

# Grane Valley Reservoirs

## future-proofing United Utilities reservoirs

by Daniel Thomson MSc BEng (Hons)

United Utilities' Grane Valley Impounding Reservoir (IR) system in Haslingden, Lancashire, is home to three impounding reservoirs in a cascade system; Holden Wood IR (at the bottom), Ogden IR (middle) and Calf Hey IR (top). Ogden and Calf Hey IR's feed water to Haslingden Grane WTW, which supplies 14ML/d to 50,000 people. Following detailed studies, Calf Hey IR was removed from the scope of works and remedial works were undertaken at only Holden Wood and Ogden IR's, which was the largest spend and most challenging AMP5 project in Impounding Reservoirs. Work at each reservoir was programmed to be independent of each other to reduce the impact of flooding on the works. However, with the planned Haweswater Aqueduct outage, they were undertaken simultaneously to ensure the works were complete to provide an adequate water level in Ogden IR to feed the WTW.



Completed works at Holden Wood IR with Ogden IR in background  
Aerial photography by Suave Photograph - Courtesy of UU



Completed works at Holden Wood IR  
Aerial photography by Suave Photograph - Courtesy of UU



Completed works at Ogden IR  
Aerial photography by Suave Photograph - Courtesy of UU



Ogden IR looking downstream of the northern spillway  
Aerial photography by Suave Photograph - Courtesy of UU

### Brief description of existing facilities

Holden Wood IR has a capacity of 367,000m<sup>3</sup> at top water level (TWL) and was constructed by the local mill owners in 1841. Its original purpose was to supply water to local mill industry; it then changed purpose to a bleach works industry sited at the toe of the dam and it now supplies compensation water to Ogden Brook. The reservoir is retained by a 100m long, 18m high earth fill embankment with a clay core and it had an upstream slope of 1:3 with a downstream slope of 1:2.

Construction started at Ogden IR in 1902 and was completed in March 1912 after several issues during construction. Ogden IR has a capacity at TWL of 1.5 million cubic metres and it is a typical

Pennine earth fill embankment of the era it was constructed in. The embankment was constructed with a central puddle clay core, supported by a 1:2.5 clay filled downstream slope, and a 1:3 clay filled upstream slope. It is 400m long, 15m high with a crest width of 4.5m. The reservoir has by-wash channels extending along both sides of the reservoir which discharge down cascades at each mitre.

### Reason for the works and technical description of the design

The reservoir safety improvements at Ogden and Holden Wood IR's were initiated by 'in the interest of safety' (ITIOS) recommendations made under Section 10 of the Reservoirs Act 1975. The key ITIOS items required modelling of the hydrological and hydraulic systems, seismic investigations and internal erosion studies.

UU Engineering, with resources from MWH Global Engineering Consultants, began the design of the scheme in late 2009.

Geotechnical investigations at Holden Wood IR identified that the Factor of Safety (FOS) against deep seated slips had to be increased in accordance with UU's latest slope stability methodology. Portfolio Risk Assessment (PRA) studies identified that works to combat internal erosion would be required in the future. However, as the embankment required works to increase the FOS, measures to combat internal erosion were provided under this project. No such remediation requirements were required at Ogden IR.

The constraints present at both reservoirs heightened the project's design complexity. At Ogden IR the key constraints included:

- History of landslides at the southern by-wash
- Ancient post glacial landslips to the northern side of the existing spillway
- History of capacity and stability issues associated with the existing southern by-wash tunnel at the toe of the dam
- Existing live and abandoned services present at the toe of the dam
- Being a site of biological importance (SBI) environmental designation and bat habitats in the existing southern by-wash.

At Holden Wood IR the key constraints included:

- Ancient post glacial landslips to the northern abutment.
- Existing live trunk mains on the northern abutment.
- Steep sided southern abutment adjacent to the existing spillway.
- Presence of Japanese knotweed at the toe of the embankment.
- Foundations from the former bleach works containing chrysotile (white) asbestos and elevated levels of metals.

Several key stakeholders had to be consulted to ensure the final design satisfied the constraints. During the concept phase approximately 10 entirely different solutions were proposed for each site. For example one solution proposed constructing a new dam at Holden Wood although this was later ruled out due to the financial and environmental issues.

The chosen outline design for each of the spillway improvements was hydraulically and hydrologically analysed, to ensure that the spillways were sized to safely pass the probable maximum flood (PMF). The overflow capacity study at Ogden found the most severe flood event was the summer PMF event, which was approximately 25% of the required hydraulic capacity. Studies at Holden Wood IR found the most severe flood event was also the summer PMF event, which was approximately 10% of the required hydraulic capacity.

### Bats

Environmental and ecological surveys were undertaken as part of the outline design process. At Ogden IR, several colonies of Daubenton and Pipistrelle bats were found within the existing southern by-wash channel, which was to be demolished under the remediation measures.

Natural England was contacted to discuss a logical way forward to ensure that the bats were catered for and to ensure the safety of the embankment. Monitoring of the climates in the existing tunnel was set up to guarantee the new location for the bats would present a similar environment.

To ensure that the phasing of the main remediation works were not affected, it was decided to build a bat tunnel on the line of the flight path of the bats. Following the DEFRA guidelines, the bats were successfully relocated and are still using the bat tunnel to this day.





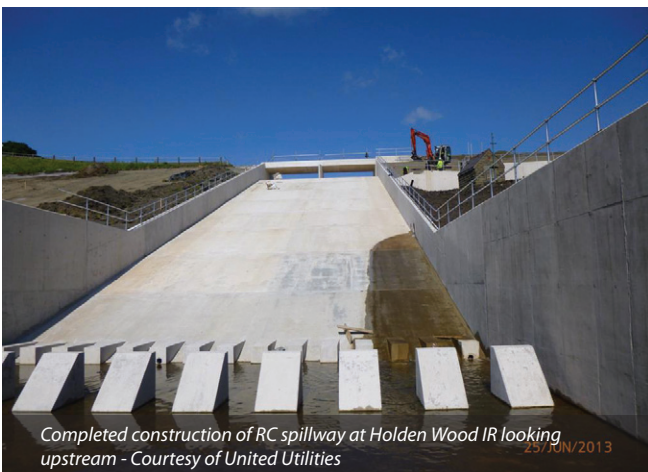
Temporary King Post wall at Holden Wood IR Looking downstream from embankment crest - Courtesy of United Utilities



Diamond chainsaw and a large diameter saw cut through Holden Wood IR crest - Courtesy of United Utilities



Ogee weir installation at Holden Wood IR  
Courtesy of United Utilities



Completed construction of RC spillway at Holden Wood IR looking upstream - Courtesy of United Utilities

### Technical description and construction of the work

Following completion of the design stage, Eric Wright Civil Engineering Ltd (EWCE) was awarded the Grane Valley Reservoir safety improvement project in spring 2012. On-site construction commenced in summer 2012, with a planned duration of 104 weeks.

The project comprised of a number of main components at both Ogden and Holden Wood IR's including:

**Ogden IR - Upgrade of the existing masonry spillway:** It was decided that the existing masonry spillway was to be retained. In order to do this, it was calculated that an auxiliary spillway was required to take half the PMF. Concerns were raised over potential plucking within the masonry spillway and therefore a reinforced concrete (RC) lining to the existing spillway was proposed. The new lining raised the existing wall heights by a minimum of 1.1m, which in effect formed a parapet.

**Ogden IR - New Auxiliary Wedge Block spillway:** Due to the geotechnical constraints of the abutments, the chosen solution resulted in the construction of a wedge block spillway. It was chosen mainly for its geotechnical capabilities, whereby potential movements in the dam can be monitored. The individual wedge blocks move with the dam ensuring that hydraulic design is not compromised whilst flexibility is maintained.

**Ogden IR - Remediation of/and new southern by-wash:** The southern by-wash tunnel was filled with foam concrete along its entire length. This was chosen because it is self-levelling, has a low unit weight for future settlement issues and also due to its ease of use during construction. A new channel was constructed above the in-filled tunnel to convey flow from the southern by-wash to the new transition channel at the toe of the dam.

**Holden Wood IR - Removal of Japanese knotweed:** At the toe of dam a 2m x 5m area of Japanese knotweed had been identified on the surface. As the knotweed could not be treated over a period of 3 years, the latest EA code of practice (COP) was followed and it was designated for removal. However, with the location of the knotweed not all of it could be removed for stability reasons. Therefore, in accordance with the COP, 120m<sup>3</sup> of contaminated spoil was removed to a licenced tip and a protective root barrier was extended 7m beyond the extent of the exposed rhizome.

**Holden Wood IR - Embankment re-profiling:** Firstly, all topsoil and turf was removed from the embankment to expose the subsoil. A 300mm filter layer was laid directly on the subsoil and 300mm drainage layer laid above it completing the granular filter. Following site trials, layers were compacted at full depth after confirmation from laboratory test results, which showed that there was minimal difference between compaction in 150mm layers compared to 300mm layers. Following successful installation of the filter, the downstream slope was re-profiled to 1 in 3 using class 1A material in 300mm layers.

**Holden Wood IR - New overflow facilities:** In order to pass the PMF, a new overflow was required and the existing was abandoned by constructing a watertight RC wall across the tumble bay at the crest.

The base of the existing spillway was filled class 6F5 material and the remainder filled with 1A as part of the re-profiling exercise. The new overflow was 15m wide, constructed from RC and movement joints were provided at 6m intervals. The weir was constructed from two-part segmental ogee units and the 4.5m deep RC stilling basin was constructed with 42 (No.) 200mm diameter anti-floatation piles.

**Holden Wood IR - Contaminated land remediation:** The most unusual of the constraints was the presence of contaminated land situated in the location of the stilling basin. In order to be environmentally

sustainable, the design in accordance with the CL:AIRE guidance, accommodated for the re-use of the contaminated material within a remediation method statement. As a result, the material was re-profiled to set contours approved by the local planners, which was then covered by a 600mm thick clay capping layer over an area covering 2500m<sup>2</sup>. Traditional drainage for the stilling basin was not appropriate as it acted as a pathway for the contaminants, which was the reason for the anti-floatation piles.

#### Phasing of works

With the reservoirs being part of a cascade, water management was a key design and construction challenge. The Contractor was required to work within stringent construction phases whilst maintaining appropriate reservoir safety standards. Construction activities at Ogden IR were divided in to four phases, whilst the works at Holden Wood IR were undertaken in two phases.

The main phase constraints for both reservoirs was protecting the new apron works from flooding, and ensuring that flood and scour flows could pass through the excavations for the new channels. In an addition to the detailed phasing, a bespoke flood contingency plan was developed and weekly meetings were set up with the contractor, operations and UU Construction to ensure works at both reservoirs were scheduled accordingly.

#### Contractor innovative thinking

The crest apron at Ogden IR was constructed in two sections by EWCE, with the upstream section being constructed first. The existing clay core was left in as a watertight element whilst the upstream section was being constructed. Temporary flood protection measures were fixed to the side of the in situ RC section of the weir, which connected into the clay core to provide a watertight seal. This subsequently enabled the construction of the tie-in between the wedge block spillway and upstream section of the apron to be completed with reducing reservoir safety risks.

A 50m long by 10m deep Larson sheet piled wall, with temporary bund, was constructed at the side of the northern spillway tunnel to convey the scour flow through to Holden Wood IR.

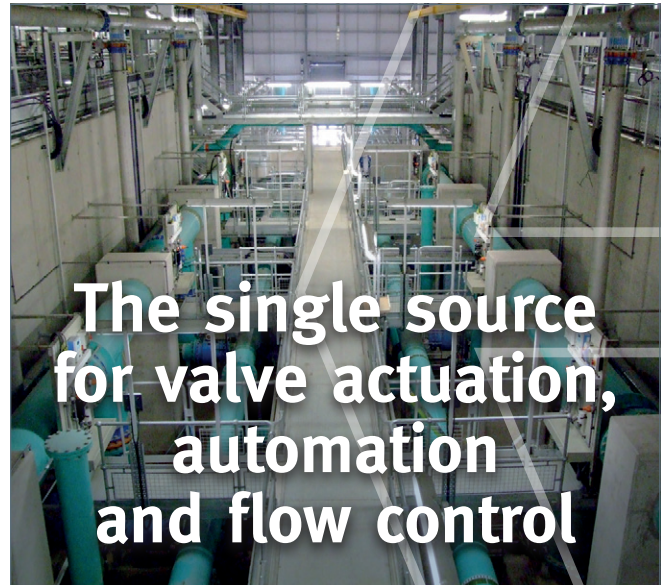
As the working area was extremely tight at Holden Wood IR, an innovative solution was employed to maintain access routes and provide temporary shoring during construction of the stilling basin. A traditional sheet pile system couldn't be used due to the presence of existing foundations from the bleach works. EWCE therefore installed a king post wall system constructed out of H piles connected using timber slats.

The crest structure at Holden Wood IR was constructed through a 600mm thick R.C wave wall. To ensure minimal restoration was required between structures, and also to reduce vibration on the crest of the dam, EWCE utilised a diamond chainsaw and a large diameter saw to produce clean vertical cuts.

#### A Success

A positive team mentality between UU and EWCE saw the project completed in 64 weeks; 40 weeks ahead of the original project programme and within budget. One of the main project drivers was to ensure that the reservoirs were at set minimum capacities during the planned shutdown of the Haweswater Aqueduct in October 2013. However, with the project completed early, the reservoirs within the cascade were at full capacity, which reduced the demand on other local water supply resources.

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