Assynt WTW

new water treatment works for the Inverness region

by
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Assynt WTW is located in the hills above Evanton on the Cromarty Firth approximately 15 miles north of Inverness. It provides water for over 22,000 Scottish Water customers in the Black Isle, Dingwall and Beauly areas. The existing works was constructed in the 1950s and operated as a coagulation-direct filtration works incorporating 28 pressurised Bell filters. As part of Scottish Water's Q&S III Capital Investment Programme quality drivers were identified for turbidity, cryptosporidium and disinfection control to be provided within the build of a new ultrafiltration membrane plant complete with associated chemical dosing systems and a new sludge thickening and storage plant. This new works will significantly improve drinking water quality and will provide for an additional 8,000 people within the catchments.

Membrane treatment plant *Courtesy of Enpure Ltd*

Project Overview

The work undertaken on the project was at three separate sites; Loch Glass raw water intake, the Treatment Works (located adjacent to the existing works), and the Clear Water Tanks. A new intake at Loch Glass was constructed in 2007 in order to significantly improve the raw water quality which in periods of high rainfall had provided a process challenge to the existing works. The new works has been designed to treat waters with a maximum colour of 54 Hazen.

The Loch Glass raw water pumping station provides an additional system pressure at high flowrates to ensure negative pressures are not present in the first section of the main to the works. The two duty / standby transfer pumps installed operate automatically with a gravity bypass depending on the Works required flowrate; with the Loch at its lowest level 10 Mld can gravitate to the Plant. The transfer of raw water to the works is along an existing 5km pipeline.

From Loch Glass through to the existing Clear Water Tanks, Assynt WTW operates as a fully pressurised system utilising the available static head from the Loch. To ensure surge effects are limited to a manageable level, specific control valve timings and shutdown sequences have been developed, along with the installation of a surge vessel and replacement air valves. These construction and operational features were a result of the considerable effort put into surge modelling.

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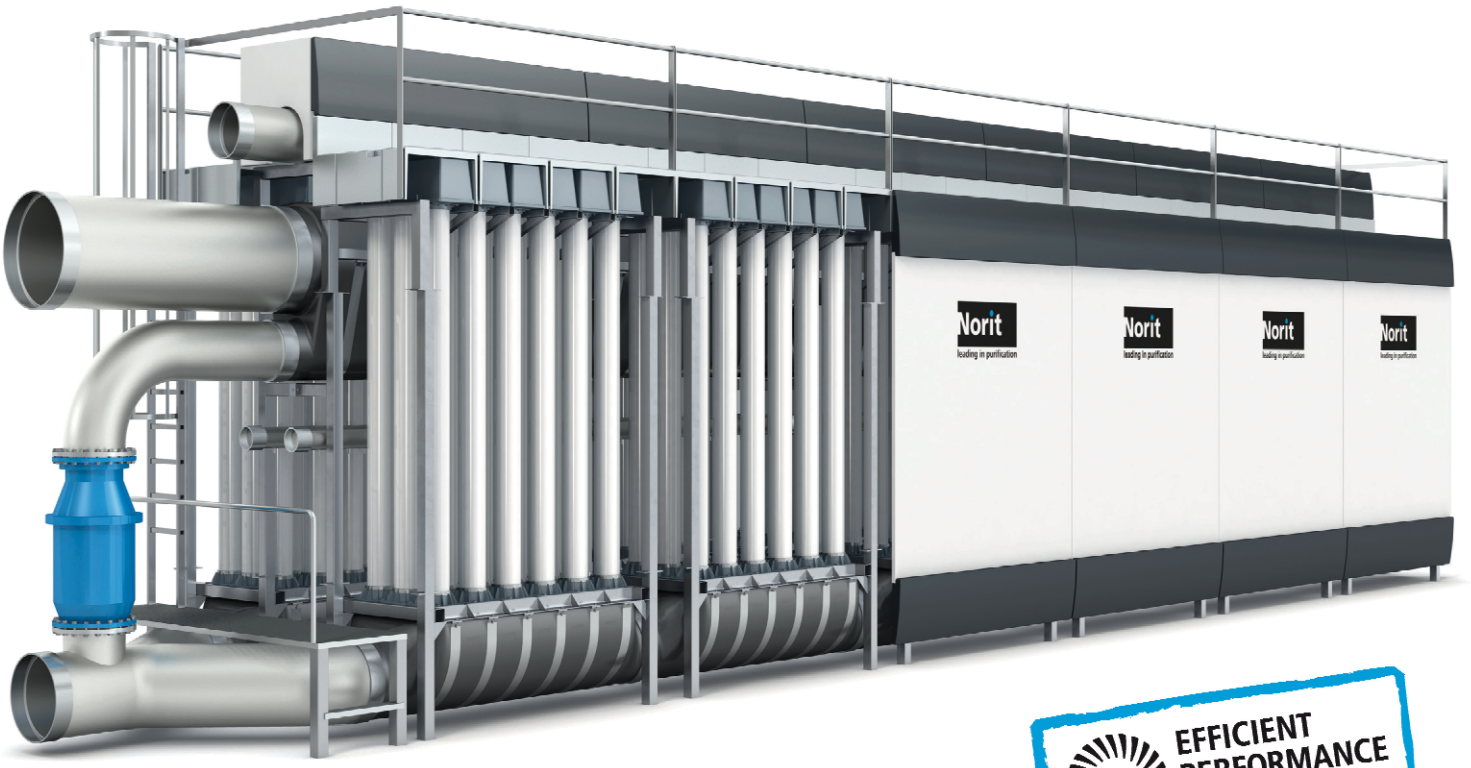

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Control between the three sites is managed by a leased line from both Loch Glass and the clear water tanks to the Treatment Works. The link between Loch Glass and the Plant has a radio back-up system. Control loop timings are optimised for surge management and leased line capabilities.

At the inlet to the main Works the raw water is screened to 3mm using automatically cleaning basket strainers. The system pressure is then boosted by 3 No. horizontal split case centrifugal pumps to drive the required flows through the membrane plant and exit to the clear water tanks.

A new ultra filtration membrane plant with a rated output of 20.5 Ml/day (capable of up to 24.6Ml/day) has been designed and installed by Norit Process Technology BV. The plant will recover up to 99% of the raw water by incorporating primary and secondary membranes operating under the pressure generated from the existing source.

An on site sludge treatment and storage system consisting of two balancing tanks, two sludge thickeners and two sludge storage tanks processes waste water from the membrane plant. Flow is pumped from the balancing tanks using three progressive cavity pumps to the sludge thickeners and dosed with polyelectrolyte to aid treatment. Supernatant from the thickeners gravitates to the existing water course, and the thickened sludge is pumped to external storage tanks for tankering off site.

Flow and level control has been added to the existing three clear water tanks to enable a fully integrated works with throughput matched to demand determined by changing levels in the three storage tanks. These improvements have given rise to increased operational flexibility of network management by Scottish Water.

Approval was given for construction of the new works in April 2008 with an estimated cost of £17.2 M. Scottish Water Solutions awarded the Design and Build contract to MEJV (Morrison Enpure Joint Venture) in May 2008 for the early design and membrane procurement with a start on site in August 2008.

Membrane Treatment

The ultrafiltration membrane system is based on Norit BV's X-Flow hollow fibre membrane technology built up of seven primary skids, and three secondary skids designed to treat primary concentrate. Each primary skid has eleven installed membrane housings within which are installed up to four membrane modules; with a vacant position to facilitate 9% future expansion. In normal operation six primary skids are online with one standby. The chemically conditioned raw water is distributed evenly across the online primary ultrafiltration units, with flow balanced using flow meters and control valves.

The membrane modules are enclosed in a standard 200mm housing. Each module contains a series of membrane fibres that run horizontally in the module assembly, each membrane has an average pore size of 0.025 / 0.028 microns. The membrane modules are connected by means of an intricate module interior complete with bypass arrangement to facilitate backwash and CEB waste. Interconnecting pipework between housings provides a parallel formation within the skid mounted assembly.

Prior to the membranes, raw water is pH adjusted with lime, conditioned with Polyaluminium Chloride, and pre treated by means of 300 micron automatically cleaning wedge wire strainers. Permeate from the membrane plant is dosed with Sodium Hypochlorite and Ammonium Sulphate for disinfection and chloramination, with both chemical doses being control by online

Sludge thickener *Courtesy of Enpure Ltd*

High lift pumping station *Courtesy of Enpure Ltd*

Membrane banks *Courtesy of Enpure Ltd*

chlorine monitors. Final water is also dosed with Orthophosphoric Acid prior to the clear water tanks this being another quality driver for lead as part of the new build. The plant is designed to achieve a turbidity of less than 0.1NTU, colour 5 Hazen, and a minimum 4 log reduction in cryptosporidium removal.

Membrane Cleaning Process

The membranes are cleaned on a regular basis by means of backwashes and chemically enhanced backwashes, for this purpose four chemical dosing sets are installed for Sodium Hypochlorite, Sulphuric Acid, Sodium Bisulphite and Sodium Hydroxide.

During the filtration process, the feed side of the membranes will collect the particulates that cannot pass through the membrane pores. This build up of particulate matter reduces the rate at which the feed can pass through the membrane and thus reduce the filtrate flow necessitating an automatic backwash which is initiated by the rising differential membrane pressure. During backwash, material accumulated on the surface of the membrane is removed by washing with permeate drawn from the membrane plant and stored in a separate holding tank. The backwash waste is discharged to the washwater balancing tanks for subsequent treatment and storage.

Chemical cleaning of the membranes using the Chemically Enhanced Backwash (CEB) is used to remove any organic and inorganic foulants from the membranes that may not be removed by backwashing. The plant control system will determine when a CEB is required which involves a short soaking period of the membranes of typically 5 to 10 minutes followed by rinse to the neutralisation tank in a sequence designed to remove all traces of cleaning chemicals from the unit. The spent chemical solutions are neutralised before discharge as per the backwash waste.

Plant Control

The membrane plant and other process units have their own dedicated control systems which monitor individual plant performance and initiate the necessary control sequences for operation. Access to the plant control for configuration and diagnostics is done via HMIs within the respective ICA sections of the 4 No motor control centres with inter communication between the plant PLCs. Telemetry connections for hardwired and derived analogue and digital signals are provided by means of outstations installed within the operational areas both on and off the site. SCADA stations are installed in the main control room.

Civil Works

The main treatment area was a sloping forested site which was cleared of timber and sold for processing, all roots and brash were mulched on site and stored in bunds for re-use in landscaping at the end of the project. A cut and fill operation was used on site to create a platform for the main building (62.5m x 21m x 9.3m high) and ancillary plant thus removing the need to dispose of surplus material off site and minimised imports of structural fill.

The main building basement, required to accommodate pipework and services supplying the process units, and ground slab was constructed with in-situ concrete incorporating five concrete tanks at ground level, these were constructed over the winter with low temperatures causing delay to the concrete works. The building structure consisted of a steel portal frame with profiled sheet clad roof and walls and which housed the ultrafiltration membrane plant, chemical storage and dosing systems, MCC room, sludge thickeners, and an administration block incorporating a laboratory, control room, kitchen and workshop. Outside the main building are two washwater balancing tanks, two sludge holding tanks, sludge pump kiosk and a booster pumping station building.

There was a very tight construction programme required to complete the building and provide access for the M&E installation. Connections were required to the existing raw water pipeline and treated water pipe, this involved night time shut downs of the existing works. Contact pipework was laid throughout the site mainly 500mm diameter ductile iron with 200m of 1200mm diameter steel pipework. The inlet contact pipe provided for coagulation and pH correction and the chlorine contact pipe provided for disinfection prior to the clear water tanks. Below ground waste tanks were installed to cater for chemical drains and spills.

To accommodate the new plant a new substation and power supply has been installed by the regional utility provider. A standby generator has also been installed to provide main works emergency power.

The Loch Glass pumping station consisted of a large insitu concrete buried chamber 14m x 11m which involved a large open cut excavation approximately 6m deep between the River Glass, the Loch Glass dam and a tributary stream. Soil nailing was utilised to reinforce the sides of the excavation and extensive dewatering was required. The Reservoir Engineer as well as SEPA had to approve the operation due to the proximity of the dam structure and the watercourses. Tie ins were made at two points to the existing raw water pipe which required shut downs of the existing works. Access to this site was problematic with heavy snow and ice often blocking the two km long forest access track.

The Clear Water Tanks located approximately one km from the main site required additional telemetry, new power supply and the installation of actuated valves on the inlet pipework which necessitated numerous shutdowns of the existing plant. Access to this site was severely hampered by the snow and ice during late January / early February 2010.

Progress

Very good progress was made during the summer of 2008 on the civil construction and the treatment building was completed by April 2009 to enable ME&I installation to commence. The original construction programme was due to be complete in October 2009, but due to additional works added to the project civil works continued into 2010 through the coldest winter in recent memory. Due to the elevated position of the site and narrow access roads access, to the site was severely hampered on numerous occasions by heavy snow and ice.

The plant commenced its performance test in April 2010 slightly later than the planned completion at the end of March 2010. The existing works flow of 15 Ml/day had to be maintained during construction which meant that the new works could only be commissioned on a reduced flow of up to 8 Ml/day. On successful completion of commissioning tests the new plant was put into supply in early April 2010 at full works flow of 18 Ml/day.

The current outturn cost of the project is £17.6 M which is slightly more that the original forecast of £17.2 M despite the inclusion of a raw water booster pump station (circa £800k). Many of the risks associated in terms of commissioning discharges and consenting issues were successfully dealt with by the team and did not materialise.

The project has achieved all of its targets in terms of cost, timescales and in striving to maintain a very high level of Health and Safety and Environmental standards was awarded 5 Star status by Morrison – the only site in Scotland to achieve this. The project won a National Bronze award as part of the Considerate Constructors Scheme and is currently undergoing assessment for a CEEQUAL award.

Note: ***The Editor & Publishers thank Glyn Lloyd, Project Manager with Scottish Water Solutions, John Scott, Project Manager with Morrison Construction Ltd, Alex Robbins, Project Engineer with Enpure Ltd and Trevor Farrow, Project Manager with Enpure Ltd, for providing the above article.***■