CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B2.4 | Project duration: July 2012 - July 2016

Hydrology and nutrient transport processes in groundwater/surface water systems

Overview

In many urban regions of Australia, the interactions between groundwater and surface water strongly impact the overall urban hydrology affecting the effectiveness of water sensitive urban design (WSUD).

This project is designed to advance the understanding of how water and nutrients are transported from the surface to the receiving waters (including groundwater), and how the nutrient cycling works that occurs along the way. This project aims, in particular, to define the hydrological responses to the urbanisation of areas where groundwater-surface water interactions exist, including those areas with high or perched groundwater tables. It also helps define the impact of modifying hydrological regimes on nutrient transport in these areas.

Key outcomes

This project will provide tools for urban designers, local government, waterway managers and developers to assess which WSUD elements should be used to help reduce nutrient inputs to rivers and waterways. It will provide insights into how high groundwater might compromise the effectiveness of WSUD and the application of water sensitive city principles. The project will lead to refined design specifications for biofilters, infiltration basins and living streams in sandy environments with significant groundwater–surface water interactions.

Results of this project will also help refine a tool developed by the Western Australian Department of Water to assess the load of nutrients coming off new urban developments. Called Urban Nutrient Decision Outcomes (UNDO), the modelling tool is specifically designed for the sandy environment of the Swan Coastal Plain in Western Australia. It will enable developers and government agencies to calculate nutrient runoff in new developments and assess proposed developments against appropriate targets to ensure that acceptable levels are achieved. The outcomes of this research project will help make UNDO a more powerful tool and fill some research gaps in the understanding of nutrient dynamics.

Project design

A key part of this project is to understand how water and nutrients move through a system with WSUD treatment (for example, with biofilters and rehabilitiated streams) by creating water mass balances that quantify all the water inputs and outputs of a system.

Comparing a water mass balance with a nutrient mass balance will identify what contribution groundwater makes to the total nutrient load entering a receiving water body and therefore can help direct resources to the right place. A few Swan Coastal Plain monitoring sites have been established to develop and validate water and nutrient mass balances, providing an understanding how nutrients are attenuated across the urban landscape and how the attenuation varies across seasons. Finally, hydrological typologies across the Swan Coastal Plain case study will be developed resulting in a classification and a series of maps for urban water designers and managers showing how these typologies are distributed.

Outlook

The monitoring sites have been established and water balances are currently being calculated. By the end of 2015, nutrient mass balances will be developed for these sites. Workshops with practitioners will be undertaken in Western Australia throughout this project to communicate findings and transfer knowledge to industry practitioners. Specific project outputs will include:

- a meta-analysis of existing urban water monitoring datasets from the Swan Coastal Plain in Western Australia
- an identification of urban water data gaps
- daily water and nutrient mass balances for selected WSUD elements
- quantification of groundwater-borne nutrient load to receiving water bodies
- guidelines for WSUD design in areas with significant ground-water-surface water interactions
- a protocol for urban water monitoring of flow and nutrients.

An Australian Government Initiative

CRC AUSTRALIA

Early insights into the hydrology of the Swan Coastal Plain

The characteristics of the Swan Coastal Plain – the narrow coastal strip stretching 650 kilometres from Geraldton in the north to Busselton in the south of Western Australia – pose a particular challenge for urban development. The issue of excess nutrients contaminating waterways is compounded by the interaction between surface water and groundwater. The dominant soil type of the plain is highly permeable with little capacity for retaining nutrients. Unlike in many eastern-state cities, surface runoff is minimal; instead stormwater rapidly infiltrates the soil and percolates through, taking nutrients with it to recharge the superficial aquifers which in turn flow into rivers and lakes. Too much phosphorus and nitrogen, in particular, can lead to excessive algal growth, which depletes oxygen resulting in bad odours and fish kills.

Early findings indicate that the very high variability in the depth to groundwater across the coastal plain ranging from more than 15 metres to less than 1 metre creates highly variable responses of hydrology to urbanisation.

This presents a challenge for a common understanding of urban hydrology in the region and for the development and application of regional WSUD guidelines.

Future urban development is planned for areas with very shallow groundwater; ironically, in some recently developed areas groundwater flooding is occurring during an acute drought. Management of this groundwater flooding may focus on reducing infiltration that is in apparent contrast to typical WSUD guidelines.

Because of the flat landscape, very old sandy soils and rapid infiltration rates, nearly all of the nutrient load to receiving waters is in dissolved form. Preliminary analysis also suggests that in areas with high groundwater tables, organic nitrogen may dominate the dissolved nitrogen signal, however, biofilters and living streams have been designed to attenuate inorganic nutrients. Data suggests that these systems may actually be a source of organic nitrogen to surface waters. The project continues to develop an understanding of the organic nitrogen dynamics and its bioavailability.

Figure 1. Depth to groundwater across the Perth coastal plain ranges from greater than 15 metres to less than one metre.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

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