Software advances expand integrated modelling and management

Water and sewer network modelling packages are providing greater opportunities for utilities to manage, monitor and model their water and wastewater pipes and assets, as well as predict and respond to external factors. **LIS STEDMAN** looks at developments in London and Lisbon.

Top-end modelling solutions are moving into interesting new territory – sophisticated integration of what would once have been seen as quite disparate datasets to enable a much more holistic view of a water or wastewater network, and the external influences on it (and of course, the network's influences on the surrounding environment).

Monitoring and modelling in London

William Neale, wastewater asset network modelling consultant for London's water and wastewater utility, Thames Water, explains that the utility began a programme of installing permanent depth loggers in 2008 to understand seasonal variations in flows, and to understand the operational performance of key assets to help with its Drainage Area Plans. He adds that Thames has also been buying daily NIMROD radar rainfall data from the Met Office for a number of years, and has begun to use its six hour forecast radar called 'Nowcast'. 'Linking the telemetry data, radar data and models is a useful planning tool to enable an understanding of the catchments in real time,' he notes.

He explains that the plan is to input the telemetry data, historical rainfall data and the new 'Nowcast' data, which predicts rainfall six hours into the future, into Innovyze's FloodWorks software. FloodWorks is more usually teamed with Innovyze's river modelling package, InfoWorks RS, for longer-term (24 hour) flood forecasting, but its ability to collate data and drive modelling means increasing interest is being shown in using it for short-range prediction in tandem with the company's urban water cycle modelling software, InfoWorks CS.

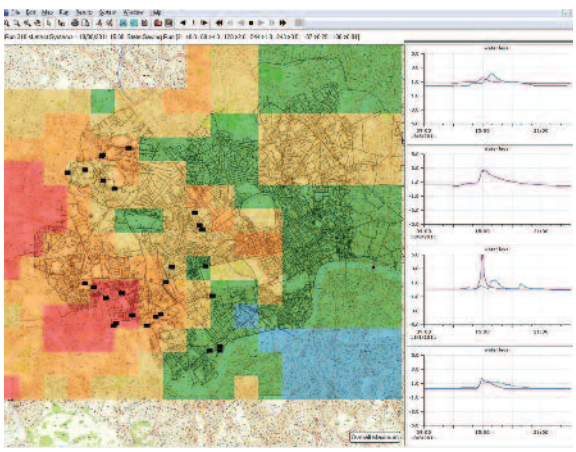
FloodWorks will use the three datasets to automatically run an existing Thames Water InfoWorks CS model on an hourly schedule. The historical data primes the model and the 'Nowcast' data provides the predictive capability, effectively providing a constant simulation of the network conditions in the near (six hour) future.

Historically, the utility would have used the Nimrod radar data for post-event analysis, but by using FloodWorks to collate and process historic and forecast rainfall for a model run, this allows a real time picture of how a catchment is performing and may perform in the future. The idea is that this predictive ability will enable the utility to make sure the catchment is running as efficiently as possible and to plan its operational and capital expenditure budgets to target less resilient assets within a catchment.

Mr Neale explains that using FloodWorks to develop Real Time Control (RTC) regimes to manage flows around the catchment is a possibility, but that this is a complex task in the capital: 'The model provides a picture of how the network is responding to rainfall, and in a smaller catchment with smaller pipes it may be possible to control flows using RTC. However, in London the volume of flow and the flow rates are so large that simply closing gates would create huge surge pressures, not to mention the added cost of maintaining such control structures, so trying to manipulate the flows around the catchment is some way off.'

He adds: 'The main focus of the project at the moment is more to do with the improving understanding of the day to day operation of the network, the performance of key assets, and targeting maintenance where it is needed the most. We believe that using our new model within FloodWorks has great potential for us to manage our systems more efficiently.'

FloodWorks screenshot from the Innovyze mirror of the Thames system, showing observed vs predicted water levels.



Having the permanent depth loggers also means that Thames has been able to monitor many operational practices and ensure the models replicate the actual operational setups. Mr Neale observes that verifying the model over a much longer dataset has also made it more robust, and though the project is still at the early stages, Thames Water has learned a lot about the catchment and how it is managed.

Mr Neale says that FloodWorks will be run with a 'base case' model and that a series of user-configured alarms will be set to warn when particular thresholds are exceeded within the network. These alarms will notify network operations that certain assets or areas of the catchment are at risk, so teams can be deployed to investigate or manage the situation as it arises.

The modelling also enables the utility to run scenarios, allowing solutions to flooding to be checked before construction to see how they would operate, and if there will be knock-on effects elsewhere, ensuring investments are thoroughly checked using real rainfall data.

The utility is also looking closely at how flows are conveyed through the catchment as a major expense of any water utility is electricity to power pumping stations.

Having the ability to predict flows in the system can also help the company to optimize pumping if a flood event does occur. Systems can be drained down in readiness for the storm, or if the company knows no more rainfall will occur in the next six hours, it may be possible to defer pumping until a point in the day when the electricity tariff is cheaper – providing a significant saving on energy costs. 'By being able to forecast what will happen in the future, you can make provision for what to do now,' says Innovyze implementation services manager Rob Millington. 'Thames is not doing this now, but there is a tremendous possibility.'

Mr Neale notes: 'Thames has the largest capital programme of all the water companies. Ofwat (the economic regulator for water and sewerage services in England and

Wales) and our customers would want to know that we are operating as efficiently as possible before further capital investment is made. Linking our network models to radar rainfall and site telemetry via FloodWorks, is one way of demonstrating that the company is operating efficiently.'

Sewage system modelling in Portugal

Another interesting example of integrated modelling comes from Lisbon's wastewater company, Simtejo, in Portugal, which manages a sewerage system including separate, combined, and partially separate networks, with a number of different materials and sewer shapes, various components (overflows, inverted siphons and all sorts of transitions) and of many different ages, with a wide range of problems and possible solutions.

Uncontrolled stormwater influent entering the sewerage systems frequently causes regular flooding that washes huge quantities of grit and coarse solids into the system, resulting in its functional collapse. Lisbon's downtown riverfront is also influenced by the tide, which meant installing permanent tide valves. 'We also had huge problems with pump stations surcharging,' Simtejo R&D director Pedro Póvoa recalls.

A number of investments were made from 2002 onwards in new and upgraded infrastructure, mathematical models were acquired, sewer and estuary GIS systems were implemented, and information systems were installed for operational issues such as sampling, maintenance and flow billing. Because of the investments the technologies improved enormously, which meant it was possible to install telemetry that provided significantly more data at a lower price.

Mr Póvoa notes: 'This situation revealed an important need to tame the huge amount of information available and move to smart systems where the existing information is applied in more efficient ways fitted to the needs of the owner / operators. This situation triggered the development of the Aquasafe project, which was applied in a pilot system north of Lisbon in Beirolas.'

The project is using real time information integrated with Bentley's SewerGems solution for forecasting and diagnosis, based on an approach that integrates weather, sewer and estuary data.

As part of its daily operations, Simtejo has to manage the drainage network, including overflows, sewers and pumping stations, wastewater treatment plant operation and discharges to the Tajo estuary. The project had to address a number of needs, including forecasts of overflow events – part of the sewer system is combined and Lisbon experiences typically short, intense Mediterranean rainfall. It also had to forecast and assess uncontrolled discharges to the Tajo estuary, which had to be reported in detail to the national environmental authorities.

The solution was also required to forecast incoming flows to the treatment works in order to improve its operation and provide continuous verification of flow sensor status – the flow sensors are used for billing and can sometimes be affected by accumulated debris. Constant evaluation of measured data against modelled flows detects occasional faults and triggers maintenance.

Also required was integrated reporting and presentation in the control room of geographically dispersed data.

Modelling tools were already in use, but were usually limited to planning activities. Mr Póvoa says that there was, however, a need for real time forecast capabilities, including scheduling of models, setting up of integrated real time boundary conditions and scheduled automatic validation (including alerts of discrepancies).

In order to make these operations simple enough to be managed by non-specialists, interfacing and reporting also needed to be properly matched to the different users' needs and skills. Pedro Galvao, a technical director of Hidromod, the project system integrator and developer, adds: 'Aquasafe has three main components – the collector, which collects data, the scheduler, which runs the model at set times, and reporting. Once it is set up it is as simple as looking at signals from any other sensor.'

Mr Póvoa says: 'SewerGems is one of the key tools of the system, allowing analysing and forecasting of sewer system transport processes, including the catchment area. It is also used for offline studies to improve operations and energy efficiency on the pumping systems. With the implementation of the AquaSafe platform, the execution of SewerGems was automated and connected to real time data and weather forecasts.'

SewerGems was integrated using Bentley's Water Objects technology and is currently being run every 15 minutes with updated measured rainfall and rainfall forecasts from an operational meteorological forecast model (MM5), which is acquired daily via FTP.

Mr Póvoa adds: 'Currently SewerGems provides a 24 hour forecast of flows, velocity, water levels and pump behaviour in the drainage network, land overflows, incoming flows to the treatment works, and discharges to the Tagus estuary. These tasks are performed without user intervention and remove the burden of maintaining SewerGems in an operational scenario.'

Managing the data

For these results to be useful in Simtejo's day-to-day activities, the results needed to be disseminated in a way that matched the varying user profiles, from management to operators. To achieve this, AquaSafe was engineered using a client-server architecture. A single server is responsible for aggregating the different data sources and managing model runs. Several configurable clients can connect to the AquaSafe server and display data in the form of maps, tables, graphs, charts and alerts. Simpler clients such as Windows' sidebar gadgets can also communicate with AquaSafe. All data sources can be combined in Excel reports using user-created templates.

For the Beirolas project, AquaSafe is using a number of data sources: eight rain gauges and three flowmeters that communicate using AquaSafe pointers to local storage databases to ensure no data duplication; three pumping stations, which communicate via files available on the local network cloud; a water quality probe that communicates directly via the sensor; radar and satellite cloud images from web-based communications with the national weather institute; the MM5 weather model; and the MOHID estuary currents and level model provided by the Instituto Superior Técnico, which communicates via FTP.

As input, SewerGems uses sensor data up to the current date and updated MM5 model rainfall for forecasting every 15 minutes. The water objects library is used to update the initial conditions for each run, such as the water level in the nodes and reservoirs, and boundary conditions (rainfall).

The discharges calculated by SewerGems are dispersed in the estuary by MOHID using a Lagrangean model. SewerGems provides the boundary conditions for MOHID. The treatment works element of the system is now under development, Mr Galvao says, with a project that will encompass inland overflows beginning shortly.

Mr Póvoa says: 'The system has been online for the last four months and counting, providing constant and accurate forecasts for Simtejo's management and operational teams. Our goal is to implement Aquasafe in all our systems and over the next year we will do so.' ●