Increasing the flood resistance of sewer systems through the strategic positioning and design of vortex flow controls

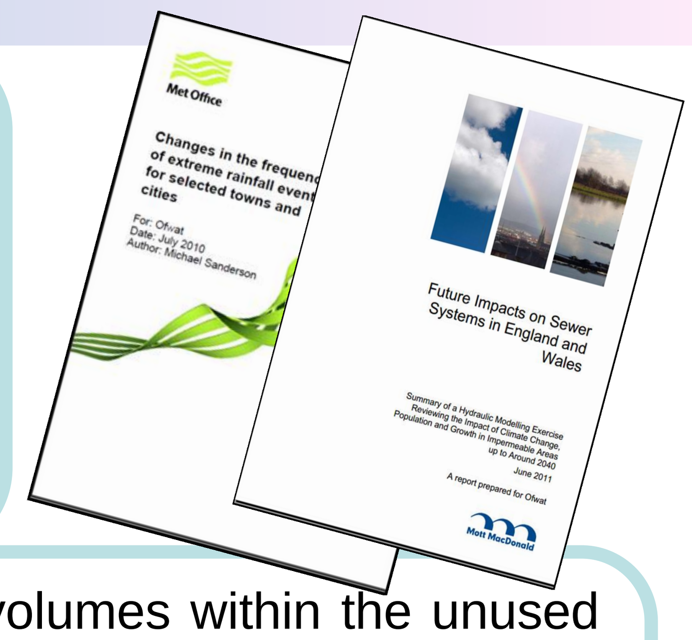
Mr Christopher Newton, Dr Daniel Jarman, Professor Fayyaz Ali Memon, Professor Robert Andoh and Professor David Butler

stream

The Industrial Doctorate Centre for the Water Sector

Problem

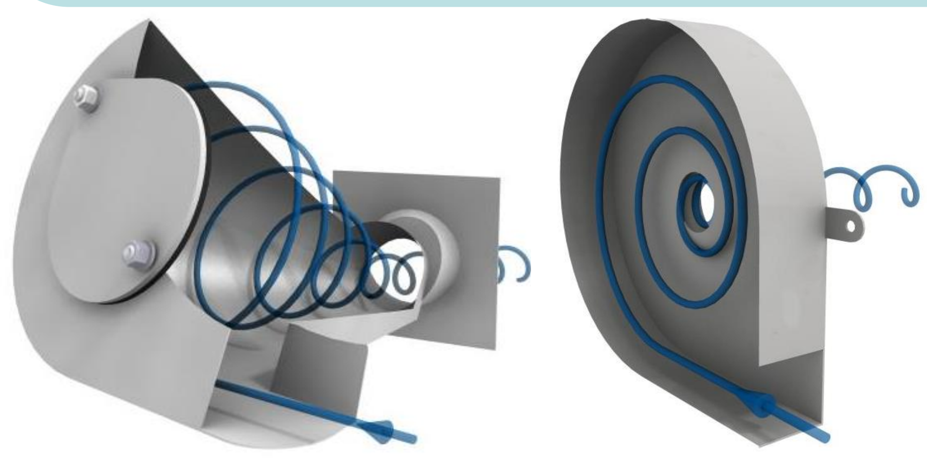
Climate change, population growth and urbanisation are predicted to have a negative impact on catchments in the future. This is due to the increase in surface runoff volumes causing an increase in flood events. Some sections of existing sewer infrastructure may not have the capacity to convey the volumes of collected runoff and sewage without flooding or failure. Enlarging existing sewer infrastructure is typically unfeasible and above ground solutions (i.e. rainwater harvesting and SuDS) can be unpractical due to a lack of available surface area and low soil infiltration rates. This project aims to find a solution to increase the flood resistance of sewers where opportunities for sewer enlargement, rainwater harvesting and SuDS are limited.



Proposed solution

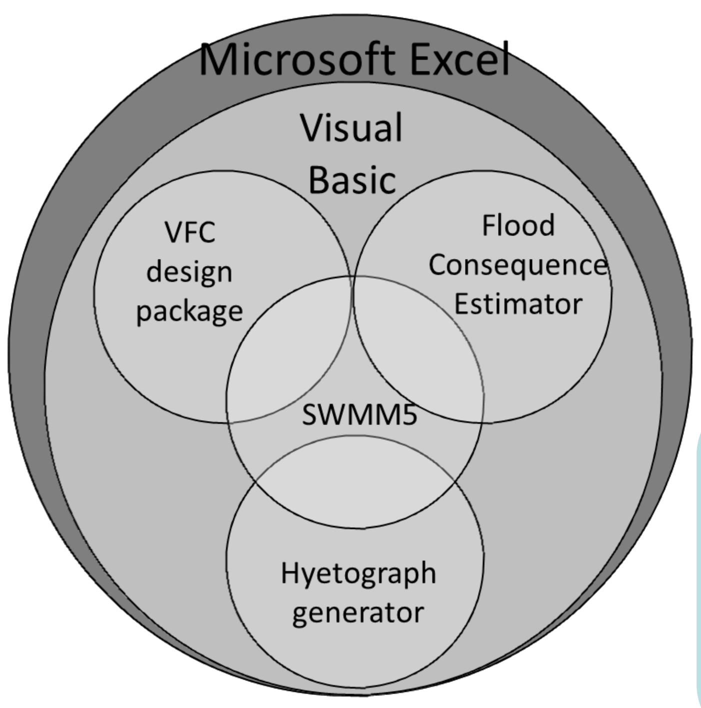
The proposed solution for increasing the flood resistance of the sewer system is to attenuate potential flood volumes within the unused storage capacities of the existing sewer system, using vortex flow controls (VFCs). The attenuation of the potential flood volumes in the upstream sections of the sewer system would enable the downstream sections of the system to convey already collected runoff and sewage volumes before receiving additional flow volumes from upstream. This method would improve the performance of the sewer system and installation would only require basic labour at individual manholes, rather than unearthing and replacing large sections of the existing sewer system. This method is being developed into a decision support tool to automate the process.

Vortex flow controls

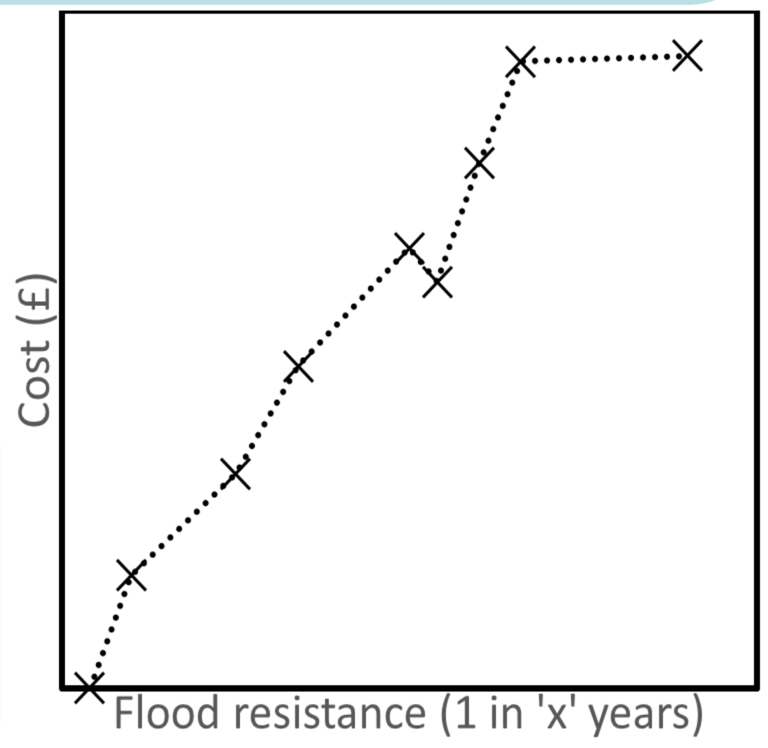


VFCs are passive, self-activating devices that use bespoke geometries to achieve desired flow-rates at selected head values. VFCs with a conical frustum geometry are used when sumps are unacceptable. VFCs with a cylindrical geometry are used when sumps are acceptable (stormwater applications). When compared to an orifice plate, the benefits include: reduced upstream storage volumes due to increased average flow-rates; reduced risk of blockage due to larger outlet area; increased cleansing velocities; and adjustability due to changing the inlet area. Both VFCs are used in the developed decision support tool.

Decision support tool & outputs

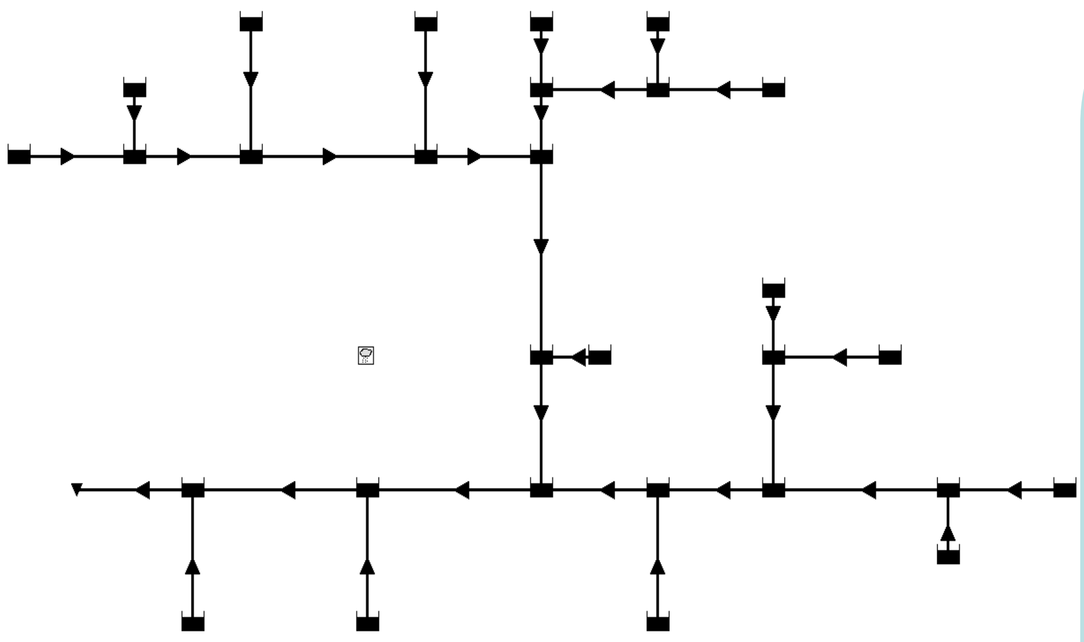


Run hydraulic simulation → Select the conduit with the greatest spare capacity → Design and install the VFC in the downstream node → Estimate costs of the VFC and to install the VFC



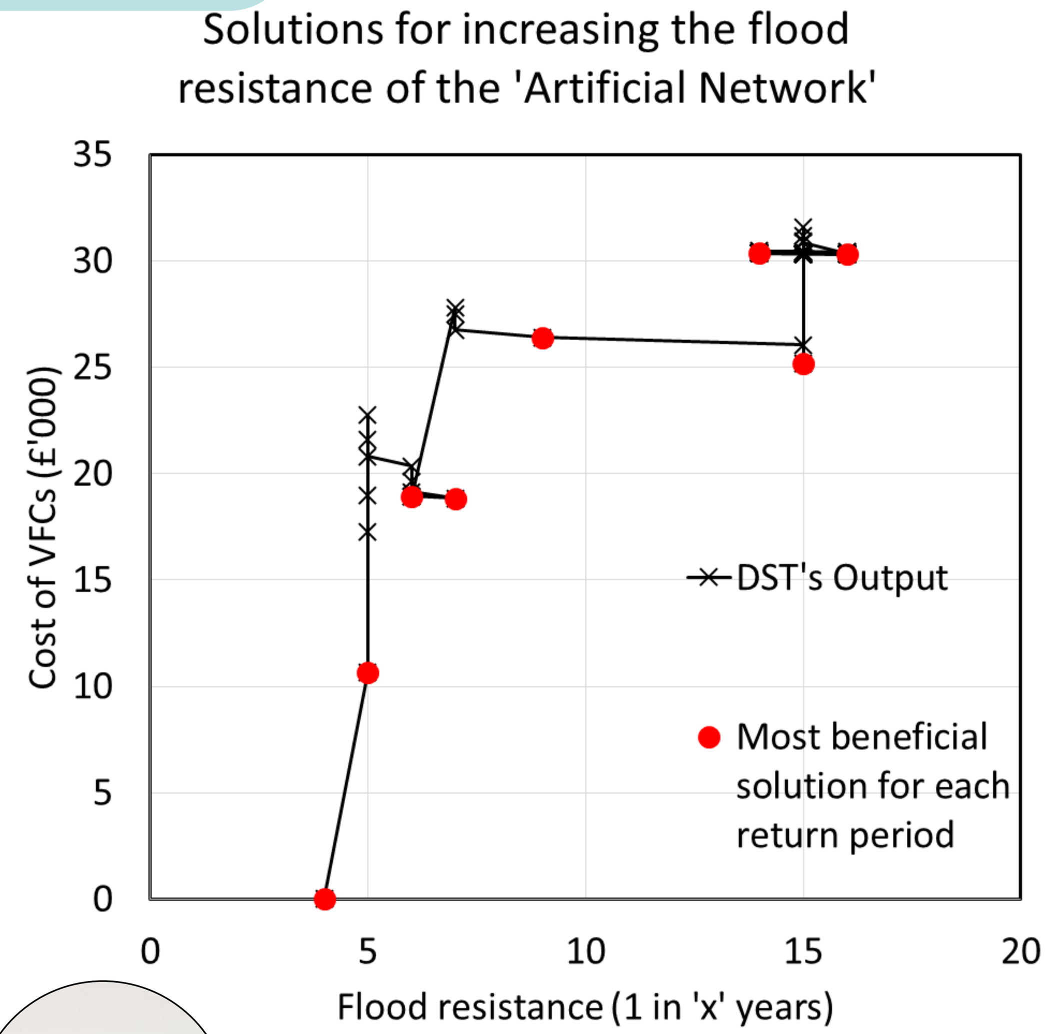
The tool iteratively positions and designs bespoke VFCs into the sewer system model. The process is continued until the design is unfeasible or there is no spare storage capacity in the sewer system. The outputs from the tool (shown right) allow the user to explore and select the most beneficial solution for their future needs and budget constraints.

Case Study



'Artificial Network'
(Atkinson, S. 2013. '*A futures approach to water distribution and sewer network (RE)design*'. University of Exeter)

The 'Artificial Network', a theoretical sewer system model, was used as an initial test case for the decision support tool. The 'Artificial Network' is a stormwater system with 30 nodes, 5.6 km of pipes and serves a 14.5 ha catchment. The discharge consent at the outlet was 200 l/s. The outputs of the tool are shown in the graph to the right. Using the decision support tool the level of flood resistance could be increased from a 1 in 4 year return period level to a 1 in 16 year return period level for a given cost constraint.



Benefits

Customer

- Increase in the sewer system's level of flood resistance
- Solutions tailored to prioritise specific areas or objectives
- Reduction of CSO spills and pollution incidents

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Compliance

- Increase in the sewer system's level of flood resistance
- Solutions tailored to prioritise specific areas or objectives
- Reduction of CSO spills and pollution incidents
- Minimal construction requirements reduces H&S risk level

Cost

- Increase in the sewer system's level of flood resistance
- Minimisation of development or rehabilitation costs
- Minimal construction requirements reduces H&S risk level
- Automated process only requiring user interaction for the initial set up

Hydro International

University of Exeter

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www.stream-idc.net/

Hydro International, Shearwater House, Clevedon Hall Estate, Victoria Road, Clevedon, UK. BS21 7RD.
cnewton@hydro-int.com