

Granary Culvert

innovative precast design solution to protect 260 properties from catastrophic flood risk in the event of culvert failure delivered within a 12-week programme

The Granary Culvert is a 60m long channel with a 6m span. It has a 2.5m headroom and forms a section of Worsley Brook. The 150 year-old brick culvert had suffered structural defects. These included some full section cracking, ring delamination, heavy deformation to the barrel, and rotation to the abutment. Sections were in such poor condition that the Environment Agency had declared “red zones” to prevent personnel access. The busy B5211 Barton road runs adjacent to Granary Culvert. This key local route links Worsley with the M60 Manchester Outer Ring Road. Surrounding the culvert are offices and residential properties meaning any collapse would have a catastrophic effect on the 11,000-strong surrounding community. This includes 260 properties that would be at risk of flooding if a failure occurred.



GHD designed a precast solution that improved workforce safety by reducing time spent working within confined spaces

Background to the works

The repair to Granary Culvert was part of a much larger Environment Agency Water and Environment Management (WEM) framework scheme. This had been awarded to VBA, a joint venture between VolkerStevin, Boskalis Westminster, and Atkins. The larger scheme covered repair works to Bridgewater and Granary culverts on Worsley Brook.

Due to its complexity, VBA awarded the £895,000 Granary Culvert section of the project to VolkerBrooks based on their specialist expertise. The intricacy of works undertaken required a collaborative approach from a fully integrated team. This delivery team included the Environment Agency, VBA, VolkerBrooks and GHD.

The challenge

VBA's winning tender was based on a concept to strengthen the culvert using a sectional steel liner. They chose this solution to provide safe cover for the workforce during installation. Due to the red zones, the “no person-entry” was an important part of the contract.

The main challenge centred on ensuring construction work could be carried out safely inside the defective culvert. This was a designated confined space and the work needed to be delivered within a tight programme to minimise local disruption. The team opted for an alternative precast concrete solution. This would provide the same level of protection to personnel as the concept solution but would be more achievable within the tight 12-week programme. This was critical to achieve with further works planned affecting the highway.

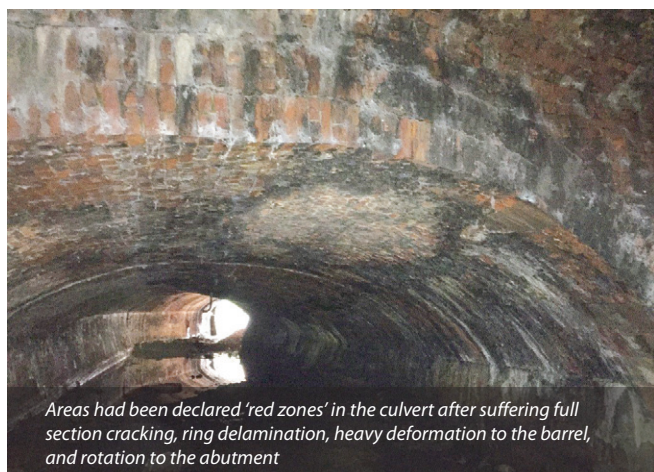
Design and construction

Instead, the team developed a solution using bespoke arched precast concrete units to line the culvert. This solution provided the required strength without the need for restrictive core propping. The units also acted as a shield to protect personnel during the construction.

In total 36 (No.) bespoke concrete sections were lifted and placed to line the defective areas of the culvert and minimise the risk of flooding to nearby properties.

GHD and VolkerBrooks developed the culvert design with cognisance to the manufacturing process (formwork striking forces), transportation and handling (lifting anchors) and permanent location. The culvert ran adjacent to heavily trafficked highways and was to be designed to support permanent loadings from vehicles and backfill materials. The collaborative approach was continual throughout the project with all GHD designs independently reviewed by VBA to ensure compliance with the contract and the wider catchment.

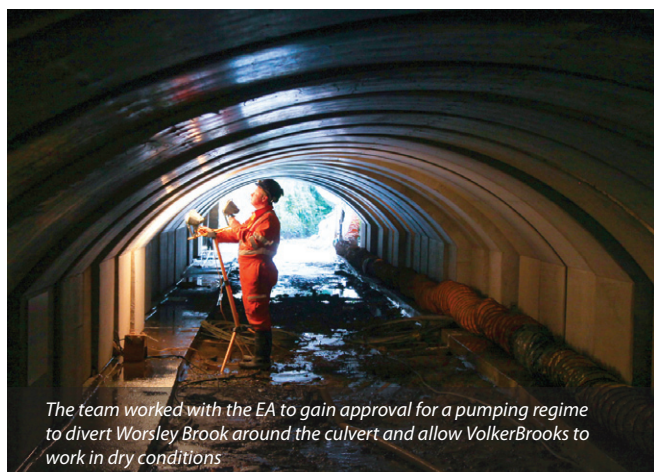
The design balanced permanent and temporary works parameters to maintain the channel area of 6.0m². Due to the use of precast concrete the prescribed roughness coefficient of 0.03mm was not achieved, however VBA assessed the hydraulic capacity of the culvert and by making changes to the bed slope could achieve the required capacity. This ensured the solution delivered the specified hydraulic performance.



Areas had been declared 'red zones' in the culvert after suffering full section cracking, ring delamination, heavy deformation to the barrel, and rotation to the abutment



VolkerBrooks put temporary traffic lights in place to protect passing pedestrians and motorists while work was carried out



The team worked with the EA to gain approval for a pumping regime to divert Worsley Brook around the culvert and allow VolkerBrooks to work in dry conditions

Concrete specification

High strength concrete was specified for the bespoke culvert units; this allowed early demoulding to speed up the manufacturing process. The fast track construction method used precast technology to reduce the amount of time required for confined space working.

GHD designed the short section of temporary support inside the existing culvert to ensure safe access for VolkerBrooks' installation team. This used modular frames that were within the manual handling limit. The solution allowed manual erection and installation within a confined space with limited room to manoeuvre.

The team also delivered a permanent formwork solution during concreting and grouting operations. The team connected the new units into the existing culvert by forming an arched structure in brickwork at the outlet to match the existing structure. At the inlet to the culvert, two flume walls ensured that the hydraulic design requirements were met.

The team also minimised imported materials by stabilising silt from the river bed using cement and lime. They then reused this as fill material in the void around the precast units. As a result, only 20 tonnes of contaminated materials were taken from site for further processing.

Collaborative project management

The project team adopted a fully integrated approach to design. This included combining permanent and temporary works designs, assuring buildability, and incorporating construction sequencing.

The team worked closely together, coordinating multiple disciplines to carry out collective reviews. This involved considering all structural load cases during transportation and handling.

By developing a precast solution, the team minimised road closures. As a result, they alleviated potential disruption for commuters along this busy road.

Workforce and public safety

The team incorporated measures to protect public and workforce safety from design into delivery. These measures included safe confined space working through structural designs and traffic control measures during construction work.

Workforce safety: VBA's confined space-trained structural engineers inspected the culvert to establish the temporary works design and confirm exclusion zones. GHD then designed temporary propping for the areas of the culvert where access was critical. This included areas where the team would carry out further inspection and subsequent installation work. The temporary propping designs used modular frames to improve installation efficiency.

Throughout design and delivery, the project team incorporated a safety in design approach. This spanned from revising the client's original sectional liner concept solution to refining the precast design. GHD reduced the weight of the precast units by changing the precast concrete invert to pumped fibre reinforced concrete. This reduced manual handling risk and avoided reinforcement fixing in the confined space. VBA reviewed the GHD design to ensure the works complied with the WEM framework health and safety code of practice - *Safety is Paramount*.

Public safety: With the scheme located in a busy residential area and along a key local route to the busy M60 motorway, public protection was at the forefront of delivery. VolkerBrooks ensured the safety of passing pedestrians and motorists by putting temporary traffic lights in place between 9:30am-3:30pm on Barton Road each day. They also provided local businesses and residents with alternative parking options to minimise disruption during the works.

VBA also undertook a public safety risk assessment to ensure that the public was protected within the Worsley Brook area as it is a Flood and Coastal Risk Management site.

Precast unit installation

The use of precast culvert units eliminated temporary shuttering and fixing rebar to form the new lining. This solution was much more cost effective and less time consuming compared to in situ reinforced concrete construction.

The units were lifted into place by a crane working within a lane closure. Working area constraints were dictated by the location and agreements with the highway authority. This meant that each unit had to be designed within a 4T crane lifting capacity. The installation process involved lifting the units onto polytetrafluoroethylene (PTFE) rails in front of the culvert. These Teflon rails reduced frictional resistance and were used to pull the units into position using Tirfor® machines. Once positioned, 400m³ of free-flow concrete was pumped into the void between old and new culvert.

Environmental and ecological protection

The team developed a bespoke environmental management plan for the project. This highlighted the key risks to be managed including minimising impacts on local wildlife and the watercourse itself. This covered bats, fish, and culvert diversion approvals.

Pre-design survey work had identified the presence of bats in the area. As part of the solution, the team installed screens at the entrance and exit of the culvert to ensure bats did not get trapped in the working area. Bat boxes were installed in the culvert to meet Natural England licence requirements.

Safe working relied on the culvert being repaired in dry conditions. To facilitate this, the team worked closely with VBA and the

Environment Agency to gain approval. This involved developing, designing, and delivering an approved pumping regime to divert Worsley Brook around the culvert. As a result, the new units could be installed safely in dry conditions.

VBA's design also included gravel traps for installation on the riverbed with GHD designing the connection detail. These gravel traps help encourage fish breeding, restore the habitat, and by extension improve the biodiversity and ecological profile of the area.

Conclusion

VBA, VolkerBrooks and GHD's collaborative approach to safety, efficiency, and value drove successful delivery of the scheme. Having already improved efficiency by using precast units, the 36 (No.) sections sat on an in situ concrete slab reinforced with steel and polypropylene fibres. This eliminated the need to fix traditional reinforcement within the culvert, reducing health and safety risks to the workforce and speeding up construction.

Despite the confined space and safety challenges, the team completed the works within a tight 12-week programme. This was critical to the project by finishing in time to avoid further works planned affecting the motorway and ensure the improvements were winter-ready for the local community's peace of mind.

The culvert repair was completed within the shortest possible timescales with zero accidents or incidents. This was testament to the team's stringent approach to safety, proactive discussions with local authority highway engineers and ongoing collaboration with the local business and residential community.

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VolkerBrooks installed 36 (No.) precast units within a lane closure on the busy adjacent road