Victoria Road, Darlington - Flood Alleviation

uCSO & Skerne syphon improvements

by
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The Environment Agency has classified the Combined Sewer Overflow (CSO) DL009 at the rear of Victoria Road, Darlington, as unsatisfactory on aesthetic grounds. The CSO is National Environment Programme (NEP) listed, identified as an AMP 3 year 5 output. It is a surcharge relief structure to a short length of sewer serving 81-93 Victoria Road, discharging storm sewage effluent to the River Skerne, a high amenity watercourse. In addition five properties between 81 and 93 Victoria Road are listed on the DG5 Flood Register.

Victoria Road: Flood alleviation work in progress *courtesy: Northumbrian Water*

History

The River Skerne Syphon, a strategic asset in the Darlington catchment, has a long history of operational and maintenance problems. Fats and sediments deposited within the duty barrel exacerbate water levels in the upstream system contributing to the DG5 flooding at Victoria Road. Access to the inlet and outlet syphon chambers is inadequate. Northumbrian Water adopted a holistic approach developing an integrated scheme addressing all problems.

Feasibility

Due to the restrictive nature of the site an innovative solution was required to minimise land take. An existing hydraulic model of the Darlington catchment constructed and verified by WRc in 1994, was locally upgraded and verified utilising *Hydroworks* Version 6. Connectivity issues were addressed with detailed manhole surveys undertaken in areas thought likely to be affected by any proposals.

It was important to understand the flooding mechanism, interviews were completed with the affected residents to gain invaluable knowledge on the origin of the flooding. The updated model identified trunk sewer incapacity causing system surcharge and flooding to the rear of Victoria Terrace at a well defined low spot in the catchment.

The study identified that both flooding and CSO issues could be addressed by adopting a "cut and pump" concept. All the options identified involved the isolation of properties from the trunk system, along with the construction of a new submersible pumping station. A twin gravity/pressurised system was preferred, avoiding the three most costly options, all of which comprised the construction of a large submersible pumping station (SPS) incorporating storm pumps of 250 l/sec and requiring 50m^3 of storage.

The option progressed to the design stage comprised:

* **15 l/sec duty/standby two pump SPS with wet well storage of 15m^3 including steel kiosk and MCC panel;**

* **170m of 600mm dia ductile iron pressurised sewer with sealed hatchboxes;**

* **70m of 300mm dia rider sewer to divert flows from affected properties to the new SPS;**

Strategic asset

The River Skerne syphon is a strategic asset in the Darlington catchment constructed in 1966/67). The syphon consists of three concrete pipe barrels comprising a 1067mm duty barrel and two 1524mm storm barrels. Flow into the storm barrel is controlled at the inlet by a single-sided weir. A single submersible pump was located within the outlet structure on the storm side to de-water the storm barrels after operation. This pump was removed in the year's following commissioning of the structure. With a clean system the theoretical flow at which the inlet weir starts to prime the storm barrels was calculated at 900 l/sec, equating to approximately 3 times dry weather flow (3DWF) sufficient to retain peak diurnal flow.

Problems

Fundamental problems with the operation of the syphon were identified. Flows were inappropriately proportioned between barrels with very low velocities throughout the flow range, In addition, maintenance was difficult due to inadequate access and isolation facilities. Calculations have shown that the velocities developed within the duty barrel vary between 0.34 and 0.51 m/s, significantly below those needed for self cleansing, A range of solutions were developed varying from 'do nothing' to a revised operation regime. Full reconstruction of the structure in an adjacent position was also considered. The option pursued included modifications to the existing cover slab to improve access, cleansing and lining down of the duty barrel to improve velocity, and the installation of a de-watering pump to empty the storm barrels.

Design

Design work was undertaken in conjunction with ground investigations. Difficult ground conditions were anticipated given the proximity of the River Skerne. Additionally, there was the possibility of below ground obstructions due to previous works and buildings. Exploratory boreholes indicated water bearing made ground over lying boulder clay. The variability of this material was considered in the design of permanent and temporary works.

Design criteria for Victoria Rd SPS & associated gravity sewer

* existing sewerage network to remain fully operational throughout construction works;
* SPS Duty Point 15 l/sec, significantly greater than Formula A flow (FAF), minimum equivalent storage volume 2hrs at 3DWF, pump starts limited to 7 per hour, wet well retention less than 6 hrs;
* DG5 listed properties shall not be statistically at risk of flooding due to hydraulic overloading the combined system more often than once in ten years. The criteria is satisfied by eliminating any model flooding for a 1 in 40 year design storm;
* velocities in the 600mm ductile "by passing' trunk sewer to be maximised. Gradient is constrained by available fall and self cleansing velocities cannot be practically achieved.
* 6mm wedgewire static screens required within the SPS storm/emergency overflow to replace CSO DL009;

Sewer work and SPS construction was undertaken in an urban environment working in a narrow back lane in close proximity to commercial/residential premises. Discussions were held to establish the occupiers requirements and any restrictions that might impact upon construction activities.

The working area contained numerous services and careful planning was required to ensure the contractor could progress without unforeseen delays. Trial holes to locate charted utilities were undertaken early in the design phase to confirm indicative record drawings.

Design criteria - River Skerne Syphon

* HR Wallingford report SR559 June 2000 "Self Cleansing Flow Conditions for Inverted Syphon" was adopted where practicable as the most authoritative guidance for syphon design;
* the Syphon will remain on line throughout construction works;
* minimum velocities in duty barrel to be 1 m/s and peak daily velocity to exceed 1.2 m/s;
* duty barrel suitably sized and storm weirs set to pass forward at least 3 DWF;
* removal of all 'blind' access points, new access to be detailed to ensure all future maintenance can be completed from the surface;
* elimination of the problem of large matted sewage solids suspended above current inlet;
* storm barrels to be emptied by de-watering pump following every storm event and telemetry to be installed.

High river levels could affect the works on the syphon. The EA were approached to obtain flow data for the River Skerne and mitigation measures included within the contractor's Health & Safety Plan. Further constraints at the syphon included the proximity of the river and adjacent dual carriageway both of which are likely to hinder construction on a relatively small site. A lane closure helped release space to undertake the syphon modifications.

Procurement & programme

The feasibility study, conceptual design, detail design and site supervision were undertaken by *MWH,* one of Northumbrian Water's framework consultants. The construction contract, NEC ECC Option C Target Cost with Activity Schedule, was awarded to NWL's list A framework contractor *Seymour (Civil Engineering Contractors) Ltd.*

Feasibility work commenced in July 2003, with the preferred option agreed by all stakeholders in December 2003. The conceptual and detail design phase was completed within 9 months between January and September 2004. A 25 week construction programme was agreed with the contractor commencing late September 2004.

Construction

Given the ground conditions, the wet well and valve chamber were constructed as caissons sunk into the underlying clay to inhibit ground water ingress. The SPS base and cover slab were insitu reinforced concrete with the cover slab designed for HB loading.An existing 2m high retaining wall was extended along the perimeter of the SPS compound. A dual trench was utilised as the most economical solution for installation of the pipeline. The 'bypass' sewer designed to operate as a pressurised main under heavy storm periods, was constructed in ductile iron with sealed hatch boxes. Installation depths varied up to 4.5m and the pipeline and bedding was wrapped with a geotextile where ground conditions dictated. No connections were made to the bypass sewer other than from the rising main. A 300mm vitrified clay (VC) gravity sewer draining to the SPS, was laid at depths up to 3.5m that intercepted the private drainage serving the DG5 properties.

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courtesy: Northumbrian Water

The overburden was removed to expose the syphon cover slab, areas of the slab were broken out using hydro-demolition and the structure was internally propped to provide temporary support. To maintain safe access over openings, open mesh flooring was temporarily installed.

To complete internal modifications, flows were diverted between storm and duty barrels, utilising steel plates, the structure remaining live throughout the construction period. The duty barrel was jetted clean, lined with a 558mm MDPE pipe jacked into position and the annulus grouted. The duty barrel inlet was re-benched into a bell mouth to create a vortex effect, swirling any floating solids into the syphon. The replacement roof slabs were precast off-site, syphon walls made good and roof units lifted onto the walls with dry joints.

Summary

Northumbrian Water Ltd is dedicated to providing a high quality service to its customers throughout the region. Despite the complexities this project was completed on time and under the £980,000 budget, demonstrating Northumbrian Water's continued commitment to deliver property flooding and environmental improvements. ■

Note: *The author of this article, Ian Davison, is Project Manager with Northumbrian Water Ltd.*