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A systematic analysis of risks to the sustainable operation of non-potable urban water schemes

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Summary of key findings

Risks to the sustainable operation of non-potable urban water schemes extend well beyond water quality risks, with schemes predominately decommissioned due to technical and financial challenges that arise as a result of changes in the contextual environment of a scheme. Root causes of scheme failure were found to occur as a result of the variance between forecast demand and actual demand and as a result of changes in water pricing, developer charges and Government grants and subsidies at the construction phase of a scheme.

Background and relevance

Non-potable urban water schemes have been implemented in Australia over the past decade as a result of water supply security concerns, constrained centralised infrastructure and increased environmental degradation. Schemes have typically comprised rainwater harvesting, stormwater harvesting, greywater recycling and/or wastewater recycling to provide non-potable water supply to urban developments, with potable water supplied through conventional centralised water services.

While a proportion of non-potable urban water schemes have been largely successful in demonstrating performance and sustainability attributes, just as many have encountered significant challenges either at the construction phase, resulting in the scheme not being commissioned, or during the operational phase, resulting in decommissioning of the scheme in some cases. In cases where schemes have been decommissioned or have encountered ongoing technical issues, the objectives of the scheme to enhance water supply security and reduce pollutant discharges to the environment have not been realised. In addition, community expectations have not been met and reputational damage has ensued.

For operational schemes, the focus has been on minimising the public health and environmental risks associated with microbial and chemical hazards of alternative water sources. However, few public health impacts have been reported to date [1], with schemes predominately decommissioned due to technical and financial challenges that have arisen as a result of changes in the contextual environment of a scheme [2-4]. Changes in the contextual environment of a scheme, and the conditions under which a scheme is designed, are inevitable given the significant time delay between planning and commissioning of a non-potable urban water scheme, in some cases up to ten years [3].

When designing a scheme, it is essential that potential changes in the operating conditions of a scheme are understood and the risks they pose to the sustainable functioning of a scheme are assessed. Comprehensively analysing risks to scheme performance will enable adaptive management measures to be developed, with risk assessment at the planning stage informing risk management during the operational phase [5].

A systematic analysis of change drivers and the risks they pose to the performance and long-term viability of non-potable urban water schemes has been undertaken. Information gathered from detailed literature review, case study investigation and from interviews with water industry personnel was collected and collated to enable a PESTLE analysis, risk mapping and fault tree construction. Outcomes of the analysis comprised the identification of root causes of failure to meet the water supply security objectives, wastewater reduction targets and financial objectives of non-potable urban water schemes and the identification of key change drivers which invoke risks to the sustainable functioning of a scheme.

Results

The outcomes of the PESTLE analysis, risk mapping and fault tree construction indicated that a major root cause of failure of a non-potable urban water scheme to meet water supply security, wastewater reduction and/or financial objectives was the variance between forecast and actual demand, occurring either at the construction phase or operational phase of a scheme. At the construction phase of a scheme, the demand forecast not being met was found to result in a delay in commissioning of the recycled water plant which in turn resulted in the requirement to supply potable water in place of non-potable water, the requirement to truck wastewater from the development in some cases and the requirement to re-service the recycled water treatment plant prior to commissioning. Each of these events increased the operational costs of the scheme and resulted in impacts to the water supply security, wastewater reduction target and financial viability of the scheme.

At the operational phase, a reduction in demand was found to have significant impacts on the technical performance of recycled water treatment, storage and distribution components. Failure of the aeration systems, excessive growth of filamentous bacteria in the secondary clarifiers, odour in the primary and secondary clarifiers and fouling of membranes was found to occur as a result of low flows through the treatment plant. Long hydraulic residence times resulted in poor water quality in the distribution network and storage structures, in addition to inadequate pressure and sedimentation in the distribution network [6].

A reduction in demand from that forecast was found to occur as a result of economic changes, consumer behavioural change, climate variability and inadequate planning, as illustrated in Figure 1. The economic environment of a scheme was found to have a significant influence on the outcomes of a scheme with respect to meeting technical and financial performance objectives. The global economic crisis severely impacted a large proportion of non-potable urban water schemes through changes in market conditions, changes in development agenda and reduced individual income which subsequently resulted in reduced demand from the non-potable water scheme [2, 7].

Schemes designed on a water balance that failed to adequately consider or account for varying climatic conditions suffered from reduced demand as a result of reduced irrigation and outdoor watering requirements [2]. In addition, the end of the drought resulted in a change in Government agenda with the removal of grants and subsidies for non-potable urban water schemes.

Change in consumer behaviour has the potential to influence the outcomes of a non-potable urban water scheme either through reduced or increased demand. Environmental conscience may incentivise a consumer to plant native vegetation thereby reducing outdoor watering requirements, or a consumer opposed to the use of recycled water for outdoor uses will opt to using potable water in place of non-potable water. In some instances, the provision of a non-potable water source resulted in an increase in potable water usage through the security gained by having two water sources [7]. As a result, the potable water reduction target for the development was compromised.

An additional root cause of failure to meet the financial objectives of a non-potable urban water scheme comprised changes in developer charges or water pricing during the construction phase of a scheme resulting in increased cost to the water utility and reduced revenue, which may not have been anticipated at the planning stage when design of the scheme was undertaken [7]. Removal of Government grants and subsidies has been shown to reduce the incentive for water utilities to invest in the extension, upgrade or management of non-potable urban water schemes, with schemes being decommissioned in some instances due to the lack of funding available for upkeep of a scheme.

Discussion

To date, risk management has focused predominately on environmental and public health risks as a result of microbial and chemical hazards arising from non-potable urban water schemes. The National Guidelines for Water Recycling [8], to which non-potable urban water schemes comply, place a strong focus on public health and environmental risks, though fail to address a broader array of contractual,

political, legal and financial risks [9]. Investigation of non-potable urban water schemes suggests, however, that broader commercial risks have been the root cause of scheme decommissioning.

A holistic understanding of risks to the long-term viability of non-potable urban water schemes will enable better decision making, with risk assessment during the planning phase of a scheme informing risk management during the operational phase [5]. An understanding of major risks and development of adaptive management measures to reduce the impact of such risks, is essential if the operational performance and long-term viability of non-potable urban water schemes is to improve [3].

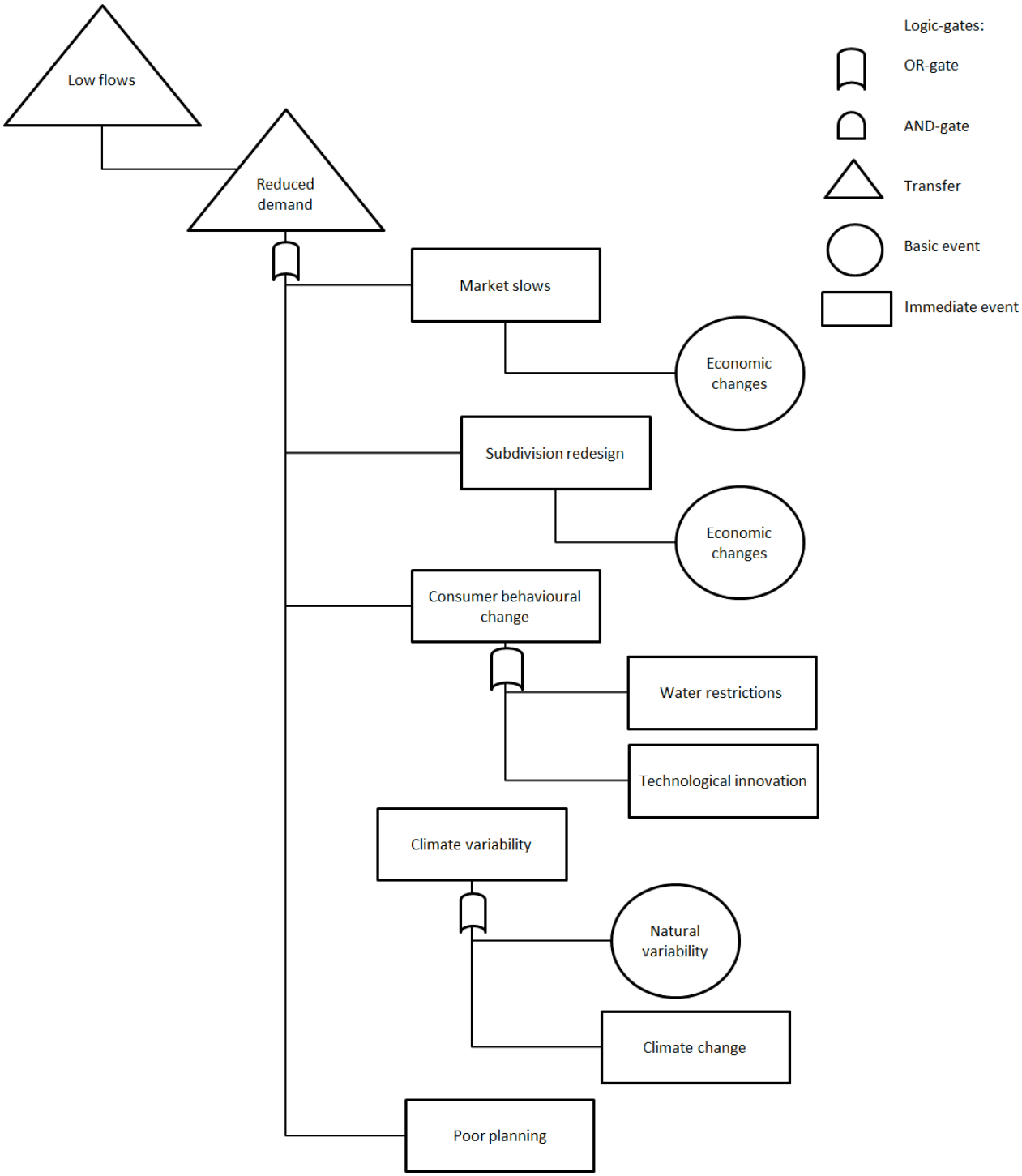

Figure 1.1 Fault tree of events leading to reduced demand from non-potable urban water schemes

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