Helston (Cober) Flood Alleviation Scheme

emergency flood relief culvert installation at Loe Bar to protect Helston, Cornwall, from 1:100 year floods

by Nigel Horwell MA (Cantab) PGCert CEng MICE MAPM

Helston is located at the northern end of the Lizard Peninsula in Cornwall and the lower town has suffered from a long history of flooding from the River Cober. This ultimately prompted the development of a flood alleviation scheme (FAS) in 1989. However, following these works, there were further flood events in 1993, 1999, 2003 and 2012. The situation left large areas within Helston at risk of flooding from relatively low annual exceedance probability (AEP) fluvial events from the River Cober. Several low spots in the embankments and river walls overtopped at a 1:5 AEP event, causing property flooding in the St Johns Road area which become more widespread in larger events causing further flooding at the 1:10 event. A 1:100 year event was predicted to damage 115 properties. Flooding in Helston also leads to closure of access routes through the town including an important A-road for transport links. If no action was taken, then the risk flooding would increase to 1:2 year by 2050 as a result of climate change.

Outlet in operation - Courtesy of BAM Nuttall

Background/project scope

JacksonHyder, a joint venture between Jackson Civil Engineering and Hyder (now Arcadis (UK) Consulting), was appointed by the Environment Agency (EA) under the Water & Environmental Management Framework to prepare detailed designs for a flood alleviation scheme on the River Cober to protect properties upstream of the A394 (Penzance Road) from 1:100 year fluvial flood events. The scheme was to be delivered in two separate but related parts:

- ***Part (i)***: Downstream improvements to the discharge capacity of Loe Bar which restricts flow from Loe Pool (SSSI) into the sea.
- ***Part (ii)***: Flood defence walls either side of the River Cober together with upstream embankment raising, flap valves and flood gate installation.

This case study covers Part (i) which was completed in 2019. Part (ii) is currently on site and due for completion by 2021.

The river flows through the town and enters Loe Pool some 2km to the south west. Loe Pool is the largest natural freshwater lake in Cornwall and discharges into Mounts Bay through a tunnel cut through the cliffs in the 19th century. Due to the limited discharge and flat gradient, the water level in the lake backs up the river into the town during storm events and creates flooding. In consequence, the EA mobilise pumps to Loe Bar to supplement the tunnel's discharge capacity and help lower water levels.

By designing an emergency relief culvert that will work under gravity, approximately 44 residential properties, 10 commercial premises and one place of worship will be better protected. The remaining 60 properties will be protected when Part (ii) is complete.

Design

JacksonHyder's solution was to build on previous design work and create a new 1.8m diameter culvert that started from the existing inlet chamber to the tunnel and ended just above the high tide mark on the beach. The pipe was designed as a lightweight

Existing tunnel outlet into Mounts Bay - Courtesy of Arcadis

Electric submersible pumps supported from temporary bridge over inlet approach channel - Courtesy of Arcadis

Pipeline pumping to the sea - Courtesy of Arcadis

Outlet showing sheet pile boxes and part construction of the baffle Courtesy of Arcadis

flexible pipe (Weholite) with as-dug material to be compacted as backfill. Under normal conditions, the outlet would remain buried under 3m or more of sand as the site is not only a SSSI but also an AONB. Under storm conditions, the outlet would be excavated and a penstock opened at the inlet chamber effectively doubling the outlet capacity of the existing arrangement from 4-5m^3/s, hence eliminating an expensive over-pumping operation.

Work on site was brought forward following a cliff collapse during a storm in early 2018, which exposed the tunnel under the cliff and led to blockage from sea-blown sand. This had the potential to raise water levels in Loe Pool to dangerously high levels, so the EA commenced over-pumping operations whilst the contractor mobilised to site.

Outlet structure

Since the beach is westerly facing into Mounts Bay (with its world-famous St Michael's Mount) and is steeply shelving, the wave conditions can be ferocious. The outlet had to be designed to both resist the impact of the waves and to be capable of being built in such an aggressive environment. One of the key challenges faced was that the client had a very constrained budget and timescale within which to accomplish the works. Thankfully the previous consultant had undertaken a dynamic probe test of the beach profile so there existed a good understanding of the ground conditions which enabled a quick start on the design work.

The outlet structure was designed as two interlocking sheet piled box structures. The western (seaward) box was designed to act as an energy dissipation basin. The eastern box was designed to allow the emergency relief culvert to pass under a concrete platform with the culvert discharging into the western box. The concrete platform on top of the eastern box was designed to allow a 21t excavator to stand and excavate sand from the western box. The sheet pile sections were selected from suitable lengths of piling in stock left unused from other EA projects in the local area thus helping to keep costs and transportation to a minimum.

In situ concrete floors/platforms were designed to brace the boxes but with a slip membrane between the piling and the floor to allow for settlement of the sand underneath. Particular attention was paid to strengthening at the culvert's discharge end where in situ walls were cast onto the piles with shear studs but braced apart by a precast concrete inverted-L baffle designed as a series of planks to keep lifting weights to within the capacity of the plant.

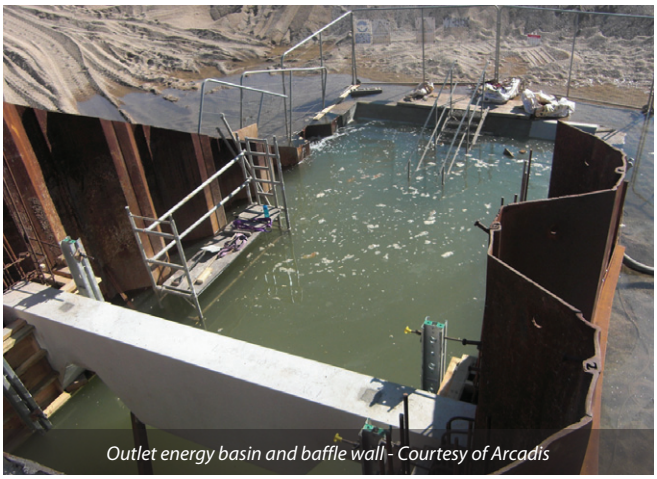
The baffle not only served to dissipate the energy of the flow out of the culvert but also to prevent hydraulic shock travelling up the culvert from the impact of waves during flood control operations.

A precast concrete planked roof over the baffle was designed so that plant could move forward from the platform on the eastern box to the front face to enable the operator to see into the western box. A gap was also built in between the top of the baffle and the soffit of the precast roof to prevent a vacuum occurring during flood discharge and also provide a secondary means of discharge should the lower discharge under the baffle become blocked by sea-blown sand.

Precast concrete elements were designed so that time spent erecting complicated shuttering and fixing heavy reinforcement on site could be eliminated and instead, the units could be cast off site and then lifted into place using the available plant on site.

All exposed concrete was sprayed with Aquron® 2000 which hardens the surface against wind-blown sand and helps increase design life. As a safety feature, holes were cast into in the platform and roof so that, after uncovering the platform, scaffolding guard railing could be safely located to prevent falls. These holes were capped before burial to prevent them from becoming clogged with sand.

Helston (Cober) Flood Alleviation Scheme Supply chain - key participants	
Supply Chain	**Company**
Client	Environment Agency
Designer	Arcadis Consulting (UK) Ltd
Main contractor	BAM Nuttall
Site supervisor	Jacobs Ltd
Penstock and stoplogs	Busch Technology GmbH
Trash Screen	Mike Davies Fabrications Ltd
Pipe	Weholite Ltd
Telemetry cabinet	Quinshield Ltd
Concrete Protection	Markham Global Ltd


Outlet energy basin and baffle wall - Courtesy of Arcadis

Although the works were protected during construction from general wave action by a sand bund, the contractor had to work around the tides for the construction of the basin floor and walls as the levels were below spring tides. However, works had to stop several times due to storm conditions and the area re-excavated afterwards as the waves had in-filled the excavation with sand.

Culvert

The structured wall (Weholite) pipe culvert was installed using open cut and fill methods in a parallel operation to the outlet construction. The pipe was transported to site in 4m lengths due to restricted site access between the contractor's compound and the beach and also the distance between props used to keep the deeper parts of the excavation apart. The pipes were placed and then jointed using plastic heat-sealing techniques (welding) on the inside and outside. Bends and junctions for manholes and bypass flow were factory created and welded on site.

At the inlet end, a separate 1.5m diameter pipe was taken to Loe Pool from the swept bend that led from the inlet chamber. Once the outlet works were complete a bypass channel was excavated from Loe Pool and fed through the bypass pipe into the completed culvert. This then enabled the existing inlet chamber to be taken offline so that modification works to it could begin.

Inlet structure

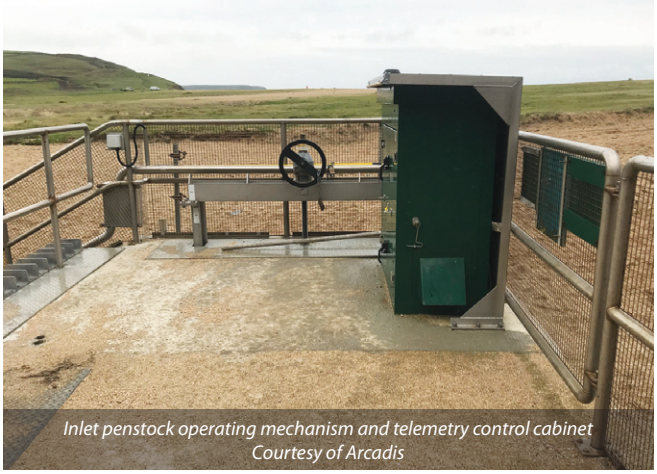
Modifications were designed to the inlet chamber lowering the inlet apron by 1m to the southern side of the outlet channel from the lake to allow water levels in the pool to artificially mimic the natural seasonal variation (high in winter/low in summer). Increasing sunlight to the macrophytes (plants) growing in the bottom of the pool would help the pool to resist the increasing eutrophic conditions which was leading to failure of the SSSI and would also create over 10ha of wetland around the pool. These conditions were the result of nitrate and phosphates entering the water and were the cause of algal blooms occasionally present in the hotter summer weather.

Both sides of the inlet apron originally had a rising penstock gate situated in a drop chamber to control water levels in Loe Pool.


Outlet energy dissipation basin; wall reinforcement and precast baffle Courtesy of Arcadis


Outlet working platform Courtesy of Arcadis

Inlet trash screens and block stone retaining wall to approach channel Courtesy of Arcadis



Inlet penstock operating mechanism and telemetry control cabinet Courtesy of Arcadis

However, these had fallen into disuse and had remained recessed in the bottom of the drop chamber for a number of years. Stoplogs were now introduced into the southern channel to replace the rising penstock gate. The intention is that more stoplogs are installed during the winter to increase water levels and are removed during the summer. The southern side of the inlet chamber was demolished and rebuilt around the new emergency relief culvert.

A slot was introduced into the roof of the chamber to allow for the installation and subsequent replacement of a penstock gate over the mouth of the culvert. Thus, in the event of flood warning, the outlet can be uncovered by excavation, stoplogs can be removed entirely and the penstock opened to maximise the flow capacity in the outlet system, hence reducing pool levels and creating a reservoir 'buffer' to prevent rising water levels in the River Cober from causing flooding in Helston.

Block stones were placed along the approach channel from Loe Pool to the inlet channel to help keep the channel open as wind-blown sand frequently creates blockages during winter storms.

As a final addition to the system, telemetry powered by photovoltaic cells was introduced into the relief culvert to monitor flows and notify the EA if any part of the system had become blocked so that a crew could be dispatched to clear the blockage.

Environment

Couch grass on the Bar had to be translocated during construction as it is an important habitat for the rare rustic sandhill moth. In addition, an invasive species (hottentot fig) was present on the cliffs immediately to the north of the site. This had to covered with sheeting to prevent its accidental spread and the sheeting disposed of after construction completion.

The scheme was successfully completed by the summer of 2019 in time to help mitigate the effects of heavy river flows experienced early in 2020.

The editor and publishers thank Nigel Horwell, Associate Technical Director with Arcadis Consulting (UK) ltd, for preparing the above article for publication.

Inlet trash screen and channel - Courtesy of Arcadis