Greywater systems: Barriers for builders

A thesis submitted in fulfillment of the requirements for the degree of Master of Applied Science

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DECLARATION

I certify that except where due acknowledgement has been made, the work is that of author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

Signature:

Date : 8/12/2008
I would like to acknowledge the assistance of Phillip Alviano from Master Builders Association Victoria for the kind supply of their data for this research project and my research supervisor Nick Blismas from RMIT University throughout the project with valuable guidance during the preparation of this thesis.

I would like to thank my family in Botswana (Africa) for their continued support through the years. This thesis is dedicated to the memory of my loving grandmother who passed away June 2008, who I didn’t get to see for the past two years. Completing this thesis brings me a step closer to finally getting to see my family again and it is a rewarding feeling to know that the tough times are behind me (until the next time). I would also like to thank my partner Caryn and her family here in Australia, most especially Barry and Elaine Whitfort who have kept me going when times were tough.

This research experience has been valuable for me and has definitely made me appreciate the finite resources we have in the world. I hope that this research, however insignificant can be useful to the building industry in Australia.
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ABSTRACT

Australia is one of the driest continents in the world with changing climatic conditions continuing to put a strain on potable water sources. The use of water saving technologies such as greywater systems in residential properties is an important water conservation tool in order to reduce the consumption of the finite potable water resources in Australia.

To this end, Master Builders Association Victoria with the assistance of RMIT University investigated the current barriers that builders face with regard to the installation of greywater systems in residential properties. Builders like other property and construction professionals have a part to play in promoting the use of sustainable technologies.

The main aims of the project were to firstly find out or identify barriers that are inhibiting builders from installing greywater systems and secondly to identify and formulate strategies to reduce or eliminate the barriers identified.

The main barriers for builders are; high cost, government regulations, lack of builder awareness or knowledge, and low client demand. The potential solutions for the reduction or elimination of the barriers identified as part of the research
include; economic and reliable greywater systems, creation of a website with link on greywater systems and educating the general public.

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**Keywords:** Greywater; Water Reuse; Barriers for builders; Sustainable technology
1 INTRODUCTION

1.1 PROBLEM ENVIRONMENT

Historically water has always been a key factor in deciding where a town is established with most cities and towns usually located within close proximity to a reliable water source. Water has subsequently been used at an increasing rate in these cities and towns for both consumption and industry over time. Rising populations and rapidly changing climatic conditions are putting a strain on water resources across the globe as a consequence of continued and increasing demand for potable water (Hughes, 2003 and Quiggin, 2006).

Water is emerging as a major problem for many countries in the world today. Issues relating to supply and consumption, in particular, are the subject of current environmental debates and disputes. Australia being the one of the driest continent, faces particularly acute water related challenges. There is mounting pressure on the approximately 21 million inhabitants (ABS, 2006) to make critical decisions on how to best manage water resources in the future (Department of Sustainability and Environment, 2007).
Climate change has been identified as a major concern as apparent changing worldwide climatic conditions appear to have an adverse impact on rainfall in most countries. Water shortages in dry countries such as Australia are likely to occur if measures are not taken to ensure that water supply is sustainable for the present and future generations. Flannery (2007) and Hughes (2003) concur, with the latter predicting that water as opposed to food and power, will be the first of the critical resources to be affected by continued climate variability.

The phenomenon referred to as global warming is held by many researchers as the cause of climate variability worldwide (Flannery, 2007). According to the International Panel on Climate Change (2001), the global average surface temperature has increased by 0.6°C over the 20th Century. This may be fairly significant when analyzing the impact of the change in temperature on a localized setting or country as the figure quoted is an average of global change. The change in temperature has, in various researchers’ opinions, had an impact on major climatic forces such as the El Nino – Southern Oscillation. Trenberth and Hoar (1996) indicating that the El Nino – Southern Oscillation is being enhanced by the greenhouse effect resulting from increasing levels of carbon dioxide in the atmosphere.

Conversely, other scientists and researchers do not agree with global warming and climatic change theories that are currently circulating within the media and academic world. Singer and Avery (2007) suggest, that global warming is an unstoppable phenomena that is part of a natural 1,500 year climatic cycle. They
postulate that there is very little that humans can do to stop or reverse this cycle (Singer and Avery, 2007).

Despite the contradictory research on climate change, the emphasis on conservation of resources is imperative as it will no doubt assist future generations in enjoying reasonably similar levels of the world’s natural resources.

Further detrimental changes in weather and climatic patterns will require most countries to preserve and utilize resources more wisely in order to avoid the dire predictions forecasted by Flannery (2007). The cause of these detrimental changes and climatic patterns should not be the only aspect that people focus on for sustainable development, but the bigger picture, in terms of the availability and supply of future world resources. Water conservation in Australia, is a critically important measure that will help reduce the strain on natural resources and will assist in preserving river systems such as the Murray Darling Basin for future generations.

Water reuse is therefore an essential aspect in the desire to reduce potable water consumption in Australia. Taylor (2006) argues the need for Australia to look at water reuse as a viable conservation measure. Dillon (2000) noted that the main problem with water resources management until the 1990’s was the failure to regard water as more than a single use disposable product. This has meant that water reuse technologies have been largely ignored in the past with
potable water continually wasted for non-essential uses such as car washing and gardening.

Water should be viewed as a finite resource that needs to be recycled and reused in order to preserve it. The diagram below (Figure 1.1) has been adapted from work by Swanson (2001) and basically illustrates the proportion of water in the natural environment and also highlights the finite water resources that are available on the planet:

![Water Resources Diagram](image)

**Figure 1.1** Water Resources based on Swanson (2001)

It is clear that water resources have to be used more efficiently in order to sustain the growing world population. Water conservation methods should be developed that reduce the need for fresh water supplies without adversely affecting the natural environment. Conservation efforts that merely reduce consumption of
fresh water supplies are not sufficient because in many countries such as Australia, the water sources are already strained with current water consumption rates at an unsustainable level (Taylor, 2007).

Water restrictions in most towns in Australia are currently at stage 2 or higher, however, the ongoing water restrictions and both State and Federal Government initiatives appear to be ineffective as water levels in the catchment areas continue to remain low throughout the country (Department of Sustainability and Environment, 2007). Stage 2 water restrictions prohibit the watering of lawns and requires all residential gardens be watered manually between 6am-8am and 8pm-10pm on alternate days (Department of Sustainability and Environment, 2007). The higher the stage in water restrictions – the more restrictions there are on watering residential and public gardens, sports grounds and vehicle washing.

Both rural and urban areas in Australia have been affected by the ongoing water crisis that is exacerbated by the drought that has afflicted the country for the past six years.

Climatic change is not the only factor for the ongoing water woes afflicting Australia. Water usage is relatively high given its low rainfall. Head and Muir (2007) identified culture as the main reason for the high consumption of water in Australia and stress that a ‘culture change’ in relation to water is necessary. Attitudes of profligacy developed in the well watered ancestral lands of Europe
have meant that usage of water has been high despite the fact the Australia is the driest inhabited continent on Earth (Head and Muir, 2007).

Several options have been forward to help improve potable water supply such as the desalination plant proposed in Wonthaggi (south east of Melbourne) by the Victorian Government and the possibility of a new dam in Gippsland suggested by some residents in the area. These two options are not without their opponents with latter being mainly criticized by environmentalists. Building dams involves regulating natural river flows with an early study by Walker (1985) suggesting that this regulation results in the changed distributions of plants and animals. This view is further supported by Kondolf (1997), when he pointed out that damming reduces delivery from the rivers to many coastal areas, leading to accelerated beach erosion.

There is a need to explore new ways to conserve water within Australia in order to preserve potable water sources which not only sustain humans but also the unique Australian flora and fauna dependent on the valuable water resources. Two alternatives namely, water reuse and ‘cultural change’, referred to by Head and Muir (2007) offer solutions to the ongoing water problems. Water reuse through sustainable technologies such as greywater systems can radically reduce the use of potable water. It is therefore essential to investigate any impediments to sustainable technologies that reduce the use of potable water.
1.1.1 GREYWATER

Greywater systems have been in the market for several years but are yet to be fully accepted by the general public. The systems provide a good water conservation tool as they reduce the use of potable water. There may be widespread confusion within the general public as to what exactly greywater comprises of, given the lack of a uniform definition within the literature. Clarity is necessary for the promotion of grey water systems as ‘safe’ water conservation technologies.

There is a slight difference in what is perceived as greywater, within the literature reviewed. Some define grey water as the untreated wastewater that is generated and can be collected from showers, kitchens, sinks and laundries (Christova-Boal, Eden and McFarlane, 1996; Jamrah, Al-Futaisi, Prathapar and Al Harrasi, 2007). Others view greywater as a less polluted stream of wastewater that is generated from hand basins, baths and showers. The notable difference being that water from kitchen sinks, and washing machines is excluded from the definition (Memon and Butler, 2007).

The difference in the above definitions can be attributed to perceived levels of contamination, with Birks and Hills (2007) indicating that water from kitchens and washing machines is more contaminated and hence wastewater from kitchens and washing machines is termed as ‘dark’ greywater. Greywater reuse, despite the above confusion, is considered to be a good tool for the conservation of
potable water and there is a need to look at the possible impediments to the adoption of greywater systems within the market.

The link between consumers and the construction industry means that the construction industry plays a key role and has a responsibility to the public to assist in the adoption of key water saving technologies in terms of new homes that are being constructed. The construction industry has a duty of care to the consumers to raise the awareness of the public in informing them about the different technologies that promote environmental sustainability.

The construction industry plays a vital role in the design phase of their projects by allowing for pipework required by greywater systems and rainwater tanks without having to install the actual systems. This benefits the consumer or client by allowing the client to choose to fit the systems at a lower cost as opposed to when the pipework is not pre-fitted.

There is therefore a need to understand what might inhibit the adoption of greywater systems from the builders point of view and try and address the barriers in order to promote a more water conscious society given the dwindling water resources.
1.2 RESEARCH PROBLEM

There is currently insufficient research relating to barriers inhibiting the installation of greywater systems by builders in Australia. The literature outlined in Chapter 3 of this study reveals issues relating to public perception and demand, current regulations, knowledge and awareness of greywater and the cost of grey water systems.

There is a need to understand how these issues affect builders as they are one of the first points of contact for many clients or consumers when they decide on a new residential development. The advice they give to clients when it comes to energy efficient designs and sustainable designs can guide clients and consumers and help improve the uptake of water conservation tools such as greywater systems.

Most of the previous work highlighted in Chapter 3 has focused on improving demand from a client perspective and has not been from a builder or developer’s point of view. Their input is crucial as they have a part (however minor) to play in the adoption of innovation within the built environment. Builders are often the main point of contact with consumers.

This research therefore ascertains the main barriers to the installation or recommendation for greywater systems by builders and suggests strategies for the reduction or elimination of these barriers.
1.2.1 RESEARCH QUESTIONS

Aim

The aim of this research is to identify the barriers inhibiting the installation of greywater systems by builders with the view of formulating strategies to overcome/address the identified barriers.

To this end two research questions are posed:

- What are the barriers inhibiting the installation of greywater systems by builders?
- What are the strategies needed to address these barriers?

In order to achieve the aims of this research, the following objectives were addressed:

- To determine the water use patterns in Australia
- To determine the current knowledge surrounding greywater use in Australia
- To develop a typology of the greywater systems available to Australian builders
- To determine what builders currently know about greywater
- To identify barriers to the installation of greywater systems by builders
- To formulate and document recommendations to reduce identified barriers
Carrying out the outlined objectives will help identify the barriers and provide answers to the two research questions that are the core of this research study.

1.2.2 JUSTIFICATION FOR THE RESEARCH

The research is vital, in order to assist the Federal Government as well as State and Local Governments represented by the different municipal councils to improve the uptake of sustainable measures such as the use of greywater systems within residential homes. Institutions such as the Building Commission and Master Builders Association will also utilise information from this research to encourage more builders to incorporate grey water systems into their projects.

The dwindling water resources in Australia make it imperative that alternative measures such as greywater systems are explored to conserve future water supplies and assist in the sustainable development effort. Other countries with similar water problems as Australia may also be interested in the results of this research as it may offer a long term solution to potential water shortages.

The research will also help advance the cause for sustainable development. Future generations will benefit from present water conservation efforts as this will help preserve water resources and help prevent future water shortages caused by strains on water sources exerted by an ever increasing human population.
1.2.3 DELIMITATIONS

The study is restricted to Victorian builders. Data was only gathered from members of the Master Builders Association of Victoria as the Institute was interested in the research and was able to provide the data for the research. Wider research is suggested for the future to verify and generalize the findings more broadly. The Master Builders Association assisted in providing data and resources for the research as confirmed in the acknowledgement letter annexed to this thesis as Appendix A. The study has therefore been limited to Victorian builders and is also accordingly limited in scope. All conclusions herein are from a Victorian perspective.

1.3 METHODOLOGY

This research is an interdisciplinary research study as it involves understanding the two distinct disciplines involved namely: construction and environmental science. This research utilizes both qualitative and quantitative research methods to obtain the advantages of both approaches and compensate for the weakness of each approach if taken in isolation.

The term triangulation is used to describe the above approach where a validity procedure is used by researchers to search for convergence among multiple and different sources of information to form themes or categories in a study (Creswell and Miller, 2000). Jick (1979) points out that the term originates from military
navigation at sea where sailors triangulated among different distant points to determine their ship’s bearing. Jick (p.604, 1979) noted the following:

“The effectiveness of triangulation rests on the premise that the weaknesses in each single method will be compensated by the counter-balancing strengths of another”

1.3.1 APPROACH

The research utilizes two approaches, namely; a multiple case study and a cross sectional approach. Four case studies are conducted of builders’ views of greywater systems and their use. Four locations across Victoria represent each case. At each location a focus group was conducted with Master Builders Association Victoria (MBAV) members regarding barriers and issues surrounding the installation of greywater systems by builders. A cross case study analysis of the four cases was then conducted.

The use of the focus group discussions identified both the barriers to the installation of greywater systems and potential solutions as the builders discussed amongst themselves what they were experiencing individually and collectively, which helped identify the key issues. McNeil and Chapman (1990) state that focus groups not only measure the extent of an opinion but can also investigate the reasons why it was formed. Finding out the underlying reasons behind what builders believe are the barriers goes some way in understanding
why the barriers exist in the first place and assists in the development of possible solutions to the barriers.

One of the main aims of the research as stated earlier is to develop a strategy to help reduce or minimize the barriers uncovered from the building industry. The focus group discussions therefore helped in understanding the psychological and behavioral underpinnings of builder behaviour and identified ways and means to influence the behaviour (Lyon and Trost, 1981).

As a method for inquiry in this topic area, focus group discussions are underutilized with the majority of the research on greywater systems and utilizing surveys and quantitative methods of analysis (Exall, Marsalek and Schaefer, 2006; Vanegas, DuBose and Pearce, 1996; Hartley, 2003; Messalem, 2006 and Jamrah et al, 2007). The need for a fresh approach is therefore imperative in order to derive more in depth information that can be sourced from this qualitative inquiry method.

The second approach involved a telephone survey of a random sample of MBAV members across Victoria to gain a broader perspective and allow triangulation of results. The time frame for this project was short, hence surveys were a suitable method for data collection. In addition, most of the literature reviewed (Exall, Marsalek and Schaefer, 2006; Vanegas et al, 1996; Hartley, 2003; Messalem, 2006 and Jamrah et al, 2007) utilized surveys which underpins the reliability and validity of using surveys as a method of inquiry within the topic area. Surveys,
according to McNeil and Chapman (1990), enable large amounts of data, usually in a statistical form, from a large number of people in a relatively short time.

According to Neuman (2007) surveys allow for the following categories of questions to be asked of respondents; behaviour, attitudes/beliefs/opinions, characteristics, expectations, self classification, knowledge which are in line with the objectives of this study.

Self administered questionnaires and online surveys were considered for the study with the latter being a data collection tool of choice in recent times (Wright, 2006). Despite the advantages of online surveys, namely, access to individuals in remote locations and the convenience of having automated data collection (thereby reducing researchers cost, time and effort), there are some disadvantages associated with this data collection method as outlined by Bryman (2008) namely;

- Access to the internet is still nowhere near universal, so that certain people are likely to be inaccessible;
- Invitations to take part in research may be viewed as just another nuisance e-mail.
- Loss of the personal touch – lack of rapport between interviewer and interviewee, inability to pick up visual or auditory cues.
- Concerns among research participants about confidentiality of replies at a time of widespread anxiety about fraud and hackers
The main second and fourth disadvantages are a major concern and therefore online questionnaires where considered less appealing in terms of a response rate from builders. The third disadvantage associated with online research, is that one can not verify the identity of the person responding, who might just be ‘playing a role’ and thus affecting the validity of the results (McNeil and Chapman, 2005).

The other data collection method considered for the study was self administered questionnaires which were also rejected as they tend to have the following disadvantages when compared to interviews (Bryman, 2008):

- One cannot prompt – there is no one present to assist respondents answer questions when they have difficulty.
- One cannot probe – there is no opportunity to probe respondents to elaborate an answer
- Difficulty of asking other kinds of questions – problems relating to asking too many questions
- Questionnaire can be read as a whole – respondents are able to read the whole questionnaire before answering the first question and when this occurs none of the questions asked is truly independent of the others.
- One does not know who answers as with online questionnaires

A discussion on the chosen data collection methods namely, phone surveys and focus group discussions, is included in the data analysis section of the thesis in order to further justify their selection within the study. The data used within the
thesis was entirely obtained from the MBA and is considered secondary data for the purposes of ethics approval process. The data collection methods were influenced by the researcher, however, the data remained that of the MBA. The supply of the data from the MBA (Appendix A) conformed with the MBA’s Privacy Policy to its members.

1.3.2 METHODOLOGY

Groat and Wang (2002) further justify taking on the approach adopted for this research. They state that the four competing research paradigms identified as positivism, postpositivism, critical theory and constructivism are along a continuum and overlap each other resulting in them not being completely exclusive of each other. Therefore answers to research questions can be enriched by a variety of approaches (Groat and Wang, 2002).

The research is mainly within the postpositivism inquiry paradigm and therefore sociological qualitative research techniques are considered to be appropriate. A postpositivist inquiry is conjectural, and less rigid in its claims than traditional logical positivism. According to Groat and Wang (2002), the key difference between positivism and postpositivism is that postpositivism uses an emphasis on the subject and requires an interpretation from within a framework of values, theory and meaning. Therefore postpositivism relies on multiple methods for the maximal capture of reality.
The validity of the model or framework that will be developed upon completion of the literature review in Chapter 3 is only realized through observations of real world situations or reality. The epistemology is therefore empirical. Empiricism or posteriori knowledge is generally a theory of knowledge emphasizing the role of experience, especially experience based on perceptual observations by the five senses (Neuman, 2004).

1.4 STRUCTURE OF THE THESIS

In addressing the research questions, the thesis is divided into seven chapters. The following section outlines the structure and main themes of the remaining six chapters of the thesis.

Chapter 2 will present information on water levels and different regulations and policies in the different states of Australia. An accurate picture as to how much water the different states and territories currently have is important to emphasise the need for water conservation. Current water demand and supply figures are also presented and are considered important as they provide an indication of how much potable water is consumed. The figures are presented with an emphasis on comparing consumption rates in the different states. The state policies that are presented in Chapter 2 are discussed and contrasted to establish whether the regulations are barriers with regards to greywater systems.

The use of greywater is discussed in Chapter 3 with a literature review discussing reasons for and against greywater systems. The literature review
yields a framework for analysis that is tested in the focus group discussions and the surveys. A brief look at the building process and construction industry in general is then undertaken in order to ascertain how builders and designers may contribute to the use of greywater systems. The main theme of the section is to justify the need to look at the construction industry as the ‘enabler’ for the adoption of greywater systems.

Chapter 4 examines the different types of greywater systems available in the market. A typology is developed to help the research adequately differentiate the greywater system types. Three case studies are presented on centralized systems, concluding with a comparison of centralized and decentralized systems.

Chapter 5 presents the results of the four case studies across Victoria. The chapter concludes with a cross-case analysis and set of barriers and strategies. Chapter 6 presents the results of the cross-sectional telephone survey, supporting the case study findings.

The final chapter (Chapter 7) summarises and concludes the general findings of the study demonstrating how each objective of the research has been achieved. The chapter also suggests further research and recommendations for the construction industry based on the findings of the study.
1.5 SUMMARY

This chapter has highlighted the problems facing Australia and the rest of the world with regard to water resources. Climatic variability and low water levels have been identified as a source for concern by various researchers with predictions from many scientists indicating that water will grow increasingly scarce (Flannery, 2007; Dillon, 2000; Taylor, 2006 and Head and Muir, 2007).

This study is therefore concerned with looking at water conservation tools namely; greywater systems with a view of ascertaining the barriers inhibiting their installation by builders. Builders are a main point of contact with consumers/clients for new residential projects and therefore their advice (or lack of it) to consumers has an influence on the adoption of sustainable technologies such as greywater systems.

In order to further support the need for water saving technologies such as greywater systems, the study will examine water levels and consumption rates of water within the different states in the next chapter. The Chapter will also analyse the existing policies and regulations regarding greywater and water reuse in the different states of Australia.
2 WATER IN AUSTRALIA

2.1 INTRODUCTION

This chapter explores the different policies that the various states have adopted in their contrastingly different State water management and conservation efforts. Understanding the level of regulations within the different states is key to determining whether builders are hindered by the current policies in place.

The chapter commences with an examination of the current climate of Australia with a view of ascertaining the current rainfall patterns which ultimately affects the supply of potable water. This section of the study compares and contrasts the levels of water consumption in the different states and territories.

The second half of the chapter focuses on State policies and regulations that affect water reuse, in particular, greywater systems. The different States are compared to determine which States require approval for greywater systems. It is important to understand how the different State Governments support the use of sustainable technologies such as greywater systems since the building industry is highly regulated and is somewhat restricted by Government. If greywater
systems are not easily approved by the different municipalities, the building industry may be reluctant to adopt them hence the need to examine the regulations.

### 2.2 CLIMATE IN AUSTRALIA

Colls and Whitaker (2001), describe Australia as a dry continent with reliable and bountiful rainfall limited to the coastal strip extending from Western Victoria through Tasmania, New South Wales, Queensland, the Northern Territory and into the north western parts of Western Australia. In general, the rains south of 35 degrees south are winter rains, and those north of 25 degrees south are summer rains (Colls and Whitaker, 2001).

As described in Chapter 1 the climate in Australia has been affected by increasing global temperatures which has resulted in flash flooding and longer droughts. According to Hughes (2003), Australia has warmed approximately 0.8°C over the last century which is slightly higher than the world average derived by the Intergovernmental Panel on Climate Change (2001) in their studies on the subject of international climate change.

The Bureau of Meteorology (Australia) has rainfall records dating from 1900. The information prior to 1900 Australia’s rainfall network is too sparse for reliable analysis therefore analysis commences as at the year 1900. Figure 2.1 shows an 11-year running average that is shown on the graph to provide an indication of
the decadal-scale variation through time. The graph clearly shows the high variability of rainfall in Australia.

![Annual Rainfall For Australia](image)

**Figure 2.1** Annual Australia Rainfall <Source: Bureau of Meteorology 2008>

The variability in rainfall has been increasing in recent times as highlighted within the graph with different scientists and studies offering several reasons for the sudden increase in variability.

According to Suppiah, Collins, and Della-Marta (2001), the El Nino Southern Oscillation phenomenon has a major influence on Australian Climatic and sea level variability and has had a sudden increase in occurrence since the 1970’s. Furthermore the increase in occurrence of the El Nino Southern Oscillation has been linked to the differential warming in the Indian Ocean, relative to the Pacific Ocean (Nicholls et al, 1996), which all ties in with the global warming theories that abound. The climatic variability due to the El Nino Southern Oscillation
phenomenon in Australia has been linked to flash floods in Queensland and drought in Victoria.

As observed in the Figure 2.1, variability has increased in occurrence particularly from the early 1970's and coincides with what many researchers believe is the period of heavy usage of CFC’s and increases in carbon emissions in the world. It is also important to note that the actual Australian rainfall has increased slightly in the past century as highlighted by Hughes (2003), however, the problem associated with this increase is that rainfall has increased in the summer as opposed to the winter time when it is most expected (Collins and Della Marta, 1999). Two issues not highlighted in Figure 2.1 is that States such as Western Australia are actually experiencing less rainfall than in the previous Century (Hughes, 2003) and also that there is an increase of rainfall in the northwest over the last 50 years (Bureau of Meteorology, 2008). The Bureau of Meteorology (2008) also indicates that rainfall in much of eastern Australia and the far southwest have experienced a decline thus further explaining the variability in Figure 2.1.

The weather and climatic patterns are clearly unpredictable but if the dire predictions by Flannery (2007) of the imminent water shortages are true, then future generations will certainly struggle. It is therefore imperative to analyse the current water levels and sources in Australia to determine whether the consumption patterns in the different states (that will be analysed in the next section of this Chapter), are sustainable.
The water sources or catchment areas are affected by the six different major climatic regions outlined in Figure 2.2 namely Northern Australia, Southern Australia, South Western Australia, South Eastern Australia and the Eastern Australia and the Murray Darling Catchment (Bureau of Meteorolgy, 2007). The rainfall and climate is different within the six regions as illustrated by Figure 2.3.

There is generally more rainfall in the eastern coastal strip that includes Victoria, New South Wales, Queensland and Tasmania (even though Tasmania is not part of the main land). Figure 2.2 illustrates the main climatic regions and also highlights a major source of water for Victoria and New South Wales which is the Murray Darling Basin.

Figure 2.2 Major Climatic Regions <Source: Bureau of Meteorology 2008>
Figure 2.3 Location Specific Annual Rainfall <Source: Bureau of Meteorology 2008>

Figure 2.3 clearly shows that the Murray Darling Basin is not the highest rainfall area but benefits from significant southerly annual river downflows from areas of higher rainfall.

Farmers are heavily dependent on irrigation from the Murray Darling basin for the seasonal outputs and over allocation of water rights have affected the river flow as highlighted in the Figure 2.4. Another issue that affects the river flow along the mid lower Murray Darling basin is the number of dams that reduce the runoff into small creeks and rivers that feed the Murray Darling basin (Quiggin, 2006).
According to National Land and Water Resources (2001), diversion of water into irrigation has significantly altered, and sometimes (mid-lower Murray-Darling Basin) led to the reversal of the annual river flow patterns (Figure 2.4).

The agricultural sector in Australia is heavily reliant on the water allocation system in irrigation farms and as a consequence, has been hard hit by the changing climatic conditions. Current water allocations for farmers are at all time lows with farmers in rural Victoria not expecting much in terms of output as a result of water shortages (Flannery, 2007; Department of Environment and Water, 2007). Major water sources such as the Murray-Darling Basin are very important for rural communities and Australia's economy in general as approximately 85% of all irrigation in Australia takes place in the Murray-Darling Basin, which supports an agricultural industry worth more than $9 billion per annum (Department of the Environment and Water, 2007).
According to the Murray-Darling Basin Commission, by 2023, there will be 5% less water flowing into the Murray-Darling system. The Department of the Environment and Water Resources (2007) estimates that approximately, three million Australians inside and outside the Murray-Darling Basin are directly dependent on its water. Apart from climate change, salinity issues have also adversely affected the fresh water levels of the Murray-Darling Basin. Clearly, with an increasing population, water shortages are imminent at current water consumption rates.
2.3 WATER CONSUMPTION BY STATE AND TERRITORY

In 2006, the Australian Bureau of Statistics (ABS) released the Water Account research publication that outlines water supply and usage within the Australian economy. The research covered the 2004/5 period and was compiled in accordance with the System of Integrated Environmental and Economic Accounting (2003).

The following section of the Chapter shows the break down of inter state water use and has been summarised using information from the Water Account publication by the ABS (2006). Due to the relatively small size of the Australian Capital Territory, information on water usage in the territory has been amalgamated with the State of New South Wales. The purpose of the statistical information on water consumption countrywide is to illustrate the high water consumption of the different States.

2.3.1 WATER CONSUMPTION IN THE AUSTRALIAN CAPITAL TERRITORY AND NEW SOUTH WALES

New South Wales (NSW) is located in the south east of Australia, north of Victoria and south of Queensland. The population of NSW is the highest of all the states and territories at 6,889,100 (ABS, 2007). NSW covers approximately 10.4% of Australia and includes an area of 800,642 square kilometers
(Geoscience, 2001). The state has what is described as a warm temperate climatic zone (Colls and Whitaker, 2001).

The Australian Capital Territory (ACT) is the capital territory of the Commonwealth of Australia and is completely surrounded by the state of New South Wales. The population of ACT is approximately 339,900 people (ABS, 2007). The Territory occupies an area of approximately 2,431 square kilometers that includes Jervis Bay. The ACT experiences 4 distinct seasons, unlike other Australian cities whose climates are moderated by the sea (Colls and Whitaker, 2001). Canberra is known for hot, dry summers, and the cold winters with occasional fog and frequent frost. Rainfall is highest in spring and lowest in winter (Colls and Whitaker, 2001).

According to ABS (2006) in the New South Wales and the Australian Capital Territory combined, water consumption was 5,978 GL during 2004-05 compared to 8,783 GL in 2000-01. This reduction in water consumption over the years can be attributed to the ongoing drought and strict water restrictions in place. The water consumption is still considerably high, with the highest consumer in 2004-05 being the agriculture industry with 4,134 GL or 69% of water consumption. This was followed by the water supply, sewerage and drainage services industry which consumed 637 GL or 11% of water. The household water consumption for the two states as at 2005 was 604 GL. Table 2.1 summarises household water consumption figures in New South Wales and the Australian Capital Territory.
Table 2.1 New South Wales Water Consumption Figures (2006)

<table>
<thead>
<tr>
<th>Household Consumption (GL)</th>
<th>Population</th>
<th>Geographical area (sqkm)</th>
<th>Consumption per Capita (L/person)</th>
<th>Consumption per Geographical Area (L/sqkm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>604</td>
<td>7,229,000</td>
<td>803,073</td>
<td>83,552</td>
<td>752,111</td>
</tr>
</tbody>
</table>

2.3.2 WATER CONSUMPTION IN THE NORTHERN TERRITORY

The Northern Territory occupies the central and central northern regions in Australia. The state shares borders with Western Australia to the west, South Australia to the south, and Queensland to the east. The Northern Territory occupies an area of 1,349,129 square kilometres and is Australia’s third largest State/Territory (Geoscience, 2008).

The population of the Northern Territory is an estimated 217,559 and is the least populous state in Australia due to its relatively harsh climatic environment. The Northern Territory has two distinctive climate zones namely the northern tropical climate and the central desert climate (Colls and Whitaker, 2001).

In the Northern Territory, 141 GL of water was consumed in 2004-05 compared to 134 GL in 2000-01. In 2004-05, the agriculture industry accounted for 47 GL (or 33%). The next highest consumer of water was households, consuming 31 GL (or 22%) (ABS, 2006). Table 2.2 summarises the household water consumption levels in the Northern Territory.
Table 2.2 Northern Territory Water Consumption Figures (2006)

<table>
<thead>
<tr>
<th>Household Consumption (GL)</th>
<th>Population</th>
<th>Geographical area (sqkm)</th>
<th>Consumption per Capita (L/person)</th>
<th>Consumption per Geographical Area (L/sqkm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>217,559</td>
<td>1,349,129</td>
<td>142,490</td>
<td>22,978</td>
</tr>
</tbody>
</table>

2.3.3 WATER CONSUMPTION IN QUEENSLAND

The state of Queensland occupies the north eastern corner of Australia. It is bordered by the Northern Territory to the west, South Australia to the south west and New South Wales to the south. The state is Australia’s second largest by area and occupies an area of approximately 1,730,648 square kilometres (Geoscience, 2008).

The population of Queensland is estimated at 4,182,100 people (ABS, 2007). There is variation in climate across the state due to the states relatively large size with low rainfall and hot summers for the inland west and monsoonal ‘wet’ season in the north. Warm temperate conditions are experienced along the coastal strip (Colls and Whitaker, 2001).

In Queensland, 4,361 GL of water was consumed in 2004-05 compared to 4,267 GL in 2000-01. The agriculture industry consumed the most water in 2004-05 with 2,916GL or 67% of Queensland’s water consumption. Sugar and Cotton were the main consumers within the agriculture industry, with 1,116 GL and 857 GL consumed respectively. The next largest consumers were Households, with
493 GL or 11% of Queensland’s water consumption (ABS, 2006). Table 2.3 summarises the household water consumption levels for the state of Queensland.

Table 2.3 Queensland Water Consumption Figures (2006)

<table>
<thead>
<tr>
<th>Household Consumption (GL)</th>
<th>Population</th>
<th>Geographical area (sqkm)</th>
<th>Consumption per Capita (L/person)</th>
<th>Consumption per Geographical Area (L/sqkm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>493</td>
<td>4,182,100</td>
<td>1,730,648</td>
<td>117,883</td>
<td>284,864</td>
</tr>
</tbody>
</table>

2.3.4 WATER CONSUMPTION IN SOUTH AUSTRALIA

The South Australian state occupies the southern central part of Australia with an area of approximately 983,482 square kilometres. The state covers some of the most arid parts of the continent. The state is bordered to the west by Western Australia, to the north by the Northern Territory and the east by NSW and Victoria. The state is also bordered by Queensland to the north east.

The population of South Australia is estimated at 1,584,500 people. The state features extremely arid northern and western parts of the state with more fertile south east (Colls and Whitaker, 2001).

Water consumption in South Australia was 1,365 GL in 2004-05 compared to 1,383 GL in 2000-01. The agriculture industry was the largest consumer of water in 2004-05, accounting for 1,020 GL or 75% of South Australia’s water consumption. Livestock, pasture, grains and other agriculture had the highest
water consumption within the agriculture industry with 483 GL (or 47%) followed by Grapes with 204 GL (or 20%). Households were also large consumers of water with 144 GL or 11% of South Australia's water consumption (ABS, 2006). Table 2.4 summarises the household water consumption levels for South Australia.

Table 2.4 South Australia Water Consumption Figures (2006)

<table>
<thead>
<tr>
<th>Household Consumption (GL)</th>
<th>Population</th>
<th>Geographical area (sqkm)</th>
<th>Consumption per Capita (L/person)</th>
<th>Consumption per Geographical Area (L/sqkm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>144</td>
<td>1,584,500</td>
<td>983,482</td>
<td>90,880</td>
<td>146,419</td>
</tr>
</tbody>
</table>

2.3.5 WATER CONSUMPTION IN TASMANIA

Tasmania is an Australian island and state located approximately 240 kilometres south of the eastern side of the continent. Tasmania occupies a total of 68,401 square kilometres and has an estimated population of approximately 493,300 people (Geoscience, 2008).

The climate of Tasmania is described as a temperate climate. The temperate climate in Tasmania can have very unpredictable weather (Colls and Whitaker, 2001). The Tasmanina climate features high fluctuations in temperature and wind speed.
Water consumption was 434 GL in Tasmania in 2004-05 compared to 408 GL in 2000-01. In 2004-05, the agriculture industry was the largest consumer accounting for 258 GL or 59% of water consumption in the State. Households were also a major consumer of water in Tasmania, with 69 GL or 16%. The manufacturing industry consumed 49 GL or 11%. Most of the water consumed by the manufacturing industry in Tasmania, was by the wood and paper products industry (71% of water consumption by the manufacturing industry in Tasmania) (ABS, 2006). Table 2.5 summarises the household water consumption figures for Tasmania.

**Table 2.5** Tasmania Water Consumption Figures (2006)

<table>
<thead>
<tr>
<th>Household Consumption (GL)</th>
<th>Population</th>
<th>Geographical area (sqkm)</th>
<th>Consumption per Capita (L/person)</th>
<th>Consumption per Geographical Area (L/sqkm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>69</td>
<td>493,300</td>
<td>68,401</td>
<td>139,874</td>
<td>1,008,757</td>
</tr>
</tbody>
</table>

### 2.3.5 WATER CONSUMPTION IN VICTORIA

The state of Victoria is located in the south eastern corner of Australia. It is the smallest mainland state in area at approximately 227,416 square kilometers. Victoria is also the second most populous State after New South Wales, with an estimated population of 5,205,200 (ABS, 2007).

Victorian climate varies from semi-arid and hot in the north west, to temperate and cool along the coast (Colls and Whitaker, 2001). The state has been
experiencing drought in past years with below average rainfall (Department of the Environment and Water Resources, 2007).

In Victoria, 4,993 GL of water was consumed in 2004-05 compared to 5,375 GL in 2000-01. The agriculture industry was the highest consumer of water in Victoria in 2004-05, with 3,281 GL (or 66%) of Victoria's water consumption. Dairy farming was the main consumer within the agriculture industry, with 1,710 GL (or 52%) of Agricultural water consumption in Victoria. The water supply, sewerage and drainage services industry was the next highest consumer of water, accounting for 793 GL (or 16%). Households were also a significant consumer of water with 405 GL or 8% of Victoria's water consumption (ABS, 2006). Table 2.5 summarises household water consumption levels within the state.

<table>
<thead>
<tr>
<th>Household Consumption (GL)</th>
<th>Population</th>
<th>Geographical area (sqkm)</th>
<th>Consumption per Capita (L/person)</th>
<th>Consumption per Geographical Area (L/sqkm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>405</td>
<td>5,205,200</td>
<td>227,416</td>
<td>77,807</td>
<td>1,780,877</td>
</tr>
</tbody>
</table>

2.3.5 WATER CONSUMPTION IN WESTERN AUSTRALIA

Western Australia is Australia’s largest state at approximately 2,529,875 square kilometres. The state covers a third of the mainland and is bordered by South Australia and the Northern Territory.
The state has a population of an estimated 2,105,800 people and constitutes only 10% of Australia’s total population despite the size of the state. Western Australia is divided in half climatically by a belt of descending dry high pressure system airflow generally along the Tropic of Capricorn between the north, in which a summer rainfall pattern predominates. The south is generally characterized by winter rainfall (Colls and Whitaker, 2001)

In Western Australia, 1,495 GL of water was consumed in 2004-05 compared to 1,353 GL in 2000-01. In 2004-05, the agriculture industry consumed the largest volume (535 GL or 36%) followed by Households (362 GL or 24%). Consumption by the mining industry was also substantial (183 GL or 12%) (ABS, 2006). Table 2.7 summarises the household water consumption levels for Western Australia.

**Table 2.7 Western Australia Water Consumption Figures (2006)**

<table>
<thead>
<tr>
<th>Household Consumption (GL)</th>
<th>Population</th>
<th>Geographical area (sqkm)</th>
<th>Consumption per Capita (L/person)</th>
<th>Consumption per Geographical Area (L/sqkm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>362</td>
<td>2,105,800</td>
<td>2,529,875</td>
<td>171,906</td>
<td>143,090</td>
</tr>
</tbody>
</table>
2.4 ANALYSIS OF STATE CONSUMPTION

Table 2.8 illustrates how the consumption of water varies from state to state with an interesting finding being that the most populous of states namely, New South Wales and Victoria are the least consumers of water at household level.

Western Australia and the Northern Territory are the two largest consumers of water at household level according to the figures analysed with 171,906 and 142,490 litres per capita respectively. The figures are very high for most of the states with only three states namely NSW (ACT included), Victoria and South Australia under 100,000 litres per person.

Table 2.8 Comparison of Water Consumption Figures Per Capita of Household Consumption (2006)

<table>
<thead>
<tr>
<th>State</th>
<th>Consumption per Capita (L/person per annum)</th>
<th>Consumption per Capita (L/person per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW and ACT</td>
<td>83,552</td>
<td>1,607</td>
</tr>
<tr>
<td>Victoria</td>
<td>77,807</td>
<td>1,496</td>
</tr>
<tr>
<td>Queensland</td>
<td>117,883</td>
<td>2,267</td>
</tr>
<tr>
<td>South Australia</td>
<td>90,880</td>
<td>1,748</td>
</tr>
<tr>
<td>Western Australia</td>
<td>171,906</td>
<td>3,306</td>
</tr>
<tr>
<td>Tasmania</td>
<td>139,874</td>
<td>2,690</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>142,490</td>
<td>2,740</td>
</tr>
</tbody>
</table>

More work has to be done by the various states to reduce consumption of water especially in the states where consumption per person is over 100,000 litres. The reuse of water can reduce the consumption of water and the high rates of consumption illustrated in Table 2.8.
In order to effectively gauge whether water consumption levels within Australia are high, a comparison can be made with other countries, for which some published data is available. Given California’s climatic similarities to the Australian South East, the data was used as an indicator. Table 2.9 shows the breakdown of wastewater amounts in a typical Californian (USA) household based on work by Ludwig (2000) with an estimated 3,748 litres a week. The estimates are based on a household comprising two adults and two children therefore each person consumes an average of just under 50,000 litres per annum. The estimates suggest that water consumption is considerably high in Australia as shown in Table 2.8. It should be noted that the Californian estimates do not include outdoor water consumption hence the estimates may be significantly less than the total household use. Apart from illustrating the general high level of water usage in Australia, Table 2.9 shows the amount of reusable water that is a by-product of indoor household use with approximately 87.3% of indoor waste water considered as reusable.

Table 2.9 Snapshot of Water Consumption within an Average Household

<table>
<thead>
<tr>
<th>Household Use</th>
<th>Usage (L/wk)</th>
<th>% of Indoor Water Use/wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washer</td>
<td>606</td>
<td>16.2%</td>
</tr>
<tr>
<td>Shower</td>
<td>1,696</td>
<td>45.3%</td>
</tr>
<tr>
<td>Tub</td>
<td>227</td>
<td>6.1%</td>
</tr>
<tr>
<td>Bathroom Sink</td>
<td>212</td>
<td>5.7%</td>
</tr>
<tr>
<td>Kitchen Sink</td>
<td>318</td>
<td>8.5%</td>
</tr>
<tr>
<td>Reverse Osmosis Water Purifier Wastewater</td>
<td>212</td>
<td>5.7%</td>
</tr>
<tr>
<td>Reusable Subtotal</td>
<td>3,271</td>
<td>87.3%</td>
</tr>
<tr>
<td>Toilet</td>
<td>477</td>
<td>12.5%</td>
</tr>
<tr>
<td><strong>Total Indoor Water Use</strong></td>
<td><strong>3,748</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

Source: Ludwig (2000)
Ludwig (2000) included kitchen and laundry wastewater within the estimates, which, as discussed in chapter 1 of this thesis, is viewed by some as ‘dark greywater’ and is more contaminated than other indoor wastewater (Memon and Butler, 2007; Birks and Hills, 2007). Adjusted reusable water estimates without the two more contaminated wastewater is approximately 62.6 % which is a considerable amount of water.

Table 2.10 illustrates the estimated water conservation benefits in kilolitres per annum for an average household when reusing ordinary greywater for watering the garden, flushing the toilet and a combination of the two. The reuse of greywater for both toilet flushing and watering the garden saves 31% of the total water use for a household and therefore can significantly reduce the use of potable water.

<table>
<thead>
<tr>
<th>Greywater Reuse</th>
<th>Saving (KL/ annum)</th>
<th>% of Total Water Use</th>
<th>% of Total Sewerage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garden</td>
<td>52</td>
<td>21</td>
<td>32</td>
</tr>
<tr>
<td>Toilet</td>
<td>49</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Toilet and garden</td>
<td>77</td>
<td>31</td>
<td>47</td>
</tr>
</tbody>
</table>


The water saving potential of greywater systems is clearly high as uses such as toilet flushing consume thousands of litres of potable water which could be conserved.
2.5 STATE POLICIES AND REGULATIONS

The policies of the Australian Government vary across the different states with regards to the treatment of greywater and issues relating to water reuse in general. It is therefore imperative that an analysis of the different States is carried out with respect to the different rules and regulations currently governing the use of grey water systems.

Regulations affect the uptake of greywater systems as the construction industry is highly regulated and therefore if greywater systems are not approved in the different states, builders will not readily adopt them. The same can be said of approval times, which can be longer for the installation of greywater systems thereby delaying the construction process.

The following section of the study therefore focuses on the different policies that govern the different states with respect to water reuse and greywater systems in general.

2.5.1 AUSTRALIAN CAPITAL TERRITORY

The Australian Capital Territory has one key policy document that references the reuse of water, which is the Water Resources Management Plan 2004: *Think water, act water*. The key point in the report is the 20% recycling target that is expected to be attained by 2013 (National Water Commission, 2006).
The responsible Authority in the Australian Capital Territory is the Australian Capital Territory Health department as their key responsibility is to provide advice on system design and health implications of water reuse (National Water Commission, 2006).

Guidelines for greywater use were released to help reach the set targets and educate the public on the safe use of greywater within households. The paper *Greywater Use, Guidelines for Residential Properties in Canberra* outlines certain owners obligations, public health considerations, legislation and general greywater use and system design. The guidelines also assert that the Australian Capital Territory does not specifically regulate greywater, but emphasise that residential property owners must comply with existing plumbing and other relevant legislation.

There are no permits or regulatory requirements at present for homeowner – installed greywater systems (Maxey, 2005). Treatment systems also do not need approval in the Australian Capital Territory.

The ACT also amended the Water and Sewerage Regulations (2001) in 2004 to accommodate for the failure of the market in adopting greywater systems and rainwater tanks. The State put into place requirements for new residential construction to have rainwater tank pipework and greywater pipework to reduce
the cost of retrospectively fitting the pipework by consumers. The ACT hopes that this will effectively deal with the market failure as cost is a major issue for greywater systems, identified in the literature review.

Table 2.11 summarises the level of support for greywater systems in ACT with the overall support considered high due to the fact that greywater systems do not require approval in the State.

<table>
<thead>
<tr>
<th>State</th>
<th>Approval of Systems</th>
<th>Level of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Capital Territory</td>
<td>• No approval required for greywater systems</td>
<td>High</td>
</tr>
</tbody>
</table>

2.5.2 NEW SOUTH WALES

New South Wales is more comprehensive with regards to legislative controls regarding the use of greywater systems as compared to the Australian Capital Territory and has two main Legislative Acts that reference the reuse of water namely:

- Protection of the Environment Operations Act 1997;

The State of New South Wales has also released guidelines for the safe use of reclaimed water in various uses. The paper titled *NSW Guidelines for Grey Water*
Reuse in Sewered, Single Household Residential Premises was released in March 2007 with the following purpose:

- To provide direction on the use of grey water diversion devices (GDDs), and to specify the conditions for exemption from prior approval by Councils for greywater diversion;
- To provide additional advisory information to the owners and/or occupiers of sewered residential premises on greywater systems and manual bucketing of greywater systems.

The use of grey water through direct diversion on residential premises may be carried out without prior approval of the Council if the requirements of the New South Wales Code of Practice: Plumbing and Drainage 2006 are met (Maxey, 2008). Greywater Treatment Systems require Local Government approval and must be accredited by the New South Wales Health Department (Maxey, 2008).

The responsible Authorities with regards to recycled water management in New South Wales are:

- The Department of Environment and Climate Change;
- The Department of Water and Energy;
- Local Council.

The Department of Environment and Climate Change administers the Protection of the Environment Operations Act 1997 while the Department of Water and
Energy issue approvals under the Local Government Act 1993 to local water utilities reusing or supplying treated sewerage effluent.

Table 2.12 summarises the level of support for greywater systems in NSW with the overall support considered to be medium because the regulations allow for untreated diversion systems without the need for approval but treatment systems do require approval.

### Table 2.12 Level of Support – NSW

<table>
<thead>
<tr>
<th>State</th>
<th>Approval of Systems</th>
<th>Level of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>New South Wales</td>
<td>• No approval for untreated diversion systems</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>• Approval required at Local Government level for treatment systems</td>
<td></td>
</tr>
</tbody>
</table>

#### 2.5.3 NORTHERN TERRITORY

The Northern Territory has one main reference in terms of recycled water management, which is the Water Supply and Sewerage Act (2001). The Act provides direction and safeguards for wastewater quality for reclaimed water schemes. The Territory has the Utilities Commission that regulates water supplies services that include issuing and auditing compliance against Operating Licenses that specify recycled water standards.

There is no permit or installation approval required for untreated greywater systems within both Building Control Areas and outside Building Control Areas, however the Greywater Diverter Device must be installed and certified by a self
certifying plumber in accordance with the requirements of the Department of Health and Community Services.

Greywater Treatment Systems do not require permits or installation approvals within Building Control Areas as with the Untreated Greywater Systems, however the Department of Health and Community Services must be notified. For the installation of the Greywater Treatment Systems in areas outside the Building Control Areas, notification to the Department of Health and Community Services is also mandatory with further requirements being that the manufacturer/agent must apply to the Department of Health and Community Services for a Site Specific Design Approval for the Greywater Treatment System (Maxey, 2008).

The main body responsible for the management of recycled water is the Department of Health and Community Services. The department administers the Water Supply and Sewerage Act 2001.

Table 2.13 summarises the level of support for greywater systems in NT with the overall support considered high due to the fact that greywater systems do not require approval in the State.

<table>
<thead>
<tr>
<th>State</th>
<th>Approval of Systems</th>
<th>Level of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Territory</td>
<td>No approval required</td>
<td>High</td>
</tr>
</tbody>
</table>

Table 2.13 Level of Support – Northern Territory
2.5.4 QUEENSLAND

The Queensland Water Recycling Strategy is the main reference point with regards to policy in the State of Queensland. The key legislation for general water management within the State is the Water Act (2000).

The state has also released the *Queensland Water Recycling Guidelines* (Waterwise Queensland, 2005) in December 2005 as a guideline for the use of recycled water. The purpose of the guidelines are:

- To encourage and support water recycling that is safe, environmentally sustainable and cost effective;
- To provide a risk management framework combined guidance on best practice to ensure that water recycling project planners and operators can match recycling water quality to intended uses in the safest and most cost effective manner.

Both Untreated Greywater Diversion Systems and Treatment Systems require Council approval in Queensland. The guidelines incorporate both domestic use and commercial property use and also cover irrigation issues that emanate from the use of recycled water. The main Government Authority dealing with recycled water management in Queensland is the Department of Natural Resources and Water which oversees and implements the Water Act 2000.
Table 2.14 summarises the level of support for greywater systems in Queensland with the overall support considered low because both untreated and treatment greywater systems require approval in the State.

Table 2.14 Level of Support – Queensland

<table>
<thead>
<tr>
<th>State</th>
<th>Approval of Systems</th>
<th>Level of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland</td>
<td>• Approval required at Local Government level for both untreated greywater diversion systems and treatment systems</td>
<td>Low</td>
</tr>
</tbody>
</table>

2.5.5 SOUTH AUSTRALIA

South Australia has two legislative controls in place with regards to recycled water management in the State. The two key legislations currently in place are the following:

- Public and Environment Health Act 1987; and
- Public and Environmental (Waste Control) Regulations 1995

The *South Australian Reclaimed Water Guidelines (Treated Effluent)* also serve as general guidance for recycled water management. The Draft Guidelines for *Permanent Onsite Domestic Greywater Systems: Greywater Products and Installation* are the most relevant in terms of specific guidance on the use of greywater within the State.
Both Untreated Greywater Diversion and Treatment Systems require permits from Council or the Department of Health, however, the temporary use of greywater such as bucketing or a hose from the washing machine do not require a permit (Maxey, 2008).

Table 2.15 summarises the level of support for greywater systems in South Australia with the overall support considered low because both untreated and treatment greywater systems require approval in the State.

<table>
<thead>
<tr>
<th>State</th>
<th>Approval of Systems</th>
<th>Level of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Australia</td>
<td>Approval required at Local Government level for both untreated greywater diversion systems and treatment systems</td>
<td>Low</td>
</tr>
</tbody>
</table>

2.5.6 TASMANIA

The State of Tasmania currently outlaws the use of untreated greywater with the greywater required to be treated before use (Maxey, 2008). The two main legislative controls on recycled water management within the State of Tasmania are:

- The Public Health Act;
There are currently two relevant documents with regards to recycled water management namely the Greywater Treatment Systems – Sustainable Living Tasmania and the Environmental Guidelines for the use of Recycled Water in Tasmania 2002.

The responsible Authorities with regards to recycled water management are the:

- Department of Health and Human Services;
- Department of Tourism, Arts and the Environment;
- Local Councils.

Table 2.16 summarises the level of support for greywater systems in Tasmania with the overall support considered low since untreated greywater systems are outlawed with treatment systems requiring approval in the State.

<table>
<thead>
<tr>
<th>State</th>
<th>Approval of Systems</th>
<th>Level of Support</th>
</tr>
</thead>
</table>
| Tasmania    | • Untreated systems are outlawed  
              • Approval required at Local Government level for treatment systems       | Low              |

2.5.7 VICTORIA

The State of Victoria has one key legislative control that references reuse of water which is the Environment Protection Act 1970.
The relevant document with regards to policy documentation concerning the reuse of water and water issues in general is the paper *Our Water, Our Future* released in 2004. Another important policy document is the Water Recycling Action Plan (2002).

The leading Authority in Victoria with respect to water reuse is the Environment Protection Authority (EPA). The EPA has released two papers outlining guidelines for the reuse of water namely:

- Guidelines for Environment Management: Use of Reclaimed Water (EPA, 2003);
- Reuse options for Household Wastewater.

The direct diversion of untreated greywater does not require a permit in Victoria in sewered areas however; the reuse of greywater in unsewered areas is considered an alteration to a septic tank and requires a Council permit. Treatment Systems require a permit as the treatment and storage of greywater requires a permit, with the main stipulation on the granting of the permit being that the system must be approved by the EPA.

Table 2.17 summarises the level of support for greywater systems in Victoria with the overall support considered medium since untreated greywater systems do not require approval in the State with approval only required for treatment systems.


### Table 2.17 Level of Support – Victoria

<table>
<thead>
<tr>
<th>State</th>
<th>Approval of Systems</th>
<th>Level of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria</td>
<td>• No permit required in sewered areas for untreated greywater diversion systems</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>• Permit required in unsewered areas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Treatment systems require a permit</td>
<td></td>
</tr>
</tbody>
</table>

#### 2.5.8 WESTERN AUSTRALIA

The State of Western Australia also has two main Acts that are relevant for recycled water management namely:

- Health Act 1911;
- Environmental Protection Act 1986.

Guidelines and relevant documents within the State include; the Code of Practice for the *Reuse of Greywater in Western Australia, 2005*, the *Greywater Factsheet* and the *Draft Recycled Water – Groundwater Recharge Guidelines*.

All greywater systems need approval from the Local Council and must be approved by the Executive Director, Public Health. There is no permit required for bucketing greywater (Maxey, 2008).

The main Authorities responsible for the management of recycled water are the Department of Health and the Environmental Protection Authority.
Table 2.18 summarises the level of support for greywater systems in Western Australia with the overall support considered low due to the fact that both untreated and treatment greywater systems require approval in the State.

### Table 2.18 Level of Support – Western Australia

<table>
<thead>
<tr>
<th>State</th>
<th>Approval of Systems</th>
<th>Level of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Australia</td>
<td>• Approval required at Local Government level for both untreated greywater diversion systems and treatment systems</td>
<td>Low</td>
</tr>
</tbody>
</table>
2.6 NATIONAL INITIATIVE

The next section of the study will focus primarily on the Federal Government’s schemes that are promoting the reuse of water in the country. The section provides a brief snapshot of the incentives being put forward by the Federal Government.

The Australian Federal Government has implemented a number of initiatives in order to help conserve the limited water resources with the following three initiatives being particularly useful for both urban and rural populations:

- National Water Initiative;
- Community water grants and efficiency labeling and standards (WELS) scheme;
- Australian Guidelines for Water Recycling (planning stages).

The first initiative mentioned above is the National Water Initiative, and according to the Department of the Environment and Water Resources (2007), its overall objective is to achieve a nationally compatible market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes. Accordingly, at the highest level, implementation of the National Water Initiative is expected to achieve the following:
• clear and nationally-compatible characteristics for secure water access entitlements;

• transparent, statutory-based water planning;

• statutory provision for environmental and other public benefit outcomes, and improved environmental management practices;

• complete the return of all currently over-allocated or overused systems to environmentally-sustainable levels of extraction;

• progressive removal of barriers to trade in water and meeting other requirements to facilitate the broadening and deepening of the water market, with an open trading market to be in place;

• clarity around the assignment of risk arising from future changes in the availability of water for the consumptive pool;

• water accounting which is able to meet the information needs of different water systems in respect to planning, monitoring, trading, environmental management and on-farm management;

• policy settings which facilitate water use efficiency and innovation in urban and rural areas;

• addressing future adjustment issues that may impact on water users and communities; and

• recognition of the connectivity between surface and groundwater resources and connected systems managed as a single resource.
The second initiative is the Australian Government’s Community Water Grants programme and offers grants to help local community organisations save recycle or improve the health of their local water resources. Grants are available for projects related to:

- water saving and efficiency;
- water recycling;
- water treatment - improving surface and groundwater health.

According to the Department of the Environment and Water Resources (2007), Round 3 is currently underway and is the final round of Community Water Grants funding under the programme's $200 million allocation. The allocation of only $200 million is a small amount considering the high level of construction of new residential properties which would benefit from subsidised water recycling technologies such as grey water systems. The Government effort is also muted in terms of public advertising campaigns which are virtually non-existant, with most people generally not well informed of the grants and or initiatives.

The Australian Guidelines for Water Recycling are currently being drafted with the view of establishing standards for the general quality of recycled water for drinking purposes. The reuse of water is a very important step to reduce the
consumption of fresh water from water sources such as the Murray-Darling Basin.

2.7 ANALYSIS

It is clear from the preceding section that regulations vary considerably between the different States in Australia. Table 2.19 summarises the information on approval of greywater systems from the preceding chapter.

<table>
<thead>
<tr>
<th>State</th>
<th>Approval of Systems</th>
<th>Level of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Capital Territory</td>
<td>• No approval required for greywater systems</td>
<td>High</td>
</tr>
<tr>
<td>New South Wales</td>
<td>• No approval for untreated diversion systems • Approval required at Local Government level for treatment systems</td>
<td>Medium</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>• No approval required</td>
<td>High</td>
</tr>
<tr>
<td>Queensland</td>
<td>• Approval required at Local Government level for both untreated greywater diversion systems and treatment systems</td>
<td>Low</td>
</tr>
<tr>
<td>South Australia</td>
<td>• Approval required at Local Government level for both untreated greywater diversion systems and treatment systems</td>
<td>Low</td>
</tr>
<tr>
<td>Tasmania</td>
<td>• Untreated systems are outlawed • Approval required at Local Government level for treatment systems</td>
<td>Low</td>
</tr>
<tr>
<td>Victoria</td>
<td>• No permit required in sewered areas for untreated greywater diversion systems • Permit required in unsewered areas • Treatment systems require a permit</td>
<td>Medium</td>
</tr>
</tbody>
</table>
There is a need for a more centralized strategy and initiative in order to have uniform requirements in terms of approval of systems and general acceptance of greywater systems (both Untreated Greywater Diversion Systems and Treatment Systems) as this might make it easier for builders to be more willing to install or recommend the systems to clients.

Two of the States stand out in terms of their level of support for systems which is based on two main factors, namely requirement for approval and the general regulations governing greywater. The two States, the ACT and the Northern Territory were assessed as high in terms of support as they were not restrictive in terms of requiring approvals for both untreated greywater systems and treatment greywater systems. The worst State was Tasmania, which has outlawed untreated greywater systems completely with approval required for the installation of greywater systems.

The apparent lack of uniform regulations and approval processes ultimately makes it difficult for builders to incorporate the greywater systems in residential projects. Chapter 4 of this thesis discusses further the implications of regulations on greywater systems based on the literature.
2.8 CONCLUSIONS

This chapter has discussed the water consumption levels in the different States with current information indicating that water usage within households is relatively high. Greywater reuse was found to be an important tool in reducing the use of potable water with a potential savings of approximately 31% of total household water use saved if greywater is used for flushing the toilet and watering the garden.

The approval of greywater systems is non uniform, which is a serious issue as this may deter some builders from installing the systems in residential developments. Further discussion of the implications of regulations on the uptake of greywater systems will be discussed in chapter 3 and 4. Chapter 3 also identifies and discusses the general issues from the literature that may be inhibiting builders from installing greywater systems in residential developments.
3 USING GREYWATER

3.1 INTRODUCTION

This Chapter focuses on the use of greywater with particular emphasis on issues in the literature involving the use of greywater systems. The literature review lists the known barriers for builders with regards to the use of greywater systems.

The review is used to derive a framework for analysis in order to determine whether the factors derived in the literature are consistent with those that are ascertained from the surveys and focus group discussions.

The Chapter ends with a discussion on how the construction industry can enable the adoption of greywater systems through different players such as architects and builders. The section includes a brief description of the building process and how greywater systems can be accommodated in the design phase of construction.
3.1 USE OF GREYWATER

Water recycling and reuse is an increasingly important element of sustainable water management strategies in both water poor and water rich regions (Messalem, 2006). This is especially true in Australia which is the driest continent in the World. Generally, wastewater reclamation and water reuse is conducted on various scales: from decentralised systems, utilizing on-site treatment and reuse in single buildings, to the municipal level, with centralised treatment (Exall, Marsalek and Schaefer, 2006).

The greywater systems used in single households are therefore considered to be decentralised as they involve single household use. The use of both centralised and decentralised systems is still at a very low level in the major cities of Australia as highlighted in studies by Taylor (2006); Troy, Holloway and Randolph (2005) and Radcliffe (2004). Radcliffe (2004) however acknowledges the relatively high level of use with regards to recycled water in Country areas. The reuse of water is used extensively for agricultural purposes in Country areas and Regional towns with its use increasing since the early 1990’s.
3.1.1 PERCEPTION AND PUBLIC DEMAND

Greywater systems can be considered a sustainable technology. In order for greywater systems to fit the criteria or classification of a sustainable technology, the systems must have the following characteristics;

- Minimize use of nonrenewable energy and natural resources; and
- Satisfy human needs and aspirations with sensitivity to cultural context; and
- Minimal negative impact on the earth’s ecosystems (Vanegas, DuBose and Pearce, 1996)

The second characteristic is in doubt, if human satisfaction is not met (Vanegas et al, 1996; Lutzkendorf and Lorenz, 2005). The trend emerging from research in the area of water reuse primarily identifies public or consumer perception as a hindrance to full utilization of water reuse technologies and schemes.

Hartley (2003) contends that during environmental decision making, individuals and groups can perceive real threats to their public health and lives resulting in feelings of disempowerment. Responses to disempowerment may appear to produce unrelated social issues and not the environmental decision at hand but the responses are normal conflict behaviour and patterns by people (Hartley, 2003). The above assertion indicates that people will always react to social and environment issues with their own cultural belief systems even though these beliefs may not be aligned with science or innovation.
This view is in line with work by Taylor (2006) when he noted that social acceptability of drinking recycled water is problematic even though it is technically feasible to treat and recycle effluent to drinking standards. Taylor (2006) also highlighted the scarcity of research in Australia regarding public opinion on grey water reuse but concluded that the existing research indicates that people in Sydney, despite, an imminent water crisis are unwilling to consider recycled water. It is therefore imperative for water reuse technologies and schemes to carefully take into consideration public perception through consultation and education of the public.

The lack of social acceptance of greywater systems results in low client demand for the systems. Client demand is a major driver of the adoption of greywater systems with work by Colebourne (1993) indicating that client demand has a bigger role in the adoption of innovation than previously alluded to in other studies.

Reed and Wilkinson (2007) suggest that there is a water source hierarchy in their study on the valuation of green buildings. The hierarchy is such that reducing consumption is highest, followed by re-use of greywater, then recycling on a large scale (centralized reuse) and finally the last resort of desalination. The fact that a water source hierarchy exists, points out the difficulty in trying to merge different technologies that reduce consumption of water with greywater recycling.
technologies. All water conservation strategies should be incorporated in all new developments without having to categorize their efficiency or importance.

An issue identified in the literature that can be classed as public perception is that identified in work by Jamrah et al (2007) that indicated that 60.1% of people surveyed on greywater reuse in Oman opposed greywater reuse on religious grounds. It should be noted that the predominant religion in Oman is Islam and it may not be the case in other countries. Messalem (2006) concurs and expands the afore mentioned finding of Jamrah et al (2007) concerning religion by stating that psychological and religious aspects have to be taken into consideration for successful implementation of reuse. Despite the context of the above statements, these findings suggest that consumer preference and culture may inhibit the utilisation of greywater systems.

Perception may also be from a builder or developer’s point of view with some of the literature (Telegen, 2005; Katz, Alevantis, Berman, Mills and Perlman, 2003) suggesting that professionals within the building industry in the United States believe that sustainable design technologies inherently cost more. This perception may result in builders ignoring or advising against technologies such as greywater systems especially with regards to the design phase where builders can retrospectively incorporate pipework for such technology as an option for clients to fit at their convenience.
3.1.2 COST

In Australia, the cost of green buildings is in reality, considerably higher than conventional or traditional buildings (Matthieson, 2004; Robinson, Lawther and Low, 2005). Generally the case for ‘buying green’ is advocated by the rationale of long term benefit, with Reed and Wilkinson (2007) noting that there is limited knowledge about the relationship between value and green buildings, including perception of tenants, owners, developers and other stakeholders. This statement may be taken out of context but possibly holds true for most sustainable technologies.

The literature outlined above may relate to buildings and not specifically to sustainable technologies or greywater systems however, work by Christova-Boal, et al (1996) indicates that a social survey carried out in Melbourne revealed that people had a strong preference for using grey water systems on gardens only if there was a short payback period for installing them. The cost of greywater systems is clearly a concern for consumers but due to limited information and research, it can only be inferred that consumers are of the view that grey water systems are expensive.

Radcliff (2004) pointed out that in estates like Rouse Hill where a dual tap system is in place allowing for separate supply of recycled water and drinking water, it is important of get the pricing of the recycled water right. If recycled water is at a significantly discounted rate, consumption of the normal drinking water will be
low. Public health and safety is another aspect that presents a barrier to greywater systems.

3.1.3 PUBLIC HEALTH AND SAFETY

Hartley (2003) highlighted public perception relating to health issues concerning water reuse when he identified terms used by the public such as “toilet to tap” and “sewerage beverage”. These common terms referring to indirect potable use of recycled water hamper efforts made by water professionals to fully utilize wastewater.

Most of the literature reviewed (Jamrah et al, 2007; Memon et al, 2007; Messalem, 2006; Troy et al, 2005) suggested that water reuse should only be directed at non-potable use. The view by Troy, Holloway and Randolph (2005) includes the use of a treatment system and they felt that recycled grey water from kitchen and bathroom consumption can only be used in the garden once it has passed through a grey water treatment system. Taylor (2006) and Radcliffe (2004), like the majority of the existing literature on water reuse, dealt with water from a central recycling point of view. The centralised recycling of water involves using centralised effluent treatment plants and pumping the treated water into a river. As a rationale Taylor (2006) explained that water is derived from a single, finite source and that everyone in the world is drinking some form of recycled water.
Studies by Birks and Hills (2007); Christova-Boal et al (1996); Jamrah et al (2007); Megdal (2007) and Messalem (2006) reveal that there are some health issues relating to the use of greywater. Christova-Boal, Eden and McFarlane (1996) in particular, found that there were high levels of zinc in grey water samples they collected from the bathroom and laundry. These high levels of zinc might cause damage to turf if the zinc is accumulated in the soil due to continual irrigation use (Christova-Boal et al, 1996). These results seem to suggest untreated greywater is unsafe. Similarly Jamrah et al (2007) found that grey water had significant levels of suspended solids, inorganic constituents, total organic carbon, total Coliforms and Escherichia Coliform bacteria. In some cases the quality of the greywater was unacceptable indicating the importance and necessity of greywater treatment prior to reuse (Jamrah et al, 2007). Simple diverter systems with no treatment systems may be harmful to plants and soil with continual use based on the above findings.

3.1.4 INFORMATION AVAILABLE AND REGULATIONS

Studies in Sydney by Taylor (2006) and Troy et al (2005) suggest that there is some information available to the public regarding water reuse and that more educational campaigns are needed to change public perception of water reuse. The former of the two studies indicated that current educational campaigns such as Sydney Water’s ‘Save Every Drop’ should be changed to ‘Every One Counts’ so as to create awareness in consumers of their individual impact and responsibility for the environment.
There is however no information to suggest that the current information on greywater systems is enough for both builders and the general public, which is an issue that can lead to the problems identified in the literature relating to perception. It appears that the public is generally aware of reuse of water as a water saving solution but unaware of specific water reuse technologies. This assertion may also be true for builders and developers and hence creates a barrier for the installation of greywater systems.

Regulations have been identified by Halliday (2008) as being a barrier to sustainable construction in the way they are interpreted. Halliday (2008) states that planning and building control provisions can sometimes be used or strictly interpreted, (not necessarily deliberately) to stifle innovation and more sustainable construction. Therefore the approval process of greywater systems may be slowed down by mundane regulations that require paperwork to be filled out and checked by planning personnel. The regulations may have public health and safety as their main objective but stifle innovative technology in the process.

It is clear from the literature review that there is insufficient research on the barriers of greywater systems from a builder’s point of view. Most of the studies within the literature reviewed were also from a European or American point of view.
3.1.5 FRAMEWORK FOR ANALYSIS

There is currently insufficient research relating to barriers inhibiting the installation of greywater systems by builders in Australia as is highlighted in the background research and literature review. The literature revealed issues relating to public perception and demand, current regulations, knowledge and awareness of greywater, cost of grey water systems and health and safety.

All previous work that was reviewed was not from a builder or developer’s point of view, which is crucial as they have a part (however minor) to play in the adoption of innovation within the built environment. Builders/developers of low rise residential accommodation are often the main point of contact with the majority of new home buyers in Australia.

This research investigates these five main variables identified in the existing literature namely:

- Cost;
- Builder’s knowledge or Perception;
- Client demand;
- Government regulations;
- and health issues.
The research also investigated the relationships that may exist between the variables. It is clear from the research that some of the variables identified, overlap with each other in terms of influence in the society. A model was developed, that incorporated these factors, providing a basis for understanding builders perceptions in the data collection phase. The model is presented in Figure 3.1 below.

Cost (Matthieson, 2004; Robinson et al, 2005) is considered to affect both client demand and builder’s knowledge or perception (Vanegas et al, 1996; Lutzkenhorf and Lorenz, 2005). There is lower client demand for more expensive greywater systems and correspondingly high demand for affordable or less
expensive systems. Low demand for greywater systems by clients is a barrier for builders when installing greywater systems (Taylor, 2006 and Troy et al, 2005). A builder/developer’s knowledge or perception of cost also influences whether or not the builder chooses to install greywater systems in their developments.

The builder/developer’s knowledge of greywater and greywater systems hampers the installation of greywater systems by builders as they will not install technology that they are not familiar with. This unfamiliarity with greywater systems results in builders and the public in general, to conclude that greywater systems are expensive (Telegen, 2005; Katz et al, 2003).

Government regulations are considered as a moderating variable due to the fact that they highly influence the uptake of new innovations within the building industry through strict control of both minimum requirements of homes built and less obvious means such as building and planning permit approval times.

In the case of uptake of optional fittings and technology, such as a greywater system, builders are less likely to adopt such technology as it represents a variation in terms of the builder’s margins. If the greywater systems were made mandatory for all new homes there would be no barriers for installation. If it were compulsory or mandatory to install greywater systems (like fire sprinklers etc.) in new homes, there would be no barriers to investigate.
Health issues identified by Hartley (2003) and Taylor (2004) strongly influence both Client Demand and Government regulations and have therefore been incorporated into the model as having a direct influence on both. The rationale of using health issues as an independent variable as opposed to being a moderating variable is that there is evidence of some use of greywater systems despite the health concerns, whereas, Government regulations can restrict the use of greywater systems completely and vice versa.

The research problem is therefore concerned with two themes of which the first and major theme involves the identification and confirmation of the barriers (illustrated in Figure 3.1) inhibiting the installation of greywater systems within residential projects. The second theme that is central to the research is the formulation of strategies to overcome or address barriers identified within the research.

The lack of research in Australia of the barriers affecting the uptake of greywater is clear from the literature review, with a further inquiry necessary in order to add to the existing body of knowledge. The model of barriers and their relationships provided a basis for interpreting the data collected in the study.

3.2 THE BUILDING INDUSTRY AS ENABLER

Spence and Mulligan (1995) point out that the construction industry contributes significantly to the current unsustainable development path of the global
economy and further believe that the construction industry is one of the largest exploiters of the natural resources, both mineral and biological.

The construction industry therefore has a role to play in adopting sustainable technologies such as greywater systems in order to reduce the stress placed on natural resources by the industry. In recent times the construction industry has been faced with increasing pressure for change toward the social impact of the environment and construction (Halliday, 2008; Van Bueren and Priemus, 2002) with terms such as ‘green buildings’ and ‘sustainable construction’ emerging as a result.

The latter of the two terms, namely, sustainable construction, has been defined by Van Bueren and Priemus (2002) as;

“the design, development, construction, and the management of real estate such that the negative environmental effects of the construction, restructuring, and management of the built environment are reduced as far as possible.”

Sustainable construction is concerned with the substitution of natural to human-made capital while accepting that some depletion of non-renewable resources is inevitable (Solow, 1993). The use of sustainable technologies such as greywater systems is therefore a part of sustainable construction as greywater systems and their product (greywater) can be thought of as human made capital that is a substitute for the natural (potable water).
In order to understand what is currently inhibiting sustainable innovation within the construction industry, the drivers of sustainable construction have to be examined. Halliday (2008) identified the following factors as having had an impact on the change in attitude regarding sustainable construction;

- The disturbing results of research into climate change;
- The increased awareness of the above and other environmental issues and their presence and importance on the political agenda (locally and internationally);
- Increasing concern about the adverse impact of typical construction activity;
- Increasing concern about poor indoor air quality and other adverse factors within buildings;
- Increasing concerns about the type of developments that are being permitted and the imposition of development projects on communities, resulting in disaffection, rather than development that meets the needs of communities;
- Increasing recognition that achieving a high quality built environment can be a major contribution to improvements to quality of life, as well as delivering productivity and health and financial benefits;
- Challenges to conventional arguments about the cost of construction and embracing the cost of externalities, leading to better understanding of the inter-relationship between a high-quality environment, productivity,
education and health, in turn leading to financial benefits and improvements in quality of life and business performance;

- Increasing focus on the corporate responsibilities of business, leading to greater emphasis on good business practice and fair trade.

These drivers are responsible for the change in attitudes but are however not enough, as people have been aware of the negative environmental effects of construction for several decades. Matar, Georgy and Ibrahim (2007) point out that the main ‘technical’ barrier that hinders the enacting of sustainable construction is the absence of an application framework that integrates both sustainability and construction practices at an operational level. This basically suggests that there is a general failure to adopt sustainable construction at operational level.

The construction industry has to focus on the physical activities involved in residential development and find solutions that will enable sustainable construction. Allen and Thallon (2002) state that one of the design considerations for a designer or architect before construction commences is that local ordinances such as building code requirements should be investigated. The designer has to make sure that these regulations have been complied with in the design of a house.
This means that regulations that were covered in Chapter 2 with regard to approval of greywater systems have to be followed and relevant permits have to be sought in order to avoid penalties. The building process for a residential house can typically take 6 to 8 months (Allen and Thallon, 2002) which means that if the permit approval process is slow for approval of greywater systems, a designer may simply omit the system from the design of the home. The regulations therefore play a big part in the adoption of sustainable technologies in the construction industry.

The role that the construction industry plays in the adoption of greywater systems should not be restricted to the design phase but should include the wider building process. Building regulations should be augmented to accommodate sustainable technologies through an institutional approach that involves Government bodies such as the Building Commission in Victoria, that can help change regulation within the industry. Spence and Mulligan (1995) concur with the above as they state that government policy can help set a general trend that creates the condition for technological innovation and progress. Spence and Mulligan (1995) also highlight the difficulty of the adoption of sustainable practices as the construction industry has to view these measures as having some economic advantage.

In other words sustainable measures have to be seen as having some economic benefit or incentive (Spence and Mulligan, 1995). In reality, if greywater systems are not demanded by clients, their uptake is limited unless government
intervenes through appropriate regulatory action. The competition between different construction companies may also hamper the adoption of greywater systems as greywater systems represent uncertainty in terms of income and construction time.

Van Bueren and Priemus (2002) concur with this assertion in their study on institutional barriers to sustainable construction when they noted that the building and real estate sector is fragmented into various phases that are strongly influenced by professional codes and cost efficiency goals. The cost efficiency goals are a priority when compared to the adoption of a new technology in a project. It should be noted that the study by Colebourne (1993) highlighted complexity and delays associated with adopting new innovation which certainly points out the uncertainty (or the perception of uncertainty) that sustainable technologies have with builders.

Hill and Bowen (1996) listed several process oriented principles of sustainable construction in their framework for the attainment of sustainable construction, with the last principle stating that;

- synergies should be identified between the environment and development rather than trade-offs, in which reducing the use of resources and pollution prevention at the source rather than clean-up can lead to increased economic efficiency (Hill and Bowen, 1996).
The adoption of greywater systems should therefore be seen as a tool to attaining sustainable construction as they reduce the use of potable water. In line with the aforementioned principle, the use of greywater systems should be utilised as a preventative measure and not just a trade off as their use improves efficient use of water resources. The building industry is an enabler for the adoption of greywater systems as the application of principles of sustainable construction such the above can increase the use and adoption of greywater systems through the emphasis of their use in the design phase of new residential buildings. The building industry can also educate clients on greywater systems available in the market as this raises consumer awareness and can potentially lead to increased demand for greywater systems as indicated by Colebourne (1993). She found that client demand is also a major accelerator of innovation within residential project for sustainable construction.

Most of the literature reviewed did not identify a possible framework for undertaking the research. A study by Hartley (2003), however, formulated a framework for water resource professionals to help address the social and political complexity of adopting potable and water reuse and recycling. The framework includes five principles which provide guidance to members of the water industry, they are;

- manage information for all;
- maintain individual motivation and demonstrate organizational commitment;
- promote communication and public dialogue;
• ensure fair and sound decision making and decisions;
• build and maintain trust (Hartley, 2003).

The above guidelines may be useful in formulating solutions or recommendations for the Building Industry in terms of reducing barriers inhibiting the uptake of greywater systems by builders, since the study by Hartley (2003) was primarily aimed at combating negative perception with regards to water reuse.

3.3 CONCLUSIONS

This Chapter outlined the current literature on the barriers to greywater reuse and greywater systems for builders. The Chapter also helped in the development of a framework for analysing the data collected from builders.

The current literature on the barriers hindering the adoption of greywater systems by builders is not sufficient, but it is clear that the construction industry has a part to play in order to help with the uptake of greywater systems and reduce potable water consumption.

The next Chapter focuses on greywater systems in the market with reference to their affordability. One of the barriers revealed within the literature review is cost, therefore the affordability of greywater systems has to be determined to find out whether this barrier is indeed a barrier for Australian builders and clients. The other aspect that is studied in the next chapter is the general comparison
between decentralized water recycling systems (grey water systems) and the centralized water recycling schemes (‘third pipe’ estates).
4 GREYWATER SYSTEMS

4.1 INTRODUCTION

The main aim of this Chapter is to identify greywater systems in the market with a view of identifying their general performance levels and how the different States in Australia view them. The systems each represent a distinct type of greywater system from the basic Diversion Systems to the more complex Treatment Systems. The systems are compared and contrasted against each other.

A brief introduction to the characteristics of greywater is also included under the section on greywater systems so as to gain further appreciation for the different levels of treatment that the systems offer consumers. There are various issues that emanate from the use of the systems and these issues are presented in the chapter.

After the initial introduction to the systems, the remaining part of the Chapter will focus on Decentralized Recycled Water Systems. An introduction to the systems briefly discusses societal issues as highlighted within a literature review. The
conclusion of the chapter shows how centralized recycled water systems compare with decentralized systems (in this case greywater systems).

4.2 GREYWATER SYSTEMS

Greywater systems are *decentralised* water reuse systems involving individual households reusing water whilst, the use of ‘third pipes’ described later in the chapter is termed as *centralised* as water is collected from a residential estate as a whole and is then treated and pumped back for reuse.

There are two main categories of greywater systems namely: Untreated Greywater Diversion Systems and Treatment Systems. These categories have further subcategories within the market that include simple diversion systems, disinfection systems, diversion and treatment, diversion and filtration and other new systems. Figure 4.1 presents a greywater typology differentiating between systems in the market and the distinction between centralised and decentralised water reuse.
When consumers decide on whether or not to install greywater systems, there are several issues to consider. Issues have been established through previous research on greywater systems (Christova-Boal et al, 1996; Lazarova, Hills and Birks, 2003; Sutherland, 2008; and Eriksson, Auffarth, Henze and Ledin, 2001). The main considerations highlighted by the studies above are:

- soil topography and characteristics and/or type of plants;
- level of maintenance and cost;
- potential change to more biodegradable household detergents and soaps;
• design and installation (in the case of retrofitting greywater systems);
• potential health concerns with the use of greywater.

Lazarova et al (2003) with respect to the last issue (health concerns), point out that greywater generally contains less suspended solids and nitrogen than typical domestic sewage (since toilet water is excluded), but point out that the concentration of phosphorus is up to two times higher than the value for urban waste. This high level of phosphorus originates from detergents and soaps and may be harmful for clay soils as they typically have higher amounts of phosphorus. Christova-Boal et al (1996) indicate that clay soils can become phosphorus saturated leading to other problems like leaching to groundwater.

Sutherland (2008) and Eriksson et al (2001) also highlight that greywater from showers and hand basins, may be contaminated by fecal matter in households with young children. The fecal matter can also originate from the washing of hands and bodies. The concentration level may be lower than typical domestic sewage but is still a harmful contaminant since the concentration level may increase over time within the transportation network (pipework) and during storage as noted by Eriksson et al (2001). The recycled greywater can therefore be potentially harmful if utilized for toilet flushing or comes into contact with people, via ‘splashing’ during flushing.

Al-Jayyoussi (2003) points out that greywater can contain at least 100,000 per 100 millilitres of potentially pathogenic microorganisms. This biological characteristic
has resulted in unfavourable public perception in the use of greywater systems for flushing toilets. Lazarova et al (2003) do however point out that greywater, once treated, can be safe for reuse in toilets. The debate on whether recycled greywater should be used for flushing toilets or not will continue until definite research on contaminant eradication by treatment systems is conducted. Furthermore research by Ottoson and Stenstrom (2001) raises their concern over contamination of greywater by bacteria such as Salmonella and Campylobacter from food handling which can pass through greywater systems.

If greywater systems are used for toilet flushing, Jefferson, Laine, Parsons, Stephenson and Judd (2000) suggest the use of a one cubic metre storage tank (adequate for most households). This is due to the fact that greywater is produced at a time slightly offset from toilet flushing and is generated over short time periods, whereas toilet flushing takes place more consistently through the day. In Victoria, the Environment Protection Authority regulates that greywater can only be stored for a maximum of 24 hours after which it should be disposed. Systems therefore require some automated aspect to dispose of the water after 24 hours (in the case of a greywater system with a storage tank). It should be noted that increasing greywater storage is associated with greywater degradation and disinfection reliability (Jefferson et al, 2000).

Most of the literature reviewed casts doubts on the safety of using recycled greywater for flushing toilets. However, the concerns are not relevant for watering
the garden and other outdoor uses that restrict the exposure of greywater to humans.

The health issues pertaining to the use of greywater systems are considered to be the most important consideration for a potential user as they affect the choice of system and whether greywater systems are installed by consumers.

Despite the above, people will inevitably have a reasonably high level of acceptance for greywater systems as water restrictions have forced people to consider water reuse. People have had to choose between a system for just gardening or a system capable for both gardening and toilet flushing. The study by Lazarova et al (2003) found that most people surveyed are generally more inclined to accept recycled water for gardening, however this declines with more personal uses such as watering vegetables. In reality, acceptance and adoption of greywater systems appears to be significantly different between households.

The consensus within the literature is that greywater should be treated or purified to some degree prior to reuse, to protect the end users. Most of the councils within Victoria as highlighted in Chapter Two have restricted the use of greywater for toilet flushing with qualified plumbers recommended for the installation of all systems in order to protect the consumer.

The other issue identified by Christova-Boal et al (1996) that is an important consideration when deciding on installing a greywater system is the soil
topography and characteristics of the consumer’s property. Most of the literature reviewed did not comment on this consideration with a possible explanation being that the studies were carried out in Europe where housing is generally medium to high density in nature. Christova-Boal et al (1996), as mentioned before, highlighted the high levels of phosphorus contained within greywater which may cause clay soil to be phosphate saturated and potentially result in the problem of leaching.

This high level of phosphorus and other impurities may also be harmful for certain plants, therefore careful selection of a greywater system is required. A study by Lanfaxlabs (2008) points out that although most plants tolerate excess phosphorus, native plants such as the Banksia species are sensitive to phosphorus and may be harmed by the use of greywater.

The level of maintenance and cost has also been highlighted in most of the literature as one of the determinants for the adoption of greywater systems by consumers. A UK study by Diaper, Jefferson, Parsons and Judd (2001) suggest that cost implications have meant that single house systems are mainly restricted to coarse filtration devices with downstream disinfection as opposed to the more advanced systems. In Australia, Christova-Boal et al (1996) lament the long payback period for greywater systems. This study may be dated but is still considered valid given the level of prices of current greywater systems that are profiled in the next section.
The design of a consumer’s house can adversely affect the cost of installing a greywater system in an existing building as noted by Surendran and Wheatley (1998) and Christova-Boal et al (1996). Larger and more complex systems that require space for the system and associated pipework can be quite expensive if the design phase of the building did not allow for the retrofitting of such a system.

It is evident from the literature that consumers have several issues to consider when choosing to install a greywater system. It is also evident that more reliable research needs to be carried out on the safety of treated greywater to determine whether microorganisms such as the bacteria Salmonella can pass through greywater systems.

The health concerns are relevant for this study in that, they affect the level of demand for greywater systems as highlighted in the literature. This study will therefore seek to confirm whether this is indeed a barrier for Victorian builders and what strategies may be adopted to reduce or eliminate the barrier.
4.3 GREYWATER ON THE MARKET

There are two main categories of greywater systems, namely: Untreated Greywater Diversion Systems and Treatment Systems. The following section will break these two classes further down to sub classes in order to provide a full introduction to greywater systems. This section will also provide information on the systems currently available in the market and whether they are approved in the different States. Only one example of each is provided for illustrative purposes.

Where possible, the prices of the systems have been included, with estimates derived from an article by Maxey (2008). It should be noted that current levels of Government rebates are $500 in all States (Home Rebates Scheme). The disinfection system is reviewed first followed by the diversion, diversion and treatment and diversion and filtration systems respectively.
4.3.1 DISINFECTION

The first system to be studied is a Disinfection Greywater System marketed by Aerocycle Water Treatment P/L. The system is called the Aquatherm and turns wastewater into treated water suitable for primary human contact using recycled heat. The system does not use any chemicals in the disinfection process.

Jefferson, et al (2000) profiled disinfection units that incorporated disinfection via chemical treatment such as chlorine or bromine use. The chemical disinfection systems were found to be ineffective in killing all pathogens and also produced chloramines and trihalomethanes that lower the disinfection rate and adversely affect human health. The use of heat for disinfection was not profiled but would certainly eliminate the negative chemical effects associated with chemical disinfection systems.
Aerocycle Water Treatment P/L claim that the system can recycle greywater from 100 litres per hour to 100,000 litres per hour. The unit operates at a temperature of 85 degrees Celsius to disinfect the greywater. The basic, domestic system costs $7,500 and has approval in the following States:

- Victoria
- New South Wales
- Queensland
- Australian Capital Territory

The Aquatherm system requires maintenance checks annually and has a minimum expected life span of approximately 30 years according to the manufacturer. The expected life span is only an estimate as the company only started manufacturing the systems in year 1995.

**Table 4.1 Summary – Disinfection**

<table>
<thead>
<tr>
<th>System</th>
<th>Aerocycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Disinfection</td>
</tr>
<tr>
<td>Greywater Quality</td>
<td>Medium</td>
</tr>
<tr>
<td>Capacity</td>
<td>100 – 100,000 litres per hour</td>
</tr>
<tr>
<td>Cost</td>
<td>$7,500</td>
</tr>
<tr>
<td>Approved</td>
<td>• Vic</td>
</tr>
<tr>
<td></td>
<td>• NSW</td>
</tr>
<tr>
<td></td>
<td>• Qld</td>
</tr>
<tr>
<td></td>
<td>• ACT</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Annual servicing</td>
</tr>
<tr>
<td></td>
<td>(high maintenance costs)</td>
</tr>
</tbody>
</table>
4.3.2 DIVERSION

The above greywater system is called the greymate and is marketed by Everwater Australia P/L. The system requires a 240 Volt power connection point and a certified plumber to install.

The system is a basic diversion system and therefore the greywater diverted by the system carries all the negative characteristics identified by Christova-Boal et al (1996), Lazarova et al (2003), Sutherland (2008) and Eriksson et al (2001). Human exposure to greywater from the system should be avoided with general use limited to outdoor uses such as gardening and washing the car. Care should be taken to monitor the impact on the pH levels of the soil in the garden and users should ensure that the water does not flow into adjoining properties as advised by the Environment Protection Authority.
EverWater P/L claim that the system can recycle greywater from 7,000 litres per hour and is fully automated with the high volume pump only operational when the tank is full or when activated by the timer. The System can be isolated when the water is not required. The cost of the system is $899 including GST (Maxey, 2008).

The Everwater is approved in all the states and is classified as a Diversion only system that pumps out untreated water. The system is one of the cheapest in the market and has a 1 year warranty with regular cleaning of the filter. The greymate can be cleaned by the user and does not require any expertise.

**Table 4.2 Summary – Diversion**

<table>
<thead>
<tr>
<th>System</th>
<th>Greymate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Diversion</td>
</tr>
<tr>
<td>Greywater Quality</td>
<td>Low</td>
</tr>
<tr>
<td>Capacity</td>
<td>7,000 litres per hour</td>
</tr>
<tr>
<td>Cost</td>
<td>$899</td>
</tr>
<tr>
<td>Approved</td>
<td>In all States</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Annual servicing by owner</td>
</tr>
</tbody>
</table>
4.3.3 DIVERSION AND TREATMENT

The above system is a Diversion and Treatment Greywater System marketed by EcoNova Pty Ltd and is called the NovaClear. The system is fairly large in size (approximately 2.2 metres by 2.2 metres) but is mainly concealed underground.

The NovaClear is described as an Aerated Wastewater Treatment System (AWTS) and has been designed to comply with requirements of the Australalain/New Zealand Standard 1546.3:2001. The system utilizes an aerobic activated sludge process in the primary section of the treatment unit, with further aerobic treatment and membrane filtration in the secondary section (EcoNova, 2007).
Jefferson et al (2000) profiled disinfection units that utilized what they described as basic two-stage systems. The only difference with this particular system and the conventional two-stage system described by Jefferson et al (2000) is that in the first stage an aerobic system is utilized with the NovaClear System as opposed to coarse filtration. The major disadvantages as highlighted in the first system profiled are:

- Not all pathogens are killed
- The use of chlorine produces a byproduct called chloramines which has lower disinfectant capability and can adversely affect human health.

The system is on the upper scale in terms of cost with the price of the system at $9,790 including GST (Maxey, 2008). The NovaClear System recycles approximately 2250 litres per day in grey water and has approval in the following States:

- Victoria
- New South Wales
- Queensland
- Australian Capital Territory
- Tasmania

The system has a 2 year electrical warranty plus a 2 year mechanical warranty and an additional 15 years warranty for the tank (Maxey, 2008). The membranes that disinfect the greywater have a warranty of two years. The system requires
servicing every four months by a competent service engineer due to the fairly complex structure of the system.

The major drawbacks with the system are the extensive maintenance required for the system and the cost. The 4 monthly service includes mainly:

- Tank structure
- Control Box structure
- Visual inspection of sludge
- Visual inspection of the activated sludge in secondary chamber
- Checking of the quality of treated water
- Checking of pipework
- Inspection of air diffuser and membrane assembly (6 month removal and clean)
- Inspection of panel and alarms

The high maintenance costs, together with significant capital outlay, make this unit expensive and therefore of limited attraction. The system does however, treat greywater to relatively high standards.
Table 4.3 Summary – Diversion and Treatment

<table>
<thead>
<tr>
<th>System</th>
<th>Novaclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Diversion and Treatment</td>
</tr>
<tr>
<td>Greywater Quality</td>
<td>High</td>
</tr>
<tr>
<td>Capacity</td>
<td>2,250 litres per day</td>
</tr>
<tr>
<td>Cost</td>
<td>$9,790</td>
</tr>
<tr>
<td>Approved</td>
<td>• Vic</td>
</tr>
<tr>
<td></td>
<td>• NSW</td>
</tr>
<tr>
<td></td>
<td>• Qld</td>
</tr>
<tr>
<td></td>
<td>• ACT</td>
</tr>
<tr>
<td></td>
<td>• TAS</td>
</tr>
<tr>
<td>Maintenance</td>
<td>4 monthly service</td>
</tr>
<tr>
<td></td>
<td>(high maintenance costs)</td>
</tr>
</tbody>
</table>

4.3.4 DIVERSION AND FILTRATION

The above system is marketed by Flo-to-GO as an automatic Diversion and Filtration System. The water is not treated but simply filtered and diverted. The diversion system has EPA Approval (Victoria).
The system features an automatic fluid system that features a wireless rain sensor that transmits a signal to shut off the system when it is raining. The system is portable and designed for shower water only. It includes an automatic-purge mechanism that disposes of residual water left in the system after use and therefore complies with the Environment Protection Authority regulation (maximum storage time of 24 hours). The system only works when the user takes a shower so the system is limited to garden watering.

The Flo-to-Go system is easy to setup, with the manufacturer claiming it takes approximately 15 minutes to install and even advocate that it is ideal for rental properties and can be installed and subsequently removed at the end of tenure.

The system is a basic diversion system like the greymate profiled above and therefore the greywater diverted by the system carries all the negative characteristics identified by Christova-Boal et al (1996), Lazarova et al (2003), Sutherland (2008) and Eriksson et al (2001). Human exposure to greywater from the system should be avoided with general use limited to outdoor uses such as gardening and washing the car. Care should be taken to monitor the impact on the pH levels of the soil in the garden and users should ensure that the water does not flow into adjoining properties as advised by the Environment Protection Authority.
The price of the system is just above $1,000 and is considered to be a reasonable amount, however, the main disadvantage is that greywater is untreated. The capacity of the system is limited only by shower time (Maxey, 2008). The system has approval only in Victoria (EPA approved system).

The system has a warranty for 1 year and requires servicing which can be done by the owner every 6 months. Filter cleaning is also required (Maxey, 2008).

**Table 4.4 Summary – Diversion and Filtration**

<table>
<thead>
<tr>
<th>System</th>
<th>Flo-to-Go</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Diversion and Filtration</td>
</tr>
<tr>
<td>Greywater Quality</td>
<td>Low</td>
</tr>
<tr>
<td>Capacity</td>
<td>All shower water is collected</td>
</tr>
<tr>
<td>Cost</td>
<td>$1,000</td>
</tr>
<tr>
<td>Approved</td>
<td>Only approved in Victoria</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Half yearly by owner</td>
</tr>
</tbody>
</table>

**4.3.4 SUMMARY OF GREYWATER SYSTEMS**

Table 4.5 shows the comparison of the four systems profiled in the study. The systems vary in terms of cost ranging from the cheapest at $899 for the greymate to $9,790 for the Novaclear system. The price difference can be directly attributed to the treatment levels of greywater systems. The greymate is a simple diversion system whereas the NovaClear is a diversion and treatment system.
Table 4.5 Comparison of Greywater Systems

<table>
<thead>
<tr>
<th>System</th>
<th>Aerocycle</th>
<th>Greymate</th>
<th>Novaclear</th>
<th>Flo-to-Go</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Disinfection</td>
<td>Diversion</td>
<td>Diversion and Treatment</td>
<td>Diversion and Filtration</td>
</tr>
<tr>
<td>Greywater Quality</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Capacity</td>
<td>100 – 100,000 litres per hour</td>
<td>7,000 litres per hour</td>
<td>2,250 litres per day</td>
<td>All shower water is collected</td>
</tr>
<tr>
<td>Cost</td>
<td>$7,500</td>
<td>$899</td>
<td>$9,790</td>
<td>$1,000</td>
</tr>
<tr>
<td>Approved</td>
<td>• Vic • NSW • Qld • ACT</td>
<td>In all States</td>
<td>• Vic • NSW • Qld • ACT • TAS</td>
<td>Only approved in Victoria</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Annual servicing (high maintenance costs)</td>
<td>Annual servicing by owner</td>
<td>4 monthly service (high maintenance costs)</td>
<td>Half yearly by owner</td>
</tr>
</tbody>
</table>

The more expensive systems that were profiled also require extensive servicing as opposed to the cheaper or more affordable systems with high costs involved in maintaining both the Aerocycle and the NovaClear systems. The two systems require appropriately qualified persons to service the systems hence the high costs involved in maintaining them as opposed to the Greymate and the Flo-to-Go systems which can be serviced by the owners.

4.4 CENTRALISED RECYCLED WATER SYSTEMS

Centralized recycled water systems are systems at the municipal level where waste water is reclaimed and treated centrally within a treatment plant and redistributed for reuse applications (Exall et al, 2006; Taylor, 2006 and Radcliffe, 2006).

In Australia, there are several established residential estates that have centralized treatment systems which utilize a ‘third pipe’ which delivers treated
waste water that is readily used for non-drinking purposes. The ‘third pipe’ is a purple coloured pipe with a purple meter connected to it. The distinct colour is a means of identifying and ensuring that the water does not get confused with potable water.

Recycled water that is pumped through the third pipe usually of high quality with most Treatment Plants producing recycled water that is classified as Class A. According to the EPA (2005), the water that has been treated to Class A is suitable for:

- Toilet Flushing;
- Watering the garden (including vegetable gardens);
- Washing machines;
- Irrigating public parks and sports grounds;
- General outdoor use.

Recycled water, however is not intended to be used for various household uses even though the water quality is very high. The uses that are prohibited include the following:

- Drinking;
- Cooking;
- Bathing;
- Filling domestic swimming pools;
- Children’s water toys (EPA, 2005).
Centralised recycled water systems are certainly a good potable water conservation tool in order to cope with the increasing strain on current water supplies. Keremane and McKay (2007) concur with the above when they noted that, freshwater is a limiting factor, because of the rapid urbanization and industrialization that is coupled with water pollution issues. This has therefore created a need to look at what Keremane and McKay (2007) identified as source substitution. Source substitution entails utilizing recycled water to augment freshwater supplies (Keremane and McKay, 2007). The reduction of the use of potable water will certainly benefit future generations and go a long way making sure that the human impact on the environment is reduced.

In Australia, as Randolph (2004) noted, using reclaimed water is not a new concept or innovation but has been confined mainly to the agricultural sector, with urban domestic use still restricted to potable water even amidst the declining water levels and water restrictions. The township of Virginia in South Australia benefits from a recycled water scheme that supplies highly treated reclaimed water to approximately 250 growers operating within an area of 200 square kilometers with the scheme helping to reduce the heavy reliance on groundwater resources that were once overburdened (Keremane and McKay, 2007).

The success of this undertaking in the rural setting can be further spread to urban areas if centralized recycled water systems are actively promoted and pursued since the water quality after treatment can be high. Agricultural land use may decline in the future as the current urban areas grow outward converting
fringe agricultural land into towns and satellite towns. In Tucson, America, the trend is already evident with the drastic reduction in use of effluent as agriculture paves the way for residential and commercial development (Megdal, 2007).

The main problem with the adoption of centralized recycled water systems as is the case with greywater systems is public perception. Megdal (2007) refers to the phrase “toilet to tap” in reference to the public and media describing the reuse of effluent. Public perception influences the adoption of centralized recycled water schemes particularly where treated effluent is introduced back into fresh water supplies. Diaper et al (2001) also point out the adverse impact of media reports on the utilization of treated wastewater pumped back into freshwater sources in England. The media is said to use the ‘shock factor’ approach when reporting on the reuse of treated effluent with wordings such as ‘the general public drinking their own sewerage’ in their reports (Diaper et al, 2001).

The study by Higgins, Warnken, Sherman and Teasdale (2002) suggests that 79% of people surveyed in Queensland, revealed that the respondents had concerns about recycled water quality. The study indicated that people had concerns regarding microbiological components such as viruses, parasite and bacteria, salinity related components, aggregate components, organic components and quality variability.

It should be noted however that the study by Higgins, Warnken, Sherman and Teasdale (2002) is contradictory to work by Marks, Cromar, Howard and Oemcke
(2003) that suggests that 95% of people in Mawson Lakes (South Australia) have no concerns about health risks. Possible explanations for the rather significant difference in findings could be that the people involved in the study have different societal backgrounds and income levels with the other possible explanation being that the Mawson Lakes community has been exposed to the systems for longer than the community interviewed in the Queensland study.

The former of the two explanations regarding societal backgrounds and income levels could be partially explained by the observations of Hurlimann and McKay (2007) as they highlighted that people of higher income and education levels have a higher marginal valuation of cost as compared to people of lower income and education levels. This basically means that if the price of recycled water is decreased, then people of higher income and education would increase the utility of recycled water. A parallel can therefore be drawn regarding the people in South Australia who are more informed or educated about water reuse within the state as compared to people in the state of Queensland. South Australia has more experience with water reuse with the agriculture sector having well established water reuse schemes as highlighted above.

Concern about water quality has been shown in the study by Hurlimann and McKay (2006) to be linked to aesthetic attributes as opposed to just health concerns. Results from their research suggests that respondents in the study, rated attributes such as ‘no colour’ and ‘no odour’ as being extremely important for clothes washing, and ‘low salt’ for garden watering (Hurlimann and McKay
(2006). The attributes highlighted above, affect the number of potential users or people willing to use recycled water.

Another concern with regard to centralized recycled water systems is the cost associated with the systems. Higgins et al (2002) noted that prospective users of recycled water envisaged expensive infrastructure and monitoring costs involved with the implementation of recycling schemes. In reality retrofitting centralized recycled water systems can be quite expensive as pipework and the sewage system has to be reconfigured to a central treatment plant therefore the concerns of prospective users in the above mentioned study are justified.

The use of centralized systems appears to be well supported by the Government particularly in Victoria, with the following section discussing three different residential estates currently utilizing centralized recycled water systems.

4.5 CASE STUDIES

There are three estates in particular that will be briefly studied for the purpose of differentiating the Centralised recycled water systems from the Decentralised systems that this study is concerned with.

The three estates that will be studied are the Sandhurst Club, the Rouse Hill and the Hunt Club Estate. There are a growing number of newly established estate
that are utilizing the use of the centralized treatment systems but the three chosen for analysis are more established and highly acclaimed.

4.5.1 HUNT CLUB

The Hunt Club Estate is located in Cranbourne East, situated approximately 45 kilometres south east of the Melbourne CBD within the municipal area under the City of Casey Council boundaries.

The Hunt Club Estate utilizes recycled water from the South East Water Ltd Treatment Plant in Lyndhurst for Parkland and approximately 1200 homes within the estate. The main aim for the project apart from water conservation was to demonstrate that it is cost effective to retrofit centralised recycled water systems for large potable consumers.

The results proved that retrofitting the Parkland was cost effective and helped conserve the consumption of 7 million litres per annum of potable water. The success of the project has seen a number of new residential estates in the south east adopting centralized recycled water systems within their developments.
4.5.2 SANDHURST

The Sandhurst Club estate is a golf course and residential development within the suburb Skye situated approximately 37 south east of the Melbourne CAD. The estate falls under the City of Frankston municipal area and utilizes recycled water from the Eastern Treatment Plant.

The Sandhurst Club is still being developed by the Links Group and is one of the pioneers of the use of recycled water within residential estates in the south east suburbs. The estate uses recycled water for the irrigation of the golf course at the estate and the residences within the estate via a ‘third pipe’.

The estate saves approximately 1200 million litres a year of potable water supplies. The success of the Sandhurst Club has resulted in the push for new south eastern estates to include mandatory third pipes.

4.5.3 ROUSE HILL

The Rouse Hill estate is located in north west Sydney and is considered to be one of Australia’s largest residential recycled water schemes. The project is estimated as saving approximately 35 percent on use of mains water.

The project is part of a larger effort by Sydney Water to help conserve the Hawkesbury Nepean River with the use of recycled water reducing the demand
for potable water. The recycled water costs $0.713 per kilolitre with a quarterly service charge of $4.69 as at July 2007.

4.6 GREYWATER SYSTEMS VS CENTRALIZED RECYCLED WATER SYSTEMS

The key issues to discuss when comparing the two water saving alternatives are the advantages and disadvantages as they relate to their practical use. Cost is an important consideration with the adoption of both greywater systems and centralized systems as identified within the literature with several other issues also highlighted within the review.

There are two main advantages of installing grey water systems over centralized systems namely; that the systems are relatively cheaper to install than centralized systems for individual households. Centralised systems have to be configured to the drainage and sewerage systems in a number of homes within an estate therefore the systems are best suited for new residential estates as opposed to retrofitting. Retrofitting centralized systems can be very costly unless the number of the ultimate consumers is very large as indicated by the case study on the South East Water Ltd in their work at the Hunt Club Estate.

The other advantage over centralized systems is that once installed, greywater systems are cost effective in that the greywater produced is free. Centralised
systems have a ‘third pipe’ with a separate meter from the main potable line with an associated charge for use of the recycled water. The fee charged is, however, subsidized so as to be cheaper than potable water.

The main weakness with greywater systems is water quality. Depending on the system selected, water quality for greywater systems, most especially the simple diverter systems, can be very poor. User education is required to ensure that only certain detergents are used that can be broken down more readily and have less amounts of zinc and phosphorus.

Centralised systems treat water to very high standards, with companies such as the South East Water Ltd company treating water to Class A standards. Water of this high standard is deemed suitable for toilet flushing, watering the garden, washing machines and general outdoor use by the EPA.

In Victoria, a number of new estates have been encouraged to follow the lead from established residential estates such as the estates reviewed in this study. New estates such as The Waterfall estate in Pakenham and Aurora in Doreen, have installed centralized systems within their developments with subsidies in place for the developers. Without the push from State Government, Centralised Recycled water systems would have similar adoption problems as greywater systems.
Greywater systems have a $500 dollar rebate at present, which is the only form of Government support that the water saving alternative enjoys. The local Governments and State Governments do not have uniform regulations as far as the use of grey water is concerned therefore affecting the uptake of the systems as noted in Chapter 1.

Apart from better Government support, centralized systems have far better water quality upon completion of the recycling process when compared to most if not all the greywater systems. As discussed earlier, the water quality from a Treatment Plant is categorized as Class A and is suitable for numerous household uses.

The following table summarises the two water saving initiatives with emphasis placed on the main issues relating to their adoption as derived from the literature reviewed;

Table 4.6 Greywater Systems Vs Centralised Systems

<table>
<thead>
<tr>
<th></th>
<th>Greywater Systems</th>
<th>Centralised Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheaper to install</td>
<td></td>
<td>Good Government</td>
</tr>
<tr>
<td>Free use of water from systems</td>
<td></td>
<td>support</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Better quality water</td>
</tr>
<tr>
<td><strong>Weaknesses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water quality issues</td>
<td></td>
<td>Retrofitting issues</td>
</tr>
<tr>
<td>Maintenance of systems</td>
<td></td>
<td>Consumers have to pay for the use of the water</td>
</tr>
</tbody>
</table>
4.7 SUMMARY

This chapter has introduced the various greywater systems in the market. A snapshot of established residential estates with centralized systems was included in order to differentiate between the two recycled water alternatives.

It is clear that the two alternatives should be treated as distinct alternatives and need to be addressed independently. The main issue with both however, is still public perception regarding their use. Secondly, both alternatives are costly – with a long payback period as established in the literature.

The purpose of this research is limited to greywater systems and their adoption therefore the next chapter will focus on the observations of builders and the perceived problems with regards to the uptake of greywater systems within the market.
5 BUILDER CASE STUDIES

5.1 INTRODUCTION

This chapter focuses on the results from the focus group discussions and surveys with a view to discovering what builders believe are the barriers that are inhibiting them from installing greywater systems in residential projects.

The previous chapters have mainly focused on the theoretical aspect of the issue and also served as background for the various Government regulations and greywater systems in the market. An appreciation of the various factors is important to fully grasp the context in which the various builders within this study and builders in general are operating.

The results of the focus group discussions and their analysis are presented in this section. The discussions have been presented as case studies in order to appreciate the background of the different builders interviewed at the locations that were selected for the study. The case studies are followed by an analysis of results from the surveys and the results are then cross analysed in order to form meaningful conclusions from the study.
The conclusion of the chapter will summarize all the findings and present them for further analysis and conclusions for the next and final chapter. Brief descriptions of the methods chosen namely; focus group discussions and survey are included prior to the presentation and analysis of the findings so as to draw out the weaknesses or limitations from the aforementioned methods and ensure that they are covered or included within the discussion of the results.

5.2 CASE STUDY ANALYSIS

5.2.1 METHODS

Focus group discussions were held in four central Victorian locations to cover views from builders from the different geographical areas regarding grey water and grey water systems.

The locations selected for the discussions were Bendigo, Melbourne, Geelong and Traralgon. The above locations were also considered to be central in terms of geographical locations and hence were ideal for the study. Also of importance was that the focus group in each of the central locations included surrounding areas. The locations were a mixture of regional and urban so as to ascertain if there are any differences. The different locations included in the study vary in terms of current water storage levels and therefore offer a variety of insights on water use. The difference in water levels in the different areas may also explain attitudes towards the reuse of water. According to Neuman (2007), a focus group
should have four to six separate groups hence the four different groups represented by the different locations.

Furthermore the advantages of focus group discussions or sessions according to Neuman (2007) are;

- The natural setting allows people to express opinions;
- Open expression among members of marginalized social groups is encouraged;
- People tend to feel empowered, especially in action oriented research projects;
- Survey researchers are provided a window into how people talk about survey topics;
- The interpretation of quantitative survey results is facilitated;
- Participants may query one another and explain their answers to each other.

Folch-Lyon and Trost (1981) concur with the above outlined advantages and state that group session research does not seek to statistically quantify group norms but to expose their underlying attitudes and opinions. The underlying attitudes and opinions are exposed through day to day interaction, including jokes, anecdotes, teasing and arguing that are not entirely encapsulated in reasoned responses to direct questions (Kitzinger, 1995).
There are several limitations to the use of focus groups which Neuman (2007) outlined as:

- Attitudes become more extreme after group discussions;
- Only one or a few topics can be discussed in a focus group session;
- A moderator may unknowingly limit open, free expression of group members;
- Focus group participants produce fewer ideas than in individual interviews;
- Focus group studies rarely report all the details of study design/procedure;
- Researchers cannot reconcile the differences that arise between individual-only and focus group-context responses.

Another issue that may arise from utilizing focus group discussions, as discussed by Bryman (2008), is people who agree to participate but do not turn up on the day (no shows). The problem of smaller group sizes as a result of this, may not affect the validity of the results as suggested by Bryman (2008) who points out that larger groups may make it more difficult if people are rather diffident about talking about a topic which they know little or have little experience. According to the literature, lack of knowledge was considered a barrier for builders therefore smaller group sizes of between 4 and 6 would still be considered appropriate for the study. Studies analyzed by Bryman (2008), ranged in group size from between 4 and 9 people.

Despite the limitations, focus groups are considered ideal for the research as the advantages outweigh the disadvantages outlined by Neuman (2007) and Bryman.
Kitzinger (1995) contends that focus groups are more suitable for examining knowledge within a given cultural context than other methods of inquiry which is what the study sets out to achieve in terms of a builders perspective.

Key to focus group discussions is the selection of a facilitator so as to run the discussions in an orderly and unbiased way (Neuman, 2007). The facilitator would also ensure that there would not be one dominating voice within the group. The facilitator selected for this research was a person that has vast experience in handling focus group discussions for various Government projects in recent times. An employee of the Master Builders Association Victoria coordinated the research work and provided background for the study to the builders invited to the focus group discussions.

The builders for the discussions or sessions were all randomly selected from the Master Builders Association Victoria database with the fifteen (15) builders invited from each location selected. Fifteen were invited in order to reduce the effect of ‘no –shows’ discussed earlier. The main focus of the discussions was to ascertain the following:

- What builders know about grey water;
- What builders know about grey water systems;
- What their practical experiences are with grey water systems;
- Client demand for systems;
- Barriers for builders in installing grey water systems;
• Possible solutions;
• Sources of information on grey water systems for builders.

The builders were given fact sheets and more information on grey water systems upon completion of the study, with key references pointed out as to where to go for further information on grey water systems and water reuse in general. This was done so as to avoid the first limitation stated by Neuman (2007) namely that attitudes become more extreme after group discussion. The participants were also assured of their anonymity in the research upon completion of the focus group discussion.

5.2.2 DATA ANALYSIS

The focus group discussions are by their very nature a good source of qualitative data. The data can also be coded and quantified to study the patterns between the different locations and identify which barriers were identified as being important. Links between the barriers that were identified within the literature review can be tested with quantitative analysis of the coded data in order to arrive at meaningful conclusions.

The Focus group discussions took place in the first half of November 2007 and as outlined earlier 15 builders were invited to each meeting or discussion. The four locations selected were Bendigo, Melbourne, Geelong and Traralgon. Each case is presented separately.
5.3 CASE 1 - BENDIGO

5.3.1 CONTEXT

Bendigo is a regional city in central Victoria, Australia and is located within the City of Greater Bendigo municipal boundaries. The city is less than two hours drive by car from Melbourne with an estimated population of 81,939 (ABS, 2006). The city was established during the gold boom of the mid 1800’s in Victoria.

The climate in Bendigo is described as dry and mild temperate with cold winters. The mean minimum and maximum temperatures in January and July are included in the following table;

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>July</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum Temperature</strong></td>
<td>14.3 Celsius</td>
<td>3.5 Celsius</td>
</tr>
<tr>
<td><strong>Maximum Temperature</strong></td>
<td>28.7 Celsius</td>
<td>12.1 Celsius</td>
</tr>
</tbody>
</table>

The city has an annual rainfall of 582.1 millimetres that falls predominantly during the winter period. Bendigo and surrounding areas have experienced severe drought in recent times with local water storage levels at record low levels.

The city has had harsh water restrictions with water restrictions currently at Stage 4. The City of Greater Bendigo has extensive drought management schemes in place to support the local and farming community such as the drought
apprenticeship retention bonus, free counseling for people affected by the
drought through Centacare and Telstra phone bill assistance for customers in
drought affected area.

The City of Greater Bendigo has one water authority namely Coliban Water
which has a several water catchment areas including, Barkers Creek, Caledonia,
Eppalock, Lauristan, Malmsbury, McCoy, Sandhurst and Upper Coliban. The
current water storage levels for Bendigo are at very low levels with only 12.6%
water storage levels as at April 22, 2008. Table 5.2 illustrates the different water
storage levels of these catchment areas.

<table>
<thead>
<tr>
<th>Catchment Area</th>
<th>Max</th>
<th>Current</th>
<th>% Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barker Creek</td>
<td>1,690</td>
<td>112</td>
<td>6.63%</td>
</tr>
<tr>
<td>Caledonia</td>
<td>215</td>
<td>124</td>
<td>57.67%</td>
</tr>
<tr>
<td>Eppalock</td>
<td>54,900</td>
<td>4,826</td>
<td>8.79%</td>
</tr>
<tr>
<td>Lauriston</td>
<td>19,790</td>
<td>7,824</td>
<td>39.54%</td>
</tr>
<tr>
<td>Malmsbury</td>
<td>17,780</td>
<td>284</td>
<td>1.60%</td>
</tr>
<tr>
<td>McCoy</td>
<td>1,360</td>
<td>1,340</td>
<td>98.53%</td>
</tr>
<tr>
<td>Sandhurst</td>
<td>2,590</td>
<td>2,391</td>
<td>92.32%</td>
</tr>
<tr>
<td>Upper Coliban</td>
<td>37,480</td>
<td>188</td>
<td>0.50%</td>
</tr>
</tbody>
</table>

| Total            | 135,805| 17,089 | 12.60%  |

5.3.2 FOCUS GROUP RESULTS

The focus group discussion at Bendigo was the first to be held with 15 builders
invited to the discussions. Builders in Bendigo and surrounding satellite towns
were randomly selected from the Master Builders Association membership
database and consequently called and invited to attend. The discussion was of
particular significance as it served as a guide for the next focus group
discussions that were scheduled for Melbourne, Geelong and Traralgon. The efficacy of the Bendigo focus group discussion would determine how the study would be carried out at the remaining locations. The attendance for the focus group discussion was at 47% with 7 builders in attendance at the meeting. The discussion went well with active participation overall.

**Key Issues Identified**

The following key points were raised during the discussion:

- “Tanks are more important”;
- “Grey water is a grey area”;
- Problems with council approvals – timely;
- Issues with council requirements – non-uniform;
- Grey water systems are a plumbers issue – not builders;
- Design phase doesn’t accommodate for the differentiation between grey water and black water;
- Issues relating to how much grey water they can use;
- Conflicting information for builders from both plumbers and council.

The builders generally felt that rain water tanks were more important in the conservation effort as they were less of a hazard and people were generally more aware about them. The builders highlighted the fact that grey water is a ‘grey area’ in their view and felt that there was insufficient knowledge about grey
water systems and grey water in general. Another related problem is that information provided by councils and plumbers is contradictory and makes it difficult to discern what the real issues are with respect to grey water systems.

One issue that was raised by the builders in the Bendigo area was that grey water systems are readily available within the market but that there is still a problem with regard to getting Council approval for the systems. The concern with Council approval is that it is a time consuming process that can easily be bypassed by not including grey water systems in projects.

One of the participants pointed out that grey water systems are a plumbers issue and are not in the Builder’s realm. The main argument was that builders are mainly concerned with the construction side of projects while plumbers as their name suggest deal with the plumbing side in projects. The concern therefore shifted to the fact that new buildings are not designed for technologies such as grey water systems.

The Design phase does not accommodate for the differentiation between grey water and black water. This creates a problem subsequently for home owners who may want to fit a grey water system in an existing residence to install one especially in homes with concrete slabs. This problem not only makes it difficult to install the grey water systems but also makes it more expensive for the client as it involves more labour and expertise to install a system.
Possible Solutions

The following suggestions were made by the participants of the focus group discussion as solutions to the barriers inhibiting the installation of grey water systems in projects by builders:

- EPA approved systems should get approval from council without any constraints;
- The Building Commission and Plumbing Commission should improve communication between the two bodies;
- Economical and reliable systems would help increase consumer demand for grey water systems;
- A collective effort must be undertaken by the manufacturers of grey water systems to get their systems approved.

The participants all felt that Councils take too long to approve grey water systems in developments even when a system is an Environment Protection Authority approved grey water system. The participants believed that if EPA approved systems were given instant approval, some of the constraints of the installation of grey water systems would be reduced.

Another suggestion raised by the builders was that communication between the Building Commission and the Plumbing Commission should be improved so as to better inform their members on issues such as grey water systems and other sustainability issues relevant to the two trades.
The participants also felt that more economical and reliable systems would help increase consumer demand for grey water systems. The builders felt that cost was one of the most important considerations for clients and hence cost-effective systems would be ideal for increased uptake of grey water systems.

The final solution that was discussed and raised by the participants was that a collective effort must be undertaken by the manufacturers of grey water systems to get their systems approved in order to eliminate ‘rogue’ manufacturers. The rogue manufacturers affect the credibility and reliability of grey water systems to the general public.

Sources of Information for Builders

The builders within the focus group discussion (in relation to what they considered to be their sources of information on grey water systems and grey water in general) identified the following information sources:

- The Internet;
- The Water Board;
- Council.

The participants unanimously agreed that the Internet was by far the best source of information for builders. The Water Board and Council were the other two sources identified by the builders.
5.3.3 SUMMARY OF FINDINGS

The results of the focus group discussion have been compared with those identified in the literature review with the following table (Table 5.3) highlighting the barriers that were discussed.

Three of the five barriers were not discussed during the focus group discussions namely; Cost of Grey Water Systems, Client Demand and Health Issues.

**Table 5.3 Literature Versus Actual findings - Bendigo**

<table>
<thead>
<tr>
<th>Barriers Identified in Literature Review</th>
<th>Barriers identified by Bendigo Builders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Grey Water Systems</td>
<td>Not Discussed</td>
</tr>
<tr>
<td>Government Regulations</td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• Problems with council approvals</td>
</tr>
<tr>
<td></td>
<td>• Issues with council requirements</td>
</tr>
<tr>
<td></td>
<td>• Design phase does not accommodate for systems</td>
</tr>
<tr>
<td>Client Demand</td>
<td>Not Discussed</td>
</tr>
<tr>
<td>Builders Awareness and Knowledge</td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• Conflicting information for builders from both plumbers and council</td>
</tr>
<tr>
<td></td>
<td>• Greywater is a grey area</td>
</tr>
<tr>
<td></td>
<td>• Greywater systems are a plumbers issue</td>
</tr>
<tr>
<td>Health Issues</td>
<td>Not Discussed</td>
</tr>
</tbody>
</table>
5.4 CASE 2 – MELBOURNE

5.4.1 CONTEXT

Melbourne is the second most populous city in Australia, with an estimated population of approximately 3.8 million people (ABS, 2006). Melbourne is the state capital of Victoria and is a major centre of commerce, industry and cultural activity.

Melbourne has a moderate oceanic climate and is known for its rapidly changeable weather conditions. Melbourne is regarded by many as having four seasons in one day. The mean minimum and maximum temperatures in January and July are included in the following table;

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>July</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum Temperature</strong></td>
<td>14.2 Celsius</td>
<td>6.0 Celsius</td>
</tr>
<tr>
<td><strong>Maximum Temperature</strong></td>
<td>25.8 Celsius</td>
<td>13.4 Celsius</td>
</tr>
</tbody>
</table>

The city of Melbourne has an annual rainfall of 646.9 millimetres that falls predominantly in the winter period. Melbourne as with most other Victorian cities, has water restrictions in place, which are currently at Stage 3a. Under Stage 3a water restrictions, there are restrictions on watering of the garden to morning periods on specified days (Melbourne City Council, 2007). The restrictions are in force to combat the water supply shortages due to decreasing water storage levels.
The local water authorities in Melbourne are:

- City West Water;
- South East Water;
- Yarra Valley Water;
- and Melbourne Water.

There are several water catchment areas in Melbourne including Thomson, Upper Yarra, O'Shannassy, Maroondah, Sugarloaf, Yan Yean, Greenvale, Silvan and Cardinia. Melbourne’s water storages were 29.4% full as at April 22, 2008. Table 5.5 illustrates the different water storage levels at the catchment areas;

**Table 5.5: Water Levels in the Catchment Areas – Melbourne <Source: Melbourne Water>**

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Capacity</th>
<th>Current Volume</th>
<th>%Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomson</td>
<td>1,068,000</td>
<td>194,722</td>
<td>18.23%</td>
</tr>
<tr>
<td>Upper Yarra</td>
<td>200,000</td>
<td>94,700</td>
<td>47.35%</td>
</tr>
<tr>
<td>O'Shannassy</td>
<td>3,000</td>
<td>2,462</td>
<td>82.07%</td>
</tr>
<tr>
<td>Maroondah</td>
<td>22,000</td>
<td>4,299</td>
<td>19.54%</td>
</tr>
<tr>
<td>Sugarloaf</td>
<td>96,000</td>
<td>14,594</td>
<td>15.20%</td>
</tr>
<tr>
<td>Yan Yean</td>
<td>30,000</td>
<td>4,591</td>
<td>15.30%</td>
</tr>
<tr>
<td>Greenvale</td>
<td>27,000</td>
<td>22,696</td>
<td>84.06%</td>
</tr>
<tr>
<td>Silvan</td>
<td>40,000</td>
<td>35,630</td>
<td>89.08%</td>
</tr>
<tr>
<td>Cardinia</td>
<td>287,000</td>
<td>147,872</td>
<td>51.52%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,773,000</td>
<td>521,566</td>
<td>29.42%</td>
</tr>
</tbody>
</table>

**5.4.2 FOCUS GROUP RESULTS**

The focus group discussion at Melbourne was the second to be held after the Bendigo meeting, with 15 builders invited to the discussions. Builders in the Melbourne Metropolitan area were randomly selected from the Master Builders
Association Victoria membership database and subsequently called and invited to attend.

The attendance for the focus group discussion was poor with attendance at a level of 27%. The turnout was lower than the Bendigo Focus Group discussion with only 4 builders in attendance at the meeting. The focus group discussion went ahead as scheduled despite the poor attendance with relatively good input from the participants.

**Key Issues Identified**

The participants raised the following key points during the discussion:

- Grey water systems are expensive;
- Grey water not good for gardens;
- No regulations;
- People generally are not aware of what grey water is;
- No information on grey water systems - awareness is low;
- Low client demand;
- Health and Pollution;
- Inadequate space on residential sites;
- Rebates not enough;
- Cost of water is currently at low levels.

Participants generally felt that grey water systems were expensive. The builders felt that the high cost of the systems adversely affect the uptake of grey water
systems by consumers. The participants believed that the initial outlay was too high for most consumers. Cost is clearly a barrier for builders installing grey water systems.

The builders also raised another key point during the study when they stated they had concerns that grey water is not safe for use in gardens. The lack of awareness on the part of the builders was highlighted by the above concern as they were not aware of the different grey water systems – more importantly treatment systems.

The participants felt that there were no regulations to force builders to include grey water systems. The lack of regulations (they felt) is therefore a hindrance as there is no push for builders to install them. The builders were, however, not aware of any current regulations regarding the installation of grey water systems. One of the participants highlighted the fact that storage for grey water systems was limited to only 24 hours, but that was the full extent of the participant’s awareness of current regulations. A cautionary note by another participant was that merely changing the regulations to make it mandatory for the installation of grey water systems would not be effective. The participant stated that people should want to put in the systems and that they should not be forced.

The builders also discussed the fact that most people generally are not aware of what grey water is including some of the builders themselves. They believed that
people will only install grey water systems if they are aware of all the issues at hand with regards to the systems and their use.

The general lack of advertising by relevant authorities of grey water as a genuine water conservation alternative was highlighted by the group as they pointed out that usually television campaigns are effective in raising awareness in the general public. This point was identified as directly impacting on the level of awareness for the builders themselves. The participants came to the conclusion that builder awareness is generally low.

Low client demand is another hindrance identified by the group as they were of the opinion that people in urban areas have no need for grey water systems. One of the participants stated that house blocks are getting smaller with gardens not a major requirement for most urban people. Urban areas therefore have no necessity for grey water systems.

Health and Pollution was only covered briefly by one member the group as the awareness level of the group regarding grey water systems was low. The participants felt that grey water has not been adequately tested to determine whether it is safe or not. One participant remarked that if research has been carried out on grey water, it has not been made public. The participant posed the question, “Where is the research?”
Inadequate space on residential sites was held as a factor restricting the installation of grey water systems in new homes. The main problem with this assertion is that the builders were not fully aware of the grey water systems in the market. As highlighted in Chapter 4, there are other potable systems within the market.

Another key issue which the participants felt adversely affected the installation of grey water systems was that the builders believed that current rebates are not enough for consumers hence the low uptake.

The last issue raised by the builders was that the cost of water in Melbourne is currently at low levels and therefore there is no need for grey water systems as their payback period is too long.

**Possible Solutions**

The participants of the focus group discussion suggested a number of possible solutions to the barriers hindering the installation of grey water systems in projects by builders:

- Links should be created on the MBA website;
- Design oriented solutions;
- Educating the general public.

The participants felt that a link on the Master Builders Association website should be created to a list of approved grey water systems and general information on
grey water regulations and possible rebates. The participants unanimously agreed that the link/s would increase awareness amongst builder members and hopefully increase the uptake of the systems.

Another key point raised by the participants was that grey water systems should be design oriented with architects as the principle persons responsible for putting them in at the design phase.

The last solution offered by the discussion group was that the general public needs to be educated as to what grey water really is through appropriate advertising methods. The participants felt that the public should be educated on all aspects of grey water including what household detergents to use to reduce certain chemical compounds in their grey water.

Sources of Information for Builders

The builders within the focus group discussion identified the following information sources:

- The Internet;
- Plumbers;
- Trade suppliers.

The most common source of information for the builders was the internet with Plumbers and Trade suppliers also mentioned as sources of information regarding grey water systems.
5.4.3 SUMMARY OF FINDINGS

The results of the focus group discussion have been compared with those identified in the literature review with the following table (Table 5.6) highlighting the barriers that were discussed.

Table 5.6 Literature Versus Actual findings - Melbourne

<table>
<thead>
<tr>
<th>Barriers Identified in Literature Review</th>
<th>Barriers identified by Melbourne Builders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost of Grey Water Systems</strong></td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• Greywater systems are expensive</td>
</tr>
<tr>
<td></td>
<td>• Rebates not enough</td>
</tr>
<tr>
<td><strong>Government Regulations</strong></td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• No regulations</td>
</tr>
<tr>
<td><strong>Client Demand</strong></td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• Low client demand</td>
</tr>
<tr>
<td></td>
<td>• People generally are not aware of what greywater is</td>
</tr>
<tr>
<td></td>
<td>• Inadequate space on residential sites</td>
</tr>
<tr>
<td></td>
<td>• Cost of water is currently at low levels</td>
</tr>
<tr>
<td><strong>Builders Awareness and Knowledge</strong></td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• People generally are not aware of what greywater is</td>
</tr>
<tr>
<td></td>
<td>• No information on greywater systems – awareness is low</td>
</tr>
<tr>
<td><strong>Health Issues</strong></td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• Health and pollution</td>
</tr>
<tr>
<td></td>
<td>• Greywater not good for gardens</td>
</tr>
</tbody>
</table>

The builders in Melbourne discussed all the barriers that were identified within the literature review. The one evident issue with the builders was their relatively low level of knowledge of greywater systems with most of the builders admitting that they did not know enough about greywater systems.
5.5 CASE 3 - GEELONG

5.5.1 CONTEXT

Geelong is a regional city in Victoria located approximately 75 kilometres south west of Melbourne. The city is within the City of Greater Geelong municipal boundaries and is the second largest city in the state. Geelong has an estimated population of approximately 160,991 people (ABS, 2006).

The climate of Geelong can be described as stable, offering four distinct seasons. Geelong has a temperate climate with dominant westerly winds, variable cloud, moderate precipitation and cool temperatures. The mean minimum and maximum temperatures in January and July are included in the following table;

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>July</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum Temperature</strong></td>
<td>13.2 Celsius</td>
<td>5.2 Celsius</td>
</tr>
<tr>
<td><strong>Maximum Temperature</strong></td>
<td>25.0 Celsius</td>
<td>13.6 Celsius</td>
</tr>
</tbody>
</table>

Geelong has an annual rainfall of 536.4 millimetres that falls predominantly during the winter period. Stage 4 water restrictions are in place in the city with generally low levels of water storage recorded in the main catchment areas. The current water storage levels in the catchment areas as at April 22, 2008 are 26.7%.
<table>
<thead>
<tr>
<th>Location</th>
<th>Capacity</th>
<th>Current Volume</th>
<th>%Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wurdee Boluc Reservoir</td>
<td>38,056</td>
<td>16,228</td>
<td>42.64%</td>
</tr>
<tr>
<td>West Barwon Reservoir</td>
<td>21,504</td>
<td>7,806</td>
<td>36.30%</td>
</tr>
<tr>
<td>Korweinguboora Reservoir</td>
<td>2,091</td>
<td>119</td>
<td>5.69%</td>
</tr>
<tr>
<td>Bostock Reservoir</td>
<td>7,455</td>
<td>64</td>
<td>0.86%</td>
</tr>
<tr>
<td>Stony Creek Reservoirs</td>
<td>9,494</td>
<td>2,033</td>
<td>21.41%</td>
</tr>
<tr>
<td>Lal Lal Res</td>
<td>19,685</td>
<td>3</td>
<td>0.02%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>98,285</strong></td>
<td><strong>26,253</strong></td>
<td><strong>26.71%</strong></td>
</tr>
</tbody>
</table>

### 5.5.2 FOCUS GROUP RESULTS

The focus group discussion at Geelong was the third meeting held with 15 builders (as was the case with the other locations) invited to the discussions. Builders in Geelong and surrounding satellite towns were randomly selected from the Master Builders Association membership database and consequently called and invited to attend.

The attendance for the focus group discussion was poor with attendance at a level of 27%. Only 4 builders were in attendance at the meeting as was the case with the earlier Melbourne study but the focus group discussion went ahead as scheduled with reasonably good information sourced from the participating builders.

#### Key Issues Identified

The following key points were raised during the discussion:

- Awareness of grey water systems is low;
- Builder awareness is low;
- Health Issues;
- No incentive to install grey water systems by clients – rebates;
- Grey water systems are expensive;
- Inadequate space on residential sites for grey water systems.

The overall consensus from the participants was that the general awareness of grey water systems is low. They felt that the problem of low public awareness was the principle reason why the uptake of the systems by the general public is low. The participants concluded that there was not enough information that people can understand on grey water and grey water systems.

Builder awareness was also identified as being a stumbling block in terms of the uptake of grey water systems as the participants felt that builders generally had no knowledge about the systems. The participating builders also felt that the Master Builders Association has not brought up issues on grey water in previous events organised by the Association. Some of the builders also felt that they had been introduced to grey water but there had been no follow ups to ensure that they were aware of further developments and also keep them interested.

Another problem mentioned by the participants was that there are health issues that affect the use of grey water. The participants felt that ‘there are too many issues’ around grey water.
The participants also discussed cost issues and concluded that there are no incentives for clients to install grey water systems. They felt that there were no rebates that they were aware of, for the installation of grey water systems which adversely affects the uptake of grey water systems. Most of the participants felt that grey water systems were too expensive for clients and therefore hindering the uptake of grey water systems by consumers in general.

The final barrier discussed by the participants was that in their opinions, there is inadequate space on residential sites for grey water systems. They noted the decreasing size of residential blocks as a stumbling block in the installation of grey water systems.

**Possible Solutions**

The participants of the focus group discussion suggested the following as possible solutions to the barriers inhibiting the installation of grey water systems in projects by builders:

- A website on grey water should be developed for builders;
- Industry fact sheets or pamphlets should be issued to builders to distribute to clients;
- The market needs more automated systems.

The participants suggested that a website should be developed for builders with all the information on grey water systems and grey water in general. The
participating builders felt that if access to information was made more readily available, then the uptake of grey water systems might be improved.

Another solution suggested by the participants was that industry fact sheets or pamphlets should be issued to builders to distribute to clients in order to raise awareness of grey water and issues relating to the use of grey water. The participants felt that raising of public awareness would improve the uptake of grey water systems.

The final solution suggested by the participants was that the market needs more automated systems given the fact that most treatment systems required constant maintenance works and also required certain physical adjustments that were difficult to carry out in cases were the actual system was situated in a ‘hard to reach’ location.

**Sources of Information for Builders**

The builders within the focus group discussion identified the following information sources for builders with regard to grey water and grey water systems:

- The Internet;
- Plumbers.
Most of the participating builders felt that the Internet was a key source of information on grey water systems for them. The builders also regarded plumbers as a good source of information on grey water systems.

**5.4.3 SUMMARY OF FINDINGS**

The results of the focus group discussion have been compared with those identified in the literature review with the following table (Table 5.9) highlighting the barriers that were discussed.

<table>
<thead>
<tr>
<th>Barriers Identified in Literature Review</th>
<th>Barriers Identified by Geelong Builders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Grey Water Systems</td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• Greywater systems are expensive</td>
</tr>
<tr>
<td></td>
<td>• No incentive to install systems (rebates)</td>
</tr>
<tr>
<td>Government Regulations</td>
<td>Not Discussed</td>
</tr>
<tr>
<td>Client Demand</td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• Awareness of greywater systems is low</td>
</tr>
<tr>
<td></td>
<td>• Inadequate space on residential sites for greywater systems</td>
</tr>
<tr>
<td>Builders Awareness and Knowledge</td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• Builder awareness is low</td>
</tr>
<tr>
<td>Health Issues</td>
<td>Discussed</td>
</tr>
<tr>
<td></td>
<td>• Health issues</td>
</tr>
</tbody>
</table>

The Geelong builders identified all the barriers except government regulations as being the main issues with regards to the poor uptake of greywater systems.
5.6 CASE 4 - TRARALGON

5.6.1 CONTEXT

Traralgon is a small town located approximately 161 kilometres south east of Melbourne within the City of Latrobe municipal boundaries. The town was established in the 1840’s as a farming town due to its relatively high rainfall.

The climate of Traralgon is described as temperate and generally humid. The mean minimum and maximum temperatures in January and July are included in the following table;

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>July</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum Temperature</strong></td>
<td>12.6 Celsius</td>
<td>3.7 Celsius</td>
</tr>
<tr>
<td><strong>Maximum Temperature</strong></td>
<td>26.0 Celsius</td>
<td>13.6 Celsius</td>
</tr>
</tbody>
</table>

Traralgon has been plagued by a persistent drought with 20% lower than average rainfall since 1997. The region, most particularly the eastern Gippsland region has however, been affected by recent flash floods in June 2007. The region, as is the case with Melbourne is on Stage 3a water restrictions. Stage 3a water restrictions mean that gardens can be watered on specified watering days only in the morning whilst new pools or spas cannot be filled (Department of Sustainability and Environment, 2007). The water storage levels as at October 1, 2005 are as follows;
### Table 5.11: Water Levels in the Catchment Areas – Traralgon <Source: South East Water>

<table>
<thead>
<tr>
<th>Location</th>
<th>Capacity</th>
<th>Current Volume</th>
<th>%Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Rock</td>
<td>198,445</td>
<td>190,683</td>
<td>96.09%</td>
</tr>
<tr>
<td>Glenmaggie</td>
<td>190,340</td>
<td>184,400</td>
<td>96.88%</td>
</tr>
<tr>
<td>Moondarra</td>
<td>29,700</td>
<td>30,178</td>
<td>101.61%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>418,485</td>
<td>405,261</td>
<td>98.19%</td>
</tr>
</tbody>
</table>

#### 5.6.2 FOCUS GROUP RESULTS

The focus group discussion at Traralgon was the final meeting to be held, with 15 builders invited to the discussions. Builders in Traralgon and surrounding suburbs and towns were randomly selected from the Master Builders Association membership database and consequently called and invited to attend. Traralgon is a central location that captured all the outer south eastern areas.

Attendance for the focus group discussion was poor, as is the case with the Melbourne and Geelong meetings, the attendance was at a level of 27%. Only 4 builders were in attendance at the meeting but the focus group discussion went ahead as planned.

**Key Issues Identified**

The following key points were raised during the discussion:

- Grey water systems are expensive;
- High maintenance required;
- Client demand low in towns;
- Water not expensive enough.
The participants all agreed that grey water systems are expensive and that this had a negative impact on the uptake of grey water systems. The participating builders felt that clients were also worried about the ongoing cost of maintaining the grey water systems hence the low demand for them. A possible reason why the builders may feel that the systems are expensive may be due to the relatively high levels of water in the area as shown in Figure 5.11.

Another problem discussed by the builders was that the grey water systems required high maintenance. The high maintenance associated with the systems means that clients are less likely to adopt the systems.

The participating builders felt that client demand in towns is low hence the low rate of adoption with regards the grey water systems. People in towns require less water than in rural areas and generally have smaller land with no gardens.

The participants within the focus group believed that water is currently not expensive enough to warrant adopting grey water systems. The participants felt people were not willing to pay the initial outlay required for grey water systems as a result.

Possible Solutions

The following were offered by the participants of the focus group discussion as possible solutions to the barriers hindering the installation of grey water systems in projects by builders:
• Reduction in cost of grey water systems
• More reliable systems need to be designed

Reduction in cost of grey water systems was suggested as a possible solution to the barriers identified by the participants as they felt that more affordable systems would attract more clients to the systems. The participants also suggested that more reliable systems need to be designed in order to reduce the ongoing costs involved with the maintenance of grey water systems so as to get more people to install them.

Sources of Information for Builders

The builders within the focus group discussion (in relation to what they considered to be their sources of information on grey water systems and grey water in general) identified the following information sources:

• The Internet;
• Plumbers;
• Trade Shows;
• Builders Magazines.

The participants all felt that the Internet was the primary source information on grey water systems for them with other sources including Plumbers, Trade Shows and Builders Magazines.
5.6.3 SUMMARY OF FINDINGS

The results of the focus group discussion have been compared with those identified in the literature review with the following table (Table 5.12) highlighting the barriers that were discussed.

Table 5.12 Literature Versus Actual findings - Traralgon

<table>
<thead>
<tr>
<th>Barriers Identified in Literature Review</th>
<th>Traralgon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Grey Water Systems</td>
<td>Discussed</td>
</tr>
<tr>
<td>• Greywater systems are expensive</td>
<td></td>
</tr>
<tr>
<td>• High maintenance required</td>
<td></td>
</tr>
<tr>
<td>• Water not expensive enough</td>
<td></td>
</tr>
<tr>
<td>Government Regulations</td>
<td>Not Discussed</td>
</tr>
<tr>
<td>Client Demand</td>
<td>Discussed</td>
</tr>
<tr>
<td>• Client demand low in towns</td>
<td></td>
</tr>
<tr>
<td>Builders Awareness and Knowledge</td>
<td>Not Discussed</td>
</tr>
<tr>
<td>Health Issues</td>
<td>Not Discussed</td>
</tr>
</tbody>
</table>

Only two of the barriers identified within the literature were discussed by the builders in Traralgon. The two barriers discussed by the builders were the cost of greywater systems and low client demand.

5.7 CROSS-CASE ANALYSIS

The results of the focus groups were very similar in the four locations namely; Bendigo, Melbourne, Geelong and Traralgon even though the turnout was low in all the locations. The purpose of this section of the Chapter is to analyse and summarise the results of the focus group discussions. The results have been cross analysed with results from the different locations so that the main barriers
common to all can be compared with the literature. The results are summarized in the table below:

**Table 5.13 Summarised Results of the Focus Group Discussion**

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Bendigo</th>
<th>Melbourne</th>
<th>Geelong</th>
<th>Traralgon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ND – Not Discussed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D - Discussed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey water systems are expensive</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Rebates on grey water systems are not enough</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>ND</td>
</tr>
<tr>
<td>Cost of water is currently at low levels</td>
<td>ND</td>
<td>D</td>
<td>ND</td>
<td>D</td>
</tr>
<tr>
<td>No mandatory regulations</td>
<td>ND</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Grey water is considered to be a grey area - low consumer awareness</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>ND</td>
</tr>
<tr>
<td>Builder awareness of grey water systems is low</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>ND</td>
</tr>
<tr>
<td>Problems with council approvals – timely</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Issues with council requirements – non-uniform</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Grey water systems are a plumbers issue</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Water Tanks are a more important consideration than grey water systems</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Design phase doesn’t accommodate for the differentiation between grey water and black water</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Conflicting information for builders from both plumbers and council</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Health and Pollution</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>ND</td>
</tr>
<tr>
<td>Low client demand</td>
<td>ND</td>
<td>D</td>
<td>ND</td>
<td>D</td>
</tr>
<tr>
<td>Inadequate space on residential sites</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>ND</td>
</tr>
<tr>
<td>High maintenance</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>D</td>
</tr>
</tbody>
</table>

The results of the Focus Group discussions seem to suggest that the Bendigo builders were more accustomed to greywater systems. They did not discuss cost issues as a barrier but discussed at length the problems they faced with council.
The builders felt that Council approval times were lengthy which would suggest they had more hands-on experience as compared to the other locations (Melbourne, Geelong and Traralgon).

A closer analysis of Table 5.13 also shows that the Melbourne, Geelong and Traralgon based builders who participated in the focus group discussions were more concerned with health issues which reflected their fear of the unknown. They were more concerned from a lack of awareness point of view rather than practical experience.

Melbourne and Geelong builders also cited the small residential blocks as a barrier for the installation of greywater systems. This would not be an issue in the regional areas as the residential lots tend to be larger in regional areas. It should be noted that from the greywater systems that were profiled in the study, the largest system was the NovaClear which occupies an area of 4.84 square metres underground (2.2 metres by 2.2 metres).

The key findings in the above table were analysed on a majority basis with points discussed in two or more locations being regarded as significant for the identification of the barriers that builders currently face. Barriers that were not discussed by the builders in two or more of the different locations were therefore disregarded and considered insignificant. From Table 5.13, it is clear that the following points are a main concern to the builders with regard to barriers inhibiting the uptake of greywater systems:
• Greywater systems are expensive;
• Cost of water is currently at low levels;
• Greywater is considered a grey area (low customer awareness);
• Builder awareness of greywater systems is low;
• Health and pollution problems;
• Low client demand;
• Inadequate space on residential sites.

The results also confirm the barriers outlined in the literature review with the following table (Table 5.14) highlighting which towns discussed the issues identified in the literature review.

### Table 5.14 Literature Versus Actual findings

<table>
<thead>
<tr>
<th>Barriers Identified in Literature Review</th>
<th>Bendigo</th>
<th>Melbourne</th>
<th>Geelong</th>
<th>Traralgon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Grey Water Systems</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Government Regulations</td>
<td>D</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Client Demand</td>
<td>ND</td>
<td>D</td>
<td>ND</td>
<td>D</td>
</tr>
<tr>
<td>Builders Awareness and Knowledge</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>ND</td>
</tr>
<tr>
<td>Health Issues</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>ND</td>
</tr>
</tbody>
</table>

The builders from Melbourne, Geelong and Traralgon noted that greywater systems are cost prohibitive but as outlined in the earlier profile of greywater systems, the only systems that would be cost prohibitive would be the Diversion and Treatment System and the Filtration System given that current Government
rebates available for greywater systems is $500. In terms of retrospective fittings of the greywater systems, the cost issue would be a real consideration for established homes. In addition smaller residential blocks as cited by the Melbourne and Geelong Builders would face difficulties with regard to fitting the larger greywater systems, retrospectively.

The builders were asked to discuss possible solutions to the barriers they identified during the discussion group discussions. The focus groups identified builder awareness as a possible hindrance to the uptake of greywater systems and therefore the results may not reflect or cover solutions that deal with institutional barriers. This is due to the fact that, the builders may not be familiar with the planning and approval processes required for the systems.

The possible solutions identified by the builders are outlined in Table 5.15.
Table 5.15  Possible Solutions

<table>
<thead>
<tr>
<th>Possible Solutions</th>
<th>Bendigo</th>
<th>Melbourne</th>
<th>Geelong</th>
<th>Traralgon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ND – Not Discussed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D - Discussed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPA approved systems should get approval from council without any constraints</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Design oriented solutions</td>
<td>ND</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>The Building Commission and Plumbing Commission should improve communication between the two bodies</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Economical and reliable systems would help increase consumer demand for grey water systems</td>
<td>D</td>
<td>ND</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>A collective effort must be undertaken by the manufacturers of grey water systems to get their systems approved</td>
<td>D</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Creation of a website or link on grey water systems</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>ND</td>
</tr>
<tr>
<td>Educating the general public</td>
<td>ND</td>
<td>D</td>
<td>D</td>
<td>ND</td>
</tr>
<tr>
<td>Reduction in cost of grey water systems</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>D</td>
</tr>
</tbody>
</table>

The main solutions identified within the focus groups and common in two or more of the locations are outlined below:

- Economical and reliable systems would help increase consumer demand for grey water systems;
- Creation of a website or link on grey water systems;
- Educating the general public.
The main sources of information that were common in two or more of the four locations are as follows:

- Internet;
- Plumbers.

It was important to understand where they got their information from so as to tailor any solution specifically for the builders. The internet was a popular source of information for the builders and even ties in with the second solution discussed by the builders namely that a website should be created with links to issues relating greywater systems in order to reduce the identified barriers. Plumbers were also identified as a source of information on greywater systems as greywater systems are meant to be fitted by qualified plumbers.

5.8 CONCLUSIONS

This chapter formally presented the results of the focus group discussions. The results are generally consistent with the literature and are further compared and contrasted with the results from the surveys in the next chapter. The aim of the next chapter therefore is to confirm the results from the focus group discussion through the cross analysis of the results from the two methods of inquiry.
CHAPTER 6 INDUSTRY PERCEPTIONS

6 INDUSTRY PERCEPTIONS

6.1 INTRODUCTION

This chapter presents the results from the surveys with the view of confirming the barriers identified in the preceding chapter. The results from the survey have been cross analysed with the results from the focus group discussion in order to form meaningful conclusions from the study. The conclusion of the chapter will summarize all the findings and present them for further analysis and conclusions for the next and final chapter.

6.2 METHODS

Surveys were carried out in the first week of October with 50 builder members of the Master Builders Association Victoria. The survey was carried out over three days namely the fourth, fifth and sixth of October 2007.
The type of survey utilized for this research was the phone interview given the busy and hectic schedule of most builders. The advantages of telephone interviews according to Neuman (2007) are:

- More people can be reached by phone;
- The method is flexible;
- The method has most of the strengths of face to face interviews but for half the cost;
- Interviewers can control the sequence of question.

Furthermore Massey (1988) concurs with the above advantages and further point out that the increase in interest for phone interviews from researchers is as a result of increase in phone coverage coupled with the fact that data collection costs for phone interviews are less than face to face interviews.

The interviews were semi-structured with both closed and open ended questions in order for both quantitative analysis and qualitative analysis tools to be utilized. The use of a semi-structured method meant that limitations of both closed and open ended questions were reduced or eliminated. The use of both methods was also utilized to counter the limitations of the phone interview method itself as Neuman (2007) noted that one of the main disadvantages of phone interviews was that open ended questions alone are difficult to use due to time constraints and potential for disruptions when using the phone. Furthermore, Neuman (2007) pointed out that phone calls reduce anonymity thus introducing interviewer bias.
Despite the aforementioned limitations of the phone interview survey method, the advantages outweigh the disadvantages with this particular research problem and hence the method has been adopted for the study.

6.3 DATA ANALYSIS

Participant builders were randomly selected from a spreadsheet of the Victorian membership roll of the Master Builders Association with the *random excel* function utilized to obtain a truly random and unbiased listing. Basic quantitative analysis tools, such as excel spreadsheets and analysis tools were used for the analysis of the data. Data was checked for trends between the different variables that were outlined within the research. The data was collected and coded within the questionnaires and transferred onto an excel spreadsheet, with each respondent’s individual responses noted. The names of the respondents were however not recorded for privacy and ethical reasons.

The coding of the closed questions was coded using numbers 1-5 and 9 for responses – strongly disagree through to strongly agree and not applicable. Respondents were allowed to respond undecided for those statements that they were not sure about. The number had no special meaning but allowed for the easy counting and sorting of data in order to determine links using “if” statements on excel.
6.4 RESULTS OF SURVEYS

The results of the phone interview surveys are presented as arranged on the questionnaire that is annexed to this thesis as Appendix A. The structure was followed to establish if there were any links between responses in other sections of the interview or survey and possibly find explanations for the builder’s responses. The basic structure of the questionnaire was as follows;

- Introductory Questions;
- Closed questions;
- Open ended questions.

The introductory questions were questions that were aimed at finding out what sort of builder the respondent was, namely, an average builder (two to three homes per annum), a green builder (a builder who occupies the sustainable construction niche) or a volume builder (in excess of 20 homes per annum). Data validation questions followed in order for the builder to be properly classified with a short response question to determine what the builders felt greywater was.

The closed questions were set statements that required the builders to respond to in order to enable quantitative analysis to be carried out once the data was collected (See Appendix B). The final section of the questionnaire was open ended and served as an important part of the survey as it provided more qualitative data that could explain the standard responses from the closed questions.
**Results from the Introductory Section**

The builders included in the survey comprised of 6% green builders, 92% average builders and 2% volume builders. The volume builders were the clear minority in the survey with the majority of the builders being average builders.

The survey revealed that a majority (54%) of the builders did not know what comprises greywater. Figure 5.5 indicates that 46% of the builders believed that greywater is shower and laundry water with 36 % indicating that greywater is laundry, kitchen and shower water.

The difference can be explained by the different definitions stated in the literature, with some of the literature defining greywater as the untreated wastewater that is generated and can be collected from showers, kitchens, sinks and laundries (Christova-Boal et al, 1996; Jamrah et al, 2007). Grey water can also be viewed as a less polluted stream of wastewater that is generated from hand basins, baths and showers. The notable difference being that water from kitchen sinks, and washing machines is excluded from the definition (Memon and Butler, 2007).
Further analysis of the findings contained in Figure 6.1 reveals that;

- 33% of green builders knew what greywater was;
- 48% of average builders knew what greywater was;
- none of volume builders knew what greywater was.

The above results clearly show that the green builders are not as knowledgeable about greywater as the average home builder even though, they are specifically focused on environmentally friendly construction and design. It should be noted however that the small sample size may distort the actual situation, hence no meaningful conclusion can be drawn apart from the fact that there is a clear confusion as to what constitutes greywater.

**Figure 6.1 Understanding of Greywater**

**Results from Section 1 (closed questions)**

Table 6.1 illustrates the results of the responses to the close statements in the survey. The responses show most notably that the majority (44%) of builders are
not aware of Government regulations regarding grey water systems. Correspondingly a similar percentage (42%) of builders indicated that they do not understand the current regulations on greywater systems. The response therefore validates and affirms the lack of knowledge on the side of builders as a barrier with regards to the adoption of greywater systems.

Table 6.1 Survey Results

<table>
<thead>
<tr>
<th>Statements</th>
<th>%disag</th>
<th>%undec</th>
<th>%agr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information on grey water use is readily available</td>
<td>22%</td>
<td>10%</td>
<td>68%</td>
</tr>
<tr>
<td>Grey water reuse is safe for non-human consumption in households</td>
<td>28%</td>
<td>6%</td>
<td>66%</td>
</tr>
<tr>
<td>The government supports the use of grey water systems</td>
<td>20%</td>
<td>16%</td>
<td>64%</td>
</tr>
<tr>
<td>Consumers/client demand for grey water systems is high</td>
<td>50%</td>
<td>18%</td>
<td>32%</td>
</tr>
<tr>
<td>I believe that current Government regulations support the installation of grey water systems by builders or developers</td>
<td>28%</td>
<td>28%</td>
<td>44%</td>
</tr>
<tr>
<td>I am aware of Government regulations regarding grey water systems</td>
<td>44%</td>
<td>16%</td>
<td>40%</td>
</tr>
<tr>
<td>I understand the Government regulations</td>
<td>42%</td>
<td>24%</td>
<td>32%</td>
</tr>
<tr>
<td>Consumer awareness with regards to grey water systems is high</td>
<td>58%</td>
<td>18%</td>
<td>24%</td>
</tr>
<tr>
<td>Grey water systems are affordable</td>
<td>52%</td>
<td>24%</td>
<td>22%</td>
</tr>
<tr>
<td>The installation of grey water systems in homes may have negative health implications for users</td>
<td>52%</td>
<td>18%</td>
<td>30%</td>
</tr>
<tr>
<td>The installation of grey water systems in homes may have a negative impact on the plants and soils.</td>
<td>54%</td>
<td>16%</td>
<td>30%</td>
</tr>
<tr>
<td>I am aware of the different grey water systems available in the market.</td>
<td>34%</td>
<td>20%</td>
<td>46%</td>
</tr>
<tr>
<td>I have installed grey water systems in previous projects</td>
<td>66%</td>
<td>0%</td>
<td>34%</td>
</tr>
</tbody>
</table>

The regulations set by the Local Governments were however deemed as being supportive in terms of the uptake and installation of greywater systems by builders. This result therefore means that Government regulations themselves are not the barrier for builders but rather the builders’ knowledge that is a problem.
The results also show that 52% of builders feel that grey water systems are unaffordable. Of the 52% of builders who felt that greywater systems were expensive, it should be noted that 10% had also indicated that they were not aware of the different greywater systems in the market. This obviously leads to the problem of perception of high cost associated with sustainable technologies that was highlighted in the literature. Approximately 24% of those who responded indicated that they were not sure if greywater systems were affordable, thus reflecting a lack of knowledge in terms of pricing or cost of the systems.

The majority of builders surveyed also believe that both consumer awareness (58%) and demand for greywater systems is low (50% as opposed to 32%). The results also reveal that the majority of builders believe that grey water use is safe for non-human consumption.

**Results from Section 2 (Open ended questions)**

The survey (Figure 6.2) revealed that 34% of the builders interviewed had incorporated grey water systems into their developments in the past. The majority (62.5%) of the builders indicated that they had installed diversion only systems. A survey from one builder was excluded from the results even though the builder had indicated that he had installed a grey water system before, because he had installed a water tank and not a grey water system. The above figure of 34% is most likely inflated given the small sample size.
The main reason for the builders incorporating grey water systems into their developments, according to the 81.3% of the builders interviewed in the survey, was that their clients requested them or wanted them. The other reasons offered by the builders as to why they incorporated grey water systems were; council regulations in places with no sewerage system in NSW and personal use.

The barriers hindering builders from installing grey water systems as identified in the open ended question section of the survey are listed as follows:
Table 6.2 Barriers identified in Survey

<table>
<thead>
<tr>
<th>Barriers Identified within Open Ended Section</th>
<th>Number of Builders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost for Builders</td>
<td>38%</td>
</tr>
<tr>
<td>Cost for Clients</td>
<td>36%</td>
</tr>
<tr>
<td>Lack of minimum Government regulations and non uniform Council requirements</td>
<td>20%</td>
</tr>
<tr>
<td>Builder awareness</td>
<td>16%</td>
</tr>
<tr>
<td>Low client demand</td>
<td>14%</td>
</tr>
<tr>
<td>Lack of information for builders</td>
<td>8%</td>
</tr>
<tr>
<td>Government input is low/rebates not enough</td>
<td>8%</td>
</tr>
<tr>
<td>Lack of information for Clients</td>
<td>6%</td>
</tr>
<tr>
<td>Lack of space in certain homes for the greywater systems</td>
<td>6%</td>
</tr>
<tr>
<td>Consumer Health</td>
<td>2%</td>
</tr>
</tbody>
</table>

It was difficult during data collection to get each respondent to say more than one or two barriers because of time constraints on their behalf. The above barriers are however, adequate for comparison with the results from the closed questions in Section 1 of the questionnaire.

The second significant barrier identified by respondents (36%) that was also identified in Section 1 was the general high cost involved with installing greywater systems. Installing greywater systems is more expensive for builders as it adds to the total construction costs which they feel they cannot recoup from the end users as clients are not familiar with greywater systems and demand for them is low as outlined earlier. This barrier was not clearly separated in terms of whether builders felt they were expensive or if builders felt the systems were too expensive for their clients. Section 2 of the survey, however clarified the builders perspective as they identified the high cost involved in installing greywater systems for both builders and clients as the top two barriers.

The second barrier uncovered from the open ended questions on what the builders thought were the barriers is that of high cost for the clients. This barrier
was also pointed out in the earlier section of the survey with 52% of the builders indicating that they felt that greywater systems were unaffordable.

The third most significant response (20%) shows that there is a lack of minimum Government regulations and non-uniform Council requirements, which is a major obstacle for builders in adopting greywater systems. The builders felt that minimum Government regulations requiring all builders to install greywater systems would help improve uptake of the systems. This means that even if the cost to install the systems is high, they would be absorbed by the fact that all builders are installing them and economies of scale may be reached whereby, the cost of the actual systems go down as more are produced. Therefore, if the systems are included in the design phase there would be an increase in uptake.

Non-uniform Council requirements also make it difficult for builders as they are not sure about the different Council requirements in terms of permits and approvals thus leading to delays in the construction process which leads to increased costs for the builders. This is a major deterrent for builders as they usually work on tight construction deadlines with delays reducing the builders’ margins.

The fourth highest barrier identified by the builders also indicated that there is a general lack of builder awareness with most of the respondents pointing out that there is no effort made by builders to get information on greywater systems hence the low rate of uptake of the systems. There is also the case that three
respondents felt that greywater systems are a ‘plumber’s issue’ therefore they felt they did not require to know more about greywater systems.

Low client demand affects the uptake of greywater systems in that the builders’ generally follow what the market requires. If clients are unaware or are not interested in particular innovations, it does become difficult to incorporate such designs into the construction and design of a new residential home. Four respondents indicated that there is a lack of specific information for builders on greywater systems. This is despite the fact that in the earlier section, the respondents (68%) indicated that information on greywater systems is readily available.

Government input was also identified by the respondents as a barrier to the uptake of greywater systems as issues such as insufficient Government rebates surfaced. The current rebate offered for greywater systems is $500 which some of the respondents felt was insufficient.

Some respondents (6%) indicated that there is a general lack of information for clients which is certainly a minority view given that 68% of the respondents in Section 1 of the surveys felt that information was readily available.

A lack of space in certain homes was identified by some respondent (6%) as an obstacle for clients when deciding on installing greywater systems in homes. This
is true for certain greywater systems especially those that require to be installed underground.

Only 2% of the respondents felt that consumer health issues were a major barrier in the adoption of greywater systems and hence the barrier is considered not significant for the findings of the survey.

The final question which served as a validation question for the earlier Section was whether or not the current information on greywater systems was adequate for builders of which most (50%) of the builders surveyed (Table 6.3) indicated that the current information on greywater systems is not adequate. There were 6% that indicated that they were not sure and 44% that indicated that they felt the information was adequate. The 6% expressed that if they made the effort to look they would get the information.

<table>
<thead>
<tr>
<th>Table 6.3 Information on Greywater Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is Information for builders adequate for grey water systems?</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

The most common source of information for the builders was the internet. The builders also sited other sources such as the Master Builders Association Victoria, local councils and plumbing supplies.
Table 6.4 Barriers Identified in Literature Vs Survey

<table>
<thead>
<tr>
<th>Barriers Identified in Literature Review</th>
<th>Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Grey Water Systems</td>
<td>Findings</td>
</tr>
<tr>
<td></td>
<td>• Greywater systems are expensive</td>
</tr>
<tr>
<td></td>
<td>• High cost for builders</td>
</tr>
<tr>
<td>Government Regulations</td>
<td>Findings</td>
</tr>
<tr>
<td></td>
<td>• Lack of minimum Government regulations</td>
</tr>
<tr>
<td></td>
<td>• Low Government input/rebates</td>
</tr>
<tr>
<td>Client Demand</td>
<td>Findings</td>
</tr>
<tr>
<td></td>
<td>• Client demand low</td>
</tr>
<tr>
<td>Builder Awareness and Knowledge</td>
<td>Findings</td>
</tr>
<tr>
<td></td>
<td>• General lack of builder awareness</td>
</tr>
<tr>
<td></td>
<td>• Lack of information for builders</td>
</tr>
<tr>
<td>Health Issues</td>
<td>Findings</td>
</tr>
<tr>
<td></td>
<td>• Not identified as a barrier</td>
</tr>
</tbody>
</table>

The above table outlines and summarises the barriers identified in the survey which generally confirm the barriers identified in the literature review with the exception of health issues.

A point of convergence, between the two selected data collection methods namely, surveys and focus group discussions, has to be sought in order to derive meaningful conclusions.

### 6.5 BARRIERS TO GREYWATER SYSTEMS

The barriers to the adoption of greywater systems were discussed within the case studies where focus group discussions confirmed the five barriers identified in the literature review, namely; cost of grey water systems, government regulations, client demand, builder awareness and knowledge and health issues. The surveys however confirmed all but one of the five barriers, with health issues considered insignificant by a majority (52%) of the respondents in the survey.
The findings of the research suggest that the main barriers inhibiting the installation of greywater for builders as being only four of the five barriers that were outlined within the literature review namely:

- cost of grey water systems;
- government regulations;
- client demand;
- builder awareness and knowledge.

Health issues have been regarded as insignificant due to the fact that the survey did not confirm the barrier as being a significant contributor to the low uptake of greywater systems. Health issues were considered a barrier for builders under the focus group discussions because two locations, namely Melbourne and Geelong had discussed health issues as a barrier even though the builders knew little about greywater systems.

It is clear from the results of this research that there are still a number of barriers that are affecting the uptake of greywater systems by builders. There is a need to address the barriers to the adoption of the systems in keeping with sustainable development.

The main solutions were identified within the focus groups with the following strategies suggested by the builders:
• Economical and reliable systems would help increase consumer demand for grey water systems;
• Creation of a website or link on grey water systems;
• Educating the general public.

The above solutions were common in two or more of the focus group locations. The surveys did not have questions on possible solutions due to time constraints associated with phone interviews therefore the solutions discussed in the focus groups have not been validated with the surveys results.

6.5 SUMMARY

The findings of the research have been generally consistent with those contained within the literature reviewed. The main barriers that were uncovered in this study are as follows:

• cost of grey water systems;
• government regulations;
• client demand;
• builder awareness and knowledge.

The only barrier not confirmed by the findings within this study is health issues as the results of the survey did not confirm the barrier as a major issue for builder with regards to the barriers inhibiting the installation of greywater systems.
The next Chapter will formally present the findings of this research, alongside the corresponding research objectives. It will also address industry recommendations for improving the uptake of greywater systems.
7 CONCLUSIONS

7.1 INTRODUCTION

The previous chapters presented and analysed the results of the surveys and focus group sessions. The aim of this chapter is to summarise the findings of the research carried out and make recommendations to the building industry. The chapter commences by restating the research questions that were presented at the beginning of the study followed by a discussion as to how these have been addressed. This is followed by recommendations for the industry and final conclusions of the study and recommendations for further research.

7.2 RESEARCH QUESTIONS

The purpose of this research is to identify the barriers inhibiting the installation of greywater systems by builders with the view to formulating strategies to overcome the identified barriers. To this end two research questions have been posed:
• What are the barriers inhibiting the installation of greywater systems by builders?
• What are the strategies needed to address the barriers?

The research questions have been answered within the main part of the thesis with next section formally presenting the findings. The findings are also compared to the findings within the literature review regarding the barriers.

7.2.1 BARRIERS TO INSTALLATION BY BUILDERS

The main findings with regard to the barriers inhibiting the installation of greywater systems in this study are:

• cost of grey water systems;
• government regulations;
• client demand;
• builder awareness and knowledge.

The five barriers identified in the literature, namely; cost of grey water systems, government regulations, client demand, builder awareness and knowledge and health issues were all confirmed except for the health issues barrier.
Cost of Greywater Systems

Most of the respondents in both the surveys and the focus group discussions identified the cost of greywater systems as a barrier to the installation of greywater systems by builders, with several three (3) out of the four locations of the case studies having identified cost as a barrier. The surveys showed that 52% of the builders felt greywater systems expensive while 22% of the builders believed they were affordable with 24% of the respondents being undecided. The literature on greywater systems affordability is scarce, with work by Christova-Boal et al (1996) indicating that a survey carried out in Melbourne revealed that people had a strong preference for using greywater systems on gardens only if there was a short payback period for installing them therefore cost is certainly an issue for clients and consequently for builders as revealed in the study.

The findings are however consistent with work by Telegen (2005) who suggests that professionals within the building industry in the United States believe that sustainable design technologies inherently cost more. The builders within this study have certainly been consistent with the aforementioned study.

Government Regulations

The findings in the survey revealed that most of the respondents felt that Government regulations were supportive in terms of the uptake of greywater systems in general but there were no minimum Government regulations to force
all builders to install the systems. The respondents also felt the different Council regulations were non-uniform which can cause delays in the construction process.

The findings are consistent with work by Halliday (2008) who points that the planning and building control provisions can sometimes be used or strictly interpreted, (not necessarily deliberately) to stifle innovation and more sustainable construction. Therefore the approval process of greywater systems may be slowed down by mundane regulations that require paperwork to be filled out.

**Client Demand**

Client demand has been identified in this study as a barrier to the installation of greywater systems by builders therefore the finding is consistent with the literature as work by Colebourne (1993) identified customer demand as a major consideration for builders in the adoption of innovation.

Results from the survey show that 50% of the respondents as opposed to 32% felt that consumer demand is low which can be explained by the fact that most of the builders (58%) interviewed believed that consumer awareness is low.
**Builder Awareness and Knowledge**

There were two sub categories under the barrier of builder awareness and knowledge that were contained within the findings of the survey namely;

- General lack of builder awareness;
- Lack of information for builders.

The fourth highest barrier identified by the respondents from the survey indicated that there is a general lack of builder awareness with most of the respondents pointing out that there is no effort made by builders to get information on greywater systems hence the low rate of uptake of the systems. Furthermore, three of the eight respondents felt that greywater systems are a ‘plumber’s issue’ therefore they felt they did not require to know more about greywater systems.

Australian studies by Taylor (2006) and Troy, Holloway and Randolph (2005) suggests that there is some information available to the public regarding water reuse and that more educational campaigns are needed to change public perception of reuse. To some extent, this study has shown that the majority of builders (50% as opposed to 44%) believe that information on greywater is not adequate.
Health Issues

Health issues according to Hartley (2003) are regarded as a result of public perception regarding water reuse from an indirect potable use of recycled water where treated effluent is discharged into rivers. This therefore suggests that health issues may not be relevant for greywater systems which are for non potable use in Australia. Furthermore all the State Policies (Chapter 2) in Australia only recommend greywater use for non potable use hence the health issue may not be a concern in Australia which is consistent with the findings.

Health issues has been regarded as insignificant due to the fact that the survey did not confirm the barrier as being a significant contributor to the low uptake of greywater systems. Health issues were considered a barrier for builders under the focus group discussions because two locations, namely Melbourne and Geelong had discussed health issues as a barrier even though the builders knew little about greywater systems. The surveys did not confirm the findings of the focus group discussion with health issues considered insignificant by a majority (52%) of the respondents in survey.

However, not being the users of the greywater systems, their low regard for health may be understandable. Therefore the potential for this to be a serious barrier should not be underestimated.
Summary

In order to summarise the findings of the research, the five (5) of the six objectives of the research that help to answer the first of the primary research questions are outlined in Table 7.1 with the key findings obtained from the research assigned to each objective. The second research question is addressed under section 7.2.2.

Table 7.1 Summarised findings

<table>
<thead>
<tr>
<th>To determine the water use patterns in Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The water use patterns were studied under Chapter 2 where the general findings were that current water consumption is relatively high.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>To determine the current knowledge surrounding greywater use in Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 36% of the builders interviewed by phone indicated they had fitted greywater systems;</td>
</tr>
<tr>
<td>• The majority of the builders are not aware of what grey water is;</td>
</tr>
<tr>
<td>• The builders are unsure of Government regulations relating to greywater and greywater systems;</td>
</tr>
<tr>
<td>• Only 44% of the builders interviewed by phone knew what greywater was.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>To develop a typology of the greywater systems available to Australian builders</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A typology has been presented in Chapter 4 of the thesis outlining the difference between untreated greywater systems and treatment systems.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>To determine what builders currently know about greywater</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 50% of the builders interviewed by phone indicated that there is insufficient information available on greywater systems;</td>
</tr>
<tr>
<td>• 44% of the builders felt that the current information is adequate;</td>
</tr>
<tr>
<td>• 6% of the builders were not sure as they had not searched for information on greywater systems.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>To identify barriers to the installation of greywater systems by builders</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low Client demand;</td>
</tr>
<tr>
<td>• Cost of greywater systems;</td>
</tr>
<tr>
<td>• Government Regulations;</td>
</tr>
<tr>
<td>• Awareness is low (both builders and clients).</td>
</tr>
</tbody>
</table>
7.2.2 STRATEGIES TO ADDRESS BARRIERS

The strategies or solutions needed to address the barriers as identified in the preceding chapter of this study are;

- Economic and reliable systems would help increase consumer demand for greywater systems
- Creation of a website with link on greywater systems
- Educating the general public

The above strategies/solutions are discussed under Section 7.4 of this Chapter as recommendations for the industry. The focus group discussions were utilized in order to ascertain from the various builders, what they felt were the potential solutions to address the barriers. The above three were common in two or more of the four locations where the discussions were held.

7.3 RESEARCH PROBLEM ADDRESSED

The research problem has been addressed with several barriers having been identified, namely; cost of grey water systems, government regulations, client demand and builder awareness and knowledge. The study met all the objectives of the research as outlined in the preceding section and has therefore addressed the research problem.
The builders interviewed in the study have suggested potential strategies and solutions for reducing the aforementioned barriers including: economic and reliable greywater systems, creation of a website with link on greywater systems and educating the general public.

The next section of the Chapter will address and discuss recommendations for the building and construction industry regarding the reduction or elimination of the solutions identified within the study.

7.4 RECOMMENDATIONS FOR INDUSTRY

The research has outlined several barriers inhibiting the installation of grey water systems by builders. Part of the purpose or objective of the research is to identify possible solutions to the barriers and the following section discusses the solutions identified by the builders within the study.

The main solutions identified within the study and outlined in Chapter 5 of this thesis are as follows:

- Economical and reliable systems would help increase consumer demand for grey water systems
- Creation of a website or link on grey water systems
- Educating the general public

The main difficulty in identifying the above three as the main possible solutions to the barriers outlined within the research is that, the significance of the other
solutions offered within the focus group discussions are relegated and completely ignored. It should be noted however, that the adoption of grey water is considered to be at its infancy and therefore the aforementioned solutions may be just what the building industry needs in order for the systems to be readily adopted.

As outlined within the literature review in Chapter 3, a study by Hartley (2003) formulated a framework to help water resource professionals to help address the social and political complexity of adopting potable and water reuse and recycling. The framework includes five principles which provide guidance to members of the water industry and they include the following:

- manage information for all;
- maintain individual motivation and demonstrate organizational commitment;
- promote communication and public dialogue;
- ensure fair and sound decision making and decisions;
- build and maintain trust (Hartley, 2003).

The principles outlined above with exception to the fourth principle, assist in the formulation of solutions to the barriers outlined within the research as they provide a benchmark for what the solutions should strive to attain. The fourth principle would be necessary from a Water Authority or Government point of view when ascertaining what statutory decisions should be made regarding the use of grey water systems and is therefore not relevant for this research.
Manage information for all

Information regarding grey water systems should be managed for all builders irrespective of their physical location and in a form that is easy to understand. Two solutions namely; educating the public and the creation of a website or link help in the management of information for builders.

A website would ideally list the different grey water systems available within the market and enable builders to identify which systems are approved by the EPA. Builders have identified the internet as a key source of information in the interviews carried out hence a website would be a good way of promoting grey water systems.

Demonstrate organizational commitment

The Building Commission can show organizational commitment to sustainable development through the promotion of sustainable technology such as grey water systems by creating a web link on grey water systems and educating the general public. The Building Commission can undertake workshops and trade fairs that feature grey water system suppliers and manufacturers with builders and the general public invited to inform them about the different systems in the market.
Promote communication and public dialogue

Educating the general public on grey water systems is a solution offered by the builders that emphasizes communication and public dialogue. Educating the general public is an initiative that is somewhat difficult at industry level and would certainly benefit from Government level intervention as advertising can be a costly endeavour.

As mentioned before, trade fairs and workshops, can get the general public involved and informed about grey water systems. Problems can also be identified that stall the installation of grey water systems from a client point of view that have not been identified and hence can be addressed with the manufacturers of the systems.

Build and maintain trust

The builders at the focus group meetings suggested that economic and reliable systems would help increase consumer demand for grey water systems. This is not a solution that the building directly controls but is a solution that would help build and maintain trust within the general public. Manufacturers have a responsibility to consumers to produce systems that are reliable and cost effective so as more consumers can adopt sustainable technologies such as grey water systems. Educating the general public through the use of trade fairs that involve the manufacturers of grey water systems can assist in improving dialogue.
between builders, manufacturers and consumers in order to build and maintain trust with the ultimate consumers.

7.5 FURTHER RESEARCH

This research has a major drawback in the fact that the study is relatively small scale with the number of respondents within the phone interview surveys being small or medium enterprises (SME). The research would be more meaningful with a larger sample size, with the use of mail or email surveys over a larger geographical area in order to validate or correct some of the findings within this study.

It was not possible to ascertain if there were any links between the different barriers as the questionnaire designed for the phone interview was streamlined in order to accommodate for the time constraints that SME builders are face. Therefore the mailed or emailed study would compensate for this apparent weakness as they would certainly be longer.

Potential research into factors that improve or increase the adoption of sustainable technologies such as greywater systems would be an interesting topic area building on from this research topic as it would allow for progression within the industry. The literature reviewed in this study also showed that there is currently very little solution oriented research that would enable a framework for the building and construction industry to use as a guide to accelerate the
adoption of sustainable technology.
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Appendix A

MBAV Letter
June 23rd, 2008

Desmond Dinama
3/7 Dresden St
Heidelberg Heights, VIC, 3081

Dear Desmond,

Thank you for helping the Master Builders Association Victoria compile a research report on the Barriers to Greywater use in the building industry. The data was completed by the Master Builders for a report commissioned by the Building commission.

Your involvement in the project comprised a survey of Master Builders members that took place between August 2007 and March 2008 and involved a phone interview with 50 Master Builders members and a series of 4 focus groups where 15 builders (also members) were invited to each one.

As the person who collected the data we are happy to allow you to use the raw data which has been separated from the names of the people who it was collected from for use in your Masters Thesis in the School of Property, Construction and Project Management at RMIT University. We understand that in this format you are unable identify individuals or organisations and that you do not possess any personal information of the members who took part in the surveys or focus groups.

As individual people or companies cannot be identified the use of the data in this manner does not contravene the Master Builders privacy policy. Under the Master Builders privacy policy, we are able to approach our members for information regarding the compilation of statistical analyses or reports from time to time. A copy is attached for your information.

Philip Alviano
Sustainable Building Advisor
Appendix B

Questionnaire
SURVEY TO DETERMINE BARRIERS FOR BUILDERS IN INSTALLING GREYWATER SYSTEMS BY BUILDERS

### Introduction

1. Please indicate which of the following best describes you/your company

<table>
<thead>
<tr>
<th>Green Builder</th>
<th>Builder</th>
<th>Volume builder</th>
<th>Green Plumber</th>
<th>Plumber</th>
<th>Other Specify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Builder</td>
<td>Volume builder</td>
<td>Green Plumber</td>
<td>Plumber</td>
<td>Other Specify</td>
</tr>
<tr>
<td>Plumber</td>
<td>Green</td>
<td>Builder</td>
<td>Volume builder</td>
<td>Green</td>
<td>Plumber</td>
</tr>
</tbody>
</table>

2. How many projects would you complete in a year?

3. Are they mostly renovations or full homes?

<table>
<thead>
<tr>
<th>Renovation</th>
<th>Full homes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Which of the following best describes your understanding of grey water?

<table>
<thead>
<tr>
<th>a) toilet water</th>
<th>b) toilet + shower water</th>
<th>c) shower + kitchen</th>
</tr>
</thead>
<tbody>
<tr>
<td>d) shower + laundry</td>
<td>e) shower + laundry + kitchen</td>
<td>f) other: specify</td>
</tr>
</tbody>
</table>

5. Have you had any questions from clients about grey water?

### Section 1

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>disagree</th>
<th>undecided</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Information on grey water use is readily available.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>8. Grey water reuse is safe for non-human consumption in households</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>9. The government supports the use of grey water systems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>10. Consumers/client demand for grey water systems is high.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>11. I believe that current Government regulations support the installation of grey water systems by builders or developers.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>

198
I am aware of Government regulations regarding grey water systems.

I understand the Government regulations.

Consumer awareness with regards to grey water systems is high.

Grey water systems are affordable.

The installation of grey water systems in homes may have negative health implications for users.

The installation of grey water systems in homes may have a negative impact on the plants and soils.

I am aware of the different grey water systems available in the market.

I have installed grey water systems in previous projects.

**Section 2**

Have you installed grey water systems in any of your projects?

If Yes

<table>
<thead>
<tr>
<th>a) treatment</th>
<th>b) diversion only</th>
</tr>
</thead>
</table>

Why?

How many, and over what period?

If No

Why not
<table>
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<tr>
<th></th>
<th>In your opinion what are the current barriers for builders in installing grey water systems?</th>
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<tr>
<td>22</td>
<td>Is the current information on grey water systems adequate for builders? Yes No</td>
</tr>
<tr>
<td>23</td>
<td>Where would you go to get the information</td>
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<td>24</td>
<td>Any other comments regarding grey water systems/reuse?</td>
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Appendix C

Excel Results
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<th>Question</th>
<th>Survey 1</th>
<th>Survey 2</th>
<th>Survey 3</th>
<th>Survey 4</th>
<th>Survey 5</th>
<th>Survey 6</th>
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<td>5 to 7</td>
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<td>Cost for Builders</td>
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