Managing the impact of HS2 on London's urban drainage network

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Abstract

Approximately 23km of London's urban drainage network is affected by the construction of High Speed 2 (HS2). MWH are working closely with HS2 and Thames Water Utilities Limited (TWUL) through the eight$_2$O alliance[1] to ensure that all drainage assets along the route are safeguarded. The impact is extensive, complex and is providing some unique challenges. This paper presents the approach that HS2, MWH and TWUL have taken to understand this complex and challenging programme of work, together with the systems and processes driving its efficient delivery. Two live project examples are used to highlight some of the specific challenges being faced by the design and construction teams.

Introduction

North London's sewer network is based around Sir Joseph Bazalgette's Victorian interceptor sewers, which transfer waste water across the city to East London for treatment. Over the years, the network has been extended and upgraded, leaving TWUL with an asset base which varies greatly in age, material and condition.

In February 2017, the Hybrid Bill for Phase 1 of HS2 gained Royal Assent from Parliament, paving the way for construction of the UK's new high speed railway. Enabling works for the project have begun, with main railway construction works due to start in 2018. The new railway will cross a significant area of London, intersecting a large number of critical third party assets, including a large portion of TWUL's sewer network and some of the largest trunk sewers in the UK. Between Central London and the M25 motorway, the majority of the HS2 route runs in twin tunnels, passing beneath TWUL's assets at varying depths.

Extensive upgrades are planned at Euston Station and a major new station is proposed at Old Oak Common to provide an interchange with Crossrail and the Great Western Main Line. A number of tunnel vent shafts and portals will link the new surface and subsurface infrastructure. Although these cover a relatively small proportion of the route, the impact of their construction on the sewer network is complex. MWH are engaged through TWUL's eight$_2$O alliance to lead and deliver a programme of works to assess impacts and develop monitoring and mitigation solutions.

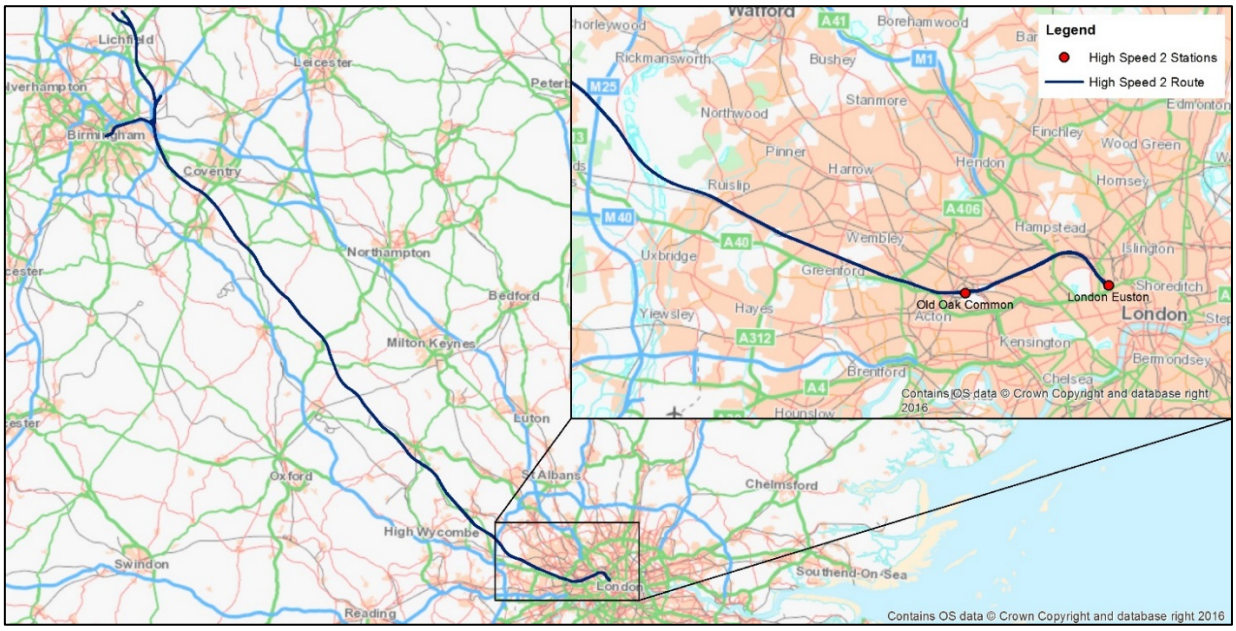

Figure 1 - HS2 Phase 1 route plan, inset showing the route within London

[1] The eight$_2$O alliance is TWUL's Capital Delivery vehicle for AMP6 and is made up of eight partners: Thames Water Utilities Ltd, Skanska, MWH Global (now part of Stantec), Balfour Beatty, Costain, Atkins, Black and Veatch and IBM.

Asset impacts and assessment

Assets are affected either through direct or indirect impacts. Direct impacts are caused by spatial clashes with new structures, such as station buildings, tunnel portals, retaining walls and vent shafts. These impacts require the diversion or realignment of assets in advance to accommodate the works. Indirect impacts are caused by ground movements resulting from tunnelling and other construction work. Assets affected by these impacts will require monitoring, protection (lining), or in the worst cases, replacement using new assets designed to withstand the predicted ground movements.

A Damage Impact Assessment is required to determine the level of mitigation for each asset. This process predicts three dimensional ground movements caused by the planned construction works and uses these to assess potential damage to existing assets from the assessment of joint 'pull out', joint rotation and strains imposed. Movements can be complex depending on the nature of the works and the acceptable level of strain and joint movement varies depending on asset size, material, joint type and condition. MWH and HS2 are currently reviewing recent projects, such as Crossrail, to incorporate lessons learnt and current best practice for Damage Impact Assessment.

In terms of tunnelling impacts, the magnitude of the movement is dependent on the tunnel diameter and shape, depth, construction method, ground material properties and the presence of other nearby man-made structures. Analysis of these impacts has recently begun by geotechnical consultants employed by HS2 and results are currently being reviewed by MWH specialists to allow mitigation measures to be agreed.

Current scope and activities

The HS2 Advance Works contract has been ongoing since July 2015, and considers all TWUL water and wastewater assets crossed by HS2. Sewers range in size from 100mm to 3m in diameter and water mains range from 90mm to 2.5m in diameter. Initially, working with HS2, MWH assigned criticality to assets based on their strategic importance, operational risk, construction complexity, size and the magnitude of interaction with HS2's works. This was achieved through extensive early engagement with HS2, TWUL and other key stakeholders, with numerous joint workshops carried out. The criticality rating has been used to prioritise assets for design development and surveys.

The current scope of work can be broadly broken down into 4 key areas:

- Input into Coordinated Utility Designs - Drawing on MWH's extensive experience working on challenging projects in subterranean London (Figure 2a), the team are currently advising HS2's consultants and contractors on complex sewer diversions, including Coordinated Utilities Designs for the new station at Old Oak Common and the redevelopment of the existing Euston Station. The Euston Station area contains approximately 60 affected TWUL assets, which are subject to a Coordinated Utilities Design, along with a multitude of other utilities (Figure 2b). These include a number of large strategic sewers, one of which is a branch of the Fleet Sewer.

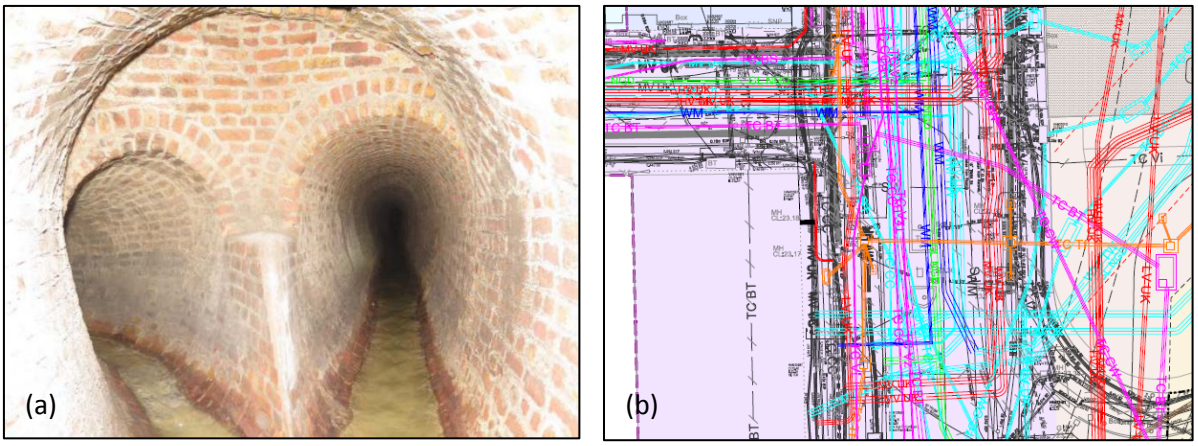

Figure 2 - (a) Typical Central London brick egg sewer junction (courtesy of TWUL) (b) Extract from the proposed Euston Station Combined Utilities Design, showing the complexity of utilities in this area of London (courtesy of HS2)

- Feasibility Assessments - These assessments are based on HS2's Hybrid Bill proposals for utility works, which were developed following an outline Damage Impact Assessment completed by HS2's consultants in 2013. The new assessments involve reviewing proposed outline asset mitigation solutions, highlighting risks, constructability issues and hydraulic impacts through modelling. Findings, survey requirements and alternative solutions (if required) are presented in concise reports and drawings. In just 12 months, outline mitigation solutions have been reviewed for 270 assets. Mitigation measures range from asset monitoring through to protection by lining, or replacement. To overcome the challenge of managing hundreds of assets across multiple locations, a bespoke design process has been developed and agreed by all parties. The process extensively utilises tablet data collected during site visits to highlight constructability issues and significant risks. This in turn enables global working by utilising MWH's offshore design hub in India. Catchment wide hydraulic modelling allows the combined effect of mitigation measures to be fully understood. Of these assets, 30 were agreed to be the most critical and more detailed assessments have been carried out, which include input from specialists, a team of construction advisors and TWUL Operations and Asset Management.
- Outline/Detailed design - Of the 30 assets mentioned above, six have been instructed as projects for direct delivery by TWUL through the eight$_2$O alliance. These schemes are at various stages of design and include the larger of the affected trunk sewers. One of most challenging is the Mid-Level No.2 sewer just north of the new Euston tunnel portal.
- Asset Surveys - To enable further design and to inform Damage Impact Assessments, a large number of sewer surveys are required. The eight$_2$O alliance is managing this significant programme, which includes CCTV, manhole surveys, flow monitoring, core sampling and laser scanning to accurately determine alignments.

Mid-Level No. 2 sewer protection (indirect impact)

HS2 tunnel boring machines are planned to pass just three metres below this 2.1m diameter interceptor sewer, which is 18m deep below the Euston Station approach tracks. The sewer was constructed in 1907 and is a 7ft (2134mm) diameter circular brick lined structure (Figure 3a). There are significant challenges in managing high flows during any potential works and accessing this deep sewer. As the intersection point (Figure 3b) coincides with the existing deep railway cutting, access to the sewer will only be possible on either side of the impact zone in the highway between properties and the existing railway cutting. The sewer's peak Dry Weather Flow rate is around 1000l/s and storm flows are predicted to be approximately 5000l/s during a 1 in 10 year storm event. MWH are currently reviewing a number of different options to protect the sewer from the expected ground movement, including using a metallic / composite lining system, or a new tunnelled diversion.

Figure 3 - (a) Recent survey photo inside the Mid-Level No. 2 sewer (Courtesy of TWUL) (b) Plan showing the intersection between the proposed HS2 tunnels and the Mid-Level No. 2 sewer (Bing Maps imagery)

Fleet sewer (Argyle and Savoy Street branch) diversion (direct impact)

Beneath the highly traffic sensitive Euston Road, the Argyle and Savoy Street branch of the Fleet Sewer runs in a narrow gap between the London Underground Metropolitan line and the basement of a listed building (Figure 4a & 4b). The 4' X 2'8" (1219mm X 813mm) brick egg sewer was constructed circa 1860 and has been realigned twice before, once for the construction, and again for the expansion of Euston Square Underground Station. HS2 plan to construct new tunnels to provide a pedestrian subway link between the underground station platforms and the upgraded Euston Station. There is a direct impact with the new subway structure, requiring the sewer to be realigned. The sewer is a major constraint on HS2's work in the area and this key diversion is being coordinated with other major HS2 utility and station construction works. MWH are advising HS2 on options and producing an outline design for the diversion, which must also link with another 1500mm sewer diversion around the new Euston Station box structure. A large bespoke manhole will be required to connect the two sewers and allow a live connection beneath this critical road. This vital element of design work is being carried out early to inform other Euston Station consultants and contractors.

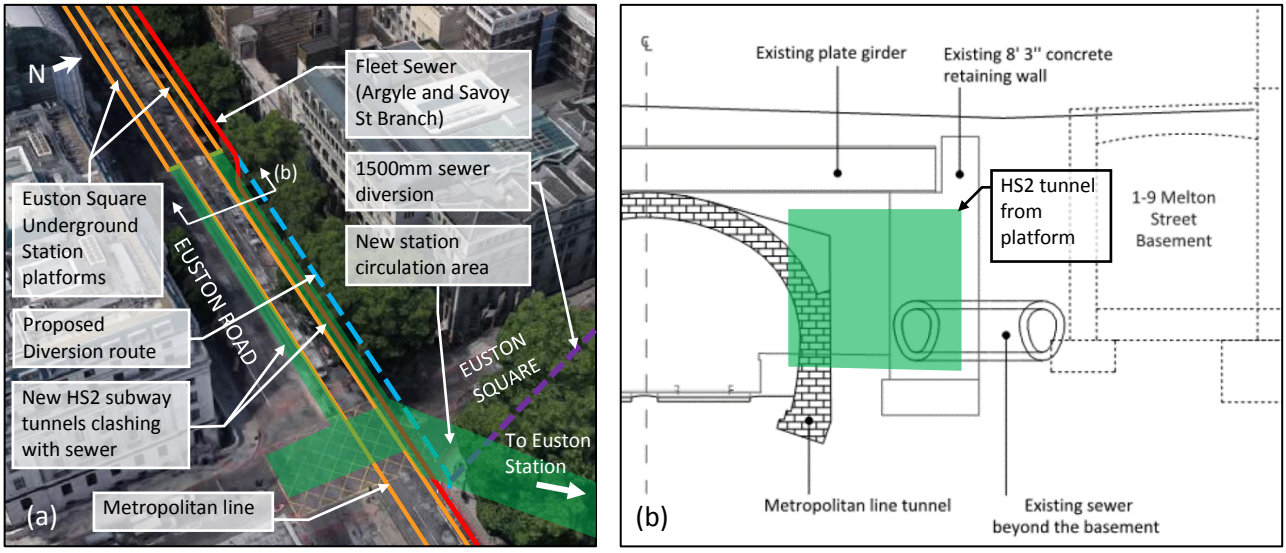

Figure 4 - (a) The Fleet Sewer (Argyle and Savoy Street branch) in Euston Road showing the Metropolitan Line and the sewer diversion route (Google Maps imagery) (b) Cross section (looking west along Euston Road) of the sewer, basement and Euston Square Underground Station (courtesy of HS2)

Conclusions

Still in its infancy, this complex programme of HS2/TWUL works is extremely challenging and will continue throughout the HS2 construction programme in London. Only through careful and effective management and planning will TWUL's assets be successfully safeguarded to guarantee their use for future generations. An integrated approach between HS2, MWH and TWUL is essential to ensure the success of this programme of work, which will have direct bearing on HS2's ability to successfully deliver key construction milestones in London. Further north along the route, HS2 impacts on other water and wastewater companies. MWH is also working with Severn Trent Water on a similar programme of work, ensuring that HS2 achieve a consistent route wide approach for the protection of wastewater assets.

Acknowledgements

The authors would like to thank the project funders, HS2 Ltd, the existing asset owners, TWUL, and the wider eight$_2$O team.

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