Lough Bradan WTW & Carmoney WTW

additional treatment capacity and process improvements

by
Mark Godfrey BEng Hons, CEng, MIET, Bob Rowntree BEng Hons, CEng, MIET and
Bob McGarvey B Eng Hons, CMIMechE

Lough Bradan Water Treatment Works is situated in a rural location 13 miles west of Omagh in Northern Ireland. It is located adjacent to Lough Bradan from where water is pumped into the works. The works currently provides an output of 8 Mld. The project at Lough Bradan will provide additional plant capacity and also reduce the risk of regulatory failure. Carmoney Water Treatment Works is situated in Eglinton (East of Londonderry) in Northern Ireland. Water is pumped up to the works from a river source at a rate of up to 54 Mld. The project at Carmoney will provide a solution to ongoing process issues and to provide a greater level of plant automation.

Carmoney WTW - Existing DAF Cells *Courtesy of AECOM Design Build Ltd*

Background

Originally constructed in the 1990's, Lough Bradan WTW is a strategically important works which currently treats lough water by clarification (Superpulsators) and filtration (RGFs) prior to disinfection and distribution into supply. A WRC thickener based sludge plant treats the waste water prior to discharging to stream. The raw water is highly coloured with normally low turbidity and low alkalinity. The catchment area includes a largely forested area adjacent to Lough Bradan Forest.

Felling of trees close to Lough Bradan results in a deterioration of the raw water, particularly increasing colour and occasionally turbidity and decreasing pH and alkalinity. Limitations on the process have resulted in the maximum plant output being restricted to 8 Mld.

Northern Ireland Water awarded a design and build contract to the joint venture partnership of AECOM Design Build Ltd and Farrans (Construction) Ltd to provide an additional 4.3 Mld capacity to the works and further treatment processes through the addition of new treatment facilities and modification of existing plant. In addition, due to the relatively high organic load following filtration, there is a possibility of a risk of regulatory failure due to trihalomethane (THM) formation following chlorination.

Project Development

The choice of process to meet the requirements of the increased demand of the plant was not defined at the start of the project and as such AECOM were asked to analyse the plant and to develop a number of solutions to address the needs of the project. A period of design development was entered into during which a number of options were identified, developed and priced for consideration.

It was identified during the initial design stage that the existing RGF plant could take the additional 4.3Mld load if a DAF front end clarification stage were to be installed as a sidestream to the Superpulsator plant. Analysis of the RGF filter media by AECOM process specialists however found that, due to the course media size, there would be a risk of turbidity breakthrough from the filters due to the quantity of clarified water typically expected from a DAF unit.

Additionally, in order to reduce the risk of trihalomethane (THM) formation following chlorination it was determined that a GAC plant would need to be installed to treat the total plant throughput of 12.3Mld.

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john.szczupak@aecom.com
nicola.henderson@aecom.com

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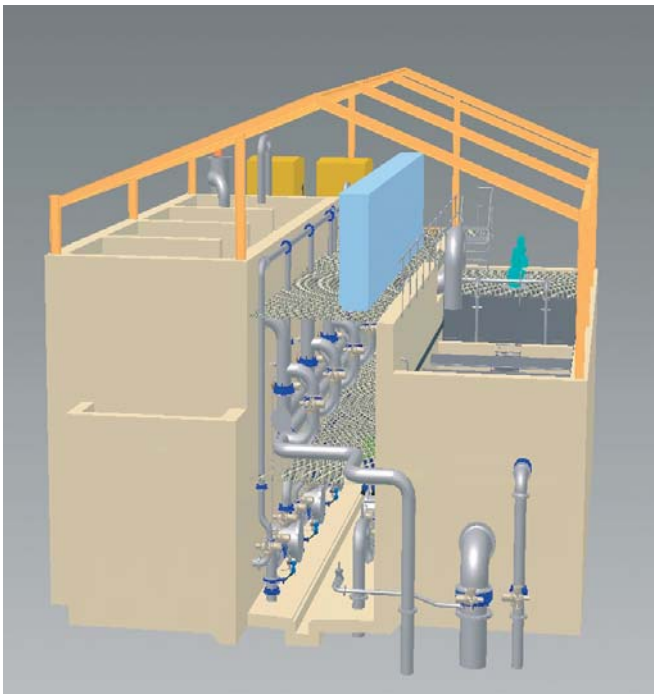
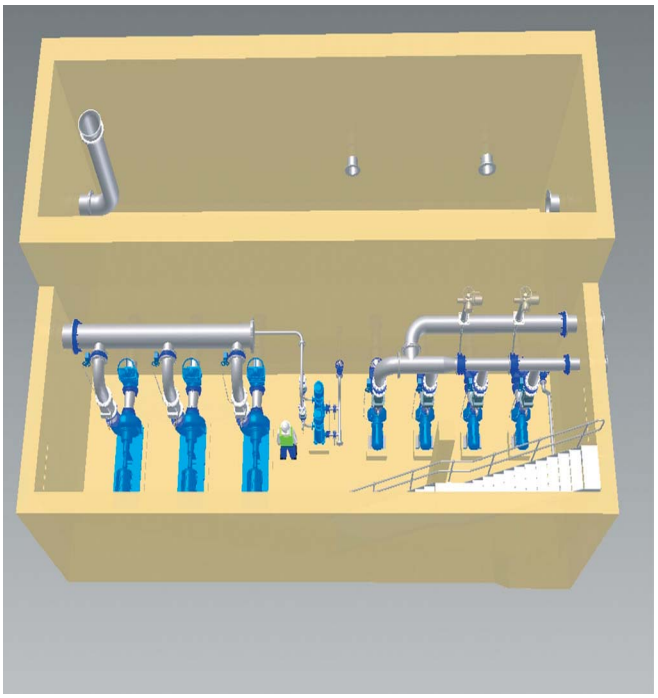
After a period of review a preferred solution was chosen which included;

- Provision of a sidestream plant comprising of a combined clarification and filtration stage – Flofilter *;
- Provision of an interstage sump for the collection and pumping of the filtered water from the new and existing plant;
- Provision of 4 GAC adsorbers to reduce the organic load of the water prior to disinfection and hence reduce the risk of regulatory failure;
- Provision of full backwashing facilities for the flofilter and the GAC adsorbers.

* The Flofilter is a combined DAF and RGF within one compact unit which has the advantage of being capable of being installed within a small footprint area, thereby providing a cost effective solution to clarification and filtration needs. The Flofilter will run in parallel with the existing Superpulsator and RGF plant and the combined output of both plants fed into a new underground 200m³ combined backwash and interstage pumping station sump.



CAD image of Treatment Works building design *Courtesy of AECOM Design Build Ltd*



CAD image of Interstage Pumping Station design *Courtesy of AECOM Design Build Ltd*

Additionally during the initial design stage, the sludge plant was analysed and a revised, simplified process based on lamellas thickening technology was developed. Rather than using the existing process of separating sludges for treatment through different stages of the plant, it was decided to combine all sludge and to provide a more constant feed into two new lamellas. Thickened sludge will be fed into the existing sludge press via an existing holding tank. The existing concentrator would be used as a polishing stage for final supernatant prior to discharge to stream.

Plant Design and Innovation

With the treatment works being located in an area adjacent to Lough Bradan and Lough Bradan Forest available space on site was limited, although a minor extension of the site boundary was unavoidable. The design team was very conscious of providing a compact design in order to reduce plant footprint and associated costs. The use of the AECOM Flofilter technology meant that a reduction in site area when compared to conventional DAF and filter technologies could be achieved.

The new underground 200m³ combined backwash and interstage pumping station sump posed one of the most difficult challenges to the design team. There was a requirement for ten pumps to be fed from the sump including backwash pumps, recycle pumps and interstage pumps. A number of options were explored including the use of submersible and trunk slung pumps. The only cost effective solution that would ensure DWI compliance however was to install centrifugal dry well pumps.

The next challenge to the team was to explore ways of reducing the number of pumps required. With an analysis of backwash requirements and a study of a large number of pumps from various suppliers a set of pumps was found which could satisfy the duties required with the ability to share a common standby pump.

Design Approach

In line with the design philosophy of AECOM Design Build, the new plant was designed in 3D. This gave immediate visibility to the client's design and operation staff without the need for them having to try to visualise the plant from 2D drawings. This approach proved particularly valuable when the core design review was held with NIW. AECOM were able to provide a virtual walkround the plant, inspecting each area in turn. As with most 3D CAD designs, clashes and errors were eliminated at design stage – removing the need for costly rework on site.

Progress

A theory of constraints programme was developed in order to target an early finish. A tough, but reasonable set of targets were developed for the team. Construction work commenced on site in October 2009 on the interstage pumping station. Whilst progress was extremely good in the first months on site, what couldn't have been foreseen was the particularly harsh winter experienced this year.

This impacted directly on the first part of the construction programme. On a number of occasions the three and a half mile rural country road up to the site became completely impassable with no construction traffic able to reach the site. Freezing conditions for days on end resulted in delays to concrete production and concrete pouring.

Despite these harsh conditions however, the team has worked hard during periods of reasonable weather and as such an early finish is still an achievable target with a water into supply date targeted for October 2010.

Site conditions proved less than favourable at times *Courtesy of AECOM Design Build Ltd*

Carmoney WTW Process Improvements

Background

Originally constructed in the early 1990s, Carmoney WTW takes water from a river extraction source and treats it through clarification and filtration stages before disinfection and distribution into supply. The quality of the river water can change significantly. A badly designed clarification stage together with a number of automation issues has resulted in a plant which requires a high level of plant operator involvement.

Northern Ireland Water awarded a design and build contract to the joint venture partnership of AECOM Design Build Ltd and Farrans (Construction) Ltd to undertake a number of process modifications and to replace the majority of the automation system including PLCs and software.

Process Modifications and Solution

Water is pumped from the River Faughan up to the works inlet mixing building over a distance of almost 1 mile at a rate of up to 54Mld. The water is dosed with alum and after ph correction, falls over a 1.5m weir where it is fed to the DAF building and is split into 8 DAF lanes through a splitter chamber and 8 feed pipes of varying lengths. The result of this DAF feed arrangement is that the flocs formed are sheared. In addition the DAFs suffer from uneven flow split. In order to achieve acceptable DAF performance poly is being added all year round to form a floc suitable for removal by flotation.

There are three existing flocculators in each of the DAF cells which are of a gate type. AECOM identified that in order to achieve flocculation and effective mixing, the flocculators need to be run at a speed above which floc shear is caused.

In order to correct these issues, it was decided to remove the first flocculation cell in each DAF stream from service in order to establish a new alum flash mixer chamber and flow distribution channel to allow a more even flow split. The relocation of the alum dosing point means that the floc destruction seen over the weir is eliminated. This will effectively negate the need for any poly dosing under normal operating conditions.

The 2 No. remaining flocculation cells are each being fitted with a high efficiency turbine type mixer to replace the existing gate type mixers. The new mixers will promote floc growth without the excessive impellor speed that can result in floc shear.

New high efficiency DAF nozzles are being fitted, along with new recycle headers to each DAF in order to improve performance. The nozzles will be located in the reaction zone of each DAF cell and

Carmoney Water Treatment Works *Courtesy of AECOM Design Build Ltd*

positioned to give good solids/air contact. The exit velocity from the nozzles is low which causes less floc shear, resulting in improved clarified water quality. Lower required applied air doses also reduce the power requirements thereby resulting in OPEX savings.

The existing aluminium filters, GAC adsorbers and manganese filters all have valves and penstocks which are operated through the use of pneumatic actuators. These actuators have proved to be unreliable over the years. Additionally, the rapid opening and closing of the valves and penstocks results in poor filter control. In order to address these issues, all filter valves and penstocks are being replaced with units equipped with electric actuators.

The lime system suffers from a capacity problem resulting in lime being made up at a higher than normal slurry strength and being fed to dosing points without any maturation time. This results in scale deposition in transfer pipelines and recirculation mains. In order to resolve these issues three maturation vessels are being provided and will be designated for filling, maturing and emptying on a cyclic basis. This will allow the lime a period of over one hour to stabilise prior to distribution. Additionally new higher capacity dosing pumps are being installed in order to allow lime to be made up at a much lower slurry strength.

All of the process modifications have to be undertaken whilst the plant is running.

Automation Modifications

The existing control system is based on a Mitsubishi platform with PLCs distributed around the plant, sitting on a number of Melsecnet B networks. The level of automation provided by the existing control system does not provide NIW with a plant that can be put into fully automatic operation 24 hours a day. The existing PLC architecture also results in a SCADA update time of 3 minutes from an event happening on site.

Analysis of the current system identified in excess of 50 PLCs in various locations around the site. In order to achieve the NIW goal of 24 hour automatic operation there were only two options that could be considered;

- Modify the existing control software to provide the level of automation required together with modifying the PLC architecture;
- Provision of a complete new control system.

The risk and complexity of modifying existing plant control software and PLC architecture resulted in this option being discounted.

A decision was therefore made to provide a complete new control system to overcome the lack of automation and remote SCADA control. The chosen platform for the upgrade was a Siemens S7-400 system consisting of a hot standby PLC located in the main plant control room with remote I/O around the plant linked back to the main PLCs on duplex Profibus utilising fibre copper and fibre interconnections.

An I/O list was developed from analysis of the existing plant P&IDs and interrogation of the existing PLCs together with a survey of all plant on site. With spare I/O, the total I/O count was in excess on 3500.

Since the existing control software was not considered to be suitable, a complete new FDS was developed based on old plant descriptions, P&IDs and operator experience to bring operation of the plant up to modern standards and to provide fully automatic control with remote telemetry monitoring to give the option of unmanned 24 hour operation.

The plant will be moved onto the new control system on a phased basis with both the existing and new control systems running, controlling different parts of the plant. This changeover is particularly difficult and will prove to be a real challenge to the team to keep a live plant operational during this time.

Progress

Construction work commenced on site in January 2010 on the DAF inlet channel, automation modifications are expected to start in September 2010 and completion of the works is expected March 2011.

Project Team

The project team for both the Lough Bradan and Carmoney projects consists of Northern Ireland Water (the client), AECOM Design Build Ltd (process contractor), Farrans (Construction) Ltd (civil contractor) and McAdam Design (civil designer). The projects have a total value of around £7.6 million.

Note: ***The Editor & Publishers thank Mark Godfrey, Project Manager with AECOM Design Build Ltd, Bob Rowntree, Project Manager with Northern Ireland Water for the Carmoney project and Bob McGarvey, Project Manager with Northern Ireland Water for the Lough Braden project, for preparing the above article for publication.***■

One of Carmoney's many switchrooms ***Courtesy of AECOM Design Build Ltd***