Sociodemographic influences on Australian urban water practitioners’ risk perceptions towards stormwater harvesting and quality treatment systems

M. F. Dobbie and R. R. Brown

School of Geography and Environmental Science and Monash Water for Liveability, Monash University, Clayton, 3800.

Abstract
Risk assessment of traditional stormwater systems has focused on flooding issues but, for stormwater harvesting and quality treatment systems, risk management is likely to involve a broader range of risks. Although risk perceptions are acknowledged in ranking management priorities, covert risk perceptions need to be understood to allow critical reflection on their wider influence in risk management activities and their outcomes. However, risk perceptions might not be shared amongst practitioners but vary with such personal and professional attributes as field of study or organisational affiliation. Thus, this study explores the influence of various sociodemographic attributes on water practitioners’ risk perceptions of stormwater harvesting and quality treatment systems. Analysis of risk perception data collected from Australian urban water practitioners (N=620) in a national on-line survey revealed that a practitioner’s work area, stakeholder group and/or primary qualification can influence perceptions of general risk of stormwater harvesting systems, of specific risks that might be associated with stormwater harvesting and treatment systems, i.e. environmental risk, flooding risk, aesthetic risk, technological risk, public health risk, political risk and risk of loss of reputation, and of risk of drinking or showering with treated stormwater. These different risk perceptions are likely to be unacknowledged in urban water management but could contribute to reluctance by some to implement alternative urban stormwater systems.
Now that these covert risk perceptions are revealed, strategies can be developed to overcome them. Dedicated social learning through experimentation is one.

**Introduction**

Historically, urban stormwater has been perceived as a hazard, to be diverted from built-up areas as efficiently as possible to prevent flooding and associated risks to public health. More recently, with the pressure of climate variability and urban population growth, stormwater is increasingly viewed as a potential resource to augment water supplies, offering multiple benefits in association with its harvesting and treatment infrastructure, such as urban heat island mitigation, waterways protection, reduced drainage infrastructure and improved landscape values. Australian water practitioners have acknowledged the importance of developing stormwater as a water source but believed that its implementation was impeded by a number of barriers associated with social and institutional processes and practices in urban water management (Brown et al., 2009; Brown and Farrelly, 2009). These barriers can be understood as types of risk.

Risk management of traditional stormwater systems has focused on public health and financial implications of flooding but management of stormwater harvesting and quality treatment systems is likely to involve a number of additional risks, including environmental, technological, cost-related and political risks (Pollard et al., 2004; Baggett et al., 2006; Salgot et al., 2006; Willetts et al., 2007). Risk assessment explicitly drives risk management but risk perception is acknowledged to have a role in ranking risks to set management priorities (Long and Fischhoff, 2000) and in establishing criteria for risk tolerance or acceptance, tradeoffs between these criteria and strategies for dealing with the remaining uncertain risks (Renn, 1998). Risk perceptions are known to covertly inform decision making more generally.
Thus, the risk perceptions of Australian urban water practitioners need to be understood, to allow reflection on their influence on urban water management and policy generally and on the adoption of alternative systems such as stormwater harvesting and treatment.

In a study designed to address this knowledge gap, Dobbie and Brown (2012) found that Australian urban water practitioners perceived the risk of stormwater harvesting and quality treatment systems to be less than slight. However, behind these general perceptions was a more complex mix of perceptions associated with 14 specific risks, including public health risk, environmental risk, cost-related risks, political risk and aesthetic risk. The highest specific risks were capital cost and maintenance/operations cost of stormwater harvesting systems, perceived by 50% of practitioners as moderate at least……but 50% perceived the risks as less than moderate. Clearly, all practitioners did not perceive the risks similarly.

All risk perceptions are subjective, varying with attitudes, beliefs and values (Slovic, 1999; Sjöberg, 2000). Studies have shown that professionals’ risk perceptions can vary with field of study and industrial affiliation (Lynn, 1986; Kraus et al., 1992; Barke and Jenkins-Smith, 1993; Rohrmann, 1994; Slovic et al., 1995; Stedman, 2004; Stedman et al., 2005) and political ideology reflected in cultural worldview (Boholm, 1998; Slovic and Peters, 1998). Water practitioners are trained in various disciplines, e.g. engineering, planning, natural resource management, environmental science, economics, urban design and business, each with its own cultural perspective and associated ontology and epistemology of risk (Thompson and Dean, 1996; Althaus, 2005; Aven et al., 2011). Perceived control and trust can also influence risk perception (Slovic, 1987, 1999; Siegrist and Cvetkovich, 2000; Po et al., 2005): practitioners working with centralised water systems might perceive greater risks
with decentralised systems such as stormwater harvesting and treatment. There have been no studies into the influence of discipline, organisational affiliation, years’ experience or other personal and professional attributes on water practitioners’ risk perceptions, either in Australia or elsewhere.

Conflicting, yet covert, risk perceptions of Australian urban water practitioners could impede the adoption of stormwater harvesting and treatment systems in Australian cities in ways that are not yet understood. Thus, this study explores the influence of selected sociodemographic variables on their risk perceptions of these systems.

Method

Data were obtained through a national on-line survey of Australian urban water practitioners. Before going live, the survey was trialled by water practitioners from each of the mainland capital cities and refined in the light of feedback. It was then posted on-line from 16 September 2010 to 31 April 2011. To ensure a high level of participation across the water industry, representatives were recruited in Perth, Adelaide, Melbourne, Sydney and Brisbane to recruit, in turn, colleagues to complete the survey. Water practitioners in regional areas of the country were also encouraged to participate. In all, 620 respondents commenced the survey, with a 40% completion rate.

The survey collected sociodemographic data (Table 1) and, among other questions, asked respondents to rate the following risks on a modified 4-point Likert scale (1, no risk; 2, slight risk; 3, moderate risk; 4, significant risk):

1. ‘general’ risk of 11 different uses of treated stormwater, varying in degree of personal contact (Table 2),
Table 1. Sociodemographic data collected from water practitioners in on-line survey.

<table>
<thead>
<tr>
<th>City</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Stakeholder group</th>
<th>Level in organization</th>
<th>Type of work within industry</th>
<th>Work area within industry</th>
<th>Primary professional qualification</th>
<th>Years’ experience</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Female (N=240)</td>
<td>25-34</td>
<td>State government professional (N=141)</td>
<td>Middle (N=298)</td>
<td>Strategy/Policy (N=185)</td>
<td>Water supply (N=103)</td>
<td>Environmental science (N=97)</td>
<td>2-5 (N=173)</td>
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<tr>
<td>Melbourne (N=92)</td>
<td>35-44</td>
<td>Water utility (N=86)</td>
<td>Local government professional (N=214)</td>
<td>Executive (N=58)</td>
<td>Regulation/Auditing (N=48)</td>
<td>Total water cycle management (N=121)</td>
<td>Natural resource management (N=47)</td>
<td>6-10 (N=121)</td>
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<tr>
<td>Sydney (N=81)</td>
<td>45-54</td>
<td>Developer (N=10)</td>
<td>Non-government organisation (N=11)</td>
<td>Research/Academic (N=28)</td>
<td>Elected official (N=0)</td>
<td>Urban design/landscape architecture (N=31)</td>
<td>Business/Economics (N=38)</td>
<td>11-15 (N=78)</td>
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<tr>
<td>Brisbane (N=161)</td>
<td>55-64</td>
<td>Consultant (N=82)</td>
<td>Construction/Plumbing (N=19)</td>
<td>Other (N=100)</td>
<td>Sewerage (N=39)</td>
<td>Physical science (N=21)</td>
<td>Biography (N=36)</td>
<td>16-20 (N=60)</td>
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<td></td>
<td>65+</td>
<td>Researcher/Academic (N=28)</td>
<td>Other (N=0)</td>
<td></td>
<td></td>
<td></td>
<td>Health science (N=14)</td>
<td>&gt;20 (N=102)</td>
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<td></td>
<td>(N=7)</td>
<td>Manufacturer (N=4)</td>
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<td>Marketing/Communication (N=13)</td>
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<td></td>
<td>Tradesman (N=10)</td>
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<td>Social science (N=13)</td>
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<td></td>
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<td>Other (N=13)</td>
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<td>Planning (N=11)</td>
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<td>Plumbing (N=11)</td>
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<td>Building construction (N=7)</td>
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<td>Education (N=7)</td>
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<td>Humanities (N=5)</td>
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<td></td>
<td></td>
<td></td>
<td>Law (N=4)</td>
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</table>
2. ‘general’ risk of stormwater harvesting and quality treatment systems, and

3. 14 specific risks associated with these systems (Table 2).

‘General’ risk was not defined but the questions were phrased to imply an overall risk.

Table 2. Uses of treated stormwater rated for ‘general’ risk, and specific risks associated with stormwater systems, explored in online survey.

<table>
<thead>
<tr>
<th>Uses of treated stormwater</th>
<th>Specific risks associated with stormwater systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports field irrigation</td>
<td>Public health</td>
</tr>
<tr>
<td>Vehicle washing</td>
<td>Environmental</td>
</tr>
<tr>
<td>Water features</td>
<td>Flooding</td>
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<tr>
<td>Garden watering</td>
<td>Aesthetic</td>
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<tr>
<td>Vegetable growing</td>
<td>Technological</td>
</tr>
<tr>
<td>Toilet flushing</td>
<td>Management failure</td>
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<tr>
<td>Hot water supply</td>
<td>Political</td>
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<tr>
<td>Clothes washing</td>
<td>Loss of end-user commitment</td>
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<tr>
<td>Dishwashing</td>
<td>Constrained future innovation</td>
</tr>
<tr>
<td>Showering</td>
<td>Compliance</td>
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<tr>
<td>Drinking</td>
<td>Capital cost</td>
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<tr>
<td></td>
<td>Maintenance/operations cost</td>
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<td></td>
<td>Commercial</td>
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<td></td>
<td>Reputation loss</td>
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</tbody>
</table>

Analysis was conducted with SPSS 20 (IBM, Armonk, NY, USA). Means (\(M\)) and standard deviations (s.d.) were calculated for perceived ‘general’ and specific risks for each water system and perceived ‘general’ risk for different uses of treated stormwater. The maximum mean value possible was 3, as the data were recoded before analysis so that 0 represented no risk; 1, slight risk; 2, moderate risk, and 3, significant risk. The results were then compared between each group for each sociodemographic variable. The normal distribution of the data was checked by skewness and kurtosis values and Q-Q plots (George and Mallery, 2007) to determine whether parametric or non-parametric analyses should be conducted. Data for ‘general’ and specific risk perceptions of stormwater harvesting and treatment systems met assumptions of normality and were subjected to parametric t-test or analysis of variance (ANOVA). The data set for primary qualification was reduced to the seven most-represented qualifications, i.e. engineering, natural resource management, environmental science, biological science, physical science, business/economics and urban design / architecture /
landscape architecture, to ensure adequate sample sizes of each variable tested. For some data for ‘general’ risk of different uses of treated stormwater, these assumptions were not met and non-parametric cross-tabulations were conducted for the entire data set for that question. For those risks that differed significantly between groups in the ANOVA, Levene’s statistic was checked to determine homogeneity of variances (George and Mallery, 2007), as was effect size ($\eta^2$) to ensure that the statistically significant result was noteworthy. Effect size can be considered as a threshold, below which significant differences are too small to have practical consequences. In this study, only those ANOVA results with a moderate effect size or greater ($\eta^2 \geq 0.06$: Pallant, 2010) are presented. For equal variances, the $F$-statistic is given, and for unequal variances, the Brown-Forsythe version of the $F$-statistic. Post-hoc tests with multiple comparisons located the source(s) of any statistically significant difference between groups, using no adjustment for multiple comparisons (Least Significant Difference; Perneger, 1998) for equal variances and the Games-Howell adjustment for unequal variances (Field, 2000). As sample sizes were small in the cross-tabulation, Fisher’s exact test was performed. For those groups that cross-tabulation showed to not be independent in regards to perceived risk, i.e. perceived risk differed significantly, effect size was again considered. In cross-tabulations, effect size (i.e. a threshold for a statistically significant difference to be considered large enough to have practical consequences) is given by Cramer’s V statistic. In this study, effect size had to be moderate at least, i.e. Cramer’s $V \geq 0.17$ (Pallant, 2010) for statistically significant results to be presented here.

**Results**

**Representativeness of respondents**

Although the completion rate was 40%, this is comparable to the average response rate for online surveys (Cook et al., 2000). However, Cook *et al.* (2000) argue that response
representativeness of a survey is more important than response rate. Frequency distributions of respondents commencing the survey showed that they were drawn from Perth, Melbourne, Sydney, Adelaide and Brisbane and regional centres in Western Australia, Queensland and New South Wales. The male:female gender split was 60:40, with all age groups represented but 75% aged between 25 and 55 years. The best-represented stakeholders were corporatised water utilities, state and local governments and consultancies, comprising all organisational levels, although middle levels predominated. Experience in the water industry ranged from less than 2 years to more than 20: almost half the respondents had 10 years or less experience. Almost two-thirds had either a design/technical/operations role or a strategy/policy role, and almost half worked either with stormwater/waterways or total water cycle management. There were no elected officials amongst the respondents. The most common primary qualification was engineering (30.6%) or science (25.8%). Frequency distributions were similar for respondents completing the survey. Thus, the completing cohort of respondents reflected the commencing cohort, ensuring that the data are representative of the full sample.

**Perceived general risk of systems**

Although general risk of stormwater harvesting systems varied significantly with the water practitioners’ gender, work type, work area and primary qualification, only the results for work area ($F(5,438)=5.959, P=0.000, \eta^2=0.060, N=444$) and primary qualification ($F(6,333)=2.681, P=0.015, \eta^2=0.076, N=340$) had a moderate effect size and so are noteworthy. For work area (Figure 1), respondents working in sewerage and water supply perceived higher risk than did those working in stormwater/waterways, land developers and total water cycle managers. In addition, total water cycle managers perceived a higher risk than did land developers. For the reduced set of primary qualifications (Figure 2), respondents qualified in engineering or biological science perceived a higher general risk than did
Figure 1. Frequency distributions and means of perceived general risk of stormwater harvesting systems, with work area.

Figure 2. Frequency distributions and means of perceived general risk of stormwater harvesting systems, with primary qualification.
environmental scientists and design professionals (urban designers, architects and landscape architects). More than 50% of biologists perceived a moderate risk, at least, associated with stormwater harvesting systems. Those with qualifications in natural resource management, physical science or business/economics also perceived a higher risk than design professionals did.

For stormwater quality treatment systems, perceived general risk varied with city, work area and primary qualification but all of these interactions had a small effect size and so are not considered noteworthy (Pallant, 2010).

**Specific risks of systems**

Of the sociodemographic variables tested for interactions with specific risks associated with stormwater harvesting systems, city, gender, age group, employment level, work area, primary qualification and experience had statistically significant interactions with some risks. However, many had only small effect sizes. The following interactions had a moderate effect size and are therefore noteworthy:

- technological risk varied significantly with stakeholder group \([F(10,343)=2.411, P=0.009, \eta^2=0.66, N=354]\]
- public health risk \([Brown-Forsythe F(5,5.547)=4.833, P=0.000, \eta^2=0.64, N=358}\], risk of loss of reputation \([Brown-Forsythe F(5,223.200)=4.402, P=0.001, \eta^2=0.62, N=354}\] and political risk \([F(5,276)=3.771, P=0.003, \eta^2=0.64, N=282]\] varied significantly with work area
- environmental \([Brown-Forsythe F(6,94.339)=2.811, P=0.015, \eta^2=0.60, N=284}\], flooding \([F(6,273)=3.246, P=0.004, \eta^2=0.67, N=280]\] and aesthetic risks
varied significantly with primary qualification.

For stormwater quality treatment systems, employment level, work area and primary qualification had statistically significant interactions with some risks. Only the interaction of primary qualification with environmental risk \(F(6,277)=3.666, P=0.002, \eta^2=0.74, N=284\) had a moderate effect size and will be discussed further.

Figure 3. Frequency distributions and means of perceived technological risk of stormwater harvesting systems, with stakeholder group.

The source of these differences can be identified from the post-hoc multiple comparisons for the interactions. For statistically significant interactions with stakeholder group (Figure 3), respondents working for state or local governments or as researchers or academics perceived higher technological risk for stormwater harvesting systems than did developers or consultants. Similarly, respondents employed by a water utility perceived a higher technological risk for these systems than did developers, consultants or practitioners working
for non-government organisations.

With work area (Figure 4), respondents working in sewerage perceived a higher public health risk than did land developers, and a higher political risk than land developers and total water cycle managers, for stormwater harvesting systems. Respondents working in water supply perceived higher public health, reputation loss and political risks associated with stormwater harvesting systems than did those working in stormwater/waterways, land development or total water cycle management.

![Figure 4. Frequency distributions and means of perceived risk of public health risk, reputation loss and political risk of stormwater harvesting systems, with work area.](image)

With primary qualification (Figure 5), practitioners trained in biological science perceived higher flooding risk for stormwater harvesting systems than did those trained in engineering, environmental science, physical science, business/economics or design. In addition, those trained in natural resource management perceived a higher flooding risk than those trained in environmental science, business/economics or design. Biological scientists also perceived a
Figure 5. Frequency distributions and means of perceived flooding risk and aesthetic risk of stormwater harvesting systems, with primary qualification.

Figure 6. Frequency distributions and means of perceived environmental risk of stormwater harvesting and treatment systems, with primary qualification.
higher aesthetic risk than all others, and engineering graduates perceived a higher aesthetic risk than did graduates in business/economics. For stormwater harvesting systems (Figure 6), biological scientists perceived higher environmental risk than designers, and also higher environmental risk for stormwater quality treatment systems (Figure 6) than did those trained in engineering, natural resource management, environmental science, business/economics or design.

![Frequency distribution of perceived general risk of drinking treated stormwater, with stakeholder.](image)

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**General risk of different uses of treated stormwater**

Cross-tabulations of the data for perceived general risk of different applications of treated stormwater revealed some statistically significant differences with gender, age group, city, employment level within organisation, work type, primary qualification and experience.
Figure 8. Frequency distribution of perceived general risk of showering in treated stormwater, with stakeholder.

Figure 9. Frequency distribution of perceived general risk of drinking treated stormwater, with primary qualification.
There was no consistent pattern, though, and few differences had a moderate effect size.

However, perceived risk of drinking treated stormwater varied significantly with stakeholder group (Fisher’s exact test, $P=0.049$, Cramer’s $V=0.179$, $N=444$) and primary qualification (Fisher’s exact test, $P=0.023$, Cramer’s $V=0.222$, $N=444$), and perceived risk of showering varied significantly with stakeholder group (Fisher’s exact test, $P=0.019$, Cramer’s $V=0.191$, $N=444$).

In SPSS 20, the cross-tabulation procedure calculates the observed and expected counts for each measure and also identifies the statistically significantly different results. Mean values are not compared. Attention here is focused on the two ends of the Likert scale – no risk and significant risk. Only statistically significantly different perceived risks are given. Thus, amongst stakeholder groups, significantly more developers perceived no risk associated with drinking treated stormwater (Figure 7) compared with state and local government practitioners, those working for water utilities and consultants, and significantly fewer researchers/academics perceived significant risk than these groups. For showering in this water (Figure 8), significantly more developers perceived no risk than did practitioners working in state government or corporatised water utilities. Significantly more practitioners working for water utilities perceived significant risk compared with those in state government and researchers/academics. Differences in perceived risk of drinking treated stormwater lay between engineers and those trained in natural resource management, biological or environmental science and design (Figure 9). Significantly fewer engineers perceived no risk, compared with biologists and designers, and significantly more engineers perceived significant risk compared with natural resource managers and environmental scientists.
Discussion

Risk perceptions of Australian water practitioners in this study varied with professional discipline, stakeholder group and area of work within the water industry. Practitioners working within sewerage and water supply often perceived risk differently from those working in stormwater and waterways, total water cycle managers and land developers, as did those working for state and/or local government and water utilities compared with other stakeholders. Engineers tended to perceive risk differently from those trained in the natural sciences or design. However, there were differences amongst natural scientists, too, with biologists generally perceiving higher risks than environmental scientists and/or natural resource managers. These results are consistent with previous studies, which found differences in risk perceptions with discipline and industrial affiliation for occupational health scientists, toxicologists and nuclear industry representatives, including scientists and engineers (Lynn, 1986; Kraus et al., 1992; Barke and Jenkins-Smith, 1993; Slovic et al., 1995; Stedman, 2004; Stedman et al., 2005).

The relationship of risk perception with discipline and affiliation has been interpreted in terms of cultural cognition (Kahan and Braman, 2006), whereby risks are perceived in a manner consistent with an individual’s sense of identity and supported ideologies, derived from attitudes, values, beliefs and knowledge. Formal academic training and the associated epistemology of risk underpinning each discipline (Althaus, 2005) are fundamental to this. In addition, within an organisation or community of practice, shared perceptions might develop through a process of social network contagion (Scherer and Cho, 2003), whereby attitudes, knowledge or behaviours are filtered through the group’s structure and particular mix of cultural “norms, expectations, knowledge and behavioural support” (p. 262). Thus, water practitioners who are employed by government departments or water utilities, which have
traditionally managed centralised urban water supplies and wastewater systems with the principal objective to protect public health, are likely to perceive higher risks with decentralised systems such as stormwater harvesting and treatment. Similarly, those who have been trained in disciplines dedicated to the provision of efficient water infrastructure, e.g. engineers, might perceive higher risks with alternative systems. On the other hand, practitioners in stormwater or waterways management, who made up one-quarter of the respondents in this study, can be expected to be sympathetic to stormwater harvesting and quality treatment systems. Then, there are the land developers and consultants, whose intermittent involvement in the water industry, with little perceived control and few ongoing responsibilities, might have a lower perception of risk associated with alternative stormwater systems.

Nevertheless, the implementation of stormwater harvesting and treatment systems will require co-operation of all disciplines, stakeholders and work areas across the water industry. To achieve this, strategies are required to challenge existing risk perceptions that disadvantage these systems in favour of the status quo. Farrelly and Brown (2011) suggest targeted social learning can lead to a change in professional and organisational cultures that might otherwise be impeding adoption of alternative water systems. Social learning builds on technical learning (acquiring technical and management skills) and conceptual learning (challenging the principles and policies of the current systems) to drive change. It is a group process, involving interaction, inter-relationships and communication between individuals working at different scales within the system, and requires a learning platform, e.g. an experiment in water management, open and flexible networks engaged with the experiment, trusted leadership and skilled facilitation. Experimentation with new technologies and governance systems offers the opportunity of learning by doing, where risks can be
identified, addressed and managed, such that mainstream implementation of the new systems is accepted.

**Conclusions**

This study has shown that field of study, stakeholder group and work area can influence risk perceptions of Australian urban water practitioners towards stormwater harvesting and quality treatment systems. These different risk perceptions are likely to be unacknowledged in urban water management but could contribute to reluctance by some to implement alternative urban stormwater systems. Now that these covert risk perceptions are revealed, strategies can be developed to overcome them. Dedicated social learning through experimentation is one.

**Acknowledgement**

The authors wish to acknowledge, with thanks, funding from CSIRO and the Centre for Water Sensitive Cities (now Monash Water for Liveability) to support this research.

**References**


'Predicting Community Behaviour in Relation to Wastewater Reuse.' What Drives Decisions to Accept or Reject? Water for a Healthy Country National Research Flagship. Perth, CSIRO Land and Water


