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Aura Stormwater Harvesting Project

An Innovative Risk Based Approach to Identifying Potential Water Quality Issues

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INTRODUCTION

Stockland is one of Australia's largest urban development companies, with a lengthy track record of delivering leading-edge urban projects. Stockland is currently undertaking the Aura development on Queensland's Sunshine Coast, a 50,000-person, 2,200 ha master-planned community, which commenced construction early in 2015 and which will be developed over the next 20-30 years.

A stormwater harvesting scheme is being investigated as a potential sustainability and water management component of Aura (McAlister et al 2017 and Figure 1). This scheme could potentially realise 2 GL/year of urban stormwater being harvested and used to augment the nearby Ewen Maddock Dam, owned and operated by Seqwater.

This paper describes an innovative and transparent risk-based approach that was developed to identify potential ecological and public health water quality issues associated with the scheme. The approach described was implemented for the first time in South East Queensland. The paper also presents previous and ongoing technical investigations conducted to inform the process, preliminary findings and lessons learnt.

KEYWORDS

Stormwater, Environment, Health, Reuse, Risk.

Figure 1: Potential Stormwater Harvesting Scheme Configuration and Possible Pipeline Route to Dam

CASE STUDY SUMMARY

The water quality characteristics of stormwater vary across urban catchments (Sidhu et al. 2012, Page et al. 2013, Reeve et al. 2015, Gernjak et al. 2017). The range and load of pollutants within stormwater from a specific catchment affect its suitability for use augmenting a drinking water supply source. Establishing the physico-chemical, chemical and microbial quality of stormwater is a critical step in determining the treatment and removal processes required to meet human and ecosystem health guidelines relevant to the drinking water supply source.

This study developed a clear and transparent framework to assess the entire suite of pollutants that may be present in stormwater for further consideration and evaluation. The framework uses a prioritisation and selection approach that gave consideration to land use, stormwater treatment, dilution and assimilation, and water treatment issues. Key actions associated with the case study were to apply the framework at Aura to guide ongoing risk assessments associated with the potential stormwater harvesting scheme.

The logical and rational risk-based approach and framework developed in this study could be applied to comparable projects elsewhere in Australia, or internationally. This case study focuses on stormwater quality only. Considerations of environmental and social impacts, and land use change, have been subject to separate investigations at Aura and are beyond the scope of this paper.

By way of general background, prior to development, the site was used primarily for pine plantation forestry. Being immediately adjacent to environmentally significant wetlands and estuaries, planning and approval of Aura required a higher than normal standard to be set for environmental performance. This required the implementation of a far greater degree of water sensitive urban design infrastructure than that of a contemporary development of this nature and also the installation of state of the art sewage collection and conveyance infrastructure to minimise potential impacts on downstream environments. Further detail of these works and the project in general are presented in McAlister et al 2017.

PROJECT SPECIFIC ISSUES OF CONCERN

Urban stormwater runoff is an underutilised resource for potable water supply in Australia. In contrast to Singapore, where urban runoff provides in the order of 15 percent of potable supply, only one region in Australia (Orange) currently proactively augments drinking water from surface runoff sources with stormwater. Limited knowledge regarding the constituents of concern to humans and ecosystems in stormwater and the fate of these constituents as they travel through water sensitive urban design (WSUD) infrastructure have been identified as notable barriers to such indirect potable reuse.

Urban stormwater is also highly variable in quality (Duncan 1999, Page et al. 2013, Gernjak et al. 2017) due to the influences of climate, topography, land use, how long the development has been in place (i.e., the age of the development) and infrastructure condition. When reuse of stormwater is being considered, this variability presents analytical and approval obstacles. There is also considerable uncertainty in regard to many less frequently studied, and hence more poorly understood, chemical contaminants (e.g. trace organics, pharmaceuticals, endocrine disrupting chemicals) (Page et al. 2013, Gernjak et al. 2017) as opposed to routinely investigated, and hence better understood, constituents (e.g. sediments and nutrients) that may be present in urban stormwater (Duncan 1999, Taylor et al. 2005, Francey 2010, Page et al. 2013, Daly et al. 2014, Reeve et al. 2015). Further, there is a lack of knowledge regarding the fate of these materials as they pass through WSUD infrastructure. Infield investigations are limited and nutrient focussed, and most treatment efficiency studies have been laboratory simulations utilising synthetic stormwater (Mangangka 2015, Li 2016, McNamara 2017). These are important issues of concern when stormwater reuse is being considered.

Existing Australian stormwater quality data can provide useful knowledge to direct parameters to be measured during water quality assessments. However, it is not appropriate for use to predict human and ecosystem health risks associated with the stormwater within Aura because of critical variances in sewerage infrastructure. Currently available stormwater quality data typically relates to samples collected from catchments with 20 to 100 year old sewerage infrastructure, with old ‘butted’ pipe sewer systems that are recognised for their propensity to leak. Such catchments also often have sewage pump stations located within them, which can overflow under heavy rainfall conditions (especially in areas with old sewer systems where infiltration can also be a major issue). In the case of Aura, with water quality management and stormwater harvesting having been a key element of the project since conception, innovative welded sewer systems are being used which are far less likely to leak. Also, all sewer pump stations have been placed downstream of sites where stormwater harvesting may occur. Hence, existing stormwater quality data are not necessarily relevant to Aura.

INVESTIGATIVE APPROACH

The study commenced in 2005 and is ongoing. The approach for identifying and prioritising water quality hazards associated with the proposed Aura stormwater harvesting and reuse scheme was developed by Stockland, Seqwater and specialist organisations (Water Technology, University of Sunshine Coast and Viridis Consultants). The purpose of the approach was to define key issues with the project to assist in guiding project design elements such as whether or not to treat stormwater, to prioritise key water quality hazards and what level of treatment may be required. The risk-based approach is summarised in Figure 1 and described further below.

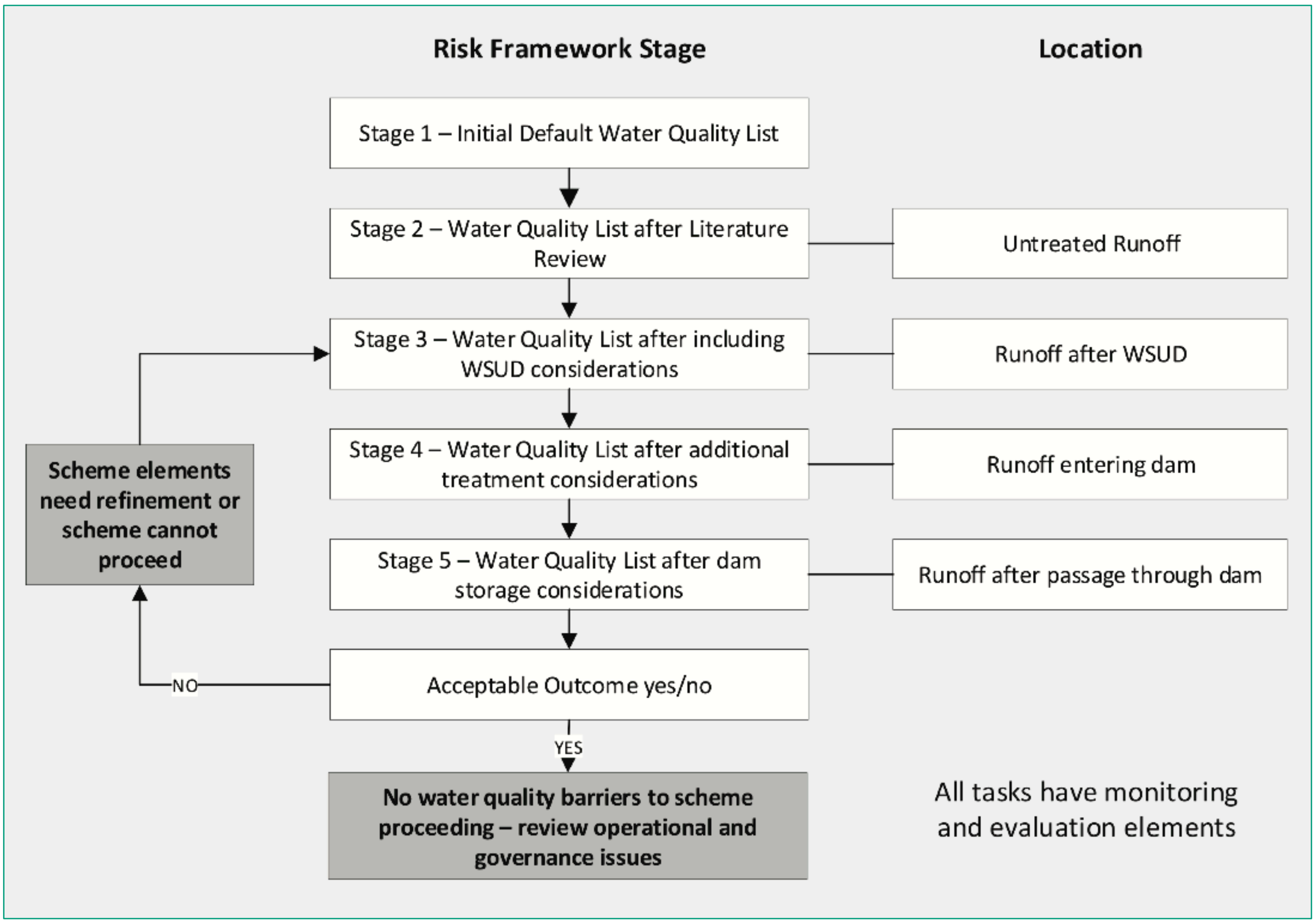

Figure 2: Risk Based Investigative Approach

In **Stage 1**, a comprehensive list of all water quality hazards and constituents of potential concern (COPCs) to human and ecosystem health is derived based on relevant guidelines (e.g. Australian Drinking Water Guidelines, Australian Guidelines for Water Recycling: Augmentation of Drinking Water Supplies, etc.) and water quality objective documents (e.g. Queensland Environmental Protection Policy for Water). This action defines the initial set of parameters that must ultimately be complied with in order to ensure that harvested stormwater is 'safe' for placement in the drinking water reservoir and subsequent potable reuse.

In **Stage 2**, literature review and relevant information database searches are used to shortlist the Stage 1 parameter set into the set of COPCs that may actually be present in stormwater at concentrations in excess of the guideline values identified by Stage 1. Consideration is given at this stage to the issue of potential bioaccumulation within Ewen Maddock Dam. This provides a prioritised list of water quality hazards to Ewen Maddock Dam that require further consideration with respect to their fate through the stormwater management process.

In **Stage 3**, consideration is given to the influence on stormwater quality of WSUD measures to be constructed at Aura. That is, water quality hazards that have the potential to be at concentrations above relevant water quality objectives after passage through WSUD devices are priortised for further consideration in Stage 4. This process also needs to account for how the treatment efficacy of WSUD devices are maintained over the life of the scheme.

In **Stage 4**, consideration is given to the influence on water quality of additional storage and treatment processes between the collection of stormwater from Aura (after passage through site WSUD devices) and its delivery into Ewen Maddock Dam. Again, if after these processes, any particular COPC has an expected concentration greater than the listing developed at Stage 1, it will require further consideration.

In **Stage 5**, consideration is given to the influences of storage, dilution, shortcircuiting of flows, background concentrations and biomodification of harvested stormwater once it is pumped into Ewen Maddock Dam.

If after these assessments, there are any remaining water quality specification exceedances, these can be assessed in regard to:

- Whether treatment processes at the Ewen Maddock Dam water treatment plant are sufficient to remove them in the case of drinking water quality hazards;
- If there are any within dam environmental (e.g. algal bloom or aquatic weed growth stimulation) or recreational contact (e.g. increased pathogens) risks that require attention; and
- If there is a need to iterate back through the previous stages to achieve an acceptable outcome, for example:
  - Refine stormwater treatment recommendations (e.g. modify how WSUD measures are configured) to reduce environmental, recreational or drinking water quality risks;
  - Define additional treatment activities at the stormwater harvesting storage (west of the Pacific motorway) or within the pumped system delivering stormwater to the Dam; or
  - Define additional treatment activities at the Ewen Maddock Dam water treatment plant.

ACTIVITY SUMMARY (TO DATE)

To date, Stage 1 and 2 works have been completed and Stage 3 works are underway. In addition, a program of stormwater sampling and analysis has commenced to provide locally specific data to confirm the findings of the desktop based investigations. A description of the findings of these activities is provided below.

STAGE 1 – INITIAL DEFAULT WATER QUALITY PARAMETER LIST

All water quality guidelines relevant to the potential stormwater harvesting scheme were reviewed to form a comprehensive list of the potential maximum suite of water quality parameters that the scheme will have to comply with to be considered safe and obtain regulatory approval. Table 1 summarises the water quality guidelines relevant to the proposed stormwater harvesting scheme.

Table 1: Water Quality Guidelines relevant to the potential Aura Stormwater Harvesting Scheme

Guideline	Section	Title
Public Health Regulation (2005) (QLD GOV, 2017)	Schedule 3B	Standards for quality of recycled water supplied to augment a drinking water supply
Australian Drinking Water Guidelines (NRMMC, 2011)	10.3.7	Summary of guideline values for microbial, chemical and physical characteristics
Australian Guidelines for Water Recycling: Augmentation of Drinking Water Supplies	Table 4.4	Chemicals detected in secondary treated sewage, maximum concentration and guideline values
Environmental Protection Policy (Water) 2009 (DERM, 2010)	a) Table 2 b) Table 13	Water quality objectives to protect aquatic ecosystem, recreational and drinking water related environmental values
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)	Table 3.4.1 (95%ile Species Protection)	Trigger values for toxicants at alternative levels of protection

At the end of this process, a total of **527** potential chemicals of concern resulted from the combined assessment of these water quality guidelines. For each chemical listed, the most conservative trigger value of all water quality guidelines assessed was retained. The relevance of each chemical to the stormwater harvesting scheme was investigated in more detail in Stage 2.

Biological parameters, pathogen indicators and pathogens listed in Table 3 were also identified at this stage.

STAGE 2 – WATER QUALITY LIST AFTER LITERATURE REVIEW

Stage 2 involved a 5-step shortlisting and review process of the 527 chemicals identified in Stage 1. This process used the following sources:

- A comprehensive stormwater quality literature review (Lampard, 2017) conducted for this project;
- The Chemical Hazard Assessment of Stormwater Micropollutants (CHASM) tool (CHASM, 2016) to identify chemicals likely to be found in stormwater generated from the land uses present within Aura or which are likely to be at concentrations above trigger levels; and
- Potential chemical persistence, bioaccumulation and toxicity (PBT) issues using an online tool developed by the US Environmental Protection Agency (www.pbtprofiler.net).

The diagram presented in Figure 3 illustrates the process followed to review and include or exclude, as appropriate, those chemicals identified in Stage 1 which require further investigation. The process is also described below.

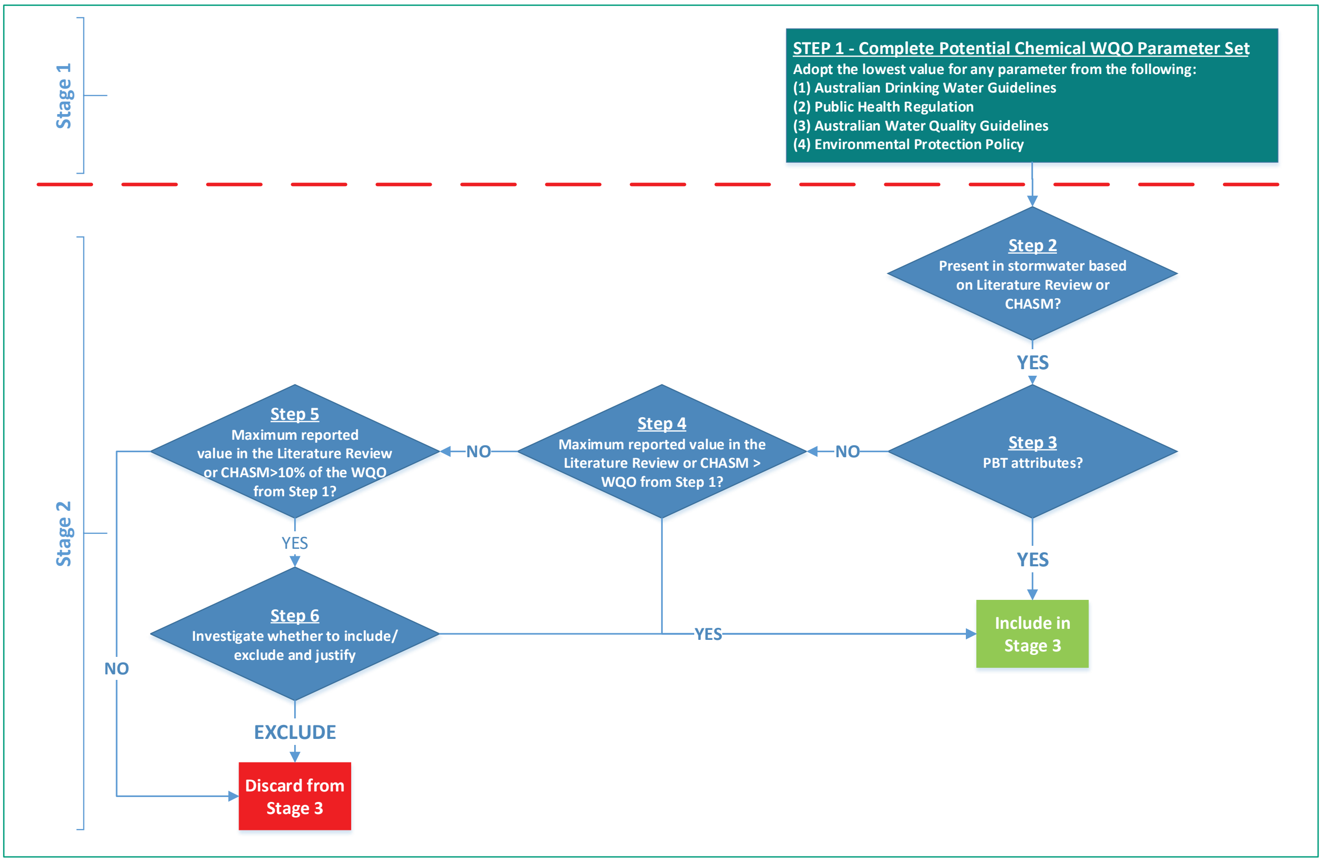

Figure 3: Stage 2 Shortlisting Process for Chemical Constituents

Step 1: Initial Chemical Constituent Shortlisting

- Literature Review: The literature review (Lampard, 2017) was used to guide and inform ongoing discussions and risk assessments associated with stormwater harvesting. The author was asked to provide the best possible guidance using available published and grey literature describing COPCs that may be present in stormwater generated from Aura.
- Chemical Hazard Assessment of Stormwater Micropollutants (CHASM): CHASM is a decision support tool that provides a list of the COPCs that may be encountered in stormwater from a catchment of known dimensions with defined land uses (CHASM, 2016). CHASM requires knowledge of the following catchment and development specific data to derive a shortlist of pollutants potentially of concern for a particular site:
  - Basic catchment information: surface area, impervious fraction, average annual rainfall;
  - Details of sewage infrastructure (if any) in the catchment;
  - Details of any specific chemical manufacture, storage or dumping activities in the catchment;
  - Specific activities in the catchment that may have micropollutant consequences (e.g. dog washers, carpet cleaners, pest control);
  - Details of any mosquito control activities in the catchment, and the chemicals being used for this; and
  - Land uses in the catchment using the Australian Land Use and Management (ALUM) classification system (DAWR, 2010).
- Joint Assessment: The list of chemicals identified by the CHASM tool was added to those identified by the literature review and an initial filter undertaken of the 527 chemicals identified by Stage 1. This resulted in the reduction of the list of chemicals to 80, which were then passed forward for further analysis.

Step 2: Persistence, Bioaccumulation and Toxicity (PBT) Assessments

The constituents remaining after Step 1 were assessed to determine their PBT potential. This was undertaken as such chemicals, regardless of their expected concentration in relation to relevant water quality guidelines, may be of concern given their propensity to bioaccumulate in a system, and hence present a potential long-term problem in Ewen Maddock Dam.

For this step, the web-based US EPA PBT profiler tool (www.pbtprofiler.net), which identifies the persistence, bioaccumultaion and toxicity potential of individual chemicals, was used. Of the **80** chemicals assessed at this stage, **3** were indicated by this tool to be persistent bioaccumulating toxicants of potential concern, these being Heptachlor, Methoxychlor and Phenanthrene.

These chemicals were passed to the list of substances requiring assessment in Stage 3.

Step 3: Water Quality Objectives (WQO) Assessments

The next step was to take the remaining **77** chemicals and assess if the maximum reported values for these chemicals in either the Literature Review or the CHASM assessments exceeded the water quality obejctives (WQO's) defined in Stage 1. In doing this, **28** chemicals of potential concern were identified. These chemicals were passed to the list of substances requiring assessment by Stage 3.

Step 4: WQO Sensitivity Assessments

Sensitivity assessments of the absolute WQO threshold approach described for Step 3 were conducted as the concentration of some compounds can vary by a factor of 10 and there are measurement and sampling uncertainties that need to be considered for some compounds. Further assessments were conducted of those chemicals anticipated to occur between the WQO and 10% of the WQO. These assessments were of the form of detailed evaluations of how many times the compound has been detected in the literature, around what land uses, and if there are already other suitable indicators within the suite from Steps 2 and 3.

In doing this, a further **7** chemicals of potential concern were identified and passed to Step 5 for assessment.

Step 5: Investigate Inclusion/Exclusion of the Sensitivity Assessments and Justify

The **7** WQO sensitivity shortlisted COPCs were evaluated against 'raw' stormwater quality data available to principal researchers from a national stormwater quality study (Gernjak et al 2016). After this assessment, and discussions with Seqwater personnel, the following **3** COPCs were included for further consideration.

- Selenium
- Sulphate
- TCEP

The final list of **34** chemicals of concern from Stage 2 (reduced from the **527** chemicals identified at Stage 1) is presented in Table 2. Their source in this analysis is summarised below.

- 28 > WQO
- 3 PBT
- 3 > 10% of WQO and with sufficient data to justify inclusion.

Some chemicals were included as indicator compounds (e.g. acesulfame - as verification of the efficacy of welded sewers) or as there are known potential uses in the catchment.

Table 2 presents the Stage 2 list of chemical constituents of potential concern.

Table 2: Stage 2 List of Chemical Constituents of Potential Concern

Chemical Compound	Conservative Guidelines Trigger Value (µg/L)	Highest CHASM - Literature Review Detection Value (µg/L)	Reason for inclusion
Acesulfame K		3.5	Indicator of wastewater
Aluminium - Total	200	11,300	Detection level > WQO
Antimony - Total	3	99.8	Detection level > WQO
Arsenic - Total	7	48	Detection level > WQO
Azinphos - methyl	0.02	0.76	Detection level > WQO
Cadmium - Total	2	50.6	Detection level > WQO
Caffeine	0.35	5.2	Detection level > WQO
Chlorpyrifos	0.01	100	Detection level > WQO
Chromium (Cr (VI))	1	130	Detection level > WQO
Copper - Total	1	151	Detection level > WQO
Diazinon	0.01	0.5	Detection level > WQO
Dicamba	100	500	Detection level > WQO
Fenitrothion	0.2	0.5	Detection level > WQO
Heptachlor	0.09	0.05	PBT
Imidacloprid		0.09	Included as known potential use in catchment
Iron – Total	300	71,000	Detection level > WQO
Lead – Total	3.4	69	Detection level > WQO
Malathion	0.05	0.5	Detection level > WQO
MCPA	2	500	Detection level > WQO
Mercury - Total	0.6	18	Detection level > WQO
Methoxychlor	300	0.02	PBT

Molybdenum - Total	50	69.7	Detection level > WQO
Nickel - Total	11	120.5	Detection level > WQO
Oil and Grease		6,000	Bulk impact indicator
Phenanthrene	150	0.1	PBT
Selenium - Total	10	7	Detection level > 10% WQO
Silver - Total	0.05	0.2	Detection level > WQO
Simazine	3.2	10,200	Detection level > WQO
Sodium - Total	180	57,355	Detection level > WQO
Sulphate (as S)	250,000	94,718	Detection level > 10% WQO
TCPP		0.6	Common flame retardant - included as generally more detected than TCEP
TCEP	1	0.3	Detection level > 10% WQO
Vanadium - Total	50	333.7	Detection level > WQO
Zinc - Total	8	1,076	Detection level > WQO

The nutrients, pathogens, pathogen indicators and cyanobacterial indicators and toxins that were also independently adopted for passage to subsequent investigations are presented in Table 3.

Table 3: Stage 2 List of Nutrients, Pathogens, Pathogen Indicators and Cyanobacterial Indicators and Toxins

Nutrients	Pathogens, Pathogen and Microbial Indicators and Cyanobacterial Indicators and Toxins
Nitrate	E. coli
Nitrite	Enterococci
Total Nitrogen	Microcystis aeruginosa
Oxidised N	Total Cyanobacteria
Ammonia N	Saxitoxin
Organic N	Microcystin
Total Phosphorus	Cylindrospermopsin
Filterable Reactive Phosphorus	Cryptosporidium
	Giardia
	Campylobacter

STAGE 3 – WATER QUALITY LIST AFTER INCLUDING WSUD CONSIDERATIONS

Stage 3 works, and other site-based validation assessments, are currently underway. Salient observations to date based on these activities are summarised below:

- Impact of WSUD measures – A comprehensive literature review is currently being conducted to assist in defining what beneficial impacts the passage of stormwater at Aura through extensive WSUD measures (approximately 4% of the developed footprint) may have on its quality and suitability for stormwater harvesting and reuse. This review is highlighting that WSUD elements, especially appropriately configured bioretention systems, can be beneficial in removing nutrients, heavy metals and pathogens from urban stormwater. The review is still underway, and is being supplemented by field-based investigations (see below);
- Impact of retention/detention of stormwater within Ewen Maddock Dam – In parallel with Stage 2, 3 and 4 investigations, numerical modelling of Ewen Maddock Dam and its catchment is being conducted. While still under development, this modelling is indicating that stormwater that may be placed in Ewen Maddock Dam from Aura would be diluted by at least a factor of 20:1 before it is withdrawn at the Ewen Maddock Dam water treatment plant; and
- Field sampling – A comprehensive program of sampling and laboratory assessment of the quality of stormwater entering and discharging from established bioretention systems in a comparable development in the Bells Reach precinct adjacent to Aura and also from within some of the recently established precincts of Aura itself is currently being conducted by Water Technology and University of Sunshine Coast personnel. As well as the usual suite of sediment and nutrient analytes, for the first time in South East Queensland, if not Australia, this program is undertaking real world testing for broad suites of heavy metals, pesticides, herbicides, toxicants, pathogen indicators and actual pathogens themselves in stormwater entering and leaving bioretention systems. While still underway, to date this programme has collected data from four separate stormwater events ranging from 15 to 60mm in magnitude. Preliminary observations based on this program are as follows:
  - Untreated stormwater from within Bells Reach and Aura appears to generally be of a better quality than indicated by the literature sources identified by this study, which is not surprising as the development is relatively new and has embedded infrastructure (welded sewers, extensive rainwater tanks) that would contribute to enhanced stormwater quality;
  - There are generally significant reductions in the concentrations of nutrients, heavy metals, pathogens and microbial indicators with passage through the bioretention systems; and
  - Pesticides and herbicides are regularly observed by the stormwater measurements, interestingly sometimes in higher concentrations in water leaving the bioretention systems than entering it. This may relate to local government operation and maintenance practices for bioretention systems within Bells Reach and Aura. This issue is currently being further investigated by Stockland personnel and fate processes will need to be addressed (e.g. are these materials accumulating and subsequently being released, etc.).

DISCUSSION AND CONCLUSIONS

An innovative and potentially regionally significant stormwater harvesting scheme is being considered in association with the Aura development project. Limited knowledge regarding the constituents of concern to humans and ecosystems in stormwater likely to be produced by Aura and the fate of these constituents as they travel through water sensitive urban design (WSUD) infrastructure within the site was identified as a potential barrier to approval for the scheme to proceed.

A comprehensive five-stage process was subsequently developed to reduce the large list of potential chemicals of concern to a more focused and manageable set of expected chemicals of concern for ongoing investigation. This process, having been developed collaboratively by the project proponent (Stockland), its consulting/research team (Water Technology/USC) and the owner of Ewen Maddock Dam (Seqwater) saw open, honest and transparent discussions and decisions being made regarding the risks associated with the proposed stormwater harvesting scheme.

To date, Stages 1 and 2 of the five-stage process have been completed and Stage 3 is underway.

Stage 1 involved the development of a comprehensive list of all water quality hazards and constituents of potential concern (COPCs) to human and ecosystem health that may be present in stormwater produced within Aura. This defined the initial set of parameters that must ultimately be complied with in order to ensure that harvested stormwater is ‘safe’ for placement in the drinking water reservoir and also for subsequent potable reuse.

Stage 2 refined the exhaustive list of **527** chemicals developed by Stage 1 using a literature review, relevant information database searches and online chemical assessment tools to produce a subsequent list of **34** COPCs, along with relevant pathogens and nutrients, which will require further investigation before a decision can be made as to whether or not the scheme can proceed.

The process that has been developed is readily applicable for consideration by other stormwater harvesting and drinking water supply augmentation projects in Australia and internationally.

Ongoing assessments (Stages 3, 4 and 5 of the previously described risk assessment framework) of the impacts of WSUD measures on stormwater quality and field validation of desktop-based stormwater quality assessments at this time appear encouraging with respect to the possibility of the stormwater harvesting scheme proceeding. The results of these assessments will hopefully be reported in future technical publications.

We note that a decision in regard to the stormwater harvesting scheme proceeding has yet to be made and that such a decision will be contingent upon:

- Ongoing data collection and modelling assessments confirming that water quality related risks are acceptable to Seqwater; and
- Continued financial and system governance related discussions between Stockland and Seqwater.

LESSONS LEARNT/ CRITICAL SUCCESS FACTORS

Key lessons learnt and critical success factors associated with the studies that have occurred in and around the Aura stormwater harvesting scheme over the last 3 to 4 years are outlined below.

Firstly, the time taken to move from identifying the concept of the stormwater harvesting scheme at Aura to a point where a decision that the stormwater harvesting scheme may actually proceed is more likely than unlikely has been considerable. An important lesson learnt by the various parties who have been involved in the studies which have been required is that the work required to assess and hopefully ultimately gain approval for a potable stormwater reuse scheme of the scale proposed at Aura is technically challenging, time-consuming and expensive.

Secondly, another key finding has been that there are major knowledge gaps regarding urban stormwater quality in Australia. These gaps are less significant for more regularly studied constituents of concern such as nutrients and sediment. However, for many of the chemicals that are of key concern when potable reuse is being considered, such as trace organics, pharmaceuticals, endocrine disrupting chemicals and pathogens, these knowledge gaps are significant. An improved, contemporary set of data collection work from several representative locations around Australia to improve our knowledge of these particular sets of constituents of concern in urban stormwater would be of considerable value.

Thirdly, compounding the point raised above, for many of the chemicals that may be present in urban stormwater for which we do have a decent knowledge base, there often is a poor understanding of the fate of these chemicals, particularly the rate of their removal with passage through contemporary water sensitive urban design infrastructure such as bioretention systems and wetlands.

Finally, a key learning of those involved in this project is that a collaborative and consultative process between the project proponent and the ultimate authority responsible for potable water safety is essential if a scheme such as that proposed at Aura is to succeed.

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Tony has more than 30 years Australian and International water engineering expertise in the areas of numerical flood and water quality modelling, field data collection and assessment, non-point source pollution assessment and mitigation, WSUD and IWCM, water quality and catchment management and sewerage and water supply investigations.

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Mark joined Stockland in 2007 and leads sustainability planning, environmental management and infrastructure delivery for Australia's largest new master planned community, Aura. Mark's industry experience spans over 20 years in Property Development with qualifications in Environmental Science and Landscape Architecture fuelling his passion for delivering sustainable communities.

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Duncan has worked in the area of drinking and recycled water quality risk management in Queensland and the ACT for more than 10 years. This has included the development and implementation of risk based monitoring programs to both drinking water and recycled water (intended to augment drinking water supply) schemes.

Dr Michael Bartkow

Michael is the Team Leader of the Water Policy and Research Unit at Seqwater and oversees the delivery of policies, strategies and the research portfolio. He has over 10 years experience managing research programs and specializes in the fields of environmental chemistry and toxicology.

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Jane-Louise Lampard

Jane-Louise Lampard is Program Leader for Environmental Health at the University of the Sunshine Coast. She has been researching human health risks associated with alternate water sources and recreational activities for 11 years focussing for the last 8 years primarily on microbial and chemical hazards in stormwater.