Falmouth STW

nitrogen removal scheme to protect the marine habitat in the River Fal

by Chris Hatton MEng CEng MICE

Falmouth is an important port on the south coast of Cornwall. Historically, much of the town's commerce was associated with the sea. This remains important to the town today and has been supplemented in recent years with the expansion of the university college and the tourist industry. The Falmouth Sewage Treatment Works (STW) serves a population equivalent (PE) of 43,000. In 2009, construction started on a major £4m upgrade of the works to secure its compliance with a new total nitrogen (N) consent imposed by the Environment Agency (EA).

Aerial view of the site at the commencement of the scheme *Courtesy of South West Water*

The consent

The STW discharges secondary treated effluent into the Fal Estuary (Carrick Roads) and was constructed in two phases – the first in 1997 and the second in 2000. In 2007, the EA applied an additional total N consent of 15mg/l on an annual average basis to the site to protect the marine habitat in the River Fal. The area immediately to the east of the STW forms part of the Fal and Helford Special Area of Conservation (SAC) and is, therefore, given special protection under the European Union's Habitats Directive. Although the existing treatment process removed some nitrogen, further process stages were required to ensure that the effluent met the total nitrogen standard applied.

The STW site is directly adjacent to the Fal estuary, as is much of the catchment sewerage, and both suffer badly from saline infiltration. Up to 30% of the flow entering the site comprises seawater on the highest spring tides. The consent also applies limits to the allowable discharge rate depending on the state of the tide, limiting the flow through the works on an incoming tide to 30l/s. Flows above this figure arriving from the catchment are stored in a tunnel upstream of the inlet pumping station and are treated and discharged on an outgoing tide to limit the amount of effluent carried back up into the estuary. Following a long period of high flows, solids accumulating in the tunnel may be discharged as a shock load when the tunnel is eventually drained down, which has historically made Falmouth a challenging site to operate. The maximum flow to full treatment is 259l/s.

In order to model these flow and salinity fluctuations and their effect on the works, a dynamic computer simulation of the works was constructed using the Hydromantis GPS-X model. This allowed various load conditions, temperatures and operational strategies to be tested in order to optimise the works and ensure achievement of the annual nitrogen discharge standard.

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Process selection for nitrogen removal

There were a wide range of methods by which the new total N consent could be achieved which were divided into two categories:

- Enhancement of nitrification in the existing aeration tanks followed by denitrification under anoxic conditions.
- Additional works downstream from the final settlement tanks (FSTs) to achieve both nitrification (oxidation of ammonium compounds to nitrite and nitrate) and denitrification requiring a supplementary carbon source such as methanol.

Process selection was heavily geared towards achieving a robust sustainable solution that maximised the natural purification capacity of the wastewater, without introducing significant additional running costs. Through an assessment of key criteria affecting the project, including operating costs, land-take, planning issues and capital costs, enhancement of nitrification in the aeration tanks by installation of a 25m diameter primary settlement tank (PST) was selected.

The original plant design did not require oxidation of ammonia in the aeration tanks to meet the site's original consent. The increased oxygen demand required for nitrification to meet the new total N consent was compensated by the reduced organic load applied to the aeration tanks, achieved by settlement of BOD and suspended solids in the new primary tank. The advantage of this arrangement was that the pollutant load is reduced to a level that requires no major enhancements to the existing oxygen transfer system. Some minor modifications to the aeration system were undertaken to reduce the effect of vertical circulation patterns in the deep aeration tanks and to improve the oxygen transfer capacity without replacement of the existing blowers.

Primary treatment also buffered the shock loads, particularly of solids, previously experienced on the works when the tunnel was drained down after a prolonged period of high flows.

To achieve overall removal of nitrogen, pre-denitrification in an enlarged anoxic tank upstream from the aeration tanks was also provided. This anoxic zone has been 'wrapped' around the new primary tank to form an annulus structure, removing the need for a separate tank, and further reducing piling and construction costs.

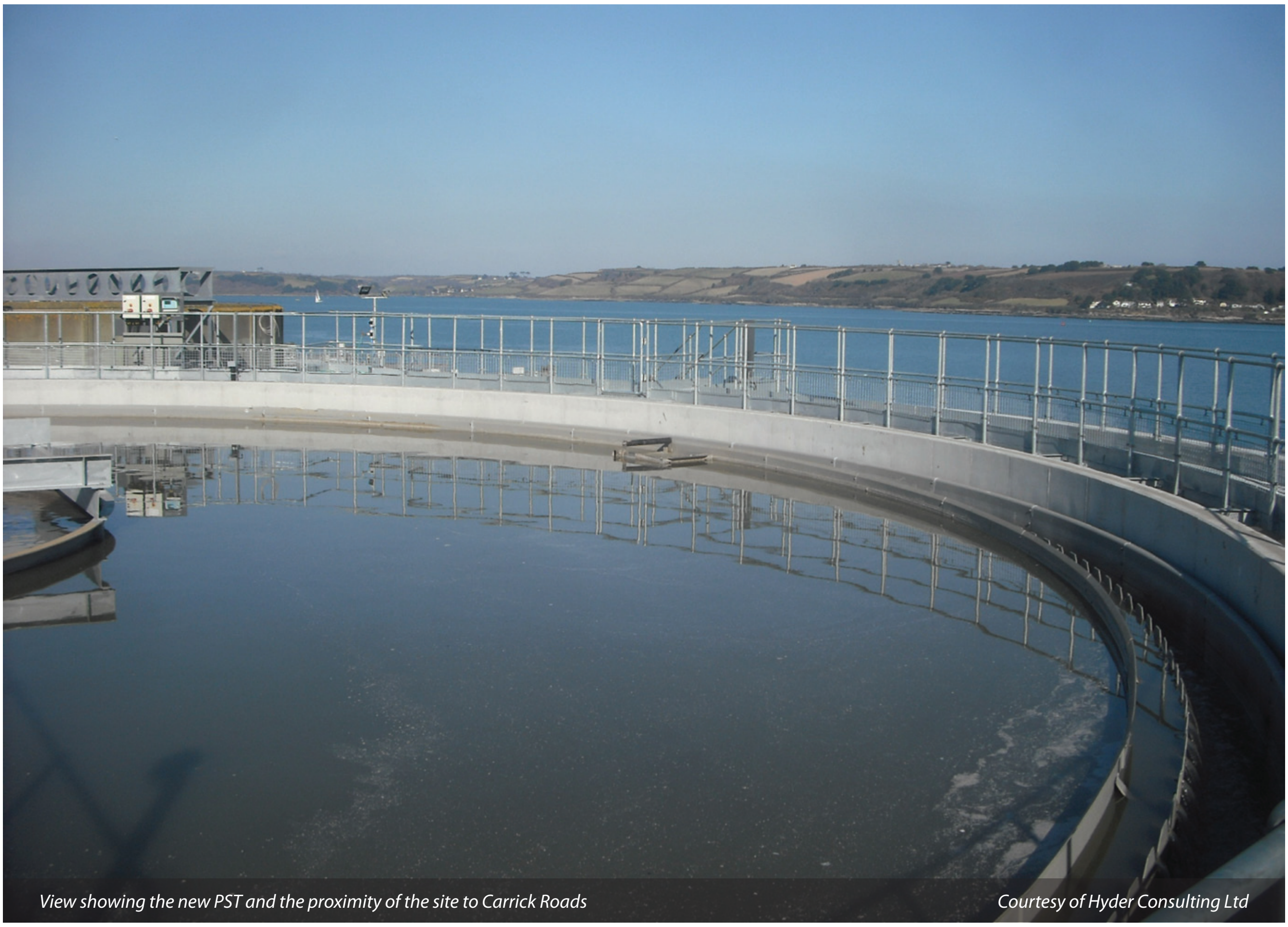
Contaminated land strategy

Falmouth STW is situated in Falmouth Docks on a former landfill site. Landfill on this site started during the construction of the docks and continued until the 1970s. A variety of hazardous, domestic and industrial waste was present within the landfill in a 'mixed and diluted' manner.

Numerous geotechnical and environmental investigations had been undertaken during previous phases of development at the site, which were supplemented by additional geochemical tests undertaken specifically for this scheme. Although elevated metals and Polycyclic Aromatic Hydrocarbons (PAHs) were recorded, the samples were not generally found to contain excessively high concentrations of contamination.

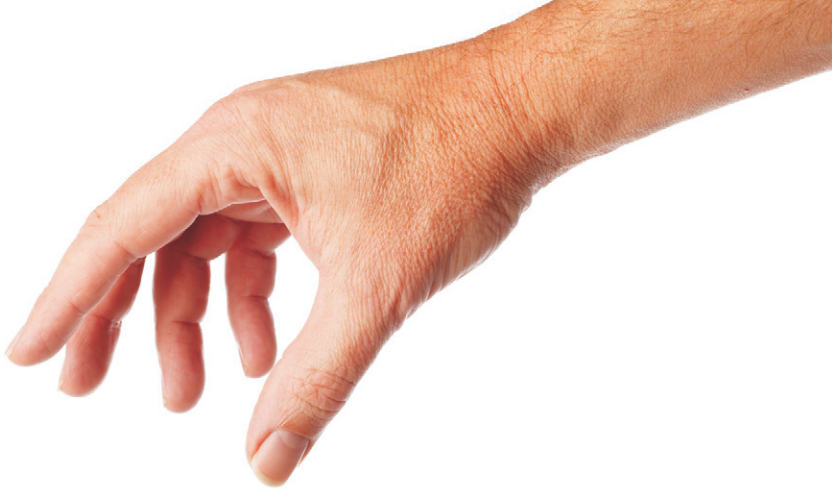
By use of a conceptual model and risk assessment, Hyder were able to gain the EA's agreement that excavated contaminated material would be suitable for re-use on site as material for an engineering cut/fill exercise to provide a level platform for the new tank.

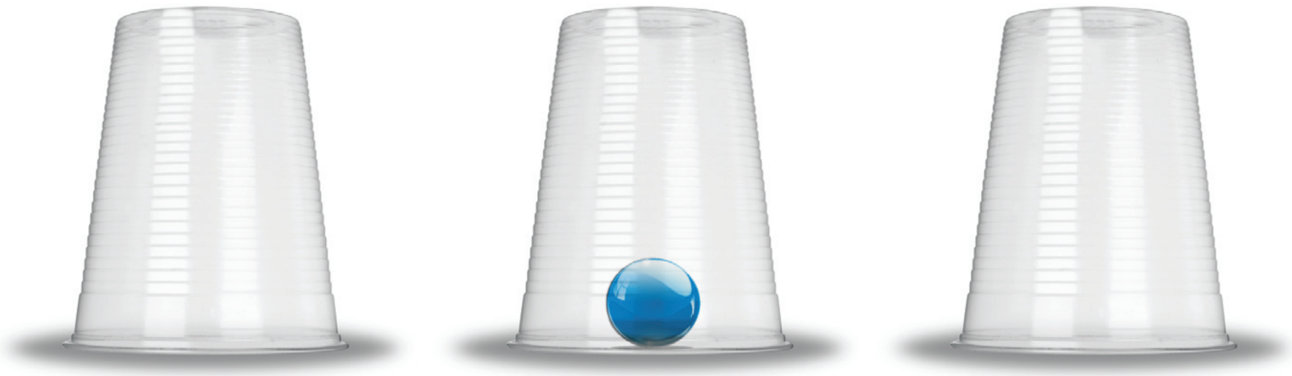
This agreement was gained on the basis that the new works would create an impermeable barrier over a significant area of the landfill, preventing leaching of contaminants from the landfill into the adjacent estuary by rainwater. In this regard, the new works have improved the security of the coastal ecosystem adjacent to the site. The new works also provide a barrier between the contaminated



View showing the new PST and the proximity of the site to Carrick Roads *Courtesy of Hyder Consulting Ltd*

If only all decisions were this simple.





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land and personnel working on the site, breaking the source-path-receptor linkage.

The new Contaminated Land: Applications in Real Environments (CL:AIRE) code of practice was used to control works within the contaminated land. The volume of excavated material was approximately 1,200m^3 which was almost entirely re-used on site. Approximately 100T of sorted waste was exported, such as large lumps of concrete or old rope, as it was not suitable for re-use as an engineering fill material.

Construction

Between 2005 and 2010, Hyder Consulting Ltd (Hyder) and BAM Nutall Ltd (BNL) worked in partnership with South West Water to deliver the company's AMP 4 Programme throughout Devon and Cornwall. Under this partnership, construction of the challenging nitrogen removal scheme at Falmouth STW began in May 2009. The new PST/Anoxic tank is supported on approximately 120 (No.) end bearing mini-piles, and was constructed insitu in reinforced concrete by Kirk Environmental using their adjustable steel shutter system. Two new pumping stations were constructed in RC in the conventional manner.

A significant number of both large and small diameter pipeline connections were required between the new and existing processes. These had to be carefully programmed to ensure that they did not coincide with high tides or expected periods of high load, such as bank holiday weekends.

A new Form 2 Motor Control Centre was constructed by Tecker, a local M&E contractor, who provided MEICA engineering services for the scheme. The new panel was designed to fit within an existing building at the site which eliminated the need for planning permission for the scheme, saving programme time.

Aerial view of the construction of the new PST and anoxic tank
Courtesy of BAM Nuttall Ltd

The scheme was constructed by Christmas 2009, and commissioning started in the New Year. The scheme was handed over by the consent deadline of the 31st March 2010.

Conclusions

The scheme was completed on time and on budget and has provided a robust additional front-end process at this site, which has provided a greater buffer against changing salinity and load patterns, and benefited the entire site.

Since commissioning, the scheme has performed well in achieving the consent. Indeed, during the warmer months the scheme has consistently achieved 10mg/l total N.

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The completed PST and Anoxic Tank structure *Courtesy of Hyder Consulting Ltd*