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Increasing the computational efficiency of optimal water infrastructure sequencing using artificial neural network metamodels

Holger R. Maier
University of Adelaide, holger.maier@adelaide.edu.au

Eva H. Y. Beh
University of Adelaide, evabeh83@gmail.com

Feifei Zheng
Zhejiang University, feifeizheng@zju.edu.cn

Graeme C. Dandy
University of Adelaide, graeme.dandy@adelaide.edu.au

Zoran Kapelan
University of Exeter, Z.Kapelan@exeter.ac.uk

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Increasing the Computational Efficiency of Optimal Water Infrastructure Sequencing using Artificial Neural Network Metamodels

Holger R. Maier[a], Eva H.Y. Beh[a], Feifei Zheng[b], Graeme C. Dandy[a] and Zoran Kapelan[c]
[a]*School of Civil, Environmental and Mining Engineering, The University of Adelaide (holger.maier@adelaide.edu.au; evabeh83@gmail.com; graeme.dandy@adelaide.edu.au)*
[b]*College of Civil Engineering and Architecture, Zhejiang University (feifeizheng@zju.edu.cn)*
[c]*College of Engineering, Mathematics and Physical Sciences, University of Exeter (z.kapelan@exeter.ac.uk)*

Abstract: The optimal long-term sequencing of water infrastructure is complicated by the need to account for uncertainty due to factors such as climate change and demographics. This requires the calculation of robustness metrics in order to assess system performance, necessitating computationally expensive simulation models to be run a large number of times within each optimisation iteration, leading to infeasible run times. In order to overcome this shortcoming, an approach is developed that uses metamodels instead of computationally expensive simulation models in robustness calculations. The approach is demonstrated for the optimal sequencing of water supply augmentation options for the southern portion of the water supply for Adelaide, South Australia. A 100-year planning horizon is subdivided into ten equal decision stages for the purpose of sequencing various water supply augmentation options, including desalination, stormwater harvesting and household rainwater tanks. The objectives include the minimization of average present value of supply augmentation costs, the minimization of average present value of greenhouse gas emissions and the maximization of supply robustness. The uncertain variables are rainfall, per capita water consumption and population. Decision variables are the implementation stages of the different water supply augmentation options. Artificial neural networks are used as metamodels to enable all objectives to be calculated in a computationally efficient manner at each of the decision stages. The results illustrate that the ANN models are able to replicate the outputs of the simulation models within 5% accuracy while reducing overall computational effort from an estimated 33.6 years to 50 hours.

***Keywords**:* Water infrastructure sequencing; multi-objective optimization; artificial neural networks; metamodelling.