Fofanny Water Treatment Works

one of the most unique water treatment works ever built

by
Paul Davison MEng, CEng, MIMechE, MCIWEM, MIWO & Norman Johnson BSc, MICE, CEng.

DRD Water Service in Northern Ireland have just commissioned its most unique water treatment facility ever built – a 52Ml/d works constructed completely underground. The £18m design and build project - the first of its kind in ireland - was undertaken in partnership with Earth Tech Engineering and Farrans (Construction) Ltd. Its forward thinking and environmentally friendly design was centred around the fact that the works is located in the heart of the Mourne Mountains, a designated 'Area of Outstanding Natural Beauty'; part of the Countryside Policy Area and a candidate for National Park status.

Foffany WTW buried in the mountains of Mourne with only the entrance showing *courtesy DRD Water Service Northern Ireland*

Project background

The remit of the Fofanny WTW contract was to construct a new water treatment works to supply some 100,000 consumers up to 52 megalitres per day of potable water to the requirements of the EC Drinking Water Directive 80/778/EEC.

At the time of contract tender, these consumers across much of the southern region of County Down, received their water supply from Fofannybane Water Treatment Works, located in the lower Mournes area on the side of Butter Mountain, overlooking the village of Kilcoo. It was was constructed in the 1960s and subsequently extended on several occasions.

Raw water is supplied to the old Works from three sources, namely Spelga Dam, Fofanny Dam and Lough Island Reavy Reservoir. Spelga and Fofanny waters both gravitate to the works whilst the Lough Island Reavy water is pumped. The Fofannybane works was capable of supplying up to 32 Ml/day.

In order to meet EC Regulations, the existing works would have had to undergo major refurbishment. Also, under Water Service's Water Supply Strategy, it would have required upsizing to provide water to the Annalong and `Kilkeel areas. Due to the difficulties of developing the existing works, in 2000 Water Service took the decision to develop a new site with the intentions of demolishing the old plant.

Locating the new works.

The Mourne area is classified as an Area of Outstanding Natural Beauty, is part of the Countryside Policy Area and is a candidate for National Park status. The local economy is dependent on tourism, and in particular scenic and activity-based tourism. It was, therefore, very important that the design of the new works had the minimum possible impact on the environment.

In siting the new works, Water Service, in association with the expert architectural and environmental engineering consultants,

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Fofanny WTW under construction

photo: courtesy DRD Water Service, Norhern Ireland

considered various locations, taking into account environmental engineering, and economic criteria.

Assessment of the criteria showed that the site most suitable for the new works was on previously disturbed land – which was used for tree cultivation – just north of the man made Fofanny Dam. Records indicated that this area showed no evidence of archaeological features and environmental studies suggested that the flora and fauna in the area demanded no special treatment.

Further consideration of environmental aspects led to a decision to merge the building into the landscape, making it invisible from as many viewpoints as possible.

In April 2003, Earth Tech Farrans were appointed as the preferred bidder for the project. The tender proposal was based on an earth sheltered design for the new water treatment works.

Nature of contract & consultation

Following the appointment of Earth Tech Farrans, the tender design went through a detailed design and development stage. This involved all parties and stakeholders working together under a partnering team ethos, for a period of five months.

At the same time, the Fofanny project management team embarked on a two phase consultation period to inform local councillors, statutory bodies, local interest groups and the general public about plans for the construction of the new works, well in advance of submitting a planning application.

During this consultation phase the design was optimised and developed to take into account, safety, buildability, whole life costing and operational requirements. This team approach enabled all parties to be involved in the initial development period and to 'buy in' to the final solution. This resulted in a more efficient detailed design and procurement phase for the project.

Environmental Management

The detailed Environmental Statement was prepared well in advance of the construction phase and addressed many issues such as ecology, air quality, noise, flora and fauna, archaeology, visual impact, cultural heritage and emissions from the new works.

Environmental specialists were retained throughout the life of the project to provide expert advice and the contractor worked to a specified Environmental Management Plan, as agreed with the Environment and Heritage Service in Northern Ireland.

Water courses

The site chosen for the location of the new works is a highly environmentally sensitive area in that it lies adjacent to the Shimna River - a well respected salmonoid river. Throughout the course of construction steps were taken to protect the local watercourses. This involved the introduction of straw bales and silt fences, specially constructed concrete settlement tanks; utilisation of a 'Siltbuster' - a machine designed to filter and clean water; tarmacked access roads; dedicated no-vehicle access areas; polythene and stoned covered paths and daily collection and analysis of river water.

This site is relatively high in the Mourne Mountains and weather conditions in the second winter were particularly harsh with heavy snow for much of November and December. In an effort to reduce the activity on site and hence ground disturbance during the winter months, the contractors ceased building operations in the area lying closest to the Shimna River. Weekly meetings with all the relevant environmental, council and local heritage bodies helped to ensure that all measures introduced to the site were acceptable and effective.

The Fofanny project management team instigated a detailed survey of the river both during and after construction work. The results from the survey showed that while there had been a very small impact on the river in the area lying adjacent to the works site, there were much greater pressures being exerted on the river from other sources. While the section of the river closest to the site remained a Grade B (good quality),areas much further downstream from the site showed poor results, obtaining only a Grade C at best.

A more recent survey of the river, carried out following completion of all civil construction, has revealed very high numbers in fish and spawning stock - amongst the highest ever recorded - a result welcomed by the project management team and all the stakeholders. involved.

Planting
To ensure a seamless integration of the building, a comprehensive landscaping plan was developed that included planting of indigenous vegetation. The varied landscaping programme involved a unique process known as hydroseeding.

Because, to date, this is the only treatment works in Ireland to be built underground, it was the first time that the process of hydroseeding had been used on such a large scale. Hydroseeding involves the spraying on of seed which has been mixed with a bonding agent to help it to bed. For the Fofanny scheme, landscaping experts *Ecoseeds* collected a variety of indigenous seed species by hand and by other means such as brush and vacuum harvesting. In order to get the seed and soil mix just right, a number of trial panels were planted out in 2004 in locations experiencing similar weather conditions to Fofanny.

The landscaping plans for the roof of the new works, which is approximately one acre in size, also included the planting of 10,000 heathers and other native plants, 4,000 of these were planted out in September 2005 by members of the Fofanny project team, Ecoseeds, volunteers from the Mourne Heritage Trust and local school children. Over time this indigenous random planting will help create an area synonymous with the Mourne Mountains, but already, Water Service's aim of blending the new Fofanny treatment works into the surrounding hillside, is being realised.

Process design innovation
The new works has been cleverly designed to treat water of varying qualities from different sources, namely Spelga Dam, Fofanny Dam and Lough Island Reavy reservoir to the same exacting standards.

The Spelga source is a soft moorland water with high colours, particularly in the winter, and moderate turbidity. The levels of iron and aluminium are above the regulatory levels. Manganese levels are variable with increasing incidence of high spikes. Fofanny Water is similar in nature but the colours are lower. Lough Island Reavy, is much lower in colour but is subject to algal blooms. Cryptosporidium has also been identified as a risk.

The process adopted is a four stage operation, consisting of DAF, rapid gravity filtration, GAC adsorbers and manganese filtration. The location and nature of the design solution will make additions to the process very difficult. Consequently, the process design parameters were agreed to provide a robust solution.

The main processes are as follows
* inlet flash mixing and chemical conditioning by dosing with aluminium sulphate and lime;
* clarification stage comprising five parallel streams of flocculation and dissolved air flotation;
* correction of pH with lime followed by six rapid gravity primary filters for removal of residual aluminium. The filters contain dual media comprising sand and anthracite suspended on a plenum floor fitted with CADAR filter nozzles;
* four granular activated carbon (GAC) adsorbers for removal of taste, odour & reduction in THM precursors;
* pH adjustment with lime and the addition of sodium hypochlorite to oxidise soluble manganese prior to removal by four fast rate sand filters;
* disinfection of treated water is provided from bulk sodium hypochlorite. A final trim dose is provided downstream of the manganese removal filters prior to water going into supply. Orthophosphoric acid is also dosed before the water leaves for plumbo solvency control.

Final water leaving the works flows by gravity to the existing clear water tank at Fofannybane. A variable speed pumping station in the works can deliver up to 8Ml/day to Crocknafeola Service Reservoir which will supply the area of Annalong and Kilkeel.

Clarification of the process sludges removed by the DAF and filter washings is achieved by lamella separation technology. The sludge produced is then pumped to a membrane filter press. Pressed sludge is removed from site for disposal at a licensed landfill site. The supernatant from the separators is treated to meet a stringent solids specification before returning to the head of the works.

The innovative design allows all wash water used in the treatment process to be fully recycled. This means that all water used in the washing of filters and other medium goes back to the head of the works to go through the treatment process again.

Intelligent Motor Control Centre
The works adopts state of the art 'Intelligent Motor Control Centres (MCCs) incorporating the use of intelligent starters where the status of plant drives and instruments throughout the plant are transmitted to the PLC control system via a duplex 'Profibus' DP communications network. Plant status and indications are made available via Human Machine Interface Devices (HMIs) fitted on the ICA section of the MCCCs.

Extensive on-line water quality instrumentation is incorporated into the design to monitor and control the plant at various process stages to allow it to run in automatic operation with minimum operator intervention. Plant status is available on SCADA systems via two PC Hardware terminals located in the plant control room and on the HMI devices at the MCCs. Group and common alarms transfer data to a telemetry station giving remote access and control of the plant.

The new water treatment works was commissioned in late summer and autumn 2005. Water from the works entered supply in December 2005 and it has run continuously without any unplanned interruptions since that date, The works has been treating a combination of Fofanny and Spelga raw water. The quality of the raw and treated water is shown in the following table.

Parameter	**Colour** HAZ	**Turbidity**	**ph**	**Aluminium** Mg/l	**Mn** Mg/l	**Iron** Mg\l
Raw Water	**40-120**	**0.5-10**	**6.5-7.5**	**0.1-0.5**	**0.03-0.08**	**0.1-0.5**
Treated Water	**<5**	**<0.10**	**7.5-8.5**	**<0.10**	**<0.05**	**<0.05**

This demonstrates that the new works is producing water well within EC regulatory requirements,

Because of the high level of confidence in the new plant, the old plant at Fofannybane has been demolished earlier than originally planned to allow construction of additional treated water storage on site. At present, construction of the new reservoir is to programme with forecast completion in October 2006.

The old works consisted of a number of green clad buildings. Demolition of these buildings has removed an eyesore on the landscape and has been much welcomed by the local community and environmental groups.

Continuous improvement
The Fofanny project is one of five water treatment works being built as part of Water Service's Water Quality and Treatment Framework. At the core of the Framework is innovation and best practice, with Water Service working with its supply chain to implement "lean thinking" modern construction techniques to drive out waste in the design, construction and commissioning of water treatment facilities.

To this end the main contractors, Earth Tech Farrans and their suppliers employed the latest construction and programme management initiatives to ensure on-time completion at best value cost. Throughout the course of the project the focus has been on supply chain management, continuity of work and taking forward the lessons learnt from one project to the next.

A unique aspect of this project was that the concept of 'Constraint Management' was used by the Earth Tech Farrans team as a tool to assist completion by the Contract Completion Date. It is based around a revised way of thinking with regard to estimating task duration and allocating the appropriate risk associated with the task or project. The time allowance included in an activity to cover task risk was removed and put into a 'project buffer'. The programme was then updated weekly and a 'project buffer' monitored with appropriate action taken to ensure that a suitable level of buffer was maintained to the end of the project. This technique was successful through close co-operation of the project supply chain and played a pivotal role in the project being completed on time.

Sustainability
The project was constructed using sustainable construction techniques – all spoil from the site was re-used in the landscaping of the area, with no spoil taken off site. This not only meant that the area was restored with native material but it also resulted in the volume of site traffic was greatly reduced - a factor welcomed by local residents.

In terms of design, forward thinking in the layout of Fofanny has resulted in the incorporation of a turbine which will utilise the increased water pressure coming from the Spelga main to recover a small amount of energy. The power produced will account for around 10% of that needed to run the plant.

The plant also allows for complete recycling of all wash water ensuring that no wastage of water occurs.

Communications
From the outset of the design Water Service and their contracting partners embarked on a comprehensive public relations campaign to inform residents, the general public and key stakeholders about the scheme and what it involved.

Not only are the benefits of the new works providing a safe and reliable drinking water resource for present and future generations, but also allows the cessation of the visually unacceptable practice of dumping sludge on the catchment of Spelga.In addition it has allowed Water Service to decommission and remove the existing Fofannybane works, viewed by many as a 'blot on the landscape'.

With a much more sophisticated design, the new works is offering increased flexibility for Water Service - allowing them to treat water to a very high standard from a variety of sources to feed a greater number of consumers.

The building of Fofanny has seen the fusion of innovative engineering skills and sustainable environmental practices to produce a fully integrated, state of the art water treatment facility for the 21st century. ■

Note: *The Editor & Publishers thank Paul Davison, Project Sponsor, Water Service, Northern Ireland, and Norman Johnson, Project Manager, Earth Tech Engineering for producing the above article.*

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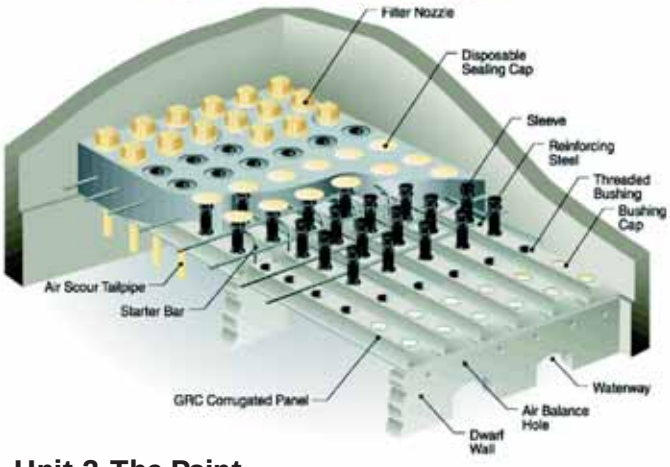
Monolithic Filter Floor



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Anatomy of a Buried Water Treatment Works

the 'inside' story of Fofanny WTW

Designing and building what is effectively a buried structure, presents a number of challenges in addition to those normally encountered during the design of a conventionally sited water treatment works. The location of this site in the mountains of Mourne, Northern Ireland, is an environmentally sensitive area next to the River Shimna with special constraints both for the construction period and final operation of the works. The works was designed to fit in with the natural contours of the site. To ensure that the structure truly blended in with the local landscape native planting was used to cover the roof.

Footprint

The buried structure was expensive - some £18m - it was important to minimise the plan area. This was done by using a compact layout involving, in part, a two tier structure and the careful choice of processes, particularly for the wastewater system.

Operability of the works

The works had to have good operational areas for all routine tasks. Building regulations had to be followed with particular attention being paid to fire escapes. The roof exits had to be designed to operate with a snow loading.

Maintainability of the works

Maintenance access needed special consideration. The option of removing part of the roof to gain access to large items of kit was not possible, so the works was designed to allow removal via a main access filter gallery. The crane facilities were provided along the gallery and were also used for the installation of equipment.

Chemical delivery and storage

Secure off loading and storage facilities were required. A common delivery area with a chemical interceptor tank was provided and the chemical lines were dual contained.

Treatment process

A robust treatment process was required. With an underground structure, any future modification to the plant would be costly and highly undesirable as it would entail disturbing the environment once again, therefore, the process stream was selected to provide long term security to treat raw water into the future.

Works layout

Access to the works is off the Slievebaman Road down the site road out into the valley side to a courtyard. The courtyard was sized to allow chemical delivery tankers to turn. The main plant and personnel access into the works are from the courtyard.

Layout is very compact. Flow through the works is all by gravity. With four treatment stages in the main process there is a hydraulic fall from the inlet channel to the outlet chamber of 8.8m.

To illustrate the steps in the process, general access and relationships between plant areas a 3D Model of the works was prepared. The 3D model proved very valuable as the plant operators were able to understand this much better than engineering general arrangement drawings.

Features of the plant layout are:

* administration areas faced by the courtyard to receive natural light;
* chemical delivery points at courtyard well;
* all chemicals bunded and dosing lines secondary contained;
* chemical storage areas are set at courtyard level;
* turbine generator on the Spelga raw water inlet to supply works;
* the main Daf and primary filters are at a common level with the main control and laboratory.
* all process filter pipework, backwash pumps, service water and air blower located in the main gallery with electric overhead craneage to vehicle loading bay;
* sludge storage and membrane press located together with cake conveyor to a roll on roll off skip at the edge of the courtyard for loading onto wagon;
* full mechanical ventilation and dehumidification system with separate chemical extract system;
* auto start generator with peak lopping facility and fuel storage;
* intelligent MCCs and Profibus communications.

Substructure of the water treatment works and walls were constructed from reinforced concrete. This was founded on grey wacky rock. At the north east corner of the plant the rock surface was deeper than the formation of the structure. In this area concrete strip footings down to the rock head had to be employed to prevent potential differential settlement. The roof of the treatment works is constructed from pre-cast concrete slabs, supported by an in-situ reinforced concrete beam and column matrix. The roof profile slopes to follow the hydraulic gradient of the plant and the natural slope of the valley side.

Roof planted

To integrate the building into the landscape the roof was planted with indigenous vegetation by hydro seeding. Local seeds were harvested by vacuum. In order to get the seed and soil mix right, a number of trial panels were planted out in 2004 in locations experiencing similar weather conditions to Foffany.

As stated in our main article on the Fofanny WTW, the landscaping plans for the roof of the new works, which is approximately one acre in size, also included the planting of 10,000 heathers and other native plants. 4000 of these were planted out in September by members of the Fofanny project team, environmental consultants, volunteers from the Mourne Heritage Trust and local schoolchildren.■

Note: *The Editor & Publishers wish to thank DRD Water Services, Northern Ireland for providing the above detailed information.*