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Environmental Modelling & Software 21 (2006) 129–134
Environmental Modelling & Software
www.elsevier.com/locate/envsoft

Short Communication

Simulating the urban water and contaminant cycle

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Received 27 October 2004; received in revised form 21 January 2005; accepted 25 March 2005
Available online 23 May 2005

Abstract

This paper presents the water and contaminant daily simulation model of the total water cycle, called UVQ. The model has been developed to provide a means for rapidly assessing the impacts of conventional and non-conventional urban water supply, stormwater and wastewater development options on the total water cycle. UVQ provides a valuable insight into the viability of prospective alternative water servicing options in terms of environmental and performance requirements.

Keywords: Stormwater; Wastewater; Water supply; Reuse; Urban; Water quality; Mass balance; Simulation model

Software availability

Name of software: UVQ (Urban Volume and Quality)
Developer: Grace Mitchell, Clare Diaper, Mike Rahilly, Eric Dell'Oro, Stephen Gray
Contact address: Urban Water Team Leader, CSIRO Manufacturing and Infrastructure Technology, PO Box 56, Highett, Vic 3190, Australia. Tel.: +61 3 9252 6000; fax: +61 3 9252 6288
Year first available: 2004
Hardware required: Pentium I processor or greater, CD-ROM, minimum screen resolution of 1024 × 768 with small fonts
Software required: Windows 98 or greater
Program language: Visual Basic 6.0
Program footprint: 8.0 MB
Availability and cost: Contact UVQ-support@csiro.au

1. Introduction

Quantifying the urban water and contaminant balance (or budget), and detailing the flow paths and contaminant concentrations within the urban water system, enables understanding of the impacts of the interaction of water with an urban area. In the move towards more integrated urban water management systems where stormwater, wastewater and potable water are considered as one system rather than individually, understanding the interactions between the flow and contaminant paths is also important. Understanding and assessing both existing and alternative water systems is vital in moving towards the goal of more sustainable urban systems, due to the dominance of water in urban materials budgets (Decker et al., 2000).

Urban total water cycle modelling activity spans several decades, with an early example being that of Graham (1976). Since the mid-1990s there has been a rapid increase in activity, and recent water cycle models have broadened their scope to include water quality aspects, albeit for specific water streams. These models

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doi:10.1016/j.envsoft.2005.03.003

have increasingly been employed by water professionals to undertake more holistic evaluations of urban water systems and to enable "what-if" type scenario modelling (Binder et al., 1997; Mitchell et al., 2002). However, few models have focused on the tracking of all waterborne contaminants within the urban environment and even fewer examine the impacts of alternative water servicing options on the total urban water cycle and contaminant flows. This was the motivation for the development of UVQ.

2. Purpose of UVQ

UVQ has been designed to simulate the integrated water system within an urban area and estimates the contaminant loads and concentrations and the volume of the water flows throughout the urban water system, from source to discharge point. The conceptual approach to simulating the urban water system enables considerable flexibility in the manner in which water services are represented and provides the ability to mimic a wide range of conventional and emerging techniques for providing water supply, stormwater and wastewater services to either an existing urban area or a site which is to be urbanised.

Some examples of UVQ function are to:

- estimate the impacts of different water servicing scenarios on the water cycle of planned urban development
- investigate the impact of altering urban form and degree of drainage connectivity on the characteristics of stormwater runoff
- identify the quantity of water that may be available for reuse throughout the water cycle and the possible end use demands
- provide insight into the primary sources of contaminants and movement of water in the urban area
- investigate the impact of implementing demand and supply side water management actions at different spatial scales
- investigate the relationship between the spatial pattern of demand, supply and storage capacity on the reliability of a range of alternative water sources
- provide insight into the potential consequences of implementing a number of non-structural changes to the system such as changing household occupancy, water usage behaviour, use of household chemical products or amount of fertiliser applied to gardens and open spaces
- provide performance requirements of treatment techniques and technologies to achieve user specified water quality discharge criteria

3. Development history

In early 1999, as part of CSIRO's Urban Water Program, some 15 urban water balance analysis and modelling projects were reviewed, with the view of identifying a new model and method for quantifying both water and contaminant flows within urban water systems. However, the review outcomes suggested that rather than develop an entirely new model, modification and extension of the existing water balance model, Aquacycle (Mitchell et al., 2001), would fulfil the requirements. Thus, UVQ (Urban Volume and Quality) was created as an in-house tool. The model was used for a number of projects but the user interface and data input requirements for the newly created contaminant balance were cumbersome and onerous.

In 2002, UVQ was selected for incorporation into a European Fifth Framework Project, Assessing and Improving Sustainability of Urban Water Resources and Systems (AISUWRS). The overall scope of the AISUWRS initiative is to assess and improve the sustainability of urban groundwater resources and systems with the help of computer tools (Mitchell et al., 2003; Mitchell and Diaper, 2004; Rueedi et al., 2004, http://www.urbanwater.de). UVQ was selected as one of these tools as it represents the complete urban water and contaminant cycle and provides flexibility in options for water management scenarios. The AISUWRS project includes the analysis of a range of existing urban water supply and disposal scenarios in four case study cities: Mt Gambier (Australia), Doncaster (UK), Rastatt (Germany) and Ljubljana (Slovenia), where groundwater forms the principal potable water supply. As a result, UVQ has been modified and extended to provide: a more compressive graphical user interface, representation of combined sewer systems, snow accumulation and melt and tailored results output files to link into the suite of models being used in the AISUWRS initiative.

In late 2003, UVQ was given to the AISUWRS project participants, while in early 2004 it was provided to an initial group of general users in Australia. From late 2004, the distribution of the model will be increased to a wider audience. Early reports of the experiences of UVQ users have been positive (Rueedi et al., 2004), with this paper presenting the application of the model to the Doncaster case study city.

4. Main features of UVQ

4.1. Complete urban water cycle and associated contaminants

Urban water models generally consider one aspect of the water cycle only, providing detailed modelling in terms of flows or contaminants of the respective