A Risk Assessment Framework for Stormwater Reuse

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Highlights

- A novel risk-based approach for assessing a range of stormwater harvesting schemes.
- A logical screening tool to shortlist exhaustive list of water quality objectives.

Introduction

Alternative water sources such as stormwater are being widely used to relieve pressures on existing water resources due to population growth and climate change. However, poor quality associated with different source waters can pose a significant risk to public health and the environment. Therefore, it is critical to adopt an appropriate preventive risk management approach in any alternative water supply schemes.

The current study presents an innovative, risk-based approach developed to assess potential water quality, environmental and public health issues associated with stormwater harvesting schemes. It also illustrates the application of the approach for a proposed stormwater harvesting scheme in Melbourne, Australia.

Methodology

Risk-based Framework

The purpose of this approach is to define water quality-related risks with stormwater harvesting schemes to assist in guiding decisions and risk management measures. These could include whether or not to treat stormwater, to prioritise key water quality hazards and what level of treatment may be required. Figure 1 provides a schematic illustration of the process underway and how it effectively relates to the location of interest 'along' the passage of a parcel of water through a typical stormwater harvesting scheme.

The first stage of the framework collates an '***initial water quality specification'*** for relevant fit-for-purpose water quality from all relevant guidelines and water quality standards specified by the water authority. The second stage uses literature review, the initial water quality specification and other key data sources such as existing catchment water quality monitoring to develop a '***raw stormwater profile'***, taking into consideration upstream land uses. The raw stormwater profile is compared with the initial water quality specification to screen water quality parameters not detected in stormwater or detected in concentrations well-below the initial water quality specification. The third stage assesses the treatment effectiveness of on-site Water Sensitive Urban Design (WSUD) measures to develop a '***Post WSUD profile'*** to further shortlist against the water quality specification. The fourth stage considers the treatment impacts of the proposed advanced treatment train ('***Fit-for-purpose Water***') to further shortlist the parameter set from Stage 3. If there are any residual water quality parameters of concern (i.e. pollutants with concentrations higher than the initial water quality specification) at the end of stage 4, it is recommended to iterate back through the earlier process as required to either refine previous treatment recommendation or to define what additional treatment may be required to achieve an acceptable outcome.

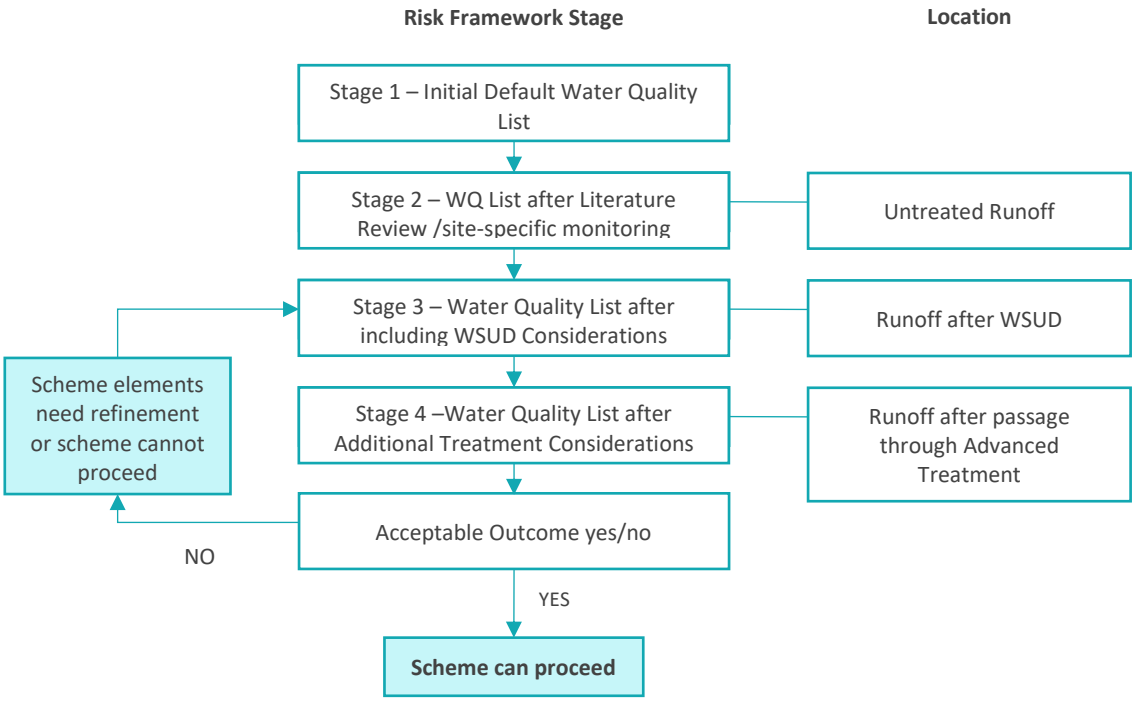

Figure 1. Overview of the proposed risk-based framework.

Stormwater Harvesting Scheme

The proposed stormwater harvesting scheme is located in a reserve in Melbourne's south-east. It is planned to harvest stormwater runoff generated from a 578 ha catchment (32% impervious) in two stages (E2Design Lab, 2020). Harvested stormwater would pass through a WSUD treatment train followed by advanced treatment. The proposed WSUD concept treatment train consists of a gross pollutant trap, sedimentation basin and wetland and post-WSUD treatment consists of ozonation, biologically activated carbon, membrane filtration and chlorination.

Harvested stormwater is proposed to be used for a range of non-potable uses. During the first stage, harvested stormwater will supplement watering of ovals and street trees. Harvested stormwater is expected to supply other non-potable uses such as toilet flushing and top ups for swimming pools in stage two. While it's proposed to use the scheme as a demonstration plant for treating stormwater to drinking water standard, it is, however, important to note that harvested stormwater will **not** be used for potable end uses.

The first stage of the scheme is currently at the detailed design stage. An initial water quality monitoring program has been conducted to characterise raw stormwater quality. The proposed stormwater harvesting scheme was assessed using the four-staged risk-based framework presented above.

Results and discussion

Stage 1 – Initial default water quality specification

In order to develop an ***initial water quality specification*** for the scheme, drinking water guidelines (NHMRC, 2011), water recycling guidelines (NRMMC-EPHC-NHMRC, 2008) and environmental water quality guidelines (ANZECC–ARMCANZ , 2000) were reviewed. Additionally, an interim water quality standard developed by South East Water for the first stage of the stormwater harvesting scheme was reviewed. An initial list of 407 chemicals of potential concern (COPC's) was identified.

Stage 2 – Raw stormwater profile

An initial raw stormwater profile was derived using on-site monitoring data, the Chemical Hazard Assessment of Stormwater Micropollutants (CHASM) tool (Leusch, et al., 2016) and the CRC for Water Sensitive Cities Stormwater Quality database (https://watersensitivecities.org.au/stormwater-quality-database/).

The exhaustive list of COPC's derived from Stage 1 was shortlisted by considering;

- Firstly, are COPC's expected to be present in stormwater?
- Secondly, are COPC's Persistent Bioaccumulating Toxicants (PBT's)?
- Thirdly, are COPC's likely to be present at concentrations that exceed relevant water quality objectives/criteria?

The initial list was reduced to 50 COPC's at the end of stage two. In addition to COPC's, a list of nutrient and pathogens/indicators was also prepared to be considered in the subsequent stages.

Stage 3 – Water quality list after including WSUD

Literature values and MUSIC modelling were used to assess WSUD performance without specific site data available. Considering the variability in reported WSUD performance, median percent removal values were compared with the required log/percent reductions to meet the water quality specification derived in Stage 1. It was found that none of the COPC's, pathogens or nutrients (except total nitrogen) could be removed to meet acceptable water quality consistently and hence further advanced treatment is needed post-WSUD.

Stage 4 – Water quality list after additional treatment

Given the design of the advanced treatment components is currently being progressed outside the study scope, Stage 4 was limited to a high-level review of the proposed advanced treatment train. The proposed treatment appeared to be adequate to achieve potable standard water quality. While it was identified that the initial design has some possible limitations/constraints, several recommendations have been made to improve treatment train sequence and treatment technologies.

Conclusions and future work

A risk-based framework was successfully applied to a proposed stormwater harvesting scheme in Melbourne's south-east. This approach has the flexibility to be adopted for other stormwater harvesting schemes.

It is planned to conduct additional water quality sampling to monitor for shortlisted COPC's and reference pathogen levels in raw stormwater. Furthermore, review outcomes/suggestions for improving the treatment train are being considered by the designers. It is critical to continue data collection once the scheme is operational to validate treatment performance.

References

ANZECC–ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Volume 1)

E2Design Lab (2020). Alternative Water Network for Fountain Gate - Narre Warren CBD

Leusch, F. et al. (2016). Chemical Hazard Assessment of Stormwater Micropollutants (CHASM) Guidance Manual

Lloyd, S., Khan, S., Osmond, S. & Knights, D., 2020. Microbial hazards in urban stormwater and their removal through WSUD.

NHMRC (2011). Australian Drinking Water Guidelines 6 (version 3.6 updated in March 2021)

NRMMC-EPHC-NHMRC (2008). Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Augmentation of Drinking Water Supplies