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New hydraulic model for integrated water management

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Abstract: A model has been developed to bridge the gap between current network hydraulic models and water security water balancing models at SA Water. The model includes integrated water, wastewater and recycled water networks including the headworks upstream of the water treatment plants. The model provides the following planning capabilities: enabling infrastructure sizing and identification of upgrades required for annual transfer; identifying infrastructure requirements and operation for the integration of new water sources (e.g. purified recycled water); investigation of reservoir storage levels and capacity to supply the water treatment plants; optimisation of pressure zone network operation; and assessing applications for supply to commercial transport customers.

Keywords: *Integrated water management, hydraulic model, headworks infrastructure, Adelaide water supply*

1. INTRODUCTION

There is currently a gap between the full water distribution network models and water security headworks water balancing models at SA Water. As integration of the whole water cycle becomes a business priority, an integrated hydraulic model that can cover the whole water cycle and that is capable of modeling the actual hydraulic capacities over annual operational scenarios with an hourly time step is a required tool. In this work a skeletonised annual model with a hydraulic timestep of one hour for the metropolitan water network in South Australia has been developed. This is required to capture the seasonal variation that occurs annually. The most novel component of the model allows the linkage between the water consumption and wastewater discharge at a network level to be investigated. The inflows, recycled water demands and available wastewater effluent from SA Water's wastewater treatment plants (WWTPs) to supplement drinking water systems have been included in the model, as an attempt of whole water cycle evaluation. In the future, stormwater and purified recycled water schemes will be included in this model.

With the current limitations of the software, the model calculates the hydraulics of the water and recycled water networks as well as a mass balance for the wastewater network and headworks rivers/creeks. Wastewater modelling platforms, including InfoWorks Integrated Catchment Modelling (ICM), have problems with modelling many pressurised pipes and demands. Hence, based on preliminary platform evaluation and testing, the hydraulic model has been developed in WaterCAD to balance the functionalities of licensing and simulation performance. In WaterCAD the capacity of free surface conducts cannot be modelled hydraulically. Free surface conducts in the model including rivers, aqueducts/tunnels and wastewater trunk mains are modelled using dummy pipes with very large diameter to maintain mass balance between systems. Rainfall and evaporation also cannot be modelled so modifications of the model have been made to account for this. Negative demand patterns can simulate rainfall and positive demand patterns can simulate evaporation.

This model allows the linkage between the water consumption and wastewater discharge at a network level to be investigated. The SA Water Metropolitan Network is supplied by River Murray water via the Murray Bridge Onkaparinga pipeline (MBOPL) and Mannum Adelaide pipeline (MAPL). Mount Lofty water is supplied via the 10 headworks reservoirs. The headworks infrastructure then supplies the 7 metropolitan water treatment plants (WTPs) which then supply the downstream tanks and customer demands. There are 5 wastewater plants included in the model. Recycled water schemes are supplied downstream of the WWTPs.

The model has been utilised to assess queries on hydraulic capacity in the headworks system to supply new customers. It has also been used to look at transfer of water across the metropolitan nework and identify future shortfalls which may be supplied by stormwater or advanced recycled water alternatives. The volume of discharge from wastewater networks informs on the available water to supplement the water security shortfalls.

2. METHODOLOGY AND RESULTS

The water network is modelled with the following components:Transfer Pipelines, Reservoirs and Weirs, Water Treatment Plants, Water Trunk Mains, Tanks, Pump Stations, Valve Stations, Water Demand Nodes. The levels

of storages are managed with controls on valves and pumps. The Adelaide Desalination Plant (ADP) and Millbrook Pump Station are controlled on at defined times.

The wastewater network is modelled with the following components:Wastewater Discharge Nodes,Trunk Mains, Wastewater Treatment Plants, Recycled Water Demand Nodes, and Ocean Discharge. The hydraulic capacity of the wastewater networks cannot be calculated in the Bentley software. However, a mass balance for the inflows and outflows has been achieved. The free surface flows are modelled using manually drawn dummy links. These are pipes with very large diameters. The dummy links convey the wastewater flows from the wastewater flow nodes to each WWTP. The dummy links also transfer water between reservoirs and weirs.

The simulations have a hydraulic time step of one hour and a reporting timestep of 2 hours. The annual simulation for the calibrated base case has a run time of approximately 3 minutes on HP zBook (11th Gen Intel(R) Core(TM) i9-11950H @ 2.60GHz, 2611 Mhz, 8 Cores, 16 Logical Processors).

Future supply and demand scenarios for dry, wet and average years are simulated in the model. As different future demand scenarios are proposed, the model can be updated with new scenarios to capture the possibilities. Depending on the volumes of water projected and the demand locations, alternative augmentation options in the network can be explored in the model.

Rainfall and evaporation corresponding to projected weather conditions are inputs to the model that inform the volume available in reservoirs and weirs. This allows shortfalls in the network to be identified and alternate transfer options in the model to be simulated so that the demands can be met in these possible future scenarios.

The developed model was validated using the measurement data from the 2019 calendar year (1/1/2019 to 1/1/2020). Model validation was complete by comparing measured SCADA data for the calibration period with the modelled outputs for WTP inlet and outlet volumes, reservoir levels, major pump station flows, water tank levels, and WWTP inflows. Good calibration was achieved.

The developed model has been used to provide information for planning for possible future network configurations at SA Water. Future demand scenarios with projected rainfall and evaporation inputs to the model have identified where storages are emptying during peak periods.

While the existing network hydraulic models identify where there are shortfalls in the network, the limitations in the pumping capacities of the headworks, reservoir capacities and available non-potable water sources (including recycled water and ARW) can only be identified using the new Integrated Water Management (IWM) Hydraulic Headworks Planning model.

The model also allows investigation of reservoir storage levels and capacity to supply the water treatment plants. Another function of the model is optimisation of pressure zone network operation, for example adjustment of tank levels to increase network transfer. We can also use the model to look at available water capacity to customers upstream of the WTPs. Application for supply to third party customers that impacts balancing across systems can be assessed. The outcomes from existing water security water balancing models can be assessed hydraulically in the new model.

The current model has the following limitations and SA Water plans to further improve and strengthen the model capabilities.

- The controls of headwork operation have not considered the system optimisations balancing the electricity tarriffs, weather forecast and SA Water's River Murray license situation. These optimisations are considered in SA Water's headwork operation model and water security model, which are monthly water balance based.
- The rainfall-runoff of Mt Lofty catchments is not considered in the current model due to the limitation of WaterCAD. The inflows are based on measurements and the catchment model WaterCrest.

3. CONCLUSIONS

For the first time in a hydraulic model, the linkage between the water consumption and wastewater discharge at a network level has been investigated. The inflows, recycled water demands and available wastewater effluent from SA Water's WWTPs to supplement drinking water systems have been included in the model, as an attempt of whole water cycle evaluation. Significant model validation efforts have been spent to evaluate the performance of the model by comparing to measured data. Based on the model validation outcomes, it is concluded that the developed model can reasonably represent the performance of Adelaide's headworks and the wastewater resources.

