Knightcott to Banwell (M5) Sewer Repair

collaboration between agencies to renovate strategic sewer under the M5 motorway in Somerset

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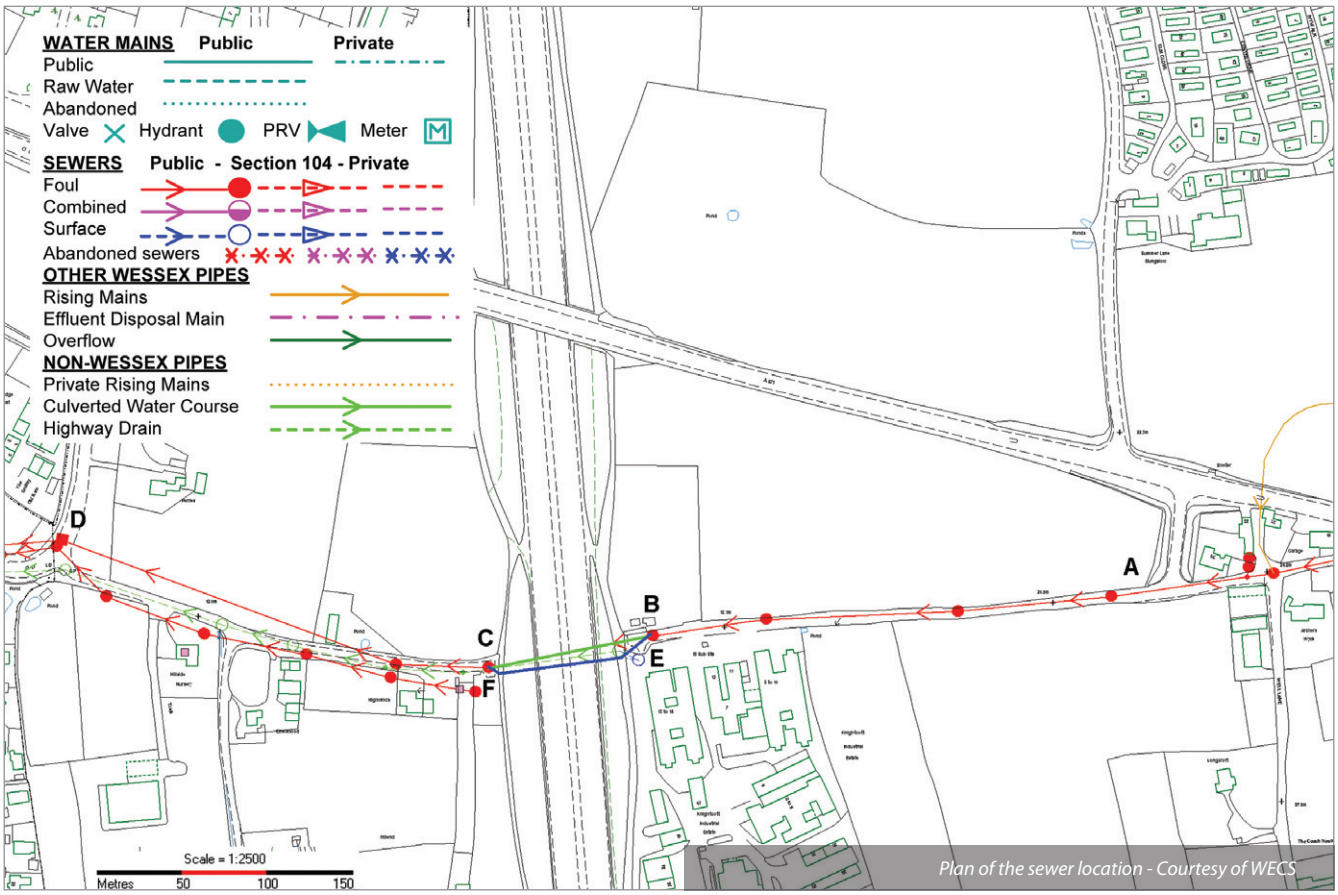
Any cementitious pipelines in a sewerage environment are susceptible to hydrogen sulphide (H_2S) attack; the action of the bacteria and H_2S forming sulphuric acid which corrodes the exposed surface above the waterline, destroying pipe strength and integrity. Wessex Water has a programme of surveying strategic sewers and pays particular attention to concrete and asbestos cement pipelines, especially downstream of rising main outfalls, where sewage can rest in long rising mains at certain times of the year undergoing natural anaerobic decomposition, resulting in the production of H_2S. It was during a resurvey in Autumn 2012 of the Banwell sewer in Knightcott, Somerset, where severe corrosion of the soffit of an AC pipe was identified. The sewer is located at the downstream end of a long dendritic sewerage network serving several villages, each pumping sewage on to the next, before it reaches the sewer in question.



Plan of the sewer location - Courtesy of WECS

Working in collaboration

The sewer was located in a narrow, single point access to a large industrial estate which fell within the jurisdiction of North Somerset Council, which, like Wessex Water, is committed to high standards of customer service. A natural collaboration between the two organisations quickly developed when Wessex Water explained the need for the emergency renovation of 780m of 375mm diameter AC sewer, circa 1960, routed from point (A) down to the industrial estate, under the M5 motorway (B – C) and across fields to 'Devils Elbow' at (D) as shown on the plan above.

The council's senior highways engineer challenged Wessex Water to devise a trenchless solution that would mitigate the effects of the work on residents, commuters and local businesses and responsibility fell to Wessex Water's renovation team to meet stringent requirements.

The design and construction proposal

A road closure was required and agreed with the local councillors at point (A). This would allow a very long eversion totalling 329m, of a traditional cured in place pipe (CIPP) polyester and resin liner, all the way to the motorway embankment at the bottom of the road leading to the industrial estate at point (B). The host pipe still retained residual strength and a partially deteriorated design based on the Timoshenko equation was proposed as an SRM Type 2 lining to BS EN ISO 11296 : part 4 : 2009.

In agreement with the council, the main works would be completed over a weekend when the industrial estate was closed. Wessex Water laid on a replacement small bus to convey children from the remote local villages around the lower Mendip hills to the Banwell school for the duration of the whole scheme, due to the confined and serpentine route of the necessary diversion route.

The motorway had been constructed over the route of the existing sewer in 1974, at which time they took the opportunity to increase the diameter of the AC sewer to a 1,050mm concrete culvert over the 60m width of the M5. This sewer was also found to have H_2S attack to the introdos. The hydraulic modellers at Wessex Water confirmed that a 300mm diameter pipe would suffice and consequently, it was decided that a 360mm ID UV cured high glass content liner would be installed along the low flow channel under the motorway which had a diameter of 375mm, the size from (A – B) and (C – D).

The Brandenberger lining was provided by Onsite, the framework contractor, and was installed and inflated within a continuous restraining jacket to prevent over expansion. An SRM Type 2 'fully deteriorated' design was required and had to allow for the overburden column load of material to the motorway surface, impact load of the traffic and the annular grout fill in its temporary fluid state, that was proposed to fill the space between the UV liner and the larger host pipe. Accordingly the design procedures of American standard ASTM F1216-09 was used to determine the capability of this liner against the loads which might be experienced in a variety of loading scenarios.

The calculations were complicated by the requirement from the hydraulics engineers to take advantage of a void by placing 2 (No.) HDPE ducts at high level above the UV liner as surcharge relief pipes. Due to the depth of the tunnel under the M5, the load due to soil burden did not significantly impinge on the new pipe/liner due to stabilisation of the existing pipe by filling with a stiff grout. Live loads from main road traffic, flowing along the motorway were negligible at this depth (less than 0.003MPa) according to the Simplified Tables of External Loads on Buried Pipelines, Department of Transport, Appendix II. The structural integrity of the corroded culvert was calculated by power washing the introdos and undertaking a laser profile to establish the degree of wall thickness diminution, all which was finally acceptable; see photograph right middle (Image and service by Exjet of Paignton, Devon).

The backgrouting pressure on the UV liner was not a real concern regarding the possibility of buckling. However, the short term elastic modulus of the plastic liner pipe was temperature sensitive and could have been affected by the heat of hydration of cementitious grout. Grouting in lifts provided the solution to minimising the heat generation effect, along with fans to pass air through the culvert and filling the annulus in three stages was required to allow the insertion of the high level surcharge relief ducts. Buoyancy of the pipes was prevented by balancing the depth of lift against the pipes temporarily filled with water during grout cure.

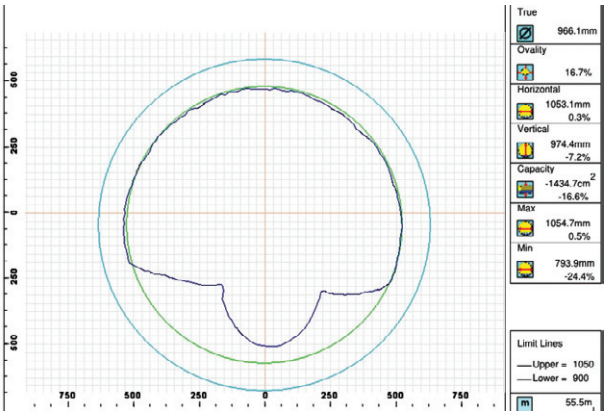
The liner design from point (C) to (D) downstream of the motorway matched the section upstream of the motorway.

Environmental aspects

A full environmental impact assessment was undertaken which identified only one concern. Over the 40 years since the motorway was constructed, time-consolidated road detritus had mobilised along the highway surface, collecting at the edge of the motorway, which was contaminated with lead. This was duly removed as special waste to ensure safety. Safety was of paramount importance; thus the regime of float grouting to limit man entry to the culvert during works.

The renovation team worked closely with the Environment Agency to initiate a Flood Defence Consent, and they agreed use of a parallel culvert for the transfer of sewage by over pumping. To achieve this, the team butt welded a single SDR17 HDPE pipe, 80m long with a 280mm OD, and winched it beneath the motorway (E–F).

Pumps were provided to by-pass the flow from the main culvert, one duty and one stand by, both connected by telemetry cell phone to Wessex Water's emergency control.



A view of the laser profile survey - Courtesy of WECS

1,050mm culvert with lower UV liner in place receiving flow and 2 (No.) HDPE surcharge relief pipes above awaiting grouting. Note the pump by-pass pipe to the left threaded through an adjacent EA culvert which had been transferring flow downstream prior to UV lining Courtesy of WECS

Inflated UV liner within a structural pre-liner as it passes along the floor of the culvert - Courtesy of WECS

Complications on site

Just prior to mobilisation to site in November 2012, there was a period of concentrated and high intensity rainfall over several weeks. This delayed works for a short period due to the effects of flooding, trapped upstream of the motorway.

The council was very understanding while working within the requirements of the Traffic Management Act and the HAUC legislation. The torrential flows had collapsed part of the soffit of the sewer leading to the industrial estate, but these were stable enough for an urgent re-evaluation of the partially deteriorated design converting it to a fully deteriorated design for full structural capability. Working with our contractor Onsite and lining supplier, Applied Felts, a thicker lining was procured to meet the programme.

The scheme was completed successfully on programme and to budget at around £272,000. All internal safety audits exceeded

the company's internal minimal compliance values with internal safety officers checking against health and safety legislation and compliance with CDM. Very few customer enquires were received, due to the extensive information signage supplied along the diversion routes, and this was reinforced by an extensive public relations brief which included:

- Press releases.
- Information to radio station traffic bulletins.
- Letters to all residents.
- Negotiations with local councillors.
- Details on the Wessex Water website including video graphics www.wessexwater.co.uk/trenchless.

Conclusion

This paper demonstrates collaboration between the local council and Wessex Water, with assistance from the Environment Agency, all of whom were keen to solve the problem quickly and efficiently.

Don Jest, Senior Engineer of NSDC, chose to use this particular scheme as an example of good practice at a quarterly HAUC utilities meeting. He congratulated all involved and encouraged other utilities to adopt this model of collaborative working, in the best interests of customers. He said: *"The council was delighted in the efficient way Wessex Water managed this scheme and consistently involved my officers, keeping them informed at all times."*

From the perspective of cost, this method of trenchless repair again proved extremely good value on unit rates, considering the location.

The Editor & Publishers would like to thank Julian Britton, Rehabilitation Manager, and Daniel Humphrey, Contracts Manager, both with Wessex Engineering & Construction Services, Wessex Water, for providing the above article for publication.

Eversion towers from which the lining is launched and the height is calculated to ensure enough head of water to drive the liner through the sewer and overcome any frictional losses - Courtesy of WECS