

Modelling the 400,000

Weimin Geng of Shanghai Waterworks Shebei Company relates how the daunting task of modelling 400,000 pipes in the distribution network of Shanghai's main water supply company is made possible

All 400,000 pipes in the distribution network of Shanghai's main water supply company have been represented in an *InfoWorks WS* model that is believed to be the largest of its kind in the world. "Currently our model is at the preliminary stage of calibration," says Ms Geng Weimin of Shanghai Waterworks Shibe Co Ltd. Once calibrated, it will provide an invaluable resource for the analysis and management of the extensive network which serves 4.3 million people.

Shanghai's water is supplied by four water companies, of which the largest is the Shibe Company. The supply area covers 507 km² (196 square miles) and includes five districts of Shanghai – Yangpu, Hongkou, Zhabei, Putuo, Baoshan – as well as part of Jiangding. Shibe supplies 41% of Shanghai's total demand and has a daily capacity of 3,140,000 m³ (830 million gallons), or 800,000,000 m³/year (211,360 million gallons).

The present network has six water treatment plants and 20 booster pumping stations, including 12 reservoir pumping stations. The six plants vary considerably



Shibe Company is the largest of the four water suppliers in Shanghai.

in size, with the largest at Yangchang supplying 1,480,000 m³/day (390 million gallons) or almost half of the company's total volume. The remaining supply is made up by three plants of 400,000 m³ (105 million gallons), one of 280,000 m³ (74 million gallons) and the smallest at Wusong which provides 180,000 m³/day (48 million gallons).

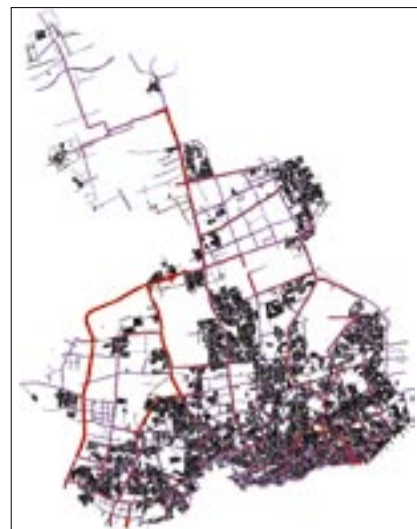
The network has challenging characteristics that affect the water supply. As well as being large, it has complex topography and ageing infrastructure. There is serious leakage, a danger of pipes bursting and regular intrusions from salty tide water. The company's leadership places great importance on the safety of the supply, as well as to the economic operation of the business, good management and scientifically-based planning. The *InfoWorks* hydraulic model will play a vital part in achieving these aims.

Gathering the data

One of the key steps in building the *InfoWorks* model involved obtaining detailed network data from Shibe Company's extensive GIS system. This extensive system contains full details of all aspects of the network before it enters the customers' property. It covers all the pipes, valves, hydrants, meters and fitting details, for pipes as small as about 15 mm.

Further data for the model building came from the billing system which records every customer's monthly consumption.

Shibe's SCADA system also provided valuable data. This contains online pressure and flow data for the six water plants and 20 pumping stations as well as information from 108 pressure measurement sites and 39 flow measurements sites. In addition, the



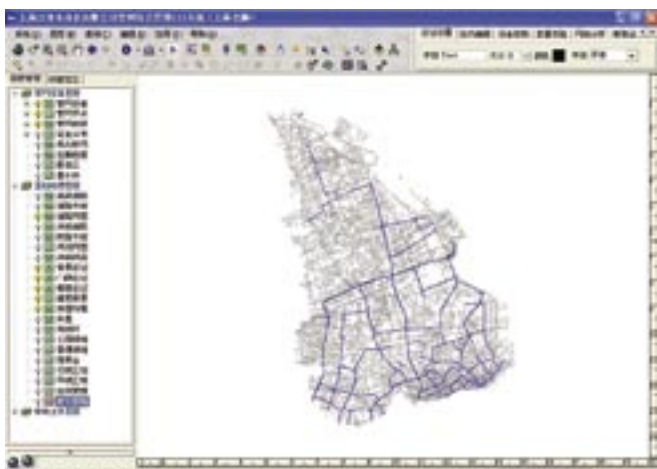
The network's flow direction is from east to west and from north to south.

company carries out annual peak flow surveys and quarterly network pressure tests.

The model is believed to be the largest being developed in China – or indeed anywhere in the world. It contains more than 214,000 pipes of diameters between 100 mm and 2 m, with the total reaching 400,000 when pipes of 75 mm minimum diameter are included for the allocation of demand. There are some 211,000 nodes, and the length of pipes totals more than 4,400 km. In addition to the pipes themselves, the *InfoWorks WS* model includes the treatment plants, pumping stations, 20 reservoirs, 132 pumps and 708 control valves. Shibe makes use of boosting and reservoir pumping stations, enabling it to increase pressure during peaks in demand and save energy when demand is low.

Assembling the model

The first step in building the connected network of pipes was to clean up the



Detailed network data was obtained from the extensive GIS system to south.

topographical data. Pipes of 75 mm or smaller were first removed and *InfoWorks*' inference tools were used to flag pipes whose diameters were missing and infer the value. Any pipes whose diameter could not be inferred were given a value of 101 mm. This avoided the deletion of key lengths and facilitated their updating with the correct values in future. The connectivity trace tool was used to identify isolated pipelines or nodes that could be deleted from the model after confirmation in the GIS. Similarly, the proximity trace tool within *InfoWorks* was used to identify any overlain or crossing pipes that could be taken out of the model after checks with the GIS.

Some challenges have been encountered during data collection and cleansing, including errors in the GIS data. *InfoWorks* proved very useful in finding and resolving these errors. "During the process, we make use of all kinds of tools that *InfoWorks* provides and this helps," says Ms Geng. This includes tools for tracing, inference, SQL queries and combining networks. *InfoWorks* was used to check the GIS information. Any errors were fed back to the GIS so that the data could be checked and updated.

The vast size of the network brought with it a heavy workload for the staff involved. "We divided the large network into three sub-networks, with one person responsible for each," says Ms Geng. Everybody was assigned their own data flag for clarity, and special attention was given at the boundaries

between the sub-networks. Use of the combining tools in *InfoWorks WS* ensured that it was straightforward to bring together all the sections after they had been processed.

Allocating demand

Water demand allocation was dealt with by dividing it into four types: normal customers, large customers, leakage and unprofiled demand.

Allocation of normal customers' demand was split into two types:



Outline of Shibe Company's water model.

demand with specific consumption and polygon demand. The demand for specific consumption made use of the link that already existed in the GIS between the customer meters and a type of valve known as JSF. Customers downstream of these valves have their monthly consumption recorded in the billing system. The diameter of the pipes downstream of the JSF valves is no larger than 75 mm.

In the GIS system, the JSF valves just sit on the pipes without attaching to them or splitting them. This avoids having too many small pipes in the GIS for performance reasons.

In setting up the *InfoWorks* model, the team needed to link the 1.9 million customer meters and the small pipes into the main network. This was not an easy task, but help came from Wallingford Software's *InfoNet* asset and data management software. This involved using the *Proximity Trace* feature which enables the automatic creation of a list of network assets – in this case, the JSF valves – adjacent, but not connected, to the supply pipes. A lateral node is automatically created on



Isolated pipes and nodes could be deleted after connectivity tracing and confirmation of the results in the GIS.

the supply pipe, and the connecting pipe is then also automatically created between the supply pipe and the JSF valves.

This approach enabled the development of the complete network asset model in *InfoWorks*, with

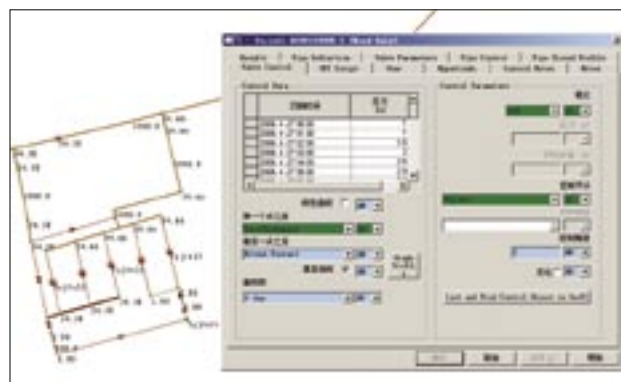
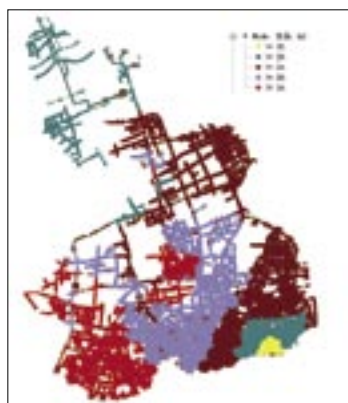
connectivity between the customer meter and the supply network. It was then imported into *InfoWorks WS* to create the 400,000-pipe hydraulic analysis network.

Static water demand allocation was performed for demand with specific consumption, and then the "skeletonizer" was used to simplify the network.

Several issues had to be resolved for polygon area demand. "Some water meters have been recorded in the billing system, but we don't have the exact location in the GIS," says Ms Geng. They were located in 99 polygon areas, but there are always multiple types of demands in each polygon. "We decided to



PRV control was used as valve control for the reservoir inflow.



More screen shots from *InfoWorks WS*.



try using the land use demand allocation in *WS*," she adds. Using the simplified network of 200,000 pipes, node polygons were created in each polygon and then water demand was allocated to the attached nodes.

A different process was used for allocating water demand for large customers. Large customers were defined as those using more than 5,000 m³ a month. Customer points represent the large customers in the network and static demand allocation was applied.

There were no detailed records for leakage and so a method of generating leakage and unprofiled demand figures had to be devised. The whole network was considered as a demand area and all the boundary pipes were linked to the live flow data recorded from each water plant. "We also considered

the factor of reservoir inflow and outflow," adds Ms Geng. This approach enabled the derivation of leakage and unprofiled demand for allocation to the nodes in the analysis.

Beginning calibration

The next step is full calibration of the model. "We are mainly focused on partial flow and pressure of water pumps and pumping stations," says Ms Geng. Pressure relief valves and pressure safety valves have been added at the network's reservoirs to ensure real inflow and outflow during calibration.

Further detailed calibration will be performed regionally in the near future, including aspects such as network topology and attributes including pipe diameters; operation records of pumps and valves; pump characteristic curves; customer demand diagrams; correction of inaccurate inputs and elimination of any odd values to ensure the extensive model is fully representative of the network. **WWA**

Enquiry No: 023

InfoWorks version 9 released

Version 9.0 of *InfoWorks* was released in April 2008. In addition to major developments – such as the ability to model 2D flows using *InfoWorks RS – InfoWorks v9.0* includes scores of enhancements that will improve personal productivity and performance. In v9.0 for instance, users can export *InfoWorks* models and results to *Google Earth* format for sharing across the Internet.

InfoWorks v9.0 includes a wealth of improvements to all four products: *InfoWorks CS* for wastewater management and sewerage provision, *SD* for stormwater, *WS* for water distribution and supply and *RS* for river, channel and floodplain flows.

Common enhancements

For many users an enduring appeal of *InfoWorks* is the common interface and functionality that is consistent across all *InfoWorks* products. Every release of *InfoWorks* therefore features a large number of improvements common to all products. v9.0 marks the introduction of *Tooltip Labels*

which provide the ability to quickly access information for any object without the need to clutter the model display with labels for all objects or predefine the objects that will be labeled. Since the *Tooltip Labels* are fully customizable the user can develop different labels to be used with different models or workspaces.

A further innovation is the introduction of *Network Templates*. The user may now specify a database and a network to be used as templates for newly created networks. Any new network that is subsequently created automatically inherits the default values of these templates. This allows the user to carry over some values from one network to another.

Finally, amongst a number of significant improvements to the use of *Standard Query Language* in *InfoWorks* is a new *SQL* tool that allows the user to query upstream and downstream from a selected object, link queries on different object types in the same script and establish links to the current time through the *NOW()* function.