BRANZ

Study Report

SR382 [2017]

Drivers and barriers to rainwater and greywater uptake in New Zealand

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Funded from the Building Research Levy

The work reported here was funded by BRANZ from the Building Research Levy.

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ISSN: 1179-6197

Acknowledgements

This 3-year research project was funded by the Building Research Levy.

We would like to thank the contribution of the Advisory Panel to the overall project for their guidance and support over the last 3 years. The last workshop with the Advisory Panel provided great insight around these findings and identified further work beyond the scope of this research.

Andrew Pollard (BRANZ Building Physicist) was key in the early development and review of the surveys and discussion of the preliminary findings.

Last, but not least, are those who replied to the online surveys in 2014 and 2016. The information from these surveys is the basis of this research, which could not have been conducted without their participation.

Drivers and barriers to rainwater and greywater uptake in New Zealand

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Reference

Bint, L. & Jaques, R. (2017). *Drivers and barriers to rainwater and greywater uptake in New Zealand*. BRANZ Study Report SR382. Judgeford, New Zealand: BRANZ Ltd.

Reviewers

Casimir MacGregor (BRANZ Ltd) and Alma Siggins (Institute of Environmental Science and Research Ltd)

Abstract

This study was undertaken to understand the perceived and actual drivers and barriers to the uptake of rainwater harvesting and greywater recycling systems in the New Zealand context. This was mainly determined through two self-selecting online surveys of a wide range of industry representatives. It was found that the biggest incentives or drivers for installing rainwater harvesting and/or greywater recycling systems were for cost savings and environmental reasons. The secondary reason for installing rainwater and/or greywater systems was for resilience. In terms of installing systems in New Zealand buildings, cost, education and storage were perceived as the biggest barriers for rainwater. For greywater recycling, education and cost were the two biggest barriers. With regard to the primary concerns with rainwater and greywater systems, the survey respondents thought that water quality, health and waterborne disease are by far the biggest perceived issues. For greywater quality, the specific recurring issues respondents had were health, general quality, cross-contamination with potable water, cleanliness of the system and society's perception of 'dirtiness'.

Keywords

Rainwater harvesting, greywater recycling, drivers, barriers, non-residential buildings.

Contents

Figures

Tables

Executive summary

An investigation into understanding the drivers and barriers to rainwater and greywater uptake in New Zealand is reported. The content of this report summarises the findings from collecting and analysing perceptions from individuals across New Zealand. It also includes a review of published literature and legislation and informal discussions with building managers and water service provider representatives.

This was achieved through undertaking two surveys, one in 2014 and then again in 2016, with 71 and 265 respondents, respectively. Both surveys used targeted emails and social media as the primary recruitment channels, providing a range of occupations, experience and locations of respondents.

The first series of questions in 2014 attempted to understand the level of water awareness and perceived importance of treated, potable water – the most important being for drinking, cooking and food preparation. However, just over half of the respondents thought that the use of rainwater was also acceptable for these purposes. Conversely, the most important purposes for greywater recycling were for irrigation and garden watering and toilet flushing.

The biggest incentives or drivers for installing rainwater harvesting and/or greywater recycling systems were cost savings and environmental reasons. A secondary (but important) reason for installing rainwater harvesting and/or greywater recycling systems was for resilience – i.e. to ensure that a building's function was maintained during and after a natural disaster.

Cost, education and storage were perceived as the biggest barriers for rainwater. For greywater recycling, education and cost were the two biggest barriers in New Zealand. Anecdotally, it seems there needs to be a maximum pay-back period in New Zealand of 3–5 years for management to approve inclusion in building design, which is a very tight timeframe. Primary concerns with rainwater harvesting or greywater recycling systems showed that water quality, health and waterborne disease are by far the biggest perceived issues. For greywater quality, the specific recurring issues respondents had were health, general quality, cross-contamination with potable water, cleanliness of the system and society's perception of 'dirtiness'.

Internationally, there have been many studies examining the barriers and drivers for rainwater harvesting. One of the better studies has summarised how the international perspective divides the barriers into four themes – institutional, economic, technological and educational (Ward, 2010). Many of the specific sub-themes from this international study reflected the New Zealand findings. The overarching issue was that there is a knowledge gap of rainwater harvesting systems, especially for non-residential systems.

1. Introduction

Almost 100% of New Zealand's non-residential buildings are totally dependent on a water reticulation network where treated potable water is used for hygiene, conditioning and other purposes, including irrigation and toilet flushing. As shown by the 2011 Christchurch earthquakes where 80% of the city's water and sewerage network was severely damaged, there is a need for greater water resilience in our buildings (Clifton, 2011). This is where independent water supply systems such as rainwater harvesting and greywater recycling systems could be very effective at providing a considerably more resilient solution to New Zealand's needs.

In addition, an increasing number of New Zealand building and facilities managers want to understand the feasibility of installing alternative water sources into their non-residential buildings (Bint, 2012). Building managers often asked about rainwater and greywater systems and their feasibility, as there are currently no New Zealand-specific answers due to the lack of New Zealand-specific research in this area.

The application of rainwater and greywater systems also has implications on the wider network. Current tariffs do not allow for higher outgoing wastewater than ingoing potable water, resulting from rainwater, for example, and water service providers do not currently know how to deal with this. In areas where water demand is approaching maximum supply capacity, research in alternative water supplies could support regional demand management strategies.

1.1 International published literature

A British study undertaken provided an international summary of existing rainwater drivers and barriers for a comparative discussion (Ward, 2010). Although there has been progress in rainwater harvesting in terms of sustainability and policy drivers, it is thought that technical and institutional barriers to the implementation remain. In Table 1, Ward (2010) categorises international barriers from various studies into four overarching themes – institutional, economic, technological and educational.

Table 1. Barriers to rainwater harvesting implementation – an international perspective (Ward, 2010).

Institutional	Economic	Technological	Educational
Insensitive government attitudes	Cheap mains water	Shortage of suitably qualified specialists	Emotional resistance
Water lobbies with special interests	Perceived abundance of water	Reduced summer efficiency due to climate change	Health and safety fears
Political structures with diverging interests	Long pay-back periods	Difficulties with operation/ maintenance	Lack of straightforward guidance
Lack of interest from water providers	Initial capital outlay, especially as retrofit	Seen as an unproven technology	Unfamiliarity with technology
Lack of willingness towards innovation	Unproven cost benefit	Lack of clearly defined water quality and other standards	Seen as an unconventional approach

The main drivers for rainwater harvesting in the United Kingdom specifically are:

- an increasing water demand
- a perceived increase of flood frequency
- a need to increase the adaptability and resilience of water infrastructure in the face of climate change and population growth (Ward, 2010).

Novak, Giesen and DeBusk (2014) concur with the quest for more resilience. In their case studies, rainwater harvesting systems have been retrofitted in response to long droughts and ageing infrastructure beset with leaks and high energy costs. Other uses Ward (2010) identified at the international level, which could be seen as presenting wider benefits, include fire-fighting and reducing the urban heat island effect (United States Environmental Protection Agency, 2017). A further benefit, which has yet to be fully explored, is the impact of rainwater harvesting on peak demand reduction.

In terms of barriers to rainwater harvesting systems and specifically in relation to the UK, Ward (2010) identified:

- the low price of water and high price of rainwater harvesting systems
- the perceived abundance of water
- unfamiliarity with the unconventional
- capital outlay
- potentially long pay-back periods (depending on the efficiency of the system design)
- operation and maintenance difficulties
- a shortage of specialists
- health and safety fears.

In terms of non-residential buildings specifically, an important potential knowledge gap identified by Ward (2010) was the lack of research on rainwater harvesting systems, especially in the United Kingdom. The availability of good monitoring was thought to limit the representation of non-residential demand in the calculation of system designs. Novak, Giesen and DeBusk (2014) grouped the development of rainwater harvesting system barriers into three areas:

- Removing stereotypes and preconceptions as the uses of rainwater.
- Understanding conflicting standards, codes, regulations and guidelines.
- Quantifying water quality testing protocols and procedures.

In 2007, the UK Market Transformation Programme conducted a review of the status of rainwater harvesting in the UK and recommended addressing:

- public awareness
- uncertainty over sewerage charges
- financial support
- regulatory drivers
- installer competency
- inspection of installation
- water quality standard
- long-term management and maintenance (Ward, 2007).

From an applied social research project in the UK, key barriers were institutional and regulatory gaps, economic and financial constraints, absent incentives, lack of information and technical knowledge, and house builder attitudes. The same study (Ward, 2010) also outlined international drivers, summarised in Table 2:

Table 2. International drivers for rainwater and greywater systems (Ward, 2010).

	Japan	Germany	Australia	UK
Driver	Flooding Water supply	Water demand + water cost + green technology market	Drought	Increased water demand, flooding
National water policy	DURIPA	No	National Water Initiative	Future Water F&WMA
Regional water policy	Rainbow Plan Basic Policy for Intense Rainfall	Rainwater Route	Various	Various via spatial planning system
Building scheme	Unknown	GSBC	BASIX	CfSH
Design / installation standards	EGRIF	DIN 1989-1:2001-10	NRTDIH	BS8515:2009
Financial support	Corporate/income tax benefits + low interest loans + subsidies	Subsidies	Subsidies, rebates	Tax allowance for businesses only
Product innovation	Yes	Yes	Yes	Yes
Public engagement	Rain network Japan + rain encyclopaedia + rainwater museum	Unknown	Public awareness campaigns	None at present

1.2 Research approach and aim

To create a holistic overview of the rainwater and greywater system feasibilities, a multi-disciplinary team has explored three research streams:

- Social and regulatory drivers and barriers to uptake.
- Investigations of buildings with rainwater harvesting and/or greywater recycling systems in operation.
- Impacts on the three water networks (potable water, stormwater and wastewater).

The work reported herein represents the first research stream – social and regulatory drivers and barriers to uptake. This study aimed to understand the perceived and actual drivers and barriers to the uptake of rainwater harvesting and greywater recycling systems in the New Zealand context.

1.3 Structure of report

This report should be read in parallel with the other BRANZ study reports SR383 (Bint, 2017) and SR384 (Garnett & Bint, 2017). The following structure is reported:

1. Introduction – sets the scene of the research and exemplar international literature.

2. Survey overview – provides the methodology, recruitment and response rate information for the two surveys conducted in 2014 and 2016.

3. Water quality and end-use acceptability – discusses the initial responses from the 2014 survey. This analyses the level of water awareness and water quality perceptions of the respondents.

4. Drivers and incentives to uptake – steps through the assessment of responses, both targeted and free-text, around the perceived drivers of both rainwater harvesting and greywater recycling systems.

5. Barriers to uptake – considers the respondent-perceived barriers to rainwater and greywater systems as well as the primary concern with the use of such systems.

6. Summary and discussion – discusses the overall findings from the two surveys and sets up key questions for future work.

Appendices – contain supplementary data, comments from survey participants and survey questions.

2. Survey overview

To get a comprehensive understanding of the social and regulatory drivers and barriers to the uptake of rainwater harvesting and greywater recycling systems, the approach was three-fold:

- Surveys were conducted starting in November 2014 and again in December 2016.
- Review of existing legislation and demand management approaches.
- Informal discussions with building managers and water service providers.

Findings from these have been combined to contextualise the perceived and actual drivers and barriers that exist within the New Zealand frame.

2.1 2014 survey

The 2014 survey was conducted using SurveyMonkey, an online surveying tool. It was open to anyone in New Zealand between July and November 2014 and used social media and email databases to recruit. The survey sought responses on experience, opinion and perception of water, rainwater harvesting and greywater recycling systems (an open, self-selecting sample).

This perhaps provides the views of people more engaged in the industry or with a specific interest in rainwater harvesting and/or greywater recycling. Therefore, the survey findings should not be used as representative of the views of all people in New Zealand.

This survey received 71 responses in total across a range of industries, experiences and locations around New Zealand. The majority of respondents had little to no experience with rainwater harvesting or greywater recycling systems, but a mix of other experiences was noted Figure 1.

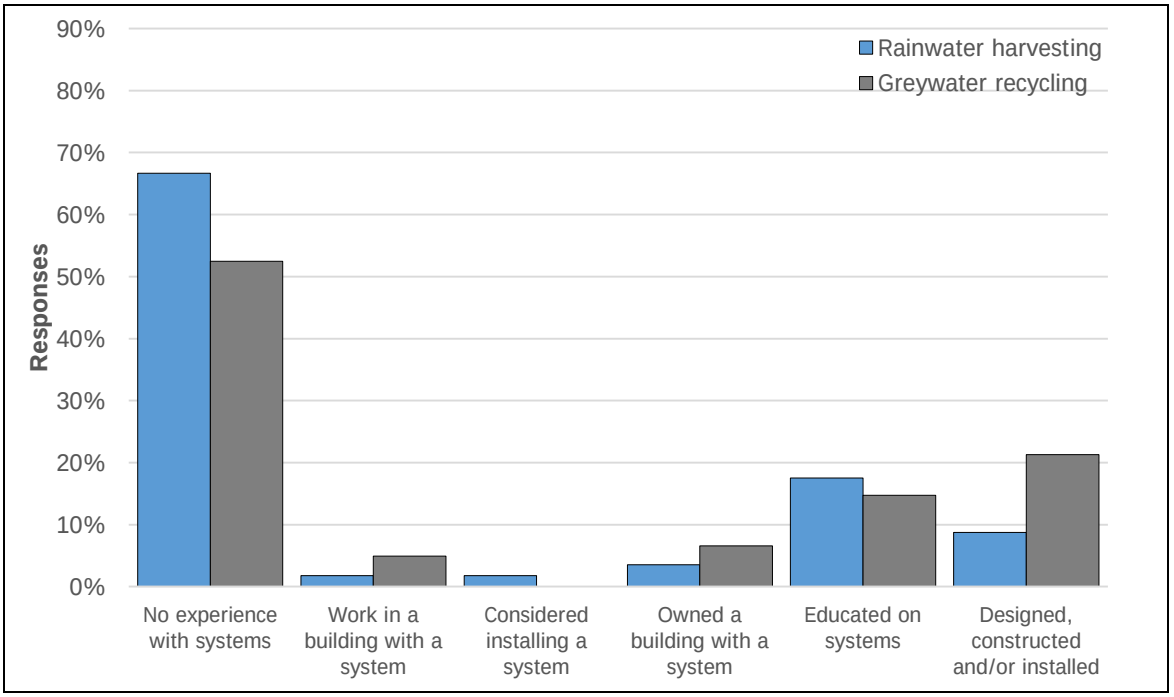

Figure 1. 2014 respondent experience with systems.

Survey questions (see Appendix C) covered many topics, including:

- environmental and water awareness
- importance of potable water
- drivers and barriers
- rainwater and rainwater harvesting
- greywater and greywater recycling
- products, technologies and expertise
- experience with systems
- water supply networks
- general feedback.

As the survey had approximately 30 questions, it was found to be too long and time consuming, especially given the technical nature. Therefore, this meant several unfinished attempts were recorded.

Several upfront questions were structured around the 2013 Lincoln University survey on people's perceptions of the state of the New Zealand environment (Hughey, Kerr, & Cullen, Public perceptions of New Zealand's Environment: 2013, 2013). Lincoln University undertakes a biennial survey of public perceptions of the New Zealand environment (Hughey, Cullen & Kerr, 2010). They considered that people's highest priority was for government action.

The alignment of this rainwater and greywater survey with the Lincoln University survey questions was important to:

- understand this sample in contrast to the wider, representative Lincoln University survey sample (of 2,200 responses from across New Zealand)
- provide some insight into the level of knowledge and awareness that exists for water in New Zealand
- aid in identifying any information gaps.

The 2014 survey showed relatively similar responses in the three questions aligned to the Lincoln University survey (shown as the grey-scale bars in Figure 2).

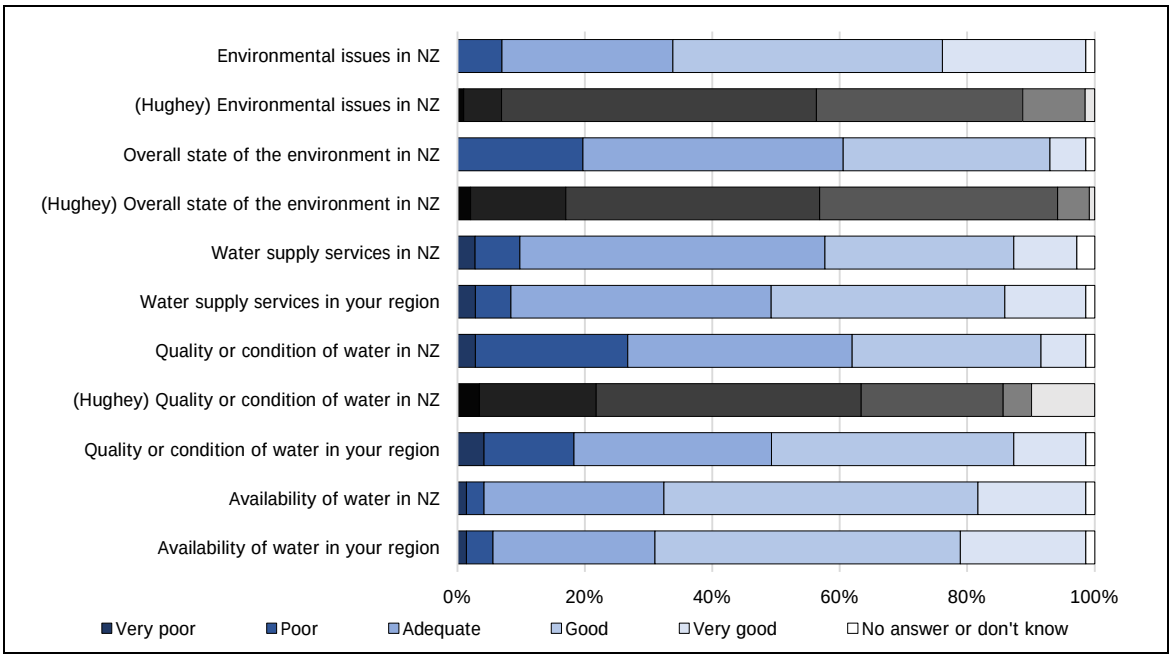

Figure 2. 2014 level of environmental and water awareness.

The findings indicate that most respondents consider themselves adequate or well educated on commonly perceived and reported issues in New Zealand. The responses from this survey may be due to the way in which the survey was marketed and therefore who it reached.

The highest-ranked questions were around the level of awareness on the availability of water in both the respondents' region and New Zealand overall. The respondents felt least informed about the water quality or condition of water in New Zealand. The finding in individual perceptions of water availability is worthwhile noting, as it is a potential barrier to uptake in an educational sense. This perhaps means people perceive there to be abundant water supplies. In fact, in regions like Northland, Auckland, Hawke's Bay, Canterbury, Marlborough and other mainly eastern regions, restrictions are imposed to balance supply with demand.

2.2 2016 survey

A second survey was conducted also using SurveyMonkey in 2016, which targeted more of the industry players in the non-residential market. The survey was open between December 2016 and February 2017 and used targeted email databases for recruitment as well as social media. It was more focused than the previous 2014 survey, only seeking responses on rainwater harvesting and greywater recycling systems, specifically:

- drivers for uptake in non-residential buildings
- barriers to uptake in non-residential buildings.

Once again, the survey used a self-selecting sampling technique, which perhaps provides the views of people more engaged in the industry or with a specific interest in rainwater harvesting and/or greywater recycling. Therefore, the survey findings should not be used as representative of the views of all people in New Zealand.

More than 265 individuals responded, from a range of locations and professions around New Zealand. Their professions are listed in Figure 3:

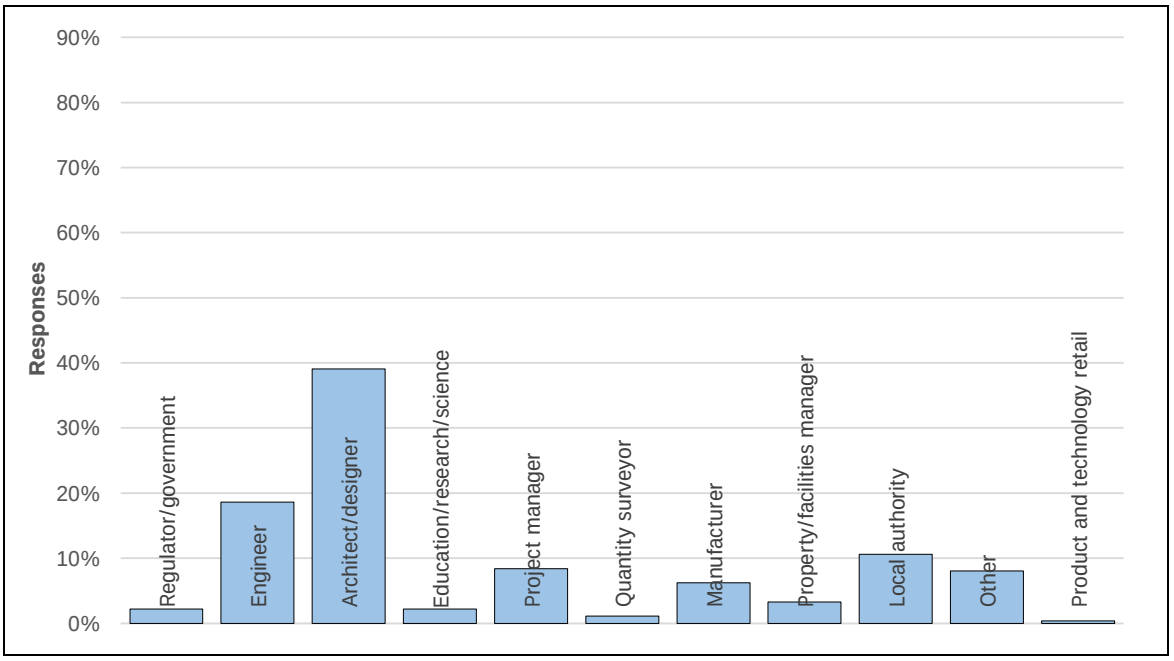

Figure 3. 2016 respondent professions.

As can be seen, the bulk of the industry sector respondents are from the design community – architects, designers and engineers. This group makes up some 58% of all respondents.

All survey findings are outlined in the following sections.

3. Water quality and end-use acceptability

Only the 2014 survey results are covered in this section, as the 2016 survey did not examine these specific issues.

Respondents were asked to describe their acceptance of where and how they think water, rainwater and greywater can be used. In this instance, the maintenance and treatment functions of rainwater and greywater systems were omitted from the survey. This was intentional to keep the already large number of questions to a minimum.

The survey asked: “For what purposes is it most important to have treated, potable water?” Figure 4 shows the average of the responses. This tells us that people think it is most important to have treated, potable water for drinking (with a score of 1.04) as opposed to toilet flushing (6.24) or irrigation (6.31).

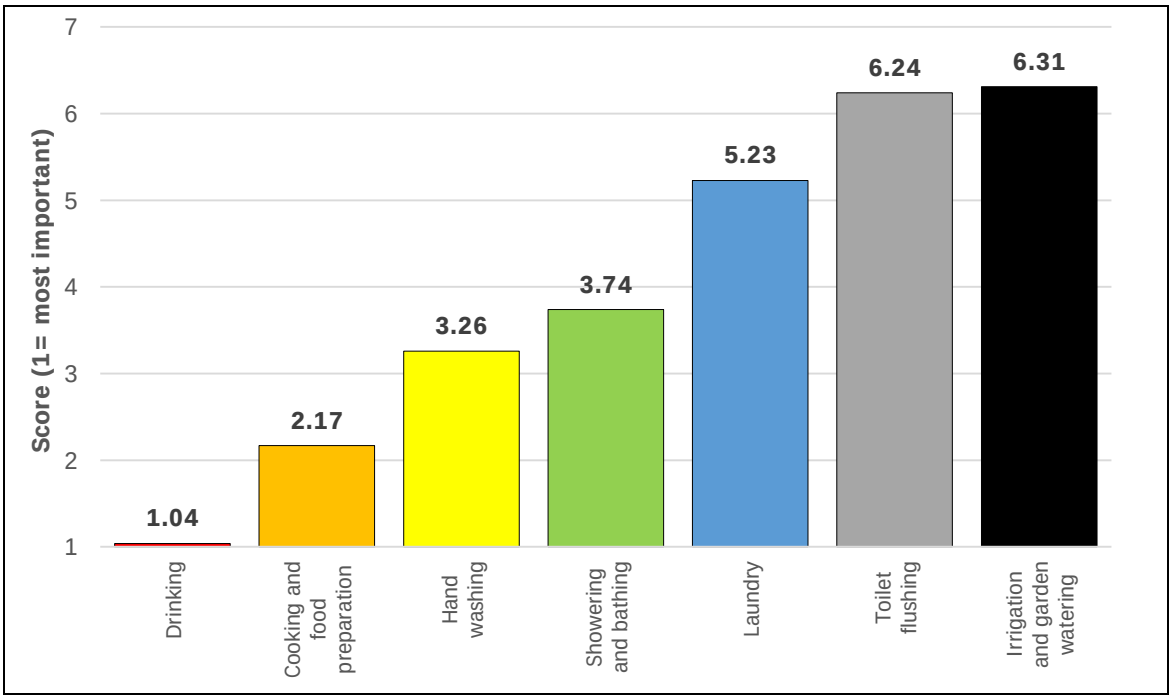

Figure 4. Water end-uses ranked by importance of having treated potable water.

The ranking of the end-uses by water quality importance appears very logical, as expected. This means the rankings in Figure 4 go from potable water (i.e. drinking) to contact water (i.e. hand washing) to non-contact, non-potable (i.e. toilet flushing) water uses.

Respondents were asked what purposes they thought it was acceptable to use harvested rainwater and recycled greywater (see Figure 5 and Figure 6). They were provided eight categories, plus ‘other’ and ‘none of the above’.

While the majority (44%) of respondents agreed that the quality of rainwater is excellent in general, rainwater used for the laundry, toilet flushing and irrigation was the most widely accepted. Interestingly, half of the respondents perceived the use of rainwater as acceptable for drinking and cooking/food preparation.

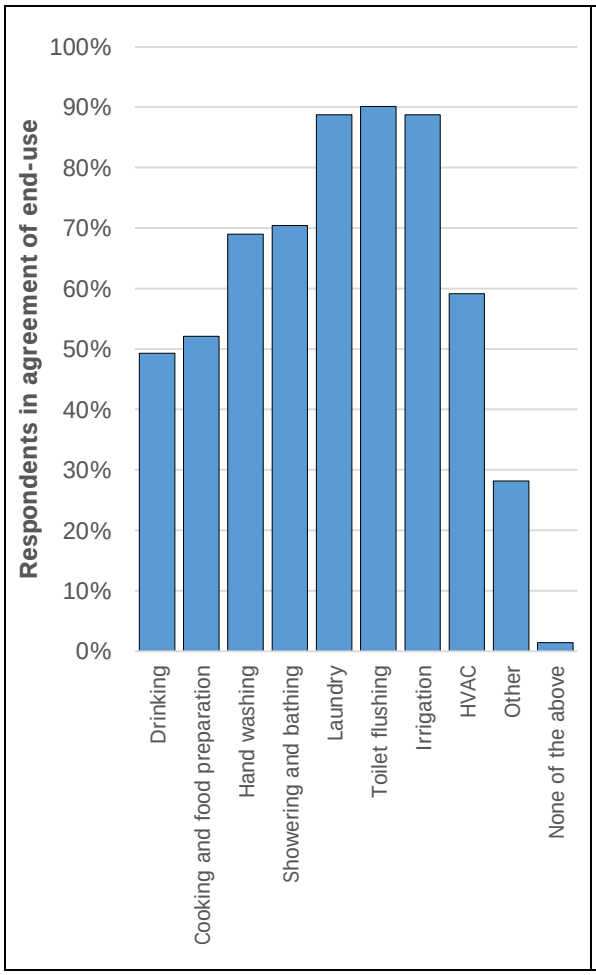

Figure 5. Acceptance of rainwater use.

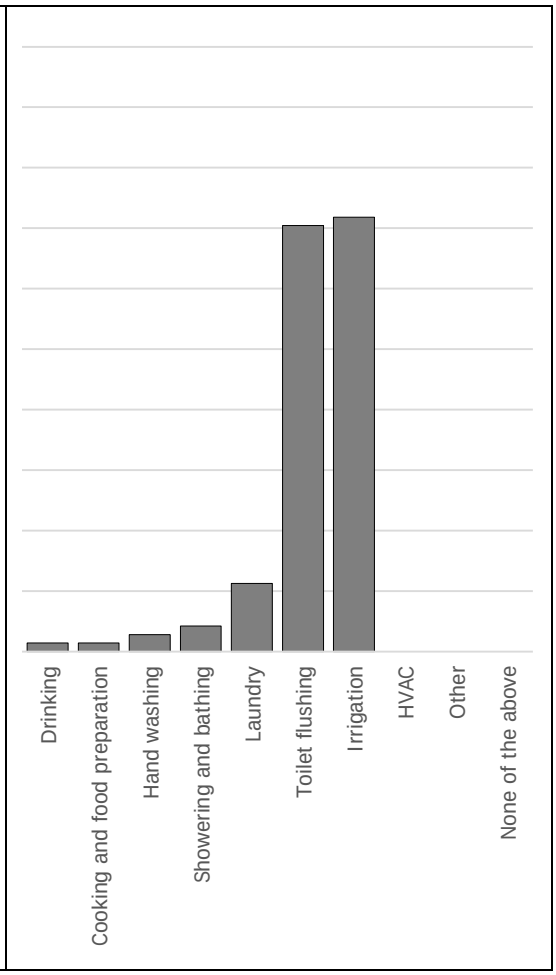

Figure 6. Acceptance of greywater use.

In a non-residential building context, heating, ventilation and air-conditioning (HVAC) was commonly identified as an opportunity for rainwater use. This presents an opportunity that should be further explored. However, caution must be administered due to prescriptive limitations on the water chemistry in HVAC units to protect human health from pathogenic micro-organisms including *Legionella* spp. (Walser, et al., 2014).

Where rainwater systems are present in non-residential buildings today, the collected rainwater is typically used for flushing of toilets and urinals and also for irrigation, garden watering and/or public water features. Most (>70%) respondents indicated that using greywater for toilet flushing and irrigation was acceptable. A minority (1%) suggest recycled greywater could be used for drinking.

There was a much greater understanding of rainwater than greywater overall. This was demonstrated by more respondents failing to answer the greywater-focused questions.

Most (69%) agreed that the quality of rainwater is excellent, while most were neutral (35%) when it came to greywater. The majority (49%) also agreed that it is acceptable to use rainwater for drinking and even more so for toilet flushing (90%). They also strongly agreed that using greywater for toilet flushing was acceptable – with one strong view that all water-using toilets “should be phased out of existence”.

Refer to Appendix A for more information.

4. Drivers and incentives to uptake

It was anticipated that the bulk of drivers in New Zealand will be either to do with environmental sustainability and/or cost savings in universally metered areas, such as Auckland. The following portrays the perceived incentives and reasons for installation.

4.1 Survey findings

Survey respondents were asked what the biggest incentives or drivers were for installing rainwater harvesting and/or greywater recycling systems. This was a free-text field, and responses were later codified for analysis.

The majority of responses in the 2014 survey (Figure 7) indicate that cost savings is a large driver for rainwater, through reduction of water fees to the water supply network. This is interesting, as not all New Zealand regions have universal volumetric water charging in place. It is not clear whether they were referring to cost savings at an individual level or at a regional/infrastructure level.

Environmental sustainability also ranked highly as a driver for both rainwater and greywater, followed by resilience and impact of supply.

The majority of responses in the 2016 survey (Figure 8) indicate that environmental reasons are the biggest driver, with cost savings coming in second. This contrasts with the 2014 survey findings, where cost savings were perceived as being the most important driver for rainwater harvesting.

The 'other' category contains an array of issues, such as when respondents were unsure or the question was not applicable for the area or where they "did not think there are any" and "to supply schools".

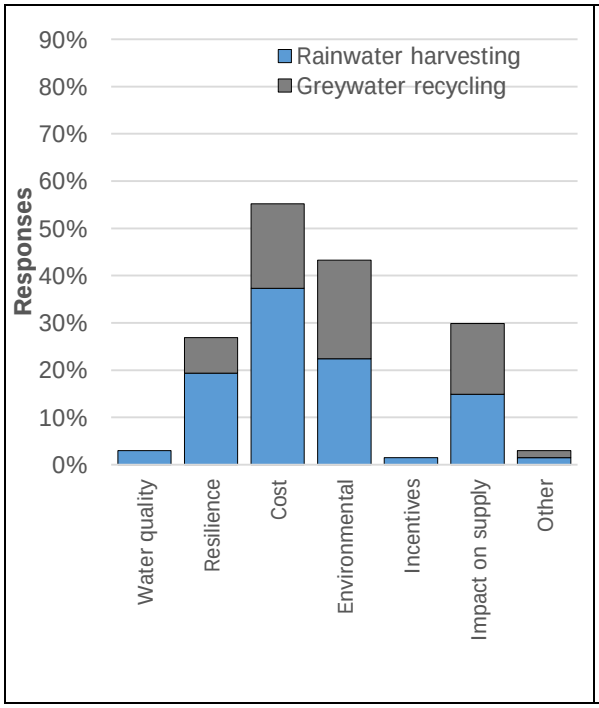

Figure 7. 2014 drivers to uptake.

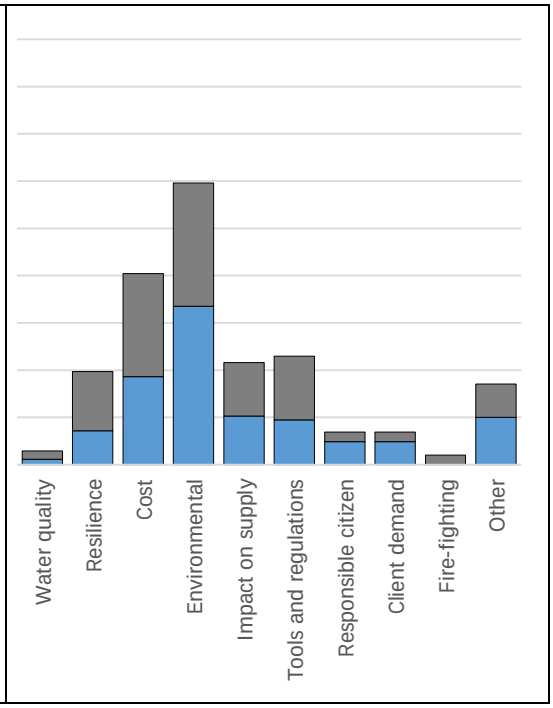

Figure 8. 2016 drivers to uptake.

Framing the question slightly differently provided a second perspective. The survey asked: “What would make you consider installing a rainwater harvesting and/or greywater recycling system?” and fielded free-text responses.

The use of rainwater and greywater for rental and sales marketability was rated low (shown as ‘marketing’ in Figure 9). This indicates that water is not yet valued highly enough to be an effective marketing mechanism in the way that energy-efficient design or renewable energy systems are. It could also indicate that the systems are too complex to be simply transferred to the next tenant or owner due to a lack of knowledge and consumer education.

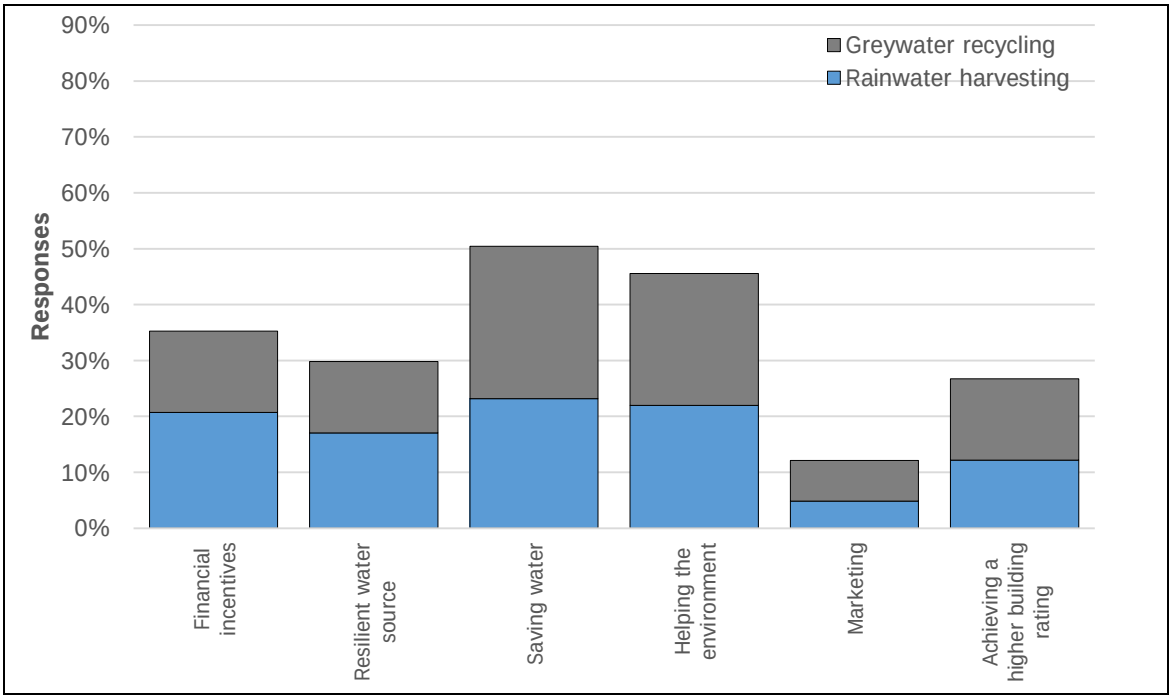

Figure 9. 2014 reasons for installing rainwater harvesting systems.

Saving water was perceived as the largest driver for installation, although it is not clear whether this has been interpreted as a cost saving or just a water saving. Due to the also highly stated reason of helping the environment, water saving may be seen as an environmentally sustainable initiative.

4.2 Discussion

These were the biggest driver and/or incentive opportunities highlighted for rainwater harvesting and greywater recycling systems in New Zealand:

- Cost savings and the environmental sustainability were the top drivers. This is understandable in places like Auckland where water and wastewater is charged volumetrically. What are the consumer cost-saving mechanisms outside of Auckland and regions with similar charging mechanisms for water?
- Reducing the load on the system/supply and resilience are very highly rated drivers and incentives.
- Consumers want to contribute to the impact on supply. This has identified an engagement opportunity for water suppliers to work with consumers, developers and property owners.

Cost savings provide the biggest perceived driver and incentive for deciding to install a rainwater and/or greywater system in the 2014 survey and the second most important driver in the 2016 survey. Feedback from a presentation at the Facilities Management Association of New Zealand (FMANZ) Summit 2015 highlighted that there needs to be a maximum pay-back period of 3–5 years. This is in order for management to approve inclusion in building design.

Findings from the buildings research stream at the Summit indicate that water metering and volumetric charging has the biggest impact on the pay-back period. The buildings research stream considered:

- additional hydraulic engineered design costs
- capital cost of the rainwater and/or greywater systems
- installation cost of the systems
- water and wastewater charging mechanisms and tariffs
- rainwater and/or greywater collected and used
- energy costs to pump rainwater and/or greywater to its end use
- additional maintenance costs.

Wellington Water is leading resilience planning for the Wellington region. It has recently identified the impact to the region after a significant event, using a large earthquake as an example scenario. It is recognised that the region's water supply is vulnerable to the risk of prolonged interruption following such an event. This is partly due to the region's limited number of water supply pipelines that would be structurally capable of surviving a significant earthquake. This is exacerbated by the water network repeatedly crossing known fault lines. On current estimates, it could be up to 70 days before normal supply is restored to most areas. For some areas, such as eastern Wellington, it could be up to 100 days before full water supply services to households are restored. If it takes too long to return to a business-as-usual economic state, many of the professional and public services that are not inherently tied to this geography may leave and not return. This creates a significant long-term economic risk for the whole region (Wellington Water, 2017).

The region's overall resilience also depends on other critical infrastructure, including roading, electricity and telecommunications. Wellington Water is working with these other providers of critical infrastructure to ensure that individual plans for improving the respective networks' resilience are strategically integrated and will maximise efficiencies. This work is ongoing as the programme business case develops.

5. Barriers to uptake

Social, economic and environmental issues are outlined as the hypothesised barriers to the uptake or rainwater harvesting and greywater recycling systems in New Zealand.

Regulations around New Zealand for the implementation of these alternative water sources are significantly varied or silent. TP58, an Auckland Regional Council publication on the use of wastewater on site (Ormiston & Floyd, 2004), is seen as the biggest barrier for implementation of greywater recycling systems. The guide covers:

- the regulatory context and requirements
- an introduction to on-site wastewater management
- design planning
- site evaluation procedures
- design flow volumes
- on-site wastewater treatment options
- dousing and distribution methods
- land disposal
- environmental effects
- system installation and maintenance.

However, this is being updated and is likely to be replaced by a national Water New Zealand guidance document (GD06).

Many of the free-text comments at the end of the survey (see Appendix B) have suggested the New Zealand Government needs to play a greater role – there needs to be a “Ministry of Water”.

The 2014 survey sought to find the biggest barriers or hindrances perceived for rainwater harvesting and/or greywater recycling. Cost, lack of information and storage issues were the three biggest barriers with rainwater. For greywater, the biggest barriers were perceived lack of knowledge and the lack of or prohibitive regulations (Figure 10). These two issues go hand in hand in terms of information availability and education influencing the regulations.

The 2016 survey also sought to find the biggest barriers perceived for rainwater harvesting and greywater recycling. The primary concerns issue was not examined. Cost was by far the leading perceived barrier with both rainwater and greywater, receiving more than double the responses of the next most common barrier. The education category was separated into two groups to better distinguish the specifics of the perceived barrier:

- Education – demanded usually by those wanting systems or issues around public perception.
- Expertise – provided by trained professionals in the field of rainwater/greywater.

For rainwater, storage was the next most common barrier. Other rainfall drivers were very evenly rated, specifically regulation, maintenance, education and quality. Education was the next most important driver for greywater, with quality and regulation following close behind. In terms of greywater quality, specific barriers identified by free-text answers included health issues, general quality issues, cross-contamination with potable water, cleanliness of the system and society’s perception of dirtiness – these are all identified under ‘quality’ in Figure 11.

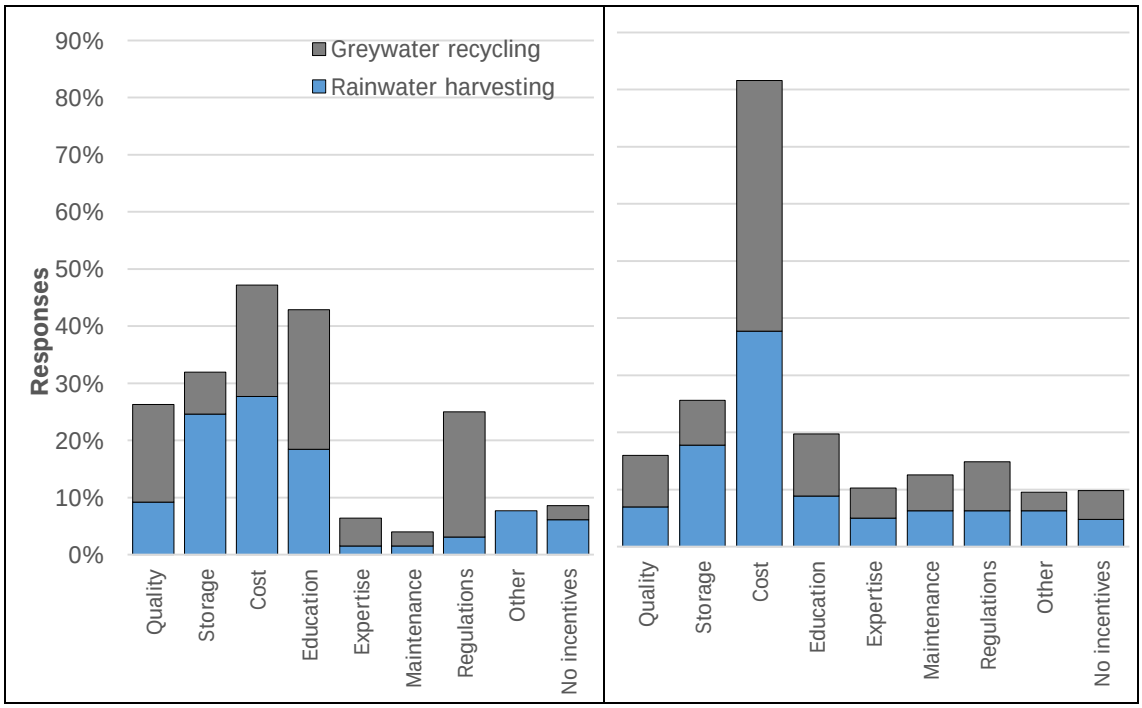

Figure 10. 2014 barriers to uptake.

Figure 11. 2016 barriers to uptake.

5.1 Primary concerns

The 2014 survey asked: "What is your primary concern with having a rainwater harvesting and/or greywater recycling system?"

Waterborne disease was the primary concern with rainwater systems, followed by water quality. Similarly, waterborne disease was the primary concern with greywater systems, closely followed by water quality and health (Figure 12). This strongly relates to the educational barrier in the previous chart.

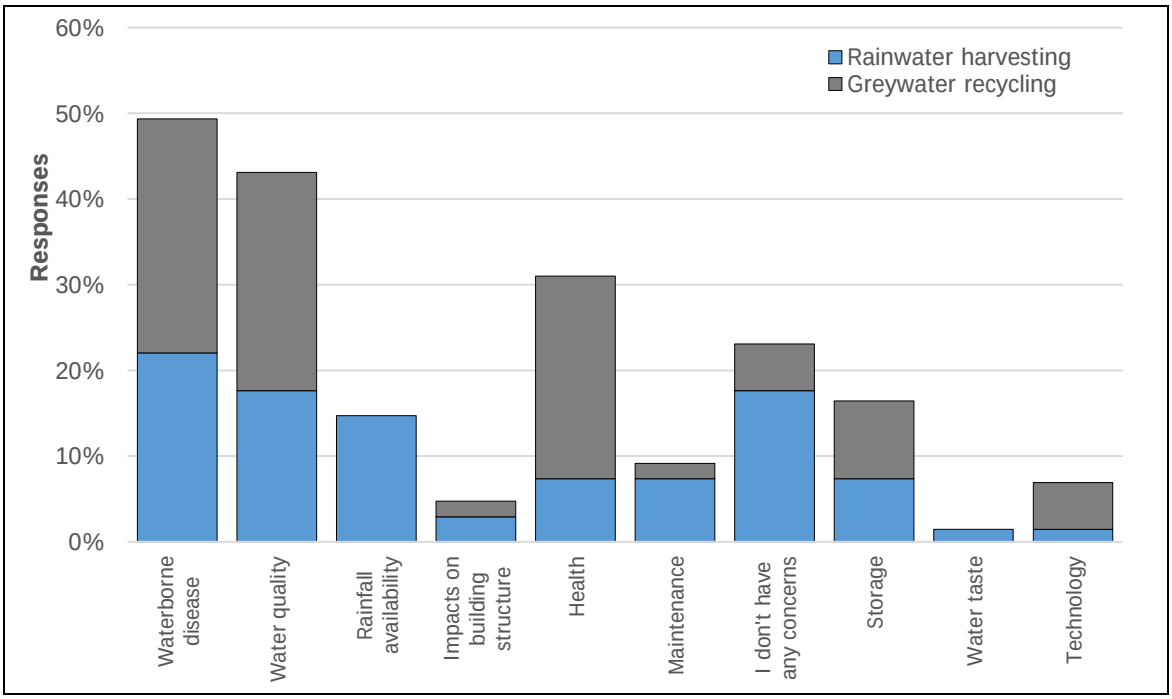

Figure 12. 2014 primary concerns with systems.

5.2 Products, technologies and expertise

One key barrier from a rainwater and greywater product and technology point of view is the lack of expertise in New Zealand to appraise new innovations. Associated with this is the educational and regulatory hurdles to overcome.

Respondents in the 2014 survey were asked about their level of agreement with key statements about rainwater and greywater-related systems. The results are summarised in tabular format in Appendix A, where two tables are provided examining harvesting and recycling-related issues separately.

In terms of rainwater and rainwater harvesting systems, the number of respondents either agreed or strongly agreed that:

- they are expensive to install (31%) but not expensive to maintain (15%) or operate (10%)
- the quality of rainwater is excellent (69%)
- there is enough specific information available in New Zealand (18%), and the systems are not difficult to operate (10%)
- the systems are mature technologies (48%), so there appears to be some scope for product development here.

Overall, there appeared to be very little understanding of system performance and whether there was sufficient design and installation expertise and information in New Zealand.

In terms of greywater and greywater recycling systems, the number of respondents either agreed or strongly agreed that:

- they are expensive to install (39%) but not expensive to maintain (23%) or operate (10%)
- the quality of greywater is excellent (11%)
- there is enough specific information available in New Zealand (8%), and the systems are not difficult to operate (10%)
- the systems are mature technologies (14%), so there appears to be considerable scope for product development here.

The survey also found that the biggest advantage of the products, technologies and expertise available in New Zealand is their availability, followed by sustainability (Figure 13).

However, in terms of specific greywater recycling expertise, there was perceived to be no advantage in New Zealand. This reflects the education gap identified earlier.

Appropriateness, low innovation, system cost and availability were perceived as the largest disadvantages to rainwater and greywater systems in New Zealand (see Figure 14).

As noted earlier, despite there potentially being more innovation in the New Zealand market than meets the eye, the lack of expertise to appraise the products and technologies for regulation and certification, a large gap has appeared. The perceived maintenance requirements for greywater are also seen as a great disadvantage.

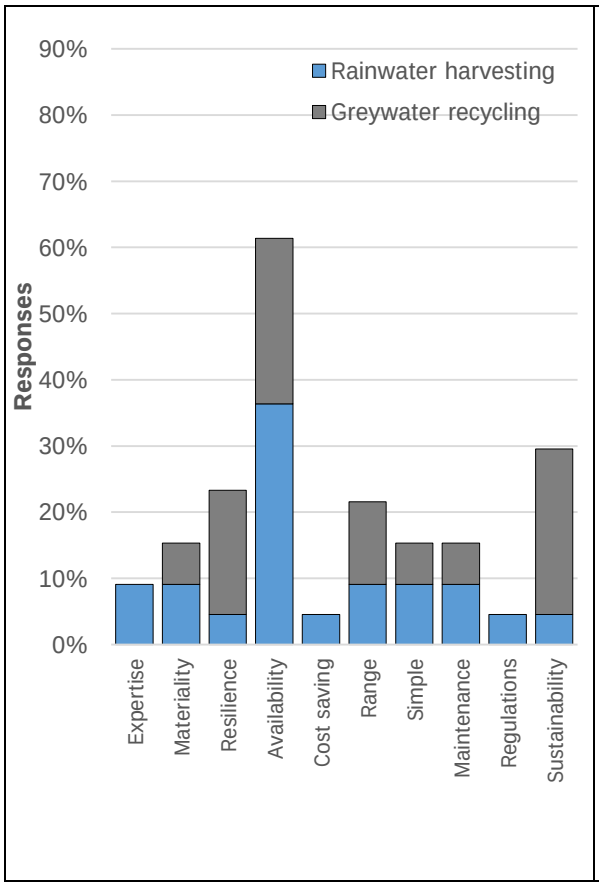

Figure 13. Advantages to products, technologies and expertise.

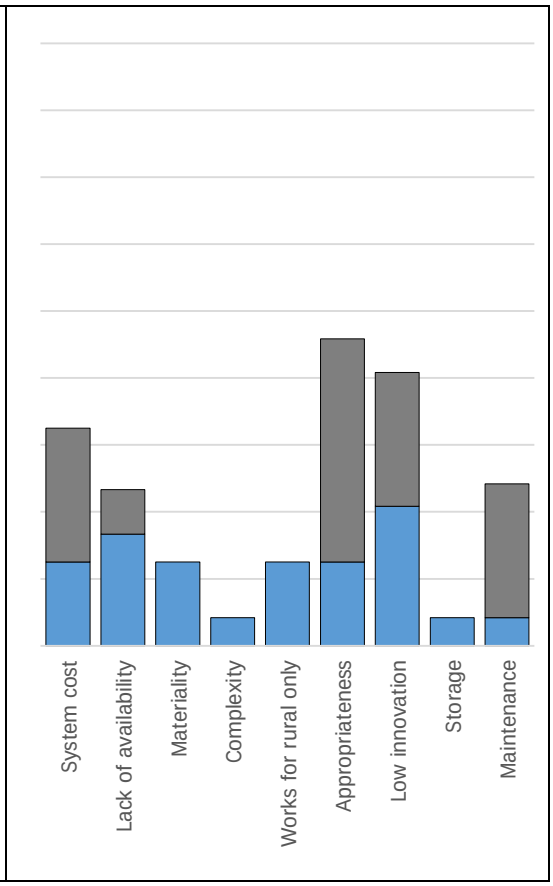

Figure 14. Disadvantages of products, technologies and expertise.

6. Summary and discussion

This study was undertaken to understand the perceived and actual drivers and barriers to the uptake of rainwater harvesting and greywater recycling systems in the New Zealand context.

Several methods were used to collect relevant information:

- Two online surveys to examine the perceptions from individuals across New Zealand in 2014 and then again in 2016.
- A review of published literature and legislation.
- Informal discussions with water-related industry professionals, including in workshops.

The two self-selecting surveys of a wide range of industry representatives found the following:

- The most important purposes for having treated, potable water were for drinking, cooking and food preparation. Just over half of the respondents thought that the use of rainwater is acceptable for these purposes.
- The most important purposes for greywater recycling were for irrigation and garden watering and toilet flushing.
- The biggest incentives or drivers for installing rainwater harvesting and/or greywater recycling systems were for cost savings and environmental reasons.
- A secondary (but important) reason for installing rainwater harvesting and/or greywater recycling systems was for resilience – i.e. to ensure that a building's function was maintained during and after a natural disaster.
- In terms of barriers to installing systems in building in New Zealand, cost and education and storage were perceived as the biggest barriers for rainwater. For greywater recycling, education and cost were the two biggest barriers in New Zealand. Anecdotally, it seems there needs to be a maximum pay-back period in New Zealand of 3–5 years for management to approve inclusion in building design, which is a very tight timeframe.
- In terms of primary concerns with rainwater harvesting or greywater recycling systems, water quality, health and waterborne disease are by far the biggest perceived issues. In terms of greywater quality, the specific recurring issues respondents had were health, general quality, cross-contamination with potable water, cleanliness of the system and society's perception of 'dirtiness'.

Internationally, there have been many studies examining the barriers and drivers for rainwater harvesting. One of the better studies has summarised how the international perspective divides the barriers into four themes – institutional, economic, technological and educational (Ward, 2010). Many of the specific sub-themes from this international study reflected the New Zealand findings, specifically those highlighted in red in Table 3.

The overarching issue was that there is a knowledge gap of rainwater harvesting systems, especially for non-residential systems. This compounds against the economic, technological and institutional barriers – all of which are present in New Zealand.

Table 3. Barriers to rainwater harvesting implementation – an international perspective (Ward, 2010).

Institutional	Economic	Technological	Educational
Insensitive government attitudes	Cheap mains water	Shortage of suitably qualified specialists	Emotional resistance
Water lobbies with special interests	Perceived abundance of water	Reduced summer efficiency due to climate change	Health and safety fears
Political structures with diverging interests	Long pay-back periods	Difficulties with operation/ maintenance	Lack of straightforward guidance
Lack of interest from water providers	Initial capital outlay, especially as retrofit	Seen as an unproven technology	Unfamiliarity with technology
Lack of willingness towards innovation	Unproven cost benefit	Lack of clearly defined water quality and other standards	Seen as an unconventional approach

The surveys also asked respondents about their level of agreement with key statements about rainwater and greywater-related systems. The strongest agreement for rainwater was around issues of:

- the sense in using rainwater for toilet flushing
- the opportunities for product development
- the excellence in rainwater quality
- the sense in using rainwater for drinking.

The strongest agreement for greywater was around issues of:

- the sense in using greywater for toilet flushing
- the opportunities for product development
- the expense of installing recycling systems.

Informal discussions with industry professionals and in workshops produced the following assertions:

- Rainwater in one non-residential building is the best quality found in the entire building, above mains potable water.
- Frustrations at not being able to use for cooling towers.
- Difference in survey findings between architects/designers and engineers.

6.1 Further and future work

The above findings have highlighted a number of possible areas for future research to explore, some of which have been incorporated into the remainder of the research programme (buildings and network impacts). These include:

- education and awareness – available information and the level of understanding
- water quality – acceptable versus actual and health impact assessment
- resource consumption – building water and energy use and water savings
- feasibility – financially and operationally
- issues/considerations – industry status and performance and design implications.

These aspects have been considered in SR383 (Bint, 2017) and SR384 (Garnett & Bint, 2017).

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Appendix A: Supplementary tables from 2014 survey

Table 4. Level of agreement to rainwater and rainwater harvesting statements.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	No answer
The quality of rainwater is excellent	25.4%	43.7%	16.9%	8.5%	1.4%	4.2%
Using rainwater for drinking is sensible	23.9%	31.0%	22.5%	12.7%	5.6%	4.2%
Using rainwater for toilet flushing is sensible	80.3%	11.3%	2.8%	-	1.4%	4.2%
Rainwater harvesting systems are complex	1.4%	9.9%	26.8%	47.9%	9.9%	4.2%
Rainwater harvesting systems are expensive to install	4.2%	26.8%	33.8%	26.8%	2.8%	5.6%
Rainwater harvesting systems are expensive to maintain	1.4%	14.1%	33.8%	36.6%	9.9%	4.2%
Rainwater harvesting systems are difficult to operate	-	9.9%	21.1%	46.5%	18.3%	4.2%
Systems are mature technologies	12.7%	35.2%	31.0%	9.9%	-	11.3%
Products are resilient	11.3%	33.8%	38.0%	5.6%	-	11.3%
Product development opportunities exist	18.3%	53.5%	15.5%	-	1.4%	11.3%
System performance in New Zealand is excellent	2.8%	21.1%	52.1%	11.3%	-	12.7%
Design and installation expertise in New Zealand is good	-	11.3%	63.4%	12.7%	1.4%	11.3%
There is enough New Zealand-specific information available	1.4%	16.9%	36.6%	26.8%	4.2%	14.1%

Table 5. Level of agreement to greywater and greywater recycling statements.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	No answer
The quality of greywater is excellent	4.2%	7.0%	35.2%	22.5%	9.9%	21.1%
Using greywater for toilet flushing is sensible	38.0%	28.2%	7.0%	4.2%	1.4%	21.1%
Greywater recycling systems are complex	4.2%	21.1%	38.0%	15.5%	-	21.1%
Greywater recycling systems are expensive to install	2.8%	36.6%	29.6%	8.5%	1.4%	21.1%
Greywater recycling systems are expensive to maintain	2.8%	19.7%	45.1%	9.9%	1.4%	21.1%
Greywater recycling systems are difficult to operate	1.4%	8.5%	52.1%	15.5%	1.4%	21.1%
Systems are mature technologies	2.8%	11.3%	39.4%	22.5%	1.4%	22.5%
Products are resilient	5.2%	12.9%	47.9%	9.9%	1.4%	23.9%
Product development opportunities exist	14.1%	39.4%	23.9%	-	-	22.5%
System performance in New Zealand is excellent	-	4.2%	59.2%	12.7%	1.4%	22.5%
Design and installation expertise in New Zealand is good	-	8.5%	43.7%	19.7%	5.6%	22.5%
There is enough New Zealand-specific information available	1.4%	7.0%	31.0%	23.9%	12.7%	23.9%

Appendix B: Free-text comments

The final part of both surveys invited free-text discussion on broader water sustainability, governance and management issues in New Zealand. The following summarises the range of responses provided, grouped under eight themes.

Governance

Respondents were asked how important it is to have the three waters (potable water, stormwater and wastewater) under one control in New Zealand. Most believed it was important or very important, however the comments left in the free-text field were mixed.

- Important to have them under one control. They will then know the overall effect on any changes that will happen. Will also mean they can organise maintenance on all waters at the same time rather than the hassle of doing them separately.
- Very important.
- Water as it moves through a catchment isn't siloed – neither are the benefits of challenges. By taking a three water approach can better assess the effectiveness of on-site systems (on each network and the receiving environment). Check out PURSS – a great model for assessing how on-site systems could impact on wastewater, metered water and stormwater for each individual home and then use to scale up for any network models such as MUSIC.
- Extremely important as the management of three waters all impact the other.
- Very important to balance drinking water demands.
- Not very important.
- Fair to middle.
- Very important as all three are related to each other.
- I do believe it is important for three waters to be handled by the same entity, however I believe that operations/maintenance and planning of these activities is best handled at a local level.

Change needed

Building off the three waters question, respondents were asked what they would most like to see changed to encourage sustainable water management in New Zealand. The results were largely regulatory and legislation focused, with one suggesting a Ministry of Water is needed to coordinate the industry.

- Advertising let people know, over incentives via council or government.
- Greywater re-use guidelines.
- Incentive schemes, more marketing of alternatives.
- Create a Ministry of Water. The policy is much too fragmented and limits the outcomes.
- Introduction of a cost for potable water use across NZ. The cost per ML should be low up to a level that is appropriate for a household but excessive water use should be charged at a higher rate. This would encourage high water users to implement rainwater harvesting systems.
- Legislation.
- Greater emphasis on water conservation in business, home and school.
- Building Act.
- Streamlining regulations for rainwater and greywater usage.

- Firstly, regulations need to be changed dramatically to allow for sustainable solutions to water/wastewater/stormwater management in NZ. At the moment, most regulations run contrary to sustainable development. Public perception needs to change. The clean green image is just that. Health of waterways is declining, drinking water standards are becoming increasingly onerous (and impractical) and the illusion that NZ is water rich (simply because we get a lot of rain) needs to be met with education, education, education.

Better education and promotion

The lack of informed people to make informed choices was a common theme.

- Industry and the community need better education around the environmental drivers for more integrated water management. Tendency to make decisions based on single benefits rather than looking at the full range of inter-related outcomes.
- Targeted education is needed for public buy-in to these systems.
- Biggest barriers for rainwater harvesting and greywater recycling are the lack of education and information available, with different regulations for both rainwater harvesting and greywater recycling throughout the country.
- There is a general lack of training (for both residential and non-residential) on this subject – across consultants and clients who can influence.
- Every young person (and many older ones too!) needs to learn how much water they use and how to operate a plunger, amongst other things. Water consciousness should be a lesson built into every school maths lessons.
- My belief is most people understand water and other resources are somewhat limited and would welcome initiatives to include eco/green or energy saving elements to buildings, both residential and non-residential, but the only way an uptake of anything other a very small minority, would be with legislation and cost recovery incentives.

Financial incentives

The lack of some financial incentive by either central or local government to encourage action was repeatedly stated.

- Will councils provide a rates-rebate for building owners that ease the burden on the utility infrastructure?
- Credits/tax cuts etc. will make a huge difference to introducing any new system to the New Zealand environment.
- There has been absolutely no financial advantage in doing so. In my view, there may be merit in initially implementing a nationwide scheme which recognized such systems in buildings in a similar way in which we are currently implementing the earthquake prone buildings legislation.
- A government incentive/local body rates rebate would encourage more people/clients to want to invest in water harvesting and greywater recycling. Currently, due to regulations and required code compliance, permits and inspections it costs more than simply hooking up to a conventional system.
- Unless legislated and made mandatory, recycling of rainwater and greywater will not become the norm.
- As per normal, all great ideas but it is human nature to be encouraged by Council support and incentives.

- Investments into water harvesting or recycling will only happen when there is an appropriate financial driver to make it worthwhile. While water is such a low-priced commodity there is no real driver.

More information

There was a general consensus that more information was needed on practical set-up issues that extended well beyond the Building Code.

- A BRANZ bulletin about how to set up and implement greywater and rainwater systems would be most helpful.
- It would be helpful for each Council to publish not only their policy on this, but also the regulations and standards required to be met.
- New Zealand Building Code (NZBC) clause G12 does not address current harvesting or recycling and it needs an over haul to include some basic solutions now available to the acceptable solutions.
- It is difficult to impose a filtration standard or method for an individual supply as there is no standard or legislation to enforce (for local authorities/BCA). NZBC G12 merely quotes that a potable supply should be used – of which there is no definition or standard to apply – like ppm or coliforms for example.
- Information tends to be weak on practical technical issues.

Mandatory requirements

Many thought that the only way forward to ensure change was by mandating the issue.

- If greywater and/or rainwater harvesting were mandatory then we could get a greater supply of different size, shapes and manufacture of storage tanks.
- Green Star New Zealand is available but not mandatory; it would be great helpful to have the tool regulated in the Building Act or NZBC.
- These systems should become mandatory in both non-residential and residential sectors of building particularly in drought prone regions, we waste huge amounts of water each year by sending it all down the drain.
- The other issue is that unless something is mandated it very seldom happens – most buildings are designed to the minimum possible standard (sadly). With this in mind, a mandatory building rating scheme (like we have for appliances) would be a good start.

Importance of issue

Most felt that there is an underappreciation of the significance of the issue, but a very few thought the opposite.

- This is hardly the most significant issue we face.
- Excellent aspiration but will be slow to be accepted by the wider market beyond the enthusiasts.
- The climate is right for change now. People are aware of the need that New Zealand needs to step up its game if it is to retain its clean, green image.
- Current economic models do not take proper account of environmental cost making it difficult to justify expenditure to minimise environmental effects.
- Water is gold. Let's use it with decency.

Other general feedback

Other general comments and feedback:

- The focus should be on conservation first. Adequate treatment of greywater for recycling is very expensive.
- The best way to achieve sustainable water management is policy based on science not what if, as well as engagement with local authorities who manage new builds and the building community to ensure good outcomes emerge that are affordable and timely for all.
- The questions here did not include whether the water sources referred to (rainwater & greywater) should receive treatment before use or what installations are required to mitigate risks associated with their use. These questions are important for gauging whether people appreciate how they could manage the risk that they may expose themselves to by use of rainwater or greywater.
- The quality of NZ rainwater is excellent, however, if collection area is not maintained then the quality of the rainwater rapidly decreases.
- Rainwater filtered and treated with chlorine or UV is safe to drink. Greywater that has received aeration treatment is safer than greywater that has not, while greywater that has received disinfectant treatment has the best quality for protections against waterborne disease. Hence, the questions that ask whether people consider these treatments are desirable, and would they pay for them, would help guide the industry as to what is required for the NZ context.
- I would like to see greater integration of the three waters (supply, waste and storm) to increase resilience and water security in NZ cities. Time to move out of silos and talk to each other.
- I think recycling of greywater and rainwater harvesting is a great idea in both non-residential and residential buildings to reduce the human impact on the water cycle.
- Environmental awareness is key. National and regional legislation coupled with encouraging procurement methods that incentivise unlocking OpEx savings would encourage uptake and technical awareness.
- The assumption in this survey that it is acceptable to use water to flush toilets is misplaced. Water based toilet facilities should be phased out of existence.
- Rainwater use for toilet flushing, irrigation, floor cleaning should be compulsory in new buildings.
- Mandatory rainwater collection for farmers and stricter limits on irrigation are required in conjunction with an increase in greywater/rainwater usage for water security in NZ.
- Many opportunities and options exist but no financial case for any, just sustainability showcasing, educational modelling and training opportunities.
- There is a perceived risk associated with rainwater, but there are a number of treatment options available to make this water safe to drink.
- I believe one impediment to uptake can be the current lack of established ways of sharing between properties. Thus, a warehouse property with, say, the ability to harvest large quantities of roof water may not have an onsite usage for the water. However, a neighbouring factory or golf course or such may find ready application for it. There could be real pay-off for an intermediate solution between “harvest and use onsite” and “send down the drain”.
- Other factors to consider for rainwater harvesting and greywater [recycling] is less processing of wastewater and rainwater. Greywater is difficult to maintain and manage in non-residential set up and is best suited for residential. The use of

greywater is somewhat limited to toilets and watering plants. Greywater is alkaline enriched and is easily affected by contaminants and cleaning chemicals!

- The farming industry is increasingly making use of both greywater and blackwater for both washing down and irrigation use both for cost saving and environmental benefits.
- I have done both of these in a new civic building. Was very expensive compared to conventional systems. Hard to factor what effects they actually have in relation to overall projects additional cost to do so. Low uptake unless incentivised.
- The difficulty in designing and convincing council of a greywater / rainwater harvesting system is compounded by the fact that no New Zealand manufacturer provides a standard package with testing and details, and there is no “acceptable solution” available. Hence Councils have to assess each proposal as a one-off design. This creates uncertainty in the cost and time to gain consent, which clients definitely do not like.

Appendix C: Survey questions

2014 survey questions

- Please rate the following (very good, good, adequate, poor, very Poor):
    - Your knowledge on environmental issues in New Zealand
    - Overall state of the natural environment in New Zealand
    - Water supply services in New Zealand
    - Water supply services in your region
    - Quality or condition of water in New Zealand
    - Quality or condition of water in your region
    - Availability of water in New Zealand
    - Availability of water in your region
- For what purposes is it most important to have treated, potable water? Please rank in order of importance, with 1 being the most important:
    - Drinking
    - Toilet flushing
    - Showering
    - Hand washing
    - Laundry
    - Cooking and food preparation
    - Irrigation and garden watering
- For what purposes do you think it is acceptable to use rainwater and/or greywater?
- From what sources do you think it is acceptable to source recycled greywater?
- What is your primary concern with having a rainwater harvesting and/or greywater recycling system?
- What are the biggest barriers to the use of rainwater and/or greywater?
- What are the biggest incentives or drivers for using rainwater and/or greywater?
- Please select your level of agreement to the following statements:
    - The quality of rainwater/greywater is excellent
    - Using rainwater for drinking is sensible
    - Using rainwater/greywater for toilet flushing is sensible
    - Rainwater harvesting/greywater recycling systems are complex
    - Rainwater harvesting/greywater recycling systems are expensive to install
    - Rainwater harvesting/greywater recycling systems are expensive to maintain
    - Rainwater harvesting/greywater recycling systems are difficult to operate
    - Systems are mature technologies
    - Products are resilient
    - Product development opportunities exist
    - System performance in New Zealand is excellent
    - Design and installation expertise in New Zealand is good
    - There is enough New Zealand-specific information available
- Discuss the products available in New Zealand for rainwater harvesting and greywater recycling:
    - Advantages
    - Disadvantages
- What is your experience with rainwater harvesting and/or greywater recycling systems?
- Please provide your opinions on rainwater harvesting and/or greywater recycling systems.

- What would make you consider installing a rainwater harvesting and/or greywater recycling system?
- Do you work in the water supply industry?
- In the event of a natural disaster, do resilience opportunities exist for the water networks?
- Please provide your opinions from a water supply network point of view from individual rainwater harvesting and greywater recycling systems:
    - General
    - Biggest impacts
    - Greatest annoyances
    - Biggest advantages
- Please indicate where you perceive positive impacts and negative impacts to occur from the use of individual systems:
    - Water network
    - Stormwater network
    - Wastewater network
- In your opinion, how important is it that the three waters are under one control in your region?
- What would you like to see changed to encourage sustainable water management in New Zealand?
- Within which New Zealand region do you reside?
- Within which industry group do you primarily work?
- What is your job title or role within your organisation?
- If you have any further comments, please leave them here.

2016 survey questions

- What industry sector do you operate in?
- What are the drivers for rainwater harvesting/greywater recycling in non-residential buildings?
- What are the barriers for rainwater harvesting/greywater recycling in non-residential buildings?
- Any other feedback or information?