

Tees Barrage White Water Course Upgrade

delivering a world-class sustainable white water facility

by Jason Corrigan

The Tees Barrage White Water Course is located on the north bank of the River Tees adjacent to the Tees Barrage in Stockton on Tees in North East England. The recent £4.6 million redevelopment of the course, funded by regional development agency One North East, Stockton Borough Council, Sport England and British Waterways, has succeeded in creating a world-class white water facility, and the site has already been confirmed as one of the official training camps ahead of the London 2012 Olympic and Paralympic Games. The project is currently the only installation in the world where Archimedean screws are used as both pumps and generators.



The pumping station with the Archimedean screws being installed

Courtesy of British Waterways and JN Bentley Ltd

Project need

The existing white water course was originally opened in 1994, at the time creating exciting and pioneering white water conditions for its users. Since 1994, slalom canoeing, white water specifications and the technical requirements of courses have advanced considerably, and other disciplines such as freestyle kayaking and white water rafting have increased dramatically in popularity too. All of these factors contributed to the case for an upgrade to the site on the north bank of the River Tees in order to maintain and expand the course's appeal, by providing the increased depth and variation in water features required.

The existing course operated by utilising the differential head available between the impounded water level upstream of the barrage and the tidal level downstream. Hence, the time in which

the course could operate was controlled entirely by the tidal cycle, limiting the range of course conditions, and meaning that it had to operate at a different time each day!

Project scope

The scope of the new project was to upgrade the site to create a modern and sustainable course providing world class competitive training, and events for paddle sport. In addition, the upgrade would ensure that revenue-generating activities could be undertaken without restriction at the same time as recreation and competitive paddle sport, thus alleviating the reliance upon tidal cycles.

JN Bentley was successful under the project's competitive tender process, and was selected by client British Waterways to work as Principal Contractor on the scheme.

Feasibility and design

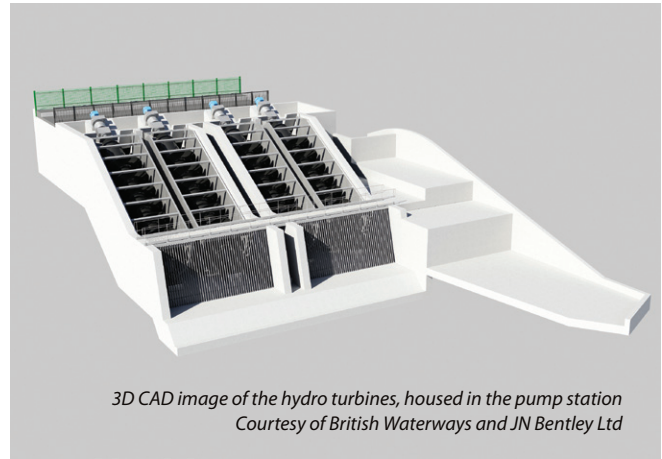
Project development and design consultation was undertaken over a four year period to ensure that the end users of the course would be fully satisfied with the completed project. This meant that the contract was designed and sufficiently developed during the consultation phase by the client to allow the tender process to take place with a degree of certainty of the final out turn cost

The adopted contract conditions for the construction phase were NEC Option C, included within which was a design-and-construct element for the new pump station that was to house four new Archimedean screws. The tender drawings included the conceptual design layout along with the works information to allow JN Bentley to design other outstanding elements of the works with its chosen designer Mott MacDonald. These further design-and-construct elements under JN Bentley's remit included:

- Conveyor to allow transfer of canoeists from the lower pool to the upper pool without the need to exit their boats (allowing continual use of the facility).
- Fully automated control system to operate the facility in both generating and pumping mode.
- Integration of the transformer to allow generated power to feed back into the National Grid.
- Bear stop design for the short and long course.
- Penstock design to the pump station housing to allow effective use of the Archimedean screws.
- M&E infrastructure to operate the course.

Construction

Construction activities began in February 2010. Improvements required to the site included reconfiguration of the existing main course (a 250m long, 7m wide 'U' shaped loop, with a 2.5m drop and a flow of 10m³/s) and the construction of a second shorter, steeper course for high-speed paddling.



3D CAD image of the hydro turbines, housed in the pump station
Courtesy of British Waterways and JN Bentley Ltd

Before redevelopment, the course could only operate two or three hours either side of low tide in the River Tees. So to extend this operating time, and improve course flow control, part of JN Bentley's commission was to install 4 (No.) 12m x 3.1m diameter Archimedean screws, each weighing more than 30 tonnes, in a newly built pumping station.

The inclusion of the screws serves two purposes:

- They transfer water from white water course's lower pool up to the upper pool during high tide, creating guaranteed conditions for canoeists and rafters regardless of the tide.
- And when not pumping water around the course, the screws facilitate electricity generation during low tides using the differential head created by the tidal system and the Tees Barrage to generate electricity for the National Grid. This means Tees is the UK's first fully-sustainable white water course.



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Works commence to the upper pool and ground works preparation for the pumping station - Courtesy of British Waterways and JN Bentley Ltd



Lower pool with the Archimedean screw and Tees Barrage
Courtesy of British Waterways and JN Bentley Ltd



The long course prior to commissioning
Courtesy of British Waterways and JN Bentley Ltd



Short course commission starts
Courtesy of British Waterways and JN Bentley Ltd

Together with the installation of the screws and construction of a new reinforced concrete pumping station, JN Bentley was also tasked with the construction of associated penstocks, stop logs and a fish pass.

The concrete walls of the long course were raised to create a deeper channel (permitted higher flows) and a new steeper short course with reinforced concrete channel, new bear gate, M-wave gate and timber footbridge built to facilitate high speed paddling.

An MCC panel and hydraulics kiosk provides local operation of the penstocks and bear gates to both the long and short courses, and a fully automated computer control system controls the Archimedean screws in both pumping and generation modes.

The design and construction of a canoe conveyor to transfer canoeists and kayakers from the lower pool to the upper pool without the need to exit their craft – they have continual use of the course without having to 'get out.'

The construction phase was delivered under a tight programme with certain design elements of the works developed alongside the construction works. The construction team developed a process to allow the works to be constructed on multiple work fronts simultaneously. This is not usually a challenge to a construction project, but with only one road in and one road out of the site, and with only just enough space for small construction plant to access the white water course, a tight logistical plan was required to maintain the project programme. To achieve this, the team developed a one-way system with access controlled by a dedicated gate-person who liaised with the JN Bentley Site Manager on expected delivery times and potential conflicts.

The construction programme also required the installation of mechanical and electrical components. Throughout the scheme, commissioning of the various elements was undertaken when they each became available, with a final commission of the system when all works completed, prior to the handover to British Waterways.

Archimedean screws

When operating as a screw pump, the power absorbed at the duty point (3,500l/s @ 4.94m) is 178.5kW per screw pump. The screws are each capable of lifting 3.5m³/s at a maximum head of 3.68m, producing a maximum flow rate of 14m³/s for the course. The screws are controlled by variable speed drives via a SCADA control system in the main control tower, and can be run in either Manual or Automatic mode.

With all four screws running they pump enough water to fill an Olympic size swimming pool in less than three minutes. When conditions permit the environmentally-friendly screws also use excess river water from the Tees to generate in excess of 130kW each, making the course sustainable in terms of energy consumption.

In Manual mode the pumps run at a fixed speed of 1,500rpm from an input of 20mA. When the pump is running up to speed, the system sends signals to the Hydraulic Power Unit to open the relevant Penstock.

Automatic mode controls the number of pumps needed from those available and varies their speeds to keep the bottom pool at its desired level of -1m. If more than one pump is available, the system only varies the speed of one pump to trim the level and run the others at their most economical speed. It also selects available pumps according to their accumulated hours to balance the running time as far as possible.

Generating mode is only available when pumping mode is set to 'Off'. When operating in reverse, i.e. generating electricity, each screw pump produces approximately 131kW. To maximise

the opportunities for exporting electricity to the National Grid, the system automatically alerts the Barrage Operator when the conditions are appropriate (when no pumps are in 'pumping mode'), the upstream level is above 2.35m AOD and lower pool level below -1m.

Stakeholder liaison

Although the upgrade of the existing course required its closure during the construction phase, a number of local business in the vicinity required a continual update on construction progress and programmed milestone dates.

When the Archimedean screws were positioned into the pump housing structure, this significant milestone event was attended by local dignitaries and important stakeholders. The placing of the screws was hailed as a particularly notable activity that signified that the construction phase was close to completion.

Conclusion

The scheme was successfully completed in April 2011, and has provided North East England with modern, sustainable and world class white water training facilities. The client has a leisure facility which can be operated throughout the day, and is no longer subject to tidal constraints. The team involved worked hard to gain a full understanding of Archimedean screw installations and their power-generating capability, and have successfully applied the traditional Archimedean screw principle to a modern facility.

The site is now managed by Tees Active and operates as the Tees Barrage International White Water Centre.

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The completed works

Courtesy of British Waterways and JN Bentley Ltd