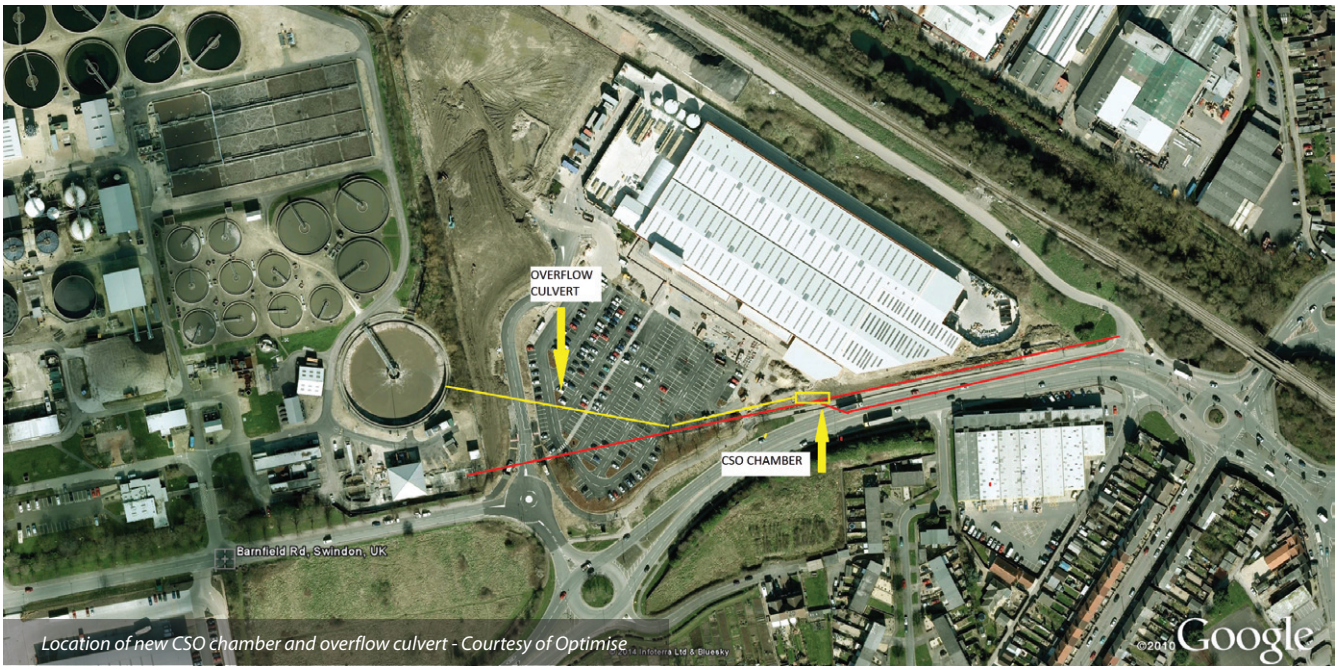
Swindon Networks Upgrade Project

design of combined storm overflow using a physical scale model

by Mike Stokes AMIStructE

The catchment served by Swindon STW is a future growth area with a population equivalent forecast of 224,000 PE (2026). The Swindon Networks Upgrade Project is being undertaken by Optimise on behalf of Thames Water to solve the historic foul flooding of domestic properties at Cheney Manor, Swindon, and to ensure all spills from the combined storm overflow and storm tank comply with the EU Urban Wastewater Treatment Directive (EU Directive No. 91/271/EEC 1991). The work is being carried out in consultation with two associated projects to solve the flooding around Cheney Manor and Rodbourne Road, namely; (i) upgrading of the existing Swindon STW inlet works and storm flow treatment, which is being undertaken by Black & Veatch on behalf of Thames Water, and (ii) surface water and highway flooding, which is being addressed by Swindon Borough Council as part of the Rodbourne Flood Alleviation Scheme.



Location of new CSO chamber and overflow culvert - Courtesy of Optimise

Background

The Rodbourne culvert has no spare capacity and its limited hydraulic capacity contributes to the flooding in the catchment upstream. The main existing culvert is a 3.5m wide by 1.1m deep reinforced concrete structure with minimal ground cover. No record drawings are available and the existing layout was obtained from on-site surveys. In Cheney Manor, the solution will remove a number of domestic properties from the Sewer Flooding History Database while not adversely affecting the flooding risks to other areas or properties in the vicinity.

Scope of work

The flooding is being resolved by the design and construction of:

- New pumping station at Cheney Manor.
- Upgrading of associated sewers and new rising main.
- Combined storm overflow (CSO) and mechanical screen on Rodbourne Culvert.
- Overflow culvert to Swindon STW storm tank.

The design and construction of the sewers and rising main had to deal with threading the new gravity sewers and rising mains through the extensive existing services, the existing foul culverts and an abandoned canal.

To avoid the existing services and reduce the road closures the pipes were installed with a combination of open cut trenches and "no dig techniques" using 600mm diameter auger bores.

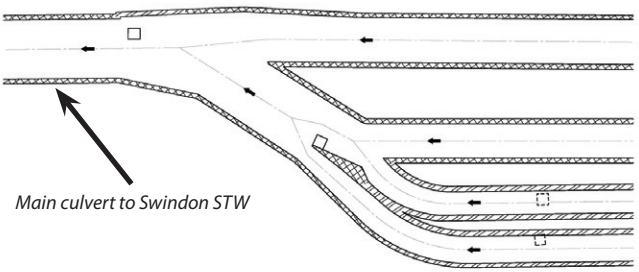
The design of the CSO was dictated by the hydraulic capacity of the sewerage network and the physical constraints and is covered in further detail.

Proposed solution for CSO chamber

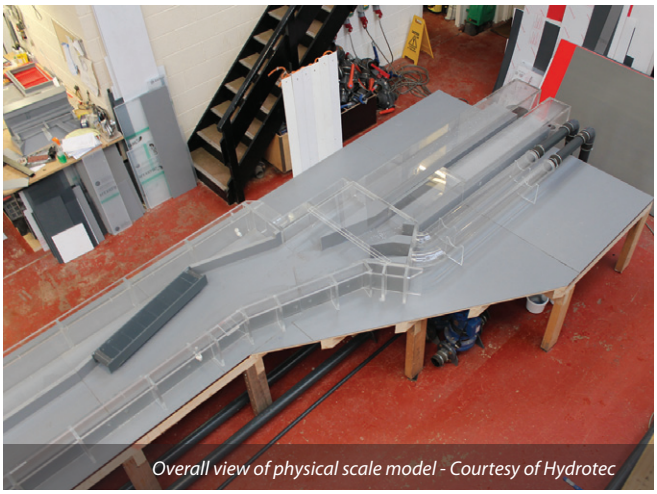
The network model confirmed that the flooding was caused by the hydraulic conditions at the convergence of the 4 main sewers and the relatively high level of the STW inlet channel. In order to maintain the dry weather flow of 780l/s and 1 in 30 year flows of 7,500l/s all proposed work would need to be carried out offline or by diverting the main culvert.

There is a separate project being carried out to upgrade Swindon STW inlet works and there is very little space within the site to divert or modify the main culvert.

After extensive Optioneering the only viable cost effective solution was to relieve the existing Rodbourne culvert with a new combined storm overflow at the convergence of the four main sewers and a new overflow culvert to the existing storm tank at Swindon STW.



GA of Rodbourne Culvert & converging sewers - Courtesy of Optimise



Overall view of physical scale model - Courtesy of Hydrotec

This dictated the location of the CSO chamber outside the Swindon STW boundary in an area owned by Swindon Borough Council with the overflow culvert passing under the B&Q car park.

To screen the spill flows of 2,500l/s, an 8,100mm long Stormgard powered screen from Longwood Engineering was identified by the design team from one of Thames Water framework suppliers.

CSO design

The design of CSO screens is based on the Wastewater Planning Users Group, Code of Practice (WaPUG, 2006) and one of the main requirements is to ensure that the flow and hydraulic gradient along the screens are uniform and stable.

Detailed hydraulic investigation identified that the originally proposed screened side weir would not comply with the WaPUG guidelines and a hydraulic jump would form alongside the CSO.

The detailed analysis, which was performed using MWH's own software package, indicated that the problem could be solved by widening the channel at the upstream end of the side weir to reduce the approach velocity and utilising a tapered overflow channel. However this did not comply with the WaPUG guidelines which are based on parallel weirs.

The WaPUG guidelines are based on test rigs used to monitor and verify the design of CSO screens. To satisfy the design team and the clients concerns, we looked at verifying the design using computational fluid dynamics (CFD), however due to the complexity of the converging sewers, the current design software or methods were not considered to be suitable to assess the issues.

Physical modelling

Hydrotec Consultants Ltd was commissioned to construct a 1:10 physical hydraulic scale model based on the AutoCAD drawings

Model results of screen and 1 in 5 year spill flow - Courtesy of Hydrotec

showing the layout of the existing culvert and proposed CSO. Hydrotec had previously investigated the operation of existing pump sumps, inlet works and other CSO screens.

The model was used to confirm the hydraulic operation of the screen for the 1 in 5 year and 1 in 30 year flows with and without the screen blinded. The initial results of the model were promising and confirmed that the tapered channel alongside the side weir achieved a stable hydraulic gradient along the overflow weir and a uniform flow through the screen and over the overflow weir.

The model identified disturbance to the water surface immediately upstream and downstream of the CSO screen that was causing local overtopping of the relief weir. This was solved by increasing the height of weir close to each end of the screen. We also used the model to investigate the use of circular columns on top of the weir to support the roof slab and this confirmed the optimum size and location to minimise the effect on the flow over the weirs.

The results of the model were recorded on video and included in Hydrotec's final report which was issued to the client and used as part of the operating and commissioning meetings with Thames Water Operations.

The use of the physical scale model allowed the Thames Water Personnel to see the operation of the CSO screen for the 1 in 5 and 30 year design flows which could not be replicated on site as the flows are dependent on the local weather conditions.

These gave Thames Water the confidence that the CSO chamber and screen would operate satisfactorily and this would be confirmed by 3 monthly visual inspections once the CSO is operational.

The design of the CSO chamber progressed based on the results of the physical model.

Construction

The construction of the CSO has progressed successfully, maintaining the structural integrity of the existing culvert and not restricting the flows to Swindon STW. The access for construction was constrained as no access was allowed from the adjacent dual carriageway and the need to minimise the distribution to the B&Q warehouse store. This has been achieved by regular coordination of the Optimise design and site team with integration of the temporary and permanent works. Prefabricated temporary tank walls, structural steelwork, precast roof slabs and CSO screen have been used to reduce the risk of working on a live foul culvert.

Third party and external stakeholders

The CSO is located in land owned by Swindon Borough Council and adjacent to a B&Q warehouse store, a public cycle way and footpath, and the Great Western Way; one of the main dual carriageways into the center of Swindon.

Optimise commenced negotiation with all the external stakeholders and local residents during the initial design stage to explain the need and benefits of the scheme.

Optimise, Thames Water and Swindon Borough Council held two open presentations at the local school and community center and regular press updates to ensure the local community was all kept informed. This resulted in successful liaison with B&Q, land owners, Swindon Borough Council, and residents of the Cheney Manor area to achieve Planning Approval for the scheme.

The scheme is due for completion in July 2014 with a budget cost of the overall scheme of approximately £7m.

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