Maghaberry WwTW

upgrade to support the local growing economy and meet discharge consent standards

by Simon Younge CEng MIEI

Maghaberry Wastewater Treatment Works (WwTW) serves the Maghaberry area and the local prison in the Lisburn and Castlereagh District Council area, in Co. Antrim, Northern Ireland. The wastewater treatment works is under the control of NI Water and provides primary and secondary treatment. The Works was insufficiently sized to suit the growing local population and the expansion of the prison and part of the site prone to flooding. A replacement works was designed and built on the existing site footprint in a phased manner whilst works remained operational.

Aerial drone photo of completed Maghaberry WwTW - Courtesy of GEDA Construction

Background

NI Water invested £4m to upgrade Maghaberry WwTW which comprised combined sewer overflow, inlet works, storm holding tanks, primary treatment tanks, secondary biological treatment tanks, final settlement humus tanks, sludge holding tanks and associated pumping stations. The new structures were elevated relative to existing to reduce risk of flooding while maintaining gravity in flows to the Works.

The Works overflows discharge into the adjacent Glen River and final effluent gravitates to the River Lagan 2.8km away. A final effluent pump station to lift flows to provide sufficient driving head during periods of high river level was included in the design. The Works would allow future development in the Maghaberry area and meet the required discharge standards.

Project drivers for the scheme

- ***Future growth***: To meet the future growth of the local population and of HMP Maghaberry to 2041, (25-year population growth - 6000 PE).
- ***Water quality discharge compliance***: To meet a Water Order Consent standard and ensure the final effluent are in accordance with Urban Wastewater Treatment Regulations (NI) 2007.
- ***Flexibility in design***: To provide flexibility in the design to permit future extensions/modifications for changes in design flows, loads or consents with simplicity, economics and disruption kept to a minimum.
- ***Construction phase discharge consent standard***: To phase the construction in such a way that the discharge from the Works during construction meets the construction phase discharge consent standard, as provided in the process specification.
- ***Environmental Impact to surroundings***: To minimise visual impact, disruption, noise, air quality (odour) and socioeconomic effects.

Design and build contract

NI Water carried out a competitive tendering procurement process for the design and build of the replacement works. The scheme was awarded to GEDA Construction in May 2017 under NEC 3 ECC Option A basis.

Process and MEICA designs were provided by Water Solutions Ireland. Atkins Ltd provided civil, structural and geotechnical design for the scheme on a Professional Services Contract to GEDA Construction. The hydraulic analysis of the outfall pipe was carried out by Hydraulic Analysis Ltd.

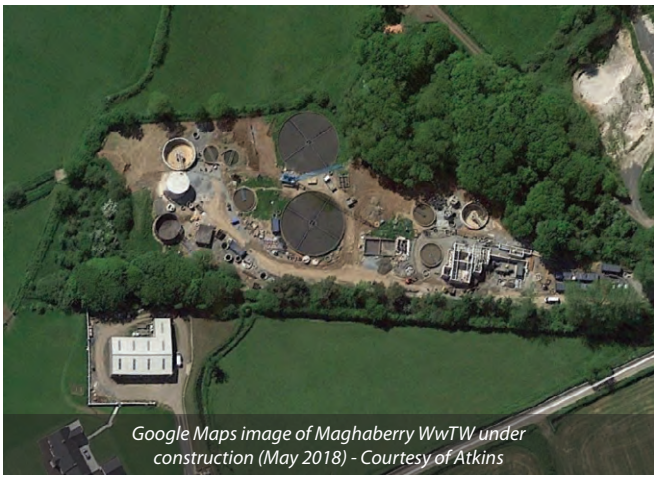
Predicting tomorrow's problems today, to build a brighter, more sustainable future for all.

As one of the UK's leading partners in the water sector, we are proud of the role we play in enabling our clients reduce leakage, optimise operations and manage assets more efficiently to deliver faster, smarter and more reliable customer outcomes.

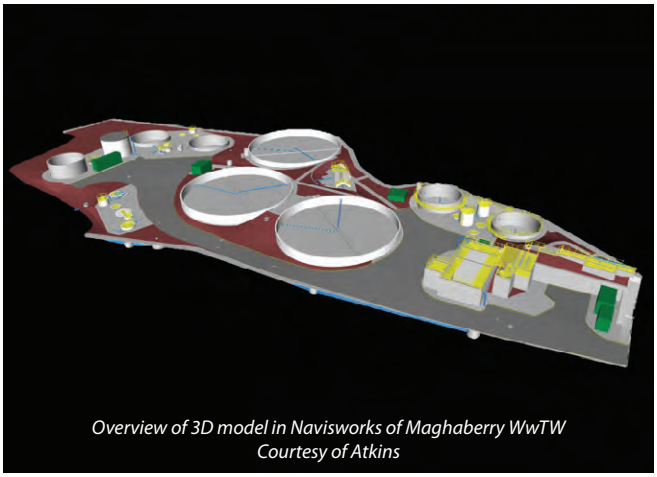
ATKINS

Member of the SNC-Lavalin Group

atkinsglobal.com | snclavalin.com



Google Maps image of Maghaberry WwTW under construction (May 2018) - Courtesy of Atkins



Overview of 3D model in Navisworks of Maghaberry WwTW Courtesy of Atkins

Overview of completed inlet works, storm tank and PST provided Courtesy of GEDA Construction

Final settlement tanks and sludge holding tanks Courtesy of GEDA Construction

Works phasing and civil design

Atkins/GEDA/WSI developed a detailed nine step phasing plan at tender stage to ensure the refurbishment of the Works could be carried out while maintaining the capacity of the existing works. Atkins used AutoCad Revit for the 3D modelling and Navisworks as a viewer and mark-up interface between designer and modellers.

The model assisted GEDA Construction in developing their construction sequencing for the major structures and coordinating positioning of new pipework whilst maintaining operational pipework and services.

The 3D site modelling optimised the storm tank size and location within the site as well as value engineering designs, by removing and reducing the retaining structures required on the site. In addition, the pipework 3D model aided clash detection when carrying out the main design and this was then provided to the Contractor and Client to show the complexity of the pipework and avoidance of clashes with existing elements.

The 3D Model was a great benefit during the design review meetings with Client and Contractor. It complemented the detailed design 2D drawings in understanding access around the site and it allowed Client operators to advise on lifting strategies and considerations for future maintenance of M&E equipment.

The ground conditions were variable on site, with made ground, gravels and sand with high groundwater at lower elevations in the site. Considering the elevated hydraulic profile, relative to existing, the foundation solution for the new structures was excavation/ demolition down to suitable stratum and replacement with compacted engineering fill to formation level. The phasing plans considered the positioning and the construction of new structures to avoid the need for temporary retaining structures for the engineering fill.

Process design

The process/MEICA plant had been selected considering the best available technology/technique (BAT), which provided high efficiencies to provide low OPEX costs for the whole design life of the project.

The new works' hydraulic profile was raised as the existing site was problematic with continuing flooding of the site during storming events. The new inlet CSO was raised 4.0m above existing ground and contained 1 (No.) 6mm motorised horizontal CSO screen at 6 mm, for a rated inflow of 300 l/sec. At the inlet works Formula 'A' passed forward flows of 83.7 l/s using 2 (No.) duty/standby 6mm bi-directional screens with each screen capable of handling flows up to maximum of 175 l/s. The inlet works was also provided with 1 (No.) manually-raked 10mm bar bypass screen and 1 (No.) vortex-type grit removal plant to handle flows of 83.7 l/s.

Between the inlet works and primary treatment tank an attenuation chamber with a capacity of 14m^3 was provided. Overflow from attenuation tanks, flows greater than FFT and less than Formula 'A', flow into a blind storm holding tanks with a capacity of 122m^3.

Overflows greater than this weir into online storm tank with capacity of 243m^3. The overall storage capacity is 365m^3 (equivalent of 2 hours' storage at Formula 'A' minus FFT). The storm tank is fitted with two storm pumps (duty/standby) return of flows to the inlet works upstream of the FFT flume and overflow.

The flow is then treated in two primary treatment/settlement tanks, 9.800m diameter with the design surface loading not exceeding 1.8m^3/m^2/hour with one tank out of service, but still provide the 2 hours' retention at FFT. This is then followed by secondary biological treatment using 3 (No.) percolating filters, each 28m diameter which can treat the 2041 flows and loads. Treated effluent from the

Continually exceeding our Client's expectations

GEDA CONSTRUCTION




Wastewater Treatment Works • Water Treatment Works • Reservoirs • Waste and Clean Water Infrastructure • Rehabilitation Works • Base Maintenance

www.geda.co.uk

percolating filter tanks pass forward to the final settlement humus tanks with final effluent from these tanks discharging to a new final outlet pumping station.

There are 2 (No.) final settlement humus tanks, each 12m diameter and the maximum upward flow velocity through the tanks at FFT is less than 0.75m/hr and provide 2 hours' retention time at maximum FFT flow with both tanks in operation. The tanks are designed to ensure that the surface loading does not exceed 1.5m^3/m^2/hour with one tank out of service. Sludge from the primary and humus tanks, is pumped to the sludge holding tank. The tank is designed for 20 days storage a minimum capacity of 255m^3 and transferred off site for sludge treatment.

Construction management

One of the main construction constraints was the careful phasing of the Works. Safe demolition of existing structures had to take place to obtain space for construction of the new structures. The phasing also had to consider the operation of the Works, as the process element had to continue while all new construction took place to maintain consent discharge. In addition, to this continual liaison with NI Water to ensure that safe access/egress around the site for NI Water staff operations to continue as normal allowing for footfall traffic and large HGV lorries to remove sludge.

The phasing construction sequencing of the Works was broken down into nine phases. The storm tank structure was the first structure to be completed due to it been at the lowest excavation level and then the other structures were constructed sequentially, and where existing structures could be removed.

GEDA worked closely with Atkins at design stage in agreeing construction and sequencing of all structures to ensure all temporary and permanent loading and thermal restraint considerations were accounted in the reinforcement design and detailing.

The storm return pumping station was constructed first followed by the base and walls of the main blind/storm tanks. Sheet piling was completed on either side of the storm tank structure, one side for stabilising the ground along the existing inlet works and the other side was along the main access to the lower section of the site. Five-metre-high reinforced concrete walls were constructed and 'box outs' were provided for any pipe penetrations through the walls – this approach was agreed at the design stage with Atkins and GEDA and saved considerable time on the programme.

Throughout the construction phase, in situ plate bearing tests were carried outs on the substrata for each structure to confirm the ground conditions considered in the geotechnical design and refine the exact excavation and replacement with compacted granular engineering fill required. In addition, GEDA Construction controlled any groundwater encountered to below the foundation level of the excavation and temporary supported existing structures to avoid undermining. When carrying out excavations of each structure site access and space was very restricted and there was no space for stockpiling of material or construction materials. Therefore, all deliveries had to be well organised in advance of delivering to site and bulk excavations were completed and all material removed off site.

Construction of the percolation filters required demolition of 3 (No.) existing tanks in a phased manner and replacement with compacted granular engineering fill to suit new hydraulic profile of the site. The percolation filters had 180m^3 of concrete in each base slab and ongoing liaison with concrete batching plant was required to ensure continuity of concrete to site. The filter bed precast concrete tiles where provided by FP McCann and where relatively light, very strong, and easy to lay compared to traditional clay design and they were designed to maintain all outflow requirements. In addition, only one quarry in Northern Ireland had the correct stone to meet the criteria for filter media for the percolating beds.

Phase 1 demolition
- Demolish existing building

Phase 2 construction items
- Retaining wall at inlet works area
- Inlet works structure and incoming sewer
- Storm tank base slab
- Screening structure, storm and attenuation tank
- Storm tank PS
- Primary settlement tank and associated chambers
- Final settlement tank and associated chambers
- Sludge holding tank
- Site flow meters, sample chambers and pumping stations
- Construct new kiosk at return liquor pumping station

Phase 3 demolition
- Demolish sludge holding tank
- Demolish existing inlet works
- Demolish one existing primary settlement tank
- Demolish final settlement tanks
- Demolish existing storm tank
- Demolish existing pumping station

Phase 3 construction
- Construct new kiosk at inlet works

Phase 4 construction
- Install new booster kiosk
- Construct new primary settlement tank
- Construct new percolating filter
- Construct new percolating filter splitter chamber
- Construct new final settlement tank

Phase 5 demolition
- Demolish remaining existing primary settlement tank
- Demolish primary settlement tank flow splitter
- Demolish existing percolating filter
- Demolish existing final settlement tank

Details of construction phasing plans 1-5 (green denotes construction, red denotes demolition) - Courtesy of Atkins

Maghaberry WwTW: Supply chain - key participants			
Client	NI Water	Pumping station pumps	Xylem Water Solutions
Client's project manager	McAdam Design	Hydraulic analysis of outfall pipe	Hydraulic Analysis Ltd
Main contractor	GEDA Construction	Metalwork	East Sperrin Fabrications
M&E contractor	Water Solutions Ireland (WSI)	Standby generator	A1 Power
Contractor's designer	Atkins Consulting	Replacement controls & MCC, instrumentation & cabling	LMP Controls
Concrete supply	Northstone NI		JC Electrics
Reinforcement steelwork	Walter Watson	Telemetry/SCADA	Northern Ireland Computing
Formwork	Marcor	Groundworks	McMackin Contracts Ltd
Precast concrete products	Acheson & Glover		D Rouslton & Son
Screens, Grit plant & percolating filters	Jacopa	Road surfacing	John Mc Quillan Contracts
Process inlet screens & conveyor	WAM GB Ltd	Specialist filter media stone	Barrick Hill Quarry
Process half-bridge scraper	Victoria Engineering Ltd	Filter bed tiles	FP McCann

Programme

The contract programme outlined the chronological methodology of the Works, to ensure the existing process performance was monitored and managed. The design and construction of the Works was focused on minimising the volume of online works required with staged commissioning of the Works. Throughout construction GEDA ensured no adverse impact upon the existing plant during construction processes, providing on the ground management of all works in relation to the existing plant and its process stream.

The high-risk structures on the critical path were the storm tank and the inlet works and by working closely with Atkins and WSI, GEDA using complex temporary works and PERI formwork (lightweight, durable innovative technopolymer formwork system) time was saved, and the critical programme dates where achieved.

One of the major key milestones for the project was when the new Works could accommodate additional flows from the newly construction wing of the HMP Maghaberry Prison.

This milestone was not just key to Client and Contractor, but all the parties associated with the prison. This key milestone was achieved months in advance of the additional flows.

Key benefits and success factors

The replacement Maghaberry WwTW project, whilst meeting future capacity requirement, also provides a safer more efficient workplace for NI Water Operatives. The layout of the hardstanding areas and footpaths allow improved access to structures and mechanical plant for future maintenance.

The new Works was a pilot BIM Stage 2 project to incorporate 3D modelling across disciplines into design, review and construction phasing. The BIM model had significant benefits for NI Water and the wider team to review and expediate the design process, but highlighted that all disciplines should input into a coordinated federated model to maximise the benefit in use of BIM modelling.

The new Maghaberry Wastewater Treatment Works was completed in December 2019 and brings many benefits to ensure the protection of public health and the environment. The Works supports the local growing economy in the Maghaberry area and enables NI Water to meet increasingly challenging European discharge consent standards.

The editor and publishers thank Simon Younge, Civil Design lead with Atkins, for providing the above article for publication.

The author thanks Paul McElroy, Contracts manager with GEDA Construction, Eamon Magee, Project Director MEICA lead with Water Solutions Ireland, Michael McCartney, Project Manager with McAdam Design, and Derek Eccles, Project Manager with NI Water, for the input and assistance with this case study.

Concrete pour of base slab of hopper - Courtesy of GEDA Construction

Percolation filter concrete pour - Courtesy of GEDA Construction

The completed Maghaberry WwTW - Courtesy of GEDA Construction