Carlisle WwTW

AMP 5 supply and demand upgrade

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Carlisle WwTW lies within the North Cumbria Region of United Utilities Northern Area. The existing site is located in the centre of Carlisle on the banks of the River Eden and serves the city of Carlisle. The treatment works receives domestic sewage, trade flows, and tankered imports, providing secondary treatment using biological filtration prior to discharge to the River Eden. The purpose of the Carlisle WWTW (AMP5 S&D) project is to improve United Utilities wastewater treatment works in order to meet the requirements of the two AMP5 drivers; (i) supply and demand (S&D) driver due to future development in the catchment area, and (ii) ensure the works have hydraulic capacity to meet the existing consent. The regulatory date was 31 March 2015.


Humus tank #06 - Courtesy of KMI

Background

Indigenous sludge from Carlisle and imported sludge from surrounding works is treated at the site where the process employed is liming prior to disposal to agriculture. The consented FTFT (flow to full treatment) is 105Mld and flows in excess of this figure are discharged through storm tanks to the River Eden.

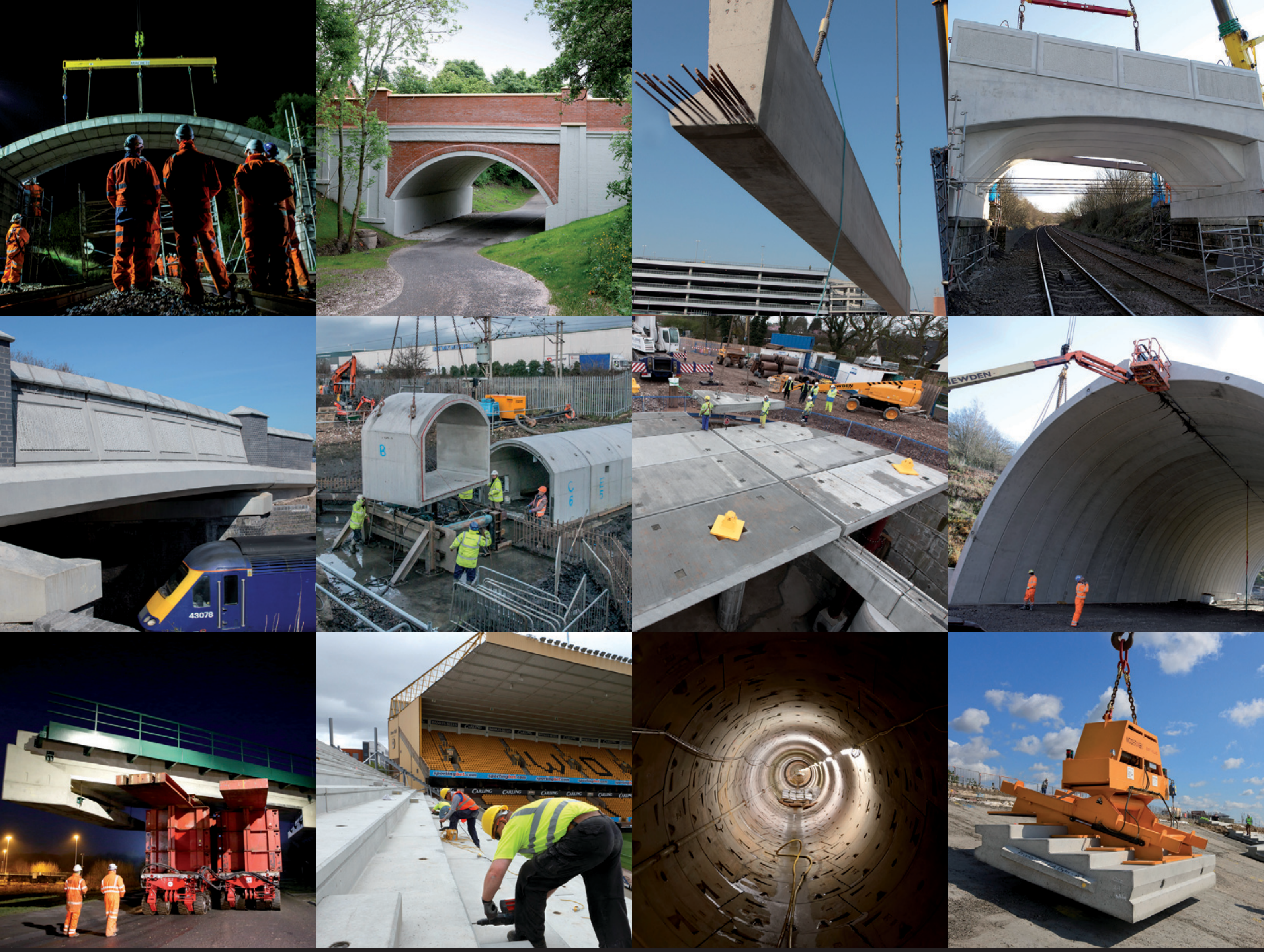
Incoming domestic and trade flows from the catchment are received in a deep underground channel. Imported industrial flows and septage are discharged by tankers in the CSO chamber, downstream of the inlet sample chamber.

Two duty/assist Archimedes screw pumps lift incoming flows and tankered imports to an elevated inlet works comprising 3 (No.) 6mm 2D inlet screens and 2 (No.) detritors. Site drainage is returned back to the inlet upstream of the FTW screw pumps via gravity. Flows in excess of the first stage pumps capacity (2,141l/s) are screened down to 6mm by a storm screen located in the CSO chamber. Screened storm overflows discharged to the River Eden while screenings pass forward to the works. Screen flows up to FTFT are lifted to an elevated PST channel via 2 (No.) duty/assist FTFT screw pumps.

Scope of Works: Civil

- Modifications to primary settling tanks (PST) inlet channel.
- Install inlet baffle to PSTs 4 & 5.
- Modification to existing PST collection chamber weirs from sharp crested to ogee weirs.
- New submersible filter feed pumping station with gantry crane.
- Filter feed distribution chamber.
- 4 (No.) new trickling filters including 480 (No.) precast piles.
- MCC control kiosk.


Site prior to construction - Courtesy of KMI



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Parameter	Value
BOD	30mg/l
SS	45mg/l (95%ile)
NH_4-N	20mg/l (95%ile)
Phosphorous (annual average)	2.5mg/l
Iron	5mg/l (upper tier)
pH	between 6-9 pH units

Table 1: The current final effluent consent

Parameter	Unit	Flow	
		Current Situation (2011)	Future Design Horizon (2031)
Domestic Flows	m^3/d	10,650	13,188
Trade Flows	m^3/d	3,364	5,764
Imported Septage Flows	m^3/d	237	237
Imported Industrial Flows	m^3/d	86	86
Imported WTW Sludge	m^3/d	95	95
Imported WwTW Sludge	m^3/d	272	300
DWF	m^3/d	22,672	30,031
Infiltration	m^3/d	9,437	11,379
Average Flow	m^3/d	31,942	39,040
FTFT	m^3/d	105,000	105,000
Flow to Works (FTW)	m^3/d	184,982	184,982

Table 2: Carlisle WwTW current and future design flows

Parameter	Unit	Value	
		Existing Situation (2012)	Future Design Horizon (2031)
Domestic	PE	78,828	103,788
Tourist	PE	3,090	3,090
Trade	PE	24,990	42,210
Total Domestic + Trade	PE	106,908	149,088

Table 3: Existing and future design population equivalent (at the head of the works excluding industrial imports, septage and imported WwTW and WTW sludge)

Parameter	Unit	Value		
		Existing Situation (2012)		Future Design Horizon (2031)
		Measured	Theoretical	
BOD Load Concentration	kg/d	6,183	6,415	8,945
	mg/l	194	210	229
COD Load Concentration	kg/d	18,073	19,381	27,067
	mg/l	566	634	693
TSS Load Concentration	kg/d	10,117	6,887	10,920(1)
	mg/l	317	226	279

Table 4: Carlisle WwTW existing and future design inlet loads and concentrations (at the head of the works excluding Industrial Imports and Septage; and imported WwTW and WTW sludges)

- Humus tanks distribution chamber.
- 2 (No.) new humus tanks including 72 (No.) 600mm diameter CFA piles.
- New humus sludge/scum draw off chamber.
- Indigenous sludge tank with duct work connecting to new odour plant.
- New indigenous sludge tank air mixing plant and manifold.
- New Indigenous sludge pumping station.
- Sludge valve chamber.
- Wash out chamber.
- New sampling chamber.
- New sewers and associated manholes and ventilation chambers.
- Online pipe replacement of final effluent sewers.
- New access roads, hard standing and associated surface drainage.

Ground remediation

Revision 2.0 of the Carlisle S&D Conformed Scope Book Issued to United Utilities Process Partner - KMI was based on provision of 5 (No.) new biological filters on existing ground between the new sludge project (AMP4) and the existing 28 (No.) works filters.

The filters had an original diameter of 34m, an average media depth of 2.4m, and an average blast furnace slag media volume of 2,179m^3/filter, providing a total new media volume of 10,895m^3.

During site investigations works in early 2013 it was found that a large portion of the site had previously been clay lined sludge lagoons. The legacy material remaining in the sludge lagoons would require removal from site to landfill as it had no engineering properties suitable for construction. In addition, samples of the sludge showed that it contained a number of contaminants classifying this as hazardous waste.

Options to deal with the sludge were:

- ***Option A*** - Disposal off site as hazardous waste (circa £2.5m)
- ***Option B*** - Rationalise the site layout (reduce the number of trickling filters to 4 (No.) larger ones) and stabilise the sludge to a standard that could be utilised within a storage mound (circa £1.2m).

In an attempt to reduce capital expenditure (CAPEX) costs and move construction away from this area of poor subsoil conditions, Option B was chosen as the preferred method by the United Utilities environmental team and KMI site team.

A decision was taken by the United Utilities/KMI project team and design team to revise the biofilters design and provide the same media volume (of 10,895m^3) using 4 (No.) instead of 5 (No.) biological filters. The filter depth remained unchanged, but their diameter was increased to 36.5m, the maximum diameter allowed under United Utilities signature design criteria.

The United Utilities/KMI project team and designers worked closely together to produce a remediation strategy and materials management plans for the project. The stabilisation process involved spreading lime using a specialised lime spreader (between 1% and 5% depending on ground conditions and how wet the material to be stabilised was).

The lime was then rotovated into the sludge material in approx 300mm layers. Time was given for the lime to cook (heating up and drying out the sludge material); once this had taken place the stabilised material was moved into a landscaped mound area and compacted. On completion of stabilising all the sludge material, the landscaped mound was capped off with a geosynthetic liner (GSL) a 400mm layer of as dug material from site and a 200mm layer of imported topsoil.

Benefits

Cost Savings

- Option A: Removal from site of sludge material: £2.5m
- Option B: Stabilisation of sludge material: £1.2m
  £1.3m Saving to Project

Environment & quality

Without the need to remove contaminated sludge material from site to landfill, between 25,000 and 30,000 tonnes of material were prevented from leaving site.

- Saving up to 1500 lorry loads of muck away.
- Saving of fuel and carbon emissions of 1,500 lorries travelling on roads to landfill site.
- Minimise waste generation and avoids using valuable landfill space.

Future Applications

The use of ground stabilisation techniques can also be considered for the following works in the future:

- As backfill to pipe trenches within public highways; suitable as dug material stabilised with lime/cement and tested to highways specification for backfill.
- Poor quality as-dug material stabilised and used as general backfill to structures.
- To limit the off-site disposal of as-dug material where suitable backfill can be stabilised/binded to further enhance the material and prevent the need to bring imported quarry products to site.

Construction methodology and activities

The design philosophy of the new works was to enable 25% of FTFT to be split from the existing biological filters and diverted to the new filters. To enable this, modifications were required to the primary settlement outlet tanks including construction of a new outlet chamber that would supply the side stream works.

The flow split was achieved by modifying the existing outlet weir heights to match the new outlet chamber weir heights to achieve the desired flow split (max 352 l/s). This was a process critical activity with a tolerance of +/- 3mm across the weir heights.

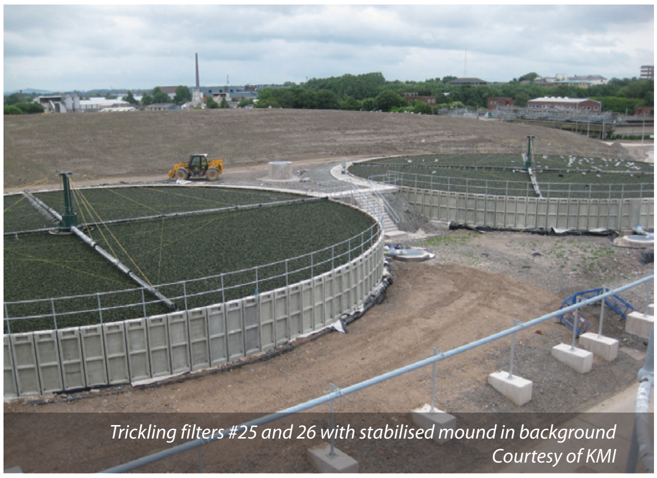
Flows from the new PST outlet chamber then gravitate via a new 800mm diameter ductile iron pipe to the new filter feed pumping station which is fitted with variable speed duty/assist/standby pumps (range 90-352l/s); variable speed pumps were chosen to ensure that the flows to the filters are delivered smoothly with as little fluctuation as possible. Flows are then lifted through a 500mm rising main to the filter distribution chamber; all flows from this point are now gravity fed.

The trickling filter distribution chambers is fed from below and splits the flows using a 4-way weir. Flows from the filters then gravitate through a series of manholes and 800mm diameter pipework to the humus distribution chamber before entering the two new 28m diameter humus tanks. The humus tanks are fitted with Stamford baffles to reduce the amount of suspended solids carry over and improve performance.

Flows then leave the humus tanks and gravitate through new 800mm, 900mm and 1,200mm ductile pipework; flows from the existing works are collected on the way to the new final effluent sampling chamber which required a number of tie ins.

The new final effluent sampling chamber was constructed immediately adjacent to the existing final effluent sampling chamber and then connected by wire saw cutting and casting a 1,200mm connection pipe between the two structures. During the pipe installation works and chamber construction, the total FTFT

Humus tanks #06, 07 and sludge holding tank - Courtesy of KMI



Trickling filters #25 and 26 with stabilised mound in background Courtesy of KMI

Trickling Filters #26, 27 and 28 - Courtesy of KMI

Trickling Filter #25, OCU Ductwork and MCC - Courtesy of KMI had to be over pumped into the final effluent pumping station (FEPS) before discharge to the River Eden. The over pumping works also included a 60l/s recirculation flow to maintain existing filter bed wetting rates during dry weather flows.

Modular construction

During the design phase and in line with United Utilities drivers, it was decided to progress design of the biological filters and humus tanks based on modular or precast construction; as a result both were constructed using precast units.

Use of precast for the biological filters carried less inherent risk due to these works being out of the ground which allowed unobstructed access, in addition to smaller units and the structures not being fully water retaining.

FP McCann fabricated a total of 612 (No.) panels (153 (No.) panels per filter) average size 750mm x 2,500mm x 200mm. These were installed on site by Day Group, with the average installation time per filter being one week to install the panels and ventilation pipes which was a reduction in 3 weeks per filter when compared to in situ construction.

Constructing the humus tanks with precast units (supplied by Carlow Precast) was a much more complex task; these structures are water retaining meaning the joints between the panels had to be formed using an in situ concrete stitch. Each panel came with a pre-formed rebate that included a hydrophilic strip to ensure an adequate water tight seal was formed between each unit and the base slab when poured.

Both tanks are 9.800m deep from coping level to underside of hopper base; this required two 32.5m circular cofferdams to be installed with an additional 16m square cofferdam installed within the circular cofferdam. Due to the proximity of the River Eden and depth of the excavation, significant dewatering was employed outside of the circular cofferdam to reduce the water table to a suitable level during construction.

Each hopper was constructed using 10 (No.) units 3,620mm x 1,620mm with an average weight of 4240kg; the outer walls and launder channel were constructed using 47 (No.) units 5,085mm x 1,474mm with an average weight of 8,000kg, requiring a 135t crawler crane to be used for installation of the units.

The central hopper was constructed first and then tied together with the base pour followed by the wet stitch between each panel before removal of the internal cofferdam. The outer walls were then positioned before cropping the CFA piles to height, fixing the reinforcement, and pouring the 500mm thick base. The outer wall stitches were then poured in 3 phases: underside of launder channel, launder channel pour and up to finished coping level.

Use of modular construction greatly reduced the complexity and the amount of formwork that would have been required to build these structures and provided an excellent finished product. Construction time was reduced thus improving health and safety by minimising workforce exposure to the risks associated with these works.

Current status

The original programmed duration for construction works on site was 136 weeks. To date all critical path activities have been completed and the works are now being commissioned with project in use achieved on 23/02/2015 (5 weeks early) and an expected project completion of 19/10/2015 (23 weeks early).

The editor and publishers would like to thank David Barker, Senior Site Manager with KMI, and Robert Horan, Section Engineer with KMI, for providing the above article for publication.

Humus tank #07 cofferdams

Humus tank #06 precast units lifted in to position

Revised 4 Filter Layout

Carlisle WwTW under construction

All images courtesy of KMI

Carlisle WwTW

Soil Stabilisation Works

Trickling filter #25 under construction

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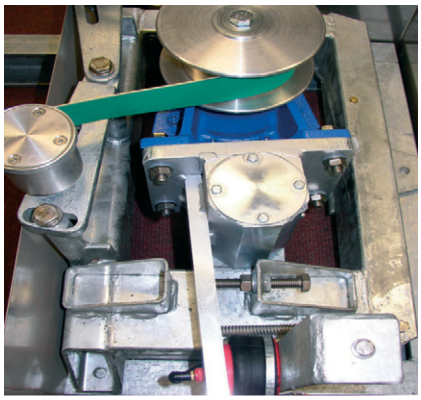

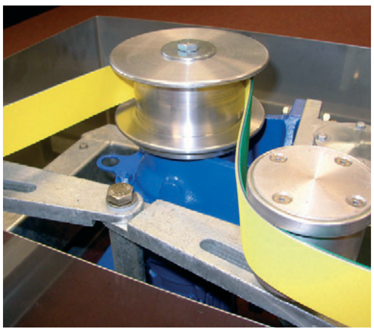

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