working demolition works is underway on the existing stream A and progress is on programme.

The editor and publishers would like to thank Alex Robbins, MEICA Project Manager with the AMK JV, for providing the above article for publication.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