Countess Wear Stormwater UV Irradiation Plant

shellfish harvesting activity in the River Exe set for growth due to improved water quality brought about by targeted sewerage asset improvements

by Dave Pateman, Christy White & Gavin Lincoln

As of May 2017 there are 137 designated shellfish protected waters in England and of these, 25 are located within the South West Water region. It is estimated that the industry associated with shellfish production areas in the South West is worth £5.35m per annum *(figure from EA based upon Shellfish Association of Great Britain estimates)*, which represents approximately a quarter of the value of the industry nationally. These figures exclude the significant added value associated with the wider tourism, food and hospitality industries. Nationally the value of shellfish aquaculture within the UK increased by 100% between 2000 and 2014. The long term trend is for continued growth, particularly in England and Wales.

UV banks during installation - Courtesy of SWW Delivery Alliance H5O

Legislative framework

To meet the legislative requirements of the National Environment Programme (NEP) South West Water was obliged to reduce bacteriological load to the River Exe estuary by 25%. In addition to the final effluent from Countess Wear STW, which already receives disinfection, there are over 50 other intermittent discharges into the estuary including discharges from the STW inlet works and settled storm discharges from the storm storage tanks and lagoon.

There are two pieces of legislation governing the shellfish harvesting industry in the UK:

- **Water Framework Directive (2000/60/EC): Replacing EC Shellfish Waters Directive (2006/113/EEC)**: Shellfish waters are designated as 'protected areas' within the Water Framework Directive and designations are part of the River Basin Management Plans. The Guideline standard for microbial pollution has been retained since the repeal of the old legislation which set the microbial water quality limit at 300cfu/100ml for E. coli. In addition, the Environmental Quality Standards Directive (EQSD) requires that the UK must endeavour to achieve a specific microbial standard of 300 E. coli /100g in shellfish flesh and intravalvular fluid in all shellfish waters. This represents a standard very close to the threshold where Class A would be achieved.
- **EU Food Hygiene Regulations (852/853/854)**: The quality of commercially harvested shellfish intended for human consumption must comply with the EA Food Hygiene Regulations (852/853/854), which became UK law on 1st January 2006. The regulations set microbial standards for the flesh quality of shellfish harvested from designated areas. Harvesting areas are classified according to the extent of contamination shown by monitoring E. coli in shellfish flesh. Treatment processes area stipulated according to the classification status of the area. The classification categories are noted in Table 1 *(next page)*.

DEFRA's position remains that they are committed to improving water quality to a level where all designated shellfish waters can support at least category 'B' production areas.

This is regarded as an achievable interim target towards meeting the guideline faecal coliform standard for shellfish flesh quality under the Water Framework Directive.

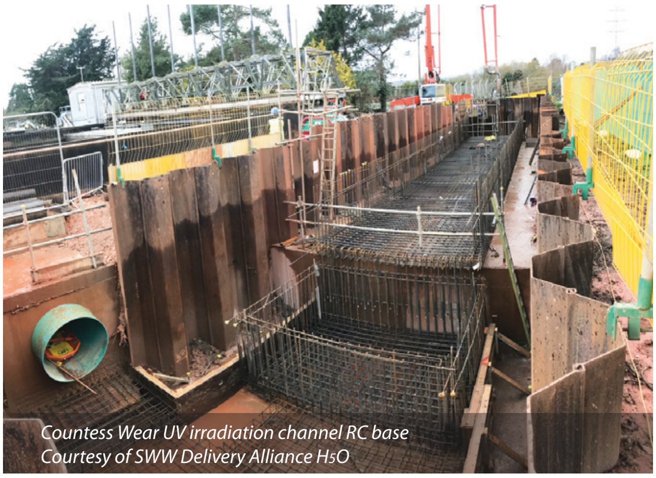

WEDECO
a xylem brand
YOU ADJUST TO CHANGING
CONDITIONS
IT'S TIME YOUR
UV SYSTEM
DOES TOO
WEDECO
Duron UV Disinfection System
Xylem's Wedeco Duron is a 45-degree, vertically-inclined, open-channel UV system possessing an integrated, compact, automatic lifting device and featuring energy-efficient, high-power Ecoray® lamps.
The Duron system is designed for new plant installations or retrofits into existing chlorine contact channels and provides ideal disinfection for mid-size to large wastewater treatment plants.
For UK sales contact 0115 940 0111 or visit fgbsales@xyleminc.com for more information
www.xylem.com/uk
xylem
Let's Solve Water

Category	E. coli/100g flesh	Treatment requirement
A	<230	May go direct for human consumption
B	<4,600	Must be depurated, heat treated or relaid to meet category A
C	<46,000	Must be laid for at least 2 months, followed where necessary, by treatment in a Purification Centre to meet category A requirements.
Prohibited	>46,000	Prohibited from production or collection.

Table 1 - Food hygiene categories

River Exe (inner) shellfish harvesting area
Courtesy of SWW Delivery Alliance H5O

Severe weather during construction
Courtesy of SWW Delivery Alliance H5O



Countess Wear UV irradiation channel RC base
Courtesy of SWW Delivery Alliance H5O

Exe Estuary

The River Exe is a Site of Special Scientific Interest, a Special Protection Area, a Special Area of Conservation, a National & Local Nature Reserve and a RAMSAR site. The waters towards the south of the Exe Estuary support the harvesting of the common (blue) mussel, *Mytilus edulis*. The September 2017 classification of the waters was Class 'B' with the area in the middle of the estuary prohibited for harvesting.

During the development of the AMP6 National Environment Programme (NEP), the Environment Agency identified that the scale of the whole shellfish water programme to meet the requirement for ten CSO discharges per annum in aggregation was not cost beneficial in the Exe catchment.

In order to comply with the DEFRA commitment to 'endeavour to achieve Class B' the EA reviewed the NEP obligation on the Exe to enable the adoption of a multi-phase/AMP approach to improving the water quality which required a 25% reduction in annual bacteriological load rather than a specific spill frequency target. This provided a meaningful initial reduction target for the load to the estuary and enabled the Countess Wear catchment to be included in future AMP shellfish water improvement programmes.

Further interrogation of the outputs of the AMP5 Exe Estuary investigation into wastewater asset performance identified that discharges from Countess Wear SSO and those into the River Clyst were most heavily influencing water quality at the shellfish waters and as part of a reduced and more affordable NEP other assets in the catchment were removed from the overall programme. It was also identified that Countess Wear SSO was volumetrically the most significant discharge and it was subsequently written into the final NEP that storm discharges from this location could be considered for stormwater treatment/disinfection.

Countess Wear SSO

Stantec has been involved in the majority of the stormwater disinfection studies and projects in the UK, as well as directly working with the EA to develop their new approach to wastewater disinfection based on the use of biodosimetry and validated UV irradiation equipment. In order to benefit from this expertise and experience, SWW employed Stantec to work with them to develop an appropriate solution that would meet the required reduction targets for bacterial load into the Exe catchment.

Essentially, the approach taken was two-fold:

- Determine the treatment options, requirements and flow rates and the disinfection targets that would achieve the required load reduction.
- Undertake an extensive programme of characterisation of the settled storm water discharges that would then be used to determine the key information for design and specification of the disinfection process and assessment of the specialist supplier equipment.

Treatment requirements

Outputs from hydraulic modelling were used to identify that the intermittent discharges from the Countess Wear SSO contribute 42% of the total average annual load from CSO discharges in the catchment. This confirmed that it was possible to meet the target reduction required by the NEP objective by removing the load from the settled stormwater overflow at the STW alone.

The level of treatment required on the storm tank discharges at Countess Wear was determined by comparing the potential E. coli load in the CSO discharges and settled storm tanks as shown in Table 2 *(below)*. This analysis concluded that treating 60% of the annual SSO discharge volume would achieve the load reduction required.

	Estimated load m^3 x cfu/100ml
Total estimated load discharge to the catchment	6.1 x10^{11}
Target load to achieve 25% reduction	4.5 x10^{11}
Total contributions from other intermittent discharges	3.5 x10^{11}
Total contribution from CW storm tank discharges	2.6 x10^{11}
Required reduction in load from CW stormwater discharges	1.6 x10^{11}
Target load discharged from CW following reduction	1.0 x10^{11}
Target percentage load reduction from CW storm tank discharges	60%

Table 2 - Summary of load reduction to determine disinfection requirements

The hydraulic model of the Countess Wear catchment was initially used to determine a target flow rate for treatment that would ensure that the load reduction requirements of the NEP objective would be met. The outputs from this assessment are indicated in Table 3 *(below)*, which estimated that disinfection of all storm tank discharges up to a rate of approximately 400l/s would provide the target load reduction, based on achieving 2 log inactivation of E. coli through disinfection.

% of Countess Wear storm discharge volume treated	Flow rate to UV irradiation (l/s)	% of overall catchment spills receiving UV irradiation
90	850	43
80	680	39
70	550	34
60	440	29
50	346	24
40	265	19

Table 3 - Determination of disinfected discharge flow required to achieve target load reduction

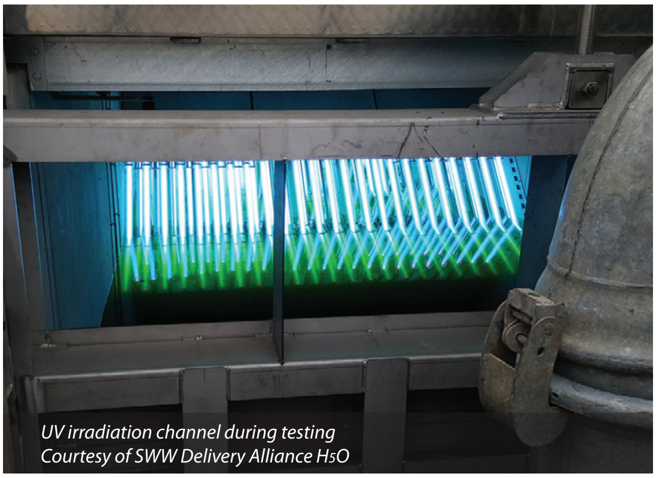
The hydraulic model was then used to investigate the discharge rate profile. The data indicated that discharge rates were greater than 400l/s for 80% of the total discharge time and over 800l/s for approximately 40% of the time. Therefore, if only 60% of the discharge was treated, a significant proportion of the flow and load for a majority of the SSO discharge duration would bypass treatment. Due to the high concentrations of E. coli in the bypass relative to the treated stream, this would result in negligible overall reduction in E. coli in each discharge during the time when most benefit in terms of water quality impacts at the shellfish waters is required.

Therefore, on the basis that the NEP targeted improvements to reduce loads to the estuary as Phase 1 of a potential multi-phase and staged approach to improving the Exe water quality, it was concluded that the disinfection process should be designed to treat all flows up to the maximum discharge flow rate of 1,340l/s.

Approximately 0.4 log reduction in the concentration of E. coli would be required to achieve the load reduction based on the treatment of all the settled storm water spills from the Countess Wear CSO. However, in practical terms this is significantly below the minimum 2 log_{10} inactivation recommended to minimise the potential for photo-reactivation of E. coli following UV irradiation.

Aerial view of Countess Wear UV irradiation plant
Courtesy of SWW Delivery Alliance H_5O

Countess Wear Stormwater UV Irradiation Plant Table of designers, contractors and suppliers	
Client	South West Water
Treatment approach, wastewater characterisation and UV irradiation plant specification	Stantec
H5O - Civil design and 1D hydraulic modelling	Pell Frischmann
STW influent sampling	Titan Environmental Surveys
H5O - Principal contractor	Balfour Beatty
UV equipment supplier	Xylem Water Solutions UK



UV irradiation channel during testing
Courtesy of SWW Delivery Alliance H5O

Countess Wear UV irradiation plant
Courtesy of SWW Delivery Alliance H5O

Based on this limitation, therefore, the final solution is predicted to provide approximately 42% of the total load reduction from the catchment overall.

Key requirements for design of the UV irradiation system

A programme of intensive sampling was carried out on a range of storm tank discharges over approximately 15-months by Titan Environmental Surveys, in addition to online monitoring over the period. Specialist sampling equipment with remote triggers was used to ensure that the variation in the characteristics of the storm water discharges over the various spill periods could be understood for design critical variables (microbial content, UV transmittance, suspended solids and various other parameters). The surveys also included a number of samples taken for collimated beam testing which was used to:

- Demonstrate that UV irradiation would be capable of disinfecting the stormwater discharges to the desired level, based on the observed ranges of concentration of suspended solids and UV transmittance);
- Develop dose-response relationships for the target microorganisms (E. coli), which were used to establish the key design parameters for the UV irradiation system, including the target UV dose required to achieve the required discharge concentrations.

Following a formal tender process, the Xylem Duron vertical lamp UV irradiation system was selected. The flow is delivered through a single channel plant containing 10 banks of lamps. The system has been sized to deliver the target UV dose at maximum instantaneous flow rate of 1,340l/s and at a minimum design UV transmittance of 20% with one additional standby bank at design conditions.

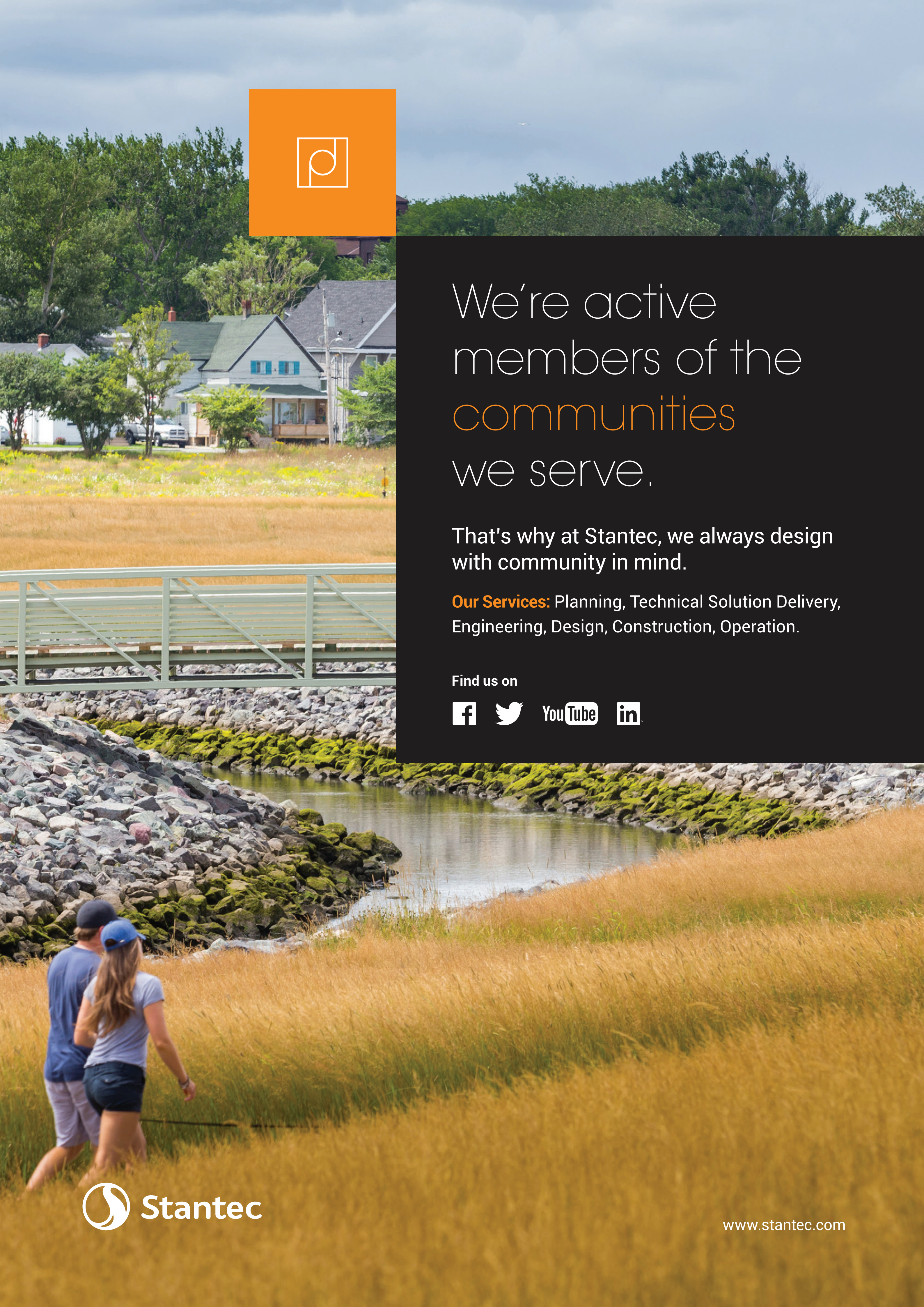
Delivery

Flood resilience work in 2016 protected Countess Wear STW from flooding from the River Exe by sheet piling the riverside site boundary (as featured in UK Water Projects 2016). This work added to the constrained nature of the site available for the location of the UV irradiation channel. Due to the tidal nature of the storm discharge location, the hydraulic design of the stormwater discharge pipework and the UV channel had little headroom which reduced the options for the location of the irradiation plant unless additional pumping was introduced.

As a consequence of these two factors the UV channel has had to be designed to form part of the flood defence wall for the site, with all control equipment and panels located in a kiosk above the local flood level. In addition, to ensure the UV irradiation plant remains operational for the maximum return period, river/tidal flood event possible without becoming drowned out by surcharge back from the river, the post-disinfection flows are now discharged through the outfall from the inlet works CSO chamber rather than via the original storm tank and lagoon discharge outfall. This has triggered a need for a revised permit.

Despite considerable challenges caused by the severe weather experienced in early March the UV irradiation system and associated works were operational in time for the NEP compliance date of 31st March 2018, providing stormwater disinfection for flows in excess of the original NEP requirement. It is anticipated that this, in conjunction with other River Exe catchment measures described in a separate article, will lead to improved water quality and in turn increase the reliability of the Class B shellfish bed classification.

The editor and publishers would like to thank Dave Pateman BEng (Hons) CEng MICE, SWW Concept Team Project Manager, Christy White PhD MEng CEng MIChemE, Stantec Principal Process Engineer, and Gavin Lincoln BSc (Hons) MCIWEM C.WEM CSci, SWW Waste Water Treatment Process Consultant, for providing the above article for publication.



We're active members of the communities we serve.

That's why at Stantec, we always design with community in mind.

Our Services: Planning, Technical Solution Delivery, Engineering, Design, Construction, Operation.

Find us on

Stantec

www.stantec.com