LITTLEBOROUGH CULVERT

TEMPORARY DEWATERING FOR THE CONSTRUCTION OF A BOX CULVERT DURING A 4-DAY RAILWAY BLOCKADE

GROUNDWATER SPECIALISTS

CLIENT

MURPHY
WORLD-CLASS INFRASTRUCTURE

FLOOD RISK

Rochdale and Littleborough in Greater Manchester are at risk of flooding, with several significant flood events occurring in the past 20 years.

As a result, improvements to infrastructure are necessary to reduce the risk of flooding in the future, particularly as climate change is increasing the likelihood of flood events occurring.

The River Roch, Rochdale and Littleborough Flood Risk Management is a partnership project between the Environment Agency (EA) and Rochdale Borough Council to address the high flood risk to the areas of Rochdale and Littleborough in Greater Manchester.

BACKGROUND

Part of the scheme to address the high flood risk to the areas of Rochdale and Littleborough involves construction of a flood overflow channel beneath the Calder Valley railway line. The railway line is a busy line with passenger and freight trains that travel between Manchester and Leeds with trains passing at least every 15 minutes.

The flood overflow channel comprises a box culvert which will connect two storage reservoirs on either side of the railway. The storage reservoirs are designed to store significant amounts of water in the event of a flood.

Because the box culvert is required to go beneath the railway line, Network Rail are responsible for undertaking the construction works. Network Rail appointed its framework contractor (J. Murphy & Sons) and their designers (Arcadis) to design and build the flood overflow channel which comprises the installation of a 45m long precast concrete box culvert.

The construction of the box culvert required the closure of the railway line. The works were undertaken at the end of October 2021 when there was a 4-day railway blockade during which the railway lines was removed, ground excavated, the box culvert installed, and the railway line reinstated. Due to the time critical nature of the construction project, the works had to be thoroughly planned in advance to reduce the risk of any delay.

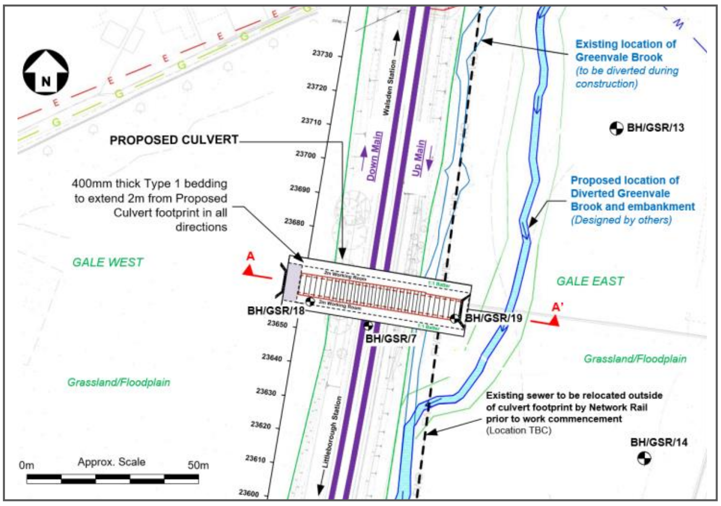

Fig. 1 Plan of Site with location of proposed Box Culvert

THE SITE

The site lies within the centre of the upper Roch Valley. Between the hills and through the site flow both the River Roch and Greenvale Brook.

Beneath the site lies alluvium consisting of interbedded clays with sand and gravels. Underlying the alluvium is a thick buried glacial channel comprising a sand and gravel aquifer.

Site investigation in the area revealed flowing artesian groundwater which is seeping towards the ground surface. Groundwater upwells at a spring located at the south of the site.

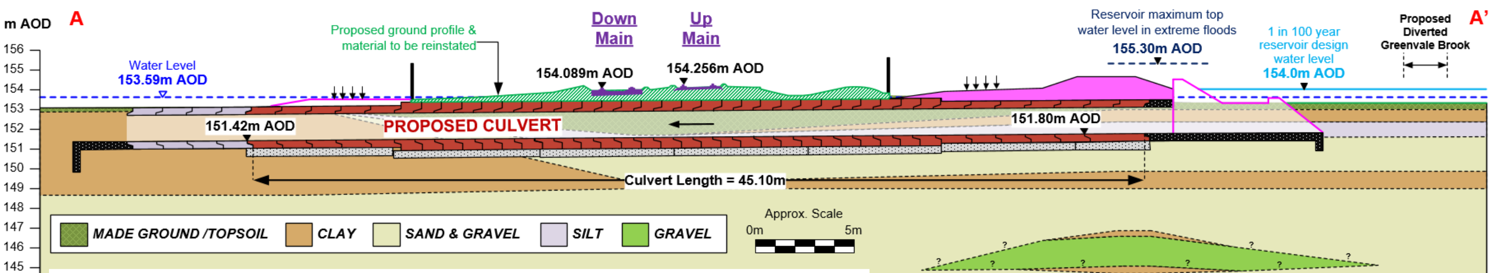

Fig. 2 Conceptual Model of Proposed Box Culvert - Cross Section A - A'

DEWATERING REQUIREMENT

With flowing artesian groundwater conditions at the site, it became clear from an early stage that dewatering would be required to enable the construction project to be completed without delay during the 4-day railway blockade.

JMS brought OGI on-board early in the project planning stage for our specialist technical advice and guidance in groundwater management and control.

Together with JMS, OGI developed a scope of works to support JMS with groundwater management throughout the project lifecycle.

This included test pumping design & analysis, Environment Agency permitting assistance, dewatering system design, railway embankment settlement analysis, site presence during the works, and finally decommissioning advice at the end of the project.

TEST PUMPING WORKS

Undertaking test pumping is critical to understanding the hydrogeological properties of the aquifer beneath the site, and for discussions with the Environment Agency when applying for an Abstraction Licence.

Aquifer transmissivity is the most important parameter to establish as this enables the calculation of total abstraction rate for various dewatering system designs.

Five separate tests were undertaken over four days, with a daily groundwater abstraction of less than 20m^3. Test pumping was undertaken on both sides of the railway line because the ground conditions were variable across the site. The results indicated that the ground was highly transmissive meaning abstraction rates were likely to be significant during the main works (within the range of 20 to 40 Lit/s).

The results from the test pumping informed all of OGI's work that followed after, including discussions with the EA and detailed groundwater control system design.

ENVIRONMENT AGENCY PERMITTING ASSISTANCE

Groundwater abstraction for temporary dewatering became a licensable activity in 2018. Construction sites that plan to abstract more than 20m^3/day of groundwater must have an abstraction licence from the Environment Agency in place. In addition, if the abstracted groundwater is to be discharged to a surface water feature such as a river or stream, then a discharge permit must also be in place.

As the soils beneath the site comprise of a sand and gravel aquifer, it was clear from the beginning of the project that an abstraction licence and discharge permit would be required to enable dewatering to be implemented on the project. OGI acted as groundwater agents to JMS on the project, which involved liaising with the EA throughout the project on their behalf.

This involved submitting a pre-application advice request at the beginning of the project, followed by preparation of the abstraction licence and discharge permit applications. Using the results from the test pumping, OGI assessed the likely abstraction and discharge rates for the dewatering system and used this to complete the EA forms. OGI prepared all the forms and supporting information and submitted these to the EA on JMS's behalf. Following the submission of the applications, OGI continued to liaise with the EA throughout the determination period and offered advice to JMS on how to work within the conditions of the abstraction licence and discharge permit.

GROUNDWATER CONTROL SYSTEM DESIGN

Following the test pumping works, OGI designed a groundwater control system to enable construction of the box culvert in dry and stable ground conditions. The groundwater control system had to meet the following primary objectives, based on a water level at ground surface:

- Lower the groundwater level in the upper 4.0m of silt, sand and gravel deposits (i.e., alluvium) to minimise groundwater inflows entering the excavation during construction of the box culvert.
- Lower the artesian piezometric head in the deeper sand and gravel deposits (buried glacial channel) to prevent hydraulic heave failure during excavation and construction of the box culvert.

To achieve these primary objectives, the groundwater control system design comprised the following items:

- Active suction dewatering system with 59 No. drilled suction wells located around the perimeter of the excavation and the Network Railway boundary fence.
- 7 No. monitoring wells to assess both the performance of the system and the groundwater levels beneath the live railway line.
- 2 No. recharge wells to enable discharge to ground to satisfy the EA abstraction licence conditions.
- Filtered sump pumping to control any residual perched water ingress and rainfall.
- An Inspection, Testing and Monitoring (ITM) Plan.

Dewatering Wells were strategically placed along the sides of the excavation batters and parallel to the railway line to ensure sufficient drawdown at the centre of the railway line where no wells could be placed.

Perched water was identified as a major risk to the project.

Once excavation works at the railway commenced, there would be no time to implement mitigation measures. Placing wells along the Network Rail boundary fence helped mitigate against the risk of perched water.

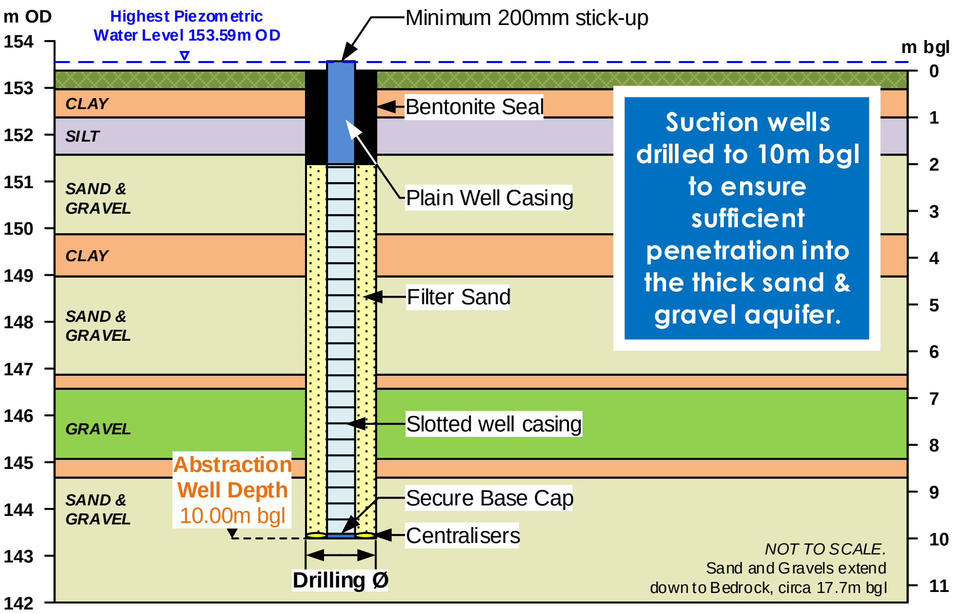

Fig.2 Suction well construction and site geology

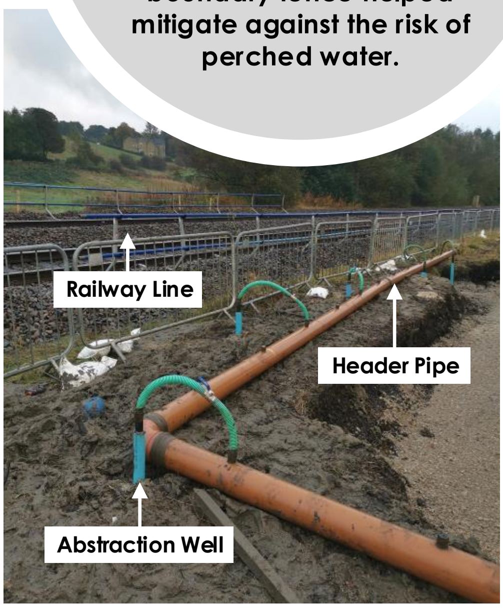

Fig.3 Dewatering Well System

MATHEMATICAL MODELLING

OGI undertook modelling of the groundwater control system to simulate the predicted groundwater level beneath the railway embankment during dewatering to ensure the system would meet the design objectives. Due to the strict 4-day blockade for the completion of the main works, there was no time for design modifications once the system was up and running. Groundwater modelling in advance helped create a robust and reliable design, ensuring no groundwater issues were encountered during construction within the railway blockade.

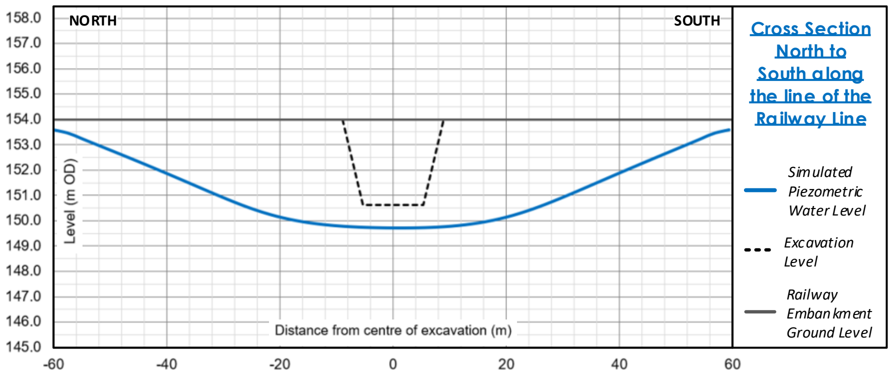

Fig. 4 Modelling of the Water Table at the centre of the Excavation

SETTLEMENT ANALYSIS

When working within proximity to a live railway line, any works that may have an impact on the live running are required to be checked in detail in advance.

For the dewatering works, an assessment of possible ground settlements at the railway embankment was required.

The purpose of this assessment was to estimate the ground settlement as a consequence of lowering the water table beneath the excavation.

OGI undertook calculations for a range of soil conditions and water table conditions. The results suggested settlement could be up to 30mm.

As a result of the findings, JMS implemented a thorough track monitoring plan to monitor any movement in the railway embankment during the dewatering operation.

SITE WORKS

In the 4 weeks leading up to the railway blockade, the wells for the dewatering system were drilled and installed by Alba Dewatering Services. Once all wells were installed, the suction pumps were connected to the wells via the connecting pipework.

Prior to switching on the dewatering system, a phased approach was agreed between OGI, Alba and JMS. This was to ensure the water table did not draw down beneath the railway line too quickly.

Firstly, some of the wells on the south side of the railway were switched on. The groundwater was monitored in the monitoring wells over a period of 1 hour before switching on some of the wells on the north side.

The selection of wells was chosen to mitigate any risk of differential settlement which could cause track bending. The water level was drawn down to 1.0m below the excavation level within two to three days of the pumps turning on.

Once the dewatering system had been operational for several days, a large trial pit was excavated to check the ground conditions. The ground was shown to be dry, which demonstrated that the dewatering was performing as designed and the remaining excavation works could progress on the east side of the railway prior to the blockade.

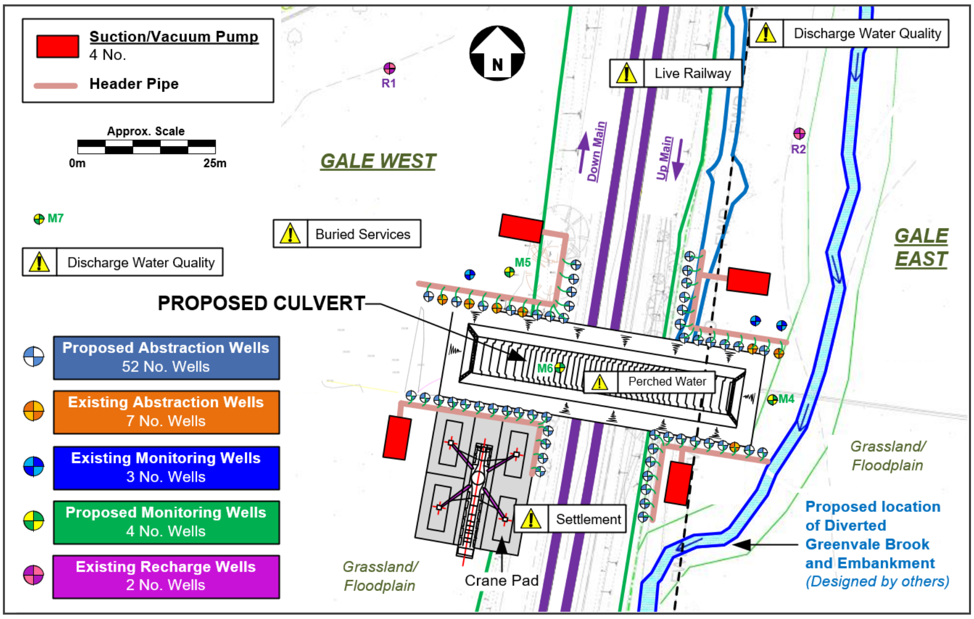

Fig.5 Plan of Site with location of Dewatering Well System

Fig.6 Trial Pit prior to Blockade

Fig.7 Commencement of Railway Blockade

SITE WORKS

During the blockade, the dewatering system continued to work effectively, resulting in a dry and safe working environment for the works to proceed at pace. The box culvert was installed within the excavation, the ground backfilled and the railway was back operational as planned at the end of the railway blockade.

The project demonstrates how careful and thought-out planning of the groundwater management can lead to successful implementation of dewatering and the overall successful delivery of a project, particularly when groundwater poses a significant risk like it did during this project.

Fig.8 Excavation Works in dry ground

Fig.9 Backfilling of Excavation

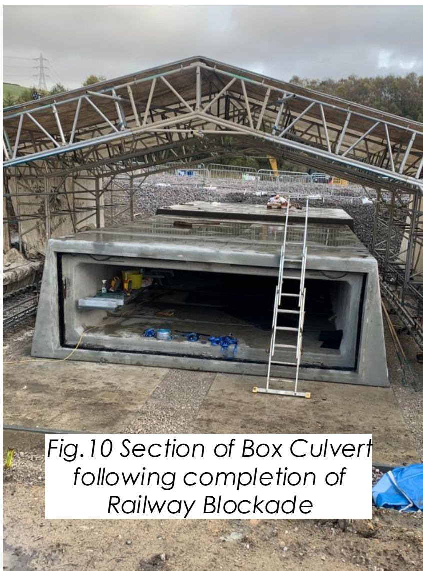

Fig.10 Section of Box Culvert following completion of Railway Blockade