The Modelling of Integrated Urban Water Management Schemes from the Allotment to the Town Scale

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BE (Hons-1)

A thesis submitted for the degree of Doctor of Philosophy

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2013

Note to examiner: This thesis is written in Times Roman size 14 to facilitate my own reading of the printed thesis. My eyes struggle with smaller print.
I hereby certify that the work embodied in this thesis contains works from published papers and other scholarly work of which I am a joint author. I hereby included as part of the thesis a written statement, endorsed by my supervisor, attesting to my contribution in said papers or scholarly works.

Prof. George Kuczera
Supervisor
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Abstract

Population growth in urban areas coupled with a potentially drier future climate is likely to stress existing water resources. One way to address this is to augment existing centralised water supply systems. An alternative is to make better use of urban water resources which, \textit{inter alia}, involves stormwater and rainwater harvesting and wastewater recycling. The basic proposition is that any augmentation of water supply that can reduce the amount of water drawn from existing centralised reservoirs will be of benefit to the whole supply region, especially in terms of drought security.

This thesis describes a versatile modelling framework that can simulate a wide variety of Integrated Urban Water Management (IUWM) schemes from the allotment to the town scale.

The framework combines two modelling approaches. The first, named urbanCycle, simulates water supply and demand, stormwater and wastewater using allotments as the basic building block. Although urbanCycle can simulate allotment processes in great detail, it assumes that the network forms a directed acyclic graph. This simplifies the connectivity logic but precludes investigation of systems with multiple storages and multiple supply paths. To overcome this, a second model, a network linear programming based modelling environment, WathNet5, is embedded in the urbanCycle framework to enable the modelling of cluster and town scale recycling and harvesting options, as well as supply and demand decision making, based on objectives rather than pre-set operating rules. This combined modelling environment has been named UrbanNet.

The UrbanNet framework is demonstrated with the aid of hypothetical case studies. These case studies focus on three different aspects of the modelling framework:
1. A series of cluster scale scenarios demonstrates the flexibility in modelling cluster scale topologies
2. A large multi-cluster case study demonstrates the design detail and flexibility from the allotment scale up to the town scale
3. A multi-objective optimisation case study demonstrates how key variables within a particular IUWM topology can be optimized.

These case studies show UrbanNet to be capable of a high degree of detail and flexibility in the design, simulation and analysis of complex Integrated Urban Water Management Schemes.