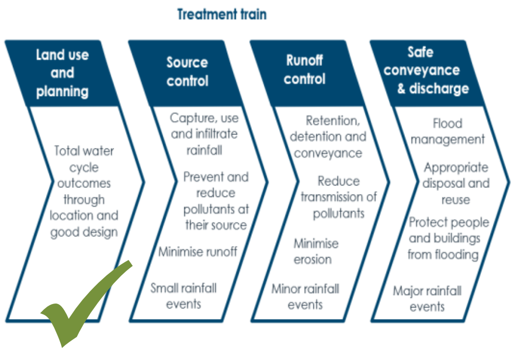
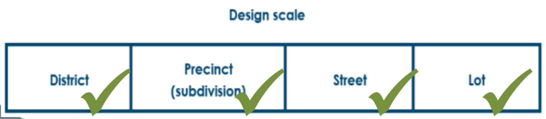
Current state of water-related knowledge for development in areas of high groundwater

Introduction

This research project undertaken by the Cooperative Research Centre for Water Sensitive Cities aims to better understand the impact of urban development in groundwater impacted environments, and provide guidance for water sensitive solutions for areas with high groundwater tables. Stage 1 of the project involved a scoping study that collated existing knowledge to guide development of a research action plan for Stage 2. This fact sheet provides a summary of the findings of Stage 1.

The Stage 1 study aimed to define the state of urban water knowledge for urban development in areas of high groundwater. The study findings were based on a literature review (published and unpublished reports), structured interviews and a stakeholder workshop.





What is high groundwater and why is it a problem?

High groundwater is when the water table is within 4 m of the natural ground surface. This includes regional unconfined aquifers and local seasonally (perched) water tables.

The Swan Coastal Plain in Western Australia is undergoing rapid urban growth, with development moving into areas with high groundwater. This is resulting in challenges for industry, with a lack of awareness and in some instances agreement on best practice urban water management solutions and design.

High groundwater has the potential to cause several impacts, including:

- loss of amenity in private and public open spaces, with seasonal or event-based waterlogging that prevents pedestrian or vehicular traffic and/or restricts conditions necessary for sustainable plant growth;
- compromised performance of infiltration systems through loss of volumetric capacity where the physical presence of groundwater prevents stormwater from entering or through reduced infiltration rates. Poor performance can lead to waterlogging and potential creation of conditions for mosquito breeding;
- damage to infrastructure from acid sulfate soils; rising groundwater and/or repeated cycles of wetting and drying leading to cracking or disintegration of concrete/bitumen and possible structural failure;
- increased potential for groundwater inflow into sewer systems due to hydraulic head differences and/or increased likelihood of leakage from sewers into groundwater;
- increased export of poor-quality water entering receiving water resources, including waterways and wetlands.

Current development responses to high groundwater

Fill is often imported in areas of high groundwater to provide separation above pre-development groundwater levels. Imported fill associated with urban development increases the available groundwater storage and head. In the greater Perth region, fill is typically sand imported to the site from an external borrow pit, which increases the infiltration potential of the site.

The requirement for separation from groundwater is variable across urban form types, though most developments import sufficient fill for simplified approvals. Although the least fill option might also be the least cost option, it is often rejected because of market or industry perceptions. Additional guidance is provided in draft *Specification: Separation distances for groundwater-controlled urban development* (IPWEA, 2016).

The use of fill can impact on housing affordability, through the cost of sand and retaining walls. The use of sand fill also impacts on the environment through land clearing at both source and destination, as well as the carbon footprint associated with transportation and resultant changes to the water and nutrient cycle.

Groundwater controls, in the form of subsoil drains, pumping systems and open drains, can be used in conjunction with imported fill to achieve separation to groundwater. Groundwater level fluctuations still occur during recharge events; however, the change in phreatic surface is diminished by the controls. Groundwater controls used in combination with imported fill will increase surface water discharge and decrease aquifer storage if the groundwater controls are installed below the pre-development maximum groundwater level; but will have negligible impact on aquifer storage if installed above the pre-development maximum groundwater level.

Groundwater Myths

Myth: High groundwater is the main driver for fill in Perth.
Although some fill may be required to achieve separation for backyard amenity, fill is more commonly driven by the need to connect to services such as roads and gravity sewer.

Myth: Buildings can't be built in areas with high groundwater. The Building Code of Australia Volume 2 – Class 1 and 10 buildings (2015) requires structures to be appropriately designed to accommodate site conditions, potentially including the use of suitable drainage and damp-proofing systems to facilitate construction of buildings in areas with high groundwater.

Myth: Services have to be installed in dry conditions. Underground gas, water, electricity and telecommunications infrastructure is largely inconsequential to high groundwater environments and temporary dewatering during installation and maintenance allows for these services to exist in high groundwater areas.

Myth: The landscape should be altered to fit the building design.
There is a preference for thin building slabs in the Perth building industry, whereas practitioners from elsewhere in Australia use piles and other construction methods in high groundwater areas. There is sufficient guidance for the design of buildings, road and services in areas affected by high groundwater.

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Urban development alters the pre-development water balance, potentially impacting water resources and the environment. Hydrological changes occur when a catchment is developed, through alteration of the proportions of overland, subsurface and groundwater flows. Consequently, urban development may result in increases in groundwater levels due to higher post-development net recharge rates, through the loss of vegetation, use of infiltration systems (raingardens, trenches and soakwells) and/or use of imported water (scheme) for irrigation. This is compounded in areas with high groundwater, which limits the ability for infiltration. The resultant rise in groundwater can impact both the development and environment.

Little guidance exists on how to predict the impact of urbanisation on groundwater balance and water levels for specific cases due to the complexity of responses. Groundwater flow components interact with each other in multiple ways and at various spatial and temporal scales, which makes it difficult to quantify the interaction. Numerous studies recognise the low reliability of predictions of groundwater flow and levels in urban catchments.

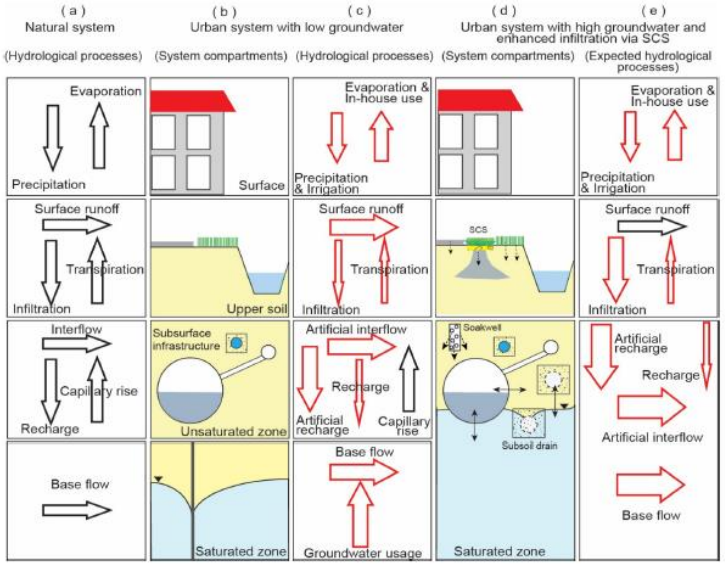
Changes to the pre-development water balance due to development also have the potential to impact water dependent ecosystems by altering water quantity, levels and periods of inundation. Development may introduce a range of new pollutant sources to a catchment and when combined with higher runoff volumes, this can increase pollutant loadings to surface water and groundwater resources. Development can also increase mobilisation of pollutants in groundwater from past land uses through sub-surface drainage. These impacts require implementation of treatment measures to protect downstream environments.

WSUD as a solution

An important aspect of water sensitive urban design (WSUD) is the capture and treatment of pollutants in stormwater and groundwater. Best practice includes structural and non-structural measures, typically implemented as a treatment train approach.

Some key issues raised by industry with regard to the application of WSUD in high groundwater environments are:

- identification of strategies that are effective in areas with flat topography or that treat organic nutrient forms;
- required clearance from groundwater for measures to provide appropriate treatment;
- maintenance of WSUD assets by local government (although this is not restricted to high groundwater environments);
- agreed standards for design and construction, including maintaining a balance between nutrient sorption of soil amendment materials and required permeability of the media; and
- predicting changes in pre-and post-development water and nutrient balances.



Conceptual model of water balance changes from urban development. Red arrows represent water flow that has been modified by development.

Understanding high groundwater

Determining pre-development groundwater levels and their fluctuation is a critical component of urban design, planning and management. The pre-development environment water balance is a product of the relationship between rainfall, runoff, infiltration, evapotranspiration and evaporation characteristics.

Understanding the conceptual water balance is needed to predict impacts of development and to enable design of suitable management measures. This requires knowledge of the environmental conditions of the site, as catchment conditions and land use influence groundwater levels and quality, whilst geotechnical and hydrogeological factors generally determine aquifer recharge.

There is no standard (or agreed) methodology in WA to define pre-development groundwater. Department of Water and Environmental Regulation (DWER) recommends two full years of groundwater level monitoring with monthly frequency. However, different approaches are often taken based on non-technical requirements, such as project budgets and schedules. The frequency and duration of monitoring and density of monitoring bores can also vary significantly between projects.

Contested science

The review identified 31 contested knowledge areas and 11 unknown areas. These knowledge gaps are clustered around the broader knowledge areas of:

1. pre- and post-development assumptions for modelling: Infiltration rates and fluxes to the aquifer, recharge rates, runoff rates, continuing losses, evapotranspiration rates, impact of trees and rainwater tanks;
2. understanding the source of pre-development nutrients and the difference in groundwater and drainage water quality between pre-development, construction and post-development phases;
3. post-development performance of WSUD in high groundwater; and
4. long-term performance of sub-soil drainage infrastructure, including volumes and quality.

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