

# Supply Demand Balance South Programme

## in the planning period to 2031/32, Scottish Water's measures to ensure resilience of supply for customers in Dumfries and Galloway

by Charlie Bull & David Gethin

Scottish Water's £15m package of measures, known as the Supply Demand Balance South programme (SDBS) encompasses transfers between raw water sources such as lochs, reservoirs and rivers, enabling water treatment works (WTW) to abstract from new sources, and expanding WTW capacity. Achieving this entailed construction of inlets, pumping and pipeline infrastructure, and control systems to manage the new assets. In addition the programme included two dam raises. The programme was divided into north and south clusters. The former consisting of projects at Inveraray, Killin and Ardrishaig; the latter comprising projects at Black Esk Reservoir, Black Esk WTW, Penwhirn WTW and Moffat Borehole and WTW. Scottish Water awarded the work, on a design/build basis, to Black & Veatch. This article focuses on the south cluster, the larger of the two, with a value of just over £12m.



*Penwhirn Reservoir: Innovative labyrinth weir resulted in operational and project benefits - Courtesy of Black & Veatch*

### Black Esk Reservoir and WTW

Black Esk Reservoir and WTW are west of Lockerbie. In the planning period to 2031/32 there is a possible maximum supply demand balance deficit within Black Esk Water Resource Zone of 4.44MI/d. The aim of this element of the SDBS was to remove the constraint on water supply in the Black Esk zone by increasing the raw water supply to the WTW through raising the height of Black Esk Dam. The dam raising would increase the reservoir's usable capacity from 2,222MI/d to 3,145MI/d (providing a 41% increase). The Black Esk elements of the programme were valued at nearly £4m.

One of the most significant elements of the reservoir work was the use of piano key (PK) weirs on the spillway. It is believed that mounting 24 (No.) precast PK weirs in a circular configuration on an existing circular overflow is a world first.

This approach, proposed at bid stage by a Black & Veatch hydraulics specialist, offered both operational and construction benefits. The longer weir offered by the PK configuration, as opposed to a circular weir, allows the design discharge to be passed with a lower flood level in the reservoir. This means a significant reduction in the

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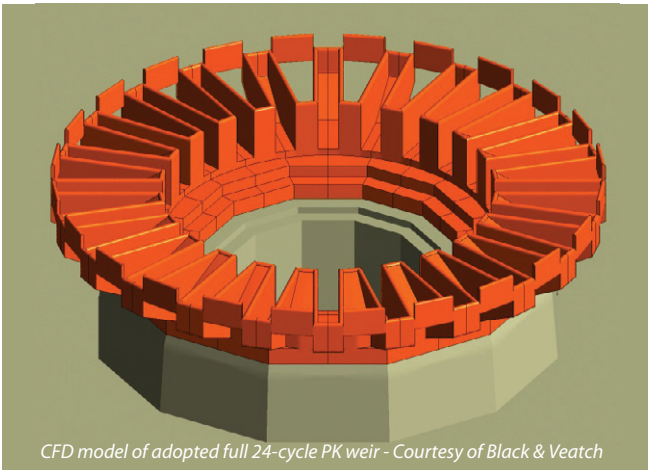
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CFD model of adopted full 24-cycle PK weir - Courtesy of Black & Veatch



Working over water was minimised, most construction occurred on the original bellmouth rim, around which temporary working platforms were deployed - Courtesy of Black & Veatch



Design of the PK weirs was developed with ease of construction a significant consideration - Courtesy of Black & Veatch



Level of crest rise was reduced thanks to the innovative weir design Courtesy of Black & Veatch

amount of dam crest raising required; which engendered both time and cost savings.

Design of the PK weirs was developed with ease of construction a significant consideration. The number of bays was determined in order to facilitate construction of the PK weirs as precast concrete units. Adoption of identical 15° units allowed the use of a single mould and made sequencing of work simpler to manage. Working over water was minimised by ensuring that most of the construction activities occurred on the original bellmouth rim, on and around which temporary working platforms were deployed.

A temporary crane platform adjacent to the bellmouth facilitated the extensive lifting required for removing the original debris boom and walkway, installation of the PK weir units, and the raising of the original valve tower.

Manufacturing the units in precast concrete allowed smaller bay widths than was feasible with in situ construction, as no scaffolding was required within the outlet key. Casting the weir units inverted allowed the casting of the rounded crest to be achieved with greater control than for in situ methods and also allowed thinner sidewall sections. The size of the units allowed two units to be carried on a standard articulated lorry without oversize load restrictions.

Most importantly the use of PK weirs allowed Scottish Water to keep the reservoir in service during the work, because the draw down was less than that required for some of the options originally proposed. Black & Veatch's solution successfully augmented the reservoir's existing capacity by raising the full supply level by 2.5m, providing an additional yield of 18.96MI/d.

In conjunction with the dam raise, reducing losses at Black Esk WTW was seen as an effective way of ensuring sustainable long-term supplies for the Black Esk zone. Fed by the reservoir, the WTW had a 21.5MI/d capacity. The scope of the project was to reduce losses by approximately 2% by returning settled supernatant to the headworks. By reducing losses the upgrade raised capacity to approximately 22MI/d.

Work at Black Esk WTW also included enhancing the treatment process with the addition of poly dosing to improve the settlement characteristics of the existing wash water recovery tanks.

The WTW element of the Black Esk portion of the programme required overcoming a number of challenges. Principle among these was the reconfiguration of an existing wet well pumping station while maintaining the integrity of the existing process. Black Esk WTW is a very congested site, which added to the complexity of selecting a route for the new rising main.

Further complexity resulted from the need to execute an under pressure tie-in, into the WTW's existing 600mm-diameter raw water inlet main, for the supernatant return.

### Penwhirn Reservoir

There are two principal elements to the £6.2m Penwhirn element of the SDBS. First was to raise the height of the existing Penwhirn Reservoir embankment by 1.5m in order to increase storage capacity. The dam raising would increase the reservoir's usable capacity from 2,218MI/d to 3,082MI/d (providing a 39% increase). Secondly, the capacity of Penwhirn WTW was increased by 1.2 MI/d to 17.2 MI/d.

Penwhirn Reservoir is the main source of supply for the Wigtownshire area. The area surrounding the reservoir is classified a site of special scientific interest (SSSI) and as such required careful planning. From the outset Black & Veatch was in close liaison with local stakeholders regarding environmental and mitigation plans to protect local wildlife including otters and water voles.

Black & Veatch was appointed to progress stage two initial design originated by others. The company introduced value through its redevelopment of the base scope to incorporate innovative labyrinth weir and dam crest upfill designs.

Adopting a labyrinth weir, as opposed to simply uplifting the existing ogee weir, brought a number of benefits. On an operational level the labyrinth design significantly increased the effective weir length of the reservoir overflow, thereby providing more rapid relief during peak flood events.

In terms of project delivery the labyrinth weir simplified the uplift solution on the narrow, existing embankment crest. The design meant the crest raise was not as high as envisaged in the base scope, cutting the construction impact. This brought significant programme and cost savings to this element of the SDBS work. Reducing the height of the dam crest also lessened landtake, a significant benefit given the SSSI designation for the area surrounding the reservoir.

#### Moffat Borehole and WTW

In terms of value, £2.1m, Moffat Borehole and WTW was the smallest element of the Supply Demand Balance South programme. Here to, there were two elements to the work; one at the water source, another at the WTW.

The scope of the water source work was to increase borehole capacity from 3MI/d to 5.5MI/d. This was achieved by facilitating an enhanced pumping regime from duty/assist/standby to duty/assist/assist during times of peak demand.

A new intelligent MCC was installed to manage the new pumping regime. In order to precipitate the pump and control upgrades, the pumping station's existing mains power supply had to be increased using a new, higher capacity transformer.

Storage capacity at Moffat WTW was increased to 3,500m<sup>3</sup> from 1,500m<sup>3</sup> to manage the increased borehole output. This required the installation of two new buried concrete storage tanks engendering significant earthworks and concrete pours.

In addition the WTW's treatment process was enhanced through the installation of new caustic soda package plant and new sodium hypochlorite package plant.

Location brought a challenging aspect to this element of the SDBS programme. With an elevation of more than 1,000 feet construction between September and March was difficult because of high winds and sub-zero temperatures. In addition access to site was via 3km of unsurfaced track.

The WTW remained in service throughout the upgrade works. This required careful management of the interface between the new chemical system and the existing process plant. Shutdowns were only possible at night to mitigate the risk of a loss of supply from the storage tanks to the local distribution network.

#### Conclusion

Successful delivery of the southern cluster of Scottish Water's Supply Demand Balance South programme required a very wide range of disciplines from the utility's design-build partner. The programme encompassed distribution network enhancements, upgrading of treatment processes and increasing reservoir capacity through specialist dam engineering and construction. The commitment to innovation brought across the programme is best exemplified by achieving a world first at Black Esk, which combined clearly demonstrable safety, cost and operational benefits.

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*The piano key weir in situ, a world first - Courtesy of Black & Veatch*