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EVALUATING RESIDENTIAL SATISFACTION WITH AN INNOVATIVE DUAL WATER SUPPLY SYSTEM IN WATER SENSITIVE URBAN DEVELOPMENT

Raju Sharma Dhakal

Doctor of Philosophy

Edith Cowan University

Faculty of Business and Law

2013

Declaration

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Date:

Dedication

To my lovely daughter - Rubina Dhakal

Acknowledgements

I would like to thank my wonderful mother and father – Umadevi and Balkrishna Dhakal - for their unconditional love and support that enabled me to accomplish this PhD.

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Abstract

The Australian water industry is facing two major challenges: a rise in water demand due to a growing population and a decrease in rainfall availability due to a drying climate. This situation has triggered a re-evaluation of traditional water schemes and promoted consideration of alternatives for sustainable urban water management. One possibility is to replace drinking water usage in garden and outdoor irrigation with non-potable groundwater. This could save almost half of the water supplied in the residential sector, which is the biggest consumer of scheme water in most Australian cities. A major hurdle for the success of such fit-for-purpose groundwater schemes can be the lack of the resident's participation and support. Currently there are uncertainties about the dynamic nature of individual's attitudes in terms of satisfaction and accepting behaviours towards the fit-for-purpose water use. This can cause ambiguity in planning and implementation of such projects.

The main purpose of this thesis is to address the following specific research questions:

- What are the factors that determine residential satisfaction with and behaviours towards the fit-for-purpose groundwater system? and
- What are the implications of such water system for community, water utilities and urban planners?

These questions have been addressed through a quasi-experimental study utilizing two northern suburbs in Perth metropolitan: Ridgewood and "The Green". "The Green" is selected as an experimental suburb and Ridgewood is selected as a control suburb, which is a standard metropolitan suburb having the usual main drinking water system. The use of non-drinking groundwater through the dual water supply system in "The Green" began in 2008 alongside the main water scheme. A broad spectrum of parallel literature from many disciplines was drawn upon to inform the research. Concurrent preliminary informal conversations with local residents and a number of field observations were helpful in refining and contextualising the research hypotheses regarding the determinants of residential satisfaction with the fit-for-purpose groundwater supply system in the context of water sensitive urban development.

An exploratory mixed method approach was adopted starting with qualitative preliminary interviews with local residents to inform the development of a survey instrument. This was followed by the administration of the survey questionnaires at household level to collect

quantitative data to measure the relationship among variables and test a model of residential satisfaction. The survey data and the secondary data about residential water consumption were analysed to develop a workable model for residential satisfaction with and behaviour towards the dual water supply system and water sensitive urban environment. Finally, qualitative information during stakeholder interviews, meetings, and seminars was used to interpret the planning implications of the model and behavioural responses towards the water system and urban development.

The research results indicated that the majority of residents (70%) are satisfied with the non-drinking groundwater supply system in their home and neighbourhood. In "The Green", the household drinking water consumption was reduced by 40% compared to the metropolitan average; however, excessive garden watering exemptions for new garden establishment caused 30% more water usage in "The Green" than the metropolitan average. This study found that the major components of residential environment satisfaction were the neighbourhood, neighbours, and home. Home satisfaction in "The Green" was determined mainly by home attributes and the garden satisfaction, which in turn was dependent upon garden attributes and satisfaction with the groundwater system. In this way, groundwater satisfaction had an indirect impact on home satisfaction mediated by garden satisfaction. The major determinants of groundwater satisfaction were: positive perceptions of operational issues, and risk of groundwater use (negative relationship), and preference for continuation of the groundwater system after its trial period.

The major research findings are explained in Chapter Six, Seven, and Eight. The dynamic nature of community attitudes and community behaviours towards the fit-for-purpose water projects at urban settings were explored, and the planning and development consequences of the implementation of the alternative water systems were explained. The results of this study are highly applicable for water providers, urban planners, and community developers in promoting the successful implementation as well as improvement of fit-for-purpose water systems from a policy perspective. This thesis equally contributes to building knowledge and understanding of residential satisfaction and its relationship to innovative dual water systems in water sensitive urban environments. It facilitates the sustainable management and planning of urban water resources. The research also demonstrates the need to integrate general models of community satisfaction with specific water system attitudes to provide an indication of the role of water supply systems in the overall success of water sensitive developments.

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Glossary

Communal supply of non-drinking groundwater via dual water system is an innovative approach for urban water management and it is an emerging industry. However, the use and interpretation of different communal groundwater supply terms are inconsistent among water providers, urban planners and developers. Therefore, it is important to establish the meanings of the terms and clarify the intention of their inclusion in this thesis. Further, the meaning and intention of the psychological and statistical terms used in this research are to be clarified, which is done below.

In order to improve the consistency of the terms, the definitions are primarily sourced from the Western Australian State Water Plan (2007) and Water Corporation (WC)'s policy for sustainable water management 'Water Forever: Towards Climate Resilience' (2009). Additionally, some terms regarding non-drinking groundwater system were also taken from the memorandum of understanding (MOU), 'Health Risk Management Plan' of the NDG trial in "The Green", and 'Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)' (2006). Similarly, terms regarding the urban designs were defined according to the Western Australian Planning Commission (WAPC)'s policy for sustainable cities 'Liveable Neighbourhood' (2007). It should be noted that WAPC is reviewing the Liveable Neighbourhood (2007), and the final version is expected to be available in 2014. The psychological and statistical terms utilised in this thesis are taken from various relevant sources for explaining and resolving the research issues. The terms with their definitions are presented below.

Terms	**Description**
Acid sulphate soils	Acid sulfate soils (ASS) are soils or sediments (pH <4) which contain iron sulfides and/or other sulfidic minerals that have previously undergone some oxidation to produce sulfuric acid.
Adaptive behaviour	Refers to a human behaviour to adjust to another type of environment or situation than the usual or desired one.
Aquifer	Soil, sand, clay or rock below the land surface that contains water in recoverable quantities.
Behavioural science	Study systematic processes of human behaviour with the help of empirical data to investigate the decision processes and communication strategies

	within and between individuals in a social system.
Catchment	Area of land that collects rainfall and contributes to surface water (streams, rivers, wetlands) or to groundwater.
Caveats	Refers to the legal notice associated with the land titles, mainly to ensure the obligation of participation of "The Green" residents to the NDG system.
COAG	COAG is the Council of Australian Government, which is the main intergovernmental forum in Australia, comprising the Prime Minister (chair), State Premiers, Territory Chief Ministers and the President of the Australian Local Government Association.
Community	Refers to a usually small, social unit of any size that shares common values.
Community bore	A community bore is a centralised bore or a number of bores supplying groundwater to several properties for watering lawns and gardens and for irrigating public open spaces in the development.
Customer	An individual or organisation that has connection with the scheme water.
Conventional water system	Refers to the centralised system for distributing drinking water via the main supply scheme and collecting the wastewater via a sewerage system.
Demand management of water	Water demand management includes any action that reduces the drinking water use, or that maintains efficient water use than it otherwise would be. It is an intervention in order to reduce the consumption of water for achieving harmony between the demand and the availability of water.
Domain	Refers to the specific component of a socio-physical environment that acts like one unit in measuring individual satisfaction with the residential environment.
Domestic garden bore	Refers to the private bore that draws groundwater from the superficial aquifer for the irrigation of domestic garden (up to 0.2 hectares of land and for household use are exempt from licensing).
Dormitory suburb	Refers to an urban community that is primarily residential, from which most of the residents commute out to create their livelihood. Also known as bedroom suburb or commuter suburb.
Drinking water	Drinking water, also known as potable water, is water of a quality suitable for drinking, cooking and personal bathing.
Ecological sustainability	Refers to the 'types of economic and social development which sustain the natural environment and promote social equity' as in Diesendorf's (1997). It considers inter and intra generational equity, as a unifying principle of sustainability, maintained in terms of ecosystem, culture, bio-diversity, and

	enhancement of well-being (Diesendorf, 1997).
Epistemology	Refers to the enquiry about the relationship between the investigator (the knower) and the knowledge (what can be known) that is according to and highly restrained by the ontology.
Evaluation	Evaluation is a systematic determination of a subject's merit, worth and significance, using criteria governed by a set of standards.
Fit-for-purpose	Water that is treated to an appropriate quality level for its intended end use(s), as described in the "Australian Guidelines for Water Recycling: Managing Health and Environmental Risks, Phase 1" (2006).
Greenfield area	A large area of land zoned for urban development and located in the fringe of urban area.
Greywater	Refers to the used household water sourced from baths, showers, bathroom basins and laundries, but excludes water from the toilet (i.e., blackwater).
Groundwater	Groundwater is a reserve of water beneath the earth's surface in pores and crevices of rocks and soil.
Home	Refers to a place in which an individual or a family can rest and be able to store personal property. It is also related to a mental or emotional state of refuge or comfort. Also known as dwelling.
Human behaviours	Refers to the range of behaviours exhibited by humans that are influenced by culture, attitudes, emotions, values, ethics, authority, rapport, hypnosis, persuasion, coercion and/or genetics.
Indicator	Refers to an indirect measure (quantitative or qualitative) or a predictor of any performance. Indicators unlike raw statistics can assist with making a range of different sorts of comparisons as a result of having a common point of reference.
Interpretive paradigm	The interpretive paradigm concerns to understand the world as it is, to understand the fundamental nature of the social reality at the level of subjective experience. It seeks explanation within the realm of individual consciousness and subjectivity considering what passes as social reality does not exist in any concrete sense, but is the product of the subjective and inter-subjective experience of individuals.
Liveable neighbourhood	Also known as walkable neighbourhood, represented by approximate circles of 400-500m radius around proposed neighbourhood and town centres, superimposed over the structural plan.
Local groundwater	Refers to superficial groundwater extracted locally for fit-for-purpose uses

Main scheme water	Main scheme water is the piped drinking water for household use supplied through a centralised scheme that provides services to more than one community.
Managed aquifer recharge (MAR)	Refers to the intentional recharge of an aquifer under controlled conditions, either by injection or infiltration via ponds and galleries, in order to store a water source for later extraction and use, or for environmental benefits.
Measure	Refers to the dimensions, quantity, or capacity as ascertained by comparison with a standard, on which calculations can be made. In simple words, a measure is a number of quantities that records has an observable value and and has a unit.
Methodology	Refers to how the investigator accomplishes the enquiry about the social reality- with what approach, theory, and methods. The methodological question is highly guided by the ontology and epistemology.
Metropolitan	Refers to water and wastewater services provided in metropolitan urban areas having in excess of 50,000 connections.
Migratory behaviour	Refers to moving out from the current living place to a new living place
Mixed use development	The compatible mixing of a range of land uses, integrated in close proximity of each other to improve the efficiency and amenity of neighbourhoods, reduce travel demand, increase walkablility, and make more efficient use of available space and buildings.
Neighbourhood	Refers to an observable, delimited, geographic area of a primarily residential character. 'Liveable neighbourhood'(2007) considers it as an area defined by 400m or a 5 minute walk along the street from the neighbourhood centre.
Non drinking water scheme	A non-drinking water scheme substitutes a non-drinking water source for scheme water. It is also referred to as 'fit-for-purpose' or 'alternative water supply system'.
Non-drinking water	Non-drinking water or non-potable water is water not treated to drinking water quality, but it may still be used for many other purposes, depending on its quality. Non-drinking water sources can include groundwater, rainwater, stormwater, greywater and treated wastewater.
Objective attributes	Refers to the directly observable, physical conditions or circumstances of an environment that shape individual perceptions towards the environment.
Ontology	Ontology enquires what is the form and nature of realities. It deals with questions concerning what entities exist, and how they can be grouped, related within a hierarchy, and subdivided according to similarities and differences- so that particular facts or properties belong to them can be revealed.

Overused	Refers to situations where the total volume of water extracted for consumptive use in a particular system at a given time exceeds the environmentally sustainable level of extraction for that system due to over allocation or inadequate monitoring and accounting of allocated water.
Paradigm	Paradigm is a set of ontological and epistemological assumptions. It refers to an implicit or explicit view of social reality that includes different schools of thoughts for approaching and explaining the shared world view.
Positivist paradigm	Refers to an enquiry approach, which assumes that the social world is composed of relatively concrete empirical artefacts and relationships which can be identified, studied, and measured through approaches derived from natural sciences (Burrell and Morgan, 1980). The positivist (or functionalist) paradigm is primarily regulative and pragmatic in its basic orientation, concerned with understanding society in a way which generates useful empirical knowledge.
Private open space	Means an area of land which is suitable for private outdoor living activities.
Public open space	Refers to land used or intended for use for recreational purposes by the public and includes parks, public gardens, foreshore reserves, playgrounds, and sports fields but does not include regional open space and foreshore reserves.
Qualitative	Refers to a type of information which deals with apparent qualities (subjective properties). It is observable (such as satisfaction, happiness) but can't be quantified in numeric units.
Quality of life	Refers the enjoyment of life at a basic level, which includes being happy and healthy, rather than being wealthy. In simple words, it is the fulfilment of needs that generates satisfaction with life (a personal psychological experience), which is not dependent upon the material possessions or external conditions of life.
Quantitative	Refers to a type of information based in quantities or else quantifiable data (objective properties). It is observable, measurable and computable in numeric units.
Rainwater	Rainwater is water collected directly from roof runoff from domestic or commercial buildings.
Rainwater tanks	A rainwater tank is a storage unit which holds the runoff from roofs.
Residential density	Means dwellings per hectare of a development site or aggregation of sites.
Residential environment	The socio-physical environment, in which the people live and that is used and experienced, rather than simply looked at. It has three fundamental

	dimensions- the dwelling (home), the neighbourhood, and the neighbours (representing social dimension).
Rural and regional	Refers to water and wastewater services provided for rural irrigation and industrial users and in regional urban areas with less than 50,000 connections.
Salinity	The presence of soluble salts in soils or waters.
Sewage or wastewater	Refers to the water used by households and business that is disposed of through the sewerage network (or into septic tanks in unsewered areas).
Sewer mining	Refers to the process of extracting untreated wastewater from the sewerage network and treating it on-site in a treatment plant for reuse.
Sewerage system	A sewerage system collects the wastewater from domestic, commercial and some industrial premises and treats it to a required standard for discharge at a wastewater treatment plant.
Siting area	Refers to the area where the building, plant or project would be constructed or developed.
Social sustainability	Refers to 'a positive social condition in terms of equity of access to key services such as: health, education, transport, housing etc.; intergenerational equity; political and cultural harmony; and community sense, ownership and responsibility' as in (McKenzie, 2004).
Society	A society is a group of people involved with each other through persistent relations, or sharing the same geographical or social territory. A society can also consist of like-minded people governed by their own norms and values.
Source water	Refers to the water in its natural state, before any treatment to make it suitable for drinking.
Spray irrigation (Sprinklers)	Water is applied to the plants and soil by spraying, usually from pipes with fixed or moving spray nozzles.
Stakeholder	Refers to a person or group (an industry, a government jurisdiction, a community group, etc) that has a common interest or concern in something.
Stormwater	Refers to the urban surface water runoff from rain events.
Strategic development studies	Refers to the studies on 'Strategic developments', which in this research is related to the urban water system. Those studies mainly focus on the role of strategic development in urban water management to change the customer's water using behaviours by creating awareness, planning and developing alternatives and producing the outcomes in terms of water conservation and efficiency.

Streetscape	Refers to the visible component in a street between the facing buildings, including the form of the buildings, garages, setbacks, utility services and street furniture such as lightings, signs, barriers and bus shelters.
Structure plan	Refers to a plan showing in outline the overall development intentions for an area, including land use, major transport and utility networks, drainage and/or urban water management, open space systems and indicative built form.
Subdivision	Refers to the division of a cadastral parcel of land into two or more lots which can be disposed of separately.
Subjective attributes	Refers to the non observable but measurable attributes (say perceptions) that are related to the individual's experiences of the environment. When an individual perceive and evaluate an objective attributes, the subjective attributes generates.
Surface Water	Water that flows over land and in water courses or artificial channels and is able to be captured and stored and supplemented from dams and reservoirs.
Third pipe scheme or Dual water supply system	A third pipe scheme provides non-drinking water to multiple users as an additional water supply network to the mains scheme that supplies drinking water and the sewerage scheme that takes used water away from the house. A third pipe scheme is also referred to as 'Dual water supply system' – a pipeline providing drinking water and a pipeline providing non-drinking water to the user.
Treated wastewater	Refers to wastewater after it has passed through treatment processes to reduce its nutrient and bio-chemical load. Subject to the intended use, treated wastewater has to undergo further treatment to provide a fit-for-purpose water quality for reuse.
Urban density	Refers to the dwelling yield from a hectare of residential land comprising 10 percent public open space, 25 percent streets and 65 percent lots.
Verge	Refers to a part of the street reserve between the road and the boundary of adjacent lots (or other limit to street reserve) that may accommodate public utilities, footpaths, stormwater flows, street lighting poles, street trees and other landscaping.
Volumes of water	One litre - 1 litre - 1L One thousand litres (1,000 litres) - 1 Kilolitre – 1 KL One million litres (1,000,000 litres) - 1 Megalitre – 1ML One thousand million litres (1,000,000,000 litres) - 1 Gigalitre – 1GL

Walkable neighbourhood	Refers to the area defined by a 400m or a five minute walk from the neighbourhood centre having an interconnected and safe walkable street network where shops, schools, public transport, community facilities and other buildings front the streets.
Water Allocation	Refers to the specific volume of water allocated to water access entitlements in a given season, defined according to rules established in the relevant water plan.
Water conservation	Refers to the activities that save the scheme water, mainly by using less water, controlling wastages and leakages, and or replacing with fit-for-purpose water.
Water efficiency	Water efficiency means using less water to provide the same level of service or to get the same result.
Water sensitive urban designs	The integration of urban planning, with the management, protection and conservation of the urban water cycle, that ensures urban water management is sensitive to natural hydrological and ecological processes.
Water types (based on salt levels)	Fresh water: Less than 500mg of salt per litre Marginal water: Between 500–1,000mg of salt per litre Brackish water: Between 1,000–5,000mg of salt per litre Saline water: Between 5,000–35,000mg of salt per litre Hyper-saline water: More than 35,000mg of salt per litre

Abbreviations

ABS	Australian Bureau of Statistics
AERA	American Educational Research Association
AHMC	Australian Health Ministers’ Conference
APA	American Psychological Association
ARCWIS	Australian Research Centre for Water in Society
ASS	Acid sulphate soils
CFA	Confirmatory factor analysis
COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DoEC	Department of Environment and Conservation
DoH	Department of Health
DoHw	Department of Housing
DoW	Department of Water
DWSS	Dual Water Supply System
ECU	Edith Cowan University
EFA	Exploratory Factor Analysis
EIA	Environmental Impact Assessment
EM	Expectation Maximization
EPHC	Environment Protection and Heritage Council
ESD	Ecologically Sustainable Development
GoWA	Government of Western Australia
GW	Groundwater
IWSS	Integrated Water Supply Scheme
KMO	‘Kaiser-Meyer-Olkin’ measure
LR	Linear Regression
MAR	Managed Aquifer Recharge
MDT	Missing Data Technique
MOU	Memorandum of understanding
NB	Neighbourhood
NCME, USA	National Council on Measurement on Education, United States of America
NDG	Non-drinking groundwater
NRMMC	National Resource Management Ministerial Council

NWC	National Water Commission
NWI	National Water Initiatives
PAF	Principal Axis Factoring
PCA	Principal Component Analysis
PDWSA	Public Drinking Water Source Areas
POS	Public open spaces
PSDP	Perth Seawater Desalination Plant
SE	Social environment
SSDP	Southern Seawater Desalination Plant
UD	Urban Design
WA	Western Australia
WAPC	Western Australian Planning Commission
WC	Water Corporation
WCED	World Commission on Environment and Development
WSAA	Water Service Association Australia
WSUD	Water Sensitive Urban Designs

VOLUME ONE

CHAPTER 1: Introduction

1.1 Introduction

Over the last three decades, the challenges to urban water providers have been growing because of the increasing population and drying climate. This situation limits the possibility of the conventional 'big pipe engineering approach' for single use only and demands the application of alternative water systems aiming for water efficiency and conservation (Syme, 2008). The social impediment is one of the crucial obstacles pertaining to the successful implementation of alternative water management approach in an urban setting (Porter, Green, Tucker, Russel, and Nancarrow, 2006; Dzidic and Green, 2012), which is still not well understood. This thesis aims to provide the theoretical knowledge about the constructs for evaluating community satisfaction with an innovative water supply system in urban development. Additionally, this thesis explores the issues regarding the sustainability and planning implications of such alternative water supply schemes. These issues will be explained fully in subsequent chapters utilising the communal non-drinking groundwater scheme in "The Green", a northern suburb of Perth, Western Australia (WA).

1.2. Research questions and aims

The principal aim of this study is to investigate the social and behavioural factors that affect residential satisfaction with the Dual Water Supply System (DWSS) in water sensitive urban environments. This study is motivated by the goal of understanding community responses to environmentally beneficial integrated land and water management practices at a local scale.

"The Green" is a water sensitive land development trial project in a northern suburb of Perth that involves a non-drinking groundwater (NDG) scheme in addition to the regular drinking water supply via a dual pipe network. The drinking water supply is for in-house use and NDG is for outdoor use, especially for watering private gardens, and public open spaces (POS). The overarching objective of this trial development is overall water efficiency and water conservation at a community level. To achieve this objective, “The Green” has implemented demand management practices along with an innovative NDG scheme and water sensitive urban designs (WSUD), which provides the foundation for this research.

The wider issues of community concerns and residential satisfaction with such unique land and water management practice in an urban setting need to be explored to identify constraints and opportunities for sustainable urban water management. This study conducts an evaluation of the unique NDG trial of “The Green” to provide useful insights about community responses and behaviours relating to the NDG system in the water sensitive urban development. This has been achieved mainly by addressing the four main research questions:

1. What are the key factors of community satisfaction with NDG system?;
2. How does satisfaction with NDG system impact residential satisfaction?;
3. What are the impacts of the NDG system in water conservation and water efficiency? and
4. What are the implications of the NDG system for urban water planning?

The findings on these enquiries will be beneficial for water authorities, urban planners and developers for successful implementation and better management of such alternatives. These enquires provide a deeper understanding on the social and behavioural issues pertaining to the community attitudes and responses towards the alternative water system in an urban setting. Concurrently, these enquiries assist in achieving a number of specific aims of this research. The specific aims are developed to serve the main research by providing rich information on the research topic from different perspectives. These include:

1. To develop a model of residential satisfaction with NDG system in water sensitive urban environment;
2. To examine the utility of the centrally controlled NDG system to meet the community’s watering needs, reduce water demand and enhance overall water efficiency;
3. To explore the implications of the residential satisfaction with NDG system and the water efficiency of the trial in sustainable urban water planning; and
4. To make some policy recommendations regarding social acceptance and sustainability of innovative urban water management.

This study builds on the existing knowledge from a wide range of literature regarding climate change, urban development, alternative water management practices, and community attitudes towards the alternative water systems. The gaps in knowledge identified during this process will assist to shape the research enquiries for this study. This study utilises the NDG scheme in “The

Green” to accomplish the aims to develop the theoretical knowledge to fill the gaps. The theoretical contributions of this research are explained later in this chapter that adds to the body of knowledge in the area of residential satisfaction and implementation of dual water systems in urban residential setting of WA.

1.3. Research issues

1.3.1. Challenges to urban water resources

Water is a very precious resource. Throughout the world, the pressure on fresh water resources has been increasing tremendously. This is mainly due to the increasing demand for residential, industrial, and agricultural consumption on the one hand and because of the decreasing rainfall caused by the drying climate on the other hand. The growing number of cities, where a large population lives in a small geographical area, multiplies the pressure on water authorities to provide safe and reliable water supply from a limited available water resources. This demonstrates a challenging future and how difficult it is getting to meet the gap between water demand and supply. In this situation, the traditional water management approaches will no longer be sufficient and sustainable. Therefore, innovative approaches compatible with increased population, climate change and rainfall variability are needed to achieve sustainability in water resource management.

Urban water utilities endeavour to provide an efficient and effective supply of potable water to the residential and industrial areas and removal of the wastewater produced therein. The age-old practice of conventional water management in Australia was “Big pipes in and big pipes out”, which describes the process of supplying treated water through big pipes to the end users and once used, discharging the wastewater through big pipes to a distant environment (Troy, 1996). When the demand for water increases, the conventional system responds either by getting more from existing sources or by harnessing new surface or groundwater sources (Syme, 2008). The approach of relying only on surface water or groundwater is no longer sustainable due to a reducing inflow into dams and reservoirs, and a depleting groundwater levels due to the decreasing rainfall in a drying climate (Water Corporation, 2009).

Australian water authorities have adopted several strategies for responding to such growing water demand in residential settings. One strategy is demand management through persuasion, incentives, restrictions, and mandatory provisions (for example- mandatory dual flush toilets in new homes and retrofitting in existing properties). Demand management has been regularly practiced as a water saving strategy since the 1970's drought (Syme and Nancarrow, 2011). Additionally, the provision of blocked-tariff pricing has contributed to reducing per-capita water consumption. These strategies have had some success in decreasing household water demand but have become insufficient to meet the ever increasing water demand due to a rapid population growth. The pressing need to increase water supply is a priority concern for urban water planners. However, increasing supply from the existing sources is infeasible with the drying climate. Similarly, the potential to develop new sources is limited as most easy options have already been explored or implemented (Water Corporation, 2009).

1.3.2. Fit-for-purpose water system

One way to secure sustainable water resource management is to develop alternative water systems that utilize possible available water resources for fit-for-purpose uses, so that the drinking water demands for non-potable purposes can either be replaced or reduced. For example, stormwater, rainwater, and recycled water could be used for 'other than drinking' purposes depending upon quality of the water. These fit-for-purpose water sources can thus retard the conventional strategy of 'big pipe in big pipe out' with the help of site-specific water schemes (Newman, 2001).

The 'fit-for-purpose water use' is not a rapid technological development or a 'quick fix'. It is a gradual process replacing drinking water use with non-drinking water in activities where potable quality water is not essential. When considering fit-for-purpose water strategies, the desalination option is usually included in the discussion. The choice to adopt desalination depends on several factors such as: the availability of other options, environmental impacts, the long run opportunity costs for each available supply option, and stakeholders' perceptions. To some extent, desalination is an immediate and large scale solution that can meet some of the pressure from the growing population and drying climate. However, small scale and diversified solutions could present 'cost effective' and 'sustainable' opportunities to achieve similar solutions while obtaining wider social benefits (Mitchell, 2006).

With the aim of sustainable water resource management in Australia, The Council of Australian Governments (COAG) signed and developed an intergovernmental agreement on water policy - the 'National Water Initiatives (NWI)' in 2004. The NWI is a national approach that manages, measures, plans for, prices, and trades water resources throughout Australia (National Water Commission, 2013). Every state signing the NWI was to develop their state water planning to reflect and achieve the objectives of NWI, and manage the state water resources for the long term. The NWI (2004) as well as the Western Australian State Water Plan (2007) considered water sensitive urban designs and fit-for-purpose water supply via dual water system for sustainable management of water resources at a local and district level (Western Australian Planning Commission, 2008a).

Following the guidelines of NWI (2004), State Water Plan (2007), a fit-for-purpose NDG supply via a separate piping network has been implemented as a five year trial for “The Green” community at Butler, WA. “The Green” is a north-west suburb of the City of Wanneroo and is situated 35 kilometres north to Perth. The NDG network, comprised of five communal bores, extracts and supplies local groundwater for watering residential gardens and public parks. Thus, the communal bore network replaced the drinking water use in garden watering, and targets a reduction of 30% household water consumption and 40% POS usage in comparison to the average metropolitan suburb. The groundwater system is automatically operated overnight on the basis of weather information provided by a local weather station. There are several technological innovations involved in the groundwater system, such as: in-situ soil moisture sensors to avoid over watering, subsurface drip reticulation to deploy water efficiently, a reduction in lawn areas and use of the native plants in gardens to demand less water. Further, the water sensitive designs, such as: porous pavement, bio-retention trench and basins, grassed swale, and sand filters control stormwater at the source and increase groundwater recharge. These innovative technologies and designs are supposed to support the sustainable groundwater supply to the NDG system.

1.3.3. Community attitudes and responses

Community concerns play a significant role in determining the success of any alternative water system. This is also true for the non-drinking groundwater trial. Western Australians and local communities have been utilising the groundwater via private domestic bores for watering their gardens for at least a century, and therefore were likely to accept the introduction of a community bore system into their neighbourhood. A major change was that private bores are personally controlled, whereas communal bores are centrally controlled by a third party. Therefore, it would be unwise to presuppose such acceptance and positive feedback from the community without understanding the wider community nuances. Further, community attitudes can change between pre-development and post-development situations when the water using activities become more personal. Therefore, a continuous monitoring of their attitudes is necessary to achieve the success in implementation and management of the NDG trial.

Another challenge for water authorities and urban planners is the gap in knowledge relating to the social impact of the innovative water systems. In the past, community attitudes were assumed to be obstacles for alternative water systems, therefore persuasion and marketing approaches were emphasized to promote acceptance. However, these approaches were often ineffective (Po, Kaercher, and Nancarrow, 2003). In this context, it is essential to conduct research to determine community attitudes and behaviours towards alternative water systems.

The implementation of the NDG trial in “The Green” provided the foundation for this current research project. This study aimed to explore and understand community attitudes and behaviours towards the NDG trial and associated urban developments. The attitudes were measured in terms of residential satisfaction with the NDG system and the urban environment, and the corresponding water consuming behaviours were evaluated. This simultaneously explored the residential satisfaction and the associated relationship with behaviour. The newly developed NDG system is considered an integral part of “The Green” development (Davis and Farrelly, 2009b; Satterley Property Group, 2010b). Hence, this study aimed to link the satisfaction with the NDG systems to the overall residential satisfaction and then to behavioural responses towards the water system and residential environment.

As this is the first attempt to evaluate the satisfaction with dual water system in an urban residential setting, this research adopts an exploratory approach for identifying the variables and their measures and developing them into valid and reliable constructs. To bridge the theoretical gaps in knowledge about satisfaction with the new urban water system, parallel literatures examining the urban water management and community attitudes and behaviours were utilised.

The findings of this study will contribute to address the gap in the knowledge and provide useful guidelines to urban planners, water providers, developers, and local government regarding the community concerns and responses towards the alternative dual water systems. This will also be useful for the water management authorities who deal with the community to implement alternative water systems, to improve attitudes towards the alternatives, and to encourage the water conserving behaviour at urban residential settings.

1.4. Contribution to knowledge

The research is interdisciplinary in that it integrates water management, engineering and urban structural planning with human psychology and sociology. This integration contributes in generating a new understanding of residential attitudes and behaviours towards an innovative water management in an urban setting, where water planning leads the land planning. In addition, this research contributes in undertaking a post-land development study of an innovative urban water management practice, which examines the changes in residential attitudes and behaviours from the pre-development condition. The innovative NDG trial as a part of the dual water system is evaluated in terms of residential satisfaction with the system and the associated developments. This, when linked with the actual water and land using behaviours, portrays the impact of innovative urban water management to residential satisfaction and behaviours.

The main focus of the research is to explore the quality of life in water smart urban environment. The research further delves into the social and environmental issues of the unique alternative water system in newly established Greenfield development in WA. The research had access to the people who planned and developed the unique water system and water smart community, and performed a comparative study with the help of standard metropolitan suburb as a control setting. Hence, the thesis underpins the pragmatic aspects of such unique urban development planning regarding the community satisfaction and their behavioural responses towards the development.

The research findings will contribute to the body of knowledge of residential satisfaction that in turn, will be important for a number of practical implementations. Firstly, this research not only measures the residential satisfaction and behaviours but also explains the variations in pre- and post-development situations. Secondly, this research explains the impacts of the urban water system for the variation in residential satisfaction and behaviours. Finally, the research findings will be useful for formulating government policy, planning framework, and implementation guidelines for water utilities, urban planners, local councils, and developers regarding community preference, attitudes, and water using behaviours towards the innovative urban water management alternatives.

A detail description of the research plan is provided in the next section. Knowledge from previous studies was gathered and applied to specific research conditions to generate new knowledge about the community attitudes and behaviours that contribute towards novel urban water management approaches. The whole process for the knowledge development process is described in the different chapters of this thesis as explained below.

1.5. Outline of the thesis

This thesis comprises nine chapters. The introductory chapter provides an overview of the research aims, research questions, and the outline of the entire research process. Chapter Two outlines a detailed description of the background and literature review regarding the urban water crisis, alternative water management, community acceptance and satisfaction, and sustainable urban water management. This chapter draws on knowledge from two diverse disciplines: strategic development studies of alternative water planning in urban residential settings; and psychological studies of quality of human life and satisfaction with the residential environments. This chapter integrates those two disciplines and provides the theoretical basis for possible interactions of the residential satisfaction and behaviour with the innovative water alternatives in an urban residential setting. This chapter also explains previous studies and outlines the gaps regarding:

- Innovative urban water management, and
- Residential satisfaction with urban environment

Building on empirical studies, Chapter Two explains the significance of this study and how it will fill the gaps in knowledge, especially in terms the role of the innovative water alternatives in residential satisfaction with the urban residential settings. This chapter also reviews the tools and method used in previous studies in both literatures, and makes a case for justifying the mixed approach adopted in this research.

Chapter Three outlines the historical planning, implementation and development of the NDG trial at "The Green". This chapter provides brief description of different agreements between the stakeholders about their roles and responsibilities as well as associated statutory regulations. This chapter elaborates on the structure, operation and regulation strategies of the dual water system at the residential level. Further, this chapter explains the outcomes of the field observation and informal talks with local residents in the research area. The observations as well as the informal discussions assisted in focusing the literature review and preparing the conceptual framework for this research.

Throughout the Chapter Two and Three, a list of observations are prepared on the research issues and gap in knowledge that are backed by the empirical studies and field visits. The observations are categorised into six different research propositions that are aligned with four major research themes (or research questions). Chapter Four explains about the research themes, research propositions, and subsequent research hypotheses that are built on the observations in Chapter Two and Three; and tested and explained in Chapter Six, Seven, and Eight in this thesis.

Following the research proposition and hypotheses, Chapter Five starts with the conceptual framework that guides the next phase of this research: data collection, which is commenced with qualitative interviews with local residents. Chapter Five mainly discusses the overall methodology and specific methods used in this research. This chapter explains and justifies the exploratory research approach with a mixed methodology. Furthermore, Chapter Five provides the details about the study areas and participants' selection and instrument development process. Finally, this chapter provides detailed explanation on each research tools and activities that were used to complete the research program including data collection, and data analysis.

The data analysis and research findings are included in Chapter Six, Seven, and Eight. These chapters explain the qualitative and quantitative data analysis of preliminary interviews, household survey, secondary data and stakeholders' interviews, meetings and seminars. The three chapters outline the results from the respective studies in sequence, i.e., starting from the results of preliminary interviews that develop the research instrument (survey questionnaire), the household survey results that test the research questions and develop a model of residential satisfaction with NDG system and urban environment, and finally the results from secondary data and stakeholders' interviews and meetings that interpreted the utility and planning implication of the NDG system and residential satisfaction with the system in the context of WA.

The three result chapters provide a path for the critical discussion of the research findings, detailed in Chapter Nine. Chapter Nine provides a rigorous discussion on the results and the model obtained from the research. This chapter compares the results with previous studies, discusses the results by drawing knowledge from multiple sources, and validates and interprets the results from different analytical perspectives. In this way, the thesis explicitly describes the community response to NDG system as an alternative approach to ease water challenges in urban settings and develops a model of residential satisfaction with the dual water (NDG) system. In addition, it outlines the planning recommendations for better implementation of the NDG system and improving community satisfaction with the system in WA context.

CHAPTER 2: Literature review

2.1. Introduction

This chapter outlines empirical studies about the topic under investigation. It draws on the knowledge from two diverse disciplines: strategic development studies of alternative water planning in urban residential setting; and psychological studies of quality of human life and satisfaction with residential environment. This chapter provides a detailed description of the background and literature review regarding the urban water crisis, innovative urban water management, community acceptance, residential satisfaction and sustainability of alternative water planning. This chapter provides a description of and theoretical basis for possible interactions of the residential satisfaction and behaviour with the innovative water alternatives in an urban residential setting, so that the community responses towards such innovative water system and urban development can be evaluated. Additionally, this chapter utilises the literatures on the acceptance of alternative water systems in order to develop a concept of satisfaction with the innovative dual water system. Then, the satisfaction with the dual water system is linked to the overall environmental satisfaction and residential behaviour towards the water system and the environment. This leads to a complete model of residential satisfaction and behaviour towards the innovative water alternatives in an urban residential setting.

In this way, this chapter explains previous studies and outlines the gaps in knowledge regarding:

- Current water challenges and need for innovative approaches;
- Sustainability and community concerns; and
- Residential satisfaction and behaviour.

This chapter commences with the description of the current water crisis that is mainly due to the rapidly growing population and the drying climate. This is followed by the description of available alternative opportunities in urban water management to resolve the water crisis. The development of one such alternative water supply system in the study area is then briefly explained. Then different aspects and critical issues of community responses towards such alternative water systems are identified and explained. This provides the basis for establishing the residential satisfaction concepts using the theories of community acceptance of alternative water systems. This chapter also includes and explains the theories as well as critical issues regarding the environmental sustainability of such alternative water systems. Building on these empirical studies, this chapter identifies a number of gaps in knowledge regarding residential satisfaction with an innovative water system in urban residential settings. Additionally, the experience of an innovative water trial helps to inform and develop a number of research propositions and hypotheses that will be tested in this study.

2.2. Water resource management

This section details the essence of alternative water schemes to resolve the urban water crisis in the light of drying climate. No matter how technologically innovative the alternatives are, the success of the alternatives greatly depends upon positive support of the end users (community) (Po et al., 2005; Hurlimann, 2008). Even after the implementation, community perception and behaviours towards the alternative water systems are very important for sustainability of such alternatives. In this way, the post-development assessment of the innovative urban water alternative in terms of community satisfaction is utmost necessary. This section also elaborates the importance of community satisfaction with alternative water systems and its planning implications that is beneficial for urban planners, developers, and governments in formulating guidelines and policy for better implementation and improved adoption of such alternative systems in future.

2.2.1. Climate change

Australia is one of the driest inhabited continents in the world but paradoxically it has the highest per capita water consumption (>100KL/person/year). Approximately 93% households are connected with the main (town) water scheme and main use activity is garden and lawn watering (>40% of household consumption) (Australian Bureau of Statistics, 2013b). The Australian mean temperature has increased by 0.9^{0}C from 1950 to 2005, and is predicted to increase by another 1.0^{0} by 2030. At the same time, there has been a substantial decline in rainfall in the east coast, Victoria and south-west Australia since 1950 to 2005, which is predicted to decline a further 2-5% all over Australia, but by 10% in south-west Australia by 2030 (CSIRO, 2007). Moreover after prolonged drought, the extreme rainfall events causing flooding are rising faster than the trends in mean rainfall all over Australia, mostly in eastern Australia. The weather pattern suggests that Australia is facing climate uncertainties with regards to the water availability. This situation has triggered debates among the stakeholders and planners for the sustainable management of water resources. This understanding has been reflected in strategic planning and policies for urban water management all around Australia; however, it has been very rarely translated into implementation (Mercer, Christesen, and Buxton, 2007; Syme, 2008; Brown and Farrelly, 2009).

The climate change has hit hard in the southern part (Perth-Bunbury) of WA. A recent study by the Department of Environment and Conservation, WA found that the rainfall is predicted to decrease by a further 2-20% and temperature is predicted to increase by 0.5-2.1^{0}C by 2030 (Department of Environment and Conservation, 2011b). As a result of climate change in South-West Australia, the average annual inflow to major dams and reservoirs of Perth was reduced from 338 GL during 1911–1974 to 177GL by 2000 (almost half in 25 years time), and further reduced to 65.8 GL by the end of 2012, which is less than 20% of the inflow during 1911-74 (Water Corporation, 2013b).

The implications of such climate change projections are wide-ranging. As a consequence of reduced rainfall and increased temperatures, droughts will occur more often and be more severe. The drying climate has already reduced the amount of water entering into major dams around Australia and this trend is likely to continue in future (Department of Environment and Conservation, 2011b). In recent years, eastern Australia has experienced extreme flooding events after prolonged droughts. Such extreme weather patterns have devastating impacts over a wide-range of urban communities. The climatic uncertainty could jeopardise Australia's agricultural industry, infrastructure, and community development.

2.2.2. Population growth

Australian population, concentrated in major cities lying in coastal plains, has grown very fast especially in the last few decades. According to Australian Bureau of Statistics (ABS), the total population of Australia in 2012 was 22.6 million and the population growth rate was 1.6%, a decrease from 1.8% during 2004-09. However, WA is the fastest growing state with average growth rate of 3.3% in 2012, an increase of 2.4% during the 2004-09 period (Australian Bureau of Statistics, 2013a). The population of WA has almost doubled in last 30 years, and at current rate, is predicted to double by 2030 (Western Australian Planning Commission, 2010). Most

Western Australians live around Perth metropolitan and suburban areas of the city, which is predicted to experience substantial population growth in the coming decades. The impact of the population growth will be widespread for the sustainable resources management. This, when coupled with reduced rainfall will increase water demand for residential, agricultural and industrial purposes, and will provide major challenges for the Water Corporation to meet the soaring water demand (Fane and Patterson, 2009).

2.2.3. Water crisis

In this way, growing population and drying climate in Australia impose a huge pressure on water authorities to secure future water supply to meet the demand. To meet the water demands of increasing population at midst of climatic uncertainties, water authorities need a robust adaptation and resilient sustainable strategy to deal with the climate change. Currently, adapting to the climate change is the major driver of activities in the urban water industry (Water Service Association of Australia, 2009). The majority of work being undertaken is to develop an integrated water management practice, where alternative water sources are developed to mitigate the risks associated with the climate change. It is accepted that if diversified water sources can be developed, then the water supply would be more sustainable by having lower reliance with the rainfall availability (Water Service Association of Australia, 2009).

Reducing current water consumption, increasing water recycling and reuse, and developing new water sources are three major options for securing future water supply. The possibility of developing any new water sources is limited and resource exhaustive. The surface water source is limited, and it is expensive to build dams and big pipes for transferring water. Similarly, a substantial investment is required to install desalination plants. Further, developing a new water source always attracts significant community concerns.

In WA, the rainfall has declined by more than 15% since 1975, resulting a 60% reduction in runoff into major metropolitan dams and surface reservoirs (Government of Western Australia, 2007; Barron et al., 2010). During 2006-12, the average annual inflow into major dams of Perth metropolitan was only 68 GL, which is only 20% of the inflow during 1911-74 (Water Corporation, 2013b).

The reduced inflow into dams and reservoirs ultimately resulted in the reduced availability of water for supply, causing a significant pressure to water authorities who are responsible for meeting the increasing demand. The challenge to mitigate the gap between the divergent water demand and supply in urban area has been driving most of the activities of water utilities. As a response to the water crisis, harnessing every possible water source has been the priority of WA Water Corporation. In addition, the 'demand management' to reduce water consumption, 'water recycling' at small and large scale, 'water reuse' at residential and industrial settings, and the development of 'alternative water supply systems' at local level, have become the vital components of the integrated water management policy. These diversified sources in an integrated approach are intended to secure Western Australian future water supply (Water Corporation, 2009).

2.2.4. Integrated approach for water supply

In 2005, the Water Corporation developed an Integrated Water Supply Scheme (IWSS) as a long term plan for future water source development by assessing the rate of water demand in the future; the desired reliability of water supply; and the average water yield from existing and future sources. The IWSS (2005) was developed to "ensure that water supply solutions are progressed, ahead of time, to a point of readiness for implementation". It further identified the importance of integrated source development (existing and new), water conservation and reuse, and development of climate independent sources (desalination), which could be explored and developed into an integrated water strategy (Water Corporation, 2005). However, the 'Water Forever' plan prepared by the Water Corporation (2009) identified the need for developing more flexible and adaptive portfolio approach to address the ever increasing gap between water demand and availability. This included rigorous water conservation, water recycling and reuse, and developing existing and new water sources.

Surface water

The readily available safe drinking water was once taken for granted in WA because the state had a consistent rainfall pattern, and therefore reliable stream-flow and abundant groundwater (Water Corporation, 2010). Paradoxically, WA now is in the third decade of drying climate and has experienced a severe decline in rainfall since 1975, which has reduced the stream-flow and availability of water to dams and reservoirs.

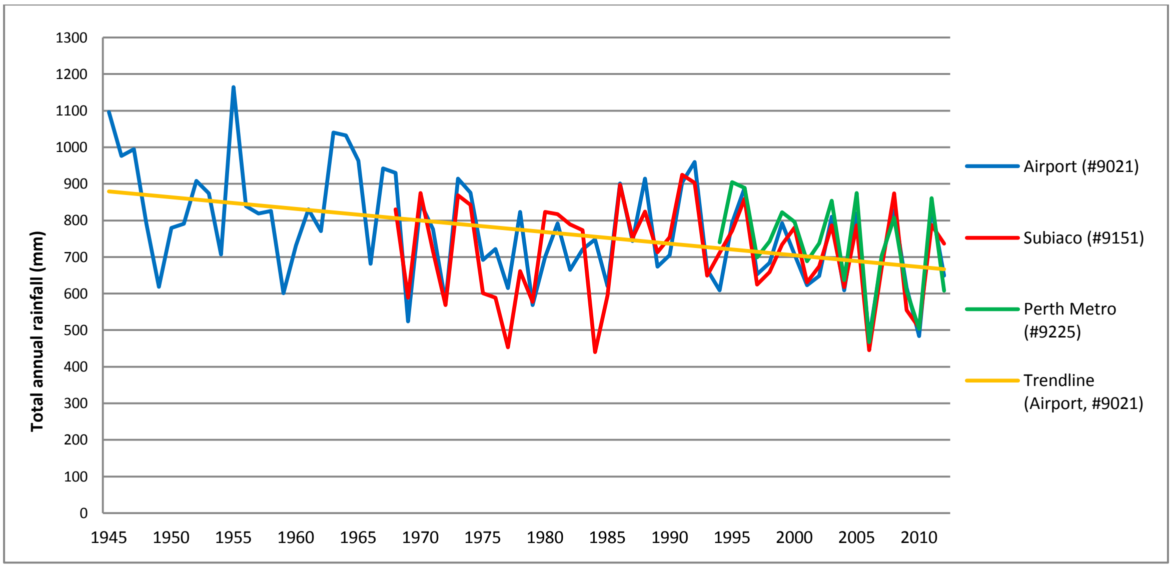


Figure 1: Historical overview of rainfall pattern in Perth (Bureau of Meteorology, 2013)

Figure 1 shows the historical rainfall pattern in Perth based on three major weather stations since 1945. Since the measurement began in 1945, the annual rainfall has been decreasing continuously from approximately 900mm during 1945-1950 to less than 700mm during 2005-2012 (Bureau of Meteorology, 2013). The decline in rainfall has accelerated during early in the 21^{st} century (Figure 1) with a record low annual rainfall of 435mm in 2006 and 504mm in 2010 (Department of Water, 2010; Bureau of Meteorology, 2013; Water Corporation, 2013b).

In WA, most of the rainfall falls during the winter months - from May to October (Loh and Coghlan, 2003). As indicated in Figure 1, the annual rainfall in the south west of WA (catchment of Perth) has declined by more than 20% since the 1950s, resulting in a significant reduction of water flowing into the major dams and reservoirs of Perth (Department of Water, 2010; Bureau of Meteorology, 2013).

This fact has also been reflected in Figure 2, the reduction of 'water inflows' was more than 70%, from approximately 340 GL per year during 1911-1974 to 92.7 GL per year during 2001-05. During 2006-2012, this amount has further declined to approximately 68 GL and the major dams are now operated with only 35% of their capacity (Water Corporation, 2013b). The declining surface sources are insufficient to ensure reliable water supplies; therefore, the water supply system of Perth is heavily dependent upon groundwater. Groundwater is the second main source of water supply in Australia; however it is a primary source for water supply in WA. Currently, the groundwater sources contribute 40% (though it varies from 30-60% depending upon rainfall availability) of the drinking water supply system of Perth (Water Corporation, 2005, 2013b).

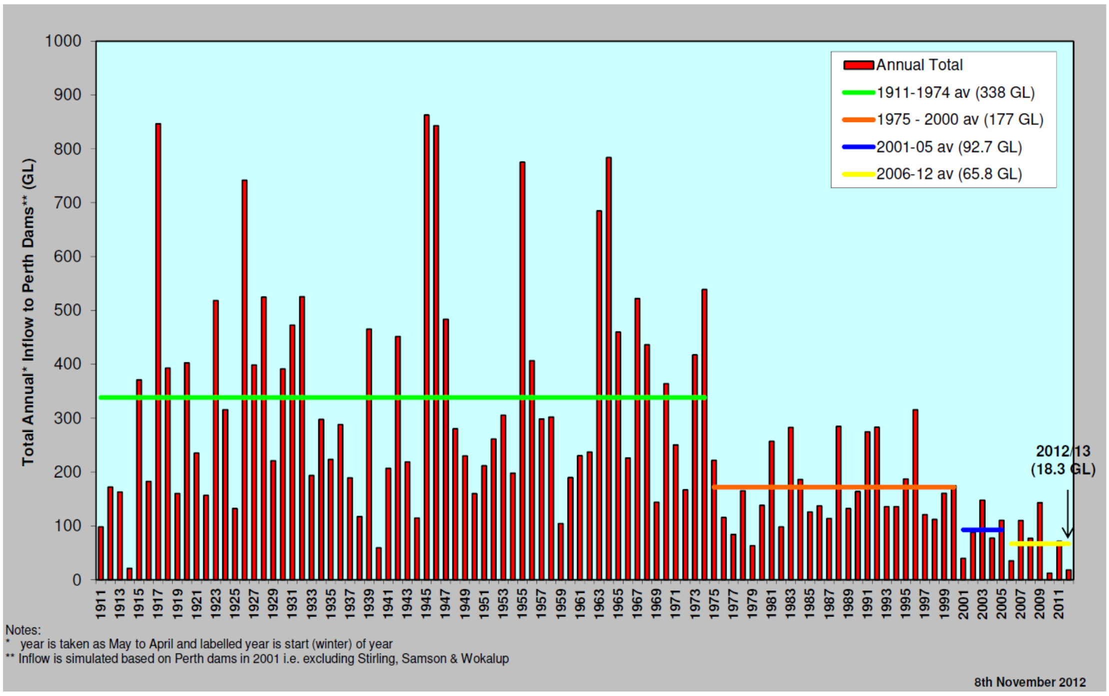


Figure 2: Reduced inflows and reduced water availability in Perth dams (Water Corporation, 2013b)

Groundwater

Most of the Perth metropolitan area lies on a coastal sand plain about 20 km wide between the Indian Ocean and the Darling Range (Loh and Coghlan, 2003). Below the plain, large unconfined groundwater resource exists at depths varying from 2m to 50m with a thickness of between 20 to 70 metres. All the rainfall and runoff, by default, infiltrate into the immediate aquifer, which is increasingly being used as a source for water supply. The Integrated Water Supply Scheme (IWSS) during 2011-12 estimated that about half of the water supply in Perth comes from groundwater. During the current dry years when there was reduced inflow into the major dams and reservoirs of Perth, this source has been heavily extracted to meet the water shortage (Water Corporation, 2012a).

The Gnangara groundwater system is Perth's largest source of groundwater and the Gnangara Mound is a major part of the Gnangara groundwater system (Figure 3). In the last 30 years, the groundwater from Gnangara Mound has been significantly utilized for supplying water to the Perth Metropolitan Region (Department of Water, 2009). The Gnangara groundwater system is approximately a 2200 KM^2 area, stretching from Gingin in the north to the Swan River in the south and to the Darling Scarp in the east to the Indian Ocean in the west. It is comprised of four main aquifers: the unconfined superficial aquifer, the semi-confined Mirrabooka aquifer, and mostly confined Leederville and Yarragadee aquifers (Figure 3).

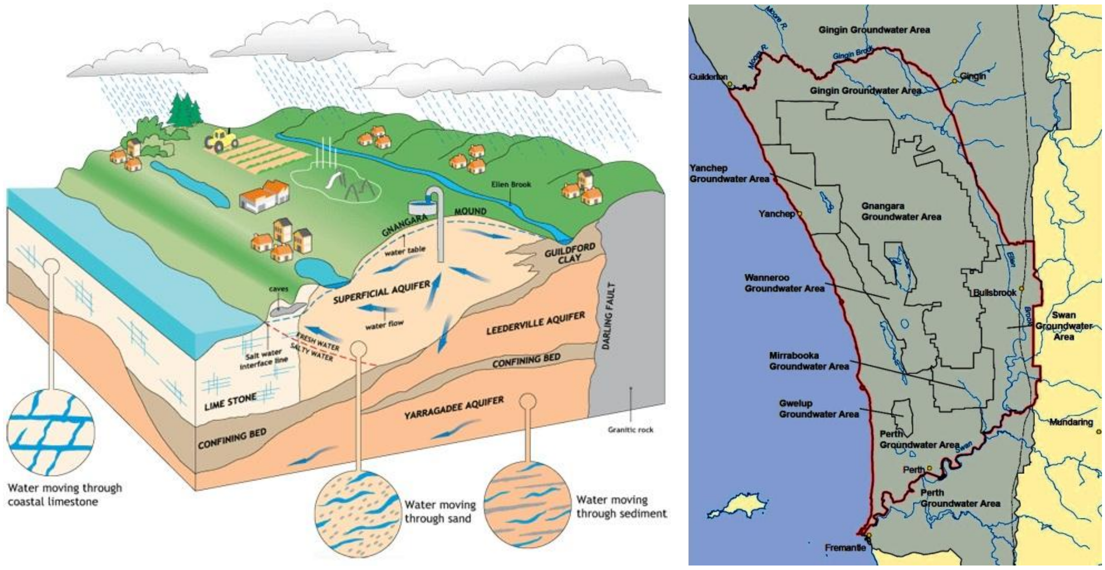


Figure 3: Gnangara groundwater system with associated aquifer (Department of Water, 2009)

The groundwater depletion in the Gnangara mound has resulted in declining groundwater levels in the Mirrabooka aquifer; Wanneroo-Pinjar area, Swan River and Gingin area of Leederville aquifer; and Yarragadee aquifer (Bekesi, 2007 cited in Department of Water, 2009). The increasing decline in the groundwater table in these aquifers had caused significant problems to private bore owners as well as the wetlands and ecological systems of the catchments and the city (Syme and Nancarrow, 2011).

In addition to utilising groundwater for drinking water supply, 167,000 householders in Perth have domestic bores that extract groundwater for watering their gardens (Department of Water, 2011). Perth householders are not required to have any license for their domestic bores for watering less than 2000 m^2 area, except they have to follow a separate provision of sprinkler restrictions. In fact, government policy until very recently (and likely to continue in future) is to encourage householders to install bores, which has aimed to ease the pressure on mains water supply. However, the domestic bores are using a significant amount of groundwater (in the vicinity of 73 GL per year) (Department of Water, 2011), which is almost half of the total groundwater allocated for IWSS purposes (Water Corporation, 2005). Due to the drying climate, the shallow aquifer is declining further that demands domestic bores to deepen into more depth to function well. If householders don't wish to invest to deepen their bores and eventually shut their bores down, it can dramatically increase the consumption of the main scheme water supply (Syme and Nancarrow, 2011).

In this context it is important to remember that the water shortage is being projected to be up to 120 GL per year by 2030 (Water Corporation, 2009), which is likely to continue increasing as WA's dry years continue. In this situation, the excessive use of groundwater for IWSS or for garden irrigation can deplete the groundwater beyond the sustainable yield level, leaving minimal opportunities for additional water availability from these sources in future. The declining rainfall has negatively affected aquifer recharge as well as the loss of surface flow. The current over sourcing of water from groundwater also has negative impacts on the catchment's environment, vegetation, and water bodies. All these problems demand a new way of thinking and planning to develop better strategies for a more sustainable, climate resilient, and environmentally responsible water management approach.

To plan for the predicted dryer future conditions, two desalination plants - one in Kwinana (45GL per year) and the other in Binningup (50GL per year) have been added to IWSS. In addition, Harvey Dam (17 GL per year), South-West Yarragadee Groundwater Project (45GL per year), and the Beenyup Groundwater Replenishment Trial (2.6 GL per year) have been added to IWSS since 2005 (Water Corporation, 2012a, 2013a). These were supposed to relieve the pressure on groundwater resources as well as to recover the water level.

Desalination

Desalination is climate independent water source and is emerging as an important water source for the coastal urban communities. As Perth is increasingly gripped by a drying climate, desalination was embraced as an important part of the IWSS (2005). Water authorities have moved quickly to desalination options, mainly to reduce reliance on surface water and groundwater by developing a rainfall independent source. However, there are debates around project cost, energy use, and the environmental impacts of desalination (Syme and Nancarrow, 2011).

The first 'Perth Seawater Desalination Plant (PSDP)' in the southern suburb of Kwinana, was completed in 2006, and was the first large-scale desalination plant in Australia to provide annually 45 GL of drinking water for public consumption. Following the success of the first plant, the second 'Southern Seawater Desalination Plant (SSDP)' at Binningup was completed in 2011, which produces 50GL water per year. Water authorities are planning to expand the capacity of the second desalination plant to deliver 100 GL water per year. Currently across WA, two desalination plants provide fresh drinking water into the IWSS, which is almost half of the total state's drinking water demand.

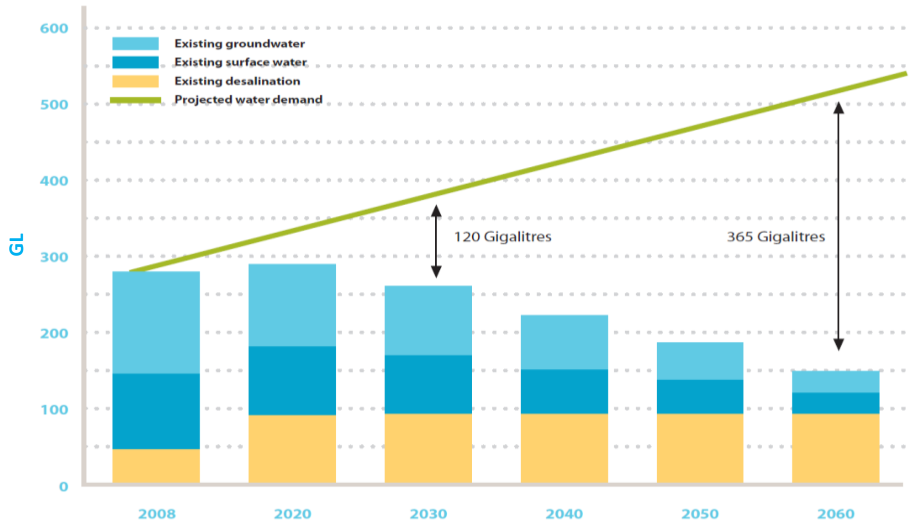


Figure 4: The projected gap between the demand and water availability in Perth (Water Corporation, 2009)

However, it is unfeasible to continue building desalination plants which apart from having substantial energy requirements, have other limitations. The 'Water Forever (2009)' report stated that the gap between demand and water availability is growing (Figure 4) and it is almost impossible to rely entirely on desalination. Therefore, If the increasing water demand relied on desalination only, a third plant would be required by 2020, and one additional desalination plant every five years thereafter to meet the predicted 2060 demands (Water Corporation, 2009). By then, the universal justification of desalination plants in terms of climate independency would be insufficient for trading off the operational costs, energy use (or carbon emission), environmental impacts, and siting issues for additional ten desalination plants (Water Corporation, 2009; Syme and Nancarrow, 2011).

This situation demands that new water sources should be both cost and energy efficient, adaptive to the changing climate, and having minimal environmental and regional issues. Therefore, the attention of water authorities has focussed on reusing and recycling wastewaters, and reducing the use of scheme water with water smart initiatives.

Recycled water

The IWSS (2005) and Water Forever (2009) have considered water recycling as an essential option for maintaining a reliable, sustainable and safe water supply for WA. Water Corporation is involved in approximately 71 water recycling schemes and has a target of increasing the current level of 6% wastewater recycling to 60% by 2060 in collaboration with State and Local Government, business, industry and the community (Water Corporation, 2009).

Most of the wastewater is often 'wasted water'. The conventional water supply system, so far, supplies water for single usage, which then becomes ‘wastewater’. Recycling wastewater is crucial to managing the water resources efficiently and making most of it out from ‘wasted water’. Currently the wastewater resource is estimated to be approximately 125 GL, with predictions that it will increase to twice that amount in 2060. The wastewater, if not allocated to potable use, could be used for fit-for-purpose water supply in dual reticulation, environmental amenity, industrial use, and other potable replacement activities (Syme and Nancarrow, 2011).

In Perth, the treated wastewater is being recharged into groundwater since 2010 on a trial basis. The Beenyup groundwater replenishment trial project was commenced in November 2010 for a three years trial period. The project involved the further treatment of secondary treated wastewater to drinking water quality and recharging it to the Leederville aquifer. As of October 2013, 3299 ML of treated wastewater has been recharged into the Gnangara mound (Water Corporation, 2013a). A number of other trials are currently underway to investigate the feasibility of using recycled wastewater for environmental purpose, such as providing for threatened wetlands and preventing saline intrusion from the ocean.

Some important aspects for wastewater recycling are: the community acceptance; trading of recycled water; and impact of demand management. Several studies on community acceptance to use recycled water illustrate that community acceptance decreases as the use of recycled water become closer to human contact or more personal (Po et al., 2005; Hurlimann, 2008). A recent study suggests that Perth residents are accepting the use of recycled water for watering parks and recreational areas as well as for industrial or agricultural use (Barron et al., 2010; Dzidic and Green, 2012). However, there are still uncertainties about community responses to more personal use of recycled water.

The trading of recycled water is another important aspect to ensure recycling is cost effective and sustainable. Despite the large cost of recycling wastewater, the Western Australian Water Corporation provides treated wastewater free of charge to any community that is willing to irrigate the public parks, ovals, recreation areas, school grounds as well as other community uses with the relevant regulatory approvals. This is not cost effective for the Water Corporation.

Finally, the impact of demand management and water conservation warrants investigation. When demand management succeeds in its targets, it should result in lower levels of water usage. Thus, decreased water consumption will result in decreased wastewater available for recycling, which in turn will impact on the sustainability of the wastewater recycling projects.

Water conservation

For more than three decades, the drying climate has reduced water availability from climate dependent water sources (surface water, groundwater) around Perth and climate independent sources (desalination, recycled water) are not yet developed to meet the growing water demand. This situation forces water authorities to endorse strategies that reduce water uses across end-users. Those strategies include: increasing block water tariffs; sprinkler restriction to two days a week; showerhead swap; H_2OME smart; rainwater reward; and so on. Further, the initiatives such as: 'Waterwise Products', 'Waterwise Specialists', and 'Waterwise Councils', try to engage community and industry with the aim of promoting water conservation in community.

In Perth, 71% of the total water supplied by the Water Corporation is consumed by the residential sector with an average annual water consumption rate of 106KL per person. The average per capita water consumption has been reduced by almost 20%, from 128KL in 2001 to 106 KL in 2009, but Perth is still one of the highest water consuming cities in Australia (Water Corporation, 2010). Being the highest water user, the residential sector could contribute significantly towards reducing water consumption. Nonetheless, water efficiency in the industrial and business sectors as well as reducing system leakage is very important for water conservation (Water Corporation, 2010).

The reduction in water consumption can be regarded as equivalent to creating new water sources, as it reduces the pressure to develop new water sources. Water conservation is a cost effective, risk free and sustainable option but requires the participation and support from all water users, including residential, business and industrial, and governmental sectors (Water Corporation, 2009). Besides these major options to supplement the water supply of Perth, there are a number of other measures that could be used for the purposes of meeting the gap between water demand and supply as follows:

- Water trading with individual sellers and or agricultural irrigators;
- Reduce evaporation from surface water reservoirs;
- Reallocation of regional and/or recreational water;
- Transport water from the Kimberley;
- Cloud seeding; and
- Towing icebergs.

Water trading has already begun, the practices for reducing evaporation from surface water reservoirs are being considered. However, the other options have either not yet been considered or regarded as infeasible or unsustainable (Syme and Nancarrow, 2011).

Every water system engages a wide range of end users; however, communities, industries, business, local government and developers have different water usage patterns. Any alterations in the system would impact over the different needs of end users in terms of water quantity and quality. However, a thorough understanding of these differences could lead to more effective water saving strategies.

2.2.5. Water consumption scenario in Perth

Australia is a dry continent, but contrarily it has one of the highest water consumption rate, and Perth remains one of the highest water using cities in Australia. The 'Perth Residential Water Use Study 2008/09' states that the average per-capita water consumption has been reduced from 128KL in 2000 to 106KL in 2009. The outdoor scheme water consumption has been reduced by 40% during that time but the garden irrigation is still the main outdoor water using activity (Water Corporation, 2010). The reduction in outdoor scheme water use is mainly due to 2 days a week garden watering restriction and an increase in the number of domestic bores from 135000 in 2001 (Smith, Pollock, and McFarlane, 2005) to 167000 in 2010 (Department of Water, 2011).

The average indoor water use for a person has remained almost unchanged; i.e., from 57KL in 2001 to 59.36KL in 2009; however, the proportion has changed from 42% to 56%. This is mainly due to a significant reduction in garden watering usage. The proportion for different indoor water using activities has been altered, such as: water usage for shower and bath activities has increased by 15%, whilst a decrease of 13% in washing machine usage; 5% in taps usage; and 3% in toilet usage has been recorded. In addition, the evaporative air conditioner consumes on average 7% of total indoor water (Loh and Coghlan, 2003; Water Corporation, 2010).

The 'Perth Residential Water Use Study 2008/09' shows that average household water consumption was reduced by 22% during 2000-09, which was mainly due to demand management, domestic bores and water conservation programs (Water Corporation, 2010). Despite this reduction, water demand in the residential sector is continuously increasing due to the growing population and high level of personal consumption for activities which always do not need drinking quality water. For example, increasing adoption of water using technologies and services such as shower and bath, toilet flush, washing machine, dish-washer, evaporative air conditioner etc., inside the houses; and sprinklers, pool, and spa etc., outside the houses has a tendency to increase household water consumption. Householders are being supplied with drinking quality water to avoid any possible health hazards, however all above activities do not require drinking quality water.

Wide-spread suburbs with detached housing and a Mediterranean climate of Perth have put a value on outdoor living and entertainment in a green environment. The domestic gardens were highly valued as a source of recreation and beauty (Syme, Shao, Po, and Campbell, 2004). The higher value on green-space, garden recreation, and green lifestyle demands an increase in the outdoor water consumption (Syme et al., 2004). Similarly, access to open space and water bodies have been highly prized, both aesthetically and economically, which has reflected in house prices (Syme, Fenton, and Coakes, 2001). Such a landscape requires a reliable source of water, which is mostly the main water that eventually adds the pressure on main water supply.

The water demand associated with the projected population growth and climate change scenario estimates a gap of 120 GL water by 2030, which is predicted to increase to 365 GL by 2060 (Water Corporation, 2009). If the water saving scheme works properly, there will be 50 GL water conserved by 2030, so the gap will be reduced to 70 GL. Even after considering similar pace of water conservation; there will still be a gap of 120 GL of water by 2060 (Syme and Nancarrow, 2011).

Observation 1: Literature indicates that the drying climate and increasing population in Australia create an essence for the alternative water systems that can augment the scheme water supply and promote water conservation and water efficiency at the residential settings.

Currently, the main concern for water authorities is how to meet the increasing water demand with declining availability in a drying climate. The reduction in per-capita consumption can retard the water demand as well as contribute in water savings, which could be utilized for the further extension of services.

2.2.6. Urban water management

A. Demand management (Demand side)

Water demand management includes any action that reduces the drinking water use, or that maintains efficient water use than it otherwise would be (Brooks, 2006). Demand management is an intervention to reduce the consumption of water for achieving harmony between the demand and the availability of water. In simple words, the demand management aims to meet a water shortage simultaneously with achieving the efficiency and sustainable use of water (Savenije and van der Zaag, 2002; White and Fane, 2002; Russell and Fielding, 2010). There is a debate that the community do not usually perceive demand management with the same importance as the built solutions. This may be because of more visibility of the built solutions in terms of volume produced. However, the amount of water saved by innovative demand management can be as significant as the volume produced, and often at lower capital and environmental cost (Speers, 2008).

Water demand management through persuasion or incentives, restrictions or mandatory provisions, and increasing block tariffs have been a regular feature of Perth's water management since the early 1970's (Syme and Nancarrow, 2011). Demand management is highly inscribed in most of the strategic policy for water management in Perth. The State Water Strategy for Western Australia (2003), Water forever (2009), and several other water policy documents strongly promote the demand management practices and aims to improve water use efficiency throughout the state.

Undoubtedly, demand management is a cost effective way to conserve water, and is less intrusive on communities, therefore it should be prioritized in urban water management planning. Additionally, the negative effects of demand management will be less if introduced incrementally and in a transparent and predictable way (Speers, 2008).

Persuasions and restrictions

As part of the State Water Strategy for Western Australia (2003), several community education (awareness) campaigns have been conducted to encourage community acceptance and commitment towards water conservation. The community have also been offered incentives and rebates for water efficient technology and appliances. The public have been offered attractive financial rebates to install water efficient shower heads, kitchen taps, washing machines, dual-flush toilets inside the house, and drips reticulation, garden bores and native plants outside the house. Incentives and rebate programs are still going on, which are likely to continue and increase focus on major investments such as home rainwater tanks and garden bores (Syme and Nancarrow, 2011). Ongoing 'Waterwise Initiatives' and 'H_2OME-Smart' programs in the Perth Metropolitan Region have prompted the community as well as the householders to be water-efficient. These have included education programs labelled as waterwise council (local government), waterwise community and waterwise garden and so on.

Several education campaigns were organised throughout the state to promote awareness about the need to reduce water use and to encourage the adoption of water efficient practices and appliances at the household level. Persuasion and information flow about conservation and social outing for high water consumption at a suburban level along with mild restrictions on garden watering seems to be effective for reducing water consumption. Although Perth remains a high per capita water use city.

Another demand management strategy is restriction. Restriction generally refers to limiting households by law to use water for selected activities. For example, two days a week watering restrictions, sprinkler bans in daylight hours, mandatory dual flush toilet systems in new home construction or retrofitting etc. In Perth and the surrounding areas supplied by Water Corporation, the daytime sprinkler ban (9am-6pm) and mandatory dual flush toilets were implemented in 1994 and 2 days a week garden watering restriction since 2001 (Loh and Coghlan, 2003). These strategies encourage people to change their water consumption habits and help to reduce the household water consumption.

Similarly, a decrease in water pressure may be another possible water saving technique. Reduced pressure means less water flow per time, so that the amount of water used per time can be reduced. This has been discussed at a strategic level but has not yet been implemented.

<u>Water Pricing</u>

Water pricing is one of the effective tools for shaping water demand. The logic is that increases in price will lead to decreases in consumption. The Council of Australian Government (COAG) initiated water pricing system as a key reform, i.e., from water-taxation to pay-for-usage since early 1990s (COAG, 1994). The basic intention of the reform was to charge a price that reflects the actual cost of water supply systems, and to ensure the return on investment. Further, the ‘pay for use’ strategy aims to make customers responsible for their water consumption, and to enable the utilities to be financially self-sustaining. The national and Western Australian per-capita water consumption has fallen since the beginning of the price reform; however little research has been conducted to accurately examine the exact contribution of price reform to this fall (Speers, 2008).

Similar to the other Australian states, the Water Corporation, WA charges for water usage is based on an increasing block system; which means the more water is used, more the users have to pay. The Water Corporation reads the water meter twice a year but the tiered prices apply over a full year and do not reset after the first reading. On other hand, “The Green” residents who have dual water supply have to pay a flat annual levy for groundwater supply additional to the blocked tariff for drinking water. The annual levy is based on the block sizes, which is AU$74.00 for blocks less than 400m^2 and AU$148.00 for blocks more than 400m^2 (Water Corporation, 2013d).

The savings from demand management strategies are promising; however, that would hardly equate with the increase in water demand because of growing population. In these circumstances, the replacement of scheme water by local groundwater at household level has a great potential to reduce outdoor use of scheme water, which is almost half of the total household water consumption (Loh and Coghlan, 2003; Water Corporation, 2010). If this approach can be extended at a community level, it significantly conserves scheme water. The successful application of domestic bores to replace scheme water use for garden watering at a community level can possibly be an alternative system in Perth. Such an approach requires a separate reticulation (or pipe network) to deliver non-drinking groundwater for fit-for-purpose uses and to reduce the risk of cross-connection and possible health hazards. Recently, a communal groundwater supply system has been implemented as a trial for “The Green” community at Butler. “The Green” trial has expanded the domestic bore concept at the community level for the first time in WA (Water Corporation, 2007b).

Observation 2: Literature indicates that a centrally controlled NDG system for watering gardens and parks at a community level can possibly be an alternative water system for water conservation and water efficiency in urban settings.

B. Fit-for-purpose water supply (supply side)

As described in the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks, Phase 1 (2006), Fit-for-purpose water is treated to an appropriate quality level for its intended end-use(s). Providing fit-for-purpose water is about matching water source and quality to the intended use. The fit-for-purpose water can be used in garden watering, toilet flushing, fire-fighting etc., which does not require drinking quality water. Fit-for-purpose water can be sourced from groundwater, rainwater, stormwater, greywater and treated wastewater. The source may require further treatment to a quality suitable for its intended end use(s).

A fit-for-purpose scheme substitutes non-drinking water for scheme water. It is sometimes referred to as ‘alternative water supply’. The scheme requires a dual reticulation (or “third pipe") system to differentiate non-drinking water from the drinking water. Distinct piping, fixtures and labelling could be used to reduce the risk of cross connection and inappropriate consumption.

A fit-for-purpose water supply system has been implemented for "The Green" community in Butler as an alternative trial, where superficial groundwater sourced the non-drinking water supply. Superficial groundwater is the water from shallow aquifer that is 2 to 60m below the ground surface, which is the same water used by domestic bores in surrounding communities. A separate pipe network has been established to deliver the non-drinking groundwater to the households (Satterley Property Group, 2010a). The trial aims to reduce 30% household water consumption and 40% POS usage compared to that of the average metropolitan suburb. The groundwater use for garden watering is a common practice in Perth, hence the system was presumed to be well accepted by the community. Similarly, state-of-art landscaping and water sensitive urban designs are supposed to enhance the resident's satisfaction with an 'eco-friendly' and 'water sensitive' community development.

Relying only on the efficient design of the alternative urban water system is not sufficient to ensure its acceptability to the community (Porter et al., 2006). Therefore, it is important to understand the community concerns about alternative water systems and resolve these concerns as soon as possible. Therefore, single approach is unlikely to be sustainable or fit to all situations; just as any single solution for dealing with the water crisis will not be effective in isolation.

The literature indicates gaps in research about community concerns and responses towards alternative water systems and the associated developments. This research project provides a good opportunity to explore the community concerns, responses and understand the nuances of this particular area. In addition, the socio-economic impacts and planning implications of such innovative alternatives can be explored. The findings could possibly determine the applicability of the fit-for-purpose system as an alternative for securing the urban water future. The research questions identified in this study will delve into these gaps and provides knowledge regarding community responses and attitudes towards the alternative dual water system and its planning implications.

The alternative water systems should also be evaluated regarding their resilience towards climate change, which is a fairly recent approach highlighted in the Water Forever (2009) program. The resilience towards climate change demands a portfolio approach that could reduce water demand, develop new sources, ensure efficient water use and promote water reuse in the light of drying climate and growing population (Water Corporation, 2009).This study will provide valuable insights into the resilience aspect of the alternative water system trial, mainly in terms of community acceptance and participation, water conservation and efficiency, and sustainability of the alternative system.

Observation 3: Literature indicates that the success of alternative water systems and water sensitive development greatly depends upon the positive support (acceptance and participation) from the community.

In addition, this study examines the alternative management of urban water resources via an integration of water planning with land planning, where water planning leads land planning (Western Australian Planning Commission, 2008a). This can be reflected in an urban development with water sensitive designs and innovative fit-for-purpose water supply schemes.

C. Water sensitive urban development

Impact of Urbanisation

Urbanisation directly affects the water balance of the catchment and impacts groundwater and stormwater quality over the long term (Appleyard, 1995; Foster, 2001). The increased groundwater mobility, urban discharge and the nutrient export are major effects of urbanisation. First of all, it increases the mobility of groundwater via surface and subsurface drainage system, which increases the mobility of soil nutrients stored in shallow groundwater. Secondly, it increases the area of *impervious surfaces,* which increases runoff and reduces evapo-transpiration losses. As a result, annual volumetric flow (runoff) to the water bodies will be increased (Lerner, 2002). Thirdly, the subsurface drainage system improves catchment connectivity and contribution to subsequent water bodies. This will increase groundwater resource availability, which can be used for supplementary water supply (Barron et al., 2010). The first and second effects cause negative impacts to the environment, while the third one can be a possible alternative water sources for fit-for-purposes.

The impacts of urbanisation on urban discharge; nutrient load in urban water; and water residence time largely depends on the urban density; use of local water; climatic variability; and nutrient management in such urban development (Barron et al., 2010). To minimize the impacts of urbanisation on hydrology, the increased availability of groundwater can be used for fit-for-purpose supply. The extraction of groundwater not only reduces the urban discharge and nutrients export but also circulates the groundwater and nutrients in the local area. However in Australian context, the groundwater level in an urban area tends to decrease regularly since there is a drying climate and declining infiltration into groundwater. Only extraction of groundwater without considering these consequences can lead to groundwater depletion. This situation can be averted if urban discharge will be infiltrated in the immediate catchment to enrich the local groundwater. Appropriate water sensitive designs can serve for controlling and infiltrating the urban discharge at the source. Thus enriched groundwater can be extracted and supplied for fit-for-purpose schemes. Additionally, the application of soil amendments can withhold more water and nutrients in the local catchment; hence, reduce nutrient exports into water bodies.

Observation 4: Literature indicates that the urbanisation increases the local groundwater availability, and the utilisation of local groundwater for non-drinking purposes in urban settings not only helps to augment the mains water supply but also to reduce the urban discharge, and nutrient export into the water bodies.

In this way, the fit-for-purpose groundwater schemes with water sensitive designs can be mutually beneficial for the urban hydrology and the local community. However, it is essential to build development guidelines with respect to urban discharge and nutrient exports to maximise possible benefits and minimise negative impacts (Barron et al., 2010).

<u>Water sensitive urban designs (WSUD)</u>

The application of WSUD for urban planning has been operational since the 1980s with a specific view of stormwater management approach that has now been developed as a widely accepted design framework for minimizing the impact of urbanization on the natural water cycle and surrounding environment (Wong, 2007; Morison and Brown, 2011). Western Australian Planning Commission (WAPC) considers that Water Sensitive Urban Designs (WSUD) is 'a philosophy of achieving better water resource management outcomes in an urban context' by utilising an integrated land and water planning approach that incorporates total water cycle management objectives in the planning process. The key elements of WSUD are: sustainable management of quantity and quality of urban water resources to minimise environmental impacts caused by the urban development; efficient use and saving of scheme water, re-use of water, and better utilization of all possible water resources to reduce drinking water demand at each level (Lloyd, Wong, and Chesterfield, 2002; Wong, 2007; WAPC, 2008a).

The integration of land and water planning during the application of WSUD in an urban context can properly address the issues imposed by the drying climate, increasing population and consolidating urban areas, mainly in terms of sustainable water management and drainage facilities. WSUD is the effective way to manage all water resources within new and existing urban development. WSUD can be used as a tool to achieve more efficient water use and better environmental outcomes. WSUD maximises the use of drainage and stormwater to recharge groundwater, replenish lakes and wetlands and also to help naturally irrigate streetscapes, parks and gardens. WSUD encompasses all aspects of the integrated urban water cycle management, including the mains water saving, stormwater harvesting, wastewater recycling, improving drainage infrastructure to facilitate infiltration, and reducing volumetric runoff into water bodies. It provides both the planning framework and management practices for achieving cost effective solutions and improved environmental benefits (Lloyd et al., 2002; Wong, 2007).

WSUD with the provision of a fit-for-purpose water supply system can be a possible and advanced approach for sustainable water management in urban settings. This integrated approach in harmony with ongoing water smart initiatives is a high priority strategy in WA (Water Corporation, 2009) for water sensitive community development; where the water planning leads the land planning (Government of Western Australia, 2007).

Urban density is another important factor of WSUD since it is believed that increases in urban density leads to water use efficiency, and reduces water consumption mainly by increasing occupancy rate and reducing private gardens and private water amenities (Loh and Coghlan, 2003; Syme and Nancarrow, 2011). Further, increasing urban density is believed to be helpful in improving the efficiency of existing infrastructure, retarding the investment in new services, and reducing the transport cost of centralised scheme water supply. However, an increase in urban density does not always reduce the domestic water consumption. Troy (2011) found no significant relationship between the housing density and domestic water consumption in Sydney. This study examines the relationship between the urban density and the domestic water consumption in Perth, which will help to illustrate the impact of urban density over residential water efficiency.

The sustainability of WSUD and the integrated water management approach is always a concern among water authorities, since any alteration to the conventional water system affects a wide-array of end-users. The innovative water technology has its social, economic and environmental impacts that determine its sustainability. Sometimes, the environment-friendly approach may not be economically feasible, and/or a socially desirable approach may not be environmentally appropriate. In addition, the lessening degrees of freedom for new supplies and increasing demand projections has placed new debates about how best to incorporate sustainability concepts into the planning of urban water resources. Now, it has been realized that economic solutions for water challenges wouldn't be sufficient on their own, the social and environmental aspects should equally be considered.

Observation 5: Literature indicates that the application of WSUD with a provision of a fit-for-purpose water system can be the appropriate alternatives for the sustainable water management in urban settings in the light of drying climate.

In this way, the issues around the urban water crisis in the light of drying climate and growing population are discussed that identified the essence and significance of innovative fit-for-purpose water supply system in an urban setting to promote water conservation and efficiency. The literature indicates that there are increased inclusions of alternative water management practices in the policy documents; however, a limited number of field implementations are evident so far. This in turn, limits the actual experience of the systems as well as the opportunity to explore community response, the efficiency and utility of the alternatives, and other wider issues pertaining with the success of the innovative water alternatives. This study enquires the sustainability issues of the NDG trial in "The Green"; investigates the utility, and management aspects; evaluates community experience, attitude and behaviour towards the NDG trial and the associated development; and explores the implications in urban water management planning.

2.3. Community concern and sustainability

2.3.1. Community acceptance of an innovative water management

Acceptance of alternative water system means more agreement with the provision of the system that positively impact their life style. Community acceptance was previously regarded as the principal obstacle for successful implementation of any innovative water management project. Earlier works were either focused to develop strategies to persuade people to accept the new project and/or to attract people by social marketing (Nancarrow, Leviston, Po, Porter, and Tucker, 2008). Now-a-days, these approaches are proved to be largely ineffective in influencing public acceptance. Community acceptance is still the significant impediment for the success of any new water systems (Porter et al., 2006; Hurlimann, 2008; Barron et al., 2010).

Water recycling has been widely accepted by the Australian community as a key component for securing water futures in the context of drying climate (Hurlimann, 2006; Maheepala and Blackmore, 2008; Nancarrow et al., 2008; Barron et al., 2010). However, acceptance of a concept does not automatically mean the immediate acceptance of recycled water for any personal or community uses (Nancarrow et al., 2008). Despite a higher acceptance for water recycling projects, there is very little acceptance for using the recycled wastewater, stormwater and or groundwater for personal uses, such as; drinking, washing or toilet flushing. Some communities might actively resist even sometime deny the water recycling projects to be held in or near their locality. However, there is a higher acceptance for using the recycled water in watering public parks, play grounds, and or agricultural farms. This indicates that the acceptance for recycled or fit-for-purpose water system decreases as the uses become more personal or closer to human contact (Po et al., 2005; Hurlimann, 2008; Barron et al., 2010; Dzidic and Green, 2012) and/or the system sites closer to their residential area (Marks and von Winterfeldt, 1984).

In addition, the post-development studies on water recycling (Po et al., 2005; Hurlimann and Dolnicar, 2010) indicate that the public reactions can vary significantly to those prior to implementation. A number of hi-tech national and international water recycling projects failed due to the absence of community support and acceptance, for example: Toowoomba, Australia (Hurlimann and Dolnicar, 2010), Caloundra-Maroochy, Australia (Stenekes, Colebatch, Waite, and Ashbolt, 2006), and San Diego, USA (Hartley, 2006). This demonstrates that high tech and innovative water saving projects may not necessarily result in high community uptake.

Coming back to the innovative use of non-drinking groundwater in Australia, a limited literature are available. The groundwater is perceived as the default source of drinking water. In WA, groundwater provides more than half of the total scheme water supply for about two million people (Water Corporation, 2012a). In addition, the use of groundwater for watering household garden via domestic bores has been established as a tradition in Perth and more than 175,000 bores are in operation (Department of Water, 2011). Recently at a sub-division level, local groundwater has been utilized for watering the household gardens and Public Open Spaces (POS).

The non-drinking groundwater system has been implemented as a five year trial for “The Green” community at Butler (Water Corporation, 2007b). The NDG trial is an expansion of the domestic bores to a community level; hence the developers have assumed that the community responses will not be different from that for the domestic bores. However, without understanding community nuances for communal groundwater system, it would be unwise to presuppose community response and acceptance (Barron et al., 2010). Barron et al., (2010) conducted a social research to investigate community acceptance of the non-drinking groundwater use; whereas Dzidic & Green (2012), and Tucker et al., (2009) conducted their studies to understand the role of aesthetics, social norms and other issues to the community acceptance of non-drinking groundwater supply and associated urban designs. These studies indicate that the community generally accept the groundwater supply for non-potable uses, most preferably for garden watering, even when the water has some degree of colour, turbidity, or odour.

Observation 6: Literature suggests that the success of alternative water systems greatly depends upon the positive community support and acceptance of the system.

Observation 7: Literature indicates that community attitudes towards the alternative water systems can vary significantly prior, during, and after the implementation of the systems.

This post-development evaluation study aims to understand the actual community attitudes and behaviour towards the non-drinking groundwater supply system and to explore if there are any changes from the pre-development attitudes and behaviours.

2.3.2. Attitudinal model for community acceptance of alternative water supply system

This research adopted the 'attitudinal model for community acceptance of alternative water systems' as a starting point to measure community attitudes and behaviours towards the non-drinking groundwater system (say dual water system). Australian Research Centre for Water in Society (ARCWIS) was the first to develop an attitudinal model for water system acceptability (Porter et al., 2006). The model utilized Fishbein and Ajzen (1974) attitude-behaviour concept, and Ajzen (1991) 'Theory of planned behaviour' to understand the individuals' evaluative attitudes (norms, and beliefs) to the water systems, and their intention to conserve water (CSIRO, 1999). The study conducted by ARCWIS (1999) found that the socially based norms and values, such as: helping communities, conserving environment were more important than economic incentives in decision making, such as accepting alternative water systems, altering water use behaviour etc. Based on ARCWIS (1999) work, CSIRO conducted a series of studies to understand community attitude towards different water supply systems and alternatives across Australia. Initially, Porter et al., (2005) studied householder preferences to water supply systems and developed a working model of the determinants of acceptability of water supply systems. This model identified community trust in water authorities, perception of risk with water supply system, perception of fairness and equity, perceived outcomes of the water supply system, and subjective assessment as the main components for the acceptability of any water supply system. Community trust was the most influential factor; however, the personal values as well as the need for service provision had no significant contribution to the acceptance model (Porter et al., 2005). In a successive study, Porter et al., (2006) reported that individuals tend to be neutral in terms of trust on water authorities and make decisions about the acceptability of the water supply system by observing how the water authorities handle the water system. Therefore, it is considered very important to consult the public frequently and understand their concerns before and/or during implementation of the alternative water supply systems (Porter et al., 2006).

After testing the model in three water supply system scenarios (say alternatives) in Sydney, Melbourne, and Brisbane; Leviston, Porter, & Nancarrow (2006) confirmed that the model can be generalised for predicting the acceptability of alternative water supply systems. However, due to the difference in scale and level of control in these three scenarios, the relationships between the model components were not identical. Porter et al., (2006) continued the study to predict the acceptability of a fit-for-purpose (non-drinking) water supply system. The authors revised the previous model, added several attitudinal items that cover the community attitudes, norms and behaviours towards the fit-for-purpose water system. The results of the study confirmed that the general acceptability model of water supply system can sufficiently predict the acceptability of the fit-for-purpose water supply system. Porter et al. (2006) model shows that the acceptability of alternative water system mainly depends upon the individual perception of the outcomes of the system and their subjective assessment. These two are mainly dependent upon the perception of risks, fairness and equity, and community trust. In this way, the positive perception of risks, fairness and equity, and community trust lead to the positive perception of outcomes and subjective assessment, which in turn, increase the acceptability of the alternative water systems (Figure 5).

According to Porter et al. (2006), the perception of fairness and equity acts as the most important factor, and has a strong relationship with subjective assessment and risk perception, and a moderate relationship with the community trust and perceived outcomes. Similarly, risk perception and community trust have moderate relationship with each other and relatively weaker relationships with subjective assessment and perceived outcomes of the model. This model accounted for 74% of the overall variance in acceptability of any alternative water supply system (Porter et al., 2006). In this study, the attitudinal model of community acceptance of alternative water systems (Figure Five) is slightly modified to measure the level of satisfaction with the NDG systems. The modified model accommodates the satisfaction with alternative water (say NDG) system equivalent to the acceptance of the system.

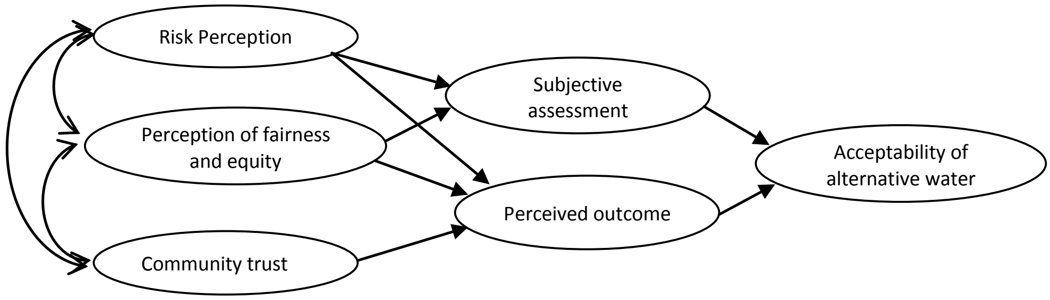


Figure 5: An attitudinal model for acceptability of alternative water supply (Porter et al., 2006)

In a study on community attitudes towards recycled water use at Mawson Lakes Australia, Hurlimann (2008) found that most of the community were satisfied with the recycled water use and the acceptance has increased since the use commenced. Hurlimann (2008) illustrated that community's perceptions and attitudes to recycled water use gradually become more positive as the community become more familiar with the recycled water system. In addition, positive perception of communication, trust with the water authorities, risk associated with the recycled water use, fairness, quality of the recycled water and environmental concerns were important factors for promoting community satisfaction with the recycled water use (Hurlimann, 2008).

Similarly, Tucker et al. (2009), and Dzidic and Green (2012) explored the role of aesthetic characteristics to acceptability of the fit-for-purpose groundwater. The studies found that community acceptance decreases when the uses become more personal; however, they generally accept the aesthetically degraded groundwater for non-drinking purposes, especially when non-drinking water costs lower than the mains water. Tucker et al. (2009) suggests that the pricing, water using activities and aesthetic degradation should be considered as a package; and Dzidic and Green (2012) added the social conformity, and personal presentation factors are crucial for the acceptability of the aesthetically degraded non-potable groundwater. Tucker et al. (2009) identified that water aesthetics (colour, odour and cleanliness) have potential to impact on evaluation of the alternative water system, especially where the non-drinking water is aesthetically degraded. The authors suggested that subtle interactions between non-drinking water quality, relative pricing and water use purpose could shift the water supply systems from unacceptable to acceptable. This is not a silver bullet for all types of water quality degradation, mostly where the context and supply parameters are important to consider. Furthermore, a regular information provision and consideration towards community concerns and inputs will be helpful for improving the acceptance of the aesthetically degraded non-drinking water systems (Tucker et al., 2009).

The studies regarding the acceptability of the non-drinking groundwater system for garden irrigation in Perth (Tucker et al., 2009; Barron et al., 2010; Dzidic and Green, 2012) found that people are generally accepting the non-potable supply of local groundwater controlled by a third party for watering their gardens and public parks. The major factors for acceptance were perceived fairness, benefits to wider community, and better outcomes of the system (Barron et al., 2010). The acceptability of groundwater system may be due to great familiarity with groundwater use for garden irrigation through the backyard bores (Water Corporation, 2010), perception of groundwater as a default or natural source of drinking water supply, low health risk from its non-potable use (Beekman, 1998), and limited personal contact in outdoor watering (Dzidic and Green, 2012).

It is also evident that Australian public behaviour and responses towards the fit-for-purpose water supply systems are changing from ‘sceptic’ to ‘favourable’ due to ongoing climatic variability and rocketing water demand (Nancarrow et al., 2008). Australian urban water authorities, through several ‘policy interventions’, attempt to make communities aware - in general, about the consecutive impacts of their water consuming behaviours to the environment, and its associated costs that are to be shared by this and future generations (Dovers, 2008). In addition, a number of successful alternative water system trials and their evaluation studies demonstrated the practical utility, costs and benefits to the community and environment, and the scope of alternatives in sustainable water management planning (Hurlimann, 2008; Davis and Farrelly, 2009c, 2009a, 2009b; Barron et al., 2010). The on-site trials of the alternatives not only engaged and familiarised the community with the alternatives but also encouraged them for water conservation and water efficiency. Concurrently, Western Australian water authorities have developed several policies regarding sustainable management of urban water resources aimed at community engagement and participation (Government of Western Australia, 2007; Water Corporation, 2009). It is also evident that implementing the alternatives in a new development would result higher acceptability than to fit it into an existing development (Barron et al., 2010). Nowadays, Australian communities are more positive towards the alternative water systems; however, it is always essential to understand the varying degree of community concerns towards the alternatives.

In this way, the public perceptions, attitudes, and responses are important in both planning and development phase of alternative water supply systems. Other equally important factors that influence community perceptions, attitudes and behavioural responses toward these alternatives are: water quality; relative pricing; and end-use activities (Hurlimann, 2008; Barron et al., 2010), public emotions (Po et al., 2005), trust in technology, and knowledge and education (Hurlimann, 2006, 2008). Similarly, the perceptions of native vegetation in parks and gardens, and water sensitive urban designs (Barron et al., 2010); water source, aesthetics, governance and control issues (i.e. rights and ownership of alternative systems) are important (Tucker et al., 2009) for acceptance of the alternative water systems. Social conformity, personal presentation and appearance (Dzidic and Green, 2012) along with appropriate pricing of alternative water is equally important for accepting the alternatives. The appropriate pricing means a pricing system that supports water efficiency and water conservation by maintaining a balance between two extremes: a profligate use of non-drinking water due to its lower price than mains water, and a reduced use due to a higher price (Xayavong, Burton, and White, 2008).

Observation 8: Literature indicates that the acceptance of non-drinking water systems decreases as its use became closer to personal contacts, such as: washing, bathing, and cooking etc.

Observation 9: Literature indicates that the major factors influencing the acceptance of non-drinking water systems are: a) aesthetic quality (mainly staining); b) pricing; c) information provision; d) trust to the technology used and the authorities involved; e) perception of fairness; f) perception of risks; g) social conformity; and h) operation and governance of the system.

Observation 10: The on-site trial is important for the awareness, participation, and acceptance of an alternative water system.

Observation 11: The acceptance of NDG system will be higher if the system is implemented in a new development and/or every resident thinks that the system is uniformly accepted by his/her community.

Observation 12: The acceptance of NDG system will be higher if the water is scarce and people think that they have a responsibility to conserve water.

Observation 13: The acceptance of and the satisfaction with the non-drinking water systems mutually influence each other.

2.3.3. Sustainable urban water management

A. Sustainability Concept

The World Commission on Environment and Development (WCED, 1987) provided a broad definition of sustainable development as “development that meets the need of the present without compromising the ability of future generations to meet their own needs”, hoping simultaneous achievement of economic growth and environmental sustainability. The definition of sustainability in Western Australian State Sustainability Strategy is ‘meeting the needs of current and future generations through an integration of environmental protection, social advancement and economic prosperity’ (Government of Western Australia, 2003a). The sustainability concepts include several complex issues, such as: ecology, economics, science, politics, ethics, participation, intra- and inter-generational equity of the development. These were incorporated under three basic components: environment, economic and social components, which are commonly referred to as ‘triple bottom line’ of sustainability (WCED, 1987). Since then, the concept of ‘sustainable development’ has been considered as a core element in policy development all over the world (Finco and Nijkamp, 2001). Furthermore, the concept has now evolved to embrace the institution and governance aspects under the broad umbrella of sustainability.

Australia developed the National Strategy for Ecologically Sustainable Development (ESD) between 1989 and 1991 to address the global call for sustainability. The national strategy aimed to improve the quality of human life of current and future generations by economic prosperity along with maintaining environment and bio-diversity that supports the life systems. The ESD prioritised socio-environmental component of sustainable development over the economic growth. The Government of WA also developed the state sustainability strategy entitled, ‘Hope for the Future’, (2003) with prime agenda being to find ways of incorporating and integrating environmental and social considerations into the economic development process, recognising that they are not subservient but mutually supportive and/or synergistic (Government of Western Australia, 2003a). For most of the time, the social and environmental components have been overlapped by the economic agendas; however, the achievement of socio-environmental goals can never be assumed to be possible merely because of economic development.

Sustainability principles have often been developed through global agreements and have begun to be placed in legislation over the past decades in Australia and overseas. The Western Australian state sustainability strategy 'Hope for the Future' (2003) reiterated the national strategy for sustainability in seven foundation principles that established the basis of sustainability through long-term economic health, equity and human rights, biodiversity and ecological integrity, settlement efficiency and quality of life, community and sense of place, net benefit from development and common good from planning. The 'Hope for the Future', (2003) also included four process principles that emphasised the need for integration, transparency and engagement, precaution and hope through gradual change towards a broad vision (Government of Western Australia, 2003a). The 'Hope for the Future' (2003) also defined a set of visions for governance, natural resources, settlements, community and business at various spatial levels so that the sustainability principles could be embraced on development activities. The vision and principles are utilised in this research as the benchmark for testing the sustainability of the NDG system and water sensitive development at "The Green".

The sustainability concept accepts that there are interactions (say tensions) between economic, environmental and social goals, and seeks to improve the development process via finding mutual benefits. The broader analysis of economic, environmental and social sustainability will be out of scope for one thesis; hence this thesis only explores the socio-environmental sustainability of the NDG system and associated urban development. The social-environmental aspects of the development are the least explored ones and mostly overlapped by the economic agendas (McKenzie, 2004, 2013). Lack of attention for socio-environmental sustainability may be due to the ambiguity of the social and environmental elements and/or greater difficulty to quantify the social and environmental impacts of development (Littig and Griessler, 2005; McKenzie, 2013).

B. Sustainable water resources management

The sustainable use of water resources has been acknowledged as an important concept in planning, but not achieved yet (Hurlimann, 2006). In Australia, sustainable water management has been discussed in almost all planning sectors and widely called for. All state governments have set policy for the achievement of sustainable water management and development. The Government of WA has given water and its management strategic priority basically due to climate change and variability, and resource scarcity but a continued increase in demand. The State Water Plan (2007) aimed for achieving sustainable management and development of water resource and services by maintaining and enhancing natural environment, cultural and spiritual value, human health and quality of life, and economic development of the state (Government of Western Australia, 2007).

There are four main strategies developed by the State Water Plan, (2007) to manage water sustainably in WA: using less water; reuse of water; improve productivity of water and development of new sources of water. In addition, the State Water Plan, (2007) considered the groundwater as an important resource for sustainable water management mainly due to its reliable availability and proximity to demand. The State Water Plan, (2007) acknowledged groundwater for its significant contributions to the ecosystem, public health, business, culture and recreational pursuits in WA (Government of Western Australia, 2007).

A research conducted by ARCWIS (2005) in various parts of Australia has identified "long term sustainability" as one of the critical factor for community acceptance with water supply systems. This clearly indicates that Australian communities desire sustainable water supply systems, however, their water using behaviour seldom reflects their values for sustainability (Kantola, Syme, and Campbell, 1984; Browne, Tucker, Johnston, and Leviston, 2007). This is the attitude-behaviour disconnect, which indicates water *attitudes* have weaker relationships with water using *behaviours,* which is another major enquiry in this research.

'Sustainability in water resource' urges the integration of all possible water resources and different water systems rather than considering one perfect solution in isolation. Water using behaviours have changed significantly in last decades in Australia, especially in terms of water saving and re-using water resources (Browne et al., 2007) that are imperative to secure a sustainable water future. However, there are debates around sustainability of water resources under a drying climate in WA. This discourse occurs especially in Perth, where most of the drinking water comes from groundwater and public parks as well as large numbers of domestic gardens that utilize groundwater resources. This way of groundwater usage caused a decrease in groundwater level and saline intrusion in some coastal parts of the city. This situation demands the social and environmental sustainability analysis of the alternative water systems utilising local groundwater resource, such as: a NDG supply trial in "The Green".

Observation 14: Water conservation, water efficiency, water recycling, and improving productivity of water are foundation for sustainability in water resources that eventually demands the integration of all possible water resources and available water management strategies.

The ‘sustainability in water resource’ is a fairly new concept and is yet dominated by economic feasibility analysis prior and even after the development. The Environmental Impact Assessments (EIA) are usually conducted as prerequisite of new water management projects, whereas the social sustainability analysis are rarely conducted or conducted as subordinate of economic agenda (McKenzie, 2004). This study aims to build on the gap in knowledge by exploring the post-development socio-environmental sustainability of an innovative alternative water system in Perth. This study also explores the operation, utility, and efficiency as well as planning implications of the alternative water system in urban settings.

C. Theory of sustainability for this research

This study utilizes definitions of McKenzie’s (2004) ‘social sustainability’ and Diesendorf’s (1997) ‘ecologically sustainable development’ to explain the socio-environmental sustainability approach in this research. McKenzie (2004) defines ‘social sustainability’ as “a positive condition within communities, and a process within communities that can achieve that condition”. In simple words, McKenzie’s (2004) considers the social sustainability is a positive social condition in terms of equity of access to key services such as: health, education, transport, housing etc.; intergenerational equity; political and cultural harmony; and community sense, ownership and responsibility. Diesendorf (1997) defines ‘ecologically sustainable development’ as “types of economic and social development which sustain the natural environment and promote social equity”. Diesendorf’s (1997) sustainability approach considers economy as a sub-set of ecology that also includes social equity, thus a triple bottom approach of sustainability. In addition, this approach considers inter and intra generational equity, as a unifying principle of sustainability, maintained in terms of ecosystem, culture, bio-diversity, and enhancement of well-being (Diesendorf, 1997). According to Amartya Sen, (1993), well-being is "a person’s ability to do valuable acts or reach valuable states of being”.

These two approaches contribute in evaluating socio-environmental sustainability of the alternative NDG system and water sensitive urban development in terms of the equity of access to key community and water services; community sense, feelings, and responsibility towards the alternative water system and development; intergenerational equity; contribution to the environment; and enhancement of well-being from the alternative water system and development. The notion of wellbeing is mainly related to dimensions of residential satisfaction. In addition, the implications of the water system and urban community responses for the urban land and water planning will also be integrated in evaluating the socio-environmental sustainability.

Above mentioned discussions around the sustainability issues of the alternative water system inform and develop a broad research proposition that examines the roles of positive community engagement for the success and sustainable development of the alternative water systems. This proposition aims to clarify and establish the post-development social and environmental issues pertaining to the successful implementation and sustainable development of the NDG system in urban settings.

Observation 15: Literature indicates that the social and environmental issues are crucial for sustainable development of alternative water systems, which are least explored so far.

Observation 16: The community participation in alternative water systems increases the acceptance of the systems, which in turn, increases the sustainability of the systems.

2.4. Residential satisfaction

Whatever the technology, planning and services, or development activities - no matter how sustainable it is, has to come to the community for its successful implementation and business. The community subjective responses and behaviours towards the alternative systems greatly determine the success of the alternatives (Porter et al., 2006; Hurlimann, 2008; Hurlimann and Dolnicar, 2010). The subjective responses, in turn, depend upon the physical attributes of the alternatives, community expectations and aspirations, and the comparing standards (Campbell, Converse, and Rodgers, 1976; Weidemann and Anderson, 1985; Amerigo and Aragones, 1997; Amerigo, 2002). This study focuses on evaluating the community feelings and responses to determine the level of residential satisfaction with an innovative NDG system in an urban community in Perth.

The concept of residential satisfaction is central to this research. Residential satisfaction is an important social indicator that evaluates the quality of living environment and predicts behaviour towards the residential environment (Speare, 1974; Campbell et al., 1976; Weidemann and Anderson, 1985; Amerigo and Aragones, 1997; Amerigo, 2002; Adriaanse, 2007). This research investigates the determinants of residential satisfaction with the NDG system in a water sensitive urban environment. In addition, this research explores the relationship between the satisfaction with the NDG system in a water sensitive environment and residents' behaviour towards the water system and the environment.

This section proceeds with an empirical description of residential environment and postulate a model of residential satisfaction with the water sensitive urban environment. Figure 6 portrays the flow-structure of the empirical discussions that starts with 'home' environment to residential satisfaction. This helps in explaining the logic of the satisfaction with the NDG system as an additional component of residential satisfaction.

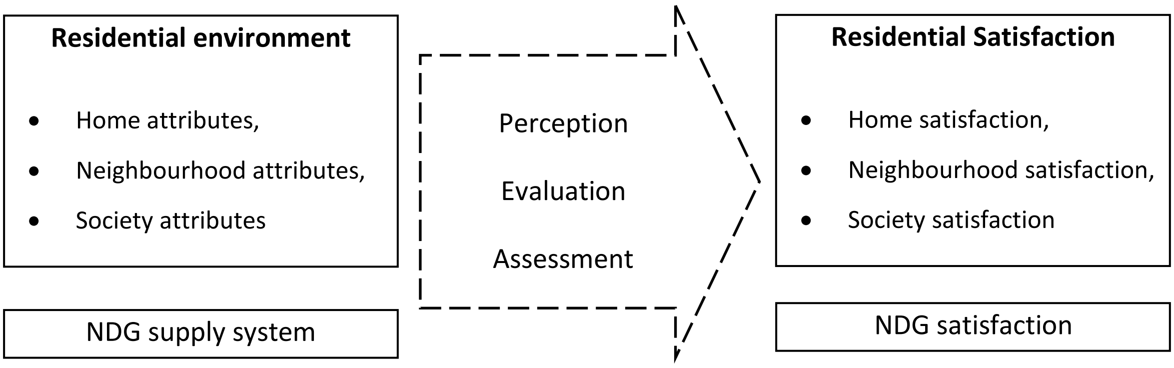


Figure 6: The structure of literature review and logic for NDG satisfaction concept

The following section explains the home role of housing and different approaches for evaluating home environment in terms of the residential satisfaction. This leads to the discussion of theories of residential satisfaction used in this research.

2.4.1. The 'home' concept of housing

Housing has been regarded as multifaceted in character, which has complicated its evaluation. It has been considered as a place for home, an economic asset, a community asset, a set of buildings, quality of buildings but more generally as an activity support system. Single-facet evaluation approach is unable to provide information about the relative importance of other aspects of housing. Therefore a multi-facet evaluation approach should be used to evaluate the home environment as a whole.

Home, may be broadly, defined as a place of shelter and comfort that is an activity support system for an individual or a family unit in a western culture. The role of housing as 'home' has evolved during mid - 1980s and is viewed today as a place that represents the core of the physical portion of the socio-physical environment, where the human accommodates, and sustains safe and quality life (Government of Western Australia, 2013). As an outcome of several studies on social satisfaction, Campbell, et al., (1976) consider the place of residence (i.e., the home role of housing) is an important domain of overall life satisfaction. This emphasis for the evaluation of housing may be due to the market perspectives, considering housing as a product; or due to the concern about the impact of poor housing on society; or because every person lives in a home and everyone knows what the homes are (Weidemann and Anderson, 1985). The consideration of home as a domain of life satisfaction justifies the home environment as a social indicator.

Albeit diversified reasons, the evaluation of home environment has become an established reality. The economic issue of housing has been studied since 1930, while the evaluation of community-health aspect of home go back to the social reform of the late 19^{th} century (Weidemann and Anderson, 1985). Earlier housing evaluation in USA was initiated in 1977 by the Environment Research and Development Foundation of the Department of Housing and Urban Development, which extensively conducted post occupancy evaluation of housing (i.e., home environment). Such evaluation was initially focused on the pleasure and satisfaction that the individuals derived from their living environment, more precisely to evaluate the quality of life. Since then, arrays of evaluation studies were conducted from two major perspectives: quality of housing (development) perspective, and quality of life (socio-psychological) perspective.

This study draws knowledge from both perspectives to evaluate residential satisfaction and behaviour towards urban environment having an innovative NDG system. The quality of housing perspective evaluates the physical attributes of the urban environments and examines if the environmental attributes address the community needs and expectations. The socio-psychological evaluation of satisfaction examines the impact of the water sensitive urban environment on the quality of life in that environment. The behavioural responses further inform about the quality of life, such as: if the quality of an urban environment is perceived lower than a certain level, it triggers adjusting in or moving out behaviour.

The socio-psychological perspective focuses on how the individual evaluates their living environment and how the evaluation could be representative of their satisfaction with that environment. Initially, Weidemann and Anderson (1985) organised all previous disjointed socio-psychological studies and synthesized the underlying theory for the evaluation of the home environment in terms of the occupant’s satisfaction. Later on, Amerigo and co-workers (1990, 1997; 2002) refined and promoted this synthesis, and outlined two broad approaches for evaluating the home environment: a) as a criteria of quality of life (or living environment), and b) as a predictor of behaviours towards the living environment. These two approaches are well documented and supported (Speare, 1974; Marans and Rodgers, 1975; Newman and Duncan, 1979; Canter and Rees, 1982; Amerigo and Aragones, 1990, 1997; Marans, 2003; Po et al., 2005; Adriaanse, 2007). The following sections explain both approaches one by one, and then, combine them to get a third (integrative) approach for evaluating the residential environment satisfaction.

2.4.2. Concept of quality of life

"The revolution of rising expectations is not simply a desire for a larger house, a second car but a growing demand for fulfilment of needs which are not basically material but are primarily needs of the spirit, needs for a larger and more satisfying life experience".

Campbell, et al., (1976)

The discussion of 'quality of life' goes back to 1970, when American societies surpassed the elemental needs of foods and shelter and started to desire the higher-order needs for social esteem, recognition and self-actualization (Campbell et al., 1976). That situation changed the national focus from elementary needs to the needs for participation, respect, growth and equity of all people. The economic indicators were neither enough nor precise for measuring the quality of life; therefore, more comprehensive "social indicators" were officially announced in the USA for the first time in 1973 by its statistical body (The statistical office of the 'Office of Management and Budget' in Executive office of the President). Housing was one of the crucial social indicators of quality of life that measures the achievement and well-being of a person or a society (Campbell et al., 1976). However, there were debates (or concern) about how well the objective attributes (e.g., housing, education, employment, public services, and basic facilities) could represent underlying subjective experience of life (or measure the quality of life).

Those debates around quality of life on the basis of material possessions didn't articulate an easier model for measuring the quality of life until Campbell, et al., (1976) put forth a psychological perspective of quality of life. Campbell, et al., (1976) explained that the personal subjective responses towards the objective attributes, mainly: perceptions and feelings, expectations and aspirations, and values are equally important to measure the quality of life. In fact, the quality of life depends both on the objective attributes of the residential environment as well as subjective responses towards the environment (Campbell et al., 1976). This notion is useful in evaluating the satisfaction with the environment, which is a measure of quality of life.

Satisfaction is a personal psychological experience that is independent with the material possessions or objective attributes of the environment; however it is heavily influenced by present needs and aspirations (expectations) (Campbell et al., 1976). The objective attributes fulfils the personal needs, which generates satisfaction (subjective attribute). The level of needs greatly depends upon the person types and circumstances; hence, satisfaction also differs in the same way. That in turn, influences the quality of life. However, Campbell et al. (1976) and Marans and Rodgers (1975) have found that the overall quality of life (or life satisfaction) is influenced by a variety of social and physical domains (e.g., family, job, religious affiliation, residence, neighbourhood, and community). A person's overall life satisfaction can be conceptualized as a combination of satisfaction with these numerous domains. Nonetheless, it is simply an additive process. There may be many interacting or competing influences between these domains. Among several domains of life satisfaction, the main concern of this study is satisfaction with the 'home' aspect of housing, more specifically satisfaction with residential environment.

2.4.3. Evaluation of residential Environment

There are three fundamental approaches for evaluating residential environment in terms of satisfaction. The first approach is quality of life approach, which explains residential satisfaction as a criterion of quality of life in the residential environment. The second approach considers residential satisfaction as a predictor of behaviour towards the residential environment. The third approach utilises the age-old environment-response trilogy as a basis for evaluating residential satisfaction. The response trilogy explains that an individual responds in three ways to any socio-physical environment: a) perceptions/beliefs (cognitive), b) emotional (affective), and c) behavioural (conative) responses (Weidemann and Anderson, 1985).

The three responses are considered as three components (affective, cognitive, and behaviour) of an attitude towards the environment (Rosenberg, 1960; Ostrom, 1969; Fishbein and Ajzen, 1974; Ajzen and Fishbein, 1977; Ajzen, 2005). Residential satisfaction is considered as a 'global attitude' of the resident towards the environment (Adriaanse, 2007); hence, the response trilogy determines the satisfaction with and behaviours towards the residential environment.

In this way, the concept of attitude towards the environment integrates the previous two approaches for evaluating the socio-physical environment in terms of satisfaction with the environment. On the same theoretical foundation, this research aims to develop an integrated model of residential satisfaction with an innovative NDG system in water sensitive urban development.

A. Subjective evaluation of residential environment

People live in an objective world, but they make decisions based on their subjective assessments (or evaluation) of an element or a situation of the objective world. This evaluation mainly depends on three factors: the attributes of the element or situation; how the attributes are perceived; and the standard of comparison (e.g., personal needs, expectations, aspirations, reference group, etc.) against which the attributes are judged (Rojek, Clemente, and Summers, 1974; Marans and Rodgers, 1975; Campbell et al., 1976; Weidemann and Anderson, 1985; Amerigo, 2002; Adriaanse, 2007). These fundamental principles have been utilised in a number of recent studies (Hurlimann, Hemphill, McKay, and Geursen, 2008; Ganglmair-Wooliscroft and Lawson, 2012; Gou, Lau, and Chen, 2012) with a few research specific alterations.

As modelled by Campbell et al., (1976) the process of evaluating an environment (say home environment) begins with the objective attributes of the environment, for example, the block size, home type, space for activities, facilities, residents, road network, landscaping, and gardens. The assessment process depends on how an individual perceives and compares these objective attributes against some standard attributes (or standard home environment). The end result of the assessment is the subjective outcome, 'satisfaction with home environment', which is equally affected by the objective attributes, the perception of the attributes and the standards of comparison. In general, the more an individual perceives the attributes closer to his/her standard ones, the assessment become more positive. Such positive assessment, then, results in a higher level of satisfaction. Perceiving objective attributes and comparing against a standard are simultaneous and closely concerned with one another (Campbell et al., 1976).

The standard of comparison might be different for different individuals, because it is composed of multiple criteria. These criteria are: aspiration (a situation that an individual hopes to attain), expectation (what the individual feels likely to attain in near future), equity (what the individual thinks might happen when perfect justice prevails), reference groups (what the individual thinks to be a true condition of his friends, relatives and others), personal needs (assets, housing, money, safety etc) and personal values (likes, freedom, equality). The individual sets the standards for comparing any specific domain on the basis of any of or all of these criteria (Campbell et al., 1976).

Another important thing to consider is the perception of the attributes is dependent, but distinct from, the objective environment. That means the attributes of an environment can't necessarily be equated with how an individual feels about that environment. This justifies the variations in individual perception as well as the variations in the evaluation of an environment. The variation in perception depends on individual experience, social location, and personality, i.e., collectively the person characteristics (Campbell et al., 1976). The difference in personal characteristics not only makes individuals perceive an environment differently but also brings different standards of comparison for evaluating the environment. Thus, a variable assessment of the environment results in different levels of satisfaction with the same or similar environment, or even the higher level of satisfaction in an inferior environment (Amerigo and Aragones, 1990; Amerigo, 2002). As shown in Figure 7, the personal characteristics have influences over all components of the satisfaction model.

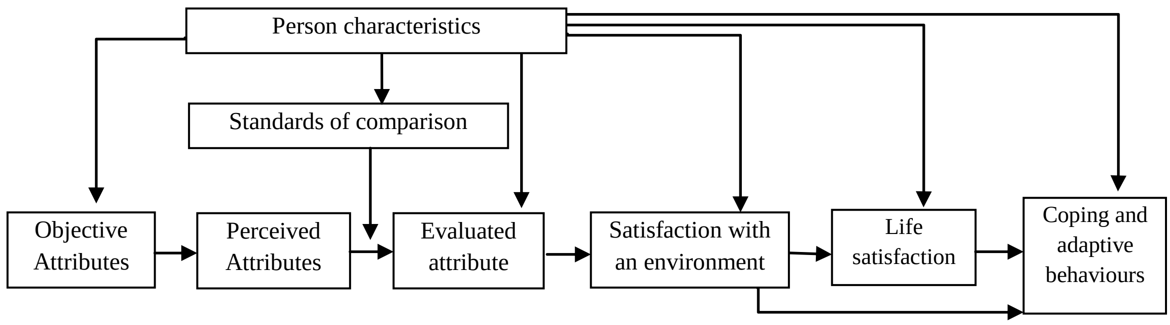


Figure 7: Campbell et al. (1976) model of satisfaction

Campbell et al. (1976) extends the model of satisfaction to the overall life satisfaction and behaviour responses towards the environment. Satisfaction with different environments, such as: home, work, education etc., collectively result in the overall life satisfaction. Finally, the environment satisfaction and overall life satisfaction (or global level of satisfaction) predict various forms of coping and adaptive behaviour.

Utilizing the Campbell et al., (1976) model of satisfaction, Marans and co-workers (1975; 1981; 2003) broadly examine satisfaction with the 'home' environment to develop and justify their model of residential satisfaction. Marans and Spreckelmeyer (1981) developed the basic conceptual model of residential satisfaction, where individuals perceive, assess and evaluate the objective attributes of residential environment to achieve subjective responses (mainly the satisfaction) that are also influenced by the objective attributes of the environment. Finally, the residential environment satisfaction determines the behaviour towards the environment. Marans and co-workers included the behaviour component in their basic model but they didn't consider it explicitly in succeeding studies (Marans, 2003; Potter, Cantarero, and Boren, 2009).

Campbell et al. (1976) and Marans and co-workers (1975; 2003) fundamentally differentiated the residential environment into three major domains namely: community, neighbourhood (macro and micro), and dwelling (house) in their detailed version of residential satisfaction model. The objective attributes were categorised into their respective domains. The objective attributes, when perceived and assessed by individuals, generate satisfaction with each domain. Collectively, the domain satisfactions result in 'overall residential satisfaction'.

Canter and Rees (1982) dealt similarly with residential satisfaction, but replaced the community component of residential environment with neighbours that has been widely adopted (Amerigo and Aragones, 1990; Adriaanse, 2007). Furthermore, Canter and Rees (1982) define the neighbourhood as the immediate community only (one street or 10-15 households). This neighbourhood is the most frequently connected part of a society for an individual, so is assumed to be enough for a person to evaluate his/her residential environment without considering the broader community. There are ongoing debates about the appropriate scale of the 'neighbourhood' component of residential environment (Hipp, 2010). However, this study utilizes Canter and Rees (1982) concept of neighbourhood that is considered more appropriate than broad community for evaluating residential satisfaction (Hipp, 2010).

Observation 17: Literature indicates that Individual perceptions, belief and subjective evaluation of different objective attribute of the residential environment (composed of three fundamental domains: the home, neighbourhood, and society (mostly neighbours)) generate satisfaction with the residential environment.

Most of the subjective evaluation studies consider satisfaction as a criterion variable of the objective environment (Marans, 2003; Nakanishi and Hu, 2012). This is only one approach of evaluating the environment, where the most important missing part is the connection of satisfaction with behavioural response towards the environment. The following section describes the connection with empirical evidence.

B. Behavioural responses towards the residential environment

During the late 1980s and early 1990s, many researchers showed great interest in the analysis of the determinants of satisfaction with residential environment and residential mobility. Nonetheless, the two issues have been addressed separately, and research on the behavioural consequences of residential environment satisfaction are scarce (Diaz-Serrano and Stoyanova, 2010). This research aims to address the gap in knowledge regarding the behavioural approaches to evaluate the residential environment. The approach provides the link between residential satisfaction and residential behaviour and explains the satisfaction as an intervening variable that determines the migratory or adaptive behaviour (Speare, 1974; Newman and Duncan, 1979; Priemus, 1986; Diaz-Serrano and Stoyanova, 2010).

In simple words, an individual determines to move out from his/her residential environment depending on the level of residential stress (dissatisfaction) he/she experiences. If the level of residential dissatisfaction is more than the threshold level, an individual is likely to consider moving out from the environment (Wolpert, 1965). The threshold level is a scalar value that is unique for every individual, and represents the minimum level of dissatisfaction at which the movement can be initiated (Golant, 1971). Based on the concept of 'threshold level of dissatisfaction', Spears (1974) developed a widely accepted model for mobility decision-making in a residential setting as shown in Figure 8.

Housing dissatisfaction is considered as a gap between household's need and environmental attributes (Brown and Moore, 1970; Priemus, 1986) and an individual tries three major approaches to adjust the gap. The first is 'adjusting the household's needs' that can be fulfilled in the current environment (adapting); the second is 'restructuring the current environment' to satisfy the household's needs (coping); and the final one is 'relocating' to a new environment (migrating) (Brown and Moore, 1970). Either of the first two approaches result in a decision not to migrate; however, the third approach results a migration to a better environment that fulfils the needs of the individual and/or yields higher level of satisfaction. It is equally possible that if a person decides to migrate but fails to get better residential environment; s/he may revert his/her decisions back to adaptation and/or coping (Brown and Moore, 1970). Therefore, dissatisfaction is necessary but not a sufficient condition for moving behaviours (mobility) (Brown and Moore, 1970; Speare, 1974). Mobility occurs only if the adjustments are almost impossible or can't suffice the household's needs. In simpler words, moving decision is only taken when there is no adaptive way to resolve the dissatisfaction or bring it back to the threshold level (Speare, 1974; Priemus, 1986).

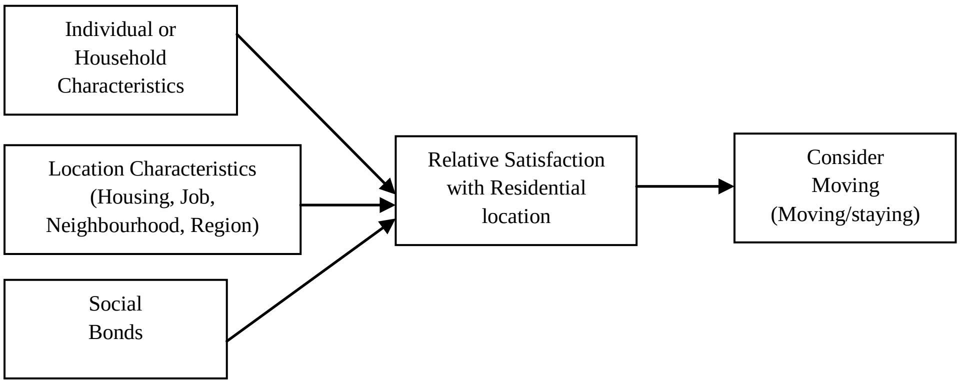


Figure 8: A model for mobility decision-making (Speare, 1974)

An individual's decision to adapt, cope, or migrate from the residential environment is a complex process. An individual is tied up to a particular residential environment via several social bonds, such as: friends and neighbours, family etc; and attachments to house, jobs, neighbourhood etc. The positive nature of these bonds/attachments results a higher level of satisfaction. Longer residence duration also assists in positive evaluation of the residential environment. In addition, the objective attributes of the environment and the standards for comparing these attributes significantly impact on satisfaction with the environment. The higher satisfaction level is usually associated with the less chance of migratory behaviour and vice versa (Speare, 1974).

The dissatisfaction is relative to personal needs and/or expectations that depend upon the personal characteristics. Hence, the personal characteristics result a variation in the level of dissatisfaction. Since the threshold level of dissatisfaction is unique for each person, the variation in dissatisfaction level results in varying behavioural decisions towards the residential environment (Speare, 1974). The standard of comparison also plays vital role in mobility-decision making. Prior to migrating, a person compares the attributes of an alternative environment and decides to migrate only if the alternative yields a higher level of satisfaction than the current one, otherwise the person decides to adjust to the current residential environment. Speare (1974) includes cost-benefit comparison between the new and existing environment, which is similar to the standard of comparison component in previous model (Figure 7) in determining behaviour (moving or adaptive) towards the environment.

Observation 18: Literature indicates that the satisfaction level with the residential environment determines the behavioural (adaptive or migratory) responses towards the environment. The *satisfied individual does not move out from the environment, recommend the environment to others, and choose similar living environment again.*

In this way, the behavioural approach explains explicitly the link between the residential satisfaction and migratory behaviour (Wolpert, 1965; Brown and Moore, 1970; Speare, 1974; Priemus, 1986). However, this approach is centred on only one component of the response-trilogy, the behavioural response; and surpasses the cognitive and affective responses. This study considers the integration of all three - cognitive, affective, and behavioural responses to develop an explicit model of residential satisfaction with water sensitive urban environment.

C. Attitudinal approach for evaluating the residential environment

Affective, cognitive and behavioural approaches

The affect is the emotional response (or a feeling) towards an object or environment, and has a evaluation with valence having a positive or negative value (Abelson, Kinder, Peters, and Fiske, 1982). This notion suggests that individual affective responses to their residential environment in terms of positive or negative feelings, perceptions, and evaluations can directly measure their level of satisfaction with the environment (Weidemann and Anderson, 1985). In addition, the affective responses are a stronger predictor of preferences and evaluation (Abelson et al., 1982) of any environment than the semantic judgement of the environment, and therefore are used for dealing with the environment satisfaction in many studies.

Francescato, Weidemann, Anderson, and Chenoweth (1975) focused on the affective responses (perceptions and evaluations) towards physical attributes of home environment to determine residential satisfaction. They utilized the affective responses for home to measure the quality of home environment. Francescato et al. (1975) also have the resident's characteristics and beliefs component in the model, which represents a second category of response - trilogy - the cognition. Later on, Campbell et al. (1976) explained the affective responses as a determinant of quality of life. Campbell et al. (1976) recognized that the evaluation of an objective environment depends upon the perception of the objective attributes (affective response), but distinct from the objective environment. In simple words, the evaluation of an environment is not necessarily equivalent to the environment itself, which greatly depends upon individual perception and assessment of the environment. This illustrates a very important role of perception and assessment in evaluating environment and simultaneously the associated risks of under- or over-evaluation of the environment than the actual ones (Marans and Rodgers, 1975).

To resolve this issue, Marans and co-workers (1975; 1981; 2003) explicitly explained the objective attributes have a direct relationship with the satisfaction as well as an indirect relationship through the perception and evaluation of the attributes. Using this notion, Marans and Spreckelmeyer (1981) illustrated the relationships between objective environment, subjective evaluation and residential satisfaction. In addition, their model also included the third element of response trilogy - the behaviour alike Campbell et al. (1976) model of satisfaction. Marans and Spreckelmeyer (1981) model of residential satisfaction attempted to contextualise the 'behaviour' component in residential environment but they didn't consider it in later studies.

The behavioural responses to residential environment were overshadowed by the affective and cognitive responses in earlier studies until Tomkins (1962) considered the affective responses as the "motor" for behaviour. Similarly, Campbell et al. (1976) and Marans and Spreckelmeyer (1981) stated that individual perceptions and assessments of objective attributes (affective responses) generate the satisfaction (attitude) that predicts the behaviour towards the environment. Moreover, the objective attributes of the environment as well as the evaluation process equally influence the individual behaviour towards the environment (Marans and Rodgers, 1975; Campbell et al., 1976; Marans and Spreckelmeyer, 1981; Marans, 2003).

Furthermore, Amerigo and co-workers (1997; 2002) explicitly explained the behavioural response as an important component of attitudinal evaluating approach along with the affective, and cognitive responses. Better understanding of the linkage between the three responses is extremely important to explain the integrated approach for evaluating residential satisfaction.

Interrelationship among Cognitive, Affective, and Behavioural responses

In reality, all previous discussions on the approaches to evaluate residential environment in terms of satisfaction lead in the same direction; thus, are supporting the concept of attitude. This simply explains residential satisfaction is an affective attitude towards the home environment that results from perceptions and evaluations of objective attributes of the environment and causes an individual to behave accordingly (Campbell et al., 1976; Weidemann and Anderson, 1985; Amerigo, 2002; Marans, 2003). In this way, residential satisfaction is the product of a cyclical and dynamic process in which the subject perceives and evaluates the environment to generate a certain level of quality of life experience and adapts to specific residential situation. The construct of residential satisfaction is complex, multidimensional, global appraisal combining cognitive, affective, and conative facets, thus fulfilling the criteria for defining it as an attitude (Amerigo, 2002).

An attitude can be viewed not only as an implicit mediating response but also as an evaluative mediating response (implicit evaluative reaction) that predisposes an individual to perform various overt behaviours (Ajzen, 2005). Attitude is a relatively stable affective reaction to a physical object or event that is accompanied by a cognitive structure made up of beliefs about the potentialities of that object or event for attaining certain values (Rosenberg, 1960, 1965). In this way, the interaction of the cognitive (beliefs, values etc.) and the affective components (perception and evaluation) generates an attitude, which in turn, predisposes the individual to perform the overt behaviour towards the objects or events (Ajzen and Fishbein, 1977).

Weidemann and Anderson (1985) compared Marans and Spreckelmeyer (1981) and Francescato et al. (1975) model of residential satisfaction to identify the inter-relationship among the affective (perception and evaluation), the cognitive (beliefs, judgement etc.) and behavioural (adoption or migration) component of the model. Both models considered the cognitive components (beliefs in Franncescato model and subjective evaluation in Marans model) are determinants of affective attitude (positive or negative emotional experience); which in turn, determines the behaviours towards the environment.

However, those direct relationships were widely criticised (Lazarus, 1984; Zajonc, 1984). Various authors have suggested that these relationships indeed are more complex and reciprocal than it was previously thought. However, Weidemann and Anderson (1985) argue that the relationships can be theoretically multidirectional but there is a general sense of causality when moving from cognitive to affective components and then to behavioural responses towards the environment. This ‘general sense of causality’ is evident in several previous and recent studies on residential satisfaction (Speare, 1974; Campbell et al., 1976; Canter and Rees, 1982; Weidemann and Anderson, 1985; Amerigo, 2002; Marans, 2003; Adriaanse, 2007; Hurlimann, 2008; Dzidic and Green, 2012). This study also utilizes the notion of ‘general sense of causality’ from affective to cognitive and then to behavioural component to highlight the quality of water sensitive urban environment in terms of residential satisfaction with and behaviours towards the environment.

Weidemann and Anderson (1985) further pointed out that both of the models failed to include the behavioural components (mainly the behavioural intentions), which is the mediating factor between individual affective response (perception and evaluation) and actual behaviour. The concept of behavioural intention was proposed and developed by Fishbein and Ajzen (1975), for which extensive support (Amerigo, 2002; Baker, 2002; Adriaanse, 2007) exists. The concept of behavioural intention justifies that attitude is essential but can't always determine behaviour. For example, although having negative feelings about an environment, an individual may still have no intention to move away from it, which results in no mobility.

Incorporating the concept of behavioural intention, Weidemann and Anderson (1985) put forth an integrated model that better describe existing research having relationships among beliefs, affective attitudes, and their behavioural responses as well as rationalize the intermediary role of behavioural intentions between affective attitude and behavioural responses. Amerigo and co-workers (1997; 2002) further refined and promoted the integrated model that simultaneously considers residential satisfaction as a criterion variable of quality of residential environment (affective and cognitive responses) as well as the predictor of behaviour towards the environment (conative response). The integrated model embraces that the objective attributes of the environment and personal characteristics are equally important as the subjective assessment process for a complete interpretation of the satisfaction with the residential environment (Weidemann and Anderson, 1985; Amerigo and Aragones, 1997; Amerigo, 2002).

This research utilises the integrated model for the study of residential satisfaction with an alternative NDG system and water sensitive urban development in Perth. The integrated model help this research to explore whether the quality criteria expected by the residents (affect and cognition) were met so that the residents are satisfied with the water system and development (attitude); and whether the residents needs and aspirations were sufficiently addressed so that they have no intention for adjusting or moving out (behaviour).

Observation 19: Residential satisfaction is considered as a global attitude towards the residential environment that concurrently measures the quality of residential environment, and determines the behavioural responses towards the environment that is mediated by behavioural intention.

Observation 20: The subjective evaluation of the objective environment (i.e., satisfaction) greatly depends upon an individual perceptions and assessment of the environment but distinct from the environment itself, which has a direct impact over the evaluation process.

2.5. Conclusion

This chapter presents the empirical descriptions about the climate change and other challenges to the urban water management in Australia, and the development strategies to resolve the challenges. This chapter further outlines the essence to develop an alternative water supply scheme and innovative water sensitive development plan and policies. Community participation, acceptance, and satisfaction with the innovative alternative urban water management practices are discussed and the associated planning implications are also considered. Further, the sustainability of the alternative urban water resource management practices is explained from a socio-environmental perspective which is one of the least studied aspects of alternative water system in urban setting.

The major gaps in the knowledge are identified, mainly in terms of the community acceptance, satisfaction and their behavioural responses regarding the alternative water system and water sensitive development in Perth. This chapter draws a number of observations around the water issue, innovative technologies and sustainability, community acceptance and residential satisfaction issues. Similarly, Chapter Three provides the details of a NDG system and water sensitive development in “The Green” at Butler, and draws main observations regarding the system and the development. The observations assist in formulating a number of research propositions and constituting hypotheses to address the assumptions, uncertainty and gaps in knowledge. The research propositions and hypotheses are described in Chapter Four. A conceptual framework is developed and a number of qualitative and quantitative research tools are deployed to investigate and evaluate the research enquiries (Chapter Five) and the findings are given in subsequent chapters (Chapter Six, Seven, and Eight).

CHAPTER 3: Historical overview of the 'Non-drinking Groundwater (NDG) Trial'

3.1. Introduction

This chapter provides a historical overview of the planning and development of a NDG system in "The Green" at Butler. This chapter describes the agreements between the stakeholders and the associated statutory regulations regarding the duties and responsibilities of the parties involved in the NDG trial. This chapter also elaborates about the structure, operation and regulation strategies of the NDG trial in the form of a dual water supply system at a residential setting. In addition, the findings of the field observation and informal talks with local residents before the formal interviews are also described. Finally, the planning implications of the NDG trial regarding the urban water management and land development are briefly mentioned to give an idea about the utility of the system and its impact over the planning policies and legislations regarding water resource management at various spatial levels.

3.2. Historical overview of NDG trial

3.2.1. Why NDG?

As discussed earlier in the literature review chapter, the drying climate and growing population of Perth have demanded the alternative water management approaches to secure urban water supply in future. The increasing urbanisation is likely to increase urban water resources (runoff and groundwater). The possible groundwater extraction in such urban areas will have dual benefits; first, utilizing the enhanced groundwater resource for a non-drinking water supply, and second, reducing urban drainage and nutrient export to water bodies (Barron et al., 2010).

This type of groundwater supply could be a viable alternative for most of Perth metropolitan areas for watering residential gardens and Public Open Space (POS) (Smith et al., 2005). In Perth, the groundwater use for watering gardens and parks via domestic bores is an established tradition (Department of Water, 2011; Syme and Nancarrow, 2011). The expansion of the bore system for the whole community (domestic to communal) could save almost half of the scheme water used in outdoor watering (Loh and Coghlan, 2003; Water Corporation, 2010). However, there should be sufficient recharge into the immediate aquifer to ensure sustainable supply of non-drinking groundwater (Lloyd et al., 2002).

The discussed non-drinking groundwater system has been implemented for “The Green” community of Butler (Figure 9) as a five year trial since 2006. The trial development embraced a number of water sensitive designs in land planning to support the NDG system and local environment. Main aim of this trial is water conservation (30% in household and 40% in POS). The trial equally aims to determine whether the NDG scheme can meet the garden irrigation needs of local community; and whether the system can increase the overall water efficiency in residential settings.

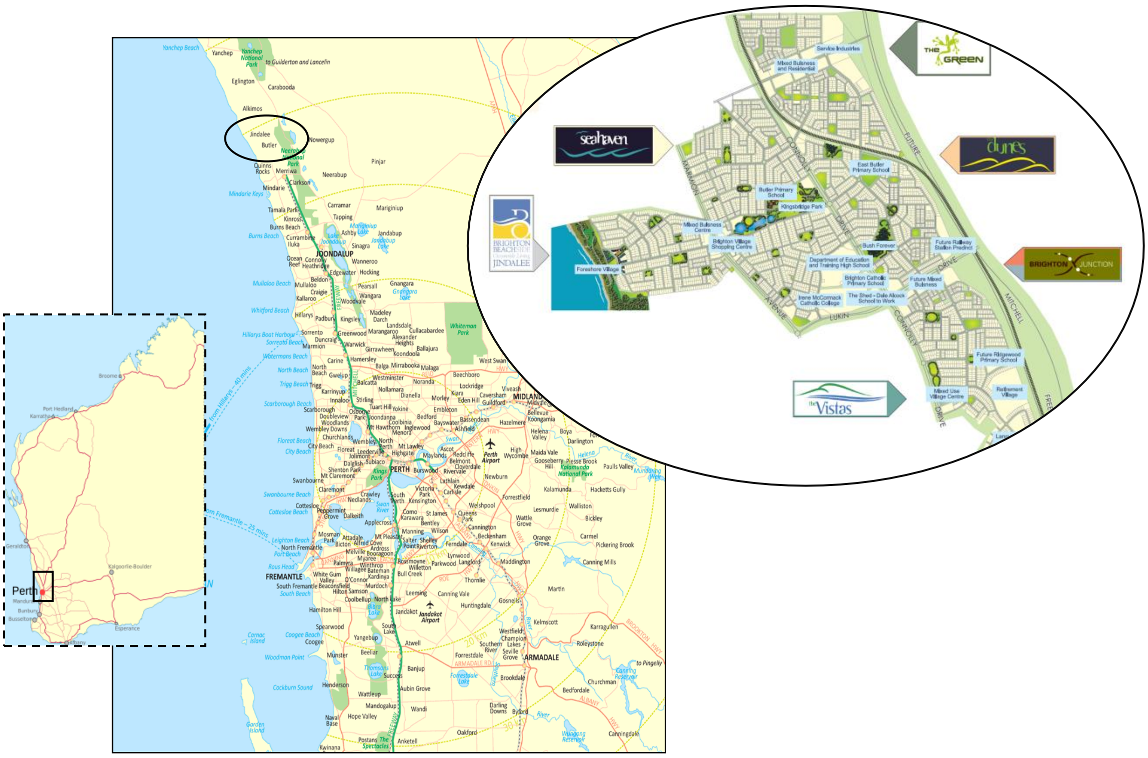


Figure 9: Location of groundwater trial in Butler, WA (Google Images, 2013 and Satterley Property Group, 2010)

3.2.2. Why Trial Development in ‘The Green’?

After embracing the concept of fit-for-purpose non-drinking groundwater supply, WA Water Corporation directed its efforts to the site-specific estimation of groundwater resources both in terms of water quantity and quality, so that it can be utilised for a decentralised non-drinking supply. Initially, Ranford Road development at Harrisdale, WA (in the Southern suburb of Perth) was considered for such a non-drinking groundwater supply trial. The Ranford Road trial was abandoned due to the aesthetically degraded quality of groundwater, especially a high iron concentration that may cause staining as well as malfunction of the watering system. The only way to succeed the Randford Road trial was the water treatment, which would increase the cost of the non-drinking groundwater supply from \$0.66 to 0.90 per KL to more than \$3.0 per KL (Barron et al., 2010). Therefore, the NDG trial was not considered viable at Ranford Road, mainly because of the groundwater quality constraints, and relocated to "The Green" development at Butler, WA (in the northern suburb of Perth). However, the outcomes of the Ranford Road trial investigations enforced the need for better understanding of groundwater quality (Barron et al., 2010) and other relevant issues before implementing fit-for-purpose groundwater systems. The reasons to select "The Green" at Butler for the trial of a NDG system are described below.

A. Non-drinking groundwater quality

The analysis of groundwater quality data in "The Green" confirmed that groundwater in the area is acceptable for non-drinking purposes; such as watering garden and parks, with a low level of salinity; moderate alkalinity (calcium oxides); low iron concentration; and slightly high hardness than the Australian Drinking Water Guidelines (GHD, 2006). The presence of iron and calcium oxides may cause white and or brown staining (Barron et al., 2010) while exposed during outdoor watering. The drip or subsurface irrigation practices can effectively reduce the staining issues and promote water efficiency.

Another key issue associated with the NDG quality is the risk to public health. Toze, Page, and Barron (2008) conducted a risk assessment of NDG use to the public health in "The Green" and indicated that the use of untreated groundwater in subsurface and drip irrigation has a low health risk than the exposed watering (sprinklers). At the same time, a risk management plan has been developed to manage and mitigate the risks associated with the NDG use to public health and environment (Water Corporation, 2007a). According to the plan, the appropriate designs and operations of the NDG system can effectively manage the risks associated with NDG use. Moreover, the risk management plan also considers a regular monitoring of NDG quality, end-use activities, and cross-connections to ensure the NDG system poses no risks to public health and environment.

B. Risk of acid sulphate soils (ASS)

Acid sulphate soils (ASS) are naturally occurring soils and sediments containing iron sulphides, most commonly pyrite. When disturbed or exposed to oxygen, ASS cause significant environmental and economic impacts, such as: contamination of groundwater by acid, arsenic and heavy metals; loss of biodiversity in wetlands and waterways; and corrosion of steel and concrete infrastructure (Department of Environment and Conservation, 2011a). Therefore, the projects involved in disturbing ASS need to assess the risks associated with the ASS disturbance. However, the Hydrological Assessment Report of GHD (2006) explains that there is no presence of acid sulphate soils (ASS) in “The Green”. “The Green” area has well-drained soils - mainly the sand derived from Tamala Limestone. Therefore the ASS is not a significant issue for groundwater extraction and use in “The Green”.

C. Flows and levels of superficial aquifer

The natural ground surface elevation in “The Green” ranges from a minimum of 22m (East) to a maximum of 50m (North) above mean sea level with an average height of 30-40m; and the shallow aquifer ranges from 20 to 48m below natural ground surface with an average thickness of 50m (GHD, 2006; de Silva, 2009). Further, groundwater flow is mainly towards the south-west and ultimately discharges to the ocean at a flow rate of 90m/yr (GHD, 2006). Such rapid groundwater movement into the ocean is because of the high permeability of the land profile of “The Green” that is derived from Tamala limestone.

“The Green” lies within the Quinns Rocks groundwater management sub-area. This area currently has 8 GL of available groundwater allocation and is within a ‘Public Drinking Water Supply Area Priority 3’ classification, where water resource protection is achieved through management guidelines rather than restricted land use. This ensures the absence of competition for groundwater resource between drinking and non-drinking water usages (GHD, 2006). The proposed NDG trial in “The Green” consists of five community-bores (200-250mm) linking in a ring loop configuration. The bores are drilled at a depth of approximately 65 m that collectively can extract a maximum 6.7 ML groundwater per week (348 ML per year) (GHD, 2006).

While considering the available groundwater resource and water-flow in “The Green”, the extraction of 348 ML groundwater per year has negligible impacts over local environments and wetland. In other words, the groundwater extraction in "The Green" area (about 4 km west from the coast) has a negligible effect on local groundwater levels (GHD, 2006).

D. Local water balance

Urbanisation is likely to alter local water balance by increasing runoff, reducing evapo-transpiration, importing drinking water and exporting wastewater. Further, the introduction of drainage channels changes the runoff flow path and water resource availability. The changes in local water balance can have wider impacts on the local environment; hence the best way to mitigate these impacts is to maintain the pre-development water balance. This can be done by the use of water sensitive urban designs to control stormwater and increase recharge, and re-use of the enhanced groundwater for fit-for-purpose activities in local area (Barron et al., 2010).

GHD (2006) reports that water sensitive urban development in "The Green" results in a net increase of 174 ML of shallow groundwater per year than that of pre-development condition even after extracting 209 ML for non-drinking groundwater supply. This excess in recharge creates a sustainable opportunity for further fit-for-purpose activities and or extension to new development.

E. Potential impact of groundwater system

The water sensitive urban development in "The Green" has increased the net groundwater recharge by 174 ML/yr than that of the pre-development condition. The increase in local water resource may cause rise in groundwater level, flooding and other associated environmental consequences in areas with higher water table. Such consequences are highly unlikely to occur in "The Green" because of significant depth of water table (average of 30-45 m below the ground surface) and faster water flow (>90 m/yr) towards the Indian ocean (GHD, 2006; Barron et al., 2010). In addition, there is negligible or no risk associated with the acid sulphate soils (ASS) for groundwater extraction as well as recharge in "The Green". Therefore, the increase in groundwater recharge in "The Green" does not cause any adverse impacts to the local hydrology, environment, and communities.

F. Developing decentralised water schemes trials

As the urban development expands out, the development of the centralised water scheme became difficult and complex. The rapid and expanded urbanisation demands a huge investment in infrastructure for supplying water and managing wastewater. This also increases the complexity of the centralised water system. In WA, Water Corporation is the sole provider of the centralised drinking water and wastewater services; however, the Corporation actively participates in the development of alternative water supply systems, especially in newly developed urban fringe and distant cities. The decentralised water schemes could reduce the transport cost of water supply, provide water and manage wastewater locally, and thus relieve pressure on conventional water supply system (Mankad and Tapsuwan, 2011).

The theories and speculation wouldn't be sufficient for calculating the actual efficiency, utility, and acceptability of the alternative water schemes. The trial development of the alternatives could be a breakthrough that could be experienced, explored, and measured in terms of the technical and social outcomes. Implementing the alternatives in a new development would be easier and the acceptability would be higher than to fit it in an established development (Barron et al., 2010). Hence, an alternative water system in the form of a NDG supply via a dual water system has been implemented for "The Green" community at Butler, WA.

On the basis of these reasons, "The Green" has been selected for the implementation of the non-drinking groundwater trial for watering gardens and parks. Further, the joint initiatives of the property developer, water provider and local council has synergistically contributed in the implementation of the trial project (Davis and Farrelly, 2009b).

Observation 21: The groundwater quality in "The Green" is appropriate for the non-drinking outdoor watering purposes.

3.2.3. Features of NDG trial

The non-drinking groundwater supply system has been implemented for "The Green" community at Butler, WA as a 5 year trial in a joint initiative of the WA Water Corporation (water provider), Satterley Property Group (property developer), and City of Wanneroo (local council). "The Green" is a fourth village of the newly developed 'Brighton Estate' in the City of

Wanneroo that is officially known as Butler. The 'Brighton Estate' is assumed as a landmark for 'state-of-the-art' urban planning with sustainable community development in 'Greenfield locations' of Perth. The 'Brighton Estate' is situated in the northern corridor of Perth (35 KM north from Perth CBD) that has 4 villages (suburbs) to accommodate 10000 households in 7000 lots. "The Green" accommodates about 1500 dwellings in 1000 lots (City of Wanneroo, 2006). "The Green" is claimed to be an environmentally friendly sub-divisional development and this village aims to 'create better communities', by adopting a 'new infrastructure and system-based approach to delivering water savings' on a large scale (Satterley Property Group, 2010b).

The basic principle for the NDG trial in "The Green" is 'Drinking Water is for people, not for plants'. Based on the principle, "The Green" implemented a dual water supply system (DWSS), where one pipe supplies drinking water for human consumption and next supplies NDG for watering gardens and POS. The NDG comes from the local superficial aquifer (below 30-65 meter of surface) that is directly recharged by the rainfall and infiltration of stormwater. "The Green" includes several water sensitive urban designs, such as: porous pavements, grassed swales, terraced gardens, bio-filtration trench and basins, an artificial pond etc., which control retain and infiltrate stormwater into aquifer. As a result, the groundwater recharge has been increased by 174 ML per year, compared to that of pre-development stage (GHD, 2006).

The main objectives of the NDG trial are water conservation and water efficiency. The trial aims to reduce household water consumption by 30% and Public Open Space (POS) water usage by 40% than that of average metropolitan suburb. The objectives are supposed to be achieved through the following arrangements:

- Five communal bores network for extracting and supplying non-drinking groundwater;
- A separate piping system for delivering non-drinking groundwater to every household gardens and Public Open Spaces (POS);
- Central weather station control to determine the irrigation need of gardens and operate the community bores automatically;
- Household irrigation controller to communicate with local weather station and control garden watering;
- Use of Soil amendments and native plants in landscaping of gardens, verges, and POS to reduce water demand and use water efficiently; and
- Encouraging water efficient appliances in-house to increase water savings.

The NDG trial (Figure 10) is based on optimisation of outdoor use of water. The optimization is based on real time weather information from the local meteorological station to avoid irrigation after rain; in-situ soil moisture measurement to avoid over watering; organic matters and soil amendments to increase soil moisture holding capacity, and use of indigenous plants and vegetation in all outdoor areas and POS to reduce water demands for evapo-transpiration needs. Water efficiency is further ensured through evening watering regimes (10pm to 6am); and installation of flow restrictors (30Lpm/350 kPa) (Water Corporation, 2007b).

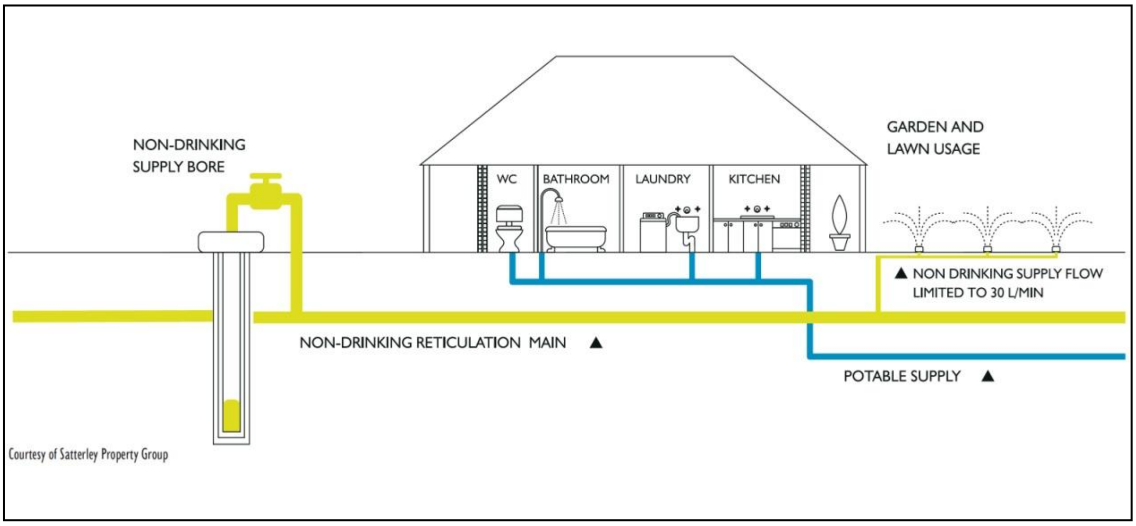


Figure 10: the NDG system in "The Green" at Butler, WA (Satterley Property Group, 2010a)

The NDG trial utilizes the local weather station for better management of non-drinking groundwater. The weather station gathers the weather information, such as: rainfall, temperature, relative humidity, wind velocity etc., and the soil moisture censors measure the soil moisture level at the gardens and parks. The weather station correspond the weather information with the soil moisture data, and when there is a need of water, the bores automatically operate and deliver groundwater to the gardens and parks. The system has the ability to globally switch off when sufficient rainfall occurs. Under dry conditions, groundwater is delivered to domestic gardens on alternate days and five nights per week for the POS irrigation at the rate of 8mm per night (City of Wanneroo, 2006). The weather station further communicates with the 'residential lot reticulation controller' to ensure watering the gardens at designed time and duration, and to avoid over-watering. In addition, the households have no volitional control over the NDG system. The reticulation bores are operated with a four digit pin code, which is accessed only by authorised technicians. This restriction is targeted mainly to avoid wasteful groundwater use, to ensure a fair distribution as there is no meter yet for NDG, and to reduce the risks of health hazards to the household accessing lower quality groundwater (Water Corporation, 2007a; Davis and Farrelly, 2009b).

An overriding principle is that the addition of superficial groundwater to the household supply should not result an increase in the household water consumption (the total of drinking and NDG consumption). In "The Green", the NDG supply is not metered; i.e., each household is charged a flat annual fee for the groundwater service. The fixed annual levy (service charge), calculated on the basis of lot sizes, are AU$74.00 for lot less than 400m^2 and AU$148.00 for lots more than 400m^2 (Water Corporation, 2013d). Such flat pricing is considered more cost-effective than the block tariff (consumption based pricing) (Water Corporation, 2007b). The current pricing structure does not reflect the full cost recovery; however, it was calculated as the most viable pricing option for the operation and sustainable management of the trial. The authorities believe that the current pricing (or at 2nd tier of scheme water pricing ($1.84/KL) if NDG is metered) will recover the full cost of the system in longer term.

All households are provided with a connection point into the groundwater supply system during the trial period. This is ensured with a provision of 'CAVEATS' associated with the land-titles- an 'obligation to participate' by subsequent owners (City of Wanneroo, 2006). If the trial has to be terminated for any reasons, the households will be reverted back to the main water and bore ownership will be transferred to the local council (Water Corporation, 2007b).In "The Green" the housing densities have been increased (R20 to R60) and lot sizes have been decreased (up to 165 m^2) along with an increase in POS area by 2.5% over the standard sub-divisional developments (GHD, 2006; Water Corporation, 2007b; Satterley Property Group, 2010a). The higher density development has wider planning aims; e.g., increasing metropolitan density, reducing outdoor water use by reducing garden size, encouraging use of public open space over private gardens, and encouraging use of existing infrastructure and public amenities. In addition, the increased density and reduced lot size may significantly contribute for implanting better outcomes from the NDG trial and water sensitive development in "The Green". First of all, the reduction in lot size reduces the garden areas, which in turn reduces the water demand for garden irrigation. Second, the increase in POS area encourages residents to visit the parks and public areas, interact with neighbours, and strengthen the sense of community. This is believed to build social integrity and harmony, which will eventually be helpful for addressing various neighbourhood issues.

Observation 22: The provision of the weather station control (third party control) can ensure a fair distribution of groundwater and assist in water conservation and water efficiency.

In this way, the implementation of an innovative dual water supply system with water efficient technologies, water sensitive designs, and eco-friendly urban development creates a most desired ‘water sensitive’ urban community in “The Green”. The NDG trial and the associated water sensitive development in “The Green” provide the opportunity for water authorities to investigate the utility of centrally controlled NDG system for garden watering; and to determine whether the system will increase overall water efficiency and reduce drinking water demand or not (Water Corporation, 2007b). Similarly for urban planners, “The Green” provides a real experimental field to explore residents’ actual feelings, and responses towards the new dual water system and associated urban community development. This understanding will be useful for improving current alternative water systems and/or implementing similar alternatives in the future.

Observation 23: The drivers for groundwater satisfaction are similar to that of the NDG acceptance (Observation 9); mainly: perception of trust, risks, and fairness; value for water conservation; operation and governance; quality of groundwater; pricing; control; and information provision etc.

3.3. Preliminary overview of research area

3.3.1. Preparation and procedures

Chapter Two and earlier sections of this chapter have provided insights into the non-drinking groundwater trial in “The Green”. In addition, at least five field visits to “The Green” and adjacent suburbs were made to perceive and understand the actual NDG system implemented in field, and the innovation in water sensitive landscaping and urban designs. These field visits were conducted during July-August 2010, prior to any other research activities. Some of the field visits were accompanied by the research supervisors too. During these field visits, the NDG system, communal bores, the garden reticulation, parks and vegetation, the weather station and other components of the groundwater reticulation were observed. Similarly, the street scaping and urban designs, the garden and park designs, lawn types and plants used in gardens were observed.

In addition, ten informal talks were conducted with the local residents during these field visits. There was no formal structure for such talks; however, discussions were around the home, neighbourhood, NDG system, and garden and parks. The talks were totally voluntarily and most of the talks were of 10 to 15 minutes long. There was no sampling plan for the talks and taken place wherever the researcher met the residents. Most of the talks were happened in public parks, shopping centres and or at the front yards of their homes where they were working, gardening, and playing. Based on the field visits and notes taken during the talks, a number of issues were perceived and identified that are described in the next section.

3.3.2. Field observations

During the field visits, the NDG system and its components were closely observed and the associated developments were explored. The garden and parks development, and the incorporation of native plants in landscaping were also studied. In "The Green", the public parks were designed into grassed swales to collect the storm runoff during winter but the turf areas were reduced. The public bores were installed in the parks that supplied groundwater for watering gardens and parks throughout the suburb. The streetscape, verges and median strips appeared to be properly developed and maintained by the developer except where the construction works were going on. Most of the gardens were beautifully designed with native plants (Figure 11) and had drip reticulation for garden beds and sprinklers for turf watering.

Figure 11: Some pictures of public parks and home gardens in "The Green"

The non-drinking groundwater system in “The Green” was barely visible as there was no meter and over-ground tap for the non-drinking scheme. In addition, the underground irrigation system did not operate during the day time. The signage-boards at the entrance of “The Green”, and in public parks (Appendix A) were the main indicators of the non-drinking groundwater trial. The other visible indicators were the household irrigation controller and the filter box that had a label of ‘non-drinking water’ at their cover as shown in Figure 12.

Figure 12: The labels of NDG system at the connection point, filter box, and controller

Despite not imagined in development planning, a number of household were found to have the filters connected to their groundwater reticulation. The groundwater was supplied without any treatment for garden watering although it contains the staining elements, mainly calcium and iron oxides; and solids, mainly sand that generally pass through the bores to the garden reticulation. A number of households having brown staining were noticed during the field visits that may be due to the staining quality of groundwater. The filters were supposed to remove the solid materials and dissolved elements from the water so that the staining as well as the blockage problem wouldn’t occur.

The NDG system was proposed to be centrally controlled by the local weather station from the beginning of the trial. However, the weather station was not commissioned during the field visits although it was already established in the premises of East Butler Primary School. Instead the community bores were found to be manually operated three days a week. However, manual bore operation is said to be congruent with the information provided by the weather station.

3.3.3. Informal talks with local residents

Ten informal talks, eight in “The Green” and two in the neighbouring suburb – Ridgewood, were held with local residents at their front yards, public parks and shopping centres. The talks were informal, totally voluntary and of about 10-15 minutes long. The talks were focused on the residents' feelings towards the groundwater reticulation, their water using behaviours, their gardens and park designs, and the development activities. The talks were helpful to identify and prioritize the issues relevant to the dual water (NDG) system and urban environment. The findings guided the literature review process to explore and generate a list of important variables and helped in preparing for focus group discussions (later switched into preliminary interviews) to justify and contextualize these variables. The major issues emerged from the informal talks are briefly discussed below.

A. Dual Water system issues

In "The Green", the initial marketing campaigns and information packages created better awareness about the NDG system. First home owners got enough information at the beginning and a frequent updates afterwards; however, the information flow to the other owners (second home owners, state housing occupants, or renters) was minimal. The signage at public places (Appendix A) and the "Caveats" in land title are the major source of information for other owners, unless the authorities and the primary owners make the information available to them.

In surrounding suburbs, the awareness about the NDG system was quite low as they do not have a dual water system in their development. Whoever knows about the dual water system in "The Green", considered it as water saving, affordable, and environmentally friendly alternative water system. People in surrounding suburbs appreciated the idea of a centrally controlled automatic NDG supply for garden watering. However, "The Green" residents expressed some concerns about the NDG system. The first concern was the staining quality of groundwater that caused the white and/or brown (iron) staining in their gardens, driveway, and fences. However, the staining was less evident in the blocks with subsurface drip irrigation than the blocks with sprinklers and hose. The second concern was the insufficient water for garden irrigation. Most of "The Green" residents were using a 'hose' to top up their garden irrespective of automatic garden irrigation. This may be because the NDG was inadequately supplied or they were not fully confident about the automatic water supply, so that the residents were protecting their gardens from drying. In either case, the 'hose watering' led to an increase in the overall household water consumption, and corresponding water bill.

Other concerns were related to the operation, and control of the NDG system. The operation of NDG system was perceived as inconsistent in watering household gardens. Residents wished to have some flexibility in terms of watering time, and testing time, and some control over the garden reticulation to make it user friendly and applicable for varying gardening needs.

B. Urban design issues

<u>Neighbourhood and parks</u>

As “The Green” has implemented higher density development. The residential density was increased up to R60 and the sizes were reduced down to 160 m^2. Higher density development reduced private garden areas and increased the area of public parks. People were happy with the reduced block size, because it was affordable and there were a number of parks nearby. This development on the one hand demanded less water for garden irrigation, and on the other hand traded-off the limited personal activity areas with the easy access to the public parks to entertain themselves, children and pets. People were more than happy with the proposed northern extension of Mitchell freeway and Clarkson line railway as it was expected to increase property values, land demands, and better living environment, even in surrounding suburbs.

The residents were happy and hopeful with “The Green” development, mainly because the place was reasonably close to the beach, good quality schools, the city centre, the community and commercial centres; and well connected with road and railway network. However, the main concern was the increased number of small blocks that was likely to increase the local population; attract lower income owners, renters, and investors; thus, decrease the standard (quality) of living environment. In addition, people were anxious about the slow development of blocks, roads, railway, parks, and shopping centres.

All public parks in “The Green” were developed as multi-purpose parks. The parks were used as the venue for family outdoor activities, and for entertaining children and pets. These parks replaced the traditional sumps with grassed swales to control the stormwater and recharge into aquifer. In addition, the parks also utilised the native vegetation (Paper-bark, Eucalyptus and Bottle brush etc) and reduced turf area to use less water. The people were happy with the public parks; however, there were some concerns about the "rough" appearance of native plants. Some people also expressed their concerns about the swales, which collect the runoff during winter and dispose the rubbish into the public parks.

<u>Home and Garden</u>

Most of the residents considered that properties in “The Green” are affordable, attractive and suitable for families to live. Apart from the affordability issue, this locality was seen to be close to the city, schools, public services, shopping centre, and other basic facilities. Residents appreciated the easy access to day to day requirements and the nature-friendly development with bigger parks, and green gardens. Smaller blocks (higher density) were equally preferred as they were relatively cheaper, and efficient than larger blocks; however, some people had strong preference for larger blocks that provide more flexibility in terms of outdoor and backyard activities.

"The Green" residents were happy with their 'home development package' offered by the developer that included free landscaping of both front and back-gardens. The package was helpful in establishing water efficient gardens, and installation of water efficient reticulation. Furthermore, there were no restrictions for individuals in designing their own gardens with their own plants and reticulation. A number of garden modifications were observed; such as: enlarging lawn area, vegetable growing, planting more exotic plants and potted plants (rose, seasonal etc.), installing artificial lawn, paving the outdoor area etc. The modifications indicated the adjusting behaviour of residents. The behaviour could have link with their feelings, perceptions and attitudes towards the alternative water system and the associated urban developments in terms of the adequacy of the water system to meet the garden watering needs and other household quality criteria.

Observation 24: The major attributes of home domain are: the size and designs of home and gardens, indoor and outdoor space, safe from noise and crime, affordable, suitable for the family needs and privacy, residence duration, pleasant environment, close access to services and facilities, and resale value.

Observation 25: The major attributes of the urban neighbourhood are: higher density; safety from crime and neighbourhood watch; road and transport network; public services and basic facilities; schools, shopping centres, parks, beaches, and community centres; and employment and recreation opportunities.

C. Satisfaction and Behaviours

In general, most of the residents were happy with the dual water supply system and water sensitive development in "The Green". Major reasons for satisfaction were affordable price, green and natural living environment, proximity to beach, proposed extension of freeway and railway, schools, and city centre. However, some raised concerns about current public transport, road network, and higher density development. The NDG system was considered important for the garden and parks development; however, the staining appeared to be a major issue regarding the satisfaction with the NDG system.

Since “The Green” is a newly developed suburb, the houses, gardens, and parks are still under construction. During garden establishment, most of the houses received the exemptions in watering. People presumed that the exemptions definitely consumed a huge amount of NDG. Although, people had some concerns about insufficient and unreliable operation of NDG system, they were happy with the system in overall.

They perceived the NDG system as one important component of their home that encouraged to establish water efficient gardens and to perform more water saving behaviour. While considering the neighbours and neighbourhood, there were other issues than the NDG system issues. However, the higher density development, water sensitive designs, and public parks with native vegetation are counted as the unique developments in their locality. A few home owners moved out from this area, which indicates that the water system or the home and neighbourhood development issues may possibly impact on the migratory decisions.

The neighbours and community were perceived as other important issues for obtaining a sense of social security and a happy life. Residents also appreciated the support from local community organisations and frequent community events, which help in interactions among the neighbours and strengthen the community network. However, “The Green” being a dormitory suburb, residents had very little interaction with their neighbours and community. Hence, the general view was “good neighbours and strong community are important, however, the most important thing for the individual satisfaction is home and family”.

Observation 26: The major attributes of the society (neighbours) are: close friends and relatives, friendly neighbours, social events, and community organisations.

Observation 27: Anecdotal evidence suggests that the home and neighbourhood attributes are perceived as most important for the satisfaction with the residential environment.

On the basis of these preliminary talks, we have outlined the major issues around the NDG system and the attributes of water sensitive urban development. The attributes of the NDG system as well as urban residential environment are further explored using preliminary interviews that are detailed in Section 5.2.4 in this thesis. The following section will describe the possible planning implication of this trial development for urban land and water planning.

3.4. Planning implication of alternative water system

3.4.1. Current planning implications

The implementation of NDG system and water sensitive designs in “The Green” has reflected the integrated land and water planning approach developed by the Western Australian State Water Plan (2007) and Better Urban Water Management (2008) at a sub-division level (Figure 13), and adds value to adjacent landscapes (Western Australian Planning Commission, 2007). The water sensitive urban development generally increases the availability of local water resources that can be used for various fit-for-purposes. In “The Green”, similar fit-for-purpose water system has been developed that deliver NDG via separate pipe network (i.e., dual water system) for the whole community. The integrated water and land planning processes for different strategic level is illustrated in Figure 13 with reference (dotted circle) to the implementation of dual water system and water sensitive designs in “The Green”.

The fit-for-purpose water, however, can be generated by a number of methods and technologies using different sources as groundwater, stormwater, wastewater and desalination. This water if not allowed for direct potable uses, can be used for indirect potable purposes, industrial use, use in environmental amenity, and other potable replacement activities such as irrigation of private gardens and POS, toilet flushing, washing machine and heating system usage (Hurlimann, 2008; Barron et al., 2010). The groundwater in WA is considered as the most safe and low risk source of non-potable water regarding the technologies involved, public perception, economic consideration, and health issues. Groundwater is widely utilised in Perth over many years and the community are exposed to its use for outdoor activities through backyard bores (Barron et al., 2010).

The development of NDG trial in “The Green” aims for reducing household water consumption by 30% and public parks usage by 40% than that of the metropolitan average. In order to achieve this target, “The Green” includes careful planning and designs of reticulations, gardens, POS, verges and median stripes to reduce the outdoor water use. The groundwater consumption trend in “The Green” will indicate the contribution of the trial development in terms of the water conservation and water efficiency, which in turn will determine the utility of the trial for promoting water conservation in an urban residential setting.

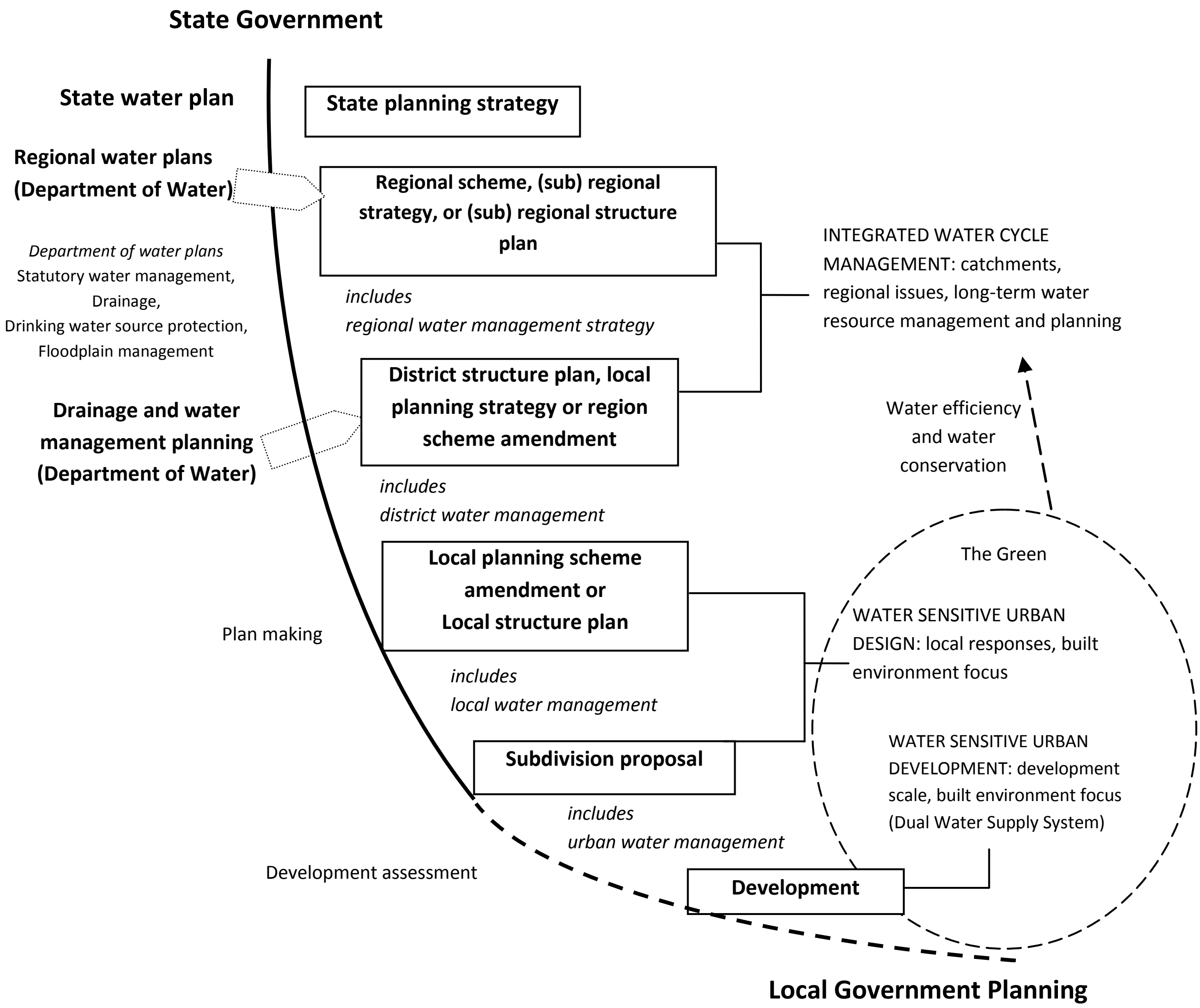


Figure 13: Integrating water planning with land planning processes (Western Australian Planning Commission, 2008b)

In addition, the customer satisfaction with the non-drinking groundwater trial will determine the social acceptability, which will promote the sustainability of the trial(Barron et al., 2010). The residential satisfaction and water using behaviours will indicate the successful implementation and adoption of the non-drinking water system at the community. The outcomes regarding the water conservation and residential satisfaction indicate the overall success of the trial development. Further it will provide useful insights and decision-inputs for promoting the decentralised and/or fit-for-purpose water systems for urban water management planning.

The trial period was set for 5 years after the completion of the development, during which the developers operate and manage the system. After the trial period, the non-drinking groundwater system will be handed to the water corporation. The continuity of this trial greatly depends upon the community acceptance and satisfaction with the trial. The consistency in water conservation and efficiency even in climatic variability will be another criterion for its continuity. The households will be reverted back to the scheme water supply, if for any reasons; the groundwater system couldn't be continued.

There are multiple stakeholders involved in the development and management of the non-drinking trial in "The Green". The groundwater quality is regularly monitored by the WA Water Corporation and Department of Water. The groundwater allocation license is issued by the Department of Water and held by WA Water Corporation, whereas the groundwater system is developed and maintained by the Satterley Property Group. Satterley contracted 'Total Eden', a garden and irrigation specialist company, for day-to-day operation and management of the system. 'Total Eden' installs the groundwater reticulation at household gardens and parks, landscapes the gardens and parks, and is responsible for repairing and maintaining the groundwater system during the trial period. In this way, there is an involvement of multiple institutions with different roles and responsibilities, which is aimed at providing the most appropriate and advanced NDG service to the households.

Observation 27: The success of NDG will depend upon resident's satisfaction with it and its contribution in water conservation.

3.4.2. Future extension policy

The experience and apparent success of the NDG trial at "The Green" has led to another dual water supply system in Evermore Heights at Baldivis (in the Southern River catchment area located about 20KM south of Perth CBD). In Evermore Heights, a rainwater tank of 3000L has been plumbed into each household for retaining the rainwater and using it for toilet flushing and laundry purposes. In addition, a fit-for-purpose groundwater has been supplied for watering garden and parks (Satterley Property Group, 2013). Similarly, a number of successive projects are being planned and implemented around Perth metropolitan aiming to establish a culture to use fit-for-purpose groundwater for all possible indoor or outdoor non-drinking activities.

"The Green" trial is a novel option that is utilised to explore alternative water supply options to reduce drinking water demand with minimal environmental cost and health risk to the costumer. One way to minimise risk to the community is to prepare a 'Health Risk Management Plan' that provides the fundamental guidelines to address the concern of public health in using fit-for-purpose groundwater with some level of quality degradation. Such plan has already been prepared and practiced. This plan includes the provision of a separate pipe network, restrictive availability (third party control), lower pressure than the drinking water scheme, and subsurface watering systems. With these provisions, the fit-for-purpose groundwater could replace all types of drinking water usage in non-drinking activities, both indoor and outdoor.

The possible indoor use of NDG for toilet flushing, washing machines, etc., indicates not only the bright potentiality of fit-for-purpose groundwater supply but also warrants the essence of understanding the community acceptability of NDG use within the house. The community concerns should be dealt before, during and even after the planning and development of alternative fit-for-purpose water systems to ensure a wider acceptability of such alternatives. A continuous interaction and consultation with the community at all levels should be practiced in the decision making process for sustainable development of alternative water systems.

Observation 28: The implementation of NDG trial provides a real world experience to customers; a platform for research activities exploring the social, economic, and environmental aspects of the system; and valuable insights into efficiency, utility, acceptability, and satisfaction with the NDG system in urban settings.

Observation 29: The study of a successful trial of the fit-for-purpose water system will provide valuable lessons on better planning, implementation, operation and management of the existing and/or future fit-for-purpose water systems.

3.5. Conclusion

"The Green" has implemented an innovative dual water supply system with water efficient technologies, water sensitive designs, and eco-friendly urban development, which creates a most desired water efficient urban community. This has created an opportunity to examine the community response towards the alternative water systems and utility of the centrally controlled NDG system for water efficiency and water conservation at urban settings.

The field visits and preliminary talks with local residents were beneficial for understanding the study area and the major community concerns about the NDG system and water sensitive development in "The Green". The understanding guided the literature reviews and further research activities; such as: the preliminary interviews and community survey. In addition, the field visits and informal talks were helpful for exploring the recent development and planning adjustment regarding the operation, pricing and management of the NDG system that were focused on achieving the project targets and accommodating community concerns as much as possible.

The detailed descriptions of the historical development of NDG trial, NDG attributes, and planning implications created several observations. The observations in Chapter Two and this Chapter are summarised in Chapter Four into relevant research propositions. Under the research propositions, relevant hypotheses are developed. Thus developed hypotheses are then connected with related observations, and tested in this study with the help of suitable research tools and the findings are explained in Chapter Six, Seven, and Eight.

CHAPTER 4: Research propositions and hypotheses

4.1. Introduction

The literature review in Chapter Two provides explicit descriptions of the assumptions, uncertainties, and gaps in knowledge about the residential attitudes and behavioural responses towards an alternative water (NDG) system in urban settings. Due to this, a large number of parallel literatures are considered; and the experience of the alternative water systems is drawn upon. Chapter three describes the attributes of the NDG system, and its wider implication in developing water sensitive communities. The two chapters explain and justify the key research enquiries in this thesis. In addition, the initial consultation with and qualitative information from the stakeholders, namely: WA Water Corporation, Satterley Property Group, and City of Wanneroo personnel were utilised in devising and refining the relevant hypotheses.

The main focus of this chapter is to provide the overview of the major issues to be investigated, which are labelled ‘Research Propositions’. The research propositions are the overriding hypotheses that include a set of ‘research hypotheses’. This study tests the hypotheses utilising the NDG system in “The Green” community at Butler, Western Australia. The propositions are developed systematically according to the major research enquiries, which are presented under the following major themes:

- Concept of alternative water system
- Acceptability and sustainability of alternative water system
- Residential satisfaction with alternative water and water sensitive urban environment
- Planning implications of the alternative water systems

Due to the lack of direct literatures on residential satisfaction and behaviour towards the NDG system, this study adopts exploratory research methods over the confirmatory ones. This thesis adopts an exploratory quasi-experimental research design with mixed methodology as advocated by (Cook and Campbell, 1979; Kerlinger, 1986). This investigation provides evidence to accept and/or reject the multiple hypotheses developed from the literature and the field observation. Chapter Five establishes the conceptual framework and explains the multiple methods used to test the hypotheses and the findings are given in Chapter Six, Seven, and Eight.

The propositions are presented thematically and justified through links to the observations in Chapter Two and Three. Under each proposition, a number of hypotheses are developed and linked with the relevant observations (Chapter Two and Three) and respective findings (Chapter Six, Seven, and Eight).

4.2. Alternative water system at urban settings

The issues around the urban water crisis in the light of drying climate and growing population are discussed and essence of alternative water system is justified (Section 2.2). The empirical discussion informs a broad research proposition and several constituting hypotheses regarding urban water issues and essence of alternative fit-for-purpose water system for sustainable urban water management, which are given below:

> Proposition 1:
>
> In the light of drying climate and growing population in Australian urban areas, there is a felt need of innovative alternative water systems and a water sensitive urban development at strategic level to: 1) supplement the scheme water supply; 2) promote water conservation and water efficiency at residential settings; and 3) develop sustainable urban water system.

As established in literature review (particularly in sections 2.2.1 to 2.2.6), the drying climate and population growth in urban areas of Australia hard-pressed the urban water authorities to fulfil the increasing water demands from declining resources. This establishes the role of an innovative alternative water system in augmenting the scheme water supply and saving water at urban residential settings. Table 1 below provides the list of research hypothesis relating to the alternative water systems in urban settings. These hypotheses are formed to explore the individual feelings about the need of such alternatives, and the utility and efficiency of the alternatives in water sensitive urban developments. The findings regarding the utility and efficiency of the alternative water systems in water conservation are given in chapter Seven and Eight.

Table 1: Hypotheses relating to Proposition 1: Alternative water systems at urban settings

Hypothesis Label	Hypothesis	Observation (Thesis sections)	Result Sections
H1	Individuals think that there is an essence to develop alternative water system to secure water in future	1 (2.2.1, 2.2.2, 2.2.5)	7.4
H2	The alternative water system augments the conventional water system by supplementing water for all possible non-drinking activities	1 (2.2.5, 2.2.6)	7.4
H3	Automated alternative water systems ensures a fair supply of water to each household, and assists in water conservation and sustainable water management	2, 25 (2.2.2, 3.2.3)	7.4
H4	Water sensitive designs assist in sustainable supply for alternative urban water systems	4, 5 (2.2.6)	7.4, 7.5
H5	Application of the fit-for-purpose groundwater supply with water sensitive designs is a sustainable alternative water system in urban settings.	5 (2.2.6)	7.4, 7.5

4.3. Acceptability and sustainability of alternative water system

4.3.1. Acceptability of alternative water system

Research proposition two is informed predominantly by observation 6 'Literature suggests that the success of alternative water systems greatly depends upon the positive community support and acceptance of the system' (Section 2.3). This indicates the essence of evaluating community attitudes prior and after the planning and implementation of the alternative water systems. Furthermore, this proposition investigates on the driving factors for community acceptance of the alternative water systems.

> Proposition 2:
>
> The community's positive support and acceptance are extremely important for the successful implementation and management of alternative water supply system. The acceptance is dependent upon the water use activities; quality of water; governance and pricing; social conformity, and personal needs and aspirations.

Research proposition 2 mainly concerns for the community acceptance and positive supports for the alternative water supply systems before and after the implementation of such projects. As established in section 2.3.1 and 2.3.2 of literature review, the important issues for acceptance of such alternatives are the end-use activities, water quality, trust in technology, fairness and risk perceptions, social conformity, information, governance and control issues, and appropriate pricing (Po et al., 2005; Hurlimann, 2006, 2008; Tucker et al., 2009; Barron et al., 2010; Dzidic and Green, 2012). The appropriate pricing can balance between profligate use due to the lower price than drinking water and the reduced use due to higher price (Xayavong et al., 2008). Table 2 gives the hypotheses relating to the acceptance of alternative water systems and the findings are described in Chapter Seven.

Table 2: Hypotheses relating to Proposition 2: Acceptability of alternative water system

Hypothesis Label	Hypothesis	Observation (Thesis sections)	Result Sections
H6	The success of alternative water system depends upon community support and acceptance	6 (2.3.1)	7.5, 7.7
H7	The acceptance of alternative water system decreases as the uses become more personal or closer to human contact, such as: washing, bathing, and cooking etc.	8 (2.3.1, 2.3.2	7.4, 7.5
H8	The aesthetic quality (mainly staining) decreases the acceptance of the alternatives	9 (2.3.2)	7.4, 7.7
H9	The reliable information provision increases the acceptance of the alternatives	9 (2.3.2)	7.4, 7.5
H10	A cheaper pricing than the main water increases the acceptance of the alternatives	9 (2.3.2)	7.4, 7.7
H11	The acceptance of the alternative water system in a new development will be higher than that in existing development	11 (2.3.2)	7.4, 7.6
H12	The on-site trial of alternative water systems encourages people to participate and accept the alternative water systems.	10 (2.3.2)	7.4, 7.6, 7.7
H13	The acceptance of NDG system will be higher if an individual thinks that it is uniformly accepted by his/her community	11 (2.3.2)	7.4, 7.5,
H14	The automatic control provision increases the acceptance of NDG system	9 (2.3.2)	7.5, 7.7
H15	Community perception of water scarcity and essence to conserve water will increase the acceptance of NDG system	12 (2.3.2)	7.4, 7.5, 8.2
H16	Trust to the technology and water authorities increases the acceptance of NDG system	9 (2.3.2)	7.4, 7.5, 7.7
H17	Positive perception of fairness will increase the acceptance of NDG system	9 (2.3.2)	7.4, 7.5, 7.7
H18	The perception of health hazards and other risks will decrease the NDG acceptance	9 (2.3.2)	7.4, 7.5, 7.7
H19	The acceptance of NDG system will be higher since a large proportion of Perth's community use groundwater via domestic bores	11 (2.3.2, 2.3.3)	7.4, 7.5, 7.7
H20	Higher acceptance of NDG system will result higher satisfaction with NDG system	13 (2.3.2)	7.4, 7.5, 7.7

4.3.2. Sustainability of alternative water systems

Section 2.3.3 of literature review has established that the social component of sustainability of the alternative water systems. Literatures explain that the sustainability of alternatives greatly depends upon positive community participation, fair and equitable distribution among stakeholders and generations, and the ownership of and responsibility towards the alternatives. This informs research proposition 3, which draws mainly from observation 15 and 16.

> Proposition 3:
>
> Social aspects are crucial for sustainable development of alternative water systems, which are least explored so far. The community participation and responsibility towards the alternatives, fair and equitable access, and the ownership of the alternatives should be considered to understand the complete sustainability scenario of the alternative water systems.

Research proposition 3 mainly concerns with the post-development social aspect of the sustainability of the alternative water system, which are often overlooked and shadowed by the economic and environmental aspects. Under this proposition the following hypotheses are included:

Table 3: Hypotheses relating to Proposition 3: Sustainability of alternative water systems

Hypothesis Label	Hypothesis	Observation (Thesis sections)	Result Sections
H21	Positive community participation in alternative water systems increases the acceptance of the system	15, 16 (2.3.3)	7.4, 7.5, 8.3
H22	The equitable distribution of alternative water systems promotes the acceptance of the system	14 (2.3.3)	7.4, 7.5
H23	The community acceptance of alternative water systems ensures the sustainability of the system	15, 16 (2.3.3)	7.4, 7.5, 8.3
H24	The NDG system for outdoor watering assists in water conservation and water recycling; hence, ensures the sustainability of water resources	14 (2.3.3)	7.4, 7.5, 8.3
H25	Water sensitive designs in landscaping ensures the sustainability of NDG system and water resources	14 (2.3.3)	7.4, 7.5, 8.3

The hypotheses are tested with the help of survey data and interviews with the stakeholders, and the findings are detailed in Chapter Seven and Eight.

4.4. Residential satisfaction with the NDG system and water sensitive urban environment

4.4.1. Residential satisfaction as criteria of residential environment

As established in section 2.4 of literature review, there is significant gap regarding the residential satisfaction with an alternative water system in a water sensitive urban environment. This information would be highly beneficial to ensuring that the alternative NDG system meets the satisfaction of the community, and thereby ensuring its acceptance. Research proposition 4 is predominantly informed by the observation 17 'individual perceptions and evaluations of different objective attributes of the residential environment to generate residential satisfaction' and considers the NDG system as one of the important domains, along with home, neighbourhood and society, of water sensitive urban environment.

> Proposition 4:
>
> Individuals' perceptions, belief and subjective evaluation of different objective attributes of the residential environment (having three fundamental domains: the home, neighbourhood, society (mostly neighbours); and one additional domain: the NGD system) generate satisfaction with the residential environment that is utilised in measuring the quality of life in the environment

Research proposition 4 includes two broad issues, which are: the alternative water system in urban residential environment and residential satisfaction with the environment. Hence the hypotheses comprising this proposition investigate the two broad issues. The hypotheses regarding the alternative water system aim to develop working model of satisfaction with NDG system. While the rest that are included in three different headings: home, neighbourhood, and society, represent the satisfaction with each domain of the residential environment. All these four domain-satisfactions will collectively result in the overall residential satisfaction that is then corresponded with the behavioural responses.

Table 4 presents the hypotheses regarding residential satisfaction with the NDG system and water sensitive urbane environment. These hypotheses are tested using multiple research tools and the findings are described in the section 7.5 in this thesis.

Table 4: Hypotheses relating to Proposition 4: Residential satisfaction as criteria of residential environment

Hypothesis Label	Hypothesis	Observation (Thesis sections)	Result Sections
H25	Positive perception of trust to water authorities increases the NDG satisfaction	9, 13, 23 (2.3.2, 3.2)	7.5, 7.7
H26	Positive perception of groundwater pricing increases satisfaction with the NDG system	9, 13, 23 (2.3.2, 3.2)	7.5, 7.7
H27	Positive perception of groundwater operation increases satisfaction with the NDG system	9, 13, 23 (2.3.2, 3.2)	7.5, 7.7
H28	Perceived fairness in groundwater supply increases the NDG satisfaction	9, 13, 23 (2.3.2, 3.2)	7.5, 7.7
H29	Perceived risks and hazards from groundwater supply decreases the NDG satisfaction	9, 13, 23 (2.3.2, 3.2)	7.5, 7.7
H30	People having water conserving motives and behaviour are more satisfied with the NDG system	23 (3.2)	7.5, 7.7
H31	The aesthetic degradation of groundwater (mainly staining) decreases the NDG satisfaction	9, 13, 23 (2.3.2, 3.2)	7.5, 7.7
H32	Early information increases the NDG satisfaction	13, 23 (2.3.2, 3.2)	7.5, 7.7
H33	The third party (local weather station) control decreases the NDG satisfaction	22 (3.2.3)	7.5, 7.7
H34	Positive evaluation of NDG system attributes results higher NDG satisfaction	17, 23 (2.4.3, 3.2)	7.5, 7.7
H35	Positive evaluation of garden attributes will results higher garden satisfaction	17 (2.4.3)	7.5, 7.7
H36	Pleasant feel to home environment results higher home satisfaction	24 (3.3)	7.5, 7.7
H37	People residing a longer duration in their home will be more satisfied with the home environment	24 (3.3)	7.5, 7.7
H38	Positive perception and evaluation of home attributes results higher home satisfaction	17, 24 (2.4.3, 3.3)	7.5, 7.7
H39	Positive evaluation of neighbourhood attributes results higher neighbourhood satisfaction	17, 25 (2.4.3, 3.3)	7.5, 7.7
H40	Positive evaluation of park attributes results higher neighbourhood satisfaction	17, 25 (2.4.3, 3.3)	7.5, 7.7
H41	Home satisfaction improves the neighbourhood satisfaction	25 (3.3)	7.5, 7.7
H42	Good neighbours enhance the neighbourhood satisfaction	25 (3.3)	7.5, 7.7
H43	Positive perceptions towards the higher density development increase neighbourhood satisfaction	25 (3.3)	7.5, 7.7
H44	Better educational and employment opportunities result higher neighbourhood satisfaction	25 (3.3)	7.5, 7.7
H45	Easy access to public services results higher neighbourhood satisfaction	25 (3.3)	7.5, 7.7
H46	The community safety (neighbourhood watch) enhances neighbourhood satisfaction	25 (3.3)	7.5, 7.7
H47	Positive relationship with neighbours increases society satisfaction	26 (3.3)	7.5, 7.7
H48	The more neighbours, friends and relatives live closely, the higher will be the society satisfaction	26 (3.3)	7.5, 7.7

H49	Positive perceptions towards the mix of cultures increase society satisfaction	26 (3.3)	7.5, 7.7
H50	More participation in community events and social organisation results higher society satisfaction	26 (3.3)	7.5, 7.7

4.4.2. Residential satisfaction as a predictor for behavioural responses

As established in section 2.4.3 of literature review, another important role of the residential satisfaction is to determine the resident's adaptive and/or migratory behavioural responses towards the environment. This role of residential satisfaction is explained by research proposition 5 that predominantly draws from the observation 18 'Literature indicates that the satisfaction with the residential environment determines the behavioural responses towards the environment'.

Proposition 5:

Residential satisfaction not only measures the quality of residential environment but also determine the behavioural responses towards the environment that is mediated by behavioural intention.

Research proposition 5 mainly explains the role of residential satisfaction to predict their adapting or moving behaviours toward the environment. This proposition explains that there is a direct link between the actual behaviour and the behavioural intentions, where the intentions are determined by the level of satisfaction with residential environment. This proposition comprises the following research hypotheses:

Table 5: Hypotheses relating to Proposition 5: Residential satisfaction as a predictor for behavioural responses

Hypothesis Label	Hypothesis	Observation (Thesis sections)	Result Sections
H51	Higher the residential satisfaction level there will be lower moving or adaptive behaviours	18 (2.4.3)	7.5, 7.7, 7.8
H52	The relationship between the satisfaction and actual behaviour is mediated by the behavioural intentions	18 (2.4.3)	7.5, 7.7, 7.8
H53	Satisfied people will recommend their living place to their friends and relatives	18 (2.4.3)	7.5, 7.7, 7.8
H54	Satisfied people, if have to move by any reason, move not too far away	18 (2.4.3)	7.5, 7.7, 7.8
H55	Satisfied people, if have to move out by any reason, choose similar environment again	18 (2.4.3)	7.5, 7.7, 7.8

4.5. Planning implications of the alternative water systems

Research proposition 6 is predominantly informed by the observation 28 ‘the NDG trial provides real world experience to customers, a platform for research activities, and valuable insights into efficiency, utility, and acceptability of, as well as satisfaction with the NDG system in urban settings’. The trial also provides the valuable lessons for the water planners, urban developers and government agencies on better planning, implementation and operation of such NDG systems in future.

> Proposition 6:
>
> The real world experience (in terms of the utility, efficiency, and acceptability) of the NDG trial and the community response (satisfaction and behaviour) towards the system are extremely important for sustainable water management planning. This would outline the strengths and constraints, and provide important guidelines for planning, and developing the alternative water systems in urban settings.

Proposition 6 explores the planning implications of the experience and satisfaction with the alternative NDG system in urban water resource management. The hypotheses (Table 6) were tested utilising the NDG trial in “The Green”, and the findings are explained in Chapter Eight.

Table 6: Hypotheses relating to Proposition 6: Planning implications of the NDG system

Hypothesis Label	Hypothesis	Observation (Thesis sections)	Result Sections
H56	Residential satisfaction with the NDG system and its contribution in water conservation determines the success of NDG system	27 (3.4)	8.2, 8.3
H57	The NDG trial exposes the strength and constraints as well as actual community response towards the system.	28 (3.4)	8.2, 8.3, 8.4
H58	The successful NDG system provides experiences and lessons for better planning, development, and management of existing and future NDG systems.	29 (3.4)	8.4, 9.3

4.6. Conclusion

This chapter provides explicit description of the 6 research propositions and 58 research hypotheses in this thesis. The research propositions are developed systematically to support the research enquiries and grounded on the observations taken in Chapter Two and Three. Then, research hypotheses are developed under each propositions and linked to respective observations as well as the section of thesis where they are tested.

Next chapter (Chapter Five) explains the conceptual framework for evaluating residential satisfaction with the dual water (NDG) system, behavioural responses towards the system, and the planning implications these three. Chapter Five also outlines and justifies the theoretical bases for utilising the quasi-experimental design, control, and mixed methodology with the qualitative and quantitative research tools.

CHAPTER 5: Research methodology and methods

5.1. Introduction

This chapter explains the theoretical approach has been adopted and the research tools used to answer the research enquiries. This chapter starts with the concept of satisfaction with dual water (NDG) system in a water sensitive urban environment. The satisfaction with the dual water system is considered as a social indicator for the success of the system in the light of drying climate and growing population. However, the satisfaction with the dual water system only makes a limited meaning while interpreting its implications to the water planning and community development. Hence, the concept of satisfaction with residential environment is adopted, where the quality of the urban residential environment is evaluated in terms of satisfaction with multiple components of the environment, namely: dual water system, home, neighbourhood and society. The conceptual framework section provides the detailed description about these components and develops a working concept for evaluating residential satisfaction.

The satisfaction is a multi-dimensional issue that is dependent upon the physical condition of the environment (objective attributes); individual perceptions, feelings and evaluations; and the state of the individuals (person characteristics). Evaluation of satisfaction therefore, demands multiple approaches and measures to be accurate for the findings. Hence, this research recognises and confronts both the interpretive and positivist paradigms to inform the research enquiries, which is reflected but not limited in the adoption of mixed methodology. The exploratory approach taken in this research enquires and establishes the instrument, which is tested, refined, and generalised using a quantitative survey. In this way, a mixed methodology and triangulation of qualitative and quantitative research activities are arranged and oriented towards resolving the research enquiries in this research program.

This study adopts a ‘quasi-experimental research design’ equipped with the stratified random sampling and control selection. A sub-divisional development that is similar in socio-economic parameters, geographical situations, demographics, and development condition is selected as a control area, where the dual water supply system is not implemented. Both the qualitative and quantitative research activities are sequentially utilised, starting with the preliminary interviews with local residents. The preliminary interviews inform and develop the research instruments that are used during the household survey that explored the satisfaction value and relationships among the satisfaction variables. Furthermore, the qualitative information from stakeholders' interviews, meetings and seminars provide the interpretation and planning implication of the findings that helps improving and developing alternative water management planning in urban and regional level.

5.2. Conceptual framework

5.2.1. Importance of alternative water schemes for residential satisfaction

Any alteration to the traditional urban water system will ultimately impact not only the wide range of end users but also the urban residential environment (Barron et al., 2010). The end users may have to change their water using behaviours, appliances and household reticulation. The alternatives may change the catchments, landscape designs, and vegetation of the environment. These changes significantly impact the community attitudes, acceptance and satisfaction with the alternative water schemes and associated changes in the environment. This may alter the community satisfaction level with the alternative itself and/or the residential environment.

This study aims to evaluate and measure the residential satisfaction with a dual water supply system, where NDG is supplied for watering gardens and parks. This is impossible to measure in isolation; hence, the satisfaction with the whole residential environment is evaluated, considering the NDG system as a component of the environment. In this way, this study not only evaluates the satisfaction with the dual water system, but also explains the impact of dual water satisfaction to the overall residential satisfaction with the urban environment.

As discussed in the Literature review chapter, the quality of urban environment can be measured by measuring individual satisfaction with the domains of the environment. The most common domains were the: i) social domain; ii) neighbourhood domain; and iii) home domain. In this research, the alternative water system is considered as a fourth domain of urban environment. The domains and their attributes are to be explored, validated, contextualised, and rationalised using community knowledge from preliminary interviews with local residents.

5.2.2. The Water System

The different components and attributes of water sensitive urban environment with a dual water (NDG) system is portrayed in Figure 14 below. The dual water system has adopted the usual demand management practices and aims for two major outcomes: water efficiency, and water conservation. The objective attributes of the system are explained and other aspects of water sensitive environment are also included. The objective attributes of the system and environment, when evaluated by an individual using different subjective parameters, such as: belief, value, attachment, norms, and evaluation), generate satisfaction with the system and environment (Campbell et al., 1976; Amerigo and Aragones, 1990, 1997; Marans, 2003). Figure 14 not only provides the overview of water sensitive urban environment but also alludes to a variety of objective and subjective indicators of the environment.

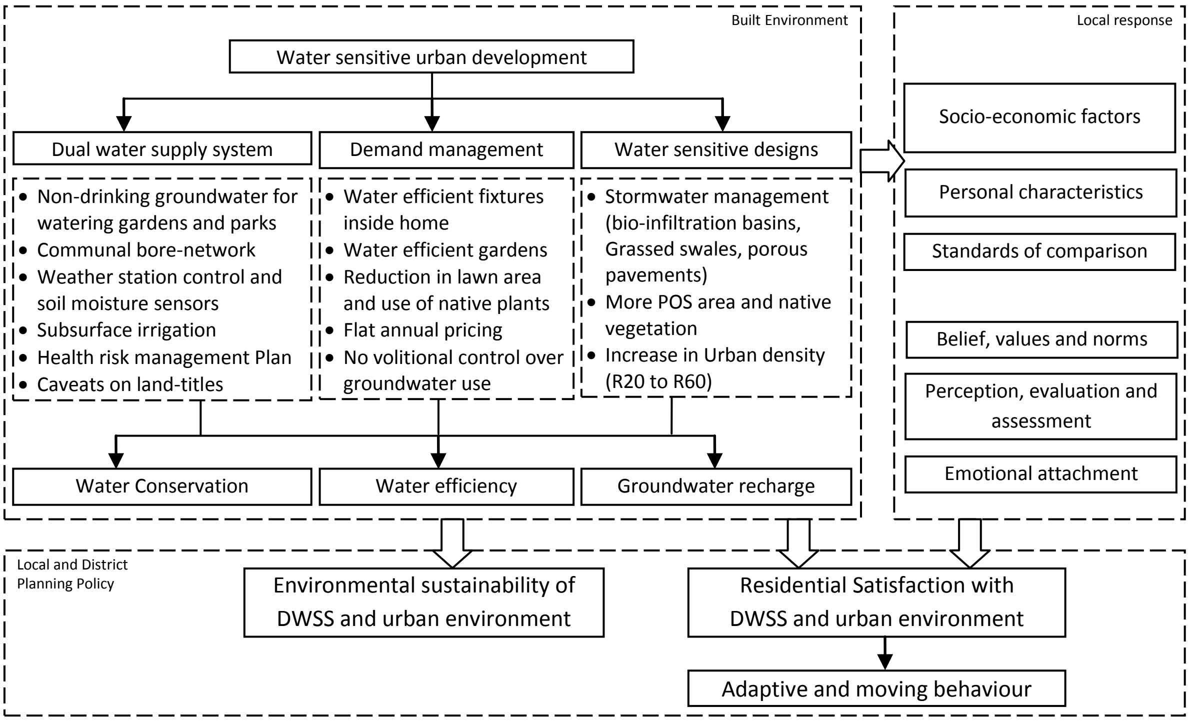


Figure 14: A framework showing the interrelationship of the built environment, social indicators, community response, sustainability, and planning

The level of satisfaction indicates the quality of life in such water sensitive environment and interacts with the sustainability of the environment (Porter et al., 2005). On the other hand, the satisfaction level determines the residential behaviour towards the system and environment. In simple words, the higher level of satisfaction corresponds with the intention to remain in the area and reduce the migratory behaviours. Higher satisfaction also increases the acceptability of the NDG system and the urban environment that will eventually ensure the sustainability of the system and environment. The acceptability, satisfaction and behavioural responses have their implications for planning and sustainable development of the dual water systems and water sensitive environment at local and district levels.

5.2.3. Objective-subjective concept for evaluating residential satisfaction

As previously discussed, an individual generates his/her satisfaction with the given objective environment by perceiving, assessing and evaluating different attributes of the environment. The satisfaction is a subjective attribute, a non-physical but observable attribute, indicating the quality of the objective environment.

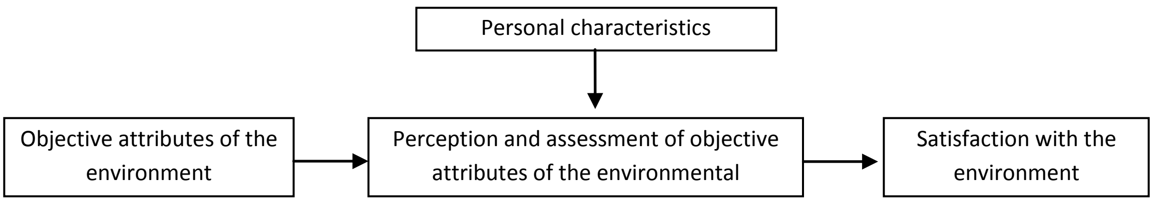


Figure 15: Subjective assessment of objective environment

As shown in Figure 15, the satisfaction with the environment is generated from the perception and evaluation of the objective attributes and services of the environment. The evaluation of an objective environment is highly dependent upon the personal characteristics and the standards of comparison (Marans and Rodgers, 1975; Campbell et al., 1976; Weidemann and Anderson, 1985; Amerigo, 2002). Therefore, the relationship between the objective attributes and subjective responses is mostly moderated by the personal characteristics and standards of comparison. Most of the time there is weaker correlation between the objective attributes and subjective attributes of an environment, so care should be taken while explaining the subjective attributes as an indicator of the quality of objective attributes (McCrea, Shyy, and Stimson, 2006). Marans (2003) explains the subjective indicators of an environment are merely the meaning of the objective environment to the individual.

This research adopts the objective-subjective concept of environmental evaluation to explore the 'general sense of causality' (Weidemann and Anderson, 1985; Amerigo, 2002) between the objective and subjective attributes. Several studies (Campbell et al., 1976; Marans and Spreckelmeyer, 1981; Weidemann and Anderson, 1985; Amerigo and Aragones, 1997) elaborated on the basic objective-subjective model of environmental satisfaction and also included the behavioural component of the satisfaction as shown in Figure 16. The addition of behavioural component indicates that the satisfaction with the environment also acts as a predictor of the adaptive or migratory behaviour towards the environment.

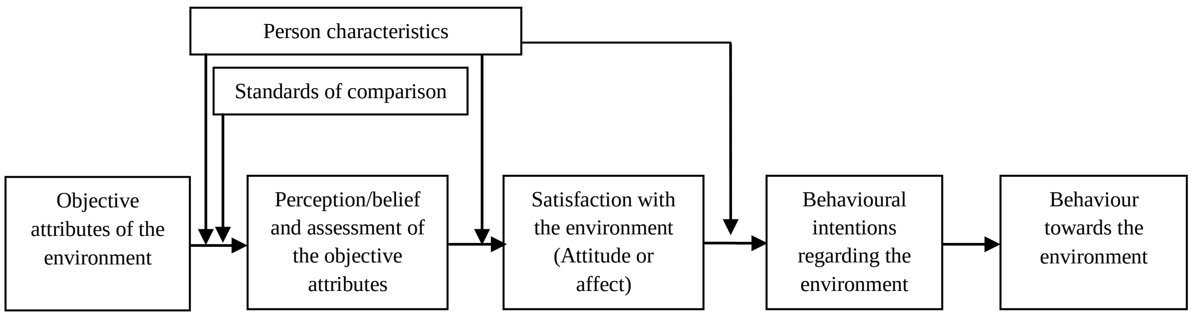


Figure 16: Elaborated model of satisfaction with an environment showing the relationship between the objective and subjective satisfaction attributes regarding the environment.

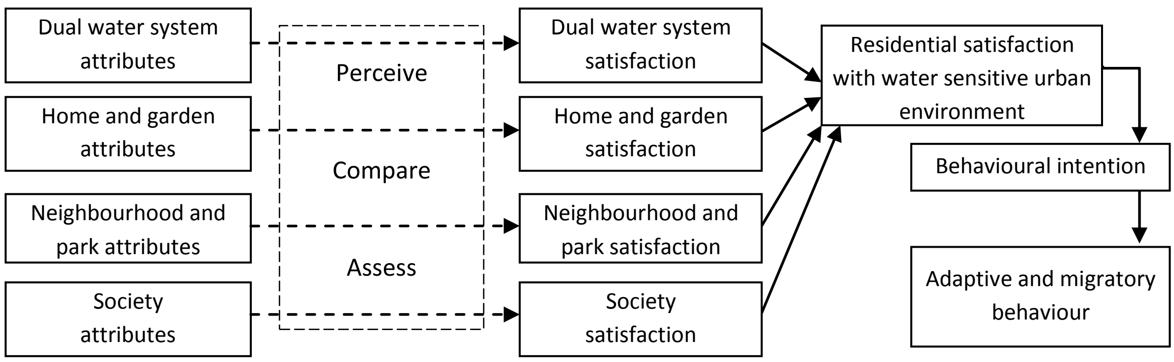


Figure 17: Conceptual framework for residential satisfaction with water sensitive urban environment

Using the basic principles of the elaborated model of satisfaction with an environment, a conceptual framework (Figure 17) is developed and used in this study. As the public parks and gardens are important components of water sensitive urban environment, the garden attributes are included in the home domain and the attributes of public park are included in the neighbourhood domain. An individual perceives, compares and evaluates different objective attributes of the four domains to generate satisfaction with respective domains that collectively results in the overall satisfaction with the residential envrionment. The satisfaction with the environment then determines the behavioural responses via the intentions. Though not displayed in Figure 17, the conceptual framework embraces that the personal characteristics influence the evaluation process and each component of the framework.

5.2.4. Domains of water sensitive urban residential environment

The dual water system and that of other three components (home, neighbourhood and society) as depicted in Figure 17 represent the newly established water sensitive urban environment in the study area. The "Liveable Neighbourhood (LN)" concept defined by WAPC (2007) is used to contextualise the domains and parallel literatures are utilised to provide the working definition of the domains. Currently, the LN concept is being reviewed by WAPC and final version is supposed to be available at the end of 2014. However, the LN includes 8 major elements: community design, movement network (roads and trails), block layout (home, garden, lawn, etc), public parkland, urban water management, utilities, activity centres and employment, and schools (Western Australian Planning Commission, 2007).

These elements mainly focus on the physical part of an environment, which makes a complete residential environment when human-beings dwell in it. The human element constitutes the society component. The main elements of this component are: neighbours, friends, social organisations and individual's relationship with them. Urban community design, road network, public parkland, activity centres and employment, and schools are included as elements of neighbourhood component, while the block layout (size and design of home and gardens; lawn and plant types), and utilities are considered as the attributes of home domain. In addition, the urban water management is considered as a separate component, because a NDG system in the form of dual water supply system has been implemented for "The Green" at Butler. The implementation of NDG trial transformed "The Green" into a water sensitive development having unique attributes of home, and neighbourhood.

A. Society

As previously discussed, society is a subjective domain, and generally explains the emotional relationship among people and with the environment. This research considers the society as a separate and higher domain than the neighbourhood. The LN concept has not explicitly separated the society from the neighbourhood domain; however, emphasized the importance of the subjective interface between the neighbourhood attributes and dwellers. This subjective interface (or society) is considered a very important domain for any living environment, and in fact, is the strongest contributor for community satisfaction in most of the published studies (Amerigo, 2002; Marans, 2003; Adriaanse, 2007).

In this research, the main components of the society domain are the neighbours, friends and relatives, and social organisations. Individuals' perception and assessment of these components and their relationships with these components determine their satisfaction with the society. The society satisfaction then imparts the overall residential satisfaction that then determines the behaviours towards the society and environment.

B. Neighbourhood

This research has adopted Canter and Rees (1982) concept of neighbourhood that is essentially a micro-neighbourhood (a street or 10-20 households), which is widely supported as a unit for evaluating the quality of residential environment (Hipp, 2010). Western Australian Planning Commission (2007) considers the neighbourhood as a bigger unit of urban environment that has mixed residential and commercial developments, and which meets daily and weekly needs, community facilities, and employment. The 'Liveable Neighbourhood' considers neighbourhood should be walkable and of approximate circles of 400-500m radius around proposed neighbourhood and town centres (Western Australian Planning Commission, 2007). This research utilizes several attributes of the 'liveable neighbourhood', and modifies them to fit into a much smaller scale of neighbourhood as described by Canter and Rees (1982) and followers. This approach ensures the inclusion of important attributes of the neighbourhood, so that the attributes would be applicable in determining the quality of water sensitive urban environment in WA. In this research, the access to the public facilities and services, transport and road network, public parkland, urban density, community services, schools, safety, environment management, activity centres and employment are considered as important attributes of the neighbourhood. Individual perception and evaluation of these attributes generate their satisfaction with the neighbourhood and eventually with the residential environment.

C. Home

The home environment represents the indoor and outdoor physical attributes of the housing block as well as feelings attached to the attributes. The usual physical attributes are: the block layout; size and design of home, the space inside and outside of the home, the garden size and design, lawn, plants and other utilities etc. In addition, the subjective feelings are: home ownership, suitability, privacy, sense of comfort, safety, and settlement. The subjective feelings are equally included as important home attributes regarding satisfaction with the home environment (Weidemann and Anderson, 1985; Amerigo and Aragones, 1997; Amerigo, 2002; Marans, 2003; Adriaanse, 2007). Individual perception and evaluation of the physical attributes and subjective feelings generate satisfaction with the home environment and eventually with the residential environment.

D. The dual water system

The different attributes of the dual water supply system in "The Green" have already been explained in section 3.2.3. All the attributes of NDG system are considered and evaluated to generate satisfaction with the dual water system. The attributes of NDG system are mainly about the quality, the operation, the control, and pricing of the groundwater. In addition, the other subjective attributes of the system to be considered are perception of risks, benefits, fairness, and equity issues. Individual perception and assessment of the attributes determine the satisfaction with the dual water (NDG) system that influences the overall residential satisfaction.

This research considered the acceptability model of alternative water supply system (Porter et al., 2006) as a starting point prior to examining the dual water (NDG) satisfaction. The model has been developed from a series of CSIRO studies focused on community attitudes towards the alternative water systems and the water consumption behaviours using Fishbein and Ajzen (1975) attitude-behaviour theory. The acceptability model helps for deeper and contextual understanding of community feelings, attitudes and behaviours towards the dual water system. Furthermore, this study utilizes the Barron et al. (2010) study as a pre-development study and explores the post development consequences of the NDG trial in terms of the acceptance and satisfaction with the trial and urban development.

5.2.5. The link between 'Satisfaction' and 'Acceptance' of the NDG system

Acceptance and satisfaction are two different states of the human mind, however, this research utilises the satisfaction as an attitude and the acceptance as the behaviour regarding the NDG system and water sensitive urban development. According to Ajzen and Fishbein's (1974; 2005) 'attitude-behaviour' concept, individuals satisfaction (attitude) with the NDG system and urban environment determines the acceptance (behaviour) of the system and environment. However, the impacts of attitudes over the behaviours are often questioned (Wicker, 1969). In response, Ajzen and Fishbein (2005) pointed out the need to assess the multidimensionality (affective, cognitive and conative aspects) of attitude and consider the behavioural intention as another important factor influencing the behaviours. When there is a higher correlation between the intention and behaviour, the attitudes can better predict the behaviours (Ajzen and Fishbein, 1977). Using this notion, multiple aspects of attitudes as well as behavioural intentions are considered to get a better evaluation of satisfaction and provide a better explanation of the behaviour towards the water system and urban environment.

In addition, Ridgewood was selected as a control suburb to ensure no exogenous variables remained unidentified in the research area. "The Green" (experimental suburb) provides information on satisfaction with the NDG system, whereas the control lacks the NDG system, so it can only provide the information regarding the acceptance of the NDG system (assuming if NDG would happen in future). In such case the acceptance of the NDG system in control can be considered as equivalent to the satisfaction with the system in the experimental area.

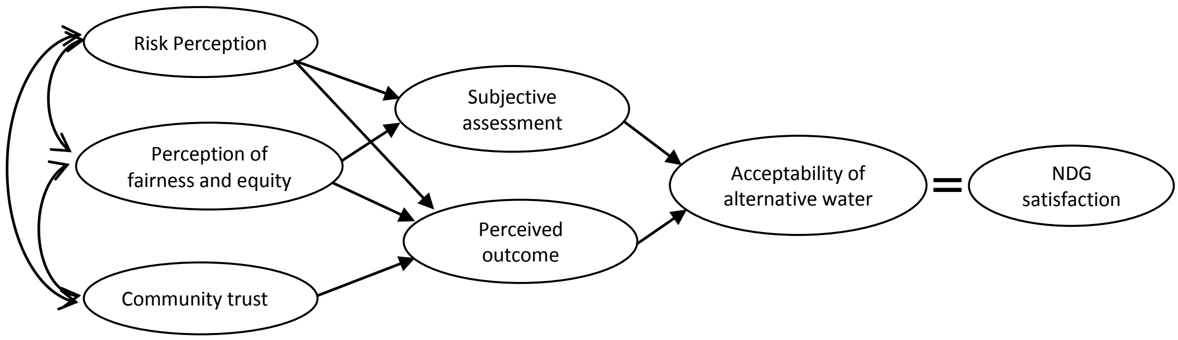


Figure 18: An attitudinal model for dual water acceptability

Figure 18 depicts Porter et al. (2006) attitudinal model of community acceptance of alternative water systems. This model is slightly modified to accommodate a dual water (NDG) satisfaction as equivalent to the acceptance of the system. This modification suits this research model (post-development evaluation), where the acceptance of the NDG (alternative) system in the control is considered equivalent to the satisfaction with the NDG system in the experimental area.

However, acceptance has a different meaning than satisfaction. Acceptance can be the closest behaviour of a satisfied individual, whereas satisfaction is a global attitude that is generated from the perception and evaluation of the object and/or environment. The relationship between acceptance and satisfaction is not easy to explain. It looks like the reverse of attitude-behaviour relationship, but there is no literature that supports the acceptance-satisfaction concept is exactly the reverse of the Fishbein and Ajzen (1975) attitude-behaviour concept. Some previous studies (Hurlimann et al., 2008; Barron et al., 2010) utilised the measures of the acceptance of alternative water systems to predict the satisfaction with the alternatives; however none explained the acceptance-satisfaction relationship explicitly. Neither Ajzen and co-workers (1974, 1975; 1991, 2005; 2012) have explicitly explained the behaviour-attitude pathway. There are a number of critiques on the relationship between attitude and behaviour (Wicker, 1969, 1971; Schneider, 1987; Greenwald, Poehlman, Uhlmann, and Banaji, 2009); and so are the supporters (Marans and Rodgers, 1975; Marans and Spreckelmeyer, 1981; Weidemann and Anderson, 1985; Kraus, 1995; Amerigo and Aragones, 1997; Albarracín, Johnson, Fishbein, and Muellerleile, 2001; Amerigo, 2002; Po et al., 2003). Therefore, this research adopts the attitude-behaviour theory to explore the acceptance-satisfaction relationship regarding NDG system and inform whether the findings are congruent with attitude-behaviour theory.

Since the acceptability model is considered as the starting point to develop a model of satisfaction with NDG system, the measures of the acceptability are contextualized, reworded, and rationalized with the help of site-specific knowledge (Chapter 6). In addition, some new variables are added to get a complete scenario of the NDG system. The variation in satisfaction in control and the experimental area informs the impact of the NDG system to the residential satisfaction.

5.3. Research Methodology

This research is a post-development study and has two levels of aims: first, to evaluate the satisfaction with a NDG system and its influence on residential satisfaction with the water sensitive urban environment; and second, to explore the impact and utility of NDG system for urban water and land planning in the light of drying climate and growing population. To address the aims, both interpretive and positivist approach have been utilised as advocated by Schultz and Hatch (1996). The interpretive approach was adopted to explore the impact of innovative NDG system on residential development and the end-user community, and the positivist approach was taken to test the hypothesis about the major influencing issues of the water system, and urban community development to residential satisfaction with the NDG system and water sensitive environment. The research propositions and hypotheses were developed from the extensive review of literatures and also from the preliminary field visits, and are explained in Chapter Four. These research propositions are reflected in the four major research enquiries that are tested by using a number of research tools and the findings are detailed in Chapter Six, Seven, and Eight.

The organisation and application of the research tools and methodology in this research is mainly guided by a multi-paradigm approach of Schultz and Hatch (1996). A paradigm is defined as the 'set of ontological and epistemological assumptions that deals with the core reality in the organisational theory' (Morgan, 1980). Schultz and Hatch (1996) approach respects paradigm differences while crossing the paradigms; recognizes and confronts multiple paradigms, especially positivist and interpretive paradigms (ex- Willmott, 1993); rather than ignoring them or refusing to confront them (ex- Burrell and Morgan, 1980).

The multi-paradigm, i.e., the use of both the interpretive and positivist approach, has been reflected but not limited by adopting a combination of qualitative and quantitative research methods in this research. The main research approach is the positivist, while the interpretive informs it at the beginning and draws research inferences at the end. The mixed methodology is not uncommon especially when research questions aim to explore knowledge rather than to confirm it. A combination of qualitative (observation and interviews) and quantitative (surveys and secondary data) research methods in this study yielded rich and complementary data and strengthen the results (Corbin and Strauss, 2008). Qualitative study provided depth and richness of data and when combined with a quantitative study, this enabled better extraction of key issues, greater generalisability of the findings, and greater validity through triangulation (Onwuegbuzie and Johnson, 2006). Moreover, using multiple methods often results in findings that would not have been possible using one method alone.

However, the main challenge in adopting both positivist and interpretive approach was to capture sufficient quantitative data that could describe and deal with the context and utilise the qualitative data to rectify and enrich such findings. The positivist approach is a surface approach; it only describes the tip of the iceberg, while interpretive approach enquires and deals with the rich and detailed qualitative information. More often, the qualitative issues drive the decision makings, provided ample amount of quantitative information for precision. Hence, the difficulties were to balance these two approaches to draw research inferences and recommendations regarding community perspectives towards the alternative NDG system and water smart developments.

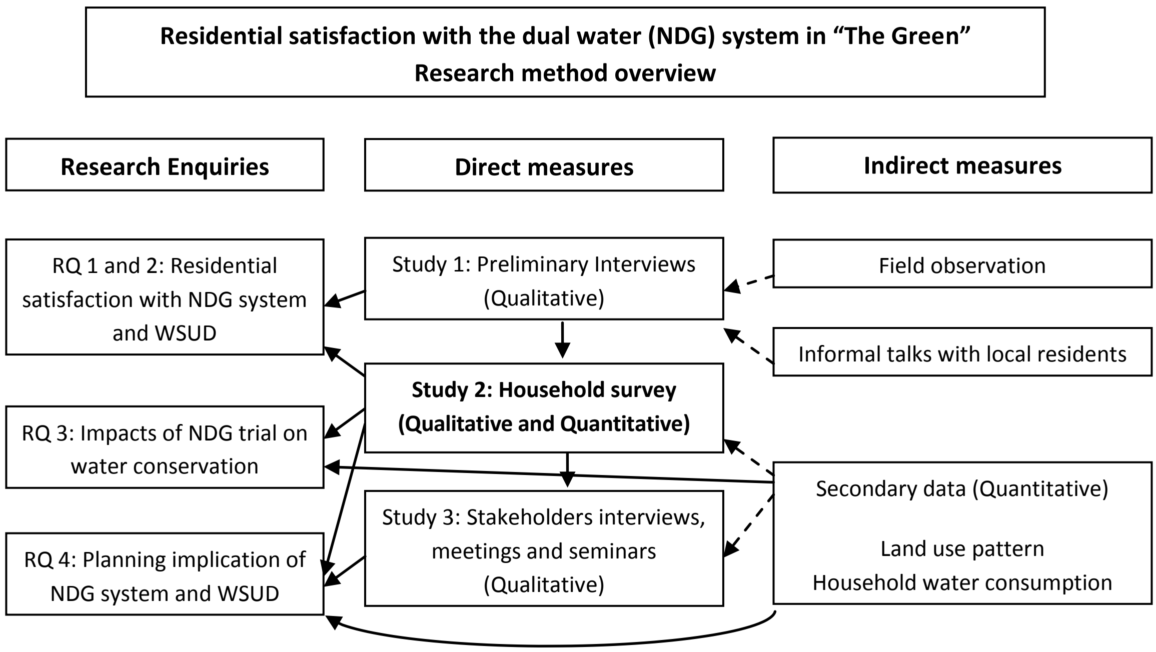
5.3.1. Justification of Mixed Methodology

Two broad disciplines, namely: the psychological studies on quality of human life; and the strategic development studies of urban development, have studied the residential satisfaction issues in America and Europe since 1960s. The psychological studies consider the satisfaction as a social indicator of quality of life (Marans and Rodgers, 1975; Campbell et al., 1976; Weidemann and Anderson, 1985; Amerigo and Aragones, 1997; Adriaanse, 2007). The development studies consider the housing as a commodity and studied customers (residents) satisfaction and behaviours with the commodity. This focused on evaluating the physical attributes of the housing in terms of residential satisfaction, which in turn, predict the behaviour (adaptive or migratory) towards the living environment (Speare, 1974; Newman and Duncan, 1979; Priemus, 1986). In addition, the development studies attempt to harmonise the planning, development and finally the utility in terms of water conservation, water efficiency and environmental benefits.

This research draws from both the psychological studies, and development studies (marketing research and strategic planning) in order to explore residential satisfaction with and behaviour towards the innovative NDG system in a water sensitive urban development. The alternative water system significantly impacts the behaviours of end users (customers) and influences the quality of their community and environment. Nonetheless, a limited number studies have focused on the impact of water system on the evaluation of urban living environment and corresponding behaviours towards the environment (Hurlimann, 2006). Such context demands an exploratory research design involving qualitative methods to explore the wider issues, and the quantitative methods to test and measure the theories and propositions. The qualitative approach helps to identify the variables and the constructs and the quantitative approach assists to test and develop suitable scales for these constructs, so that the hypothesis can be tested and research model can be built (Malhotra, 1996).

This study utilises the existing models of residential satisfaction and alternative water system acceptance as a starting point to develop a model of residential satisfaction with NDG system and water sensitive residential environment. The qualitative approach (preliminary interviews) rationalised the variables and constructs, then the relationships were mathematically tested and verified by the quantitative approach. The quantitative approach (household survey) utilised the larger representative samples, statistically tested the relationships between target variables, and generalised the model of residential satisfaction for a population. Finally, the qualitative approach (in-depth talks with stakeholders) helped in interpreting and rationalising the model and its planning implication to different planning levels.

This study proceeds through a number of equally important and sequential studies, which reflect the mixed sequential research design as in Leech and Onwuegbuzie (2009). Firstly, preliminary interview utilises deductive-inductive approach to identify and establish the key variables for residential satisfaction with NDG system and urban residential environment. Secondly, the household survey serves as a deductive study that utilises the variables and instrument developed during preliminary interviews, and develops and tests measurement scales for residential satisfaction. The survey coupled with secondary data examines and finds out the contribution of NDG system in water conservation. Finally, the major findings of the preliminary interviews, survey, and secondary data analysis are discussed with stakeholders in personal interviews, meetings and seminars. The qualitative information from stakeholders' perspectives explains the planning implications of the NDG system in urban residential settings. In this way, the research enquiries are addressed using sequential methods as shown in Figure 19 below.



The dotted arrow indicates the influence of one component over another.

Figure 19: The overview of research program

As displayed in Figure 19, the first and second studies address the research question 1 and 2; i.e., satisfaction with the NDG system and its contribution to the residential satisfaction. With the help of secondary data on water consumption, second study examines the utility and contribution of the NDG system in terms of the water conservation and water efficiency, which is research question 3. Finally, third study deals with the research question 4, the implication of the NDG system in urban water and land planning.

5.4. Research Design

The main purpose of the quasi-experimental research (Kerlinger, 1986) design is to explicitly test the research hypotheses. In addition, this study utilises the control suburb to prevent the extraneous water related variables from affecting the community perceptions and attitudes towards the NDG system and water sensitive environment. The statistical principle behind the quasi-experimental research design is to control variance, i.e., maximize systematic variance, control extraneous systematic variance, and minimize error variance. Thus, research design enables the investigator to answer research questions as much validly, objectively, accurately, and economically as possible (Kerlinger, 1986).

The main aim of a researcher is to design, plan and conduct research so that the experimental conditions are as different as possible. In simpler words, the researcher has to maximize the experimental variance, i.e., the variance in the outcome (say satisfaction) influenced by the independent variables, especially by the manipulated independent variables. This is necessary to illustrate the effect of the independent variables from the total variance of the outcome. Furthermore, the influences of independent variables irrelevant to the purposes of the study to the dependent variable should be minimized, nullified, or isolated from the influences of other independent variables. For example: the changes in garden watering restriction, water pricing, water pressure as well as community campaign against the NDG usage in their locality among others could impact significantly over the residential satisfaction with the NDG system in "The Green", which is not necessarily because of the quality and other attributes of the system itself. In addition, the climatic pattern, the geographic location, the culture, residence duration, the lifestyle and awareness about the water crisis in WA also greatly impact over the individual assessment of the NDG system and water sensitive development.

The variance caused by these exogenous variables can be controlled by sampling homogenous subjects; assigning subjects and treatments randomly; and (if required) studying the influence of extraneous variables separately. The design for this research is "the post-test-only control group design" (Kerlinger, 1986). Randomization is utilized to ensure the equalization of the two groups, without a pre-test, as in the Van Noord and Kagan(1976) study. The variance in outcome between areas is then, presumed to be only due to the effects of experimental variables. That means any difference in residential satisfaction between areas will be due to the dual water system. Furthermore, Ridgewood is selected as a control group, for comparability required by science, as it is similar in location, climate, socio-demographics and development but lacks the dual water supply system. This design also aims to minimize the error variance by controlling experimental conditions at first hand, and then by increasing reliability of the measures at 99% level of confidence ($p \leq 0.01$).

5.4.1. Post-test only control group design: randomized subjects

The research fits into the post-test only control group research design. The internal validity of this design is basically solid, and due to the random assignment of subjects, the selection of subjects is not supposed to present a threat to internal validity. According to Cook and Campbell (1979), the post-test only group design is prototypical (ideal) experimental design, which most closely exemplifies a condition in which causal relationship can be distinguished between an independent and dependent variable. The main weakness of this design concerns external validity, i.e., the interaction of selection and treatment (Cook and Campbell, 1979). That means the absence of pre-test leads to the possibility that any post-test differences (of outcome) between groups can be attributed either to a treatment effect or to the selection differences between the groups (pre-existing difference or sampling effects). This would be worse when there are more than two experimental groups to compare with one control group, and the variances among groups may account for the variance in outcome rather than treatment effect. This research involves only one control and one experimental group, and such complication is highly unlikely to happen. However, it is often unknown whether the result of the study would generalize to another population, for example: there could potentially be great differences between the results of a course on SPEED taught to a graduate class and that to a high school class (Dawson, 1997).

The variability in the dependent variables is another important issue to consider. A random assignment is supposed to account for the pre-existing variability; however, the random assignment wouldn't always be possible. As explained by Huck and Cormier (1996), there are two major causes for this: a) many researchers have a very loose definition of what the randomisation is, and b) true randomisation carries with its very stringent criteria and many researchers are unaware of the necessary precisions and falsely believe that they have true randomisation, when they do not. Therefore, Huck and Cormier (1996) suggest that researchers should explain how they accomplished the randomization and all the associated method development processes. In this research, the randomization and method development process are explicitly described.

This study examines the causal effect of the dual water system and water sensitive urban environment (treatment or independent variables) on individual's satisfaction and behavioural responses (outcome or dependent variable). The experimental treatment was already assigned, meaning that the outcomes should have already been affected. This research evaluates/measures the post-development outcomes and investigates the relationship of the treatment variables with the outcomes. The relationships in the control area represent the pre-development situation because the control is the proxy of time before the treatment. This notion enables the comparison between pre- and post-development situations.

5.4.2. Quasi-Experiment

In social research, the social researcher is often a guest at the research sites while in laboratory research; the researcher has almost total control over the setting and acts as the host (Kerlinger, 1986). It is obviously true that assigning a large number of people to a number of random treatments is more difficult than it is to assign the objects in agricultural plots or in laboratory settings. This implies that the random assignment will be less frequent with humans than with objects and less frequent with humans in the social settings than in the laboratory. Therefore, social research has treatment, outcome measures, and experimental units, but do not use random assignment of subjects to create the comparisons from which treatment-caused change is inferred. Instead, the comparisons depend upon almost equivalent or non-equivalent groups (control group) that differ from the experimental one in none or many ways other than the presence of an experimental treatment. This type of social experiments are termed as quasi-experiments (Cook and Campbell, 1979).

The task of the researcher who tries to interpret the results from quasi-experiments is basically to separate the effects of the treatment from the pre-existing differences between the groups. Only the treatment effects are of research interests. To achieve this separation, the researcher has to explain the specific threats to valid causal inference that random assignment (doesn't) rule-out and then in some way deal with these threats. Therefore, quasi-experiments require explicit description of the irrelevant forces hidden within the *ceteris paribus* (a condition other things being equal) of random assignment (Cook and Campbell, 1979).

In the research context, there can be some hidden relationships (impacts), either of randomisation or of background changes other than treatments (dual water system/water sensitive designs) over the outcome (satisfaction). For example: the change in water price, rainfall, watering restriction can cause changes in the level of residential satisfaction with the NDG system, garden and home, which may not be due to the treatment itself. Furthermore, the study area is predominantly occupied by the migrants either from highly developed and densely populated part of the world; such as: European countries, Japan, USA, and Eastern part of Australia; or from the developing and water scarce countries; such as Asian, Latin American, and African countries. The migrants may find “The Green” more affordable and the dual water system more acceptable than their previous living environment. Similarly, there may be positive minded people for environmental-friendly development, who would be happier with the dual water system and water sensitive development in “The Green” over the average urban development.

These leverages could only be distinguished if the hidden or irrelevant causal relationship can be neutralised with the provision of the control group. In such case, the hidden impacts/relations also occur in the control area that induces changes in the control too, which neutralises the differences in the outcome caused by the irrelevant/hidden impacts/relationships. In this way, a valid relationship of experimental treatment with the outcomes can be generated. Finally, a better statistical control with the help of cross-sectional table and multiple regressions under a variety of different guises will substitute the lack of experimental control. This belief may sometime underestimate the importance or necessity of the random assignment in field experiments. This is not always possible and the efforts for error control should be exercised in every step of the research process.

5.4.3. Practical Complication

The quasi-experimental design has a practical complication because this research has been started after three year of the NDG trial in “The Green”. Additionally, the NDG trial and water sensitive development had been placed well before people actually move into “The Green”. Hence, the question of pre-testing and random placement of the subjects was totally impossible.

To resemble the pre-test and post-test experiment, an equivalent control area has been selected, which is considered as a proxy of time before the implementation (i.e. pre-test) of the water system and the water sensitive development in "The Green".

In this way, this is a quasi-experiment research with a post-test only control group design, where the control group is equivalent to the experimental group. Being a post-test research, it is impossible to measure any pre-existing variance of the outcome variable in these two groups. This might cause difficulties while interpreting the result of the experiments. However, the randomisation addresses the pre-variance of outcome in the two groups and makes the two groups comparable. In this research, the control is equivalent to the experimental area except the NDG trial; hence, it is supposed that the satisfaction in the control is equivalent to the satisfaction in the experimental area before the treatment (NDG trial).

5.4.4. Control Selection

A control is used for the comparisons that are essential in all scientific investigations. The control should be approximately equal to the experimental group on any variables related to the dependent variable/s but shouldn't receive the manipulated variable/s (or experimental treatment) (Kerlinger, 1986). In this study, "The Green" is the experimental area since it contains the experimental manipulation (NDG trial). Ridgewood is selected as a control that has similar socio-demographics, urban design, and climate but only lacks the NDG trial. Both are newly established residential and mixed development in the northern corridor of Perth, which is about 35 Km north of the Perth CBD (Figure 19). Both have similar urban designs in terms of the lots size, residential density, landscaping, proximity to parks and design of parks. The only difference is the NDG system in "The Green" that is not available in Ridgewood.

During the control selection process, the details about the lot size, residential density, land use pattern, and street directory were acquired from two sources: the GIS mapping system (online), and the Property Information Section of City of Wanneroo. The information confirmed that the two suburbs have similarity in terms of location, land use pattern, residential densities, community facilities and urban development. In addition, a number of field observations as well as formal and informal talks with the property developer (Satterley Property Group) also indicated that the two suburbs have similar climate, population, culture and socio-economic status.

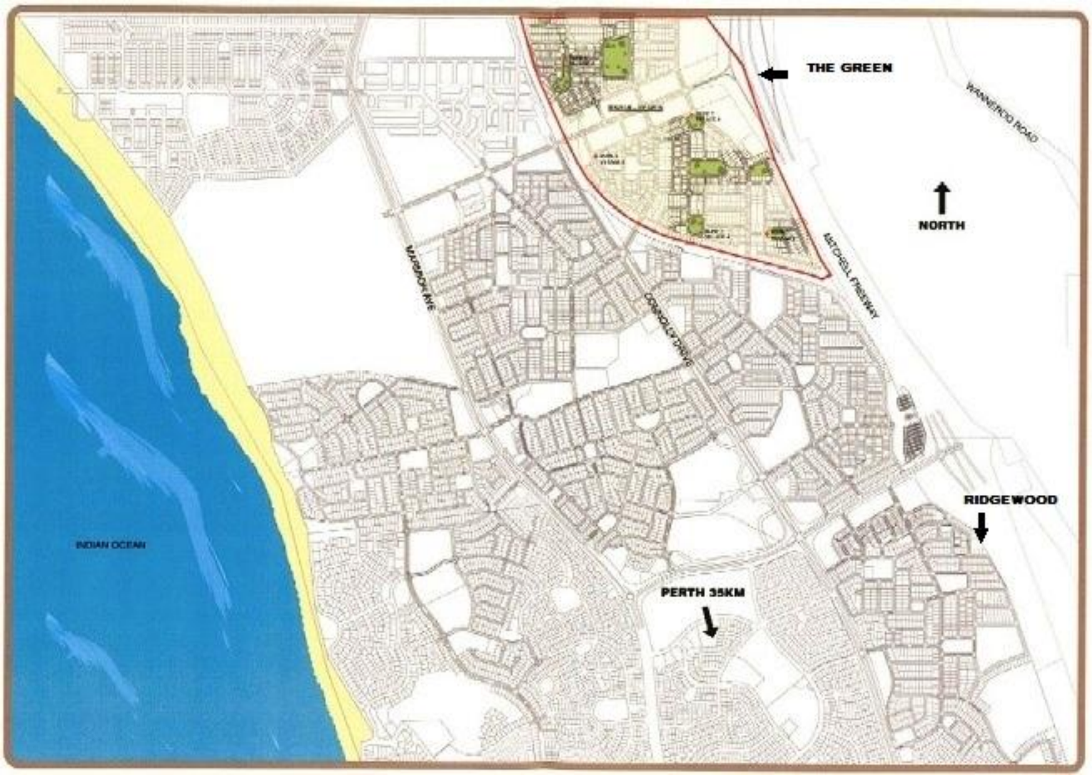


Figure 20: The location map of research area (Satterley Property Group, 2010a)

The two suburbs have virtually separate activity centres, such as shops and cafes, schools and community centre. The control is near but not right next to the experimental suburb (Figure 19), which means there is very little chance for interaction between these two communities, and so for any significant contamination of responses. Hence, Ridgewood is selected as a comparable and equivalent suburb (control) in terms of all relevant attributes (independent variables) except the dual water system (experimental variable) that possibly have impacts over residential satisfaction (the dependent variable).

5.4.5. Random Sampling

Sampling means taking a portion of a population as representative of that population so that the sample exactly exemplifies the characteristics of the population relevant to the research in question. A particular sample may not always be representative of the population, but if drawn at random, it will be unbiased and most likely represent the relevant characteristics of the population (Kerlinger, 1986). Random sampling is that method of drawing a sample (or portion) of a population so that all possible samples in given sample size have the same probability of being selected (Feller, 1968). Random samples are most likely to include the characteristics typical of the population if the characteristics are frequent in the population. This research attempts to draw random samples whenever possible assuming that the samples are representative and try to minimize the uncertainty with the help of knowledge of random sampling and random outcomes (Kerlinger, 1986).

A. Why randomization?

Randomisation is the assignment of objects of a population to subsets of the population in such a way that, for any given assignment to a subset, every member of the universe has an equal probability of being chosen for that assignment (Kerlinger, 1986). Thus randomisation generates (at least) two equal groups in terms of independent variables other than the one under test, the experimental manipulation (Fisher, 1966), so that the impact of the experimental manipulation can be tested. Thus, randomisation controls the influences of all other independent variables than that of the experimental manipulation on the dependent variable (outcome).

Given a sufficient number of units relative to the variability between units, the random selection procedure will make the average unit in any one treatment group comparable to the average unit in any other treatment group before the treatments are applied (Cook and Campbell, 1979). It means that if there are a sufficient number of participants in each group, then a random sampling of these participants makes the average outcome in experimental group comparable to the average outcome in the control group before the treatments are allocated. Then after the experimental manipulation, the outcome in the control area will remain unchanged while that of the experimental area will change, thus illustrating the impacts of the experimental treatment.

B. How randomization?

During the focus group discussion, it was proposed to select stratified random participants on the basis of lot size and proximity to the public parks. However, no participants attended the focus group discussion that was subsequently replaced with preliminary interviews. During preliminary interviews, the participants were randomly selected as representative of block size and residential density irrespective of proximity to the public parks. This modification was adopted because the public parks were well distributed throughout the study area and all houses were relatively closer to the public parks in comparison to the average metropolitan suburbs. In addition, the higher density development increased the number of smaller (cottage) blocks around the city centres, train stations and shopping centres that could result the variations in satisfaction with the water system, home, and urban environment. The modified randomisation criteria (on the basis of lot sizes and residential density) were applied for sampling not only during preliminary interviews, but also during the household survey.

When the research was designed, only the homeowners were considered as the participants, because the other types of residents (e.g. renters, public housing tenants) were less likely to be aware about and responsible for the NDG trial. They were also not the direct payer of the NDG supply. This exclusion was well practiced during the preliminary interviews but loosen during the survey. The responses from renters and public housing residents were accepted because the survey questionnaires were dropped off to randomly selected households. It was impossible to identify the home ownership before dropping off the questionnaires that might be renters or public housing residents. However, the responses may provide useful insights into the renters and other non-owner's perspective and their participation towards the alternative water system and water sensitive urban development.

C. Randomized participants

Due to ongoing construction during the study period, all the blocks were not completed in study area and the uncompleted blocks were excluded. 828 lots in “The Green” and 822 lots in Ridgewood were completed and occupied that were selected as the population for the research purpose. The detail on land use patterns (mainly the block size and residential density) is given in Table 7, which is also the basis for the stratified sampling method adopted in this study.

Table 7: The land use pattern of “The Green” and Ridgewood

Density code	**Housing lots in “The Green”**			**Housing lots in Ridgewood***		
	>400m^2	<400m^2	Subtotal	>400m^2	<400m^2	Subtotal
R20-30	534	82	616	379	40	419
R40	6	21	27	160	78	238
R60	28^	157	185	12	153	165
Total Lots	568	260	828	551	271	822

R60 blocks may contain multi-houses

**Only residential blocks developed by Satterley Property Group were included*

Table 7 indicates that both areas have similar numbers of larger (>400m^2) and smaller (<400m^2) blocks. Taking 400m^2 as a cut-off point, the proportion of larger and smaller blocks in each area is appeared to be approximate 70% to 30% of total blocks. Regarding the densities, both areas have almost equal numbers of R60 blocks, “The Green” has higher number of R20-30 blocks (about 200 more than Ridgewood), and Ridgewood has almost all of R40 blocks. In “The Green”, R40 blocks are less than 5% of total blocks but in Ridgewood, R40 blocks count almost a quarter of total blocks. Almost equal number of larger and smaller blocks in each area, but a variation in proportion of densities is mainly due to a higher number of larger R40 blocks in Ridgewood.

A stratified random sampling on the basis of lot size and residential density was adopted. In both areas, higher densities are closer to the proposed train station, city centres, and existing public parks. This means there are very little mix of densities in particular streets. Hence, the street would serve as the unit of particular strata of block sizes and residential densities. We’ve used randomised streets and selected every second household in that street as a member of the stratified random sample. In this way, we’ve sampled about 410 random households out of about 820 households in each area.

5.5. Research Methods

A number of research techniques were used to derive and design the items that examine the research phenomena, develop the valid variables and their measurement scales, and finally test the relationship among variables to address the research questions. The research methods facilitated the scale development process - starting from selecting the study area and context; items and variable identification, the measurement scale development, and collecting and analysing data to test the reliability and validity of the construct to explain the research queries, and finally confirming the construct-relationship by replicating in independent samples as advocated by Hinkin (1998). The different research activities assist the scale development process which is sequentially explained later in section 5.5.1.

A mixed method approach was adopted that utilized both the qualitative and quantitative research techniques; such as: preliminary interviews with local residents; household questionnaire survey; in-depth interviews, meetings and seminars with stakeholders; and secondary data analysis. Preliminary interviews with local residents provided rich qualitative information that helped to refine, rationalize and contextualize the variables and their measures identified in the literature. The refined variables were mostly the physical and social attributes of the dual water system, water sensitive urban development and the community. The variables and their measures were developed into the semi-structured survey questionnaire (the research instrument) that collected relevant quantitative and qualitative information from the participants. In addition, secondary data about water consumption were collected to facilitate the quantitative analyses to measure water conservation and water efficiency. Altogether the qualitative and quantitative data were analysed to test the hypothesized relationships among different variables and develop a working model of residential satisfaction with the dual water system and the associated urban environment. The stakeholders' perspectives and explanations regarding the research outcomes explored the planning implications and utility of the dual water trial in sustainable water management in the urban and regional settings. Information from these multiple sources has offered the opportunity for triangulation in validating and interpreting the findings through cross-verification rather than depending upon only one tool to do so (Flick, 2009).

5.5.1. Scale development process

Hinkin (1995, 1998) argued that developing good constructs and their measures is the most difficult yet the most important part of any attitudinally based study. The main constructs under enquiry are satisfaction with the dual water system and living environment (home, neighbourhood, and society). The constructs are measured by resident's perceptions and assessment of the physical attributes of the water system and urban residential environment. The literature (Amerigo, 2002; Marans, 2003; Adriaanse, 2007) also indicate that the physical and social components are important determinants of resident's satisfaction with the environment. This notion indicates that the dual water system and the associated urban development in "The Green" have potential ramifications for the built and natural environments as well as impacts on community interaction. Hence, the physical as well as social components of the environment should be evaluated and measured with the help of reliable and valid scales and measures.

It is crucial that the measures on the research instrument (questionnaire) adequately represent the constructs under examination (Hinkin, 1998). The sound measure should demonstrate content validity, criterion-related validity, construct validity and internal consistency (AERA, APA, & NCME, 1999). Hinkin (1995, 1998) proposed the following main steps for the development of scales in accordance with established psychometric principles. These are:

1. Item generation;
2. Questionnaire administration;
3. Item reduction;

4. Confirmatory factor analysis (scale refinement);
5. Assessment of reliability and validity; and
6. Replication with an independent sample.

The exploratory nature of this research demands one initial step - the domain specification, which explains the issues and phenomena that need to be measured using suitable constructs. The literature review and preliminary interviews with local residents represented the two initial steps of the scale development process. The literature review mainly helped in specifying the research issues and drawing the items from different sources. Then, the interviews with the study participants not only helped to reword, redefine the items, and re-specify the measures, but also to develop additional items and measures (Mason, 2002).

In this way, a pool of items was generated and developed into the questionnaire that was administered during the household survey (the third step). As the fourth step, the survey data was reduced, analysed, and valid constructs were developed. Hinkin (1995, 1998) suggested two steps, a) item reduction and b) confirmatory factor analysis, for this process that can be undertaken as an integrated step to 'reduce items, factor analyse, and scale refinement'. Then the constructs were taken into advanced univariate- and multivariate-analysis, where the reliability and validity of the constructs to predict the hypothesised relationships were tested (the fifth step). This would complete the scale development process, however to ensure the genralisability of the scale, the whole process is replicated with an independent (the control sample). In this way, the scale development process was slightly modified and accomplished in six steps as follows:

1. Domain specification;
2. Item generation*;*
3. Questionnaire administration;
4. Item reduction, factor analysis and scale refinement;
5. Assessment of reliability and validity and
6. Replication with independent sample.

Chapter Two and Three include the specific details around the alternative water management, NDG trial development, residential satisfaction, and planning implication of the trial development (domain specification), Following sections in this chapter briefly explain the item generation (questionnaire) and questionnaire administration processes. The detail on item generation is available in Chapter Six, and rest steps are explained in Chapter Seven and Eight.

5.5.2. Preliminary Interviews

This research has adopted Hinkin's (1995, 1998) deductive-inductive guidelines for generating items and developing the measures. The literature review was the deductive approach and the preliminary interview was the inductive approach to generate items of the measures. As previously discussed, ten face to face preliminary interviews with local residents were conducted using a door to door approach. “The Green” participants shared their experiences and feelings towards the new type of NDG system and the associated urban development, while Ridgewood participants expressed their thoughts for the NDG trial in “The Green” if such a trial were to be implemented in Ridgewood.

It was initially proposed to precede with the focus group discussions with local residents to understand the critical research issues. In each control and experimental area, 50 households were invited to participate in the group discussions. Unfortunately, no participants attended the discussion sessions; hence the focus groups were replaced with preliminary interviews. The interviews addressed exactly the same issues as selected for the focus groups but conducted at participant’s convenient time and place to ensure better participation.

A. Interview guides

The qualitative interviews usually don’t have a structured set of questions; however, use an interview guide that ensures greater flexibility and allows extra issues to emerge during interviews (Mason, 2002). Therefore, the interviews with local residents were conducted using a flexible semi-structured interview guide (appendix E) that contains open ended questions about the groundwater system, community satisfaction and urban development issues. The key topics and issues to be discussed in interviews were developed from the literatures, field visits and informal talks with the residents before the preliminary interviews.

Same interview guide was used in both the experimental and control suburb; however, the experimental participants were asked their experience and feelings of the dual water system and water sensitive development, and the control participants were asked their thoughts and preferences towards the dual water system if that was developed in their locality. In this way, the control provided the hypothetical (or in principle) attitudes, while “The Green” provided actual attitudes towards the dual water system and associated urban development.

The interviews were started with a brief description of the research project and the NDG trial in "The Green". Participants were asked for recording the interviews, informed about ethics confirmation, and assured about the anonymity and confidentiality of the information. Participants were asked about the important things they were happy with in living in their locality. On the basis of their prioritization, the important attributes under the home, neighbourhood and society domain were discussed. Participants' feelings, perceptions and preferences towards most of these attributes were asked, and where possible the reasons behind their thoughts and preferences were also examined. After the interviews, the participants were asked to fill a short questionnaire (appendix F) regarding their socio-demographic characters and water using behaviours.

B. Interviewee selection

Only home owners were selected for preliminary interviews. The selected participants were contacted personally using door to door approach to arrange mutually convenient time for the interviews. Ten face-to-face interviews were conducted, five in each area. The interviewees were proportional of lot sizes, and residential densities. The interviews provided better knowledge about resident's perceptions, feelings, and experiences with their household, NDG system, and water sensitive development in their locality. The interviewing process was terminated after ten interviews, as most of the issues around individual satisfaction with dual water system and water sensitive development appeared to be covered, thus achieving the point of saturation of themes (Mason, 2002).

C. Interview procedures

The interviews were conducted during May-June 2011. Most of the interviews occurred during morning or evening time rather than the working hours. Each interview lasted about one hour on average, while some extended up to 2 hours with more descriptions and flow of information. Prior to interview, an information letter (Appendix B) was provided that explained the storage, anonymity, and confidentiality of the information. The information letter also explained that a donation of AU$5 was made to the local surf lifesaving club on behalf of each participant to appreciate their participation. The participants were asked to sign a consent form (Appendix C) to enable the researcher to utilise their information for the research only purposes.

In addition, the participants were informed about the audio-recording of the interviews. The interviews were conducted in a friendly environment. Two out of ten preliminary interviews were conducted with the couple that outlined family perspectives towards the research issues.

At the end of each interview, participants were thanked for their co-operation and re-assured about the anonymity and confidentiality.

D. Qualitative analysis

The audio-taped interviews were transcribed and analysed using the (Miles and Huberman, 1994) qualitative data analysis framework, proceeding through data reduction, data display, hypothesis generation and verification. For the analysis, 'NVivo 9' computer software program was used. As further explained by (Marshall and Rossman, 2006), the transcribed data were organised into major categories, major themes were identified, coding were done, memos were created for interpretation of the codes, and finally the data were transformed into some interpretable findings. The pools of items were generated to measure the constructs under examination. During this process, relevant existing items available in the literature are also consideration. The major themes, constructs, and the attitudinal items emerged out of the preliminary interviews will be described in the Chapter Six.

5.5.3. Pilot Test

The literature review and preliminary interviews helped in specifying the research domains and generating items that measure the constructs of research enquiries. More than 150 items measuring different aspects of satisfaction and behaviours with the NDG system and residential environment were included into the structured and semi-structured questionnaire (research instrument). Apart from these items, a few socio-demographic variables and participants' consent to obtain secondary data were included in the questionnaire. The questionnaires were pilot tested with 15 participants in Perth. The pilot test improved and finalised the item generation and questionnaire development process that is followed by the questionnaire administration.

A. What is pilot?

Pilot test is a small scale preliminary study prior to conducting a full-scale research project. Pilot test is usually conducted to evaluate the research feasibility, instrument, and methods; so that the research instrument and design of a research can be improved before a huge amount of time and resources are expended. The pilot evaluates the clarity of questions, respondents' understandings of the questions, and the appropriateness of the response measures. The responses from pilot test help in changing the structure of questions, re-wording and clarifying the questions, and determining whether the questions measure the right items and/or constructs. In this way, a pilot determines whether the equipment (questionnaires) is appropriate to be administered in a 'real world' experiment or not.

B. Pilot test Procedures

A pilot test with 15 participants of Perth; 10 colleagues and 5 local residents was conducted prior to administering the questionnaire to survey participants. Colleagues were contacted by email, whereas local residents were contacted by phone and/or personal visit. The participants were given a brief description about the nature of questionnaire and the purpose of the pilot. They were requested to fill out the questionnaire as well as to provide comments or inputs on it. Colleagues were further requested to consider the structure and readability of the questionnaire, while the local residents were asked for their comments on the timing and language. A pilot with colleagues was conducted in the premises of Joondalup Campus and that with local residents took place in their homes in the study area.

The researcher observed the whole pilot test and noted the timing; participants' expressions, and hesitations, and the skipped questions. It took 20 to 30 minutes for most of the colleagues to complete the questionnaire, whereas it took more than 30 minutes for the local residents. The timing indicated a need to refine and shorten the questionnaire. After completion of the questionnaire, verbal feedback from the pilot participants was received. The feedback was audio-tapped and transcribed later for further analysis. The researcher's observation and participants' feedback were matched and analysed to generate major outcomes. On the basis of these outcomes, the instruments were refined and the research methods were adjusted. The main outcomes of the pilot questionnaire and resulting adjustment in questionnaire were described in Chapter Six. After the pilot, two sets of questionnaires (Appendix H and I) were developed - one for experimental area and another for control area; however, there were a lot of overlaps in these questionnaires.

5.5.4. Household Survey

A survey is a data collection tool, which is used to collect self-report data from study participants regarding the factual information related to participants; their opinions, preferences, or behaviours as per research purpose. For a survey, there should be at least a study sample, a tool for data collection, and a set of items (variables) that can be analysed statistically to reveal the research questions. The success of the survey is always dependent on the representativeness of the sample with respect to a target population of research interest.

In this study, a random sample of households in both experimental and control area was selected, the questionnaires were administered during March and April 2012 to the selected households and data on their satisfaction with dual water system and associated urban development were collected. The survey served as the questionnaire administration process for scale development, and the control served as the replication of the scale development process in the independent sample.

A. Preliminary preparation for household survey

Prior to conducting the actual household survey, several internal preparations were performed. The first step was the preparation of the stratified random sample list according to the residential density and the block size. The second step was the field observation to ensure the sampled households are constructed and occupied. This step helped to refine the stratified random sample list to most of the probable participants by eliminating non-constructed and unoccupied blocks. The third step was to print out the questionnaire and the information letter as well as organise the general envelope and self-addressed reply paid envelopes. An information letter and a questionnaire along with one reply paid envelope were included in a post envelope as a questionnaire package, which was administered to each selected household. The fourth step was to recruit the research assistants to conduct the questionnaire administration and data collection. Two university students were recruited, trained and provided with the participants list to contact and distribute the questionnaire packages. When all internal preparation were ready and the survey was ready to start, a news item about the research and ongoing survey was published in the local community newspaper (Appendix D) to inform the local residents about the research and their roles in it.

B. Stratified random sampling procedure

The survey participants were randomly selected using the stratified sampling procedure on the basis of lot size and residential density. The information about the block size and residential density were received from the developer and local council. Such stratification was a theoretically perfect mode of random sampling; however it had some limitations in a dormitory suburb like the research area. Residents were enforced to travel to the CBD and other major cities for their jobs, so they had very little time to spend in their home and neighbourhood. Due to this particular reason, this study adopted a door to door approach rather than a distant mode of questionnaire administration.

In “The Green”, about 800 households were connected to the groundwater reticulation, and the population was sufficient to start the survey. Ridgewood had a similar population; hence, about 1600 households were considered as a total population for this research. In this type of social research, it was highly unlikely to get a response rate higher than 30%, but any research having 15-25% responses would be considered a representative study (Dey, 1997). However, this research assumed the 25% as an ideal response rate and aimed to get at least 200 responses so that most of the advanced statistical analysis could be supported. To ensure such responses, at least 800 households should be sampled; hence at least 400 households were randomly selected in each suburb for distributing household survey questionnaires.

The rationale for selecting a half population as a sample, i.e., every second house, was to ensure enough responses from the small population size and the logistic impossibility to conduct a census survey. The selected participants were personally visited using door to door approach to distribute the survey questionnaire that has been found to be helpful in promoting survey responses (Baruch, 1999). The door of every second households in stratified streets was knocked, the participants were visited and requested to participate in the survey. On top of that, a donation of AU$5 on behalf of each participants was offered to the local surf lifesaving club as an indirect incentive as suggested by (Biner and Kidd, 1994) to promote participation.

c. Door to door approach

The door of each selected household was knocked and the resident was briefed about the research and requested to participate in the survey. Once agreed, the questionnaire package was handed to the resident that contained the questionnaire, an introduction letter explaining the research, and reply-paid envelope. Participants could answer the questionnaire immediately or were given two choices for sending their responses: via post using the reply-paid envelope or pickup by the researcher.

Refusals were recorded. If nobody was at home at the time of survey and the house appeared to be occupied to researcher, the questionnaire package was dropped into the mailbox. As the package contained an information letter explaining about the survey, the residents could fill out the questionnaire themselves. In cases of unavailability of adult members, the questionnaire package was dropped and asked to be filled out only by an adult family member.

D. Follow-ups

Follow-ups are the best way to improve the response rate. Three follow ups were conducted at a weekly interval using door to door approach with reminder cards (Appendix J) to remind the participants to respond. The follow-ups were made to the households where the questionnaire packages were dropped off and where participants agreed to participate in the survey.

E. Data collection

The door to door approach to questionnaire distribution and three follow-ups at weekly intervals resulted in the distribution of 880 questionnaires in total. Once the responses were received, they were registered as a valid response using the codes in each questionnaire. The codes were then used for further identification and analysis of the information in the questionnaire. At the end of data collection process, out of 880 total distributed questionnaires, 175 responses were received, which is a 20% response rate. The responses were stored in a file locked cabinet in Edith Cowan University premises under the researcher's supervision.

F. Data analysis

The collected responses were recorded using the questionnaire codes. These codes were related to the respective household street address where the questionnaire was dropped. This technique was adopted to utilise the block size, residential density, and water consumption data of respondents without asking them. Then the questionnaires were thoroughly examined for any missing data and inappropriate answering and arranged sequentially in questionnaire codes.

After sorting the responses, the information was entered into the computers using the statistical softwares “Microsoft Excel, 2007” “IBM SPSS Amos 21” and “IBM SPSS Statistics 21”. The variables were created, defined and refined simultaneously using the same statistical computer softwares. The binomial variables, nominal and scale variables were defined and the missing data are recorded. Afterwards, the data were analysed using different statistical tools and analyses, such as - descriptive analysis, factor analysis, correlation and regression analysis, discriminant analysis, and path analysis. The overview of the data analysis is presented in Figure 21 below and the details of findings from the analysis will be explained later in the Chapter 6.

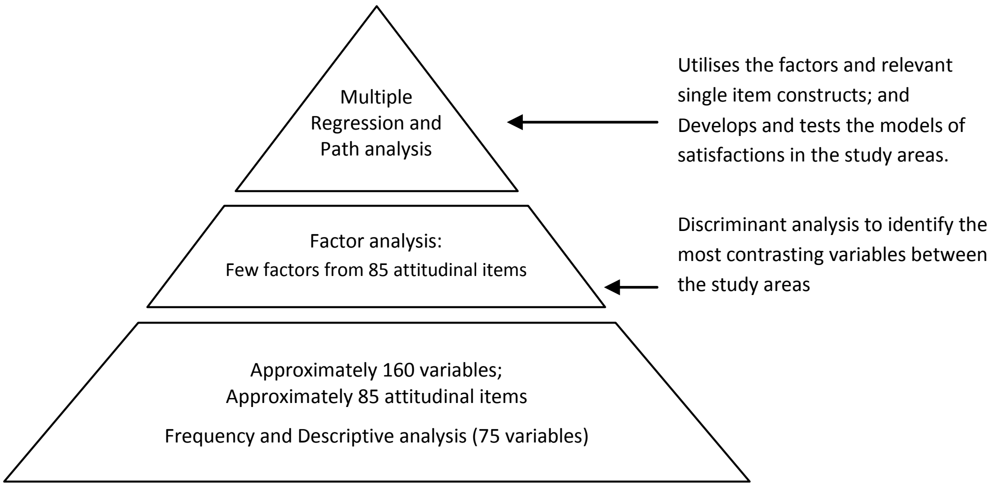


Figure 21: Overview of data analysis process for quantitative survey data

5.5.5. Secondary Data

To support incoming participant sampling on the basis of block sizes and residential density and interpreting the outcome as per strata; as well as supplement the analysis of community water consumption and conservation behaviour, two major sources were utilized. These were:

- Land use pattern data from City of Wanneroo, and
- Water consumption data from Water Corporation.

The land use pattern data was received from the Property Information Office and 'IntraMaps GIS- Online Mapping System' of City of Wanneroo. The data about the block number, size and residential density were received from the office that were cross-checked and refined using the online GIS mapping system available on City of Wanneroo's website. The street address could be figured out with the help of the block number, then with the size and residential density. Thus, a complete land development detail of desired blocks in the study area could be generated that helped to stratify the households according to the smaller or larger blocks taking 400 m^2 as a cut-off point, and residential densities. Further, such stratification was used to correlate and interpret the outcomes of particular strata.

The water consumption data was received from Water Corporation as per consent received from the householders during the survey. The water consumption data provided a deeper insight into the individual's water consumption behaviours and the relationship with their attitudes and responses towards the water system. The secondary data on water consumption was mainly used for calculating the average household water consumption in the research area and comparing the experimental household water consumption with that of the average metropolitan figure to explore whether the dual water system helped in conserving water or not. The results are described in the next chapter. This research also utilises the drinking water consumption data of Ridgewood and compares it against the metropolitan average to examine the water consumption scenario in Ridgewood, which can be compared with the water consumption scenario in "The Green" to understand the impacts of NDG system. Here, the metropolitan average water consumption was used rather than Ridgewood figures because Ridgewood is also a newly developed suburb that might presumably have higher water consumption rate than that of standard metropolitan average.

5.5.6. In-Depth Interviews, Meetings and Seminars

The qualitative information from the stakeholders, namely the water utilities, the local council and property developers was received in the form of in-depth interviews, meetings and seminars over the course of the study. This qualitative information was mainly focused on issues with non-drinking groundwater development policy and management approaches. Community needs, expectations, and responses; relationship and harmony among stakeholders to deliver project objectives; and sustainability of the non-drinking trial in the light of drying climate were mainly discussed.

Two in-depth interviews with the personnel in Satterly Property Group (property developer) and Water Corporation (water provider) along with four meetings, and two seminars in the presence of all types of stakeholders - water authorities, developer, and local council were the main source for qualitative information from stakeholders' perspectives. The in-depth interviews were conducted to understand the history and implementation of the non-drinking groundwater system as a trial in "The Green" and concurrent planning implications for each of the stakeholders. The meetings and seminars were organised to inform the stakeholders about the progress of this research and to get their concerns, perspectives and planning towards the sustainable management of the groundwater trial.

5.6. Conclusion

The purpose of this Chapter is to justify the mixed paradigm and mixed methodology used in this research. This research is an exploratory study about the community satisfaction with the dual water system and their behaviours towards the system. This chapter started with the conceptual framework of the satisfaction with dual water supply system and water sensitive development and a detailed description of the methods employed has been provided.

This research utilizes a control for comparative study and to avoid any extraneous variable impacting the interpretation of the research. Further, randomization has been adopted to ensure the approximate representation of the population in the samples and make the two groups comparable for selected variables. Further, both qualitative and quantitative research tools are applied in both control and experimental suburbs to yield the information regarding the dual water and urban environment satisfaction.

CHAPTER 6: Preliminary interviews and instrument development

6.1. Introduction

The information available in qualitative interviews are analysed using qualitative analysis techniques, and with the help of computer software "NVivo 9", while the quantitative information are managed and analysed using statistical computer softwares "Microsoft Excel 2007" and "IBM SPSS 21". As this research has adopted mixed methodology to accomplish the questions under investigation, both the qualitative as well as quantitative data analysis techniques have been used. On the basis of these data analysis techniques, the results are presented and described in three chapters: Chapter Six, Seven, and Eight. This chapter includes the qualitative findings in preliminary interviews and describes the instrument development process. Chapter Seven describes the household survey findings and develops a model of residential satisfaction with NDG system in water sensitive urban environment. Chapter Eight utilises secondary data on water consumption and includes the qualitative information from the stakeholders' interviews, meetings, and seminars. The secondary data explores the utility of the NDG system for water conservation and water efficiency, whereas the qualitative information presents the stakeholders' perspectives towards the NDG trial, and its planning implications over the urban water management.

6.2. Preliminary interviews

The preliminary interviews with local residents served as the item generation step of the scale development process. The interviews were helpful not only for the refinement and contextualisation of previous scale items and their measures regarding residential satisfaction with dual water system and urban development; but also for development of new scale items and measures that were important for explaining the site-specific causal relationship among the variables under study. Thus rationalised and developed scale items and their measures were included in the questionnaires that were administered to the survey participants to test the reliability and validity of the construct under examination. This following sections explain the procedures, analyses, and outcomes of the preliminary interviews. The details of the items, their measures, and the construct they are supposed to measure are given in section 6.2.2; whereas, the final items are detailed in questionnaires (Appendix H and I).

6.2.1. Procedures and participants

Section 5.5.2 has already provided a brief description of the procedures and methods for the preliminary interviews; hence, this section mainly explains the results of the preliminary interviews. Starting with the response rate, this section explains the socio-demographic characteristics of participants, and proceeds into the major categories, themes, and items generated from the qualitative analysis of interviews.

The participants were contacted using door to door approach during May and June 2011. A total of 98 doors were knocked and 10 interviews were conducted. The details about the responses received during the interview are given in Table 8 below.

Table 8: Preliminary interview response rate

Particular	Brighton	Ridgewood
Total door knocking	48	50
No response	32	31
Refusal	11	14
Interviews	5	5
Response rate	10.5%	10%

As shown in table 8, only 10% response was a low response rate, which may be due to the dormitory nature of suburb and door knocking at day time (working hours) when the homeowner were at work in cities. The low response rate suggested a need to change the visit time from day to either at morning or evening. However, similar studies (Po et al., 2005; Porter et al., 2006) were also suffered from low responses in their focus group discussions.

There was equal participation of male (5) and female (5) in preliminary interviews. Most of the participants were at their forties or sixties, native to Australia, had higher secondary level of education, and had blocks larger than 400m^2 with residential density of R20-30.

6.2.2. Results from Preliminary interviews

As discussed above, the qualitative analysis of the preliminary interviews was conducted using Miles and Huberman (1994); and Marshall and Rossman (2006) qualitative analysis approach. The first step was to reduce the rich interview data from "The Green" and Ridgewood into a few broad categories of responses towards the dual water system, urban development, society, and behaviours towards the residential environment. Then the second step was to display the data into major themes by coding the responses. Each theme contained several items representing a common underlying construct. In that sense, the theme could be taken as the construct and the codes constituting the theme as items of the construct. The final step was the interpretation of the result that was accomplished by generating the hypothesis about the relationship among constructs and also with their constituting items.

The qualitative analysis of the preliminary interview produced themes under the following broad categories of responses and created the template for developing the measures of satisfaction with the dual water system and water sensitive urban environment. Following the discussion on these broad categories and underlying themes, a list of respective items were developed and included in questionnaire. It should be noted that interviews in both "areas were combined and analysed, and the findings were included under the following headings.

A. Dual water supply system issues;
B. Urban living environment issues, and
C. Buying and moving behaviours.

A. Dual water supply system issues

<u>The groundwater system in domestic garden</u>

The NDG system was connected only for watering gardens and parks in "The Green". The default reticulation was supposed to be the subsurface drip and water efficient sprinklers; however, a proportion of residents had installed either the drips or the sprinklers only. The groundwater reticulation was said to be pressurised only during night time (10pm to 6am) and for limited hours only; however, the newly constructed gardens were exempted from such restrictions. Further, there were filters connected to the NDG reticulation although these were not considered essential in planning stage. The filters were primarily supposed to screen the sand and solid particles from groundwater supply to avoid blockage in drips and sprinklers, though there might be several reasons behind the filter installation.

Residents were asked about their feelings and perception to the groundwater operation and preferences to the types of garden reticulation to better understand the community attitude towards the groundwater reticulation types. Residents' feelings were important parameters for measuring their satisfaction with the NDG system, whereas the preferences to the type of garden reticulation were related to water using behaviours and staining. Sprinklers would use water exposed and cause staining, while subsurface drips use groundwater in a confined way and cause no staining.

Most of the interview participants expressed that the NDG system is a good effort to save drinking water supply in Perth. The groundwater system influenced some participants to buy their property in "The Green". Ridgewood participants also intended to buy the property in the areas with a similar NDG system in future. However, there were some irritating issues of the NDG system that are: the staining, inconsistent operation, and no volitional control over it.

Staining quality of groundwater

In general, the chemical and microbial quality of groundwater has been approved for the garden irrigation in "The Green" (Toze et al., 2008). However, the residents expressed concerns about the staining quality of groundwater. The staining appeared to influence resident's satisfaction with NDG system as people felt the staining spoiled the appearance as well as the value of their house and garden. As a remedy, they wished the water provider to remove the staining elements from the groundwater. They paid for the groundwater supply and in turn, none wished to reduce the resale value of their house. The impact of this issue to individual satisfaction with the NDG system was further explored during the household survey (Section 7.4.4).

The amount of groundwater supplied and types of reticulations installed in the garden were found to have some linkage to the occurrence of staining. The more groundwater used, more likely the staining occurs on a surface. This was evident for the larger gardens and gardens with non-natives since they required more groundwater. In addition, the sprinklers which spray out the groundwater would make the staining visible; however, the drips would supply the groundwater under the surface, thus restrict staining from appearing on the ground. In this way, the reticulation type and amount of groundwater appeared to be linked with the staining events. These issues were further explained in section 7.4.4 of this thesis.

Control of groundwater system

In "The Green", the NDG system operates automatically according to the weather information provided by the local meteorological station; this means households have no volitional control over their garden watering using the groundwater system. In addition, every household pays a flat annual levy according to their block size for the groundwater service.

There were mixed responses regarding the control of the groundwater supply system. Some participants expressed their support for the automatic groundwater supply (weather station control) and some preferred full household control over it. The supporters for the weather station control thought that auto-control would ensure equitable and efficient distribution of the groundwater whilst reducing abuse and waste of water resources. Contrarily, the supporters for household control tried to justify such control as user friendly and effective as the resident could allocate water as per his/her wishes and/or the plants requirements. They believe that increased awareness about the water resource scarcity would automatically make residents water efficient in their gardens. There was a third view that preferred the mid-way, happy with the automatic weather station control provided their preferred watering time and sufficient testing time.

Those responses indicated the need to ask about the time of reticulation, suitability of reticulation, preferences for different control settings and private bore supply; which were enquired with the help of two questions, and 10 attitudinal items. However, there were some incidents reported to the Water Corporation; such as, tampering with the original setting and the ripping off of the household controller, so that no control mechanism for garden watering would be in place. That would result in garden watering whenever the supply bore would have been operated. Such wasteful watering at household gardens eventually caused the exceeding of the allocation of groundwater supply. Thus to explore these issues, two questions asking about the alteration in reticulation settings and the reasons for such alteration were included.

Operation of groundwater system

In General, the participants were happy with the operation of the groundwater system; however some wished to have more control over it. The prior group believed that there was enough watering for their plants and reported that their garden reticulations were operating without problems. The automatic operation saved their time and resources and enabled them to engage in more important activities than gardening. However, the latter group were unhappy with the NDG system due to its haphazard operation, low pressure, and frequent disruption of the reticulation without any prior information. The ongoing development activities could cause such obstructions; however, prior information should be given to the residents so that they could manage the alternative ways to water their gardens.

In addition, there were some concerns about the noisy drip reticulation and reduced pressure of groundwater that sometimes had impaired the sprinklers operation. They wished to have sufficient groundwater pressure for their sprinklers operation. Residents also noticed that the weather station was not employed to control the NDG system. This was mainly due to the incomplete connection (development) and for each additional connection; the main pressure gauge should be re-calibrated to maintain the pressure below the mains water system. This was perceived as a weakness in the operation of the groundwater system. The maintenance work was another issue raised by the residents. The maintenance works were restrictive; and the technicians were rarely available, expensive, and unfriendly. Those issues appeared to be important for residential satisfaction with the NDG system; hence included in the questionnaire.

Trust, fairness and Risk assessment issues

As previously explained, the perception of trust in water providers, fairness among users of the system, risks associated with the alternative water system, and overall system performance are important factors for the acceptance of the alternative water system. These factors also influence the level of satisfaction with the alternatives. During the preliminary interviews, the existing trust, fairness, risk and overall performance measures of the groundwater system were discussed refined and reworded. In addition, some relevant measures were added for the purposes of reinforcing contextualization. The measures were used to predict the acceptability of and satisfaction with the groundwater system.

- *Trust in authorities*

The residents expressed their trust to the water providers and developers regarding the development and operation of the groundwater system. They trusted the Water Corporation to utilize groundwater responsibly and to ensure reliable supply of (quality) groundwater. They believed the developers to maintain the minimum standards of the NDG system, and to operate the system sustainably. However, they raised a few concerns about developers' promises regarding the quality and operation of groundwater. This was reflected on some complaints about the staining quality, haphazard operation and poor maintenance of the groundwater system.

- *Fairness*

The use of groundwater for watering gardens and parks was considered a fair approach for the environment in the context of drying climate of Perth. In addition, the pricing was lower than the mains water; hence was supposed to be accepted. However, the fixed flat annual levy and the mandatory provision of groundwater use were perceived as unfair factors. The fairness perceptions would contribute positively towards the satisfaction and acceptance of the NDG system; hence, 3-5 fairness items were added into the questionnaire.

- *Risks and benefits*

Most of the people were comfortable with groundwater use in their gardens, however, a low level of risk was perceived in terms of the staining and health hazards due to cross connection. The staining was perceived as a major risk for reducing the resale value of the property. In contrast benefits were also identified. These included: reduction in water bill, saving drinking water, green gardens, a sustainable water system, and less groundwater depletion. The higher perception of risks would result the lower satisfaction level and vice versa. The community evaluation of the possible risks and benefits of the NDG system (5-7 items in questionnaire) were examined in terms of their impacts over the satisfaction with the NDG system.

<u>Governance and performance of NDG system</u>

Every household in WA can enjoy the unrestricted supply of groundwater via the domestic (backyard) bores. The NDG system in “The Green” was just the extension of the domestic bore for the whole community. Nevertheless, each household are paying a flat annual levy for the free groundwater otherwise. The positive aspects of the communal NDG system are: less overhead cost for groundwater use than domestic bore installation, and a reduction in drinking water bill. Most people appreciated the NDG system for its lower cost, yet some wished to have a separate meter for groundwater and pay only for what they use. Community responses about the current pricing system, and separate meter charging (5-7 attitudinal items) were thus important for understanding the end-users behaviour and sustainability of the system.

There were some operational issues limiting the performance of the system. The NDG system was supposed to perform better with the weather station control that was not functional at the time of study. The weather station control is said to be possible only when all the households would be connected to the groundwater reticulation. The above discussed and other major issues about the NDG system emerged during the interviews are presented below in Table 9.

Table 9: Summary of the dual water (NDG) system issues

Themes	Responses
Groundwater reticulation	This is very excellent (1), ..included in package (1), ..no drinking water in gardens (2), ..good for water scarcity of Perth (7), ..recycles water (10), ..that's why we've bought here (2), ...the groundwater system would influence me to buy a property there (7) ...the garden reticulation doesn't work all the time so it is a nuisance (3), ..The water system irritates a lot of people, but we are the foolish to bought here (4).
Staining due to groundwater	No rusting colour yet (1) ...and developer has promised us that the groundwater doesn't stain (5). Groundwater stains on everything, we have to use oxide paste to clean the staining in our windows, and we can't leave our children toys out in the lawn because of that staining. (4). ...prefer to stop it permanently and swap it with main (3), ...because it wrecks everything, stains everything (4).
Control of groundwater	Auto control is very good because if GW is unrestricted, people will go crazy and abuse it (2), ...all people get equal amount of water (5, 7), ...your plants would get optimum water all the time, you need not to worry about that (1),... good to keep outdoor water usage out of the residents' hands but it would be better if people could choose their watering time (10). People hate the groundwater system because they don't have control over the water timing (4). ... prefer the private bore because you get full control over it (3, 4); you can use your water whenever you want (8), ...not to wake up at night, not to run out for collecting toys (4) I think local control would be user friendly because the different plants in my garden have different specific water requirements (8).
Operation and Maintenance of groundwater	...groundwater comes when the plants need the water; it works without hassles (1). Good to have completely three watering days (2),... because it's windy here and the type of lawn here uses more water (8). ....groundwater (drip irrigation system) has a pitching noise that wakes up the people at night (4), ..the pressure is not good (3), ..sprinklers don't work sometimes, so we have to hand water (2). ...no timely information of pump breakings and other disturbances in groundwater (5),... we will notice only after our plants start wilting (2, 4). ...why the gauge system (automatic control) is not in operation? (2) 'Total Eden' charges the call out fee for every maintenance (4),...the council or developer should do regular inspection and maintenance of reticulation (2, 4, 7)
Trust	The groundwater system is excellent, developers have done good job (5),... and it is included in package (1) ...no prior information about the disturbances in GW supply (2, 4, 5), ...who knows our garden get enough water? ...sometimes, it (groundwater) is also coming in rainy days. If they (authorities) are worried too much, why the gauge system (automatic control) is not in operation? (2)
Fairness	...well informed at the beginning (1), ...fair and equitable supply of water (2, 7, 10) ...not treated fairly as we've got no options (4),..fixed price is not fair to everyone (3, 8)
Risks and benefits	...no risk of using groundwater because we are using it since our childhood (2, 6, 7), ...if there is something risky, our plants are the first to suffer, but they are fine and even my pets are fine till now (1, 7). Good for environment (2, 4, 8), ...stops drenching drinking water into garden (2, 8),...it recycles water every time (1, 10) ...risk to reduce the groundwater table (10), ...wouldn't sustain staining that reduces value of my house (2, 4, 8),
Pricing and metering of groundwater	Groundwater is cheaper (1),... I don't bother paying groundwater; at least you got good things to do- saving drinking water with its use (7). We were said that groundwater is free, but got this (groundwater levy) added to our

	water rates (4),... not sure exactly how much to pay (1, 3) Metering groundwater is a good idea to control people going crazy at free groundwater (2),... very Good, no matter how much I have to pay, at least I can use water whenever I want (4)
Other issues	...the authorities should be more vigilant to stop the garden irrigation at restricted periods, which motivates water savers (2), ...in new areas, the rainwater tanks should be mandatory (10),...install shower timer that will cut off shower after certain time (10),...there was cloudy or dirty water at initial days (2), ...it is better to transport water from North rather than doing groundwater reticulation (3).
Satisfaction with GW	...very satisfied, it's for us (5),... cheaper water (1, 2), automatic watering, not to worry too much (1, 5),... ...totally dissatisfied- have no control, it stains (4),..the levy is a new type of rate (3, 4).

The number in bracket represents the number of participants who made the statement.

B. Urban living environment issues

In the previous section, the different attributes and issues of the NDG system are described and possible attitudinal items that measure residents' perception and evaluation of the attributes are explained. This eventually generates satisfaction with the NDG system. This section describes different objective attributes of the "waterwise" urban living environment, and possible attitudinal items that measure residents' perception and assessment of the waterwise urban environment, which then contribute to their satisfaction with the urban environment.

As discussed in the conceptual framework, the society, neighbourhood, and home were the three major domains of urban residential environment. This was confirmed from the qualitative analysis of preliminary interviews and explained in this section. In addition, the scale and items found in literature were refined and contextualised, and new relevant items were added for measuring satisfaction with each domain of urban residential environment.

<u>Social issues: Neighbours, friends and social organisations</u>

Neighbours, friends and social organization comprise the community, or society, or social environment. This component was reported as a strong factor of residential satisfaction in American and European studies. However, the preliminary interviews indicated that it has weaker influence over residential satisfaction in Australian communities. Australian communities prefer to have friends and friendly neighbours but want privacy in their personal life as a priority. In the study areas, people were busy with their own jobs/businesses and had extremely limited time for leisure, family and friends. They reported their preferences to spend time mostly with their own family than with their neighbours and community. In their perception, it was enough to know neighbours by the sight and with the verbal acquaintance. Neighbours were perceived as important for the neighbourhood watch and sense of security; however, none intended to compromise their privacy over neighbours. In other words, it seems that people are more concerned about their personal space than the community to dwell happily in the urban residential environment.

However, the number of friends and the relationship with immediate neighbours count for the satisfaction with the society. In addition, social organisations connect an individual to a broader group of people with similar interests, which will promote individual happiness as well as attachment with the living environment. The interviews helped to inscribe the relevant issues of social environment (Table 10) and to develop critical items in the form of attitudinal statements (8 items). The statements would measure individual perceptions and evaluation of neighbours, friends and society, and eventually generate society satisfaction.

Table 10: Summary of social environment issues

Themes	Responses
Friends and neighbours	...have heaps of friends and neighbours, because all knew me and I know almost all of my neighbours. It's just like a big family (6) ...not much friends myself, but have moms of my son's classmates as my new friends (4) ...we keep relation with neighbours by sights only, don't invite them to BBQ and weddings (2, 7, 10). ..very important for neighbourhood watch (2, 4, 7, 8),...give you the moral support sense of settling and sense of security (8), ...knowing and being friendly with your neighbours is very important to get support whenever you need, and really good for resale if you be able to say that your neighbours are good, friendly and helpful. People tend to invest in areas with friendly and helpful neighbours (2). ...good to know them but don't want to keep on top of my privacy, I can't live only with my neighbours for all time (7), ...friends and neighbours wouldn't make any difference for me now, but it would be a big thing if I were young girl (10) ...it is not so essential If you're happy with your family environment (1).
Social organisations	...involvement in social organisation help us to know what's going on in our locality, what people think and want, and what should be done for betterment of our locality (6), ...social groups are good for our children to develop social culture and dynamic personality (2), ...you will be satisfied when you could do help for others (6, 7), ...it's good to involve in social organisations if you can manage time and happy to do it (8, 9).
Attachment to locality	...like the facilities and services available in the area, we've got a lot more than earlier developments (4, 6, 7), ...however, it could be a lot better than current one (4). ...very happy living in this area, I want to live here until they take me in pine-box (6).

The number in brackets represents the number of participants mentioning the issue.

Neighbourhood and park issues

Participants were happy with their neighbourhood, as they had more facilities closer to their neighbourhood in comparison to other previous developments. The study areas were newly developed areas with art-de-fact designs. People were hopeful for a prestigious living as well as better resale value. They regarded the areas as a good place to live and raise a family because of the peaceful and clean environment. They highly valued the areas for its proximity to the city centre, beach and proposed freeway and railway station. There were good quality schools for children, more day-to-day facilities (shops, restaurants, banks, and recreation centres) and better community services (post-office, police, garbage collection etc) in the vicinity of their neighbourhood. People enjoyed easy access to the community centres, sport clubs and play grounds and natural bush land. However, some residents had concerns about the higher density development and the public housing in their neighbourhood, which in their words, might degrade the neighbourhood environment. In addition, some were disappointed with limited transport facilities and road links to the city and surrounding suburbs.

Residents were happy with the landscaping of the development and they appreciated the way that public parks were developed in their neighbourhood. The inclusion of the sump into the park in the form of grassed swale and the removal of bollards were perceived as better designs to improve the appearance of parks and make them multipurpose. People preferred to live near public parks, as parks would provide the outdoor space to take their children and pets to play when their backyard become smaller. However, people were not happy with the lack of playing equipment in parks for children and teenagers, poor facilities for family and social events. On the contrary, some people preferred a bigger backyard that would enable them for a range of social activities and provide a playing space for their children and pets when there was no time for an outing.

The residents also mentioned their concerns about the development and employment opportunities around. Most of the residential areas had been completed, but the city centre, train station, business and activity centres were not developed. This resulted in limited employment opportunities nearby to their neighbourhood, so most of the residents have to travel to cities and urban areas for their jobs. This dormitory nature of their neighbourhood was somewhat disappointing; however, participants were equally hopeful for better employment opportunities and liveability after the completion of railway station, city centre and business centres. The major issues and important statements about the neighbourhood issues from the preliminary interviews are summarised in Table 11 below.

Table 11: Summary of the neighbourhood issues

Themes	Responses
Location	...close to city centre, shopping centre, good quality schools, parks, beach; good public transport facilities; better resale, near hospitals (5, 2, 6)..., it is close to everything plus away from the hustle-bustle of the city (2)...

	The green area, the nice fountain, the trees and the facilities at the parks and the proximity to beach, drew us here (2). ...it would be good to leave some reserve area for the animals too (6)..., ...very far from Perth (3) ...going to be crowded very soon because of cottage blocks, so no more prestigious living (4).
Public parks	...we have plenty of public parks (1, 5, 6, 8), ...parks are multi-functional (10) ...almost all the streets end up to parks (8). Parks are important when backyards are getting smaller, especially for children and pets to play(1, 2), ...and for community functions (2, 6); ...good to remove the bollards from the parks (10), ...Parks are not kid friendly, and are a little bit isolated (2, 6, 7), ...some parks are like a big dip that becomes swimming pool in winter that's not good for children(4), ...there are no swings, nasal walks, slides etc in the park for children (4, 6, 7), ...no toilets, no BBQ for community functions (2, 6, 7), ...people leave small children unsupervised in parks for whole day, that's not good (10)..
Public service and activity centres	Postals, garbage collection are regular and good (1, 4, 10), ...good police watch (4), City centre is very close,...will be good restaurants and shops (1, 7), ...will be more jobs and make this area more lively (7, 4). ...plenty of good-quality private and public schools within 10 minutes (2, 4, 5, 6) ...heaps of community events, facilities, and sports throughout the year (2, 6). ...good sport facility in the community centre (6). Zindalee beach is within 10 minutes drive, and is a bonus for this area (1, 2, 5). ...need more shopping centres, and recreational centres like gym, stadium (1, 9) ...the corner street shops or delis would be good idea (10). ...tree plantation is very slow (2, 6), ...there was no replacement of dead tree (2), ...should be more street lights and wider streets around the area (6), ...the sharp turns of roads and lots of speed bumps annoy people (2), ...verges are not kept well, no prompt construction of the gutter and pedestrian way (2, 4).
Public transport and road network	...a lot of bus stops; railway is coming (5) ...railway station should not move away from Ridgewood (7, 8), ...we hope railway will come on time; otherwise it would be a great disappointment (2, 8) ...need more links to side roads like Wanneroo drive (2)... We are restricted to our houses if we have no vehicles because of the wider interval of public buses, one in an hour; we need more buses, and train line to lift up the area (7). ...most important is railway and driveway, not the noise of the freeway (2, 5), ...OK to have public buses but I personally never use that (1, 4, 8), I have car.
Urban design issues	...every lot is of descent size, no lot is tiny ...Satterley come up very prompt to develop this area beautiful (5), After railway and freeway extension, the bridges and pedestrian roads will make this place beautiful and valuable (2, 4) ...no noise issues and crowd issues even there is ongoing construction (5), ...a bit of thievery, and graffiti in this area but under control of police,-not directly affecting me (5) ...developer squeezed more blocks into smaller area for the sake of money (3, 4), ...they (developers) are not creating lifestyles (3), ...this development is for working peoples and cheaper home buyers, not for family, no prestigious living here (3), ...cottage blocks are not for family; only for a couple who have just started (3, 6), There are a lot of investors, renters and indigenous people, who bring the area down and ruin the family environment. This situation brings the resale value of this locality down (4), ... the Homes West housing in this area is ridiculous (3, 4, 8, 10), There is no such things good in homes-west housing (4), ...it is the private state where we live, but it got house-west housing, a bit of extra problem (10), The fighting, drinking, crying and other crimes are increasing due to the presence of indigenous and renters (4, 10), ...developers had not fulfilled all their promises (4)...
Climate and environment	The climate is dry but we are at right place (1); ...climate is not issue, because we all have air conditioning here (1, 2, 7). We are happy to try a new environmental step to improve water situation and hope a lot of people thinks in this way (2). I only use the air conditioning in summer, but not in winter because I don't want coal

	fuelled power stations (10). Climate is dry and a unappealing, no more 'green' here than any other area (4)
Cultural diversity	No matter, where we born, what we are, we are same human being (5). I don't mind having people from different countries (6, 8). Living with indigenous people is not too nice; they are not good family type people (4, 8)

The number in brackets represents the number of participants mentioning the issue.

Home and garden issues

Participants in both areas were happy with the design and size of their home, and space inside and outside of the house. Participants found their housing blocks affordable and were very happy in getting both the front and backyard gardens inclusive of the 'home and garden package', i.e., the developer had landscaped both of their gardens for free. They were also happy with the native plants in their gardens and their garden reticulation; however, some were concerned about the type of the lawn and numbers of plants in their garden.

Most of the design work was done in consultation with the resident; hence, residents were satisfied with the utilities and appliances inside their homes. Regarding the garden and outdoor landscaping, "The Green" residents were provided with limited plant and reticulation options to ensure safe NDG connections and water efficient gardens. The important home and garden issues emerged during the preliminary interviews are summarised in Table 12 below. The issues were developed into 10 attitudinal items that explore residents' perceptions and evaluation of their houses and gardens attributes to measure satisfaction with the home environment.

Table 12: Summary of the home and garden issues

Themes	Responses
House design issues	Our house suits our needs, size doesn't matter (1),...every blocks and houses are of descent sized (5), ...like the designs, layout and everything of our house (2,4,5), ..I like the smashing brightness of my houses, a lot of windows (2), ...good to have dual layer brick-walled house (8), ...everyone had chosen their homes- so may have chosen the best (5) I think my backyard can fit the pool and entertainment area because it is big (8). It is better to live near public parks rather than having bigger blocks and bigger backyard, so that you can swiftly go to the parks with your children and pets (7). ...have smaller backyard, nothing interesting in it. The houses here are very basic, it is just for working families, professional peoples, single family, young couples and first home owners, who don't home much. If you home much, you need bigger backyard for interesting lifestyles, it's boring and isolated here (3)... ...when you are busy, it is good to put your children in backyards where you can watch them and do works, that's what the society does now, but our backyard is really small (4). If your backyard is getting smaller, you need the parks to take your children and pets to play and entertain (2, 4, 7)
Gardens issues	...got both the front yard and backyard in our home package, the backyard is a real bonus (2, 5), ...our garden gave vibrant outlook to our home (4, 8). I love gardening; it's a sort of relief for me (5), ...the front garden is the first impression of your house, so it is very important (6),

	...my gardens are still larger; I don't want a huge garden that needs hard work for maintenance (2, 7), ...keen gardener should stick on the natives, otherwise they lose them (5, 10), A descent lawn is essential for family to live in, play with children and pets while not going out and important in every resale (2, 4, 10), ...if I hadn't children, I wouldn't have lawn; instead I would have places to sit (2, 4). ...garden beds were too wide to work (2, 8), ...they gave us very few plants, we put a lot of plants ourselves (2, 4, 8) ...the natives are dry looking (3),...the lawn is very hard to work with, it goes into the soil, it is not nice lawn at all (4, 8), ..it's not the lawn that was said to put in our garden (4) ...we put artificial lawn, because it uses no water and fertilizer and it saves times and money (10) ...I would put artificial lawn, which is of low maintenance (2) ...they put just a hand-full of soil conditioner, ...use fertilizers to bring the lawn back (2) Developers said that the gardens are included but they added up that in our block price (4)
Adjustment and change	It's very right everything, I don't want to change anything (1). ...we would like to put down a lot of brick paving (4), ...put a pool, a full lawn and entertainment area at backyard (4, 8), ...connect this lounge up to back garden by putting a big patio (2, 6), ...reduce lawn and put nice native plants in rest of the garden (2, 8), ...add more attractive plants in the garden (3), ...would like to rip off the lawn completely and put a good type of lawn (4) ...prefer backyard to be bigger, which would make for our family lifestyle more comfortable (3)
Utilities in home	...water, gas, electricity, telephone facilities in this locality are very good (2, 4, 7) ...all are complaining about the water electricity prices, that's the usual human behaviour, nothing is for free (7).
Value of house	...it is much more affordable (1, 5, 8), ...we found block price was on bargain due to onset of world economic crisis and a huge release of properties (8). Resale is very important because you never want to get the repay less than what you've paid (4, 7), ...a lush green garden, a descent lawn is very important in every resale (2, 5, 10) ...the cheaper home buyers, renters and the homes-west housing reduce the resale value (4), ...there are a lot of houses on market that induces competition badly and reduces resale value (2), ...it seems that government closed the first home buyer grant; this has discouraged capable home buyer (8). Resale doesn't matter as we have not bought this property for sale; when Butler-Ridgewood area grows, we would easily get people to buy it whenever we want to sell it (1, 4, 10).

The number in brackets represents the number of participants mentioning the issue.

C. Moving behaviours

Literature suggests that if residents are satisfied with their living environment; they will intend to stay longer in the environment, recommend it to their relatives or friends, will choose to live in similar places again, and vice versa (Weidemann, Anderson, Butterfield, and O'Donnell, 1982; Theodori, 2001; Amerigo, 2002). Initially (Weidemann et al., 1982) utilises the behavioural intentions as the measures of residential satisfaction. This research adopts that the behavioural intentions not only determine the actual behaviour, but also mediate the influence of the satisfaction over behaviour.

In general, if an individual experiences dissatisfaction with the living environment beyond a certain limit or threshold level (Golant, 1971), then he/she will either move out (moving behaviour) or stay in with adjustment (adaptive behaviour) (Wolpert, 1965; Brown and Moore, 1970; Speare, 1974),. The literature review and conceptual framework section have already explained about this process. Section 6.2.2 has explained the themes and items under the four domains of residential environment. The evaluation of one or all domains of the environment (i.e., satisfaction) would trigger the intentions that correspond with actual behaviour. The behavioural issues emerged during the preliminary interviews are detailed in Table 13 below. In addition, the preliminary interviews enquired about the reasons to buy in, which give a standard (reference) for comparing the living environment.

Table 13: Summary of behavioural intentions to residential environment

Themes	**Responses**
Reasons to buy	...close to city centre, beach, railway, freeway, schools (1, 4, 5) ...natural environment, modern community design, water sensitive urban development ...family friendly development, far from hustle-bustle, crowd, and noise (1, 5, 7). ...affordable and good resale value (1, 8).
Intention to live	...want to live in this locality till death (6), ...it is a very good area for mom and dad to grow up their children (2, 4), ...the schools, cities, beaches, railway, freeway, parks and everything are very close, so don't want to move out very soon (5, 7, 8). ...want to live how long my children get me (5) ...until I win lottery and afford another house (1) ...probably next 10 years till our children grow up (8) ...next 5-6 years till our retirement (10).
Intention to move	...want to move not due to locality and facilities but due to the types of people around here (4), ... want to move because there is no lifestyle here and far from city and families (3), ...want to move closer to cities, so easy to go to shows and theatres (10), ...want to move to more rural areas, larger blocks, more greenery and natural peace (7), ...wants to move because of the cottage blocks, homes-west housing and renters (3, 4).
Intention to choose again	...yes, but it would be struggle to find such great area having everything nearby (2, 4) ...depends upon the family size and facilities available (1, 8) ...depends upon your age and life stage (10). ...not again like this area, because we are looking a different, a descent, a more social environment (3), ...closer to city (4, 10), ...closer to rural areas (5).
Intention to Recommend	...yes, I already did (7), ...my friends live here (2) ...no, it's not my type, so friends won't be satisfied; my friends won't come so far (4).
Overall residential satisfaction	...very satisfied, 100% satisfied (1, 6) ...satisfied but there are still rooms for improvements (2, 7, 8). ...not satisfied at all (3), ...we are not satisfied customers (4)

The number in brackets represents the number of participants mentioning the issue.

Thus, from the qualitative analysis of the preliminary interviews generated the major themes and issues of NDG system, and water sensitive residential environment (Table 3, 4, 5, 6, and 7). The themes and issues were helpful in generating the attitudinal items regarding individual perceptions, preferences, attitudes, and behaviour towards the NDG system and water sensitive residential environment. The attitudinal items were measured by using uni-polar or bi-polar Likert Scale ratings. The rest of the issues were developed either as nominal or categorical variables. Along with thus developed variables, the socio-demographics and open-ended questions were added into the questionnaires that were the main tools for household survey. The questionnaires can be found in Appendix H and I.

6.3. Pilot test

The pilot test not only refined and contextualised the items and measures under the study but also helped to create a complete and valid instrument (questionnaire) that was used to collect primary information to explore and fulfil the research questions and research aims. The pilot not only provided the initial positive feedback but also refined the items, and structure of the questionnaire in a sequential format- starting with the satisfaction with the overall living environment; the water system issues; attitudinal statements of dual water system, and urban living environment; moving behaviours; and finally the socio-demographics. The major outcomes of the pilot test and respective refinement in the questionnaires are given below.

6.3.1. Elimination of mid-point of the Likert-scale type question

For the attitudinal statements measuring residential satisfaction, a 5 point Likert-scale was used, where 1 = strongly disagree, 5 = strongly agree and the mid-point, 3 was for a neutral position. The mid-point, indicating neutrality, was suggested for deletion to get distinctive responses rather than uncertain ones. Such suggestion was because some thought the mid-point would be prone to the social desirability bias (Matell and Jacoby, 1972), especially in a questionnaire about the residents' satisfaction with urban water system and neighbourhood designs. This issue could be addressed somehow by self-administered questionnaire (Nederhof, 1985), but still there would be a possible easy socially acceptable escape for a number of people who were uncertain about their satisfaction.

This suggestion was accepted and the midpoint from the Likert scale was eliminated to minimize the social desirability bias (Matell and Jacoby, 1972; Garland, 1991). In addition, the scale points were increased from 4 to 6 points (Literally, a 7 point Likert scales without the midpoint) and used for rating all the attitudinal items that measure residential satisfaction with the dual water system and urban environment.

6.3.2. Refinement for individual scales

A. The Trust scale

The trust scale mainly evaluated community trust with the water providers and developers in terms of reliable and responsible supply of good quality groundwater and standards of NDG system. The trust in the water provider was measured in terms of perceptions of the reliability of the water supply, good quality groundwater supply for garden watering, responsible utilization of groundwater, and the adequacy of information about NDG system. Trust in the developer was measured in terms of perceptions of ensuring the standards in NDG system, reliable operation of NDG system, and regular maintenance and information. Each of these perception were developed into simple attitudinal statements that can be rated in a 6 point Likert scale as explained above. After the pilot test, the trust scale included the following items:

- Water authorities in WA are serious about water conservation,
- I trust in any information provided by the water authorities about the safety of groundwater system,
- I trust the water authorities will manage our groundwater responsibly,
- I trust water authorities will treat groundwater to correct standards for watering our gardens,
- I trust developers will ensure infrastructure for groundwater system meets acceptable standards,
- I trust the water authorities will ensure I have a good groundwater supply, and
- Water authorities inform us about any interruptions in groundwater system as soon as possible

B. The Fairness scale

The fairness scale was measured in terms of fairness of groundwater use to different group of people for different activities. During the pilot, these issues were refined and additional fairness measures were included. Hence, the final fairness scale included the attitudinal items regarding fairness of groundwater system in terms of pricing, restrictions, control and conservation. The following attitudinal items were included in the fairness scale:

- "The Green" residents should have the same watering restrictions for their groundwater as everyone else;
- "The Green" people should pay for how much water they use on the garden like everyone in Perth,
- Having to pay a fixed price for access to water is unfair to those with small gardens;
- It's not fair that people in "The Green" have no control over their watering;
- The weather station control ensures equitable GW supply; and
- We need to conserve water now to provide for the next generation.

C. The Risk and benefit assessment scale

During pilot, two questions that were focused on the risks and benefits perceptions were converted into a number of attitudinal items (as given below). These attitudinal items mainly explained the perceived risk of the NDG system to person, family, community, and environment; and overall risk-benefit assessment. Further, few issues such as risk in future availability of groundwater, operation failure of groundwater reticulation, cross-connection and health hazards were discussed and suggested for inclusion. These issues were included as per the suggestion and finally the risk-benefit assessment scale included the following items:

- I see no health risk in using the GW for watering my garden;
- Groundwater in our locality is safe for human health while using in garden;
- There is a risk of something going wrong with GW supply in future;
- Community bores may pose a risk to the level of local groundwater; and
- The overall benefits of using GW for watering our gardens outweigh the overall risks associated with it.

D. The performance scale

The performance scale included several items explaining the performance of the groundwater system; such as essentiality, reliability, efficiency, sustainability, and appropriateness. In order to reduce the length of the questionnaire, some of these items were eliminated and the rest were developed into a simple attitudinal statement for each item. Attempts were made to include both the subjective as well as objective aspects of the NDG system performance, as follows:

- Using groundwater for watering gardens and parks is environmentally sustainable;
- Groundwater reticulation helps to reduce outdoor water consumption;
- Community bore supply is a reliable system for watering our gardens;
- Groundwater reticulation is essential to manage future water shortage; and
- GW reticulation contributes to the quality of my garden.

E. The behavioural intention scale

The scale included items about the staying, moving, recommending, choosing again intentions. Attempts were made to tap the reasons behind the moving intentions and intended places to move. This would explore the possible impact of satisfaction on behaviours via behavioural intentions. The pilot refined and finalised the intentions scale items, and added questions regarding the reasons to move in, living history, and property possession issues. All the variables and questions were intended to generate broad understanding about the factors of moving in and moving out behaviours and to evaluate the impacts of residential satisfaction over their behaviours.

6.3.3. Reduction of items

The pilot participants suggested reducing the length of the questionnaire so that it could be completed within 20 minutes. Using this suggestion, questions that could be resolved from the secondary data and other sources were excluded from the questionnaires. In addition, the questions that were not too critical, repetitive, and obvious items were eliminated. Similarly, the ambiguous items were either simplified or eliminated; and the appropriate ones were refined and retained.

6.3.4. Structure of questionnaire

The pilot test was helpful to refine the structure of the questionnaire. The questionnaire started with the broad introduction of the research project and its objectives. This ensured the confidentiality and anonymity of the participants. Further it informed the participants about the provision of AU$5 donation on behalf of each respondent to a local surf life saving club. Participants were provided with the contact of research team and university ethics officer if the participants wished to enquire about the research.

Following the introduction, the major 6 domain satisfactions - the NDG, garden, home, neighbours, parks, and neighbourhood satisfaction were included. Then NDG system issues, home and neighbourhood issues, moving in behaviours, residence duration, moving out intentions, recommending intentions, and choosing intentions were included in a sequence.

Those issues were followed by the socio-demographics, namely: age, gender, education, income, and family size. After the socio-demographics, information and consents sections were included to collect the water consumption data from the Water Corporation, and to contact again for future communication.

6.4. Conclusion

This chapter describes the results from the qualitative analysis of the preliminary interviews with local residents that identified, contextualised, and established several constructs for evaluating residential satisfaction with the NDG system and associated water sensitive developments. The preliminary interviews also outlined various items that constitute the construct under enquiry. Those items were included in the form of structured and semi-structured questionnaires tailored for "The Green" and Ridgewood. The questionnaires before distributing to the survey participants, was tested with a pilot sample. The pilot test made some changes and refinement, and finalised two sets of questionnaires (Appendix H and I). These two sets of questionnaires had a significant overlaps because of the similar issues under study, where the only difference was the NDG system in "The Green".

CHAPTER 7: Quantitative data analysis of Household survey

7.1. Introduction

This chapter includes the quantitative analysis of the data obtained from the household survey in “The Green” and Ridgewood. The main objective of the quantitative analysis of survey data is to test and confirm the relationships among constructs of satisfaction with NDG system and urban residential environment. The analyses of survey data also develop a model of residential satisfaction and their behavioural responses towards the NDG system and urban environment.

The detail on methods and procedures for conducting household survey has already been described in section 5.5 in this thesis. This chapter starts with a brief outline of the survey responses and missing data analysis at first. Then, the socio-demographic characteristics of participants and the findings on descriptive analysis are described. Following to the descriptive analysis, the details of factor analysis that reduced the attitudinal items into a fewer meaningful and valid factors of NDG system and other domains of residential environment are given in section 7.5. After that, the details on discriminant analysis are presented that identified the most contrasting variables between the study areas. Section 7.7 describes the outcomes of the multiple regression analysis that explores the contribution as well as relationships of the factors to respective domain satisfaction in the form of the regression models. Finally in section 7.8, path analysis tested these models in terms of the validity and reliability, and the results are presented and described in this chapter.

7.2. Survey Response Pattern

Once the survey questionnaires were distributed most of the participants responded within five weeks. One anonymous and three blank responses were received. Though each questionnaire was provided with a unique questionnaire code to track down the household detail where the questionnaire was distributed; one respondent omitted the code and succeed to make it anonymous. However, with the help of the question-types, the study area was identified where it was distributed and the response was used in the analysis.

Table 14: Survey response rate

SN	Activities	"The Green"	Ridgewood	Total
1	Pilot test	1	2	3
2	Survey returns	97	81	178
	Anonymous Response	0	1	1
	Blank response (Counted as a refusal)	1	2	3
3	Total Response	96	79	175
4	Total door knocking	465	508	973
5	Total distributed questionnaire	432	448	880
6	Instant refusal **(4 - 5)**	33	60	93
7	Total refusal **(4 - 3)**	369	429	798
8	Total survey refusal **(5 - 3)**	336	369	705
9	**Response rate (with respect to 4)**	**20.64%**	**15.55%**	**17.98%**
10	**Response rate (with respect to 5)**	**22.22%**	**17.63%**	**19.88%**

As shown in Table 14, a total of 465 doors in "The Green" and 508 doors in Ridgewood were knocked (once or thrice in a month time) for distributing, follow-ups and collecting the survey questionnaires. A total of 432 questionnaires were distributed in "The Green" and similarly, 448 questionnaires in Ridgewood (including the questionnaire re-sent to few households during follow-ups). Out of the distributed questionnaires, 178 questionnaires were returned (97 from "The Green" and 81 from Ridgewood). There were one blank response from "The Green"; and two blank responses, and one anonymous response from Ridgewood. The anonymous response was counted as a response while the blank responses were counted as refusals. In this way, a final total of 96 households in "The Green" and 79 households from Ridgewood responded during the household questionnaire survey.

The response rate, as in Table 14, was comparatively lower than many marketing and online research. However, lower response rate is evident in most of the social experimental research. This fact is supported by several studies (Dey, 1997; Groves, Singer, and Corning, 2000) indicating 15-30% responses can be considered as adequately representative response that can address the research aims. Furthermore, in a meta analysis of mail survey responses in the organizational study, Armstrong and Lusk (1987); and Dey (1997) found that the response rate vary from about 5% to 66%. Hence, the 20% response in this research is considered adequate for the study purpose.

Similar previous studies (Po et al., 2005; Porter et al., 2005) were having lower (approximately 27% to 40%) responses in household telephone survey, whereas in focus group discussion, the response was much lower (7-10%). Moreover, those studies contacted and confirmed the possible participants in advance. Since this study didn't contact the possible participants to confirm their participation in advance and just distributed questionnaire at once, higher refusal rate was obvious. Other possible reasons for the lower response rate may be due to a 12 pages long questionnaire that demanded more time of participants in a dormitory suburb, where the participants had to work on distant places and spend most of their time out of their homes.

7.2.1. Follow ups

To increase the survey response, three waves of follow-ups were conducted at weekly intervals after 14 days of questionnaire distribution. During the door-knockings, some participants instantly refused to participate (33 in "The Green" and 60 in Ridgewood), while some agreed to participate and took the questionnaires. A number of participants were not present at their home during the survey time; hence, the questionnaires were dropped into their mailboxes. The first follow-ups were conducted only with the non-responding households where the questionnaires were dropped off (220 in "The Green" and 240 in Ridgewood). After a week, the second follow-ups were conducted with all non-responding households, including the agreed and the dropped-off ones during the survey and first week's follow-ups (347 in "The Green" and 363 in Ridgewood). Finally, the third week follow-ups were conducted with the non-responding households only that agreed to participate during survey and or previous two follow-ups (134 in "The Green" and 157 in Ridgewood). The first and second follow-ups were effective to increase the responses, however the response rate gradually decreased as the response time increased; therefore, no further follow-ups were undertaken after the third week's follow-up.

7.2.2. Survey response time

The five weeks time duration was set as the cut off point to ensure the responses were not subjected to any response biases due to the knowledge and time. The majority of the responses were received within first five weeks after the distribution (Table 15). More than 90% responses in "The Green" and 100% responses in Ridgewood were received within the 5 weeks duration. Only 8 responses from "The Green" were received after 5 weeks. The responses received after 5 weeks were excluded from the analysis, which ensured the two suburbs comparable regarding the response duration.

Table 15: Survey response time

Response week	**"The Green" (96)**	**Ridgewood (79)**
1	31 (32.3%)	39 (49.4%)
2	22(22.9%)	14 (17.7%)
3	16 (16.7%)	12 (15.2%)
4	16 (16.7%)	10 (12.7%)
5	3 (3.1%)	4 (5.1%)
After 5 weeks	8(8.3%)	0
Usable response (Within 5 weeks)	88	79
Response rate (with respect to distributed questionnaires)	(20.4%)	(17.6%)

As shown in Table 15, the responses were higher in initial weeks and reduced sharply in later weeks. The responses within five weeks of distribution in "The Green" were 88 and in Ridgewood were 79, thus the total responses at the end for the data analysis purpose were 167.

7.3. Missing data analysis

The problem of missing data is a relatively common and it needs to be addressed by the researchers (Malhotra, 1987; Roth, 1994). In surveys, it is common that participants do not answer all the questions. This issue was pertinent in this research as well because the survey data was collected via questionnaires. Missing data is problematic, because it reduces statistical power, i.e. the ability of a statistical technique to detect a significant relationship in the data set. Thus, it affects the accuracy of estimating the parameters for the population under study. It can also affect the generalisability and validity of the findings. Therefore, dealing with missing data is highly important prior to the analysis.

The best possible way to deal with missing data is to avoid its occurrence by careful planning and paying special attention during data collection. Pilot testing of the instrument, motivating respondents to create high interest in the study, and doing follow-ups can reduce the missing data in survey (Roth, 1994). In this study, the questionnaires were pilot tested; participants were personally visited; follow-ups were done; and a provision of $5 donation to support a local social organisation on behalf of participants was established to reduce the missing data. The door to door approach of questionnaire distribution and follow-ups were adopted to maximize personal contact with participants. Personal contact was supposed to be effective to promote survey responses as well as to reduce missing data (Yu and Cooper, 1983). Even with careful planning and use of these strategies to minimise the missing data, some gaps in the data occurred.

In deciding how to handle missing data, Roth (1994) argued that the amount and pattern of missing data needs to be evaluated to determine the most appropriate technique. To select the missing data technique (MDT) to handle the missing data, one should consider the level of bias and accuracy as well as the power and complexity of the MDT used. There are no commonly agreed amounts of missing data at which case or item should be eliminated. Roth (1994) extensively reviewed the missing data literature and provided guidelines to handle the missing data. Roth (1994) argued that the pattern of missing data is more important than the actual amount of missing data and the powerful MDTs, such as: Regression, Hot-deck, or Maximum Likelihood Estimation could adequately resolve the missing data up to 30% of total data.

Out of 88 cases in “The Green”, 46 cases have missing data and only 2 cases have more than 10% missing data. Similarly in Ridgewood, out of 79 cases, 48 cases have missing data; 8 cases have more than 10%; and 3 cases have more than 30% of missing data. There were no hard and fast rules for deleting cases or variables; however, three cases having more than 30% missing data were excluded from Ridgewood data set considering the missing data statistically unreliable (Malhotra, 1987; Raymond and Roberts, 1987; Roth, 1994). The remaining 88 cases in “The Green” and 76 in Ridgewood were within reasonable limits (less than 30%) of missing data and had no specific missing pattern (missing at random). The results described in the following sections were generated from the remaining cases.

While analysing the missing data variable wise, there was no special pattern of missing data. In both areas, the variables missing more than 10% were ‘the importance of parks (UD13)’ for children and ‘the importance of community organisations to children (SE7)’. Additionally, ‘the preference to lawn (UD22)’ in “The Green”; and ‘the preference for weather station control, preference for flat charge for alternative water supply, and water conservation attitude (GW18)’ in Ridgewood were missed by more than 10%.

Linear regression method was adopted to impute the missing values as practiced by Raymond and Roberts (1987). According to the authors, linear regression estimation is a convenient and effective method to compute a large amount of missing data (up to 30%) when the pattern of missing data is random. They also claimed that the regression imputation results would be more accurate than listwise/pairwise deletion or mean substitution. Expectation Maximization (EM) method was tried initially for imputing the missing data; however, the EM didn’t converge even in 100 iterations. This might be due to comparatively smaller sample size with numerous variables. Then the linear regression (LR) method was used that converged well. Hence in this research, all the missing data were computed using the linear regression method.

7.4. Descriptive analysis

This section starts with the description of socio-demographic characteristics of the participants that is followed by the description of general attributes of the dual water system and community preferences towards it in the study area. This section also explains the community feelings towards their home gardens and landscaping.

7.4.1. Socio-demographics characteristics of participants

Participants were asked about their gender, age, education level, family size and members, and family income. The block size and residential density (the numbers of households per 10000 m2 specified in planning) were identified using the questionnaire distribution record. The results from the above mentioned enquiry and observation are displayed in Table 16 below.

Table 16: Socio-demographics of survey participants

	The Green	**Ridgewood**
Gender	**N=87**	**N=76**
• Male	42 (48.3%)	27 (35.5%)
• Female	45 (51.7%)	49(64.5%)
Age	**N=87**	**N=76**
• Under 31 years	12 (13.8%)	14 (18.4%)
• 31-40 years	21 (24.1%)	21 (27.6%)
• 41-50 years	25 (28.7%)	19 (25.0%)
• 51-60 years	14 (16.1%)	12 (15.8%)
• Over 60 years	15 (17.2%)	10(13.2%)
Education level	**N=83**	**N=74**
• Year 10 or below	10 (12.0%)	7 (9.5%)
• Year 11-12 or equivalent	18 (21.7%)	18(24.3%)
• TAFE certificate or equivalent	15 (18.1%)	14(18.9%)
• TAFE diploma/advanced diploma or equivalent	17 (20.5%)	22 (29.7%)
• An undergraduate university degree	10 (12.0%)	6 (8.1%)
• A post graduate university degree	13 (15.7%)	7 (9.5%)

Income before tax	N=80	N=71
• Less than $ 22000 per annum	6 (7.5%)	4(5.6%)
• $ 22000 to $ 49999 per annum	9 (11.3%)	9 (12.7%)
• $ 50000 to $ 74999 per annum	19 (23.8%)	15 (21.1%)
• $ 75000 to $ 99999 per annum	15 (18.8%)	16 (22.5%)
• $ 100000 to $ 124999 per annum	15 (18.8%)	12 (16.9%)
• $ 125000 per annum or more	16 (20.0%)	15 (21.1%)
Family size	**N=84**	**N=76**
• 1	5 (6.0%)	12 (15.8%)
• 2	39 (46.4%)	27(35.5%)
• 3	9 (10.7%)	13(17.1%)
• 4	19 (22.6%)	13 (17.1%)
• 5 and more	12 (14.3%)	11 (14.5%)
Number of children	**N=84**	**N=76**
• 0	45 (53.6%)	39(51.3%)
• 1	13 (15.5%)	18 (23.7%)
• 2	17 (20.2%)	11 (14.5%)
• 3 or more	9 (10.7%)	8 (10.5%)
Block Size	**N=87**	**N=75**
• ≤ 400 sq meter	27 (31.0%)	31(41.3%)
• > 400 sq meter	60 (69.0%)	44 (58.7%)
R-code	**N=87**	**N=75**
• R20-30	65 (74.7%)	43 (57.3%)
• R40	1 (1.1%)	20(26.7%)
• R60	21 (24.1%)	12(16.0%)

Table 16 illustrates that a good cross-section of community participated in this research. In total, there was comparatively higher female participation than males in the survey. In Ridgewood females led males by approximately 20%; however, in “The Green”, there was almost equal participation. Most of the participants were of middle age, i.e., in their 30-50 years age. The age group below 21 years old turned out to be empty, so this group was eliminated from the analysis. The majority of the participants were reported to have education up-to diploma or advanced diploma level. University graduates also participated in the survey, though small in number, and comparatively more from “The Green” than from Ridgewood, In terms of income status, almost equal proportion of participation from each income group was received in both areas. Half of the participants had no children; they were either a couple, or two adults living under a roof. While talking about block sizes and residential density, the majority of participants were from larger blocks and lower density development. However in Ridgewood, the smaller block response numbers were very close to larger blocks mainly because of higher participation from R40 blocks. The lower participation from higher density development (R40 and R60), and smaller blocks may be due to ongoing construction, and limited occupancy in those higher density areas.

7.4.2. Residence Issues

The participants were asked their birth place to know whether they were Australian or from the migrant community. If they immigrated they were asked how long they have been in Australia. Further all participants were asked about their residence duration in the study area. The results are displayed in Table 17 below.

Table 17: Residence issues

Birth place	**The Green (N=88)**	**Ridgewood (N=75)**
Australia	33 (37.5%)	31 (41.3%)
Immigrants	55 (62.5%)	44 (58.7%)
United Kingdom (UK)	34 (36.6%)	25 (33.3%)
New Zealand	9 (10.2%)	7 (9.3%)
South Africa	6 (6.8%)	4 (5.3%)
Other**	6 (6.8%)	8(10.7%)
Stay in Australia (Immigrants only)	**(N=50)**	**(N=44)**
Less than 5 year	19 (38.0%)	9 (20.5%)
5 to 10 years	10 (20.0%)	10(22.7%)
More than 10 years	21 (42.0%)	25(56.8%)
Current residence duration	**(N=88)**	**(N=76)**
Less than 1 year	19 (21.6%)	11 (14.5%)
1 year	10 (11.4%)	9(11.8%)
2 years	24 (27.3%)	13(17.1%)
3 years	22 (25.0%)	17 (22.4%)
4 years	5 (5.7%)	10 (13.2%)
More than 4 years	8 (9.1%)	16 (21.0%)

***In "The Green", the other group means participants from Zimbabwe, Papua New Guinea, Singapore, Pakistan, Mauritius, and Seychelles Island, Venezuela (1 from each country), whereas in Ridgewood, they were from Zimbabwe (2), Uruguay (2), Namibia, Kuwait, Mauritius, Sri-Lanka and Croatia (1 from each).*

The 2011 census (Australian Bureau of Statistics, 2012) indicates that the Butler-Ridgewood area is dominated by the English community (39.25%), followed by Australian community (20%). This was somehow reflected in this study, where there was higher participation from immigrants (mostly from UK) than that of Australians. In “The Green”, almost equal participation was found of Australian and United Kingdom born people (approximately 37%) followed by people from New Zealand (10%) and South Africa (7%). However in Ridgewood, the Australian community participated higher than the immigrants from UK and other countries.

It is evident from Table 17 that Ridgewood participants were living in Australia and/or in Ridgewood comparatively longer than “The Green” participants doing so. This may be because Ridgewood was developed comparatively earlier, hence more Australians settled there from the beginning. “The Green” in other hand is a new development and has been developed during the resource boom period of WA – when the migratory influx was the highest in WA’s history (Australian Bureau of Statistics, 2013a).

7.4.3. Moving in and moving out behaviours

Participants were asked about the major reasons they chose their locality and from whom they bought their blocks. Further, they were asked about their intentions to stay in, recommend, and or move out from their suburb within the next year. After that, they were asked for their intentions to choose a similar living environment again if they were planning to move out very soon. The results are explained using the following figures and tables.

A. Reasons to choose current suburb

Figure 22 below shows the mean rating of 13 main reasons that made participants choose their current living place. These reasons were rated in a five point scale 1 to 5, where 1= not important at all and 5= most important and the mean for each reason in each area was calculated and presented (see Figure 22). Since none of the reasons were rated less than slightly important (2), the vertical axis is fixed at minimum 2.0, which is equivalent to a ‘slightly important’ reason.

In both areas, almost all reasons were considered highly important but the block price was the most important reason followed by proximity to the railway. Additionally, lifestyle, neighbourhood, freeway, and environmental friendly development were the top "important" reasons that made people select "The Green" and Ridgewood. "The Green" participants rated lifestyle, neighbourhood, and environmental sustainability more important reasons than the proximity to freeway, whereas Ridgewood participants considered the freeway 3rd most important reason followed by neighbourhood, lifestyle, and modern housing design to live in Ridgewood. The groundwater reticulation was considered an important reason to live in "The Green"; however, it was influencing least strongly on their choice.

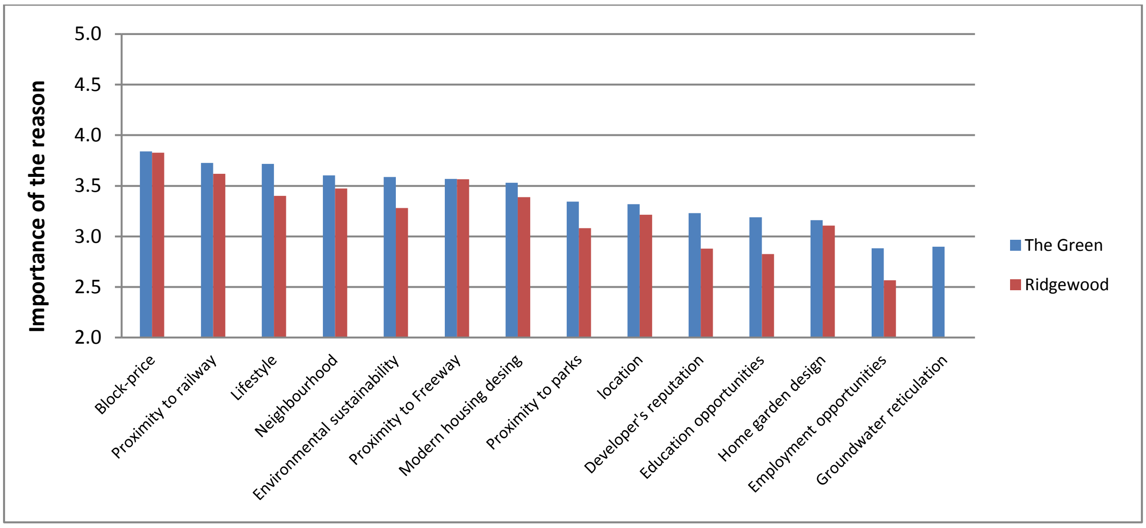


Figure 22: Reasons to buy property in study area

B. Property providers

Participants were asked from whom they bought their house and block? There was a mixed response. Most of the people in **"**The Green**"** bought their property from the Home Buyer Centre, whereas in Ridgewood, people equally bought the land from the developer and built their homes themselves with their chosen builders.

Table 18: The details about the property providers

Property Providers:	**"The Green" (N=87)**	**Ridgewood (N=79)**
Satterley- Home and Land Package	42 (48.3%)	18(23.7%)
Satterley- Land only	12 (13.8%)	21 (27.6%)
Previous residents	11 (12.6%)	13 (17.1%)
I rent	14 (16.1%)	14(18.4%)
Others	7 (8.0%)	8(10.5%)
Don't know	1 (1.2%)	2 (2.6%)

The "Others" group of property ownership in Table 18 includes the 'Homes-West' public housing[1], Foundation housing[2] etc., that with renters occupy about 25% of houses in "The Green" and about 30% of houses in Ridgewood. This may be the reason for participants' concern about the investors, renters, and public housings that are considered to arguably have an impact on the quality of the living environment in the study area during interviews and surveys.

C. Recommendation, staying or moving intentions

Participants were asked whether they would recommend their current living place to one of their friends or relatives. Further they were asked whether they wish to move out from their current home within the next year. The participants who wouldn't (definitely or possibly) move out within next year were asked how long they want to live in their current location and those who would move out were asked where they were moving into. They were also asked whether they would choose a similar suburb and 3rd pipe system again or not.

Table 19: Intention to recommend, stay in, move out, and choose again

Recommend	**The Green (N=88)**	**Ridgewood (N=76)**
• Yes	70 (79.5%)	54 (71.0%)
• No	8 (9.1%)	11 (14.5%)
• Not sure	10 (11.4%)	11 (14.5%)
Moving out	**(N=88)**	**(N=75)**
• Definitely no	40 (45.5%)	31 (41.3%)
• Probably no	22 (25.0%)	22 (29.3%)
• Not sure but would like to	12 (13.6%)	12 (16.0%)
• Probably yes	6 (6.8%)	7 (9.3%)
• Definitely yes	8 (9.1%)	3 (4.0%)
How long you want to live here?	**(N=50)**	**(N=45)**
• More than 10 years	15 (30.0%)	6 (13.3%)
• 5 to 10 years	24 (48.0%)	16 (35.6%)
• 1 to 5 years	10 (20.0%)	19 (42.2%)
• Not sure	1 (2.0%)	4 (8.9%)

[1] Homes-west public housing is the rental accommodation provided by the Department of Housing of Western Australian Government to the eligible household earning no more than the income limits.
[2] Foundation housing, also referred as community housing, is affordable housing provided by the legal community housing organizations or local governments for people on low to moderate incomes with a housing need (Department of Housing, 2013).

Where are you moving to?	(N=12)	(N=8)
• Outside WA	2 (16.6%)	0
• Within WA	2 (16.6%)	1 (12.5%)
• Closer suburbs	4 (33.3%)*	4 (50.0%)**
• Don't know	4 (33.3%)	3 (37.5%)
Would you choose again to live in similar place?	**(N=13)**	**(N=10)**
• Yes	10 (76.9%)	6 (60.0%)
• No	2 (15.4%)	3 (30.0%)
• Maybe	1 (7.7%)	1 (10.0%)
Would you choose again 3rd pipe system?	**(N=13)**	**(N=10)**
• Yes	10 (76.9%)	2 (20.0%)
• No	2 (15.4%)	0 (0%)
• Maybe	1 (7.7%)	8 (80.0%)

**Burns beach, Connolly, Ocean Reef, Mindarie, Shorehaven Rise, Trinity, Alkimos*

***Another part of Ridgewood, Butler, Quinns Rocks, Carramar, Pearsall*

As shown in Table 19, approximately 80% participants in Brighton and 71% in Ridgewood would recommend their places to their relatives or friends. Approximately 70% participants in both areas wouldn't either definitely or probably move out from their current living area within the next year. In "The Green", approximately 14% were not sure but would like to move; and approximately 16% would definitely or probably move out. Whereas in Ridgewood, 16% were unsure and approximately 13% would move out.

While asking the staying participants how long they want to stay in the current suburb, Ridgewood participants wanted to live comparatively less time in Ridgewood than "The Green participants" - about 80% of "The Green" participants wanted to live there at least for 5 more years. Those participants who would (definitely or possibly) move within the next year were asked where they were planning to move. Majority of these participants reported that they either didn't know or planned to move to neighbouring (surrounding) suburbs in Perth. Among the participants who were moving out within the next year, 77% participants in "The Green" and 60% of participants in Ridgewood would choose again to live in similar locality. Similarly, more than half of total moving participants want to live in a place installed with a 3rd pipe system.

D. Reason for moving out from current locality

Participants who wished to move within the next year were asked to indicate which dissatisfactions among 6 different dissatisfactions with their living environment made them move out from their locality in a five point scale where 1= most critical reason and 5= least critical reason. The lower the mean rating, more critical the dissatisfaction would be for moving out. The result for mean rating of each type of dissatisfaction is presented in Figure 23 below.

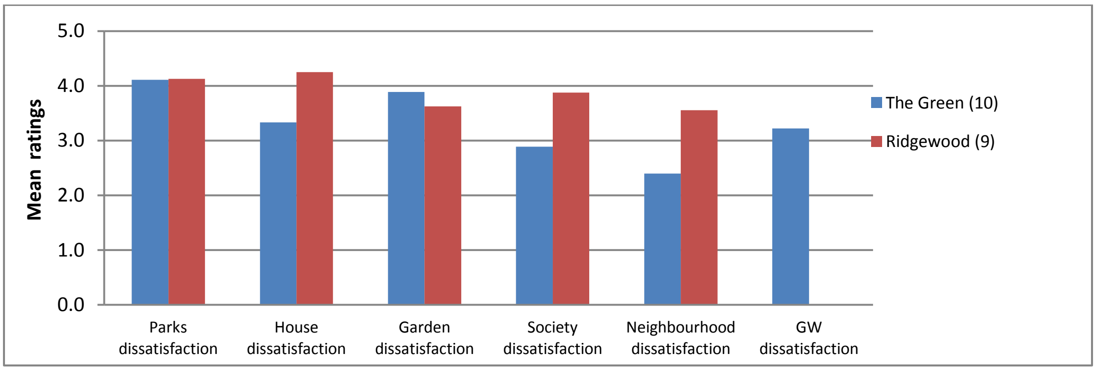


Figure 23: Reasons for moving out from current locality

"The Green" participants reported neighbourhood dissatisfaction followed by society dissatisfaction as the most critical reasons to move out. In Ridgewood, the higher mean ratings for all types of dissatisfactions indicate that all given options are not critical for their moving decisions. This result indicates the notion that dissatisfaction with neighbourhood has impacts over moving behaviour, but not limited to. There may be several other reasons for moving out than dissatisfaction with neighbourhood, home, and water system.

7.4.4. Groundwater System Issues

In "The Green", all the households were connected with the community bore network that supplies non-drinking quality groundwater for watering gardens and lawns. Most of the gardens were installed with water efficient reticulation (drip and sprinklers) and less water demanding (native) plants. In Ridgewood, there was no community bore network; therefore each garden reticulation was connected to the main drinking water supply. There was a great diversity in garden types in both areas; however, most were with the natives, drips, and the sprinklers. Participants in "The Green" and Ridgewood were asked about the garden reticulation, its impact to garden quality, their gardening behaviours, and preferences for groundwater control and staining. "The Green" participants expressed their views based on actual experiences with the NDG system, while Ridgewood participants only shared their preferences for such alternative water system.

A. Awareness of groundwater system

The first inquiry was about their awareness of the non-drinking groundwater supply in "The Green" for watering garden and parks. Most of "The Green" participants were aware of the groundwater system and contrarily most of Ridgewood participants were unaware about it as shown in Table 20.

Table 20: Awareness of groundwater system in The Green

Awareness	Not aware at all	Slightly aware	Moderately aware	Well aware	Very well aware
The Green (88)	8 (9.1%)	11 (12.5%)	12 (13.6%)	14 (15.9%)	43 (48.9%)
Ridgewood (76)	55 (72.4%)	8 (10.5%)	5 (6.6%)	4 (5.3%)	4 (5.3%)

B. Garden reticulation issues

Participants in both "The Green" and Ridgewood were asked about the source of their garden reticulation, type of reticulation, the filters in garden reticulation and their functions, the time of garden reticulation, suitability of the timing and reticulation, and finally whether the participants made any changes or adjustment in reticulation and if they did, what were the reasons for such changes. The results are explained below.

a. Source of garden reticulation

Since it was compulsory to connect to the groundwater system in "The Green", all garden reticulation systems were sourced from Groundwater via the community bore. However, about 5% of households had rainwater tanks as additional sources and the 2% of households having no garden reticulation; used a hose or bucket for watering their gardens. In Ridgewood, the garden reticulations of 92% households were connected to the main drinking water supply. There were 5 households practicing alternative water systems only, such as a shared bore, private bore, hose and bucket; and 9 households used both the alternative sources and main drinking water supply for their garden reticulation.

b. Garden reticulation type, reticulation filters and their functions

In “The Green”, approximately 65% of households had both drip and sprinklers for watering their gardens and only a quarter households had the drips only. However in Ridgewood, 43% households had sprinklers only followed by a third of households having both drips and sprinklers (approximately 32%), and approximately 15% households having drips only.

In “The Green”, approximately 35% households had filters connected to their groundwater reticulation, 40% households had no such filters, and a quarter of households were unsure about it. The main function of the filter was reported to remove the coarse solid materials to avoid blockage in drips and sprinklers. Only 17% of participants with filters supposed that the filters can remove the staining materials too. In Ridgewood, over 95% households had either no filters or were not sure about it, and only 4% households had filters connected to their reticulation that were only intended for solids removal.

Table 21: Garden reticulation types, reticulation filters and their functions

Reticulation type	**The Green (N=88)**	**Ridgewood (N= 76)**
• Drip irrigation system only	22 (25.0%)	11 (14.5%)
• Sprinklers only	7 (8.0%)	33 (43.4%)
• Both drip and sprinklers	57 (64.7%)	24 (31.6%)
• None	2 (2.3%)	8 (10.5%)
Reticulation filters	**(N= 86)**	**(N= 68)**
• Yes	30 (34.9%)	3 (4.4%)
• No	34 (39.5%)	55 (80.9%)
• Not sure	22 (25.6%)	10 (14.7%)
Function of reticulation filter	**(N= 30)**	**(N= 3)**
• For removal of coarse solids	16 (53.3%)	3 (100%)
• For removal of staining elements	0	0
• For removal of both	5 (16.7%)	0
• Not sure	9 (30.0%)	0

c. Reticulation time and suitability

In “The Green”, the majority of the households (60%) reported their groundwater reticulation time in between 3am-6am; however, 28% households had their reticulation operating in between 6am-9am - contrary to the 10pm-6am watering provision (Water Corporation, 2007b). This indicates that the households had altered their watering times. Further, none reported watering their garden during evening time (6pm-9pm) and a very few (2%) had their reticulation on during 9pm-3am.

In Ridgewood, 65% households reported watering their garden at morning time, 20% at evening and 9% at night time (Table 22). The operation of reticulation was found to be in accordance with the standard suburb; i.e., watering during 9am-6pm and 2 days a week (Water Corporation, 2012b).

Table 22: Garden reticulation time and suitability

Time of reticulation	**The Green (N= 85)**	**Ridgewood (N= 67)**
• Early morning (3am-6am)	51 (60.0%)	22 (32.8%)
• Morning (6am-9am)	24 (28.2%)	22 (32.8%)
• Evening (6pm-9pm)	0	14 (20.9%)
• Night (9pm-3am)	2 (2.4%)	6 (9.0%)
• Not sure	8 (9.4%)	3 (4.5%)
Does this time suits your garden needs?	**(N=84)**	**(N= 68)**
• Yes	54 (64.3%)	55 (80.9%)
• No	17 (20.2%)	4 (5.9%)
• Not sure	13 (15.5%)	9 (13.2%)

In "The Green", majority of the households (64%) were happy with their reticulation timing that suited their garden needs, however 20% reported the reticulation timing was not suitable and 16% were not sure. In Ridgewood, 81% households were happy with the watering timing and only 6% considered the timing was insufficient for their garden. This reason might be because Ridgewood people could alter their reticulation setting at any time to make it more suitable for their gardens unlike "The Green".

d. Preferred adjustment in garden reticulation

The MOU of NDG trial (Water Corporation, 2007b) restricts any alteration in the setting of garden reticulation controller in "The Green" and if anyone wishes to adjust the settings or watering time, s/he needs to seek assistance of the authorised technicians. "The Green" participants, who considered their garden reticulation insufficient to meet their garden needs, were asked whether they had changed the reticulation setting or had a wish to change it in future. Out of 33 of such participants, one third participants either changed their reticulation setting or expressed their wishes to change it in future. Those who tried themselves, found that their reticulation either stopped working or reverted back to the default setting – so they needed to inform the technician to correct it. Hence in either way, most of the reticulations in "The Green" are being operated at default setting (set at installation or altered setting by an authorised technician).

When further asking the unhappy participants about their preferences for adjustment in their garden reticulation, a diversity of preferences was recorded. Most notably they preferred to have more watering time (more hours and more frequent), alter their current watering time to a more suitable time, and have more household control over the reticulation. Other preferences were to have flexibility in testing time; more dripper stations; more pressure and more frequent maintenance of the reticulation. Currently there was a ‘2 minutes time’ for reticulation test, which the residents preferred to increase up to 5 or more minutes. Further, participants wanted to plant or change their plants and lawn, but complained that the reticulation had restricted such changes. People also wanted the water authorities to conduct more frequent inspections and control of wasteful water use around the locality. Overall, most responses were oriented towards the better and more flexible (customer-friendly) operation of the groundwater system.

For these issues, responses from Ridgewood participants were fairly simple and focused on the enforcement of restrictions; use of water efficient garden, plants and reticulations; and utilization of alternatives rather than using mains drinking water for garden watering.

C. Staining issues

Participants in both areas were asked whether they had noticed any staining in their properties due to their garden reticulation or not. If the participants noticed the staining; they were further asked where the staining was mainly seen, how important the staining was for their satisfaction with NDG system as well as home, and what were their preferences for removing the staining. The responses are presented below.

Table 23: Notice of staining in the property

Staining in the property?	**The Green (N=88)**	**Ridgewood (N=76)**
• No	54 (61.4%)	69 (90.8%)
• White	17 (19.3%)	4 (5.3%)
• Rust	8 (9.1%)	0
• Both	9 (10.2%)	3 (3.9%)

As shown in Table 23, approximately 39% participants in “The Green” have noticed staining in their property but only 9% of participants reported staining in Ridgewood. This is a clear indication of the staining quality of the groundwater used in “The Green”. Mostly white staining only or mixed with rust staining was noticed. This was because of the presence of calcium and or iron elements in local groundwater used in “The Green”, as mentioned in the GHD hydrological assessment report (GHD, 2006). Having said that, the groundwater was approved for garden irrigation purpose without any pre-treatment (Water Corporation, 2007a) though the quality differs at different location even within a specific suburb.

a. Places for staining

Figure 24 shows the places where the participants noticed the staining. In both areas, staining was mostly noticed at walls and windows followed by garden edges and footpaths. One household could have noticed staining at more than one place. Staining was also noticed at footpaths, driveway, post box, sheds, and cars.

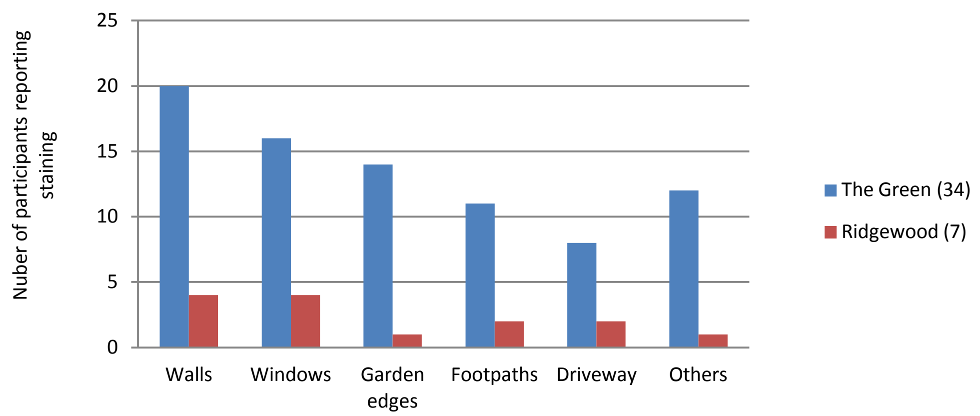


Figure 24: Major places for staining

b. Impact of Staining

In Ridgewood staining was a minor issue because of the relative lack of groundwater use, so only the impact of staining in "The Green" is discussed. Participants who noticed the staining in their property were asked about the impact of staining on their satisfaction with their house and garden reticulation. One third of participants responded along the lines that the staining highly or extremely impacted their satisfaction with their houses, and 16% of participants had the same view for their satisfaction with their garden (or groundwater) reticulation. Approximately a quarter of participants reported that the staining wouldn't critically impact on their satisfaction with their homes and garden reticulation and the rest considered such impact would slightly to moderately be critical to their satisfaction.

c. Preference for stain-removal

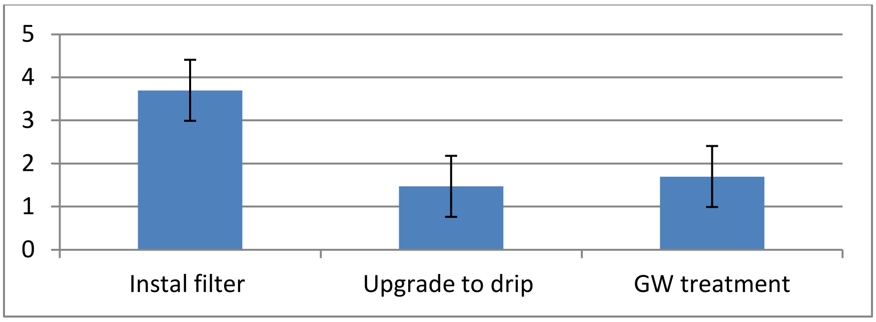


Figure 25: Preference for stain-removal techniques

The participants who considered that the staining would impact on their satisfaction with their home and garden reticulation were further asked about their preferences for different stain removal techniques on a five point scale 1 to 5, where 1=not preferred at all and 5=most preferred. Figure 25 shows the mean rating of household's preference (as indicated by Y axis) of three different options (placed in X axis) for removing the staining element from the groundwater. The most preferred option was installing a suitable filter to the groundwater reticulation. Over two third participants having staining issues rated the filter as highly or extremely preferred option for getting rid of staining. The other two options were not preferred by the majority of participants. When asked about their preferences with the possible prices of the treated groundwater, 7 out of 10 participants who prefer the groundwater treatment had reported that they will pay only if the price of treated groundwater is less than the price of main scheme water, 2 remained undecided and 1 participant was prepared to pay even if the treated groundwater costs equal to the drinking water.

D. Preferences for groundwater control and pricing

Participants were asked about their preferences on three different control types and two different pricing types in a five point scale where 1= not preferred at all and 5= extremely preferred. The three control options were: a. Current weather station control, b. Full household control, and c. Rostered 3 day supply; and two pricing options were: a. Current flat annual pricing, and b. Metered charging. The mean rating of the preferences towards these options are presented below in Figure 26 a, and b, where Y axis represents the preference rating and X axis has the above mentioned control and pricing options. The higher the mean value, the more would be the preferences.

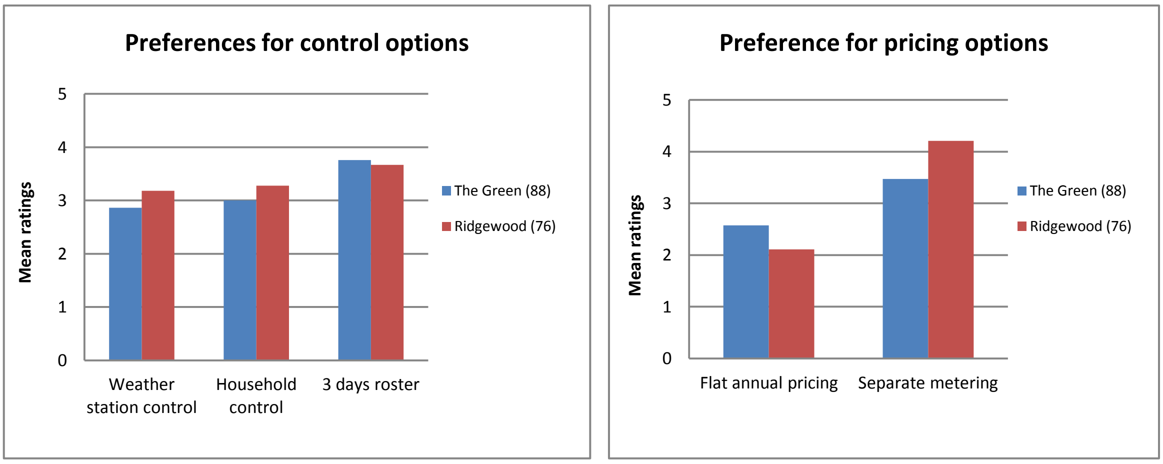


Figure 26 a: Preferences for Control b: Preferences for pricing

Figure 26a shows that there was a higher preference for the rostered 3 days watering in both "The Green" and Ridgewood. In "The Green" almost 70% participants highly or extremely preferred the 3 day roster, whereas 42% highly or extremely preferred the full household control and only 35% highly or extremely preferred the weather station control. The Chi-square value at 0.01 level of significance was higher (Chi-square value= 71.1, df= 10) for '3 day roster' than the household control (Chi-square value= 47.1, df=7) and the weather station control (Chi-square value= 46.4, df=7) options. This clearly indicates that there was comparatively less preference for the weather station control options, which is the default control option for non-drinking groundwater system in "The Green".

Figure 26b shows that the metered charging was more preferred than the flat annual charging in both areas. In "The Green" 55% of participants highly or extremely preferred the metered charging, while only 28% participants highly or extremely preferred the flat annual charging. However, the Chi-square value at 0.01 level of confidence is higher for the flat annual pricing (Chi-square value= 104.8, df=10) than the metered pricing (Chi-square value= 72.7, df=7). This indicates that "The Green" people preference for the metered charging over the flat annual pricing is statistically not significant.

E. Preference for adjustment in the groundwater system

Participants were asked about their thoughts for improvements in their garden reticulation. Their responses indicate that there were some concerns about the insufficiency of the groundwater supply system and a number of adjustments were suggested by the residents. Some of those suggestions were to upgrade the current restrictive groundwater supply to unrestrictive supply, water metered and charged accordance to the meter readings, on-site treatment (at bore) to remove staining. Residents were willing to pay for such improvement because they wanted to get rid of staining that could decrease the value of their lifetime investment (the property).

Some people planned to change the drips reticulation to sprinklers- mainly to make the watering visible. However, it could increase the risk of staining. There was some support for adjusting the reticulation setting to operate garden watering on desired time and get more water without the assistance of technicians.

F. Happiness with the quality of gardens

In “The Green”, the gardens were landscaped for free with water efficient plants, lawns, and reticulation. Both the front and back gardens were landscaped by the developer, however participants raised some issues with the quality of gardens, plants and reticulation systems during the preliminary interviews. Therefore in the questionnaire participants in both areas were asked to provide their perceptions on the quality of garden, reasons for both good or bad perceptions, and preferences for changes in their garden. The results are explained with the help of Table 24 below.

Table 24: Happiness with the quality of gardens

Are you happy with the quality of your garden?	**“The Green” (N=87)**	**Ridgewood (N=78)**
Yes	46 (52.9%)	49 (62.8%)
No	32 (36.8%)	29 (37.2%)
Not sure	9 (10.3%)	0 (0%)

The majority of participants in both areas were happy with their gardens leaving approximately 37% of participants not happy in either area. The unhappy and unsure participants were asked about the reasons for being unhappy with their gardens and a number of reasons were obtained that is described in the following paragraphs.

In “The Green”, more than half of unhappy participants reported that the main reason was the poor quality landscaping of their gardens. Similarly, a quarter were unhappy with the limited number of plants, cheap and native plants, smaller gardens, incorrect placement of plants, sloppy lawn and bare verges, and no residential inputs while designing their gardens. All these issues were collectively perceived as the limiting factors for the quality of their gardens. Furthermore, approximately 20% of unhappy participants complained that the lawn was of poor quality, rough, hard to maintain, die too quickly, and have patches or holes in it. Another 15% were unhappy with the insufficient and unreliable groundwater reticulation and the quality of soil preparation. They reported their garden soil was poorly prepared with less top-soil, less conditioner and sparely laid mulch. Finally, a small proportion (10%) of unhappy participants reported their concerns regarding poor information provision and unfriendly service as the reason to be unhappy with their garden.

While asking about the adjustment in their gardens; about 30% of unhappy participants in “The Green” mentioned that they had already modified (or were still changing) their gardens to suit their needs. Most of them had changed the design of their garden (area and slopes), replaced or added the plants, replaced or increased the lawn area (some installed artificial lawn), and improved the verges. “The Green” participants reported that the groundwater reticulation was restricting the adjustment process in their gardens; however this issue was not evident in Ridgewood. Ridgewood participants were mainly unhappy with their lawn type, unkempt gardens and verges around their neighbourhood.

While asking about their preferences for improving their gardens, most of the participants wanted to have more plants (trees in verge), better quality lawn, more soil conditioner and mulches, sufficient watering, more information and follow-ups, and better maintenance of verges. Some participants reported that the poorly maintained or unkempt gardens in their neighbourhood were causing difficulties for maintaining their gardens and also degrading the appearance or beauty of their community. Hence, they urged the authorities to encourage those households to maintain their garden and verges properly. The issues were also emerged in Ridgewood, as some homeowners didn’t keep their verges and gardens well maintained and the perception was that this had damaged the neighbourhood appearance.

7.5. Attitudinal modelling

After exploring these descriptive issues about the NDG system, garden reticulation and gardens in the study area, this research now focuses on the attitudinal model of residential satisfaction. The modelling process engages two major steps of scale development; namely: the item reduction and scale refinement, and assessment of reliability and validity of scales. Firstly, the attitudinal items regarding the NDG system, home, neighbourhood and society were reduced into fewer valid and reliable constructs/factors with the help of factor analysis. Secondly, thus resulted constructs/factors were used in regression analysis to test and develop the attitudinal model of satisfaction with NDG system, home, neighbourhood, and society. These models were finally tested by using path analysis. The outcomes of the two steps and respective analyses are sequentially described below.

7.5.1. Factor analysis for items reduction

Factor analysis is the most important step in the scale development process, which is associated with the item reduction and scale refinement. It is a statistical method to identify unobserved variables (factors) by analysing the pattern of relationships among observed variables (items). In other words, factor analysis is used to uncover and or confirm the underlying structure of a relatively large set of observed variables in terms of a much smaller number of unobserved variables called factors.

Factor analysis was adopted to reduce the items, or to summarise a multitude of measurements with a smaller number of factors without losing too much information (Bryant and Yarnold, 1995). Factor analysis can simply help to confirm that sets of questionnaire items (observed variables) are, in fact, all measuring the same underlying variable or factor (perhaps with varying reliability) and so can be combined to form a more reliable measure of that variable (Jolliffe, 2002). It is also possible that factor analysis will allow us to test theories involving variables which are hard to measure directly, for example: trust and fairness.

There are two types of factor analysis: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The EFA assumes that any indicator variable may be associated with any factors, whereas the CFA seeks to determine each specific subset of indicator variables that are associated with specific factors. In this research, mostly EFA was used to identify the main factors of a large set of attitudinal statements explaining residential perceptions to different attributes of dual water supply system and water sensitive urban development to measure residential satisfaction with the system and development as a whole. As this is first study on satisfaction with unique NDG supply system, no previous structured items could be utilised to perform a CFA. A variety of items was drawn from previous studies, and parallel literatures. The existing items were refined and contextualised with the help of preliminary interviews, which also generated several new items. It was hard to prioritise these items as well as impossible to throw each item into the advanced statistical analysis subject to reliability, validity and generalizability. Therefore only consistent and robust items were clustered together into a few valid and reliable constructs; and the constructs, in turn, were undergone further analysis as a funnelled technique.

This research conducts EFA utilising the Principal Component Analysis (PCA) methods for factors extraction with varimax rotation. The method and rotation were applied for reducing items and generating common factors using a statistical computer software package, called "IBM SPSS 21". PCA is largely used as a dimension-reducing procedure that can identify a small set of synthetic variables, called factors (Bryant and Yarnold, 1995). PCA seeks a linear combination of observed variables such that the maximum variance is extracted from the variables. It then removes this variance and seeks a second linear combination which explains the maximum proportion of the remaining variance, and so on. In this way, PCA transform a large number of observed variables into a set of ordered, orthogonal (uncorrelated) factors, where the first few retain most of the variation present in all of the original observed variables (Fabrigar, Wegener, MacCallum, and Strahan, 1999; Jolliffe, 2002).

Kaiser's (1958) varimax rotation is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor on all the variables in a factor matrix, which has the effect of differentiating the original variables by the extracted factor. Although each factor will tend to have either large or small loadings of any particular variable, the varimax solution yields easily interpretable results by identifying the possible variables constituting each factor.

In this research, the EFA using PCA with varimax rotation was mainly used for reducing items regarding groundwater system to derive reliable and valid factors of individual satisfaction with the system. Side by side, the Principle Axis Factoring (PAF) with direct oblimin rotation was used to explore the underlying factors of water sensitive urban environment and the relationships among factors in measuring an individual satisfaction with such environment. As there were no previous studies on satisfaction with groundwater system and no constructs were available, the PCA aimed to develop valid and reliable factors and utilise them to measure the satisfaction with the system. Nonetheless, there were several studies on satisfaction with residential environment, and the study aimed to understand the reliability of the previously developed scales to measure satisfaction with the water sensitive residential environment. Therefore, it is more sensible to use PAF than PCA to reduce items and identify the latent constructs regarding the water sensitive urban environment (Fabrigar et al., 1999).

With PAF, the direct oblimin rotation was used. This was because PAF assumes the underlying variables are correlated with each other and the oblique rotations permit/support correlations among factors (Fabrigar et al., 1999). The direct oblimin rotation allows factors orientation less than a right angle (90^0). Unlike varimax rotation, the direct oblimin will produce more simple and interpretable factors when the clusters of variables are less than 90^0 from one another in multidimensional space (Fabrigar et al., 1999).

After fixing factor extraction and rotation methods, some additional criteria were set prior to conducting actual factor analysis. One important criterion was the sample size, i.e., "How large should the sample be?" The simple rule of thumb was – "More measured variables require larger sample sizes". However, there are varying recommendations: Nunnally (1978) proposed ratios of 10 participants per variable; Gorsuch (1997) suggested a ratio of 5 participants per variable but with condition of the sample size should be over 100. Further, MacCallum, Widaman, Zhang, and Hong (1999) conducted a Monte Carlo Study on sample size effects and obtained 100% convergence of population factor structure with a small sample size of 60 having 20 variables (3 to 1 ratio). Similarly in a meta-analysis of EFA, Fabrigar et al. (1999) reported that about 15-20% articles in psychological journals had a sample size of 100 or less whereas 25-35% articles had 4:1 or less ratio of variable to factors. Further, Kline (2008) provides support for the subject variable ratio of at least 3:1 in factor analysis with a minimum of 100 subjects. Preacher and MacCallum (2002) concludes that a good factor solution can be obtained even from very small sample size as long as the communalities are high, and expected factors are few in number. Since this study has a sample size of 167 participants, the ratio of participants per variable is consistent with Gorsuch (1997) recommendation. The subject variable ratio and variable factor ratio will be explained in successive factor analyses. Further, the Kaiser-Meyer-Olkin (KMO) measures (0.6), communalities of variables (0.6), eigenvalues (1.0), and factor loadings (0.3) were applied as the cut off point for the exclusion of items and/or factors.

The reliability of each factor (latent variable) was tested in terms of the Cronbach's alpha value (0.6 or more) and at least three items per factor. Cronbach (1951) defined alpha as an "estimate of the correlation between two random samples of items from a universe of items" and developed as an index of common-factor concentration and or homogeneity of items. The criteria of at least 3 highly reliable and relevant items were included as suggested by Fabrigar et al. (1999). The constituting items were also examined on the basis of their underlying concept and the content validity (Haynes, Richard, and Kubany, 1995; Rubio, Berg-Weger, Tebb, Lee, and Rauch, 2003). Moreover, the items were examined in terms of their communalities, and factor loadings; in which the higher yielding items were retained. Another criterion was each item should be cleanly loaded on one factor only or with a minimum difference of more than 0.2 loading. During the factor analysis, the factors having less than three items were also retained as they had higher content validity, higher correlation between the items, and or higher alpha value. Moreover, the number of factors to retain were decided according to their eigenvalues (>1.0), and the scree-plots (with contrasting difference). These criteria are also explained in successive factor analyses.

The naming convention during factor analysis was carried out by rigorous discussions among the investigator and supervisors. The basic rule was selecting the term that best possibly capture and describe the underlying and integrative concept of the items constituting the construct.

7.5.2. Constructs of groundwater satisfaction

A. Groundwater satisfaction in "The Green"

"The Green" participants were asked to rate several attitudinal statements explaining different attributes of the groundwater supply system on a 6 point scale, where 1= strongly disagree, and 6= strongly agree. The attitudinal statements mainly measured resident's perception, feelings, and evaluation of different attributes of the system. These multiple items were generated with the help of literature review and preliminary interviews, which were supposed to measure a few major aspects (or say factors) of dual water system in terms of individual satisfaction with the system. The main purpose of the factor analysis was to generate these few meaningful factors (or variables) by reducing the observed items (attitudinal statements), and thus derived factors could explain the satisfaction with groundwater system.

The iterative principal component analysis (PCA) with varimax rotation was conducted using the above mentioned criteria, and 6 factors with 17 items were extracted out of 42 observed items of groundwater system. The factor analysis resulted variables to factors ratio of 7 to 1, and item factor ratio of almost 3 to 1. The KMO Measure was 0.748, Bartlett's Sphericity Test was highly significant and the 6 factors explained 74% of variance in total observed items of groundwater system. The factor solution for groundwater system is given in Table 25.

Table 25: Factor structure of groundwater satisfaction in "The Green"

Items	Factors					
	Trust	Operation	Pricing	Fairness	Safety	WC
I trust the water authorities will manage our GW responsibly	.862					
I trust developers will ensure infrastructure for GW reticulation meets acceptable standards	.828					
I trust the water authorities will ensure I have a good GW supply	.771	.404				
I trust water authorities will treat GW to correct standards for watering our gardens	.766		.324			
I am happy with the pressure of GW supply in my garden		.822				
The GW reticulation is well operated in my garden	.392	.802				
I am happy with the automatic supply of GW in my garden	.421	.773				
The cost of GW can't overshadow its environmental benefits			.811			
Recoded- Having to pay a fixed price for access of GW is fair for all households			.700	-.344		
I don't mind paying an increased price for GW if our gardens will be better maintained in summer			.551			
We should pay for how much water we use on our garden like everyone else				.848		
Brighton residents should have the same watering restriction for their GW reticulation as everyone else in Perth				.846		
GW supply here is safe for human health*		.364			.790	
I have no objection in using GW for non-potable indoor uses as long as appropriate quality is guaranteed			.432		.711	
I see no health risk in using the GW for watering my garden	.358				.602	.378
Individuals can make a difference in solving water problems by saving more water on regular basis						.790
Reducing rainfall makes it very important for us to conserve water now						.769
Cronbach's alpha value	**0.882**	**0.910**	**.607**	**0.699**	**0.590**	**0.570**

Table 25 illustrates that the 17 attitudinal items were clustered as 6 main factors, namely: Trust in water authorities, Groundwater operation, Groundwater pricing, Groundwater fairness, Groundwater safety, and Water conservation. The reliability of each factor was tested in terms of at least 3 items per factor and the Cronbach's alpha value setting (0.6 or more). Since the Cronbach's alpha value for groundwater fairness factor was more than 0.6 though having only 2 items and that of the risk factor was very close to 0.6 and contained 3 items, both factors were retained for further analysis. In this way, 5 factors were retained, while the sixth water conservation factor failed to meet the criteria and was eliminated. Further any single item that explained a particular concept and has factor loading of more than 0.6 was considered as a single item factor and included for further analysis.

Description of factors

1. Trust in water authorities

The first factor contains four items and measures the residents' trust perception in relation to water authorities and the developers to design, develop, and operate the groundwater reticulation in their locality. This factor has Cronbach's alpha value 0.882, which indicates the contributing four items were internally consistent and reliable measures of the trust construct. The items of this factor explain participants perception of trust of the authorities involved in groundwater supply system. The items were mainly for responsible management, standard infrastructure, good water supply and correct treatment of the groundwater. As a factor of the groundwater system, the trust factor scores may be positively related to satisfaction with the groundwater system.

2. Perception of Operation

The second factor contains three items that explain householders' feelings and evaluation of the overall operation of groundwater system in their locality and in their garden. This factor has a very high Cronbach's alpha value 0.910, which indicates that the items are highly correlated, consistent and valid measures of the operation factor. The three items mainly explain individual happiness with the groundwater pressure, groundwater operation in their gardens, and the automatic supply of groundwater. As another factor of groundwater system, the operation factor may have a positive relationship with the groundwater satisfaction.

3. Pricing of GW

The third factor contains three items that explain participants' feelings towards the groundwater pricing compared with environmental benefits and betterment of gardens. This factor has Cronbach's alpha value 0.607 that indicates the items are internally consistent in measuring the pricing construct. The three items explain participants' perception towards the fixed prices of groundwater system, the cost compared with environmental benefits and the willingness to pay more for better groundwater system for maintaining gardens during summer. During the preliminary interviews, the pricing issue was supposed to have nominal influence over the participants' evaluation of the groundwater system; however from the factor analysis, it appeared as a third factor of groundwater system. From this fact, it was hypothesised that the pricing factor may have a direct influence over the satisfaction with groundwater system.

4. Perception of fairness:

The fourth factor contains 2 items that explain the fairness issue regarding groundwater supply system. Though having two items, the fairness factor has a high Cronbach's alpha value 0.70, which indicates the two items were internally consistent and valid measures of the fairness construct. The two items mainly measure the participants' fairness perceptions towards the similar pricing practice to everyone else using groundwater and similar watering restriction for groundwater use as everyone else. The fairness factor mainly represents the fairness in using groundwater (consumption fairness) rather than fairness in the system as a whole. As a factor of groundwater system, the fairness factor may have a direct impact over the groundwater satisfaction.

5. Perception of GW safety

The fifth factor contains three items that explain the risk or safety of groundwater use for human health when used for non-drinking activities, for example: garden watering. This factor has Cronbach's alpha 0.590 that is below the criteria albeit by very small margin, hence retained for further analysis. The three items mainly measure individual perception towards the health hazards from the groundwater use, risks in groundwater for watering gardens, and use of groundwater for non-potable indoor uses. To make all the items oriented towards the safety of groundwater use, the values of items that measure risks were reversed to obtain the safety measure of groundwater use. The groundwater safety factor score may have a positive relationship with the groundwater satisfaction.

The sixth factor contains 2 items that explain the need of groundwater reticulation for water conservation and individual's roles in it. However, this factor has Cronbach's alpha value 0.570, which is lower than the criteria and contains two items only; hence, it was excluded from the further analysis. In this way, 5 factors of groundwater system with 15 items were resulted from the factor analysis. During the iterative factor analysis process, the items with higher factor loadings (0.6 or more) but not clustered with any of the factors and represent underlying concepts of significance during interviews were considered as the single item factors. The following single items were resulted from factor analysis and will be used in regression and further analysis.

1. My household uses less water than others in our neighbourhood
2. Groundwater reticulation helps to reduce outdoor use of drinking water
3. The overall benefits of using NDG for watering our gardens outweigh the overall risks
4. Groundwater reticulation contributes the quality of my garden
5. It is unfair that people in "The Green" have no control over groundwater reticulation
6. There is a risk of something going wrong with groundwater system in future
7. I prefer the continuation of groundwater supply system in "The Green" (Reversely coded)

B. Groundwater satisfaction in Ridgewood

It was easy to ask "The Green" participants about their perceptions and feelings towards different aspects of the NDG system because they were connected with and had experiences of the NDG system. However, the same questions couldn't be asked of Ridgewood participants as almost all were only connected to the main drinking water system. Therefore, it was decided to put a hypothetical situation in which all of the households in Ridgewood were connected to an alternative NDG supply via dual reticulation as similar to "The Green". Then they were briefed about different aspects of the dual water system in "The Green" and asked to provide their perceptions and preferences toward the different attributes of the dual water system. Apart from this hypothetical attitudinal test, Ridgewood participants provided the independent sample to replicate the whole scale development process.

37 attitudinal statements were developed and Ridgewood participants rated them on a 6 point scale where 1=strongly disagree and 6=strongly agree. Such ratings measured participants' perceptions and preferences towards different attributes of the dual water system (hypothetical) and generated their satisfaction with the alternative dual water system. As discussed earlier, factor analysis was utilized to reduce the observed items into a few meaningful factors that explain the major aspects of the alternative dual water system and finally measure their satisfaction with the system. The main purpose of the factor analysis is to outline those factors. The criteria were the same as discussed in earlier section.

Since an item explaining the 'acceptance of groundwater for garden irrigation' was intentionally excluded from the factor analysis to use as dependent variable- 'acceptance of groundwater', only 36 attitudinal items remained for consideration of Ridgewood participants. Similar to "The Green", the iterative Principal Component Analysis (PCA) with varimax rotation was conducted using the previously mentioned criteria. The PCA extracted following 4 factors with 17 items out of 36 observed items. That means that the factor analysis resulted in a variables to factors ratio that equals to 9 to 1 (over-determination), and item factor ratio of almost 4 to 1. The KMO Measure was 0.825, Bartlett's Sphericity Test was highly significant. Further, the Cronbach's alpha values and the items per factors were also examined to establish the reliability of the factors. The factor solution is given in Table 26 below.

Table 26: Factor structure of groundwater satisfaction in Ridgewood

Items	**Factors**			
	Trust	**Performance**	**WC**	**Fairness**
I trust the water authorities would ensure I have a good GW supply	.897			
I trust the water authorities would treat GW to correct standards for its use in watering our gardens	.810			
I trust the water authorities would manage our GW responsibly	.802			
I trust developers would operate a reliable groundwater reticulation here	.794			
I trust the water authorities would provide us every bits of information about the GW reticulation	.763	.310		
I trust developers will ensure infrastructure for GW reticulation meets acceptable standards	.740			
The overall benefits of the GW reticulation for watering our gardens outweigh the overall risks associated with it		.791		
Using GW for watering gardens and parks is an environmentally sustainable approach		.749		
It would be easy for most people to use groundwater in their gardens	.350	.693		
I wouldn't care about the lower pressure of GW reticulation as long as my garden gets water on a regular basis		.691	.384	
Community bore supply is a reliable system for watering our gardens	.363	.682		
Reducing rainfall makes it very important for us to conserve water now			.825	
We have a duty to conserve our water for the next generation			.783	
Individuals can make a difference in solving water problems by saving more water on regular basis			.620	.432
We should pay for how much water we use on our garden like everyone else				.791
The weather station control would ensure equitable GW supply				.659
We should have the same watering restriction for GW supply in our garden as everyone else in Perth				.630
Cronbach's alpha value	**0.916**	**0.832**	**0.696**	**0.570**

Table 26 illustrates the 17 attitudinal items that were clustered as 4 main factors, namely: Trust in water authorities, Performance of alternative groundwater system, Water conservation issues, and Fairness and Equity in alternative water supply. As discussed earlier, the reliability of each factor was tested in terms of at least 3 items per factor and the Cronbach's alpha value setting (0.6 or more). Although the Cronbach's alpha value for fairness and equity factor was less than 0.6, and contained 3 items, it was retained for further analysis. Further any single item that explained a particular concept and had a factor loading of more than 0.6 was considered as single item factor and included for further analysis.

Description of factors

1. Trust in water authorities

The first factor contains 6 items that explain and measure participants trust towards the water provider and developer to design, develop, and operate the dual water system in their locality. This factor has Cronbach's alpha value 0.916, which indicates that the items are internally consistent to explain and measure the trust construct. The 6 items mainly explain the participants' trust in water authorities to ensure good supply and reliable alternative water system, to treat the groundwater to correct treatment standards, manage the alternative water system responsibly, ensure the infrastructure standards, and provide information regarding the alternative groundwater systems. As in "The Green", trust in water authorities appeared as the first important factor of the dual water system in Ridgewood, which means the trust scores may have a positive relationship with the alternative groundwater satisfaction.

2. Performance

The second factor contains five items that explain resident's perceptions towards the performance of the dual water system. This factor has a high Cronbach's alpha value 0.832, which indicates the items were consistent and reliable for explaining and measuring the performance construct. The five items mainly explain and measure participants' assessment of the overall benefits to the risks associated with the alternative system; the environmental sustainability, and reliability of the alternative; easiness of use in the garden, and finally the regular garden watering irrespective of pressure. As the performance factor appeared as a second important factor of the dual water system, the performance scores may have a positive relationship with the dual water satisfaction.

3. Water conservation

The third factor contains 3 items that explain residents' feelings towards the essence of water conservation to secure water for future. This factor has Cronbach's alpha value 0.696, which indicates that the constituting items are highly related and contribute to the water conservation construct. The three items mainly explain and measure participants' perceptions towards the current need for water conservation and the individual responsibility and duty for saving water. As the water conservation factor appeared as third important factor of alternative groundwater system, the water conservation factor scores may have a positive impact over satisfaction with the dual water system.

4. Fairness and equity

The fourth factor contains 3 items that explain participants feelings towards the fair pricing, similar restrictions and equal availability of alternative groundwater supply. This factor has Cronbach's alpha value 0.570, which is a bit lower than the criteria of 0.6; however, this factor has been retained for further analysis as it explains an important aspect of alternative groundwater system and has 3 items. The items mainly explain and measure participants' perception of fair pricing according to the water usage in their gardens, similar watering restriction for alternative water supply as everyone else, and weather station control for equitable water supply. The fairness factor scores may have a positive relationship with the dual water satisfaction.

Apart from these four main factors, there were some single items with higher factor loadings (0.6 or more) but not clustered with any of the factors. Each of these items explained different underlying aspects of the alternative water system, therefore they were considered as a single item factors. Out of 36 attitudinal items, the following 5 were selected as single item factors, and used in regression and further analysis.

1. I will avoid using groundwater in my garden due to its lower quality.
2. GW supply should be cheaper than the main drinking water supply.
3. My household uses less water than others in this neighbourhood.
4. Groundwater reticulation here would be safe for human health.
5. I don't mind using GW for non-potable indoor uses (ex- toilet flushing) as long as appropriate quality is guaranteed.

C. Comparison of Groundwater satisfaction constructs in "The Green" and Ridgewood

As apparent in Table 25 and 26, the factor structure for the groundwater system in "The Green" and the alternative groundwater system in Ridgewood are different, though some factors are similar. Trust appeared to be the first factor in both areas. However, trust has 4 items with Cronbach's alpha value 0.882 in "The Green", and 6 items with Cronbach's alpha value 0.916 in Ridgewood. The additional trust items in Ridgewood were: trust in authorities to operate a reliable new water system, and to provide comprehensive information on the alternative water system. These items did not appear in the trust factor in "The Green" because the participants were already provided with the information and were experiencing the dual water system, therefore trust on these issues were not highly relevant there. However in Ridgewood, all these items were relevant since participants haven't experienced the new water system yet.

In "The Green", a second factor was groundwater operation, which was not appeared in Ridgewood. In Ridgewood, the second factor was the performance of the groundwater system. The operation factor in "The Green" mainly deals with the residents' perceptions and feelings towards the automatic operation of the groundwater reticulation in their gardens. However, the performance factor in Ridgewood deals with the reliability, sustainability, benefits, efficiency and easiness of the groundwater supply while using in garden watering. Since Ridgewood participants lacked the experience of actual dual water system, they only perceive the performances of the system as important and relevant for their satisfaction with the system rather than the operation issues. Similar justification would be appropriate for the Groundwater pricing and Groundwater safety factors that appeared only in "The Green". Furthermore, water conservation factor in "The Green" was very weak in terms of reliability; hence, it was excluded from any further analysis. However in Ridgewood, the water conservation factor is significant and reliable. The fairness factor appeared in both areas; however in Ridgewood, it was weaker in terms of reliability.

7.5.3. Constructs of urban residential environment

A. Urban residential environment in "The Green"

"The Green" has implemented water sensitive designs, such as grassed swales, porous pavements, bio-retention trenches, water efficient parks, and a non-drinking groundwater supply via dual pipe system; hence, it is classified as a water sensitive urban residential development. The participants were asked to rate several attitudinal statements explaining different attributes of home and neighbourhood in water sensitive urban residential environment on a 6 point scale, where 1= strongly disagree, and 6= strongly agree. The attitudinal statements when rated would measure resident's perception, feelings, and evaluation of the water sensitive residential environment that would eventually generate residential satisfaction with the environment.

The factor analysis aims not only to extract a few meaningful and valid constructs from the multiple items but also explore the underlying relationships among the factors, which will measure and explain the factors of satisfaction with the urban residential environment at once. For this purpose, exploratory factor analysis using Principle Axis Factoring (PAF) method with direct oblimin rotation was performed with previously defined criteria. However, the following two items were excluded at the very beginning of the analysis as these appeared to be more associated with groundwater issues.

1. Native plants are always good for better home gardens even in summer, and
2. I like the way that the public parks here collect the stormwater during winter.

After the exclusion of the above two items, factor analysis using PAF and direct oblimin rotation was conducted with the remaining 26 items and following 3 main factors of urban residential environment were obtained.

Description of iterative factor analysis

Factor analysis was conducted in two phases. As the item pool of urban residential environment contained the items explaining different attributes of home, garden, neighbourhood and parks. The first phase removed the weak and least reliable items for each component. The second phase included the strong and highly reliable items under each component and conducted the analysis to get the final factors of urban residential environment. The iterative factor analysis yielded 3 factors with 12 items, where the KMO was high (0.767) and Bartlett's sphericity test was highly significant. The outcome of factor analysis is explained below.

The first phase of factor analysis utilised Principal Axis Factoring with direct oblimin rotation. The factor selection criteria was slightly modified; i.e., restricted to yield one factor rather than factors that were higher than or equal to Eigenvalue 1.0. The analysis reduced the items and yielded a reliable structure for each neighbourhood, park, home and garden construct that is given in Table 27.

Out of 9 items, 5 items appeared to be clustered together to yield a Neighbourhood construct with Cronbach's alpha 0.872. In terms of public parks construct, only 3 items out of 7 items turned out to be reliable with Cronbach's alpha 0.573. The Cronbach's alpha value is marginal but this construct represented an important component of the living environment, hence it was retained for final factor analysis. Similarly for the home construct, 5 items out of 10 home and garden attributes clustered together as a home and garden factor (Cronbach's alpha 0.702); and 2 items for garden value factor (Cronbach's alpha 0.665) were resulted. The first phase of factor analysis also yielded one single item for each neighbourhood, park, and home constructs that were included in the final factor analysis. Table 27 shows the outcomes of first phase factor analysis; i.e., four major constructs and their constituting items along with the single item variables.

Table 27: The first phase of factor analysis of urban residential environment in "The Green"

Neighbourhood attributes	**Factor loadings**
I am sure the resale value will go up in this NB	.848
I feel at home in this NB	.825
This NB has a prestigious living environment	.808
This NB is safe place for raising children	.694
This NB is easy to get around	.645
Cronbach's alpha value	**0.872(5)**
Park attributes	
My children enjoy playing in the public parks	.641
I often use the public parks for recreational activities	.574
I go to public parks to get myself out of my house	.501
Cronbach's alpha value	**0.573**
Home and garden attributes	
My home environment has a pleasant feel to it	.760
My house suits my family needs	.598
I am happy with the design of my home garden	.571
I am happy with the size of my home garden	.506
The landscaped backyard is a real bonus to my house	.498
Cronbach's alpha value	**0.702**
Garden value factor	
A well kept garden increases the resale value of house	.904
Gardening is a pleasant break from everyday stress	.571
Cronbach's alpha value	**0.665**

Single items:

1. Higher density development makes this NB a lively place (Reversely coded).

2. We have enough public open space in this neighbourhood.
3. I would rather live near public parks than have a bigger backyard.

In this way, out of 26 items, 4 factors with 15 items and 3 single items were resulted that were undergone the second phase of factor analysis. The second phase yielded 3 major factors with 12 items, where KMO was high (0.767) and the Bartlett's sphericity test was highly significant. The variables factor ratio as 9 to 1 and item factor ratio as 3 to 1. Table 28 shows the factor solution in second phase of factor analysis of urban residential environment.

Table 28: The second phase of factor analysis of urban residential environment in "The Green"

	Neighbourhood and park	**Garden value**	**Outdoor and Garden attributes**
I feel at home in this NB	.890		
This NB has a prestigious living environment	.837		
I am sure the resale value will go up in this NB	.769		
My children enjoy playing in the public parks	.528		
I often use the public parks for recreational activities	.445		
Gardening is a pleasant break from everyday stress		.797	-.139
A well kept garden increases the resale value of house	-.100	.666	
We have enough (public) open space in this NB		-.109	.755
I am happy with the size of my home garden			.552
I am happy with the design of my home garden			.517
My house suits my family needs		.237	.453
The landscaped backyard is a real bonus to my house	.249		.402
Cronbach's alpha value	**0.823**	**0.665**	**0.704**

Description of factors

1. Neighbourhood and park attributes

The first factor contains five items that explain different attributes of the neighbourhood and public parks. This factor has Cronbach's alpha value 0.823, which indicates the constituting five items were internally consistent and reliable measures of the Neighbourhood and park attributes construct. The five items mainly explain residents' perception and feelings towards the neighbourhood environment, the attachment with and the value of the neighbourhood, and the importance of parks for family and children activities. The measurement of such perceptions would result in the level of residents' satisfaction with the neighbourhood and parks. That means the neighbourhood and park attribute factor scores may be positively related to the satisfaction with the urban environment.

2. Garden value factor

The second factor contains 2 items that explain the value of gardens for pleasures as well as resale value addition. Although the garden value factor has two items, the Cronbach's alpha value is 0.665, higher than the criteria of 0.6 that indicates the constituting items are highly reliable and consistent in measuring garden value construct. The items mainly explain the participants' appreciation for pleasure received from the garden and the increase in home resale value due to the gardens. Thus extracted garden value factor scores may be positively related to the satisfaction with the urban environment.

3. Outdoor and garden attributes

The third factor contains 5 items that explain the home, garden and outdoor attributes. In preliminary interviews the home and garden attributes were found closely associated; which was also expected during the factor analysis process but a slightly different factor structure, containing public open space around home, was received. This factor contains items explaining participants' perceptions towards the size and design of gardens, the free backyard landscaping, the suitability of home along with the appreciation for enough open space in the neighbourhood. The appreciation for public open space was under the public park component during the first phase factor analysis, however clustered with the home and garden items in the final factor analysis. This item increases the Cronbach's alpha value from 0.619 to 0.704, which indicates that this item is internally consistent with the construct. Therefore, the inclusion of open space issue in home and garden attributes alters the nature of the construct, which is more outdoor and garden attributes. It is hypothesised that this scale has a positive relationship with overall satisfaction with the urban residential environment.

B. Urban residential environment in Ridgewood

The participants in Ridgewood were also asked to rate several attitudinal statements explaining different attributes of garden, home, parks and neighbourhood in water sensitive urban residential environment on a 6 point scale, where 1= strongly disagree, and 6= strongly agree. The attitudinal statements were used to explain and measure residents' perceptions, feelings and evaluation of the urban residential environment that would eventually generate satisfaction with the environment. The factor analysis on urban residential issues in Ridgewood was conducted similarly to that in "The Green", which used previously explained factor extracting criteria and the Principle Axis Factoring (PAF) method with direct oblimin rotation. The factor analysis aimed to extract a few meaningful and valid constructs and explore the underlying relationship among the factors to measure the satisfaction with the urban residential environment. However, before conducting the factor analysis, the following two items were excluded because these items appeared to be more associated with groundwater issues.

1. Native plants are always good for better home gardens even in summer, and
2. I like the way that the public parks here collect the stormwater during winter.

After the exclusion of these two items, factor analysis using PAF with Direct Oblimin rotation was conducted with remaining 23 items and following 4 main factors obtained during the two phase of analysis.

Description of iterative factor analysis

Similar to "The Green", the factor analysis of urban environment in Ridgewood was conducted in two phases. The first phase removed the weak and least reliable items from each component of urban environment, namely the garden, home, parks and neighbourhood. The second phase included the strong and highly reliable items under each component and conducted the factor analysis again to get the final factors of urban residential environment. The iterative factor analysis yielded 4 factors with 13 items, where the KMO was high (0.815) and Bartlett's sphericity test was highly significant. The two phase of factor analysis are explained below.

The first phase of factor analysis utilised a modified factor selection criteria in the Principal Axis Factoring with direct oblimin rotation. The criteria were restricted to yield one factor rather than all possible factors that were higher than or equal to Eigenvalue 1.0. Such analysis yielded reduced and reliable item structure for each neighbourhood, park, home and garden construct that is given in Table 29. Out of 9 items, 3 items appeared to be clustered together to yield a Neighbourhood quality construct with Cronbach's alpha 0.843, and two single items. In terms of public parks construct, 5 items out of 7 items turned out to be reliable with Cronbach's alpha 0.732. Similarly for the home construct, 4 out of 10 home and garden attributes clustered together as a home and garden factor (Cronbach's alpha 0.731); and 2 single items. In this way, the first phase of factor analysis yielded 3 factors with 12 items and 4 single items that were included in second phase (final) factor analysis. Table 29 shows the outcomes of first phase factor analysis; i.e., three major constructs and their constituting items along with the single items.

Table 29: The first phase factor analysis of urban residential environment in Ridgewood

Neighbourhood attributes	**Factor loadings**
I feel at home in this NB	.882
This NB has a prestigious living environment	.847
This NB is safe place for raising children	.670
Cronbach's alpha	**0.843**
Public parks	
My children enjoy playing in the public parks	.747
I often use the public parks for recreational activities	.739
I like native plants in the public parks around here	.576
I go to public parks to get myself out of my house	.511
We have enough public open space in this NB	.458
Cronbach's alpha value	**0.732**
Home and garden attributes	
I am happy with the design of my home garden	.726
My home environment has a pleasant feel to it	.679
I am happy with the size of my home garden	.623
My house suits my family needs	.570
Cronbach's alpha value	**0.731**

Single items:

1. I have a good access to community services from my house;
2. This NB is easy to get around;
3. I would rather live near parks than have a bigger backyard; and
4. A well-kept garden increases the resale value of house.

In this way, out of 23 items, 3 factors with 12 items and 4 single items were resulted that were gone through the second phase of factor analysis. The second phase yielded 4 major factors with 13 items, where KMO was high (0.815) and the Bartlett's sphericity test was highly significant. Table 30 shows the factor solution resulted in second phase of factor analysis of urban residential environment.

Table 30: The second phase factor analysis of urban residential environment in Ridgewood

Items	**NB quality**	**Home attributes**	**NB access**	**Public parks**
This NB has a prestigious living environment	.787			
I feel at home in this NB	.775			
This NB is safe place for raising children	.708			
I am happy with the design of my home garden		.762		
My home environment has a pleasant feel to it		.598		
I am happy with the size of my home garden		.587		
My house suits my family needs		.511	.417	
This NB is easy to get around			.826	
I have a good access to community services from my house			.599	
I go to public parks to get myself out of my house				.645
I often use the public parks for recreational activities				.594
My children enjoy playing in the public parks				.560
I like native plants in the public parks around here				.401
Cronbach's alpha value	**0.843**	**0.731**	**0.724**	**0.721**

Description of factors

1. Neighbourhood quality

The first factor has three items that explain residential perception towards the different qualities of neighbourhood. This factor has Cronbach's alpha value of 0.843 indicating the valid and reliable construct. The items mainly explain the neighbourhood as a place having a sense of home, the prestigious living, and safe place for raising children. As the neighbourhood quality appeared to be one of the important factors of urban residential environment, it may be positively related to the satisfaction with the urban environment.

2. Home attributes

The second factor contains four items that explain participants' perceptions towards the home and garden attributes. This factor has Cronbach's alpha value of 0.731, which indicates high reliability of the construct as well as high internal consistency of items to measure the construct. The items mainly explain the suitability of the home and pleasure gained from the home environment along with happiness with the size and design of home gardens. However, the home suitability item was cross loaded with the third factor- the neighbourhood access. Such cross loadings are undesirable and thus this item was rejected from the neighbourhood analysis; but it was retained in the home attribute factor because it is contextually matching with the home but not with neighbourhood access. The home attributes factor score may have a positive relationship with the urban environment satisfaction.

3. Neighbourhood access

The third factor is neighbourhood access, which explains participants' perceptions towards the access to community facilities and public services around the neighbourhood. This factor contains two items but the Cronbach's alpha value is 0.724, indicating that this is a highly reliable variable for measuring the construct. The neighbourhood access factor may be positively related to the satisfaction with the urban environment.

4. Public Parks attributes

The fourth factor contains four items that explain participants' feelings towards different attributes and services of public parks in their locality. This factor has Cronbach's alpha value 0.721, which indicates that the constituting items are internally consistent to construct the valid and reliable public park factor. The public park factor scores may be positively related to the satisfaction with urban environment.

Apart from these 4 major factors, two single items explaining unique underlying concepts and having factor loading more than 0.6 were considered as single item factor and included for further analysis. The single items were:

1. I would rather live near parks than have a bigger backyard and
2. A well kept garden increases the resale value of house.

In this way, the iterative factor analysis utilized 23 items, adopting PAF and direct oblimin rotation method, and yielded 4 factors with 13 items, and with 2 single item factors. That gives the variables factor ratio as 6 to 1 and item factor ratio as 3 to 1.

C. Comparison of urban residential environment constructs in "The Green" and Ridgewood

When comparing the factors of urban environment in "The Green" and Ridgewood, the first difference is the factor number. "The Green" has 3 major factors with 12 items while, Ridgewood has 4 major factors with 13 items and 2 single item factors. In "The Green", the neighbourhood and parks were perceived as one components of urban environment, while in

Ridgewood these two are perceived as two different component of the urban environment. In "The Green", the garden value, and outdoor and garden attributes were considered two different constructs of the urban environment, while in Ridgewood the garden and home attributes are perceived as one construct. Additionally in Ridgewood, neighbourhood access appeared as an important construct of urban environment. The relationship of these constructs to the satisfaction with urban residential environment will be tested by regression analysis and the findings will be explained later in this chapter.

7.5.4. Construct of social environment

A. Social environment in "The Green"

The social environment for an individual means his/her friends, relatives, and neighbours; interaction and relationship with them along with the social institutions. To understand the individual perception towards these components of society, the participants were asked to rate eight attitudinal statements that included the perceptions and relationships with friends, neighbours and social organisations. Also the participants were asked to rate those statements on a 6 point scale, where 1=strongly disagree, and 6=strongly agree. Out of these eight items, the "I am happy with the social mix of local population" item (SE1) was excluded from the analysis as it was considered as a dependent variable, the society satisfaction. Therefore the factor analysis was conducted only with 7 attitudinal items.

The factor analysis aimed to reduce these 7 attitudinal items into a few reliable and valid constructs of social environment and to explain the underlying relationships among the constructs in terms of social satisfaction. For this purpose, exploratory factor analysis using Principle Axis Factoring (PAF) method with direct oblimin rotation was conducted. The factor analysis obtained two major factors with 5 items, which is presented in Table 31. The KMO was 0.693, and Bartlett's sphericity test was highly significant. Further the ratio of item to factor was 2.5 to 1 and the ratio of variables to factor was 3.5 to 1.

Table 31: The factor structure for social environment in “The Green”

Items	Social harmony	Social cohesion
I have good contacts with my neighbours	.849	
We have a good neighbourhood watch around here	.779	
In this NB, residents treat each other pleasantly	.678	
Recoded- There is plenty of privacy in this neighbourhood		.563
Recoded- I never feel socially isolated living here		.558
Cronbach’s alpha value	**0.815**	**0.482**

Description of factors

1. Social harmony factor

The first factor contains 3 items that explain individual perceptions towards the neighbours and their pleasant social behaviours. This factor has Cronbach alpha value 0.815, which indicates the three items are internally reliable and consistent to measure the social harmony construct. The three items mainly explain the nature of contact and behaviour with the neighbours and appreciation for neighbours’ good behaviour to look after the community. As social harmony is the first construct of society, it will have a positive relationship with the society satisfaction.

2. Social cohesion factor

The social cohesion factor contains two items that explain about the privacy in society and help of social organisations. This construct appeared to be very weak in reliability. It has the Cronbach’s alpha value 0.482, which is far below the criteria. Hence the construct itself couldn’t be considered for further analysis, but the 2 items could be used as single item constructs.

In this way, the factor analysis yield only one valid construct with 3 items out of 7 items. Hence the item construct ratio became 3 to 1 and the variable construct ratio became 7 to 1. All these criteria indicate that the constructs were the valid constructs of social environment.

B. Constructs of social environment in Ridgewood

As previously explained, the attitudinal statements ‘I am happy with the social mix of population’ was excluded from the analysis. The remaining 7 items explain various attributes of the neighbours and friends as well as social organisations that constitute the social environment. The factor analysis aimed to reduce these 7 attitudinal items into a few reliable and valid constructs and to explain the underlying relationships among the constructs.

Table 32: The factor structure of Social environment in Ridgewood

Items	Neighbours	Community
In this NB, residents treat each other pleasantly	.767	
Recoded- There is plenty of privacy in this neighbourhood	.693	-.379
Recoded- I never feel socially isolated living here	.668	
I have good contacts with my neighbours	.571	.335
We have a good neighbourhood watch around here		.733
I like the way that the community organisations in Ridgewood help our children to be social		.474
Cronbach's alpha value	**0.745**	**0.526**

Similar to "The Green", factor analysis using PAF method with direct oblimin rotation was conducted for the above mentioned purposes. The factor analysis obtained two major factors with 6 items, which is presented in Table 32. The KMO was 0.690, and Bartlett's sphericity test was highly significant. Further the ratio of item to factor was 3 to 1 and the ratio of variables to factor was 3.5 to 1. All these criteria indicate the constructs were the valid constructs of social environment in Ridgewood.

Description of factors

1. Neighbours

Neighbours factor contains four items that explain the participants' relationship with their neighbours, such as: pleasant behaviours, plenty of privacy, friendly neighbours, and good contacts with neighbours. This factor has Cronbach's alpha value of 0.745 that indicates internally consistent and valid construct of social environment, and may be positively related to the satisfaction with social environment.

2. Community

The community factor contains two items that explain the participants' perception towards community organisation and neighbourhood watch. The community factor has Cronbach's alpha value of 0.526 that indicates the low reliability of the community construct; hence the construct itself is not used for further analysis. However, the constituting items would be used as two single items in further analysis. Additionally, another item about the importance of friendly neighbours for resale value of house is also used as a single item factor.

In this way, the factor analysis resulted in one major factor and three single item variables, which ended up with the variable factor ratio as 7 to 1 and item factor ratio as 4 to 1.

C. Comparison of social environment constructs in "The Green" and Ridgewood

While comparing the social environment factors in "The Green" and Ridgewood, a few differences can be observed. The major one is the factor structure. In "The Green", the social harmony became the single factor of social environment with 3 items that explain the participants' perception towards the activities of their neighbours, such as: good neighbourhood watch, pleasant treatment to each other, and good contact with neighbours. However in Ridgewood, 'the neighbours' factor (with 4 items) explains the participants' relationship with neighbours, such as: good contacts with neighbours, pleasant treatment to each other, plenty of privacy from friends and neighbours, no feeling of isolation due to presence of friends and neighbours. The relationship of these factors to the society satisfaction and overall residential satisfaction will be tested in regression analysis, which is described later on this chapter.

7.5.5. Constructs for overall residential satisfaction

In previous sections, the constructs for satisfaction with individual domains of residential environment were examined. As conceptualised in this research, all 7 different domain satisfactions collectively result in the overall residential satisfaction. To find out the constructs of overall residential satisfaction, the 7 satisfaction items should undergone the factor analysis. If the satisfaction items factor together to result one or a few constructs of the overall residential satisfaction, as hypothesised, there will be no need to of regression analysis to re-evaluate the relationships of the domain satisfaction to the residential satisfaction. The overall residential satisfaction, then, will be tested for its relationship with the behavioural intentions by using regression analysis. The factor structure of behavioural intention will be explained later in section 7.5.6.

A. Residential satisfaction in "The Green"

In "The Green", seven satisfaction items were included to measure residential satisfaction with seven domains of water sensitive urban environment. These were:

1. Overall satisfaction with your house,

2. Overall satisfaction with your garden,
3. Overall satisfaction with your groundwater reticulation,
4. Overall satisfaction with your neighbours,
5. Overall satisfaction with your neighbourhood,
6. Overall satisfaction with the public parks in your locality, and
7. I am happy with the social mix of the local population here

These seven satisfaction items were measured in a 6 point scale 1 to 6, where 1= strongly disagree and 6= strongly agree. These seven items were entered into the factor analysis and resulted in a few reliable and valid constructs to measure the residential satisfaction. The factor analysis was conducted with PAF extraction method and direct oblimin rotation with all previously explained criteria. Out of seven items, 6 items were included in the factor solution that resulted in major factors as shown in Table 33. The KMO was 0.776 and Bartlett's sphericity test was highly significant.

Table 33: Factor structure of Residential satisfaction in "The Green"

	Home Domain	**Neighbourhood Domain**
Garden satisfaction	.958	
House satisfaction	.631	
Groundwater satisfaction	.541	
Society satisfaction		.777
Neighbourhood satisfaction		.671
Neighbours satisfaction	.304	.633
Cronbach's alpha value	**.737**	**.790**

Out of the seven satisfaction items, the parks satisfaction was cross-loaded with both factors, hence was excluded from the factor analysis. The remaining 6 items resulted in two factors, the home domain satisfaction and neighbourhood domain satisfaction.

Description of factors

Three items, namely: garden, house and groundwater satisfaction constituted the home domain satisfaction with Cronbach's alpha value 0.737. This indicated the construct to be internally consistent and reliable. The second factor was the neighbourhood domain satisfaction that was constituted by three items: society, neighbourhood and neighbours satisfaction. This factor had

Cronbach's alpha value 0.790 that indicated the three items are internally consistent and valid measures of the neighbourhood domain satisfaction.

B. Residential satisfaction in Ridgewood

As in "The Green", seven satisfaction items were included to measure residential satisfaction with their living environment in Ridgewood. These were:

1. Overall satisfaction with your garden reticulation,
2. Overall satisfaction with your garden,
3. Overall satisfaction with your house,
4. Overall satisfaction with your neighbours,
5. Overall satisfaction with your neighbourhood,
6. Overall satisfaction with the public parks in your locality, and
7. I am happy with the social mix of the local population here.

As previously explained, these items were measured in a 6 point scale 1 to 6, where 1= strongly disagree and 6= strongly agree. The factor analysis aimed to reduce seven items into a few reliable and valid construct to measure the residential satisfaction. The factor analysis utilised PAF method and direct oblimin rotation. Out of seven items, 6 items were included in the factor solution that yielded two major factors (Table 34). The park satisfaction was lowest in communalities, hence was excluded from the factor analysis. The KMO for the factor analysis was 0.58 (slightly lower than 0.6, but retained the factors) and Bartlett's sphericity test was highly significant.

Table 34: Factor structure of residential satisfaction in Ridgewood

	Home domain	**Neighbourhood domain**
Garden reticulation satisfaction	.887	
Garden satisfaction	.695	
House satisfaction	.620	
Society satisfaction		.668
Neighbours satisfaction	.332	.566
Neighbourhood satisfaction		.474
Cronbach's alpha value	**0.761**	**0.580**

Description of factors

As in “The Green”, two major factors were resulted. The first factor contained three items that were the satisfaction with garden reticulation, garden and house. The Cronbach’s alpha value for home domain satisfaction was 0.761, which indicated higher internal consistency and reliability of the three items to measure the domain satisfaction. The second factor was also constituted with three items: society, neighbours and neighbourhood satisfaction. This factor had marginal Cronbach’s alpha value 0.580; however it was retained because it represented an important domain for residential satisfaction in Ridgewood.

C. Comparison or Residential satisfaction in “The Green” and Ridgewood

The factor analysis yielded two similar factors in both areas, namely: the home domain satisfaction and neighbourhood satisfaction. The only differences were in terms of the factor structure and reliability. The groundwater reticulation appeared to be the last item to measure home domain satisfaction in “The Green”, whereas it (garden reticulation) appeared to be the first item in Ridgewood to measure home domain satisfaction. Another difference was in Cronbach’s alpha value of neighbourhood domain satisfaction. In “The Green” it was 0.790, while in Ridgewood it was 0.580; i.e., the three items couldn’t measure neighbourhood domain satisfaction in Ridgewood as reliably as in “The Green”.

7.5.6. Constructs for behavioural intention

The relationship of the residential satisfaction with the behavioural intention was tested by using regression analysis to explore whether the satisfaction would determine behavioural intentions; and then the intentions would be associated with the respective behaviour or not. This can be implied for resident’s behaviours regarding the NDG system and urban residential environment in the study area.

For developing a construct for behavioural intention, five intentions; namely: recommending, moving, staying, choosing again and where to move, were included in a factor analysis. However, factor analysis of the items (having different scales) could be possible only if they are measuring the intentions in the same direction; i.e., measuring not moving to moving intention in either increasing or decreasing order of scales. In addition, the variables should be quantitative at the interval or ratio level and data should have a bivariate normal distribution for each pair of variables (SPSS Inc, 2010). The scales of the intentions mentioned earlier were oriented differently and required to be adjusted prior to the analysis.

The recommending intention was measured by a question "Would you like to recommend this place to your friends and relatives?" in a 3 point nominal scale: Yes, not sure and no. The moving intention was measured by a question "Would you like to move out from your place within the next year?" in a five point scale, 1 to 5, where 1= definitely no and 5= definitely yes. The third intention, staying intention was measured by an open ended question that was asked only if participants had no intention to move out from their current places. The third question was "How long you want to stay in this place?" and the answers were measured in years. The responses were later categorised into five categories where 1=more than 10 years, 2=5-10 years, 3=1-5 years, 4=unsure (don't know), and 5=moving out.

The fourth intention was choosing again intention, which was asked only if participants intend to move out from their current places. The question was "Would you like to choose again the similar place to live?" and the answers were recorded in 3 point nominal scale: Yes, not sure, and no. Finally the last intention was where to move asked by an open ended question "Where do you want to move if you have to move within next year?" and the answers were recorded in post codes. The answers were later refined into 5 major scales, 1=Not moving, 2=Don't know, 3=Closer suburbs, 4=Within WA, and 5=Outside WA. In this way, the scales were uniformly oriented to measure the ascending order of moving intentions when the values increase.

After the refinement, the intentions were entered into the factor analysis using PCA method of extraction with variamax rotation in "IBM SPSS Statistics 21" that extracted only one factor. The same intention items were entered into a confirmatory factor analysis in "IBM SPSS Amos 21" that also confirmed the same factor. The results for both areas are given below.

A. Behavioural intentions in "The Green"

A factor analysis using PCA extraction method and Varimax rotation was conducted with the five intention items in "The Green". The factor analysis yielded only one factor; the KMO value was 0.725 and Bartlett's sphericity test was significant. The factor solution is given in Table 35.

Table 35: Factor structure of Behavioural intention in "The Green"

	Migratory intention
Moving intention	.921
Staying intension	.841
Where to move	.730
Recommendation intention	.722
Cronbach's alpha value	**0.798**

The choosing intention was not included in the factor structure as it was low in communalities. The remaining four intentions reliably measured the migratory intention factor since the Cronbach's alpha value was 0.830. Higher the factor score, the higher will be the migratory intention and vice versa. The confirmatory factor analysis in "IBM SPSS Amos 21" also confirmed the above findings (Figure 27), the choosing intention had factor coefficient 0.15, that is negligible hence was deleted from the factor structure. The details about the confirmatory factor analysis in "IBM SPSS Amos 21"can be found in Appendix N.

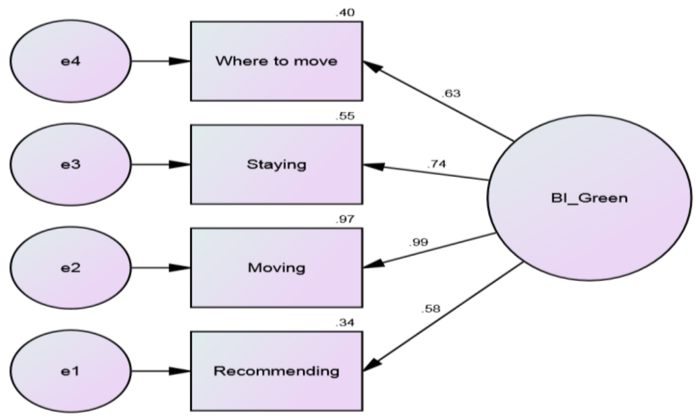


Figure 27: Confirmatory factor analysis of behavioural intentions in "The Green"

As shown in Figure 27, the behavioural intention is significantly predicted by moving (.99***), staying (.74***), where to move (intention to move closer places) (.63***) and recommending intention (.58***). The confirmatory factor analysis model has CMIN 1.64 (df 2, p value>0.05), CFI >.99, RMSEA <0.001, hence the model is an exact fit to the data is tenable. The model is significant at 99% level of confidence; hence the different intentions are valid and reliable items to measure the behavioural intentions in "The Green".

B. Behavioural intentions in Ridgewood

As in "The Green", the five intentions that are subjected to the factor analysis yielded only one factor. The KMO was 0.664 and Bartlett's sphericity test was highly significant. All the five items clustered together to construct one 'migratory intention' factor. This factor has Cronbach's alpha value 0.772, which indicates that the items were internally consistent in measuring this factor. The factor solution is given below in table 36.

Table 36: Factor structure of Behavioural intention in Ridgewood

	Migratory intention
Moving intention	.931
Staying intention	.768
Where to move	.729
Choosing intention	.716
Recommending intension	.591
Cronbach's alpha value	**0.771**

The factor structure was also confirmed by the confirmatory factor analysis in "IBM SPSS Amos 21". The standardised estimates of the model indicate that all intentions were significant at measuring behavioural intention as one construct. The output of such confirmatory factor analysis is given below (Figure 28).

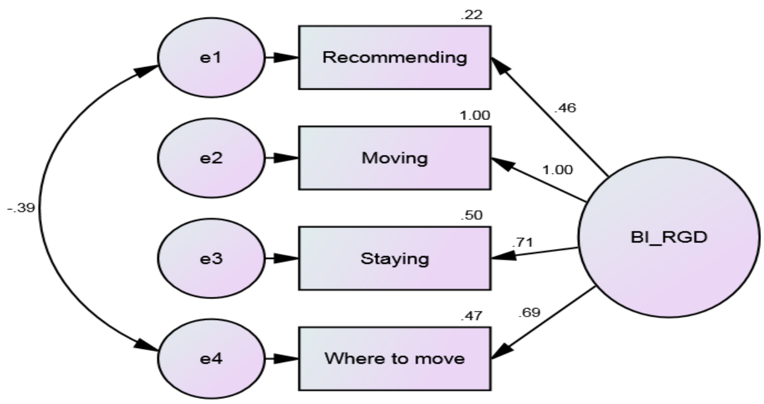


Figure 28: Confirmatory factor analysis for behavioural intentions in Ridgewood

As shown in Figure 28, the behavioural intention is significantly predicted by moving (1.00***), staying (.71***), where to move (intention to move closer places) (.69***), and recommending intention (.46***).The confirmatory factor analysis model has CMIN 2.06 (df 1, p value >0.05), and CFI >.99, hence the model is an exact fit to the data is tenable. The confirmatory factor analysis indicates the choosing intention is not significantly contributing in explaining the behavioural intention construct; and excluded from the model.

C. Comparison or Behavioural intentions in "The Green" and Ridgewood

The factor analysis yielded only one factor in both areas that measures the migratory intention of the residents. Only four intentions factored together to result in the migratory intention factor. The difference was the reliability of the migratory intention factor is comparatively higher in "The Green" than in Ridgewood.

With the help of all the factors of NDG system, water sensitive environment, society, and behavioural intention; this study explored the relationship of the satisfaction and behaviour towards the residential environment, and compared the naturally occurring differences in study areas due to the NDG trial. The discriminant analysis explored the most contrasting variables in between "The Green" and Ridgewood, which is detailed in the following sections.

7.6. Discriminant analysis

7.6.1. Why discriminant analysis?

The main purpose of discriminant analysis is to distinguish the major discriminating variables between the experimental area ("The Green") and control area (Ridgewood). As there were no previous studies like this research, the discriminating variables were selected intuitively. This involved selecting variables logically that might predict the differences between the control and experimental areas. The discriminant analysis combines the independent variable scores in some way so that a new composite value, the discriminant score, is produced. Each study area are supposed to have a normal distribution of the discriminant scores; hence, and the degree of overlap between the discriminant score distributions can be used to distinguish the control and experimental groups.

In this research, the control was chosen as per the similarity in the location, socio-demographics, and land development issues with the experimental suburb, "The Green". The attempt was to make the control as much equivalent as possible to the experimental area in every aspect except the dual water system and associated development that were the experimental manipulations. Further, exactly same research tools and procedures were utilised in both areas to reduce experimental bias and similar participation was recorded.

A detailed description about the item reduction and construct development is already provided. The constructs were the valid and reliable measures of the residential satisfaction with NDG system and urban environment. However, it was still unclear that what construct would mainly discriminate between the experimental and the control areas. In order to identify the most contrasting variables that would cause most variation in outcome in between these two areas, discriminant analysis was conducted. The details of discriminant analysis and major discriminating variables naturally occurring in between experimental and control area due to the experimental manipulations are analysed and explained in this section. For this, the survey data of both areas were combined prior to the analysis and thus combined data set was analysed for the most discriminating variables using statistical software program "IBM SPSS 21".

7.6.2. What is discriminant analysis?

Discriminant analysis (DA) involves deriving the linear combination of the two or more independent variables that will discriminate best between two or more naturally occurring groups (Hair, Anderson, Tatham, and Black, 1995). This is achieved by the statistical decision rule of maximizing the inter group variance relative to intra group variance; which is expressed as the ratio of inter-group to intra-group variance. In Discriminant Analysis, the independent variables are metric variables and predict the categorical dependent variables (two groups or classifications) (Burns and Burns, 2008). DA involves the determination of a linear equation like regression that will predict which group the case belongs to (Hair et al., 1995). The form of the equation or function of DA is:

$$D = v_1X_1 + v_2X_2 + \ldots + v_nX_n + a$$

Where, D = Discriminant function;

v = the discriminant function coefficients or discriminant weights

X = the independent variables,

a = a constant

n = the number of predictor variables

The function is similar to a regression equation or function. The 'v' is the unstandardized discriminant coefficient analogous to the b (intercept) in regression equation. The 'v' maximizes the distance between the means of the criterion (Dependent) variable; however, standardized discriminant coefficient can also be used like beta weight in regression. Good predictors tend to have large weights. The main purpose of DA is to maximize the distance between the categories, i.e. come up with an equation that has strong discriminatory power between groups. There is only one function for the basic two group discriminant analysis, i.e. one less the number of groups (Burns and Burns, 2008). A discriminant score (DA) is a weighted linear combination (sum) of the discriminating variables. DA creates an equation which will minimize the possibility of misclassifying cases into their respective groups of categories.

7.6.3. Description of discriminant analysis

The discriminant analysis was conducted between 'The Green' and Ridgewood. The common variables in the experimental and control data sets were combined and the different variables were excluded. A small number of different variables were about the groundwater supply system, and residential urban environment. When eliminating these different variables from "The Green" data set and Ridgewood data set, required combined data set was resulted.

Further, the variables about the non-drinking groundwater supply system were excluded from the discriminant analysis. This is because the groundwater supply via dual water system is the experimental manipulation for this research. The main aim of the discriminant analysis is to explore other discriminating variables than the experimental variables. However; the variables about the satisfaction with garden reticulation, garden reticulation types, timing, suitability, staining, control and pricing issues were included. Furthermore, the missing data were imputed, the large number of items were reduced to a few reliable factors, and the factors were included in the discriminant analysis to obtain the appropriate discriminant function that explain the naturally occurring differences in between the experimental and control areas.

To derive the discriminant function, the stepwise discriminant analysis method was utilised. The stepwise method involves entering the variables into discriminant function one at a time on the basis of their discriminating power (Hair et al., 1995). Then, the initial variable is paired with second best variable that improves the discriminating power of the function in combination with the first one. The discriminating power is measured in terms of the Wilks' Lambda value, the lower Wilks' Lambda value, indicates more discriminating power of the variables (Burns and

Burns, 2008). In this way, a subsequent number of variables will be selected that explain most of the differences between the groups. The stepwise discriminat analysis with Wilk's Lambda method and the criteria of F value ≤0.01 to enter and ≥0.10 to remove was used for finding major discriminating variables between "The Green" and Ridgewood.

Only three variables, namely: awareness of groundwater trial, residence duration, and garden reticulation satisfaction were entered into the discriminant analysis that explained about 55% naturally occurring discrimination between the control and experimental areas from each other. These discriminant variables were significant at $p \leq 0.01$. The discriminant analysis by statistical software "IBM SPSS 21" can conduct different tests at once to measure the discriminant coefficients, function, and reliability as well as group membership. The findings of these tests are sequentially explained below.

Test 1: Log determinant and Box's M test

The box's M test measures the equality of population covariance matrices to test the underlying assumptions of homogeneity between the group means. If the box's M test is highly significant, it illustrates a highly significant difference on the covariance matrices between the groups, which violates the underlying assumption of homogeneity between the group means. The outliers and other highly correlated items might cause such highly significant test results.

For this discriminant analysis, the log determinant values are similar and Box's M value is 4.576, where F value is 0.743, which is not significant at $p < 0.001$. The insignificant box's M value clearly indicates that the underlying assumption of homogeneity between the group means of the experimental and control groups holds well in this discriminant analysis.

Test 2: Stepwise statistics

The stepwise statistics explains the discriminant model, the main discriminant variables and their contribution in discriminating between the two areas under investigation. As shown in Table 37, three variables were entered into the discriminant analysis. Those three major discriminating variables between the experimental and control areas reduced the Wilk's Lambda to 0.443. The lower the Wilks' Lambda value, the more discrimination will be explained (Burns and Burns, 2008).

Table 37: Stepwise statistics test for discriminant analysis

Step	Entered	Wilks' Lambda							
						Exact F			
		Statistic	df1	df2	df3	Statistic	df1	df2	Sig.
1	Groundwater trial awareness	.538	1	1	127	108.840	1	127	.000
2	Residence duration	.482	2	1	127	67.832	2	126	.000
3	Garden reticulation satisfaction	.443	3	1	127	52.441	3	125	.000

a. Maximum number of steps is 164.

b. Maximum significance of F to enter is .01.

c. Minimum significance of F to remove is .10.

d. F level, tolerance, or VIN insufficient for further computation.

Wilks' Lambda value 0.443 (Table 37) indicates that only 44% differences between the experimental and control areas remained unexplained. In simpler words, almost 56% differences between the two areas were explained by these three variables. Table 37 indicates that among the discriminating variables, the awareness of groundwater supply system alone has explained approximately 46% difference between two areas resulted from the experimental manipulation.

This result indicates that participants experiencing groundwater reticulation were more aware; whereas, the participants having no experience of such system were less aware about it. Furthermore, this finding supports the notion that people usually learn and care more about what they have, therefore on-site trials are essential to increase the public awareness about the alternative water systems for water conservation.

Test 3: Summary of canonical discriminant functions

The canonical discriminant function test produces one less discriminant function than the number of groups used in discriminant analysis. The eigenvalue informs about the discriminant functions produced, which is one less than the groups used in analysis and is the multiple correlations between the variables and the discriminant function. In this analysis only one function is produced and for a single function, it provides an index of overall model fit that can be explained as a proportion of the variation explained. In this analysis, a canonical correlation (R) is 0.746; hence, R^2 will be 0.557. As in regression analysis, this means 55.7% variation in grouping variables i.e., whether the participant is from "The Green" or Ridgewood has been explained by the three discriminant variables.

a. Standardized Canonical Discriminant Function Coefficients

Table 38: Standardized canonical discriminant function coefficients

Discriminant variables	**Function 1**
Awareness of groundwater trial	1.044
Residence duration	-.487
Garden reticulation satisfaction	-.390

The discriminant coefficients (or weights) are like the beta coefficients in regression analysis that indicates the partial contribution of the variables in predicting capacity of the discriminant function. The sign indicates the direction of the relationships and whether the variable makes positive or negative contribution to the function (Hair et al., 1995).

As shown in Table 38, the awareness of groundwater trial was the strongest predictor followed by the residence duration and garden reticulation satisfaction. These three predictors predict the allocation of the participants to "The Green" or Ridgewood group. However, the closer analysis of structure matrix indicates that only the awareness of groundwater trial (0.825) is a significant discriminant factor (>0.3 cut off point).

b. Unstandardized Canonical Discriminant Function Coefficients

The unstandardized discriminant coefficients (see Table 33) are used to derive the discriminant function. In this study, the discriminant function equation, "$D = v_1X_1 + v_2X_2 + \ldots + v_nX_n + a$"; will be:

D= (.831×Awareness)+(-.306×Residence time)+(-.297×Garden reticulation satisfaction) - 0.110

Table 39: Unstandardized canonical discriminant function coefficients

	Function1
Awareness of groundwater trial	.831
Residence duration	-.306
Garden reticulation satisfaction	-.297
(Constant)	-.110

The discriminant score is then compared with the group centroids to describe each group in terms of its profile. The centroids are the group means of predictor variables which were 1.122 for "The Green" and -1.105 for Ridgewood. The cases with discriminant scores closer to the centroids are predicted to belong to that group. Figure 29 presents the mean discriminant scores for all cases that also indicate the group allocation for each case.

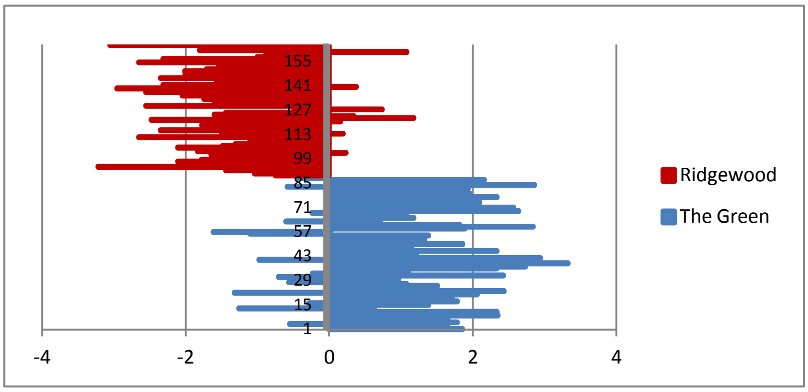


Figure 29: Mean discriminant score for the cases in each group

Figure 29 indicates most of the participants were allocated to their original group; however, a few of them are allocated to different groups. The exact amount of group classification is given below with the help of group classification statistics. This is further clarified in Figure 30. Both figures clearly illustrate that comparatively more cases of "The Green" are towards the centroids of Ridgewood and fewer cases of Ridgewood are towards the centroids of "The Green".

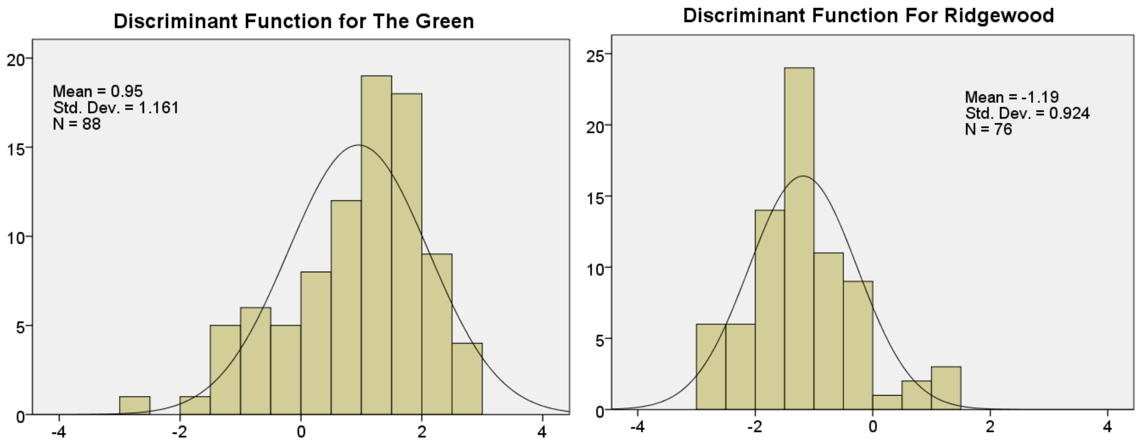


Figure 30: The graphical representation of the discriminant scores of cases in each group

Test 4: Classification of the cases into groups

The classification results reveal that 85.4% original participants and 83.5% of cross-validated participants were classified correctly into "The Green" and Ridgewood. Ridgewood participants were classified with better accuracy (90.8%) than “The Green” participants (77.3%). This finding supports and clarifies the results of above two figures (Figure 29 and 30).

Table 40: Classification test for the cases in discriminant analysis

	Area of participation	Predicted Group Membership		Total
		“The Green”	Ridgewood	
Original	“The Green”	70 (79.5%)	18 (20.5%)	88
	Ridgewood	6 (7.9%)	70 (92.1%)	76
Cross-validated	“The Green”	68 (77.3%)	20 (22.7%)	88
	Ridgewood	7 (9.2%)	69 (90.8%)	76

a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.
b. 85.4% of original grouped cases correctly classified.
c. 83.5% of cross-validated grouped cases correctly classified.

The classification test (Table 40) indicates that the choice of the control was a good one. Most of the cases are correctly classified into their original groups that indicate only a few mix up or contamination among these two areas, which is good for this research.

In this way, the discriminant analysis resolved the three major discriminant variables naturally occurring between “The Green” and Ridgewood as a result of research manipulation, i.e., the NDG system and associated urban development in “The Green”. The awareness of the experimental manipulation is more associated with the historical development of on-site NDG trial in “The Green”. The second important discriminant variable, the residence duration is also associated with the historical development of the study area; that is Ridgewood is developed few years earlier than “The Green”. The third discriminating variable, garden reticulation satisfaction is mainly associated with the main scheme water connection, full household control in garden reticulation and plant types. This shows that Ridgewood people were happier with their mains based garden reticulation than the people in "The Green”.

After the description of discriminant analysis, the following sections will explain the multiple regression analysis that tests the contribution and relationship of the constructs for NDG system and urban residential environment satisfaction. After that the relationship among the satisfaction and behavioural responses were also sought during the regression analysis.

7.7. Multiple Regression analysis

Multiple regression analysis, also known as general linear modelling, is a statistical technique used to examine the relationship between a dependent variable and a set of independent variables. The objective of multiple regression analysis is to use the set of independent variables whose values are known to predict the single dependent variable under study (Hair et al., 1995).

Multiple regression analysis function is given as:

$$Y_0 = b_0 + b_1X_1 + b_2X_2 + \ldots\ldots + b_nX_n + e,$$

Where, b_0 = the intercept (constant);

b_n = regression coefficients;

X = independent variables (metric); and

e = the residual (predictor error).

This multiple regression equation represents the closest fit solution that minimizes the sum of squared deviations from each point to the regression line (Burns and Burns, 2008).The value of the point at which the regression line meets the vertical axis is constant and denoted as the intercept (b_0). The slope of the regression line (b_n) is a geometric representation of correlation coefficient expressed as the change in latent variable (vertical change) per unit change in variable (horizontal change) and expressed in standard deviation units. The residual is also called as error, which is the difference between the actual dependent variable (Y) and the estimated one (*Y*) using the regression equation (or e= Y - *Y*).

In this research, the satisfaction with the dual water system and different components of urban environments are the dependent variables. Multiple regression analysis is used to estimate the satisfaction value for the water system and urban environment with the help of a respective set of independent variables (the factors and single items). While applying the equation to the groundwater issue in this research, the various groundwater factors and single items that appeared relevant and reliable at factor analysis represent the independent variables, i.e., X_1, X_2 .... X_n are used to predict the satisfaction with groundwater system- the dependent variable (Y_0).

7.7.1. Why regression analysis?

This research utilizes the regression analysis technique because it aims to explore the linear relationships between the different factors and attributes of water sensitive urban environment (independent variables) and the residential satisfaction with the environment (dependent variable). Further, the dependent variable is measured on a continuous scale (a 6 point Likert scale) and the predictor variables are measured mostly in the same 6 point Likert scale, and some are measured on a interval scale, and some are dichotomous (dummy variables) too. The type of dependent and independent variables wouldn't be a limiting factor for using multiple regression technique in this research; neither the sample size would be a constraint. Maxwell (2000) states that there are variation in recommendation of appropriate sample size in literature from less than 10:1 to 40:1, and there is no universal thumb rule acceptable to all yet.

However in behavioural research, the sample size of at least 100 will be sufficient for regression analysis when the variables have a medium level of correlation with one another. In this research, the sample size is 176 and the ratio of sample size to independent variable is higher than 10 to 1. The absolute minimum 5 to 1 (Burns and Burns, 2008) was sufficiently covered in this research even in dealing with the sample of each study area (88 in "The Green" and 76 in Ridgewood). While checking for the collinearity problems, the factors of dual water system, urban environment and other predictor variables have moderate level of correlation (less than 0.3) which is not a big issue for the applicability of multiple regression analysis in this study.

Additionally, this research adopts the 99% level of significance (P value = 0.01) rather than 95% level of significance (P value = 0.05) to reduce the chance for family wise error while conducting several analysis in the same sample of moderate size (88 or 76). The whole regression analysis in this study adopted the forward method and the procedures and results from the regression analysis will be described in the following sections that start with the regression model of the groundwater satisfaction followed by urban environment satisfaction and finally the residential satisfaction in each area. The hypotheses regarding each of these satisfactions were described in respective sections.

7.7.2. Regression model for groundwater satisfaction

A. Groundwater satisfaction model in "The Green"

The satisfaction with the groundwater is measured with the help of a single construct, which is, "The overall satisfaction with the groundwater supply system". Participants rated this construct in a 6 point scale 1 to 6, where 1=extremely dissatisfied and 6=extremely satisfied. Participant's satisfaction with groundwater supply system is supposed to be dependent upon their feelings and perceptions towards the groundwater system and its attributes. That means the groundwater satisfaction depends upon the major factors of groundwater system and the other single item variables that were resulted from factor analysis. Therefore, 5 factors of groundwater system, namely: trust in authorities, operation, pricing, fairness and safety; and 7 single items were included in the regression analysis. Hence 12 variables were entered into the regression analysis where the sample size is 88, thus retaining 5 to 1 ratio.

While using the linear regression analysis with forward method and criteria of F value= ≤0.05 for entering the variables, only 4 variables were entered into the regression equation, which suffices the at least 10 to 1 ratio of sample size and independent variables.

Table 41: Regression model for groundwater satisfaction in "The Green"

Model	R	Adjusted R^2	e	F	Sig. F
1	.601[a]	.353	1.080	48.509	.000
2	.678[b]	.447	.999	15.513	.000
3	.703[c]	.476	.972	5.766	.019
4	.720[d]	.496	.954	4.313	.041

a. Predictors: (Constant), Operation factor score
b. Predictors: (Constant), Operation factor score, GW risk in future
c. Predictors: (Constant), Operation factor score, GW risk in future, GW Continuation
d. Predictors: (Constant), Operation factor score, GW risk in future, GW Continuation, Reticulation efficiency

As shown in Table 41 above, the four variables were significant (<0.05) in predicting the groundwater satisfaction, and predicted almost half (50%) variability in residential satisfaction with the groundwater system. However, while examining the confidence level of these independent variables at a 99% (Table 42), only the top three variables appeared to be significant. Therefore only these variables significant at p<0.01 level were included in the regression equation that explain 47.6% variability in residential satisfaction with groundwater system.

Table 42: Coefficients of variables predicting groundwater satisfaction in "The Green"

Model	Unstandardized Coefficients		Beta	t	Sig.	99.0% Confidence Interval for B	
	B	Std. Error				Lower bound	Upper bound
(Constant)	2.495	.660		3.780	.000	.755	4.235
Operation factor	.542	.078	.577	6.955	.000	.336	.747
GW risk in future	-.301	.090	-.265	-3.360	.001	-.537	-.065
GW continuation	.255	.085	.252	2.983	.004	.030	.480
GW Reticulation efficiency	-.174	.084	-.180	-2.077	.041	-.395	.047

When used in path analysis, the standardized Beta weights are the path coefficients leading the dependent variable. In this model the path coefficients leading to GW satisfaction are: 0.577 from Operation factor, -0.265 from GW risk in future, and 0.252 from Preference for GW continuation. The highest contributor for groundwater satisfaction is the operation followed by the risk associated with the groundwater in future (negative) and continuation of groundwater. The path to groundwater satisfaction from the perception of future risk is negative, which means the higher the perceived value of GW risk in future, the less will be satisfaction with the groundwater reticulation.

B. Issues related with groundwater operation.

During preliminary interviews, participants were found to have a positive assessment of the operation of groundwater system mainly because of their trust to water authorities, cheaper supply of groundwater and contribution to their garden quality. Further, the groundwater safety and water efficiency may also lead to the positive apprehension of the groundwater operation, which eventually leads the groundwater satisfaction. To test the relationship of these issues with groundwater operation, the linear regression analysis was utilised, which resulted in the following type of relationships (Table 43).

Table 43: Regression model for Groundwater operation in "The Green"

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.577[a]	.325	1.17443	42.921	.000
2	.669[b]	.435	1.07489	17.665	.000
3	.702[c]	.475	1.03582	7.532	.007
4	.720[d]	.495	1.01553	4.390	.039

a. Predictors: (Constant), Trust factor score

b. Predictors: (Constant), Trust factor score, GW contribution

c. Predictors: (Constant), Trust factor score, GW contribution, GW reticulation efficiency

d. Predictors: (Constant), Trust factor score, GW contribution, GW reticulation efficiency, Fairness factor

As shown in Table 43, the four variables predict almost half (49.5%) variability in the operation factor that is the significant contributor of the groundwater satisfaction. However, while testing the confidence at 99% level, the fairness factor become insignificant (Table 44), thus eliminated from the regression equation. Then the resulting variables predict about 48% variability in groundwater operation factor (Table 43).

Table 44: Coefficients for variables predicting groundwater operation in "The Green"

	Unstandardized Coefficients					99.0% Confidence Interval for B	
	B	Std. Error	Beta	T	Sig.	Lower Bound	Upper Bound
(Constant)	-1.153	.628		-1.835	.070	-2.809	.504
Trust factor	.389	.082	.397	4.774	.000	.174	.605
GW contribution	.385	.095	.338	4.046	.000	.134	.636
GW reticulation efficiency	.231	.081	.224	2.849	.006	.017	.445
Fairness factor	.185	.088	.160	2.095	.039	-.048	.419

The path coefficients leading to GW operation are: 0.397 from trust factor, and 0.338 from groundwater contribution to garden quality, and 0.224 from the groundwater reticulation efficiency. All the paths are positive and significant at 99% level of confidence, i.e., at p= 0.001.

C. groundwater acceptance (satisfaction) model in Ridgewood

The regression analysis from the Ridgewood data set (control group) serves as the final step of construct development process, the replication with an independent sample. The regression analysis measures the reliability and validity of the constructs and at the same time identifies and explains the relationships of the constructs to dependent variables.

As previously discussed, Ridgewood participants were asked to rate several attitudinal statements explaining their feelings and preferences towards an alternative water supply system that utilize groundwater via community bores for watering their gardens (similar of "The Green"). Similarly, they were also asked to assess different items regarding their home, garden, neighbourhood, parks and social environment. The factor analysis, as described earlier, has resulted in similar factors for the groundwater system, urban living environment and social environment; however, with some difference in their constituent items and Cronbach's alpha value. The relationships among these factors and the single items to predict the satisfaction with respective domains of residential environment were analysed by using the regression analysis. The results of which are explained below starting from the regression analysis of the groundwater system.

The factor analysis of the items explaining attributes of groundwater system has resulted in four major factors and a few single items in Ridgewood that were supposed to be the predictor for their satisfaction with the groundwater system (alternative water system in Ridgewood). These factors and single items were included in the regression analysis to see their relationship to the dependent variable "overall satisfaction with the garden reticulation". However, while trying to get a model for satisfaction with the garden reticulation, only one item, 'the household water efficiency' appeared to be significant to predict with just 12% variability in the garden reticulation satisfaction. This may be because the dependent variable is focused on the garden reticulation rather than the alternative water system that is explained and measured by several attitudinal statements and constructs.

The conceptual framework identified that the control would provide the acceptance of alternative water system rather than satisfaction with it. Hence, the Ridgewood participants were asked their attitudinal preferences and evaluation of the alternative groundwater system assuming it would be available in their locality so that it could be related to their acceptance. This acceptance, then may be equated with or lead to the satisfaction with the system.

It also appeared very hard to predict satisfaction with such hypothetical alternative water system, which ended up being insignificant or irrelevant. Thus, the imaginary attributes become insufficient to construct valid attitudes. This suggests that the groundwater factors in Ridgewood were not strong or central enough to fit into the model of satisfaction with the alternative water system (say groundwater system). However as explained in the Chapter Two; the community, without experiencing any particular water system, could make their views on acceptance of the system by assessing different attributes and aspects of that system. Further, the control community have the fully functional standard main drinking water system already in their place (as granted) and there is no need to think about the alternative water system yet. These discussions indicate that the control data supports the attempts to develop a model of alternative water system acceptance rather than satisfaction. The major factors and significant single items of alternative water system are used to predict the acceptance of the alternative (groundwater) water system. The result of regression analysis illustrates that these variables significantly predicted the acceptance of alternative water system, which is explained below.

The dependent variable

Ridgewood participants were asked to respond to two attitudinal items about their acceptance of the alternative water system (groundwater system). These were: "How acceptable would be the groundwater via community bore for watering your gardens?" and "I would be happy to accept the groundwater for watering my garden". These two were measured in a 6 point scale, where 1 indicates the extreme unacceptance and 6 indicates the extreme acceptance. These two items were factored together (PAF with direct oblimin rotation) to get a common alternative water system acceptance factor with Cronbach's alpha value 0.728. Thus resulted acceptance factor was then considered as the dependent variable that measures the acceptance for communal groundwater supply for the garden irrigation.

Regression model for groundwater acceptance

Table 45: Regression model for acceptance of groundwater system in Ridgewood

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.507[a]	.248	1.15768	25.669	.000
2	.604[b]	.347	1.07815	12.321	.001
3	.636[c]	.379	1.05153	4.743	.033

a. Predictors: (Constant), Preference for non-potable indoor use
b. Predictors: (Constant), Preference for non-potable indoor use, Performance factor
c. Predictors: (Constant), Preference for non-potable indoor use, Performance factor, Fairness factor

The Linear regression analysis with forward method and criteria of F value ≤ 0.05 is used to analyse the relationship of the alternative water factors and single item variables to the acceptance with alternative water system. Only three variables: preference for non-potable indoor uses (such as toilet flushing), groundwater performance factor, and fairness factor were entered into the model that explains about 38% of variability in acceptance of the alternatives.

As shown in table 45, three variables predicted approximately 38% variability in the acceptance of alternative water system. The preferences for non-potable indoor uses and performance factor were highly significant at 99% level of confidence; however, the third predictor the fairness factor was significant but only at 95% level of confidence (Table 46). Since, this research set the criteria for level of confidence of 99%, the third factor was eliminated. Hence, only 35% variability in the acceptance of alternative water system was explained by the two variables: the preference for non-potable indoor uses and groundwater performance factor.

Table 46: Coefficients of the constructs for groundwater acceptance in Ridgewood

	Unstandardized Coefficients					99.0% Confidence Interval for B	
Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	.618	.618		.999	.321	-1.018	2.254
Preference for non-potable indoor uses	.309	.086	.365	3.588	.001	.081	.536
Performance factor	.139	.040	.357	3.510	.001	.034	.243
Fairness factor	-.160	.073	-.204	-2.178	.033	-.354	.034

Table 46 shows that the path coefficients for the acceptance of groundwater system are: 0.365 from preference for indoor use, and 0.357 from performance factor. Both paths are positive and highly significant at 99% level of confidence.

D. Issues related with performance of groundwater system

Similar to "The Green", some groundwater system variables were supposed to have relationship with the performance of the groundwater system, such as: trust to authorities, water conservation, risk and safety, and pricing. It was hypothesised that positive perceptions towards the trust, water conservation, safety, and cheaper pricing will lead the positive apprehension of the performance of alternative water system, which eventually lead the groundwater acceptance.

To test the relationship of these variables with the performance of groundwater system in Ridgewood, the linear regression analysis was utilised with all previously mentioned criteria. The regression analysis had shown two variables: trust perception and safety perception, which contribute about 40% variability in the performance of groundwater system in Ridgewood.

Table 47: Regression model for groundwater performance in Ridgewood

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.565[a]	.311	2.85322	34.780	.000
2	.643[b]	.397	2.66894	11.572	.001

a. Predictors: (Constant), Trust factor
b. Predictors: (Constant), Trust factor, Safety perception

As shown in Table 47, only two variables: trust factor and safety perception were entered into the regression equation that explain approximately 40% variability in groundwater performance. These two variables are highly significant with 99% level of confidence in predicting the performance of alternative water system. Table 48 gives the coefficients for these two variables.

Table 48: Coefficients for the constructs of groundwater performance in Ridgewood

Model	Unstandardized Coefficients		Beta	t	Sig.	99.0% Confidence Interval for B	
	B	Std. Error				Lower Bound	Upper Bound
(Constant)	5.831	1.500		3.887	.000	1.863	9.799
Trust factor	.315	.068	.448	4.656	.000	.136	.494
Safety perception	.922	.271	.327	3.402	.001	.205	1.638

The path coefficients for the groundwater performance construct in Ridgewood are: 0.448 from the trust factor and 0.327 from safety perception. Both the paths are positive and highly significant at 99% level of confidence.

The results of above mentioned two regression analysis indicate that the variables that significantly predict the satisfaction with groundwater reticulation in experimental area couldn't predict the satisfaction with standard reticulation in the control; but can predict the acceptance of the alternative (groundwater system). The acceptance of alternative water system couldn't be used as an independent variable for predicting garden, home and neighbourhood satisfaction. However, the garden reticulation satisfaction (single item) will be used for this purpose. This will give us insight about the importance of garden reticulation to be satisfied in living in Ridgewood, so that it could be compared with that of "The Green".

7.7.3. Regression model for garden satisfaction

A. Garden satisfaction model in "The Green"

Garden satisfaction is also measured with a single construct, which was, "The overall satisfaction with the garden". Participants rated this construct in a 6 point scale 1 to 6, where 1=extremely dissatisfied and 6=extremely satisfied. The mean of the garden satisfaction was 4.12 with standard deviation of 1.181. The garden is considered as an integral part of the housing in Australia. "The Green" has developed the dual water system for ensuring water efficiency at household level without compromising the quality of gardens. Garden attributes and gardens as a whole are perceived very positively by the residents in "The Green", which has resulted in two major factors during factor analysis regarding gardens, namely- the garden value and outdoor and garden attribute. Besides, the groundwater reticulation itself has some impact over the garden satisfaction.

The satisfaction of garden is an important component of the satisfaction with living environment, mainly with the home environment. The preliminary interviews have clearly indicated the importance of the gardens and associated attributes for creating pleasant home environment. Therefore, this research explores the impact of the two factors regarding domestic gardens, namely: the garden value, and the outdoor and garden attributes, and groundwater satisfaction as well as a few significant single items using multiple regression analysis. A linear regression analysis with forward method and criteria of F value ≤ 0.05 has been applied for this purpose and the outcome of the analysis is given below.

Three variables, namely: the groundwater satisfaction, garden and outdoor attributes, and lawn preference were included in the regression model of garden satisfaction. These three variables had explained about 39% of variability in garden satisfaction and all these variables were significant at 99% level of confidence (Table 49, 50).

Table 49: Regression model for garden satisfaction in "The Green"

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.522[a]	.264	1.013	32.261	.000
2	.596[b]	.340	.959	10.805	.001
3	.638[c]	.386	.925	7.449	.008

a. Predictors: (Constant), GW satisfaction
b. Predictors: (Constant), GW satisfaction, Garden and outdoor attributes
c. Predictors: (Constant), GW satisfaction, Garden and outdoor attributes, Lawn preference

The groundwater satisfaction was the strongest predictor of garden satisfaction that contributed about 26% variability explanations in garden satisfaction. This was followed by the outdoor and garden attributes and lawn preference. All these variables are highly significant, i.e., at 99% level of confidence, and the coefficients (Table 50) indicates that all these independent variables were positively related to the garden satisfaction.

Table 50: Coefficients of the constructs for garden satisfaction in "The Green"

	Unstandardized Coefficients					99.0% Confidence Interval for B	
Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	.179	.619		.290	.773	-1.453	1.811
GW satisfaction	.397	.076	.452	5.259	.000	.198	.596
Garden and outdoor attributes	.148	.048	.268	3.104	.003	.022	.273
Lawn preference	.164	.060	.231	2.729	.008	.006	.323

Table 50 shows that the path coefficients leading to garden satisfaction are: 0.452 from groundwater satisfaction, 0.268 from Garden and outdoor attributes, and 0.231 from Lawn preferences. All these paths are positively contributing towards improved garden satisfaction.

B. Garden satisfaction model in Ridgewood

Similar to "The Green", Ridgewood participants were asked to rate their satisfaction with their garden on a 6 point scale 1 to 6 where 1=extremely dissatisfied and 6=extremely satisfied. The mean of garden satisfaction is 4.46 and the standard deviation 1.112. The garden satisfaction is supposed to be influenced by the attributes of the garden and garden reticulation. Therefore, the items explaining the different attributes of the gardens and the garden reticulation are included in the regression analysis to predict the garden satisfaction.

The linear regression analysis with forward method and criteria of F value ≤ 0.05 was used to explore the relationship of independent variables over the garden satisfaction in Ridgewood. While doing linear regression analysis using above mentioned independent variables, only two variables were entered into the regression equation. These were: perception to garden design and garden reticulation satisfaction (Table 51).

Table 51: Regression model for garden satisfaction in Ridgewood

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.648[a]	.412	.853	53.609	.000
2	.742[b]	.538	.756	21.092	.000

a. Predictors: (Constant), Perception of Garden design
b. Predictors: (Constant), Perception of Garden design, Garden reticulation satisfaction
c. Dependent Variable: Garden satisfaction

The two variables explained approximately 54% variability in the garden satisfaction. The garden design perception is the stronger predictor than the garden reticulation satisfaction.

Table 52: Coefficients of constructs for garden satisfaction in Ridgewood

	Unstandardized Coefficients					99.0% Confidence Interval for B	
Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	.812	.401		2.024	.047	-.249	1.873
Perception of Garden design	.397	.076	.461	5.216	.000	.196	.598
Garden reticulation satisfaction	.413	.090	.406	4.593	.000	.175	.650

Table 52 indicates that the coefficients of both predictors were positive; hence they were positively related with garden satisfaction. The path coefficients for the garden satisfaction were: 0.461 from the perception of garden design and 0.406 from garden reticulation satisfaction. Both paths are positive and highly significant at 99% level of confidence.

7.7.4. Regression model for home satisfaction

A. Home satisfaction model in "The Green"

The home satisfaction was measured as a single construct, which was "overall satisfaction with the home". Participants in "The Green" rated the construct in a 6 point scale, 1 to 6 where

1=extremely dissatisfied and 6=extremely satisfied. The mean value for this construct is 4.76 with standard deviation of 1.101.

The home satisfaction is hypothesised to be dependent upon the satisfaction with the groundwater reticulation and their garden; the outdoor and garden attributes, as well as a few single items explaining home attributes. The outdoor and garden attribute factor, garden satisfaction and groundwater satisfaction along the single items resulted from factor analysis were included in the regression analysis as a predictor of the home satisfaction. Linear regression analysis with forward method and criteria of F value ≤0.05 was used to test the relationship of those predictor variables to the home satisfaction, regression analysis was conducted. Only two variables, namely: the garden satisfaction and pleasant home environment were entered into the regression equation (Table 53).

Table 53: Regression model for home satisfaction in "The Green"

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.594[a]	.345	.891	46.876	.000
2	.696[b]	.472	.800	21.594	.000

a. Predictors: (Constant), Garden satisfaction

b. Predictors: (Constant), Garden satisfaction, Pleasant home environment

These two variables were significant at p = 0.001 level, and contributed approximately 47% variability in home satisfaction. The garden satisfaction was the strongest predictor of the home satisfaction (34.5%) whereas the perception of a pleasant home environment also significantly predicted the home satisfaction.

Table 54: Coefficients of the constructs for home satisfaction in "The Green"

	Unstandardized Coefficients					99.0% Confidence Interval for B	
Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	.890	.462		1.927	.057	-.327	2.107
Garden satisfaction	.400	.080	.429	5.002	.000	.189	.610
Pleasant home environment	.449	.097	.398	4.647	.000	.195	.704

As shown in Table 54, both the predictors positively contributed for the home satisfaction. The path coefficients leading to house satisfaction are: 0.503 from garden satisfaction, and 0.398 from the pleasant home environment. Both paths are positive and significant at significance level of p=0.001.

B. Home satisfaction model in Ridgewood

As in "The Green", the home satisfaction in Ridgewood was measured by a single construct, which was – "overall satisfaction with the home". Ridgewood participants rated the construct in a 6 point scale, 1 to 6 where 1=extremely dissatisfied and 6=extremely satisfied. The mean value for this construct is 5.19 with standard deviation of 0.706. The home satisfaction in Ridgewood is hypothesised to be related to the participants' satisfaction with their garden and garden reticulation, as well as different attributes of their home environment. Therefore, the home attribute factor, garden satisfaction, garden reticulation satisfaction, and the single items of home environment were entered into the regression analysis to get the model of home satisfaction. The linear regression analysis with forward method and Criteria of F <= .050 was used to explore the relationship of these variables with home satisfaction. The result of such regression analysis is given in Table 55 below.

Table 55: Regression model for home satisfaction in Ridgewood

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.561[a]	.305	.588	33.972	.000
2	.634[b]	.385	.554	10.632	.002

a. Predictors: (Constant), Garden reticulation satisfaction

b. Predictors: (Constant), Garden reticulation satisfaction, Pleasant home environment

Only two variables, garden reticulation satisfaction and pleasant home environment were entered into the regression equation, which explained 38.5% variability in home satisfaction. These variables are highly significant, i.e., at 0.001 level of significance. Table 55 indicates that the garden reticulation satisfaction is the strongest predictor of home satisfaction in Ridgewood unlike "The Green", where garden satisfaction was the strongest predictor of home satisfaction.

Table 56: Coefficients of the constructs for home satisfaction in Ridgewood

	Unstandardized Coefficients					99.0% Confidence Interval for B	
Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	2.525	.418		6.046	.000	1.421	3.630
Garden reticulation satisfaction	.298	.062	.461	4.828	.000	.135	.461
Pleasant home environment	.259	.080	.312	3.261	.002	.049	.470

Table 56 confirms that both predictors positively contribute for the home satisfaction. The path coefficients for house satisfaction are: 0.461 from garden reticulation satisfaction, and 0.312

from the pleasant home environment. Both paths are positive and significant at significance level of p=0.001.

7.7.5. Regression model for neighbourhood satisfaction

A. Neighbourhood satisfaction model in "The Green"

The neighbourhood satisfaction was measured by a single construct, which was- "Overall satisfaction with your neighbourhood". This construct was measured in a six point scale 1 to 6, where 1=extremely dissatisfied and 6=extremely satisfied. Additionally, "The Green" participants rated several attitudinal items that evaluated different components of their neighbourhood. The factor analysis of those items resulted in a 'neighbourhood and park attribute factor' along with a few single items. The factor and single items were tested for their possible relationships with the neighbourhood satisfaction using regression analysis.

Further, the impact of the satisfaction with the groundwater reticulation, garden, home and public parks as well as neighbours and society over the neighbourhood satisfaction were tested. In this way, one neighbourhood and park attribute factor and a few single items along with 6 satisfaction constructs were included as possible predictor variables in the regression analysis. The linear regression analysis with Forward method and criteria of F value ≤ 0.05 is used to analyse the relationship among these variables with neighbourhood satisfaction. The result obtained from the analysis is given in Table 57 below.

Table 57: Regression model for neighbourhood satisfaction in "The Green"

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.669[a]	.442	.777	69.842	.000
2	.804[b]	.638	.626	47.737	.000
3	.824[c]	.667	.600	8.352	.005

a. Predictors: (Constant), Neighbourhood and park attributes
b. Predictors: (Constant), Neighbourhood and park attributes, Neighbours Satisfaction
c. Predictors: (Constant), Neighbourhood and park attributes, Neighbours Satisfaction, Parks satisfaction

As shown in Table 57, three variables: the neighbourhood and park attributes, neighbours satisfaction and park satisfaction were entered into the regression equation, which explained about 67% of variability in neighbourhood satisfaction. All the variables are highly significant (or p=0.001) in predicting neighbourhood satisfaction (see Table 58).

Table 58: Coefficients of constructs for neighbourhood satisfaction in “The Green”

Model	Unstandardized Coefficients					99.0% Confidence Interval for B	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	-.092	.372		-.249	.804	-1.073	.888
NB and park attributes	.138	.024	.411	5.685	.000	.074	.202
Neighbours Satisfaction	.326	.059	.400	5.560	.000	.171	.480
Parks satisfaction	.226	.078	.223	2.890	.005	.020	.433

As shown in Table 58, the path coefficients leading to neighbourhood satisfaction are: 0.411 from neighbourhood and park attributes, 0.400 from Neighbours satisfaction, and 0.223 from Parks satisfaction. All paths are positive and significant at 99% level of confidence.

B. Neighbourhood satisfaction model in Ridgewood

As in “The Green”, the neighbourhood satisfaction is measured by a single construct- the overall satisfaction with your neighbourhood; in a six point scale 1 to 6, where 1=extremely dissatisfied and 6=extremely satisfied. Ridgewood participants rated this construct by assessing different components of their neighbourhood and the factor analysis of the items explaining the neighbourhood components has resulted three factors: the neighbourhood quality, the neighbourhood access, the park attributes, and a few single items regarding neighbourhood and public parks. These factor and single items have their influence over the neighbourhood satisfaction, which is tested by using linear regression analysis. In regression analysis, the neighbourhood quality, neighbourhood access, the public park attribute factors, and 6 satisfactions; i.e., with the garden reticulation, garden, home, public park, neighbours and society were included as independent variables to predict neighbourhood satisfaction. The Linear regression analysis with Forward method and criteria of F value ≤ 0.05 is used to analyse the relationship among these variables with neighbourhood satisfaction. The model obtained from the analysis is given in Table 59 below.

Table 59: Regression model for neighbourhood satisfaction in Ridgewood

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.627[a]	.385	.814	47.991	.000
2	.659[b]	.419	.792	5.260	.025

a. Predictors: (Constant), Neighbourhood Quality factor

b. Predictors: (Constant), Neighbourhood Quality factor, Neighbourhood Access factor

Only two variables, the neighbourhood quality and neighbourhood access were entered into the regression equation that predict 42% variability in neighbourhood satisfaction. The neighbourhood quality factor is significant at 99% level of confidence, however the neighbourhood access is significant only at 95% level of confidence, hence the neighbourhood access has been excluded from the equation.

Table 60: Coefficients of constructs for neighbourhood satisfaction in Ridgewood

	Unstandardized Coefficients					99.0% Confidence Interval for B	
Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	1.707	.411		4.158	.000	.622	2.793
NB Quality factor	.287	.041	.627	6.928	.000	.177	.396
NB Access factor	-.170	.074	-.222	-2.293	.025	-.366	.026

As given by Table 60, the path coefficients leading to the neighbourhood satisfaction are: 0.627 from the neighbourhood quality factor, and -0.222 from the neighbourhood access factor. Neighbourhood quality factor was positively related to neighbourhood satisfaction and significant at 99% level of confidence, while the neighbourhood access is negatively related to neighbourhood satisfaction and only significant at 95% level of confidence. As explained above, the neighbourhood access has been excluded from the regression equation and such exclusion reduces the predicting power of regression model from 42% to 38.5% variability in neighbourhood satisfaction.

In this way, the multiple regression analysis explored the relationships of the constructs of different domains of residential environment to their respective domain satisfaction. The regression models and coefficients were obtained for those domains; however this research aims to understand the overall residential satisfaction in study area. For this purpose, the path analysis was used to test the relationships of the constructs within their respective domains and with the overall residential environment satisfaction. Further, the path analysis aimed to explore the relationship of the residential satisfactions to their behavioural intentions.

7.7.6. Regression model for society satisfaction

A. Society satisfaction model in "The Green"

The society satisfaction was measured by single item construct, which was "I am happy with social mix of local population". This item was measured in a 6 point scale 1 to 6, where 1=strongly disagree and 6= strongly agree. The mean of the society satisfaction is 4.32 with standard deviation 1.130. As this research considered that the society for an individual is comprised of friends, neighbours and social organisations; therefore, individuals' satisfaction with the society was hypothesised to be related with their perceptions and feelings towards their friends, neighbours and social organisations. The factor analysis resulted in one 'social harmony' factor and 2 single items, which were included in regression analysis as the predictor variables of society satisfaction. Additionally, the neighbour satisfaction is also included in the analysis. The Linear regression analysis with Forward method and criteria of F value ≤ 0.05 is used for predicting the relationship of these variables with the society satisfaction.

Table 61: Regression model for society satisfaction in "The Green"

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.583[a]	.332	.923	44.256	.000
2	.673[b]	.440	.846	17.522	.000

a. Predictors: (Constant), Social harmony

b. Predictors: (Constant), Social harmony, Neighbour Satisfaction

As shown in Table 61, only two variables; namely: the social harmony and neighbours satisfaction were included into the regression equation that explained 44% variability in society satisfaction. Both the variables are highly significant at p value 0.001. The social harmony is the strongest predictor that explains about one third variability in society satisfaction.

Table 62: Coefficients of constructs for society satisfaction in "The Green"

	Unstandardized Coefficients					99.0% Confidence Interval for B	
Model	B	Std. Error	Beta	T	Sig.	Lower Bound	Upper Bound
(Constant)	.905	.417		2.169	.033	-.195	2.005
Social Harmony	.224	.040	.468	5.526	.000	.117	.330
Neighbour Satisfaction	.314	.075	.355	4.186	.000	.116	.511

Table 62 confirms that both predictors were positively related to the society satisfaction. The path coefficients leading to society satisfaction are: 0.468 from social harmony and 0.355 from Neighbour satisfaction. Both paths are significant at 99% level of confidence.

B. Society satisfaction model in Ridgewood

As in "The Green", the item "I am happy with the social mix of local population" was used to measure the satisfaction with society (dependent variable) in Ridgewood. The single item construct was measured in a 6 point scale 1 to 6, where 1=strongly disagree and 6= strongly agree. The mean of the society satisfaction is 4.25 with standard deviation 1.021. As previously explained, the society satisfaction was hypothesised to be related to participants' perceptions and feelings towards their friends, neighbours and social organisations. The factor analysis of these items has resulted in one significant ‘neighbours’ factor and 3 single items about the society and social organisations. These variables and neighbours satisfaction are included in regression analysis as the predictor variables of society satisfaction. The Linear regression analysis with Forward method and criteria of F value ≤ 0.05 is used for predicting the relationship of these variables with the society satisfaction.

Table 63: Regression model for society satisfaction in Ridgewood

Model	R	Adjusted R^2	e	F Change	Sig. F Change
1	.363a	.120	.958	11.213	.001
2	.441b	.172	.929	5.687	.020

a. Predictors: (Constant), Neighbours satisfaction

b. Predictors: (Constant), Neighbours satisfaction, Good neighbourhood watch

As shown in Table 63, only two variables: the neighbours satisfaction and good neighbourhood watch are entered into the regression equation that explained 17% of variability in society satisfaction. The neighbours’ satisfaction is highly significant at 99% level of confidence; however, the good neighbourhood watch is significant at 95% level of confidence, but not at 99% level of confidence (Table 64), hence excluded from the regression equation.

Table 64: Coefficients of the constructs for society satisfaction in Ridgewood

	Unstandardized Coefficients					99.0% Confidence Interval for B	
Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	2.582	.510		5.064	.000	1.234	3.931
Neighbours satisfaction	.378	.113	.363	3.349	.001	.080	.676
Good neighbourhood watch	.205	.086	.263	2.385	.020	-.022	.432

As shown in Table 64, both predictors have positive path coefficients; that means they were positively related to the society satisfaction. The path coefficient of neighbour satisfaction was 0.363, and that of good neighbourhood watch was .263, both were significant at 0.05 level of significance.

Unlike in “The Green”, where neighbours’ satisfaction and social harmony predicted about 44% variability in society satisfaction, only 17% variability has been predicted in Ridgewood by the neighbours’ satisfaction and good community watch items. Further, the good community watch was excluded from the regression equation being not significant at 99% level of significance that reduced the explained variability to only 12% in society satisfaction in Ridgewood (Table 52).

7.8. Path analysis

The model of satisfaction with NDG system, home, neighbourhood and society were examined in both study areas that were explained in previous sections. As established from factor analysis, all these different aspects of residential environment eventually constitute two major domains of residential environment: the home domain, and neighbourhood domain. Path analysis aims to explore and establish the relationship of satisfaction with these two domains to the residents' behavioural intentions. The residents' behavioural intention, as explained in the factor analysis section, was a factor of five different intentions, namely: recommending, moving, staying, choosing again and where to move intentions. The relationship of these behavioural intentions was hypothesised to be positive with the residential satisfaction in this research, which is tested by the Path analysis. The detailed outcomes of the Path analysis can be found in Appendix N; and the structural model are presented and described in this section.

7.8.1. The residential environment satisfaction in "The Green"

This research conceptualizes that the satisfactions with different domains of residential environment collectively result in residential environmental satisfaction. On the basis of this, the regression model of groundwater satisfaction, garden satisfaction, home satisfaction, society satisfaction and neighbourhood satisfaction are presented in one diagram as Figure 31 below.

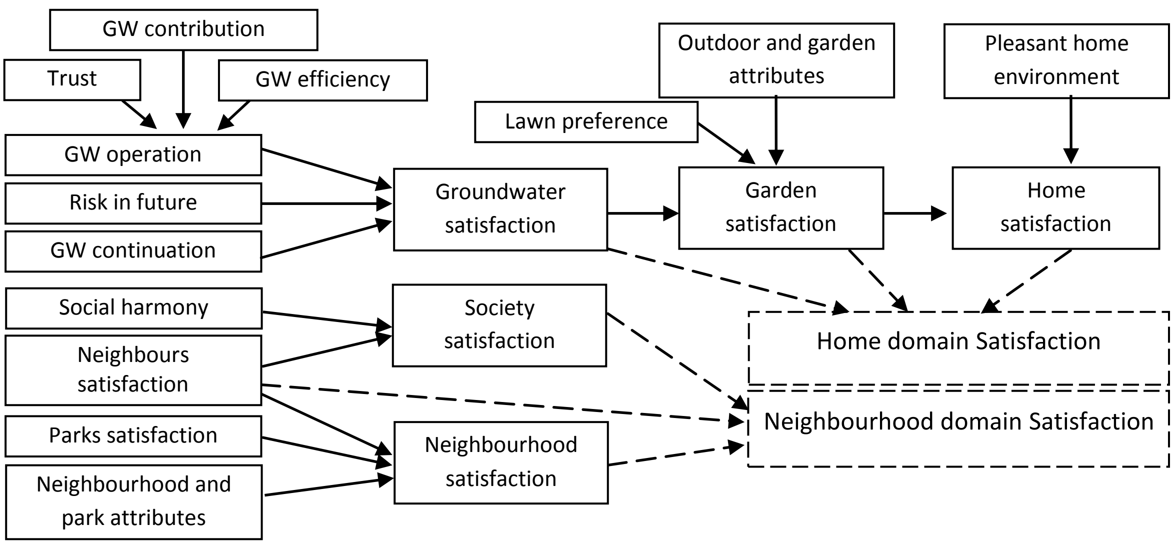


Figure 31: Overview of regression analysis of satisfaction with different aspects of residential environment and their relationship with two major domains the environment in "The Green"

The dotted lines indicate that the different domains of satisfaction factor together to produce two major factors: the home domain satisfaction and neighbourhood domain satisfaction. These two higher order factors represent the residential satisfaction that is hypothesised as a predictor of the behavioural intentions, and eventually behaviours towards the residential environment, in conceptual framework. This relationship will be tested with path analysis as below.

As explained before, the factor analysis of 7 different items explaining satisfaction with different aspects of residential environment confirmed two major factors of residential satisfaction. The factor scores of these two factors were calculated and used as the predictor variables for behavioural intentions in "The Green". The structural model of such analysis is presented in Figure 32 below, whereas the details can be found in Appendix N.

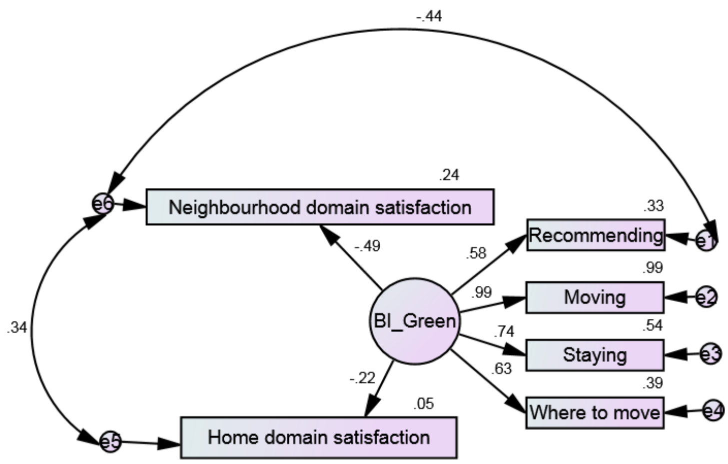


Figure 32: Model of behavioural intention in "The Green"

As shown in Figure 32, the home domain satisfaction (r=-.22**) and neighbourhood domain satisfaction (r=-.49***) both are negatively correlated to behavioural intention. Further, the two domains are positively correlated (.34***), and the neighbourhood domain satisfaction (-.44***) is negatively correlated with the recommending intention. This indicates that when people have higher level of satisfaction with their home and neighbourhood, they would have less migrating intention and vice versa. This is also supported by the significantly positive correlation of behavioural intention with its components, such as: moving intention (r=0.99***), staying intention (r = 0.74**), recommending intention (r=0.58***), and where to move (or intention to move closer) (0.63***). Additionally, the individual with higher level of neighbourhood satisfaction will have lower value for recommending intension, which means he/she will recommend the place to their friends and relatives. Hence it is linked with staying intention, so higher level of neighbourhood satisfaction also has indirect negative relationship with the behavioural intention that is mediated by the recommending intention. This model has CMIN value 6.68 (df = 7, p value >0.05), CFI>0.95, and RMSEA <.001, which indicates the above model is an exact fit to the data is tenable.

7.8.2. The residential environment satisfaction in Ridgewood

As in "The Green", the seven items that explain satisfaction with seven different components of residential environment were factored together that yielded two factors of residential satisfaction in Ridgewood, namely: the home domain and neighbourhood domain satisfaction. Further, the regression models for these satisfactions were also tested and developed. The integration of these models is presented in Figure 33 below, where the dotted line represents the relationship of the satisfaction items to their respective domains.

These two residential satisfaction factors were hypothesised to be predictive of the behavioural intentions towards the residential environment and eventually determine the behaviours towards the environment. This relationship will be tested using Path analysis and the results are described below.

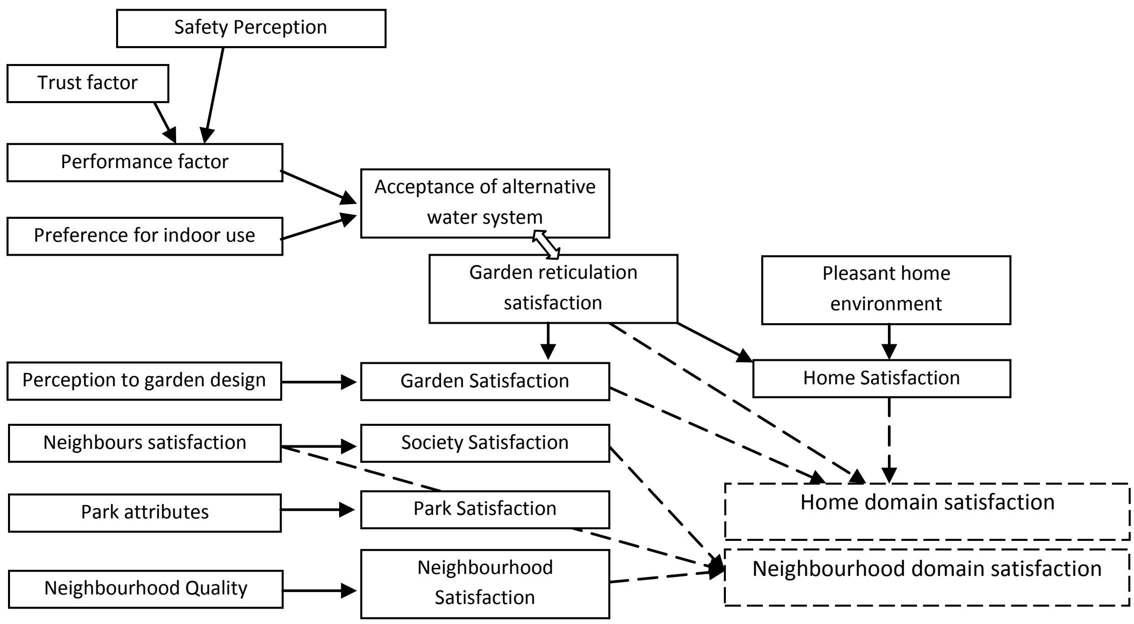


Figure 33: Overview of regression analysis of satisfaction with different aspects of residential environment and their relationship with two major domains the environment in Ridgewood

As explained before, home domain and neighbourhood domain were the two major factors of residential satisfaction in Ridgewood. The factor scores of these two factors were calculated and then used as predictor variables for behavioural intentions in Ridgewood. The structural model of such analysis is given in Figure 34 below, whereas the details can be found in Appendix N.

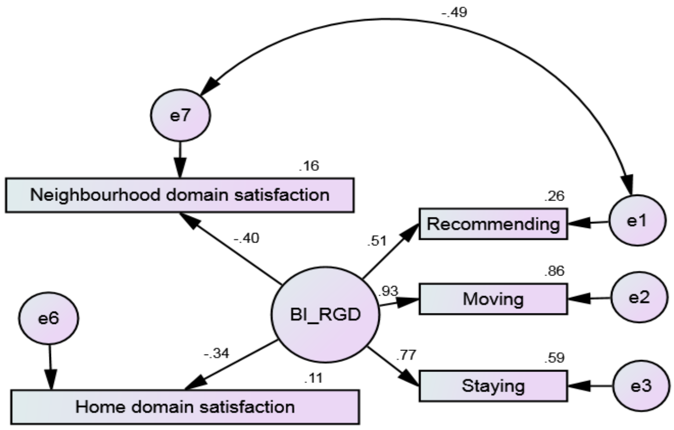


Figure 34: Model for Behavioural intention in Ridgewood

As shown in Figure 34, the home domain satisfaction (r=-.34**) and neighbourhood domain satisfaction (r=-.40***) both are negatively correlated to behavioural intention. Further, the neighbourhood domain satisfaction (-.49***) is negatively correlated with recommending intention. This indicates that the Ridgewood residents having the higher level of satisfaction with their home and neighbourhood would have less migratory intention and vice versa. Additionally, residents having the higher level of neighbourhood domain satisfaction have lower value for recommending intention, which means that they are more likely to recommend the place to their friends and relatives. Hence, they will have lower migratory intentions.

In this model, only three items of the behavioural intention were retained. All these items have significant positive correlation with behavioural intention, such as: moving intention (r=0.93***), staying intention (r = 0.77***), recommending intention (r=0.46***), and choosing again intention (0.56***). The 'where to move', and 'choosing again' became insignificant in predicting the behavioural intention, hence excluded from the model. This model has CMIN 1.23 (df 4 and p >.05), CFI >.99, and RMSEA <0.001, hence it is an exact fit model to the data and the model represents the relationships among the variables.

In this way, different satisfaction items factor together to result in two major factors, the satisfaction with home domain and neighbourhood domain. Hereafter, the regression of those items back to these factors would make no sense. The models of different domain satisfaction can be integrated (wherever possible) to see the integrated model and relationship with these two domains of residential satisfaction. Further, the factors of residential satisfaction would be utilised to predict the behavioural intention in both study areas. There appeared significant negative relationship between the factors of residential satisfaction, where the neighbourhood domain satisfaction was the most crucial predictor for behavioural intention that was directly related to the adapting or moving behaviours.

7.9. Conclusion

This chapter provides detailed descriptions on the findings of quantitative household survey on residential satisfaction with NDG system and water sensitive urban environment. This chapter explains the response rate, missing data, socio-demographics and other descriptive characteristics of the survey responses. In addition, the NDG system issues, residents' perceptions and feelings towards the groundwater reticulation in their gardens, the staining issues and control issues are explored and explained.

In this chapter, the attitudinal items reduction and construct development are explained in details as a third and fourth step of scale development process. About 80 attitudinal items regarding the attributes of NDG system, garden, home, neighbourhood, public parks and society were reduced into 14 valid and reliable constructs in "The Green" and 13 constructs in Ridgewood that are taken into further analysis to measure satisfaction with respective domains of residential environment. This chapter also explains that the influence of the domain satisfactions to overall satisfaction is moderated by either the home and or neighbourhood, evident in the factor analysis and path analysis.

Finally, the relationships of residential satisfaction with each domain satisfaction as well as with the behavioural intentions are tested with the help of regression analysis in both study area. After that, a complete model of residential satisfaction and behaviour towards the alternative water system and water sensitive environment is presented, and the reliability and robustness of the model is tested with the Help of path analysis. In this way, this chapter investigates the hypotheses regarding residential satisfaction with the alternative water system and urban residential environment, and behavioural responses towards the environment as enquired in research question one and two.

CHAPTER 8: Analysis of Challenges to water authorities

8.1. Introduction

This chapter triangulates the research findings to understand the broad picture of the residential satisfaction and behavioural responses as well as the utility and applicability of an alternative water system in urban residential settings. This chapter further explains the challenges to water authorities in managing the NDG trial to achieve the water conservation and water efficiency targets while meeting customer concerns and expectations. This chapter utilises a variety of information to explore and describe the scopes, challenges, and planning implications of the NDG system in the form of dual water system in urban settings. The main data sources were: the secondary data about the household water consumption; the qualitative responses on the open ended questions of the survey-questionnaires; and the qualitative information from the stakeholders' meetings and seminars. The secondary data analysis exposed the problem of over-consumption of groundwater in “The Green”, while the qualitative information reflected the problems of clarity in authorities’ roles and responsibilities, inconsistency in groundwater operation, and customer expectation issues in groundwater system management. As the groundwater system was developed only in “The Green”, the discussion is limited to “The Green” only, however some relevant issues from Ridgewood are also referred throughout the chapter.

8.2. Water conservation in study area

The average household water consumption in “The Green”, Ridgewood and Butler-Ridgewood area was derived from a secondary data supplied by the Water Corporation. The Butler-Ridgewood area is a north-west district of the City of Wanneroo that contains the Ridgewood, ‘Brighton Estate’ (inclusive of “The Green”) and Jindalee developments. In “The Green”, both scheme water and groundwater were supplied; whereas in Ridgewood and Butler-Ridgewood area (except “The Green”), only scheme water was supplied. Although the dual water scheme was started in 2007, the number of households connected to the system was very low until 2010

(Table 65), hence only the data of 2011 was used for analysis of overall water consumption in the study area.

Table 65: Connections and scheme water consumption data (2005-2011)

Area	**Water consumption in KL**						
	2005	2006	2007	2008	2009	2010	2011
Butler-Ridgewood Area	601616	712002	974528	1193468	1292567	1396778	1432619
Average	260.44	253.74	299.76	322.74	307.68	296.68	283.35
"The Green" Sample^ (N)			0 (1)	130 (18)	1228 (31)	4574 (46)	7349 (58)
Average			0	7.22	39.61	99.43	126.71
Ridgewood Sample^ (N)	288 (1)	545 (12)	2258 (24)	5261 (28)	9184 (33)	10843 (39)	11278 (46)
Average	288	45.42	94.08	187.89	278.30	278.02	245.17

^The sample represents only those participants who provided their consent to acquire their household water consumption data from Water Corporation. 'N' inside the small bracket indicates the number of participants connected to the water supply system in given year.

The figure for average water consumption of "The Green" and Ridgewood sample were the average figure for the households that were connected in 2011, no matter how much water they consumed throughout the year. There were 12 new connections in 2011, which were unlikely to consume water as much as the households that were already connected to the water system. To make the average figure more logical, all households consuming less than 50 KL water in the very year 2011, were excluded from the analysis. Such exclusion resulted in adjusted average household water consumption as shown in the Table 66.

Table 66: Adjusted household water consumption (KL/household/year in 2011 only)

	'The Green'	**Ridgewood**	**Butler-Ridgewood**
Scheme water average	126.7	245.2	283.4
Adjusted scheme water average (≥50 KL/year)	172.5	315.8	-
Groundwater Average	196.1	Not Available	Not Available
Total household water consumption	368.6	315.8	283.4

As shown in Table 66, the average household water consumption in "The Green" was 126.70 KL in 2011, which was about 156 KL (55.3%) less than the average water consumption of Butler-Ridgewood area (283.35 KL). While excluding those households consuming less than 50KL/year, average household water consumption in "The Green" became 172.42KL. This was about 111 KL (39%) less than the average water consumption in Butler-Ridgewood area. This illustrates that "The Green" has well achieved the target of 30% reduction in household scheme water consumption. In the same year, average household water consumption in Ridgewood was 245.17 KL, which was 38.18 KL (13.47%) less than the average water consumption in the Butler-Ridgewood area. After excluding the households consuming less than 50KL/year, average household water consumption in Ridgewood became 315.83 KL, which was 32.48 KL (11.46%) more than the average scheme water consumption in Butler-Ridgewood area. This indicates that scheme water consumption in Ridgewood is significantly higher than the average scheme water consumption in "The Green" and slightly higher than the Butler-Ridgewood area. This clearly indicates that the NDG system had contributed for the water efficiency in "The Green".

As an additional supply, the groundwater is used for garden watering in "The Green". Hence, the total household water consumption in "The Green" should consider the groundwater consumption too. For this, the average consumption was calculated by dividing the bulk amount of groundwater used for residential watering by total number of connections in "The Green", which was 196.1KL/year in 2011. When the average amount of groundwater consumed in "The Green" was added to the average drinking water consumption, the average total household water consumption became 368.6 KL in "The Green", which was 85.2 KL (30%) more than the average of Butler-Ridgewood area. This suggests that the groundwater has been consumed excessively in "The Green" which increased the total household water consumption by 30% beyond the average consumption in surrounding areas.

The over consumption of groundwater may be linked to the newly established home gardens and public parks and ongoing development around "The Green". The newly constructed home gardens were exempted from garden watering restrictions for 35 days in winter and 42 days in summer with at least 2 times a day for first 15 days of establishment (Water Corporation, 2013c). Furthermore, the groundwater in "The Green" had been consumed in some unexpected uses, such as construction and dust suppression that led to the apparent over consumption of groundwater.

Water Corporation and water providers (the developer) were fully aware about this situation and they had informed the community about the overconsumption and initiated some water saving approaches, such as: requesting households to check their reticulation controller and reduce their groundwater usage; checking the leakages and wastages; and providing groundwater one day less in a week; i.e., only two days a week. These approaches would definitely encourage the community to reduce the groundwater usage, and enable the local provider to supply groundwater well below the allocated amount. However, the conclusive remarks on the impacts of such groundwater saving approaches would be impossible and impractical with only one year data, it would be more appropriate to conduct another study after few years to assess the full impact of these groundwater saving strategies. Having said that, there is no doubt that this overconsumption would come under control once the community and groundwater system reaches maturity; i.e., the community will be fully developed, all households will be connected to groundwater system, and all the gardens will be established.

Further, it is important to consider that the groundwater in “The Green” is sourced from the superficial aquifer that is directly recharged by rainfall. The water sensitive urban design (WSUD) implemented in “The Green” has been reported to increase the recharge by 383 ML per year over that of pre-development conditions (GHD, 2006). The report also confirmed that after extracting 209 ML of groundwater per year for communal watering, there would still be an increase in net recharge by 174 ML per year to the superficial aquifer.

A net increase in recharge by 174 ML/year could not be a justification for an increase in average household water consumption by 30%; however, this observation suggests that the groundwater supply system is not depleting the groundwater resources and is environmentally sustainable. Moreover, the 39% scheme water saving illustrates the significance of the groundwater supply via dual water system in the promotion of scheme water conservation.

8.3. Qualitative survey responses

The overconsumption of groundwater was a great issue for the water providers, but not noticed by the local residents. Furthermore, residents expressed their concerns about the insufficiency and inconsistency in groundwater operation. These issues were explored by analysing the open ended questions included in the survey questionnaires.

During the survey, the participants were asked five open ended questions that enquired about their personal feelings and perceptions towards the dual water system, household gardens, garden reticulation and urban development. This information provided the rich qualitative data about resident’s feelings and attitudes towards the new water system and urban development and also provided the reasons for their behavioural responses. This qualitative information was analysed using qualitative analysis approach (Miles and Huberman, 1994) as discussed previously. Some of the issues were discussed previously in description of groundwater issues; however, the qualitative analysis regarding their wider implications is presented in this chapter.

The main issues were coded and major themes were identified. The thematic analysis not only explored some important aspects of dual water operation and management, but also explained resident's perspectives towards the issues. The issues were: concerns about clarity in roles of different authorities; concerns about automatic operation and household control of groundwater supply; customer expectation in relation to groundwater operation, maintenance and pricing; garden reticulation adjustment; and garden landscaping and plant selection. These are described in following sections.

8.3.1. Clarity of stakeholders roles and responsibility

As stated earlier, this dual water trial in 'The Green' was initiated as a joint effort of a water provider (Water Corporation), a property developer (Satterley Property Group) and the local council (City of Wanneroo). The Water Corporation supplies both drinking and non-drinking water, Satterley develops and manages the system up to 5 years after final connection, and City of Wanneroo provides land for residential and commercial development. Besides these major parties, "Total Eden" was appointed for day-to-day management of the DWSS trial and household reticulation. The Department of Water and the Department of Health have their roles for allocating groundwater and maintaining health standards of the GSS. Involvement of multiple institutions in this trial ensures integrated land and water management planning at strategic level as desired by the National Water Initiative, 2004 (National Water Commission, 2009) and Western Australian Planning Commission (2008b). However, such a multiple tier of institutional arrangements sometimes creates confusion at decision-making and results in a delayed project delivery.

The qualitative responses from survey participants indicated that most of them had little knowledge about the multiparty involvement in the non-drinking groundwater trial project. They perceived the Water Corporation as the sole developer and provider (owner) of the dual water supply system as they were paying directly to Water Corporation for both water supplies. The participants perceived the local provider "Total Eden" as the landscaping company only and the Satterley property group as property developer. Most of the participants were not aware of the roles of the property developer and landscaping company in the non-drinking groundwater trial operation and management. Such unawareness about the multi-party involvement was often reflected in participants' impatience and discontentment about ongoing trial development.

This situation could be improved with sufficient and earlier information about the groundwater trial development and multiparty involvement in it. The first home owners were provided sufficient information; however the once off information to first homebuyers is often forgotten and not likely to be transferred to second homebuyers and renters. Participants reported that they need to know precisely who is responsible for what regarding groundwater trial and associated issues.

Information provision should provide the answers but not limit to the following questions:

a. Who owns the bore network?
b. Who controls it?
c. Who operates it?
d. Who manages the pumps, and all reticulation?
e. Who charges for groundwater usage?
f. Who monitors the groundwater quality, and health hazards?
g. Who is responsible for cross-connection?
h. Who checks for the supply irregularities and wasteful water uses? and
i. Where can residents get information about the GSS?

8.3.2. Concerns about operation and control

The non-drinking groundwater system was proposed to be centrally controlled by the local weather station. The local weather station had already been established but not been commissioned yet and the community bores are being operated manually by the local operator "Total Eden". The manual bore operation is said to be congruent with the weather information provided by the weather station. The justification for not commissioning the weather station is incomplete construction of the houses that meant the groundwater system hadn't been connected to every household. For each additional groundwater connection, the pressure gauge should be recalibrated to ensure the designated pressure; hence the involvement of weather station at midst of incomplete connection could cause unreliable groundwater supply. Further, some households were reported for tampering their household controller to get watering of their gardens every time the bores were operated.

Additionally, the bores were operated with a four digit pin number which is only accessed by the designated technician from the local provider. Participants expressed their concerns if by any chance, this pin number was leaked to any residents, he/she could operate the bores at any time irrespective of rota system. The suggested solutions for this potential problem were either making the groundwater operation fully automatic or metering the groundwater and charging according to the amount of consumption. Some participants strongly supported the weather station control and full automatic groundwater supply, while others prefer the household control with metering. The household control was preferred as that would enable householder to have full control over their garden reticulation; and could alter it according to the plant types and garden designs.

The participants' perceptions towards the groundwater metering will be described in the next section; however, similar debates were also evident among the stakeholders. These will be discussed later in this chapter.

8.3.3. Metering of Groundwater system

Due to a large number of garden establishment exemptions and some unexpected uses; such as: dust suppression, construction etc., the groundwater consumption in "The Green" exceeds the allocated amount. This over consumption has triggered a debate on approaches for securing water efficiency of the groundwater trial. One such approach, the application of meters to measure the groundwater usage has been put forth by the Water Corporation. Groundwater metering is supposed to make the customer accountable for their usage and enables billing according to the amount of consumption. The other consequence of such metering would be additional cost for the meter itself and regular meter readings that may make groundwater less cost-effective for developers and more expensive for customers when compared to the current non-metered supply.

The participants were asked their preferences towards the groundwater metering during the survey. The responses were more positive for metering; however, some participants also believed that the flat annual pricing was appropriate. Participants supported the metering because they can get full control over their garden reticulation when the groundwater is metered as for the mains water supply. Participants also mentioned that most Australians are aware about the need for water conservation and they would voluntarily consume less water in their garden to achieve water conservation and water efficiency target even after metering. However, some participants strongly support automatic weather station control as it ensures equitable water supply for all households at an equal annual fee for groundwater usage.

The discussion at stakeholders' level indicates that the groundwater metering is highly likely to be implemented very soon mainly to control the excessive consumption of groundwater. Such alteration would definitely limit the applicability of the weather station control and alter the flat annual levy to meter-charging (possibly at 2nd tier of pricing, i.e., \$1.84/KL). There is still discussion among the stakeholders about the better utilisation of the weather station dedicated for the NDG system in "The Green" if not employed for controlling the system. Nevertheless, the complex nature and wider socio-economic impacts of the metering is out of the scope of this thesis and should be well explored and thoroughly planned before implementation.

8.3.4. Filters in groundwater system

In "The Green", the groundwater has been supplied without any treatment. It is approved for garden watering purposes only. However, the groundwater has slight salinity and low concentrations of iron and calcium oxides that may cause white and or brown staining. Further, the solids, mainly sand, in local groundwater may pass through the bores to household reticulation. This may block the sprinklers or drip reticulation. Despite not being included in the development planning, about one third householders have installed water filters to their groundwater supply before connecting it to their garden reticulation to remove the solid materials. Moreover, a quarter households were unsure about the filters in their garden reticulation, which may be due to either limited information by the water providers and developers or limited interest of householders to their garden reticulation as it is automatic and controlled by a third party.

The filters and other previously explained adjustments triggered discussion at the stakeholder level in relation to better and cost effective operation of the groundwater system in "The Green". The discussion is presented later in this chapter.

8.3.5. Customer expectations

Survey participants were asked about their preferences for changes in their garden reticulation and gardens. These customer expectations and preferences were appearing to be around more flexible and therefore more responsive management initiative of the non-drinking groundwater trial project. Their most expressed desire was to have control over their garden reticulation and garden design. However in the light of excessive groundwater usage, authorities should discuss with the residents as to how to meet their preferences while achieving the trial project target of water conservation and efficiency.

Participants were also expecting a participatory approach in managing the groundwater trial project, which will facilitate the education provision and regular information dissemination to the community. Thus, the participatory approach in garden reticulation technologies was perceived as effective in resolving any community concerns. Most of the community concerns may dissipate with the maturation of the groundwater system and the community. However throughout the transition period, the stakeholders should address community expectations around the operation and control of groundwater reticulation to maintain their trust and belief in the groundwater system. The following section included detailed discussions about the planning implications of the community expectations as well as stakeholders' perspectives for the groundwater trial management.

8.4. The stakeholder's perspectives (Meetings and seminars)

The secondary data analysis exposed the problem of over-consumption of groundwater and the qualitative survey responses outlined various divergent customer preferences from trial project targets for groundwater supply and garden landscaping. Additionally, the quantitative analysis of household survey data developed a model of residential satisfaction with dual water system and urban environment. These issues were presented and their planning implications were discussed with the stakeholders; mainly the Water Corporation, Satterley Property Group and City of Wanneroo. Most of the discussions were in the form of formal meetings and seminars; however some informal personal talks were also held. The information from these meetings and seminars were recorded by the researcher in two forms: paper-notes and audio-tape recording and used as qualitative data for analysis.

8.4.1. Groundwater consumption

As previously presented, the household water consumption in "The Green" is more than the average household water consumption in surrounding suburbs, mainly because of the groundwater consumption. The average groundwater consumption in "The Green" is 196KL per household per year, which is more than the average drinking water consumption. While asking the possible reasons for such excessive groundwater consumption, stakeholders provided the following details and possible reasons.

“The Green” is a new suburb which is still under construction. The garden establishment exemption is generally supposed to consume extra 50% water in comparison to the established ones. With this consideration, the groundwater overconsumption limit can be extended up to 140-150 KL per households; however about 200 KL per household was surprisingly excessive (almost double the project target).The higher groundwater consumption may be because of the construction phase of the large blocks with larger gardens, which were completed first. “The Green” will be completed with smaller blocks that might consume less water. Therefore, in coming years, the average household water consumption is highly likely to be well below the metropolitan average (about 280KL/year) and closer to the project target (about 200KL/year). Further, the groundwater was supposed to be used by the new ongoing development for construction and dust suppression purpose, which also led overconsumption. As discussed previously, the groundwater system was proposed to be centrally controlled by the local weather station, but not commissioned yet. However, the automatic operation of groundwater controlled by the weather station would be rational after the maturity of “The Green” community. This will encourage less groundwater use. Moreover, as the authorities have already initiated groundwater saving approaches, they estimated the overconsumption would be rectified in coming years. Further, the construction work is nearly completed and the community is almost established, which would definitely reduce the groundwater usage in future.

There are no debates that the customer should pay for the groundwater usage, but there are debates on the fairest form of groundwater charging. The metering of the groundwater supply can measure the amount of groundwater usage precisely, and then charge according to the usage, which could be the fairest approach. However, there are costs associated with this approach that eventually will pass down to the customers. These are: the cost of meter, meter reading, billing, and data management. Metering could increase the cost of groundwater than the current flat annual levy; however, would provide more flexibility and more control to the householders for their garden watering. Therefore, in either cases - metering or non-metering, water authorities should sort out an appropriate pricing system for the NDG supply that would be cost effective, competitive, and comfortable for costumer to pay. The pricing system should aim for cost-recovery, but neither should discourage the groundwater consumption (in case of higher prices) nor should allow the profligate use (in case of lower prices).

8.4.2. Filters and Groundwater Quality

Another issue that drew attention of the stakeholders was the filters connected to the groundwater reticulation that were not imagined during planning of the trial project. Almost 35% of households have filters connected to the groundwater system in "The Green". However, the filters do nothing for the staining. Additionally, the staining occurrence in "The Green" is lower than the average suburb that is irrespective of the filter use. The low occurrence of staining may be because of deep water table (about 60 meter below the surface), and reasonably good water quality. The groundwater quality was appropriate for watering garden and parks, so the essence of filters was not considered during the planning of the groundwater trial. However, during the development phase, the local provider started connecting the filters into groundwater reticulation as per request of the householders. The stakeholders considered this as a volunteer work of the households for improving their garden reticulation. The filters were mainly used to remove the solid particles and sand from the groundwater supply, so that the sprinklers and drips wouldn't clog up. They should change their filters every 6 months for better performance. However, approximately 25% householders had no idea about the filters and 40% of them don't have the filters connected to their groundwater reticulation.

The default setting of the groundwater reticulation was well-matched with the plant types, the garden design and the reticulation types. The sprinklers and the drips should be of given standard to fit into the system, the system should have designated pressure; i.e., lower than the drinking water supply, and the plants should be water wise. For any alteration in the system or reticulation, participants should consult the local provider and get instructions and instruments to perform changes in their garden reticulation. This arrangement was for maintaining standards of the reticulation rather than restricting residents from the changes in their reticulation and garden. However the householder's demand for an increase in testing time from current 2 minutes to at least 5 minutes was taken positively by the stakeholders.

8.5. Conclusion

Over the period of the research, residents as well as the groundwater operator have implemented a number of adjustments in the non-drinking groundwater system; mainly in terms of operation at household level and or at community level. The main adjustments were:

installation of groundwater filters; alteration of garden design, lawn and plants by households; and rota system for operation of groundwater reticulation by the water provider.

Apart from these adjustments, more water was required to establish gardens and this was provided through exemptions from restrictions. Such exemptions along with the provision of water for dust suppression and other unexpected usages led over consumption of groundwater in "The Green". Other reasons for such overconsumption may be inconsistent use of groundwater at household level, and usages in construction purposes. The overconsumption of groundwater led to an increase in overall water consumption in "The Green", which otherwise was efficient in terms of drinking water consumption (40% less than metropolitan average). As authorities initiated groundwater saving strategies, they estimate the overconsumption will come under control in coming years.

In parallel, there are ongoing discussions at the strategic level regarding the applicability of further permanent demand management practices, such as the installation of meters, and two days a week watering. The separate meter installation will facilitate measurement of groundwater usage and charge accordingly. Such provision is supposed to make the customer accountable for their groundwater usage and reduce its wasteful consumption; however, there are associated costs (both short term and long term) with such separate metering approach.

This chapter has shed a light into these inherent challenges for water authorities in developing and managing the innovative groundwater supply via dual water system. Since the system was the first large scale development (at sub-division level) experience for the WA water authorities and has been established for five years so far, this study only uncovered some issues regarding the system management and customer concerns. It indicated some immediate challenges, such as: to clarify the role of different institutes involved in the trial project, and control of over consumption of groundwater; and some long term challenges, such as: to manage customer expectations, project sustainability, and climatic uncertainties. These issues will eventually settle down once the NDG system and associated urban community development finishes and or matures. Having said that, the full assessment of the impacts of the NDG system on water conservation, water efficiency, community development, and climatic resilience would be possible only after five or ten years of establishment. After complete establishment, the only remaining challenge would be the climatic uncertainty that is common for every water system in every urban development.

CHAPTER 9: Discussion and Conclusion

9.1. Introduction

The central purpose of the research was to evaluate residential satisfaction with innovative NDG supply (via dual water system) in an urban setting and to establish its significance to overall satisfaction with the home, neighbourhood, and society. The NDG system and the associated water sensitive designs have created a unique urban environment in “The Green” This research also explores the relationship of the major domains of residential environment and then the satisfaction with the resident’s migratory intentions. The home domain satisfaction is directly associated with with the NDG system, garden and home attributes. Similarly, the neighbourhood domain satisfaction is linked with the home and neighbourhood attributes, neighbours, and society. A basic presumption is -with better NDG system, home, and neighbourhood attributes; the higher will be the satisfaction that will be reflected in less migratory activities.

This research had three specific objectives. The first objective was to identify and develop satisfaction measures (items) of the NDG system and urban living environment (home, neighbourhood, and society). The second objective was to test a model of residential satisfaction with the NDG supply via dual water system in an urban residential environment. Finally, the third objective was to examine and interpret the planning implications of residential satisfaction with and behavioural responses towards the NDG system and the urban environment.

The objectives were achieved by addressing the following four research questions:

1) What are the key factors of residential satisfaction with NDG system?;
2) How does satisfaction with NDG system impact on the overall residential satisfaction?;
3) How much does the NDG system contribute towards household water conservation?; and
4) What are the implications of the NDG system for urban land and water planning?

9.2. Overview of this research

This research program is founded on four key activities. The first was the literature review that identified major issues relating to satisfaction with the residential environment. The literature review along with the field observations helped to identify the major issues around the NDG system satisfaction. In addition, the literature around the acceptance of alternative water systems helped to refine the NDG satisfaction concept, and link it with the acceptance of the NDG system. Similarly, the important issues of home, neighbourhood, and social environment were identified and detailed as possible variables that impact over individual satisfaction with the water system and residential environment.

Literature review and preliminary field visits delineated the structure for the second activity: the exploratory preliminary interviews with local residents. The interviews re-defined or rationalised the previous items and added new variables or items regarding the NDG system, home, and urban environment. The qualitative analysis of the interviews provided a deeper understanding about the critical issues of satisfaction with the NDG system and the urban environment. In addition, the preliminary interviews enquired about the resident's behavioural responses towards the NDG system and urban residential environment using a number of items measuring their intentions. Thus generated items were developed into a set of structured and semi-structured questionnaires that were administered to the survey participants in study areas.

The third activity was the quantitative study, the household survey that utilised the research instrument (questionnaire) developed from the preliminary interviews. The quantitative data from the survey was analysed using a number of univariate and multivariate techniques to reduce the items; develop, test, and confirm the constructs and their measures; and develop and test the models of satisfaction with NDG system, home, neighbourhood, and society. A model of overall residential satisfaction was developed by integrating all the satisfaction models, which was then linked with the behavioural intentions to predict the behavioural responses towards the NDG system and waterwise urban environment.

The fourth major activity was a mixture of quantitative analysis of secondary data on water consumption and qualitative analysis of the stakeholders' interviews, meetings and seminars to explore the inherent challenges to manage NDG system. The secondary data analysis explored the water conservation scenario and the contribution (or utility) of the NDG system in water conservation and water efficiency in "The Green". The qualitative information provides the stakeholders' perspectives towards the research findings, water conservation and water efficiency, and the utility of NDG system and water sensitive development. The stakeholders' perspectives were helpful to explain and justify the integrated land and water management approach and to promote pragmatic alternative water planning to improve the quality of urban environments.

In this way, this research utilised a triangulation approach that drew the qualitative as well as quantitative information from preliminary interviews; household survey; secondary data; and stakeholders' interviews. This research drew the empirical theories and concepts from the literature, contextualises and redefined them with the help of preliminary interviews, and tested the theories/concepts via a quantitative study (survey). In addition, the research utilised the secondary data and the stakeholders' perspectives to explore the outcomes and utility of the NDG system in urban environment. The triangulation provided a valid and robust knowledge on residential satisfaction and behavioural responses towards the innovative urban water management and its implications for the integrated land and water management planning at various spatial levels. Above mentioned activities collectively addressed the research questions, research objectives and overall purpose of the research.

9.3. Theoretical contribution of the research

The overarching aim of this study was to evaluate residential satisfaction with a non-drinking groundwater system in a water sensitive urban development. As explained earlier, the qualitative data from the preliminary interviews, while triangulated with the quantitative survey data, confirmed the constructs and their measures. The relationships of the constructs to their respective domain satisfactions were tested and confirmed with the help of multiple regression analysis and path analysis. Further, the relationship of satisfaction with behavioural intentions were tested and confirmed. The findings not only contributed to building theory regarding the residential satisfaction with alternative NDG system in an urban setting but also confirmed the general causality of evaluation of objective attributes to satisfaction and then satisfaction to behaviours via behavioural intentions. These theoretical contributions are sequentially explained from the item generations to model testing in following sections.

9.3.1. Attitudinal scale development

A. Developing constructs

The factor analysis reduced 80 attitudinal items into 14 or less constructs regarding the alternative NDG system, and other components of urban residential environment, namely: society, neighbourhood and home. The details of the constructs and their measures in both "The Green" and Ridgewood are provided in section 7.5 of this thesis.

The attitudinal items regarding the NDG system attributes in both areas were almost similar in number and context; however, the factor analysis extracted slightly different constructs (with different measures and reliability values). In "The Green", the constructs for the NDG system were: trust, operation, pricing, fairness, safety, and water conservation; while in Ridgewood only four factors, namely: trust, performance, water conservation, and fairness were resulted. In addition, the common three factors, viz: trust, fairness and water conservation were different in their measures and reliability. The different in factor structure and measures indicates that participants in two areas perceive and evaluate the attributes of NDG system differently. The evaluation process appeared to be dependent upon their personal needs, expectations and aspirations; and the standards of comparison as suggested by Marans and Spreckelmeyer (1981); Weidemann and Anderson (1985); and Amerigo (2002).

A number of attitudinal items were adopted from the Po et al. (2005); Porter et al. (2006) studies on the acceptance of alternative water systems. The trust, pricing, safety (or risk), fairness, and water conservation factors for NDG satisfaction (and/or acceptance) were on the line of attitudinal studies of Po et al. (2005); Porter et al. (2006); and Hurlimann (2006, 2008). However, the operation factor in "The Green", and performance factor in Ridgewood appeared differently than the previous studies. The operation and performance factors may be the derivatives of the perceived outcome in acceptance models (Po et al., 2005; Porter et al., 2006), or appeared to be separate construct, representing the unique operational characteristics of the NDG system in "The Green".

Similarly, the constructs of urban residential environment in "The Green" were: neighbourhood and park attributes, garden value, outdoor and garden attributes, social harmony, and social cohesion; while that in Ridgewood were neighbourhood quality, home attributes, neighbourhood access, public parks, neighbours, and community. The neighbourhood and park attributes appeared as a single construct in “The Green”, while there were three in Ridgewood: neighbourhood quality and access, and public park factors. The home attributes appeared as one factor representing home and garden attributes in Ridgewood, while in “The Green” the same issues yielded two factors: garden value, and outdoor and garden attributes. Furthermore, social harmony and cohesion were two factors for social environment in “The Green”, while simply neighbours and community were resulted in Ridgewood. The findings confirmed the usual home, neighbourhood and society components (with some modifications) of residential environment (Marans and Rodgers, 1975; Campbell et al., 1976; Canter and Rees, 1982; Amerigo, 2002; Adriaanse, 2007).

The seven items measuring satisfaction with seven aspects of residential environment were associated with two major domains: the home and neighbourhood. The home environment was comprised of the NDG system, garden and house; and the neighbourhood environment was comprised of the neighbourhood attributes, neighbours and society. The neighbourhood environment contains the society component, which was different from (Marans and Rodgers, 1975; Campbell et al., 1976; Weidemann and Anderson, 1985; Adriaanse, 2007), who considered the society as a strong and independent domain of residential environment. The neighbourhood domain in this research is similar to the Canter and Rees (1982) concept of neighbourhood domain to measure residential satisfaction that was also supported by (Hipp, 2010). In this way, this study confirms that the home and neighbourhood domains are the two major domains (with subtle differences in measures and reliability) of residential satisfaction in each area.

Finally, five different migrating or staying intentions, namely: moving, staying, recommending, where to move, and choosing again items factored together to yield one behavioural intention factor in both areas. The behavioural intention factor score will represent the level of adaptive or migratory intentions of the participants. In this way, 14 factors were yielded in “The Green” and 13 factors in Ridgewood during the item reduction and factor analysis process.

B. Differences between the study areas

At the same time, the discriminant analysis examined the differences between “The Green” and Ridgewood due to the experimental manipulation. Three major discriminating variables were identified, namely: Awareness of the NDG system, Residence duration, and Garden reticulation satisfaction. The three variables explained approximately 60% of differences between the study areas; whereas the awareness of the NDG system was the strongest discriminating variable explaining more than 45% of the differences.

The NDG system was the experimental manipulation and it caused “The Green” people to be much aware about the system than Ridgewood people. This indicates that the on-site NDG trial increase the awareness about the system. The increased awareness could be related with better acceptance and adoption in the community, and eventually to the sustainability of the system (Hurlimann, 2008; Barron et al., 2010). Second discriminating variable was the residence duration that was related to the historical development of the study area. In simple words, Ridgewood was developed earlier than “The Green”; hence, Ridgewood people would have longer residence duration. The final discriminating variable was the garden reticulation satisfaction. For “The Green” it was the groundwater satisfaction and for Ridgewood it was merely a component of the garden satisfaction. Most of the Ridgewood people were connected to the scheme water supply for their garden reticulation too; hence, they were comparatively happier than “The Green” people. In addition, the NDG system in “The Green” was mandatory and controlled by a third party; hence, “The Green” people were comparatively less contented with the system.

9.3.2. Model development and testing

A. Model of NDG satisfaction/Acceptance

The constructs derived from the attitudinal items regarding the NDG trial were used for developing the NDG satisfaction model in “The Green”. Whereas in Ridgewood; the items were utilised to develop a model of NDG acceptance. The logic behind this was the presence of NDG system in “The Green” only, so that “The Green” people experienced a level of satisfaction or dissatisfaction in real; whereas, Ridgewood people could provide hypothetical evaluation of the system that would reflect the acceptability of the system as in (Po et al., 2005; Porter et al., 2006; Nancarrow et al., 2008; Dzidic and Green, 2012). The regression analysis (Chapter 7.7.2) provides the details about the NDG satisfaction model in “The Green” and the NDG acceptance model in Ridgewood. An attempt was made to derive the satisfaction model in Ridgewood; however the model wasn’t significant (with one predictor only).

In “The Green”, the operation factor was the strongest predictor followed by risk perception (negative relationship) and preference to continue with the NDG system in predicting the NDG satisfaction. This means the better the operation perception, especially when it is automatic and controlled by a third party; the higher will be the satisfaction with NDG system. Similarly in Ridgewood, the preference for non-potable indoor use of groundwater (toilet flushing, washing machine etc.,) and performance of the water system were significant predictors (positive relationship) of the NDG acceptance. This means the higher the preferences for indoor non-potable uses of groundwater, and perceived performance of the groundwater system, the higher will be the acceptance of such alternative system. The findings provide useful guidelines for the water providers and developers to improve the acceptance or satisfaction with NDG and similar alternative water systems.

Contrasting to previous attitudinal studies on alternative water system acceptance (Po et al., 2005; Porter et al., 2006; Nancarrow, Leviston, and Tucker, 2009; Barron et al., 2010; Dzidic and Green, 2012), there were no significant direct relationships of trust, pricing, and water conservation factors with the NDG satisfaction (and or acceptance). However, the trust was found to be related to the operation of the NDG system in “The Green” and performance factor of alternative NDG system in Ridgewood. Such mediation by operation and performance factor in satisfaction and or acceptance model is similar to the mediation by perceived outcome of the alternative system in acceptance model (Porter et al., 2006). In addition, the perception of groundwater contribution to improve garden quality, and perception of groundwater efficiency appeared as two significant contributors for positive perception towards the operation of NDG system in “The Green”; whereas, the perception of safety (or risk) was significant contributor for groundwater performance factor in Ridgewood.

The findings indicate that risk, trust, fairness, pricing, and water conservation factors are indirectly related to the acceptance and/or satisfaction with the NDG system. In “The Green” the operation factor mediates their relationship with NDG satisfaction; and in Ridgewood, the performance factor mediates their relationship with NDG acceptance. Along with this notion, the finding is consistent with previous attitudinal studies (Po et al., 2005; Porter et al., 2006; Barron et al., 2010). However, the findings need to be tested explicitly with multiple samples and for a longitudinal period of time to confirm the relationships, and to monitor the change in community acceptance and satisfaction with the alternative water systems over time.

B. Model of society, neighbourhood and home satisfaction

The regression analysis tested the relationships between the constructs for society, neighbourhood and home satisfaction and respective models were developed. The society satisfaction in "The Green" was significantly predicted by two variables: Social harmony and satisfaction with neighbours, while that in Ridgewood was predicted by satisfaction with neighbours and Good neighbourhood watch. Neighbours were appeared as the important component of the society satisfaction models in both areas. The finding is in line with (Marans and Rodgers, 1975; Marans and Spreckelmeyer, 1981; Canter and Rees, 1982; Weidemann and Anderson, 1985; Amerigo and Aragones, 1997; Amerigo, 2002; Adriaanse, 2007). The factor analysis and the regression models confirmed the dominance of home and neighbourhood domains in evaluating satisfaction with the urban residential environment. The society domain appeared as an important domain but was weaker in terms of predicting power and reliability than the above two domains. Further, the neighbour satisfaction was associated more with the neighbourhood domain than with society domain. This finding is different than the American and European studies (Marans and Rodgers, 1975; Amerigo, 2002; Adriaanse, 2007), where the society (or neighbours) component was the strongest predictor for the satisfaction with residential environment.

Similarly, overall neighbourhood satisfaction in "The Green" was predicted by three variables: Neighbourhood and park attributes, satisfaction with neighbours, and park satisfaction. However, the neighbourhood satisfaction in Ridgewood was predicted by one variable: neighbourhood quality. "The Green" model of neighbourhood satisfaction is supported by (Campbell et al., 1976; Weidemann and Anderson, 1985; Amerigo and Aragones, 1990, 1997; Amerigo, 2002; Marans, 2003; Adriaanse, 2007). A slightly different model of neighbourhood satisfaction in Ridgewood with lower predicting power indicates that the people having no experience of the NDG system and the associated water sensitive community development do not have the built attitudes towards the development; hence their satisfaction with neighbourhood was poorly predicted by the items and constructs of water sensitive environment.

The home satisfaction in "The Green" was positively predicted by the garden satisfaction and pleasant home environment. While in Ridgewood, it was explained by the garden reticulation satisfaction and pleasant home environment (positive relationship). In "The Green", most of the gardens were new, water efficient, and recently landscaped by the developer. In addition, the gardens were supplied with non-drinking groundwater that reticulate through drips and sprinklers; and had native plants. The personal preferences towards a freely given product (gardens) with native plants and controlled reticulation systems delivering non-drinking groundwater could impact over the satisfaction with the garden. Thus, the garden satisfaction became an important determinant of the home satisfaction in “The Green”. The findings are in line with Syme et al. (2001) that explains the gardens are perceived as a very important design feature for appreciation of homes in Australia.

However in Ridgewood, the garden reticulation promoted the home satisfaction and there was no linkage of the garden satisfaction with home satisfaction. The logic behind this may be due to self designed gardens and drinking water supply for garden watering, where the most variable factor was the garden reticulation types. In other words, better reticulation maintains better gardens that yield higher satisfaction with the home environment. Thus, the reticulation appeared as the predictor of home satisfaction.

Furthermore, the garden satisfaction in both areas was positively predicted by the satisfaction with the garden reticulation and garden attributes. The groundwater satisfaction was the strongest predictor of garden satisfaction in “The Green”, while the perception to garden design appeared as the main predictor in Ridgewood. Following the above discussions, it is inferable that a higher satisfaction with the garden reticulation promotes the garden satisfaction and eventually the satisfaction with the home in “The Green”. This further indicates that any changes in garden reticulation can impact over the individuals’ appreciation of their home environment. The findings contribute for the knowledge on home environment satisfaction, and are equally important for planners, developers and water providers in enhancing the satisfaction (subjective experience) with the water sensitive home environment by improving the groundwater irrigation systems (garden reticulation) and gardens.

C. Model of residential satisfaction and behavioural intentions

As previously described, the residential satisfaction was measured in terms of two major domains: the home domain and neighbourhood domain. The home domain was comprised of home, garden and NDG system (or garden reticulation in Ridgewood) satisfaction, while the neighbourhood domain was comprised of neighbourhood, neighbour and society satisfaction. While considering such a model of residential environment satisfaction, it appears that there is a measurable causality of the objective attributes of the environment to the satisfaction (subjective attribute) with the environment and then to behavioural responses towards the environment as argued in previous studies (Fishbein and Ajzen, 1974; Speare, 1974; Campbell et al., 1976; Ajzen and Fishbein, 1977; Marans and Spreckelmeyer, 1981; Weidemann et al., 1982; Amerigo and Aragones, 1997; Amerigo, 2002). Initially, the objective attributes are perceived and assessed by the individuals (with their personal value, belief, characteristics and standards of comparison), which results in satisfaction with the environment that determines the behaviour towards the environment. In this research, the general sense of causality was evident while progressing via the perception and evaluation process of the objective attributes of NDG system and water sensitive urban environment to generate the satisfaction with the system and urban environment, and then to link the satisfaction with the behavioural intentions. The objective attributes of the NDG system predicted NDG satisfaction. Similarly, the objective attributes regarding gardens, home, neighbourhood, society predicted respective satisfactions. The satisfactions factored together to result two major domains of residential satisfaction, namely: home and neighbourhood domain; that were significantly correlated with the behavioural intentions (negative relationship). This means when an individual perceives and evaluates the attributes of water sensitive urban environment on the basis of his/her personal characteristics and standard of comparison, the subjective outcome (satisfaction) will be generated. The satisfaction will influence the behavioural intentions that then determine the behaviour towards the residential environment; i.e., whether to adapt in or move out from the environment.

This has been reflected in the findings (Section 7.4, 7.5, 7.7) that the majority of participants in study areas are reported to be happy with the quality, quantity and operation of the groundwater system. The participants are also reported to be highly satisfied with their home, gardens, neighbourhood, neighbours, and society. This means the residents are satisfied with their urban residential environment. While linking the residential satisfaction with the behavioural intentions, the research findings confirm that majority of the research participants do not intend to move out from their locality within the next year. Hence, on the line of argument of Ajzen's and co-workers (1975; 1977; 2005); Campbell et al. (1976); Weidemann and Anderson (1985); and Amerigo (2002); the general sense of causality was held in this research, while progressing from the objective attributes to the subjective outcome (satisfaction in this research) and finally to the behavioural intention.

9.3.3. Interpretation of research findings for planning implications

The most important application of this objective-subjective evaluation approach suggests that if residents perceived positively towards the attributes of the alternative water system and the associated development, they are likely to be satisfied with the alternative water system and development. In simple words, the authorities should implement the customer preferred design and attributes in water system and urban development to harness high levels of residential satisfaction with the system and development.

In addition, the actual NDG trial performance was measured in water conservation with the help of secondary data. The secondary data analysis exposed the over consumption of groundwater resources and triggered debates about the possible causes and its impact on the project performance. The major causes for such over consumption were: the large number of garden exemptions during the establishment phase of new development, and some unexpected uses such as that in construction and dust suppression, and inconsistency in operation as well as control at household level. As the construction work was almost finished and the authorities had initiated the groundwater saving approaches, it was estimated that the overconsumption would come under project margin in coming years. However, the full assessment of the water conservation, and water efficiency due to the water saving approaches could be possible and effective only after a few years of the system as well as community establishment.

These two major findings: the evaluation of residential satisfaction with NDG system and associated development and model development; as well as the examination of project outcomes in terms of water conservation and efficiency were further interpreted from the stakeholders' perspective, so that the planning implication of the results could be better explained. Such insight satisfies the fourth aim of this research: identification of the inherent challenges and planning implications of NDG system. The discussions on the planning implications based on the real field research would be useful guidelines for the planners, developers and the water utilities to manage the existing alternative water system properly and to deal with community in future developments.

Meanwhile, the socio-environmental sustainability of the NDG trial development was also enquired in this research, mainly in terms of the community awareness, participation, water conservation, residential satisfaction, and behavioural responses towards the system and associated developments. “The Green” community appeared to be satisfied with the NDG system with some concerns regarding the operation and management of the system. These concerns would be assuaged over time; however some should be addressed immediately, such as information provision and better operation of the system. This will not only improve the perception and feelings towards the system but also promote the community participation to the system.

The NDG trial in “The Green” had shown some promising signs towards the sustainable water management in urban settings, such as: a significant reduction (>30%) in drinking water demand; an increase in awareness about the alternative water management initiatives and community roles for the success of such initiatives; a better management of stormwater to enhance the recharge with the help of water sensitive designs; and the reduction of nutrient load to water bodies by utilising the excess recharge in watering local gardens and parks.

Having said that, it is neither an easy nor a once off task to alter the water using behaviour of the community; there should be a continuous efforts, management and information to achieve this change. When the water system meets watering needs, and addresses the related concerns of the community, the social sustainability will be ensured. Afterwards, the environmental sustainability will depend upon the contribution of the alternatives in conserving water resources, better managing the stormwater to increase recharge and enhance local water bodies, and reducing the nutrient exports.

9.4. Research limitations

The study areas were developed earlier and people were settled down. There was no chance to allocate the subjects randomly across the study areas to make it perfectly experimental. In other words, the first limitation was that the experimental treatment (the NDG trial) had already been assigned in “The Green”; and the second was that the subjects (residents) have already been settled there. It was totally impossible to assign the treatment to different groups (or areas/residents) as well as allocate subjects (residents) to different treatments (i.e. with different type of water systems). Those limitations make this research design of a quasi-experimental nature, which utilises the previously established social setting and considers the previous differences among groups is not impacting over the experimental outcomes. Furthermore, the provision of control area and the stratified random sampling of the subjects during the survey were supposed to address these limitations and make the two groups comparable for the research purposes.

The third limitation of this research was the dormitory nature of the study area. Most of the residents had jobs and works in nearby cities, or in Perth CBD; hence, they virtually were out of their homes for the whole day and came back home late in the evening for dining and sleeping. There were no other activities around the suburbs except the construction works. A number of blocks were not established, public parks were incomplete, and the city centre was not started. This situation caused a limited participation in the focus group discussions; hence the preliminary interview approach had to be adopted. The dormitory situation also impacted the response rate in household survey even after utilising a door to door approach, three follow ups, news items publication, and incentive provisions. In this study, the number of sample size limited the application of sophisticated statistical analysis, such as structural equation analysis.

Evaluating residential satisfaction with urban environment is a subject of a longitudinal study rather than once off study. Many longitudinal factors impact over the satisfaction measures, such as: experience, expectations, residence duration, attachment, comfort etc. In addition, the satisfaction and community’s behaviour themselves are not of static nature. They are continuously changing and evolving; hence should be tracked properly with longitudinal study. This research took a once off approach to explore the community satisfaction and behavioural responses towards the alternative water system and water smart community development that itself limits the scope of the study. The once off study could just identify and indicate the relationship but not be able to explore in detail and confirm the full consequences of the satisfaction and behavioural relationships. However, this study attempts to explore the theories, postulate a concept and hypotheses, and finally developed a model of residential satisfaction and behavioural responses towards the NDG system and water sensitive urban environment. Undoubtedly, there are still a lot of issues to be considered and incorporated into the model to make it a complete model.

At the very beginning of the research, the limited availability of household occupancy data and the migration data also limited this study to tract down the exact migration rate. Such findings would have provided this research an insight into the exact migratory pattern that could have been linked with the behavioural intentions to explain the relationship between the intentions and actual behavioural responses. Without the migratory data, this research is limited to the theoretical description of the behavioural intentions and their relationship with the actual behaviour.

This study aimed to track down the actual NDG consumption for individual household level rather than the lump sum average as it would be useful to differentiate between the park and garden usage as well as the groundwater consumption for large and smaller blocks. There were no metering at individual households, so that the actual NDG consumption data at household level could not be obtained. However, the differentiated data about groundwater consumption in household watering and public park irrigation was obtained from WA Water Corporation. The data helped in calculating the average groundwater consumption per connection for this research purpose (Table 66); however, the average figure underestimates the consumption at larger blocks, and vice versa.

9.5. Future research perspectives

Evaluation of residential satisfaction with the NDG system was the main focus; hence, several important aspects of residential satisfaction might have been left behind. Some important issues that were rendered important to consider for future researches are outlined below.

The major one is the continuation of this study to develop a longitudinal study on community satisfaction that could track the changes in community satisfaction and their behavioural responses towards the alternative water supply system and water sensitive development over a period of time. Such findings will be useful for water authorities, urban planners and developers in urban settings to design and develop new type of integrated water and land management practices with sufficient consideration to community concerns and behaviours.

Similarly, it is extremely important to explore continuously the contribution of the NDG system on water conservation and water efficiency over the period of time. The water efficiency and conservation approaches could be counted as the new water sources. Therefore, the full assessment of the contribution of the NDG system would be useful reference for planning, implementing and developing similar alternatives in new and/or existing developments to promote water conservation and water efficiency.

Furthermore, future research should consider the wider issues about the alternative water system, such as: the economics of the system, control and ownership, innovative management and pricing, the environmental contribution, and community oriented NDG development. Similarly, studies should be focused on examining the utility of such NDG systems at regional, state and national level that could guide the feasibility and applicability of the NDG system in

Australia and/or in similar socio-geographic settings worldwide. Finally, the research that focused on integrating the technologies, infrastructure, and designs in managing the urban water systems and improving their performances could address the practical requirements for developing technologically sound and water efficient alternatives. The experience of this research also indicates that the involvement of the weather station is still lurking because of lack of knowledge in technical infrastructure development and or management.

9.6. Recommendations

This research draws information from the previous studies and literature, qualitative preliminary interviews, quantitative survey, secondary data, and stakeholders meetings and seminars. The qualitative and quantitative information were triangulated to resolve the research questions, mainly the evaluation of residential satisfaction with NDG system in urban setting. Based on the research outcome, the following specific recommendations were generated to better manage the NDG system and associated water sensitive urban development. The recommendations are focused to enhance community participation and support, their satisfaction, and behavioural responses towards the NDG system and the associated urban development.

1. To promote community participation and engagement, there should be regular community meetings in "The Green" to discuss about the NDG trial issues. Such meetings would be useful to receive community responses, concerns, and preferences to the groundwater system. Such inputs could be useful for improving the system and dealing with the community concern in a timely manner. Further, this could increase the sense of ownership of the system among the end-users that would assist in the sustainable development of the NDG system.
2. To earn trust in water authorities and developers, regular information should be provided not only in the form of newsletters delivered to the household's mailbox, but also in the form of community briefings, community education for their role in water conservation involvement of children and so on. Further, the establishment of customer support and information centre in the developer's building as well as water provider agencies could provide instant information whenever the residents want it.
3. The flexibility in NDG operation is another important strategy that the water provider should consider. Almost all residents in "The Green" are experiencing the non-drinking groundwater via community bores for watering their gardens for the first time. This trial is altering their

watering habits; however it was a difficult process to alter the usual watering habits. On top of that, the NDG system in "The Green" involves several restrictions and limitations, which make the adaptation process difficult. Hence, more flexibility in terms of watering frequency, timing, and amount should be considered to meet the watering needs and residents demands during the transition period of the NDG trial. Once the system is fully connected and the community fully developed, then the NDG system could easily apply its standard restrictive operation procedure. This approach has been adopted in previous successful dual water systems in Australia. For example: 'Mawson Lakes', South Australia (Hurlimann, 2006, 2008) residents were supplied with the drinking water through both dual pipe networks during initial years of the recycled water supply trial.

4. The 'groundwater provider' and/or responsible authorities should provide prompt services, monitoring, and regular maintenance of the bore and groundwater reticulation, so that any breach and wasteful usage can be minimised. The monitoring would further encourage the residents to maintain their garden and verges.
5. From the secondary data provided by the Water Corporation, there was over consumption of groundwater at the household level in "The Green". This was mainly because of large number of garden exemptions during the establishment phase of the community. However, some unexpected uses, such as: dust suppression, construction activities also contributed in such over consumption. When this has been tracked down, it would be effective to commission the 'weather station' for operating the bores and or controlling the groundwater supply. The weather station control would effectively maintain the groundwater consumption, reduce the excessive use, and ensures equitable groundwater distribution.
6. There should be enough information for the first as well as successive home owners regarding the plants and reticulation types, NDG distribution schedule, garden establishment, reticulation setting, garden and or reticulation maintenance and adjustments; so that they could make informed decision for regarding NDG connection, garden designs, and maintenance.
7. The developers as well as local councils usually have their working guidelines for the urban development and/or home and garden designs, which need to be updated to match the water sensitive designs, and efficient home and gardens implemented in "The Green". So that, a more consistent state-of-the-art water sensitive development could be created that would be congruent with the community's need and expectations. Furthermore, these design guidelines should be incorporated into the revised version of 'Liveable

neighbourhood' that would create the effective regulation framework throughout the new as well as retrofitting urban developments.

8. There should be effective data keeping of all kind of information regarding the garden establishment, reticulation maintenance and any alteration in reticulation settings. The effective data keeping will reduce the risk of inequity in NDG service as well as increase the reliability of the service. Furthermore, the better customer records enhance the community support to the NDG system that eventually leads to the success of the system.
9. There should be sound policy and regulation for management and ownership of alternative fit-for-purpose water systems in any new or existing development harmonised with the policies regarding public drinking water sources. Similarly, there should be better implementation and participation (mandatory) policy for development and dissemination of alternative water supply systems at different planning levels.
10. There should be a provision for annual community satisfaction survey in "The Green", which will explore the community satisfaction issues with the NDG system and associated urban developments. Such information will be helpful to precisely track the trends and identify the major drivers of residential satisfaction over time. Finally, there should be a post-development evaluation study after 5 years to examine and explore community satisfaction, water conservation and water efficiency, along with the overall planning implications of the centrally controlled automatic NDG trial in urban development.

9.7. Conclusions

In this research, a fit-for-purpose non drinking groundwater system developed for "The Green" community at Butler, WA was utilised to explore the community concerns, attitudes and behavioural responses towards the water system and the associated urban development. Various research activities were conducted to collect the qualitative and quantitative information regarding the issues under enquiry, analyse them with different analytic tools and summarise the research findings. The detailed descriptions of all the research activities were already explained throughout the previous chapters of this thesis. In this sense, this thesis is a summary and justification of the research activities, univariate and multivariate analysis techniques, and research findings on residential satisfaction with alternative NDG system in urban environment.

This chapter summarises the four major research activities, their intended objectives and observed outcomes and their significance for filling the identified gaps in the body of knowledge. Table 67 below gives the overview of the research issues (58 research hypothesis) that were established, explained and tested in this research. The details about the outcomes were presented in respective chapters as mentioned.

Table 67: The research hypotheses examined during this research

Hypotheses	**Research issues**	**Chapters tested and detailed**
H1, H2, H3, H4, H5, H6, H13, H14, H21, H23, H24, H25	NDG and WSUD issues	Chapter 6, 7 and 8
H6, H7, H9, H10, H11, H12, H13, H14, H15, H16, H17, H18, H19, H20, H21, H22	NDG acceptance	Chapter 7
H8, H15, H16, H17, H18, H19, H20, H21, H22, H25, H26, H27, H28, H29, H30, H31, H32, H33, H34	NDG satisfaction	Chapter 7
H3, H4, H5, H23, H24, H25	NDG sustainability	Chapter 7 and 8
H35, H36, H37, H38	Home satisfaction	Chapter 7
H39, H40, H41, H42. H43, H44, H45, H45, H46	Neighbourhood satisfaction	Chapter 7
H47, H48, H49, H50	Society satisfaction	Chapter 7
H51, H52, H53, H54, H55	Moving behaviours	Chapter 7
H56, H57, H58	Planning Implications of NDG and WSUD	Chapter 8

As shown in Table 67, the research hypothesis regarding NDG acceptance and satisfaction were tested and described in Chapter Seven that shows most of the community were accepting and were satisfied with the NDG supply for watering their gardens and parks. The NDG system satisfaction was positively related to the satisfaction with the home domain of residential environment. Simultaneously, the urban designs, parks, neighbours and society were positively related with the neighbourhood domain satisfaction. These two domain satisfaction were then negatively related to the migratory behavioural intentions. In this way, the research results explained in Chapter Six, Seven and Eight explicitly addressed the main objective and aims of this research.

The different domains of water sensitive urban environment and their major attributes were established in Chapter Six, tested and explained in Chapter Seven and Eight. Furthermore, the planning and development consequences of the NDG system and water sensitive urban development were also established and explained in Chapter Six and Eight. The major outcome was, the NDG system is technically water efficient, socially acceptable and the majority of the residents were satisfied with it; however the overconsumption of groundwater at this establishment phase poses a threat for the sustainability of the system. Such overconsumption is expected to be under control when the community and system will be completed and mature; however, the water using behaviours and conservation attitudes of the community should be continuously monitored to receive deeper understanding and alter such situations in long term.

Since the climatic variability poses a great uncertainty in managing urban water supply in near future; the alternative water systems drew attention of the policy makers, urban planners and water providers. The integration of fit-for-purpose water systems with water sensitive designs to promote water conservation and water efficiency in urban setting has become an possible alternative approach for urban land and water management in Australia. Australian communities also responded positively to such planning approaches; however, their attitudes and responses still vary according to their perceptions towards its operation, associated risks, and end-use contexts.

As the water industry in Australia is transitioning towards the water sensitive cities, the alternative fit-for-purpose water systems were emerging industry. The study of community satisfaction and behavioural responses towards the emerging water industry has an inherent potential to examine and justify the social goals of the alternative systems. Finally, the residential satisfaction model and the planning implications of the NDG trial would be important guidelines for dealing with the community for improving the adoption of and satisfaction with any alternative water systems. The identified future research perspectives would further strengthen such guidelines that will help to promote the development of the alternative water systems in Australian urban communities or similar urban locations for sustainable water management in the context of drying climate and growing population.

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VOLUME TWO

APPENDIX A: Signage of non drinking groundwater trial

Pictures of "The Green" icon, signage, and purple pipe network for non-drinking groundwater in "The Green", Butler

APPENDIX B: The invitation letter for preliminary interview

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31 May 2011

YOUR INFORMATION

Title of research project: Residential satisfaction: Innovative water supply system in urban designs

This information sheet is for you to keep.

My name is Raju Sharma Dhakal, a PhD candidate, and my supervisor is Prof Geoff Syme. We are conducting this research project as a partnership between Edith Cowan University's Centre for Planning and the Water Corporation. This research aims to better understand the effects of the water supply system on resident's satisfaction with their living environment and understand community water using preferences for better water planning. The findings of this research will be provided to urban developers; the Water Corporation; and government planners to better manage new water systems in urban areas, especially in the event of decreasing rainfall.

We are requesting your participation in the research to develop an understanding of how successfully you think the water supply system in your suburb provides for your lifestyle preferences. We will be talking to residents in Brighton and Ridgewood. You were selected randomly to participate in this preliminary talk, which is of 30 minutes duration. To thank you for your participation, we will donate $5 to Quinns Mindarie Surf Life Saving Club.

Your participation is completely voluntary and you may discontinue it at any stage. Your permission will be sought to record the talk for subsequent written transcriptions. The data will be reported in a PhD thesis; scholarly publications and presentations; and used in the future research project. The data you provide will be treated as confidential; available to the research team only; and your name or identity will not be revealed in any other way. The collected data will be stored in a locked filing cabinet and or password protected computer on University premises for 5 years.

If you have any questions or issues at any time during the research project and want to discuss it, please feel free to contact us, Raju Sharma Dhakal on 0434511970 or email: r.sharma_dhakal@ecu.edu.au; or Prof. Geoff Syme on 0405779638 or email: g.syme@ecu.edu.au. If you have any complaints about this research project **5915,** and wish to talk to an independent person, you may contact the Research Ethics Officer, Edith Cowan University on 08 63042170 or email: research.ethics@ecu.edu.au.

Thank you for your time. Your input into this research is very much appreciated.

Raju Sharma Dhakal

APPENDIX C: The consent form for preliminary interview

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Consent Form

I, ____ (full name in print letters) have read the information letter about the **"Residential satisfaction: Innovative water supply system in urban design"** research project conducted by Raju Sharma Dhakal (Chief Investigator) and Professor Geoff Syme (PhD Supervisor), from the Centre for Planning, Faculty of Business and Law, Edith Cowan University.

I agree to participate in the **preliminary interview** for this research project and allow the interview to be audio-tapped and transcribed. I understand that my participation in this study is voluntary. I am aware that I can withdraw at any time without being penalised or disadvantaged in any way.

I understand that the information provided will be treated strictly confidential and kept in a secure storage on University premises and accessible to the research team only.

I agree that any data that the researcher extracts from the interview may be published provided my name or other identifying information is not used under any circumstances.

Signature: ______________

Date: _______________

APPENDIX D: A news item in local newspaper

Newspaper: North Coast Times (Community Newspaper Group, Perth)

www.communitydigital.com.au/olive/ode/NorthCoastTimes/PrintComponentView.htm

Date: Mar 13, 2012; Section: News; Page: 5

Date: Mar 13, 2012; Section: News; Page: 5

Butler residents set to have say on water plan

By **LUCY JARVIS**

BUTLER residents can have a say on a non-potable water system set up to reticulate gardens and local parks.

Researchers have started knocking on doors in the suburb and are asking residents to complete a survey on the dual water supply that delivers safe drinking water into homes and untreated bore water to gardens.

Edith Cowan University professor Geoff Syme said researchers would visit homes and interview residents who were home, or leave survey packs to be completed and sent back.

"We don't know from the consumers' point of view whether they are happy with it – that's what we are trying to find out," he said.

Residents would also be able to complete the survey online.

PhD student Raju Dhakal will use the results for his thesis on residents' satisfaction with the system and water sensitive urban design

"Over a period of 30 years, pressures on water resources have increased due to population growth and climate change, widening the gap between water demand and supply," he said.

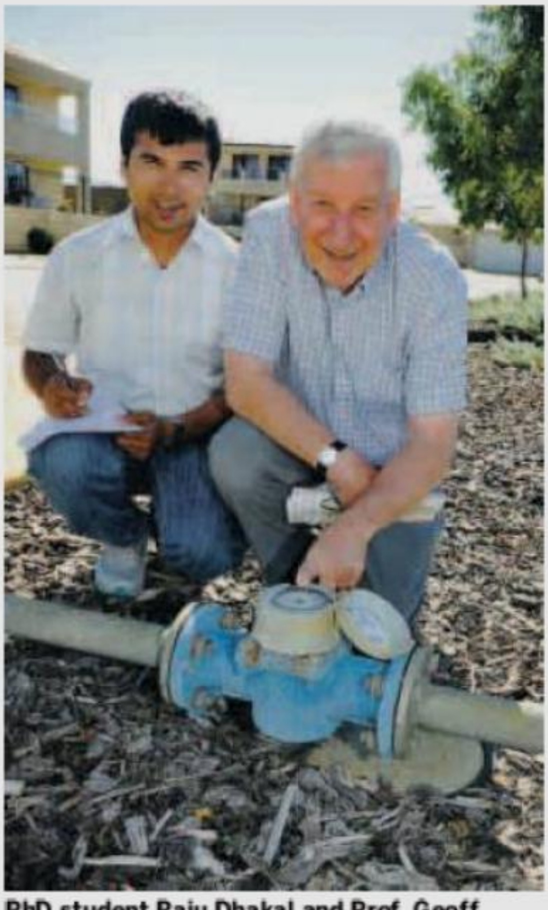
"Traditional water supply systems are deemed to be insufficient to meet the gap (so) urban planners are considering alternative systems for sustainable water resource management."

Prof. Syme said that because Perth was starting to run out of groundwater, the dual system was an efficient way to deliver water without having much of an effect on groundwater levels.

He said the control system was activated by a weather station when lawns and gardens needed watering and householders paid a flat fee for being involved.

Prof. Syme said residents in nearby Ridgewood would also be surveyed. The Water Corporation and Brighton Estate developer Satterley Property Group collaborated on the dual system.

Survey results should be available in mid-2012.



PhD student Raju Dhakal and Prof. Geoff Syme, d375008

APPENDIX E: Preliminary Interview Guides

<Brief introduction>

<Ethics and confidentiality; Information letter and consent form>

Discussion Questions

1. **What are the important things that would contribute to your overall satisfaction about living in this locality?**
   <Discussion>

Neighbourhood Environment

2. **What are the important things in your neighbourhood that directly or indirectly related to your satisfaction in living here?**
   <Discussion>

Home and Garden

3. **What are the important issues there should be in your home and garden to make your life easier?**
   <Discussion>

Relationship with your local community (friends/Neighbours)

4. **What are your thoughts about your relationship with your local community; i.e. with your friends, relatives, neighbours, and social organisation?**
   <Discussion>

Water supply system

5. **What are the important things that would make you happy with the water supply system in your locality?**
   <Discussion>

Dual water supply system and WSUD

6. **Would this type of development be able to make a contribution towards solving the**
   a. **Water scarcity problem at your locality?**
   b. **Water scarcity problem for Perth as a whole?**

   <Discussion>

Overall Satisfaction with your living place

a. **How long do you want to live in this locality?**
b. **If you have to move from here, would you live in similar place again?**
c. **Would you recommend this place to your friends?**
d. **How satisfied are you with living here?**

<Thank you very much for your information>

APPENDIX F: Short questionnaire in Preliminary interviews

Edith Cowan University
Centre for Planning

Name: **Address:**

General Questions

1. Do you have garden? ☐ Yes ☐ No
2. Have you ever changed the layout, plants and irrigation system of your garden? ☐ Yes ☐ No
   If yes, what type of changes you made and why you made such changes?

3. Are you a member of any environmental groups? ☐ Yes ☐ No
4. Do you think there is a scarcity of water in Perth? ☐Yes ☐ No ☐ Not sure
   If yes, what could be the possible solution to this problem?

5. How much important are the following issues for you to be happy with your home and locality?

	Least important		*Important*		*Most important*
Proximity to Public services (council, post office, police, hospital, school)	☐	☐	☐	☐	☐
Proximity to Basic facilities (roads, transport, jobs, shopping centre, sports)	☐	☐	☐	☐	☐
Neighbourhood Safety (from crime and noise)	☐	☐	☐	☐	☐
Unrestricted water supply	☐	☐	☐	☐	☐
Proximity to Public parks	☐	☐	☐	☐	☐
Resale value of home	☐	☐	☐	☐	☐
Water use efficiency	☐	☐	☐	☐	☐
Attractiveness of the locality (Layout and Streetscape etc)	☐	☐	☐	☐	☐
Social linkage	☐	☐	☐	☐	☐
Home garden and private open space	☐	☐	☐	☐	☐
Proximity to family and friends	☐	☐	☐	☐	☐
Dual water supply system (3rd pipe system)	☐	☐	☐	☐	☐
Proximity to beach	☐	☐	☐	☐	☐

6. We would like to know your views about the water supply system, your locality, home and social issues. Please state how much you agree or disagree with these statements.

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*
I know well about the local area and local water system in my locality	☐	☐	☐	☐	☐
I trust Water Corporation will ensure reliable, safe and quality water supply system in our locality	☐	☐	☐	☐	☐
The groundwater use has many important environmental	☐	☐	☐	☐	☐

Please return this sheet to the session Facilitator.

I do not envisage any risks in watering my garden with groundwater	☐	☐	☐	☐	☐
I have been treated fairly with regards to the local water supply system	☐	☐	☐	☐	☐
I can save money on my water bill by using groundwater to irrigate gardens	☐	☐	☐	☐	☐
I think the layout of my neighbourhood is beautiful	☐	☐	☐	☐	☐
The community here love the native plants in the parks and road-sides	☐	☐	☐	☐	☐
My home is quite accessible to the recreation centres like parks and beaches	☐	☐	☐	☐	☐
I feel the garden more greener and lively with groundwater supply	☐	☐	☐	☐	☐
I do not feel congested in living due to the density of houses in my locality	☐	☐	☐	☐	☐
I have happy living due to lots of cosy friends in my locality	☐	☐	☐	☐	☐
The increased resale value of my home is due to the green garden and plants	☐	☐	☐	☐	☐
I will move out from this locality if I find better home & garden alternatives	☐	☐	☐	☐	☐
I am happy with the size of my home garden and private open space	☐	☐	☐	☐	☐
I want to change native plants from my garden to make it beautiful	☐	☐	☐	☐	☐
The space in my home is appropriate to fulfil my personal and family needs	☐	☐	☐	☐	☐
I am happy with my living in this locality	☐	☐	☐	☐	☐

Please provide any specific suggestions that might be useful for this research.

If you want to discuss any specific issues related to this research project in private, please don't hesitate to contact us, Raju Sharma Dhakal on r.sharma_dhakal@ecu.edu.au or Geoff Syme on g.syme@ecu.edu.au.

Thank you for your feedback

Please return this sheet to the session Facilitator.

APPENDIX G: Thanks letter for preliminary interviews

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21 June 2011

Thank you very much for your participation

Dear ....

....

I would like to thank you for your participation in my research. I have completed the preliminary interviews, an important stage of my research. Your information and inputs are very important for me to develop understanding about resident's thoughts and experiences about the new type of development in your locality. Your input will be used to develop a detailed survey for the next stage of research.

To thank you for your participation, I have donated $5 to Quinns Mindarie Surf Life Saving Club on your behalf.

Thank you very much again for your participation in our research project.

Regards

Raju Sharma Dhakal

APPENDIX H: Household survey questionnaire for "The Green"

Date: / /

Household survey on "Residential satisfaction with dual water supply and water sensitive neighbourhood" in Brighton

The following questions relate to the groundwater reticulation and your neighbourhood environment. Please take some time to answer them all; it may take about 30 minutes. Any household member of 18 years or above can complete it. All your answers will be treated in strict confidence and your identity will not be included on any data-base. Your answers will be stored at ECU and only the researcher will have access to it. There are no right or wrong answers and no special knowledge is needed.

This information will provide us with a better understanding of your thoughts about the groundwater reticulation and water sensitive neighbourhood, so that water services in your suburb can be improved in the future. When it is completed, the aggregated results will be made available to the Water Corporation and developers. We will also provide you with a summary of results if you are interested. If you have any questions please do not hesitate to contact us, Raju Dhakal on 0434511970 or r.sharma_dhakal@ecu.edu.au; or Prof. Geoff Syme on 0405779638 or g.syme@ecu.edu.au.

Please read carefully and CROSS the NUMBER that best represents your opinion.

As a token of appreciation for your participation in this survey, we will donate $5 to Quinns Mindarie Surf Life Saving Club.

Thank you very much in advance for your contribution.

A. General satisfaction

1. There is a provision of **groundwater reticulation (or 3rd pipe system)** for watering gardens and parks in **Brighton**. On a five point scale as given below, please rate how aware are you of such reticulation?

Not aware at all	*Slightly aware*	*Moderately aware*	*Well aware*	*Very well aware*
①	②	③	④	⑤

2. Considering your experience living in Brighton, please **CROSS** the **NUMBER** that best represents your overall satisfaction level on each of the following question.

Your overall satisfaction with:	*Extremely dissatisfied*	*Dissatisfied*	*Somewhat dissatisfied*	*Somewhat satisfied*	*Satisfied*	*Extremely satisfied*
a. Your house	①	②	③	④	⑤	⑥
b. Your garden	①	②	③	④	⑤	⑥
c. The groundwater reticulation in your garden	①	②	③	④	⑤	⑥
d. Your neighbours	①	②	③	④	⑤	⑥
e. Public parks in your neighbourhood	①	②	③	④	⑤	⑥
f. Your neighbourhood	①	②	③	④	⑤	⑥

B. Groundwater reticulation issues

3. Do you have any of the following in your block for watering your garden?

Rainwater tank ☐ Yes ☐ No

Private backyard bore ☐ Yes ☐ No

4. What type of reticulation do you have in your garden for watering your plants?

☐ Drip irrigation system only ☐ Sprinklers only

☐ Both drip and sprinklers ☐ None **(Go to question 7)**

5. Do you have any type of water filter connected to your garden reticulation?

☐ Yes ☐ No ☐ Not sure

If **YES,** what is this filter for?

☐ For removal of coarse solids ☐ For removal of staining elements

☐ Both ☐ Not sure

☐ Others (specify)

6. What time does your garden reticulation generally operate?

☐ Early morning (3 am-6 am) ☐ Morning (6 am-9am) ☐ Daytime (9 am-6 pm)

☐ Evening (6 pm-9 pm) ☐ Night (9 am-3 am) ☐ Not sure

a. Does this timing of your garden reticulation suit your garden needs?

☐ Yes **(Go to Q 7)** ☐ No ☐ Not sure

b. Have you changed or do you plan to change the setting of your garden reticulation controller for better watering your garden?

☐ Yes ☐ No ☐ Not sure

c. If **YES**, please mention the changes and the reasons for such changes?

____
____
____
____
____
____

d. What other changes would you prefer to make your garden reticulation better suited for your garden?

____
____
____
____
____
____

7. Have you noticed any type of staining in your property from the use of groundwater in your garden?

☐ Yes ☐ No **(Go to Question 11)**

a. If **YES**, what colour is the staining?

☐ White *(Calcium staining)* ☐ Rust *(Iron staining)* ☐ Both

☐ Others (Specify): ....

b. Where is the staining seen? (**CROSS** all appropriate answers)

☐ Walls ☐ Driveway ☐ Garden edges ☐ Footpaths

☐ Other places (Please specify)____________________________

8. How would you rate the impact of **staining on your satisfaction** with each of the following?

Impact on satisfaction with:	*Not critical at all*	*Slightly critical*	*Moderately critical*	*Highly critical*	*Extremely critical*
a. Your garden reticulation	①	②	③	④	⑤
b. Your House *(property)*	①	②	③	④	⑤

9. Please rate your preference for each of the following **option on getting rid of groundwater staining**.

	Not preferred at all	*Slightly preferred*	*Moderately Preferred*	*Highly preferred*	*Extremely preferred*
Install a suitable filter to remove staining	①	②	③	④	⑤
Upgrade the garden reticulation to subsurface drip only	①	②	③	④	⑤
Pay more for groundwater treatment	①	②	③	④	⑤

10. If you **prefer** to **pay more for groundwater treatment** to make it free from staining, what should be the price of treated groundwater that you would be prepared to pay?

Less than the price of drinking water	*Same as the price of drinking water*	*More than the price of drinking water if needed*	*Don't Know*
①	②	③	④

11. While considering different water sources for garden watering, please rate how acceptable the following water sources would be for watering your garden.

	Highly Unacceptable	*Unacceptable*	*Somewhat unacceptable*	*Somewhat acceptable*	*Acceptable*	*Highly acceptable*
Treated wastewater	①	②	③	④	⑤	⑥
Groundwater via private backyard bore	①	②	③	④	⑤	⑥
Groundwater via community bore	①	②	③	④	⑤	⑥
Rainwater tank	①	②	③	④	⑤	⑥
Household grey-water (i.e. water from bathroom, laundry and kitchen)	①	②	③	④	⑤	⑥

12. Considering only the **community bores supply** for watering your garden, please rate your preference for each of the following **mode of operation**.

Mode of operation	*Not preferred*	*Slightly preferred*	*Moderately preferred*	*Highly preferred*	*Extremely preferred*
Weather station control to water your garden only when your garden needs water	①	②	③	④	⑤
Household control to water your garden when you wish	①	②	③	④	⑤
Household control and rostered 3 day supply	①	②	③	④	⑤

13. Similarly, please rate your preference for each **pricing option** for the community bore supply for watering your garden?

Pricing system	*Not preferred*	*Slightly preferred*	*Moderately preferred*	*Highly preferred*	*Extremely preferred*
Flat annual charging *(according to your block size)*	①	②	③	④	⑤
Household meter charging *(Pay as you go)*	①	②	③	④	⑤

14. What would be your general level of agreement with each of the following statements about **the groundwater reticulation** as it is now **(i.e. only for watering your gardens)**?

(*Please don't spend too long on each question. We are interested in your general thoughts only).*

	Strongly disagree	*Disagree*	*Somewhat disagree*	*Somewhat agree*	*Agree*	*Strongly agree*
Reducing rainfall makes it very important for us to conserve water now	①	②	③	④	⑤	⑥
I trust in any information provided by the water authorities about the safety of groundwater reticulation	①	②	③	④	⑤	⑥
I use a hose to water my gardens during summer	①	②	③	④	⑤	⑥
It's not fair that people in Brighton have no control over garden watering	①	②	③	④	⑤	⑥
Groundwater supply is cheaper than mains water to maintain my garden	①	②	③	④	⑤	⑥
Water authorities inform us about any interruptions in groundwater reticulation as soon as possible	①	②	③	④	⑤	⑥
I was well aware of the groundwater reticulation when I bought this house	①	②	③	④	⑤	⑥
Increasing temperature won't really affect the water needs of my garden	①	②	③	④	⑤	⑥
I have no objection in using groundwater for non-potable indoor uses (like toilet flushing, laundry etc) as long as appropriate quality is guaranteed	①	②	③	④	⑤	⑥
I see no health risk in using the groundwater for watering my garden	①	②	③	④	⑤	⑥
Using groundwater for watering gardens and parks is an environmentally sustainable approach	①	②	③	④	⑤	⑥
Brighton residents should have the same watering restrictions for their groundwater reticulation as everyone else in Perth	①	②	③	④	⑤	⑥
I trust the water authorities will manage our groundwater responsibly	①	②	③	④	⑤	⑥
It is better to have groundwater for watering my garden than severe water restrictions	①	②	③	④	⑤	⑥
Community bore supply is a reliable system for watering our gardens	①	②	③	④	⑤	⑥
I trust the water authorities will treat groundwater to correct standards for its use in watering our gardens	①	②	③	④	⑤	⑥
There is a risk of something going wrong with groundwater supply in future	①	②	③	④	⑤	⑥

	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree
My household uses less water than others in our neighbourhood	①	②	③	④	⑤	⑥
The overall benefits of using groundwater for watering our gardens outweigh the overall risks associated with it	①	②	③	④	⑤	⑥
Groundwater reticulation contributes to the quality of my garden	①	②	③	④	⑤	⑥
Groundwater reticulation helps us to reduce outdoor use of drinking water	①	②	③	④	⑤	⑥
I am happy with the pressure of groundwater supply in my garden	①	②	③	④	⑤	⑥
Groundwater reticulation is essential to manage future water shortage	①	②	③	④	⑤	⑥
I don't mind paying an increased price for groundwater if our gardens will be better maintained in summer	①	②	③	④	⑤	⑥
Water authorities in WA are serious about water conservation	①	②	③	④	⑤	⑥
The cost of groundwater can't overshadow its environmental benefits	①	②	③	④	⑤	⑥
We should pay for how much water we use on our garden like everyone else	①	②	③	④	⑤	⑥
I trust developers will ensure infrastructure for groundwater reticulation meets acceptable standards	①	②	③	④	⑤	⑥
I am happy with the automatic supply of groundwater in my garden	①	②	③	④	⑤	⑥
The groundwater reticulation is well operated in my garden	①	②	③	④	⑤	⑥
The pressure of groundwater reticulation is not adequate for the use of sprinklers in my garden	①	②	③	④	⑤	⑥
The groundwater reticulation is noisy while operating in my garden	①	②	③	④	⑤	⑥
I trust the water authorities will ensure I have good groundwater supply	①	②	③	④	⑤	⑥
I use a hose on my garden because the water is of better quality	①	②	③	④	⑤	⑥
Having to pay a fixed price for access to groundwater is unfair for those households with small gardens	①	②	③	④	⑤	⑥
Groundwater reticulation in Brighton is safe for human health	①	②	③	④	⑤	⑥
I would prefer it if the water system in Brighton is standard- no groundwater supply	①	②	③	④	⑤	⑥
Individuals can make a difference in solving water problems by saving more water on a regular basis	①	②	③	④	⑤	⑥
The weather station control ensures equitable supply of groundwater	①	②	③	④	⑤	⑥
Community bores may pose risk to the level of local groundwater	①	②	③	④	⑤	⑥

You have done great by answering questions so far, now it won't take long to finish the rest

C. Urban Design issues

15. Here are some statements about the features of **your neighbourhood, home and garden as they are now**. What would be your general level of agreement with each of the following statement?

	Strongly disagree	*Disagree*	*Somewhat disagree*	*Somewhat agree*	*Agree*	*Strongly agree*
My home environment has a pleasant feel to it	①	②	③	④	⑤	⑥
I am happy with the design of my home garden	①	②	③	④	⑤	⑥
We have enough public open spaces in this neighbourhood	①	②	③	④	⑤	⑥
This neighbourhood is a safe place for raising children	①	②	③	④	⑤	⑥
I have a good access to community services (council, transport, shopping, schools etc) from my house	①	②	③	④	⑤	⑥
I am sure the resale value will go up in this neighbourhood	①	②	③	④	⑤	⑥
The groundwater reticulation adds little to the resale value of my house	①	②	③	④	⑤	⑥
I am happy with the size of my home garden	①	②	③	④	⑤	⑥
I like the way that public parks here collect the stormwater during winter	①	②	③	④	⑤	⑥
This neighbourhood is easy to get around	①	②	③	④	⑤	⑥
I often use the public parks for recreational activities	①	②	③	④	⑤	⑥
This neighbourhood has a prestigious living environment	①	②	③	④	⑤	⑥
My kids enjoy playing in the public parks	①	②	③	④	⑤	⑥
I feel at home in this neighbourhood	①	②	③	④	⑤	⑥
The landscaped backyard is a real bonus to my house	①	②	③	④	⑤	⑥
I like native plants in the public parks around here	①	②	③	④	⑤	⑥
I usually go to other places (beach, bush etc) rather than the public parks in this neighbourhood	①	②	③	④	⑤	⑥
Higher density development makes this place a bit crowded	①	②	③	④	⑤	⑥
My house suits my family needs	①	②	③	④	⑤	⑥
I go to public parks to get myself out of my house	①	②	③	④	⑤	⑥
Native plants are good for better home-gardens even in summer	①	②	③	④	⑤	⑥
I don’t like the type of lawn provided in my garden	①	②	③	④	⑤	⑥
There are good quality schools nearby my house	①	②	③	④	⑤	⑥
The buildings in this neighbourhood are very attractive	①	②	③	④	⑤	⑥
A well kept garden increases the resale value of house	①	②	③	④	⑤	⑥
Gardening is a pleasant break from everyday stress	①	②	③	④	⑤	⑥
I would rather live near parks than have a bigger backyard	①	②	③	④	⑤	⑥
I feel I have a responsibility to look after the public parks here	①	②	③	④	⑤	⑥

16. Are you happy with the quality of your garden (including lawn)?

☐ Yes ☐ No ☐ Not sure

17. If **NO** or **NOT SURE**, have you changed or do you plan to change anything to **improve your garden?** Please explain briefly the changes and reasons for such changes.

____
____
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____
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D. Social environment (Friends, Neighbours and Society)

18. How much do you agree with each of the following statement about **your friends, neighbours and society**? Please rate these statements on given scale.

	Strongly disagree	*Disagree*	*Somewhat disagree*	*Somewhat agree*	*Agree*	*Strongly agree*
I am happy with the social mix of the local population here	①	②	③	④	⑤	⑥
I have good contacts with my neighbours	①	②	③	④	⑤	⑥
In this neighbourhood, residents treat each other pleasantly	①	②	③	④	⑤	⑥
Friendly neighbours are always good for the resale value	①	②	③	④	⑤	⑥
We have a good “neighbourhood watch” around here	①	②	③	④	⑤	⑥
There is too little privacy in this neighbourhood	①	②	③	④	⑤	⑥
I like the way that the community organisations in Brighton help our kids to be social	①	②	③	④	⑤	⑥
I feel socially isolated living here	①	②	③	④	⑤	⑥

E. Buying and moving behaviour

19. Were you born in Australia?

☐ Yes ☐ No

a. If **NO**, what is your country of birth? _____________________________________

b. Again if **NO**, how long you have been in Australia? _________ Years ________Months

20. How long you have been living in Brighton?

☐ Less than 1 year ☐ 1 year

☐ 2 years ☐ 3 years

☐ 4 years ☐ More than 4 years

21. Did you buy your home from:

- ☐ Satterley- Home Buyer Centre
- ☐ Previous residents
- ☐ I don't own this house- I rent
- ☐ Don't know
- ☐ Others (specify):____

22. Please rate the importance of each of the following reasons that make you want to live in Brighton.

	Not important at all	*Slightly important*	*Moderately important*	*Highly important*	*Extremely important*
Location	①	②	③	④	⑤
Price	①	②	③	④	⑤
Lifestyle	①	②	③	④	⑤
Neighbourhood	①	②	③	④	⑤
Modern housing designs	①	②	③	④	⑤
Design of home garden	①	②	③	④	⑤
The groundwater reticulation	①	②	③	④	⑤
Education opportunities	①	②	③	④	⑤
Employment opportunities	①	②	③	④	⑤
Proximity to public parks	①	②	③	④	⑤
Proximity to the future extension of Mitchell Freeway	①	②	③	④	⑤
Proximity to the proposed North-West Railway	①	②	③	④	⑤
Focus on environmental sustainability	①	②	③	④	⑤
Developer's reputation for building communities	①	②	③	④	⑤

23. Would you recommend this place to a friend or a family member?

☐ Yes ☐ No ☐ Not sure

24. Are you likely to move from this place within the next year? Please **CHOOSE ONE** best answer.

Definitely no	*Probably no*	*Not sure but would like to*	*Probably yes*	*Definitely yes*
①	②	③	④	⑤
Answer (a) and go to Q 25		**Go to Q 25**	**Answer (b), (c), (d),(e) and go to Q 25**	

If DEFINITELY or PROBABLY NO,

a. How long do you plan to live in this place?

_______________________________ Years

If PROBABLY or DEFINITELY YES,

b. Where are you planning to move?

______________________________ ☐ Don't know

c. Would you choose to buy a house in a 3rd pipe (i.e. groundwater) serviced place again?

☐ Yes ☐ No ☐ Not sure

d. What are the reasons that make you move to another place? Please rank the followings by putting a value 1 to 6 against each, where 1 values higher than 2; 2 higher than 3 and so on.

Due to:		*Rank*
i.	Dissatisfaction with your house in overall	☐
ii.	Dissatisfaction with your Garden	☐
iii.	Dissatisfaction with the groundwater reticulation	☐
iv.	Dissatisfaction with public parks in your neighbourhood	☐
v.	Dissatisfaction with your Neighbourhood in overall	☐
vi.	Dissatisfaction with your neighbours and local people	☐

e. If there are other than above reasons that make you move to another place, please explain briefly.

____
____
____
____
____
____

F. Socio-demographics

25. Your gender: ☐ Male ☐ Female

26. What is your highest level of education?

☐ Year 10 or below ☐ Year 11-12 or equivalent
☐ TAFE certificate or equivalent ☐ TAFE diploma/advanced diploma or equivalent
☐ An undergraduate university degree ☐ A post graduate university degree

27. What is the combined annual income of your household before tax? Please **CROSS** the most appropriate one from the following categories

☐ Less than $22,000 per annum ☐ $22,000 to $49,999 per annum
☐ $50,000 to $74,999 per annum ☐ $75,000 to $99,999 per annum
☐ $100,000 to $124,999 per annum ☐ $125,000 per annum or more

28. Which of the following categories best describe your age?

- ☐ Under 21 years
- ☐ 21-30
- ☐ 31-40
- ☐ 41-50
- ☐ 51-60
- ☐ Over 60 years

29. Including yourself, how many people usually live in your household?

Adults (18+ years) …………….. Children (up to 17 years) …………….

30. Would the rest of your family members mostly agree with most of your responses to this survey?

☐ Yes ☐ No ☐ May be

G. Your consent and comments

31. Would you like to receive a summary of results from this research?

☐ Yes ☐ No

32. We would like to relate your responses to your water consumption practice. Would you give consent for ECU to request your household water consumption data from the Water Corporation?

☐ Yes ☐ No

If **YES**, please sign here:

33. We may like to follow up with you, if there appear relevant issues to be explored in detail for better water service in Brighton. Would you be interested in taking part in one of such follow-up talks?

☐ Yes ☐ No

If **YES**, please provide your contact details as below.

Name:

Phone/Email:

34. Finally, if you would like to say something relevant to this research, feel free to write down below. Any of your views would be valuable for us. You can use separate paper if needed.

Thank you very much for your contribution in this research.

APPENDIX I: Household survey questionnaire for Ridgewood

Date: /   /

Household survey on "Residential satisfaction with the water supply system and water sensitive neighbourhood" in Ridgewood

The following questions relate to the water supply system and your neighbourhood environment. Please take some time to answer them all; it may take about 30 minutes. Any household member of 18 years or above can complete it. All your answers will be treated in strict confidence and your identity will not be included on any data-base. Your answers will be stored at ECU and only the researcher will have access to it. There are no right or wrong answers and no special knowledge is needed.

This information will provide us with a better understanding of your thoughts about your water system and water sensitive neighbourhood, so that water service in your suburb can be improved in the future. When it is completed, the aggregated results will be made available to the Water Corporation and developers. We will also provide you with a summary of results if you are interested. If you have any questions please do not hesitate to contact us, Raju Dhakal on 0434511970 or r.sharma_dhakal@ecu.edu.au; or Prof. Geoff Syme on 0405779638 or g.syme@ecu.edu.au.

Please read carefully and CROSS the NUMBER that best represents your opinion.

As a token of appreciation for your participation in this survey, we will donate $5 to Quinns Mindarie Surf Life Saving Club.

Thank you very much in advance for your contribution.

A. General Satisfaction

1. At first, considering your experience living in Ridgewood, please **CROSS** the number that best represents your overall satisfaction level on each of the following question.

Your overall satisfaction with:	*Extremely dissatisfied*	*Dissatisfied*	*Somewhat dissatisfied*	*Somewhat satisfied*	*Satisfied*	*Extremely satisfied*
a. Your house	①	②	③	④	⑤	⑥
b. Your garden	①	②	③	④	⑤	⑥
c. Your garden reticulation	①	②	③	④	⑤	⑥
d. Your neighbours	①	②	③	④	⑤	⑥
e. Public parks in your neighbourhood	①	②	③	④	⑤	⑥
f. Your neighbourhood	①	②	③	④	⑤	⑥

B. Garden reticulation issues

2. What is the source of water for watering your garden? **CROSS** all the appropriate answers.

☐ Mains drinking water ☐ Groundwater via community bores

☐ Groundwater via private backyard bores ☐ Rainwater tank

☐ Grey-water (i.e. water from bathroom, laundry & kitchen)

☐ Others(specify):____________________

3. What type of reticulation do you have in your garden for watering your plants?

☐ Drip irrigation system only ☐ Sprinklers only

☐ Both drip and sprinklers ☐ None **(Go to question 6)**

4. Do you have any type of water filter connected to your garden reticulation?

☐ Yes ☐ No ☐ Not sure

If **YES** what is this filter for?

☐ For removal of coarse solids ☐ For removal of staining elements

☐ Both ☐ Not sure

☐ Others (specify)_____________

5. What time does your garden reticulation generally operate?

☐ Early morning (3 am-6 am) ☐ Morning (6 am-9am) ☐ Daytime (9 am-6 pm)

☐ Evening (6 pm-9 pm) ☐ Night (9 am-3 am) ☐ Not sure

a. Does this timing of your garden reticulation suit your garden needs?

☐ Yes **(Go to Q 6)** ☐ No ☐ Not sure

b. What changes would you prefer to make your garden reticulation better suited for your garden?

____
____
____
____
____
____

6. Have you noticed any type of staining in your property because of your garden reticulation?

☐ Yes ☐ No **(Go to Question 10)**

c. If **YES**, what colour is the staining?

☐ White *(Calcium staining)* ☐ Rust *(Iron staining)* ☐ Both

☐ Others (Please specify):_________________________________

d. Where is the staining seen? (**CROSS** all appropriate answers)

☐ Walls ☐ Driveway ☐ Garden edges ☐ Footpaths

☐ Other places (Please specify): ___________________________

7. How would you rate the impact of such **staining on your satisfaction** with each of the following two?

	Not critical at all	*Slightly critical*	*Moderately critical*	*Highly critical*	*Extremely critical*
a. Your garden reticulation	①	②	③	④	⑤
b. Your House *(property)*	①	②	③	④	⑤

8. Please rate your preference for each of the following option on **getting rid of staining** from your garden reticulation.

	Not preferred at all	*Slightly preferred*	*Moderately Preferred*	*Highly preferred*	*Extremely preferred*
Install a suitable water filter to remove staining	①	②	③	④	⑤
Upgrade the garden reticulation to subsurface drip only	①	②	③	④	⑤
Pay more for the water treatment	①	②	③	④	⑤

9. If you **prefer** to **pay more for water treatment** to make it free from staining, what should be the price of the treated water that you would be prepared to pay?

Less than the price of drinking water	*Same as the price of drinking water*	*More than the price of drinking water if needed*	*Don't Know*
①	②	③	④

10. If authorities try to develop an **alternative water supply system** for watering your gardens using other than drinking water, please rate how acceptable the following **water sources** would be.

Source of water	*Highly Unacceptable*	*Unacceptable*	*Somewhat unacceptable*	*Somewhat acceptable*	*Acceptable*	*Highly acceptable*
Treated wastewater	①	②	③	④	⑤	⑥
Groundwater via private backyard bore	①	②	③	④	⑤	⑥
Groundwater via community bores	①	②	③	④	⑤	⑥
Rainwater tank	①	②	③	④	⑤	⑥
Household grey-water (water from bathroom, laundry and kitchen)	①	②	③	④	⑤	⑥

11. Now, considering such **an alternative water supply system** for watering your garden, please rate your preference for each of the following **mode of operation**.

Mode of operation	*Not preferred*	*Slightly preferred*	*Moderately preferred*	*Highly preferred*	*Extremely preferred*
Weather station control to water your garden only when your garden needs water	①	②	③	④	⑤
Household control to water your garden when you wish	①	②	③	④	⑤
Household control and rostered 3 day per week supply	①	②	③	④	⑤

12. Similarly, please rate your preference for each of the **pricing option** for an alternative water supply for watering your garden?

Pricing system	*Not preferred*	*Slightly preferred*	*Moderately preferred*	*Highly preferred*	*Extremely preferred*
Flat annual charging *(according to your block size)*	①	②	③	④	⑤
Household meter charging *(Pay as you go)*	①	②	③	④	⑤

13. What aspects of your **garden reticulation** you would like to retain if water authorities want to develop **an alternative water supply system** for watering your gardens?

____

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____

C. Alternative water supply system (Groundwater supply system)

In your neighbouring suburb **BRIGHTON**, there is a provision of groundwater supply system for watering private gardens and public parks. This system consists of a community bore network which is connected to all households. Watering is provided automatically overnight to households and is activated on the basis of data from a local weather station. Other features of this system are: sub-surface reticulation; lower pressure than mains; and a flat annual fee on the basis of lot size.

14. How aware are you about **the groundwater supply system (i.e. 3rd pipe system)** in Brighton for watering private gardens and public parks?

Not aware at all	*Slightly aware*	*Moderately aware*	*Well aware*	*Very well aware*
①	②	③	④	⑤

15. What would be your level of agreement with each of the following statement about **groundwater system** for watering gardens and parks if similar system was developed in your neighbourhood too?

(*Please don't spend too long on each question. We are interested in your general thoughts only).*

	Strongly disagree	*Disagree*	*Somewhat disagree*	*Somewhat agree*	*Agree*	*Strongly agree*
I would be happy to accept the use of groundwater for watering my garden	①	②	③	④	⑤	⑥
Reducing rainfall makes it very important for us to conserve water now	①	②	③	④	⑤	⑥
I trust the water authorities would provide us every bits of information about the groundwater reticulation	①	②	③	④	⑤	⑥
It would be fair if people have full control over their garden watering	①	②	③	④	⑤	⑥
We have a duty to conserve our water for the next generation	①	②	③	④	⑤	⑥
Groundwater supply should be cheaper than mains drinking water	①	②	③	④	⑤	⑥
Increasing temperature won't really affect the water needs of my garden	①	②	③	④	⑤	⑥
I don't mind using groundwater for non-potable indoor uses (like toilet flushing, laundry etc) as long as appropriate quality is guaranteed	①	②	③	④	⑤	⑥
I see no health risk in using the groundwater for watering my garden	①	②	③	④	⑤	⑥
Using groundwater for watering gardens and parks is an environmentally sustainable approach	①	②	③	④	⑤	⑥
We should have the same watering restrictions for groundwater supply in our garden as everyone else	①	②	③	④	⑤	⑥
I trust the water authorities would manage our groundwater responsibly	①	②	③	④	⑤	⑥
It would be better to have non-drinking groundwater supply for watering our gardens than severe water restrictions	①	②	③	④	⑤	⑥

	Strongly disagree	*Disagree*	*Somewhat disagree*	*Somewhat agree*	*Agree*	*Strongly agree*
Community bore supply is a reliable system for watering our gardens	①	②	③	④	⑤	⑥
I trust the water authorities would treat groundwater to correct standards for its use in watering our gardens	①	②	③	④	⑤	⑥
I see a risk of something going wrong with groundwater supply in future	①	②	③	④	⑤	⑥
My household uses less water than others in our neighbourhood.	①	②	③	④	⑤	⑥
Groundwater reticulation would reduce the outdoor use of drinking water	①	②	③	④	⑤	⑥
The overall benefits of the groundwater reticulation for watering our gardens outweigh the overall risks associated with it	①	②	③	④	⑤	⑥
I wouldn't care about the lower pressure of groundwater reticulation as long as my garden gets water on a regular basis.	①	②	③	④	⑤	⑥
Groundwater reticulation is essential to manage future water shortage	①	②	③	④	⑤	⑥
Water authorities in WA are serious about water conservation	①	②	③	④	⑤	⑥
The cost of groundwater cannot overshadow its environmental benefits	①	②	③	④	⑤	⑥
We should pay for how much water we use on our gardens like everyone else	①	②	③	④	⑤	⑥
I trust developers would ensure infrastructure for groundwater reticulation meets acceptable standards	①	②	③	④	⑤	⑥
Automatic groundwater supply would better maintain gardens and parks even in summer	①	②	③	④	⑤	⑥
The lower pressure of groundwater supply may limit the use of sprinklers	①	②	③	④	⑤	⑥
I trust the water authorities would ensure I have good groundwater supply	①	②	③	④	⑤	⑥
I would use a hose on my garden because the water is of better quality	①	②	③	④	⑤	⑥
Having to pay a fixed price for access to groundwater would be unfair for those households with small gardens	①	②	③	④	⑤	⑥
Groundwater reticulation here would be safe for human health	①	②	③	④	⑤	⑥
I plan to avoid using groundwater in my garden as it is of lower quality	①	②	③	④	⑤	⑥
Individuals can make a difference in solving water problems by saving more water on a regular basis	①	②	③	④	⑤	⑥
The weather station control would ensure equitable groundwater supply	①	②	③	④	⑤	⑥
Community bores may pose risk to the level of local groundwater	①	②	③	④	⑤	⑥
I trust developers would operate a reliable groundwater reticulation here	①	②	③	④	⑤	⑥
It would be easy for most people to use groundwater in their gardens	①	②	③	④	⑤	⑥

You have done great by answering questions so far, now it won't take long to finish the rest.

D. Urban Design issues

16. Here are some statements about the features of **your neighbourhood, home and garden as they are now**. What would be your general level of agreement with each of the following statement?

	Strongly disagree	*Disagree*	*Somewhat disagree*	*Somewhat agree*	*Agree*	*Strongly agree*
My home environment has a pleasant feel to it	①	②	③	④	⑤	⑥
I am happy with the design of my home garden	①	②	③	④	⑤	⑥
We have enough public open spaces in this neighbourhood	①	②	③	④	⑤	⑥
This neighbourhood is a safe place for raising children	①	②	③	④	⑤	⑥
I have a good access to community services (council, transport, shopping, school etc) from my house.	①	②	③	④	⑤	⑥
I am sure the resale value will go up in this neighbourhood	①	②	③	④	⑤	⑥
I am happy with the size of my home garden	①	②	③	④	⑤	⑥
I like the way that public parks here collect the stormwater during winter	①	②	③	④	⑤	⑥
This neighbourhood is easy to get around.	①	②	③	④	⑤	⑥
I often use the public parks for recreational activities	①	②	③	④	⑤	⑥
This neighbourhood has a prestigious living environment	①	②	③	④	⑤	⑥
My kids enjoy playing in the public parks	①	②	③	④	⑤	⑥
I feel at home in this neighbourhood	①	②	③	④	⑤	⑥
I like native plants in the public parks around here	①	②	③	④	⑤	⑥
I usually go to other places (beach, bush etc) rather than the public parks in this neighbourhood	①	②	③	④	⑤	⑥
Higher density development makes this place a bit crowded	①	②	③	④	⑤	⑥
My house suits my family needs	①	②	③	④	⑤	⑥
I go to public parks to get myself out of my house	①	②	③	④	⑤	⑥
Native plants are good for better home gardens even in summer	①	②	③	④	⑤	⑥
There are good quality schools nearby my house	①	②	③	④	⑤	⑥
The buildings in this neighbourhood are very attractive	①	②	③	④	⑤	⑥
A well kept garden increases the resale value of house	①	②	③	④	⑤	⑥
Gardening is a pleasant break from everyday stress	①	②	③	④	⑤	⑥
I would rather live near parks than have a bigger backyard	①	②	③	④	⑤	⑥
I feel I have a responsibility to look after the public parks here	①	②	③	④	⑤	⑥

17. Are you happy with the quality of your garden (including lawn)?

☐ Yes ☐ No

18. If **NO** or **NOT SURE**, have you changed or do you plan to change anything to **improve your garden**? Please explain briefly the changes and reasons for such changes.

____
____
____
____
____
____

E. Social Environment (Friends, Neighbours and Society)

19. How much do you agree with each of the following statements about **your friends, neighbours and society** as they are now? Please rate these statements on given scale.

	Strongly disagree	*Disagree*	*Somewhat disagree*	*Somewhat agree*	*Agree*	*Strongly agree*
I am happy with the social mix of the local population here	①	②	③	④	⑤	⑥
I have good contacts with my neighbours	①	②	③	④	⑤	⑥
In this neighbourhood, residents treat each other pleasantly	①	②	③	④	⑤	⑥
Friendly neighbours are always good for the resale value	①	②	③	④	⑤	⑥
We have a good “neighbourhood watch” around here	①	②	③	④	⑤	⑥
There is too little privacy in this neighbourhood	①	②	③	④	⑤	⑥
I like the way community organisations in Ridgewood help our kids to be social	①	②	③	④	⑤	⑥
I feel socially isolated living here	①	②	③	④	⑤	⑥

F. Buying and Moving Behaviour

20. Were you born in Australia?

☐ Yes ☐ No

a. If **NO**, what is your country of birth? ____

b. Again if **NO**, how long you have been in Australia? _________ Years __________Months

21. How long you have been living in Ridgewood?

- ☐ Less than 1 year
- ☐ 1 year
- ☐ 2 years
- ☐ 3 years
- ☐ 4 years
- ☐ More than 4 years

22. Did you buy your home from:

- ☐ Satterley- Home Buyer Centre
- ☐ Previous residents
- ☐ I don't own this house- I rent
- ☐ Don't know
- ☐ Others (specify):____

23. Please rate the importance of each of the following reasons that make you want to live in Ridgewood.

	Not important at all	*Slightly important*	*Moderately important*	*Highly important*	*Extremely important*
Location	①	②	③	④	⑤
Price	①	②	③	④	⑤
Lifestyle	①	②	③	④	⑤
Neighbourhood	①	②	③	④	⑤
Modern housing designs	①	②	③	④	⑤
Design of home garden	①	②	③	④	⑤
Education opportunities	①	②	③	④	⑤
Employment opportunities	①	②	③	④	⑤
Proximity to public parks	①	②	③	④	⑤
Proximity to the extension of Mitchell Freeway	①	②	③	④	⑤
Proximity to the proposed North-West Railway	①	②	③	④	⑤
Focus on environmental sustainability	①	②	③	④	⑤
Developer's reputation for building communities	①	②	③	④	⑤

24. Would you recommend this place to a friend or family member?

☐ Yes ☐ No ☐ Not sure

25. Are you likely to move from this place within the next year? Please **CHOOSE ONE** best answer.

Definitely no	*Probably no*	*Not sure but would like to*	*Probably yes*	*Definitely yes*
①	②	③	④	⑤
Answer (a) and go to Q 26		**Go to Q 26**	**Answer (b), (c), (d), (e) and go to Q 26**	

If DEFINITELY or **PROBABLY NO,**

f. How long do you plan to live in this place?

_______________________________ Years

If PROBABLY or **DEFINITELY YES,**

g. Where are you planning to move?

_______________________________ ☐ Don't know

h. Would you again choose to buy a house in:

i.	A place similar to Ridgewood?	☐ Yes	☐ No	☐ May be
ii.	A place with groundwater (or 3rd pipe) system?	☐ Yes	☐ No	☐ May be

i. What are the reasons that make you move to another place? Please rank the followings by putting a value 1 to 5 against each; where 1 values higher than 2, 2 higher than 3, and so on.

Due to:		*Rank*
i.	Dissatisfaction with your house in overall	☐
ii.	Dissatisfaction with your Garden	☐
iii.	Dissatisfaction with public parks in your neighbourhood	☐
iv.	Dissatisfaction with your Neighbourhood in overall	☐
v.	Dissatisfaction with your neighbours and local people	☐

j. If there are other than above reasons that make you move to another place, please explain briefly

____

____

____

____

____

G. Socio-demographics:

26. Your gender: ☐ Male ☐ Female

27. What is your highest level of education?

- ☐ Year 10 or below
- ☐ Year 11-12 or equivalent
- ☐ TAFE certificate or equivalent
- ☐ TAFE diploma/advanced diploma or equivalent
- ☐ An undergraduate university degree
- ☐ A post graduate university degree

28. What is the combined annual income of your household before tax? Please **CROSS** the most appropriate one from the following categories.

- ☐ Less than $22,000 per annum
- ☐ $22,000 to $49,999 per annum
- ☐ $50,000 to $74,999 per annum
- ☐ $75,000 to $99,999 per annum
- ☐ $100,000 to $124,999 per annum
- ☐ $125,000 per annum or more

29. Which one of the following categories best describes your age?

☐ Under 21 years ☐ 21-30

☐ 31-40 ☐ 41-50

☐ 51-60 ☐ Over 60 years

30. Including yourself, how many people usually live in your household?

Adults (18+ years) …………..... Children (up to 17 years) …………….

31. Would the rest of your family members mostly agree with most of your responses to this survey?

☐ Yes ☐ No ☐ May be

H. Your consent and comments

32. Would you like to receive a summary of results from this research?

☐ Yes ☐ No

33. We would like to relate your responses to your water consumption practice. Would you give consent for ECU to request your household water consumption data from the Water Corporation?

☐ Yes ☐ No

If **YES**, please sign here:

34. We may like to follow up with you, if there appear relevant issues to be explored in detail for better water service and urban development in Ridgewood. Would you be interested in taking part in one of such follow-up talks?

☐ Yes ☐ No

a. If **YES**, please provide your contact details as below.

Name:

Phone/Email:

35. Finally, if you would like to say something relevant to this research, feel free to write down below. Any of your views would be valuable for us. You can use separate paper if needed.

Thank you very much for your contribution in this research.

APPENDIX J: Reminder cards for household survey

A. First week reminder in "The Green" and Ridgewood

Have you completed the ECU survey?

A few weeks ago, you kindly agreed to participate in a questionnaire survey for **Edith Cowan University** about your satisfaction with groundwater reticulation. *We realise you have many claims on your time but we would be grateful if you could please fill this survey and post it to us using included reply paid envelope; or let us to collect it at a time that suits you.*

You can contact us anytime for survey collection and for any other inquiries: Raju Dhakal (0434511970, r.sharma_dhakal@ecu.edu.au); or Prof. Geoff Syme (0405779638, g.syme@ecu.edu.au).

This survey will take up to 30 minutes and your participation is completely voluntary. This survey provides a better understanding about community opinion on the waterwise neighbourhood and groundwater reticulation in Brighton. Your opinion would be useful to improve the water service in your suburb in future. To thank you for your participation, we will donate $5 to Quinns Mindarie Surf Life Saving Club.

We would be very grateful for your response. Thank you very much.

Have you completed the ECU survey?

A few weeks ago, you kindly agreed to participate in a questionnaire survey for **Edith Cowan University** about your satisfaction with groundwater reticulation. *We realise you have many claims on your time but we would be grateful if you could please fill this survey and post it to us using included reply paid envelope; or let us to collect it at a time that suits you.*

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This survey will take up to 30 minutes and your participation is completely voluntary. This survey provides a better understanding about community opinion on the waterwise neighbourhood and water system in Ridgewood. Your opinion would be useful to improve the water service in your suburb in future. To thank you for your participation, we will donate $5 to Quinns Mindarie Surf Life Saving Club.

We would be very grateful for your response. Thank you very much.

B. Second and third week reminder in “The Green” and Ridgewood

Have you completed the ECU survey?

Few weeks ago, **Edith Cowan University** has requested you to participate in a questionnaire survey about your satisfaction with groundwater reticulation. *Please fill this survey and post it to us using included reply paid envelope; or let us to collect it at a time that suits you.*

You can contact us anytime for survey collection and for any other inquiries: Raju Dhakal (0434511970, r.sharma_dhakal@ecu.edu.au); or Prof. Geoff Syme (0405779638, g.syme@ecu.edu.au).

This survey provides a better understanding about community opinion on the waterwise neighbourhood and groundwater reticulation in Brighton. Your opinion would be useful to improve the water service in your suburb in future.

This survey will take up to 30 minutes. Your participation is completely voluntary. To thank you for your participation, we will donate $5 to Quinns Mindarie Surf Life Saving Club.

We would be very grateful for your response. Thank you very much.

Have you completed the ECU survey?

Last week, **Edith Cowan University** has requested you to participate in a questionnaire survey. *Please fill this survey and post it to us using included reply paid envelope; or let us to collect it at a time that suits you.*

You can contact us anytime for survey collection and for any other inquiries: Raju Dhakal (0434511970, r.sharma_dhakal@ecu.edu.au); or Prof. Geoff Syme (0405779638, g.syme@ecu.edu.au).

This survey provides a better understanding about community opinion on the waterwise neighbourhood and water system in Ridgewood. Your opinion would be useful to improve the water service in your suburb in future.

This survey will take up to 30 minutes. Your participation is completely voluntary. To thank you for your participation, we will donate $5 to Quinns Mindarie Surf Life Saving Club.

We would be very grateful for your response. Thank you very much.

APPENDIX K: Acknowledgement of ECU donation to QMSLSC

QUINNS MINDARIE
SURF LIFESAVING CLUB

Quinns Mindarie Surf Life Saving Club (Inc.)
Established 1982
ABN 15 674 140 779

Cnr Ocean Drive & Quinns Road
Club website: www.quinnssurfclub.com
Email: quinnsmindarie@bigpond.com
PO Box 11 Quinns Rocks WA 6030
Tel: 9305 1870 Fax: 9305 1874

12th June 2012

Raju Dhakal
Edith Cowan University

Dear Raju,

On behalf of the Quinns Mindarie SLSC I would like to thank you, and the Edith Cowan University for the kind donation of $900.00.

Donations to our Club are used for a range of items to help serve our community including the training and education of our patrol members, to teach our nippers important life saving and survival skills or to purchase first aid equipment.

Please pass on our thanks to everyone involved.

Yours sincerely,

Sharon Choake
Admin Assistant

APPENDIX L: Thanks letter for survey participants

Mr Raju Sharma Dhakal
Chief Investigator
Centre for Planning
ECU Business and Law
270 Joondalup Dr
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Email: r.sharma_dhakal@ecu.edu.au

Prof Geoff Syme
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AUSTRALIA ECU EDITH COWAN UNIVERSITY
JOONDALUP CAMPUS
270 Joondalup Drive,
Joondalup
Western Australia 6027
Telephone 134 328
Facsimile: (08) 9300 1257
CRICOS 00279B
ABN 54 361 485 361

Date: 2012/09/10

Subject: Thank you for your participation in ECU survey

Dear participant

Many thanks for your participation in the 'ECU Residential Satisfaction Survey', which took place during March-April 2012. You are one of 190 people who participated in this research and shared their experiences or feelings towards the groundwater reticulation developed for 'The Green' community in Butler. In recognition of your participation, we have donated $ 950.00 to Quinns Mindarie Surf Life Saving Club.

The initial survey results indicate that over three quarters of the participants in 'The Green' and 'Ridgewood' communities are happy with their housing environment overall. Most people in 'The Green' are happy with their groundwater system; however, nearly one-third are dissatisfied with their groundwater reticulation. This is slightly greater than the dissatisfaction with standard garden reticulation in 'Ridgewood'. Further, this research has also confirmed that individual's contentment with the groundwater system in 'The Green' significantly influenced his/her satisfaction with their home and garden and thus is a significant issue for the community.

Based on the survey findings, a number of issues that may improve the groundwater system have been identified. These included more flexibility in watering time and frequency; regular information and follow- ups; and more community input into the management of the system.

By early 2013, we will publish the research findings in the form of a PhD thesis and an industry report. If you would like further information about this research or a copy of the industry report when it is completed please contact, Raju Sharma Dhakal, (08) 6304 2702, r.sharma_dhakal@ecu.edu.au; or Prof. Geoff Syme, (08) 6304 2154, g.syme@ecu.edu.au.

Once again, we greatly appreciate your participation in our research.

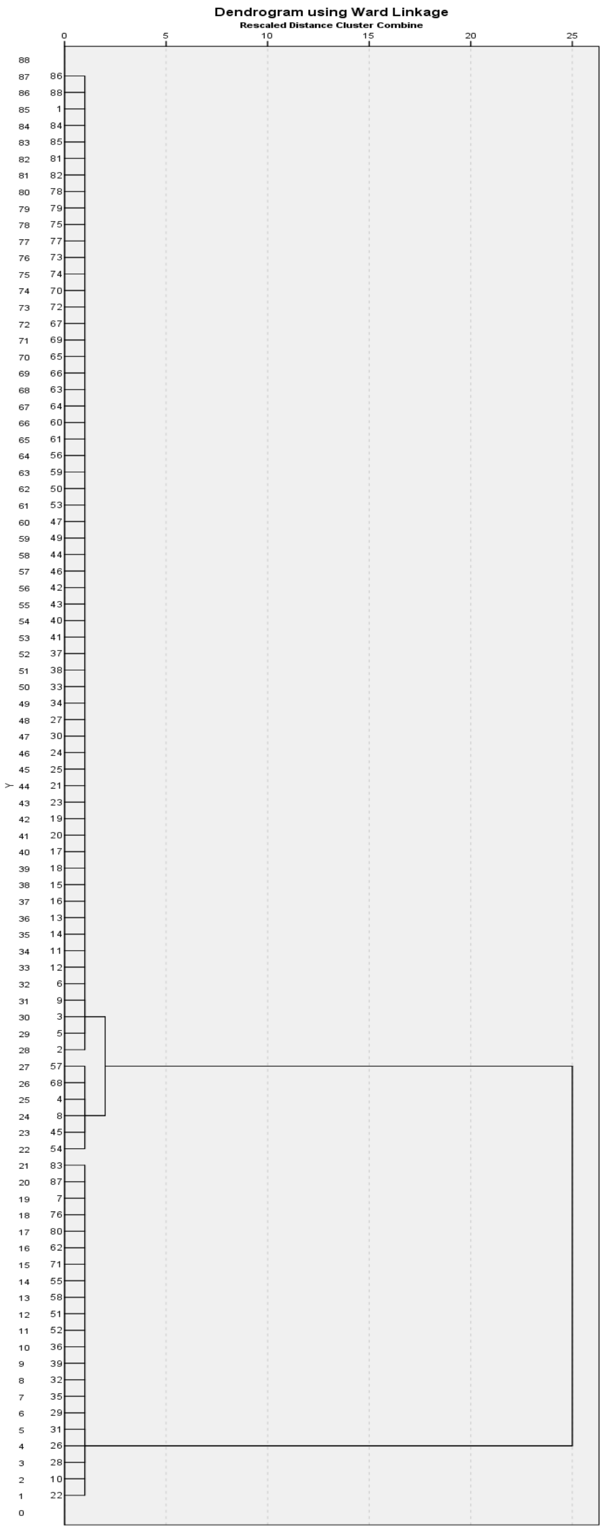
Raju Sharma Dhakal
Chief Investigator

Prof. Geoff Syme
PhD Supervisor

APPENDIX M: Cluster analysis

Cluster analysis in "The Green"

a. Dendrogram using ward linkage



b. Clusters resulted by Ward method of clustering

Clusters	Frequency	Percent
1	66	75.0
2	22	25.0
Total	88	100.0

c. One way ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Behavioural intention	Between Groups	30.383	1	30.383	31.662	.000
	Within Groups	82.526	86	.960		
	Total	112.909	87			
House satisfaction	Between Groups	6.914	1	6.914	6.039	.016
	Within Groups	98.464	86	1.145		
	Total	105.378	87			
Garden satisfaction	Between Groups	5.686	1	5.686	4.232	.043
	Within Groups	115.556	86	1.344		
	Total	121.242	87			
Groundwater satisfaction	Between Groups	3.420	1	3.420	1.915	.170
	Within Groups	153.552	86	1.785		
	Total	156.972	87			
Neighbours Satisfaction	Between Groups	24.396	1	24.396	17.818	.000
	Within Groups	117.748	86	1.369		
	Total	142.144	87			
Public parks satisfaction	Between Groups	21.879	1	21.879	27.114	.000
	Within Groups	69.394	86	.807		
	Total	91.273	87			
Neighbourhood satisfaction	Between Groups	33.921	1	33.921	48.404	.000
	Within Groups	60.267	86	.701		
	Total	94.188	87			
Society satisfaction	Between Groups	31.908	1	31.908	34.673	.000
	Within Groups	79.142	86	.920		
	Total	111.050	87			

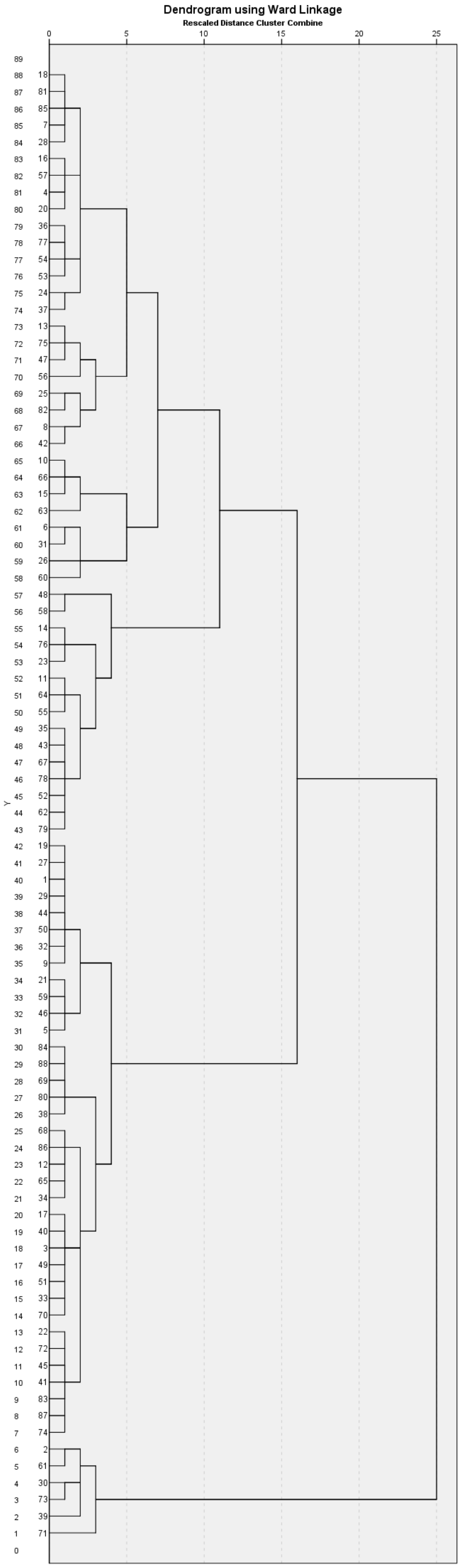
Cluster analysis in Ridgewood

a. Clusters resulted by Ward method of clustering

Ward Method

Clusters	Frequency	Percent
1	19	25.0
2	57	75.0
Total	76	100.0

b. Dendrogram using Ward method



c. One way ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
House satisfaction	Between Groups	1.577	1	1.577	3.259	.075
	Within Groups	35.810	74	.484		
	Total	37.387	75			
Garden satisfaction	Between Groups	2.254	1	2.254	1.843	.179
	Within Groups	90.497	74	1.223		
	Total	92.752	75			
Garden reticulation satisfaction	Between Groups	.019	1	.019	.016	.901
	Within Groups	89.801	74	1.214		
	Total	89.820	75			
Neighbours satisfaction	Between Groups	5.478	1	5.478	6.082	.016
	Within Groups	66.644	74	.901		
	Total	72.122	75			
Public parks satisfaction	Between Groups	3.856	1	3.856	3.857	.053
	Within Groups	73.982	74	1.000		
	Total	77.839	75			
Neighbourhood satisfaction	Between Groups	.541	1	.541	.498	.483
	Within Groups	80.368	74	1.086		
	Total	80.909	75			
Society satisfaction	Between Groups	6.004	1	6.004	6.150	.015
	Within Groups	72.246	74	.976		
	Total	78.250	75			
Behavioural intention	Between Groups	.065	1	.065	.076	.783
	Within Groups	63.484	74	.858		
	Total	63.549	75			

APPENDIX N: Confirmatory factor analysis and Path analysis in "IBM SPSS AMOS 21"

A. Output files of factor analysis for behavioural intentions in "IBM SPSS AMOS 21"

1. The Green

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Recom1	<---	BI_Green	.363	.063	5.737	***	
Moving2	<---	BI_Green	1.275	.113	11.287	***	
Stay3_1	<---	BI_Green	1.114	.145	7.695	***	
Where4_1	<---	BI_Green	.530	.084	6.296	***	

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Recom1	<---	BI_Green	.581
Moving2	<---	BI_Green	.986
Stay3_1	<---	BI_Green	.743
Where4_1	<---	BI_Green	.629

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
BI_Green	1.000				
e1	.258	.041	6.310	***	
e2	.047	.137	.344	.731	
e3	1.007	.186	5.420	***	
e4	.428	.069	6.163	***	

Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
Where4_1	.396
Stay3_1	.552
Moving2	.972
Recom1	.337

Matrices (Group number 1 - Default model)

Factor Score Weights (Group number 1 - Default model)

	Where4_1	Stay3_1	Moving2	Recom1
BI_Green	.033	.029	.714	.037

Total Effects and standardized total effects

	BI_Green	
	Total effects	Standardized effects
Where4_1	.530	.629
Stay3_1	1.114	.743
Moving2	1.275	.986
Recom1	.363	.581

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	8	1.643	2	.440	.821
Saturated model	10	.000	0		
Independence model	4	145.500	6	.000	24.250

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.020	.990	.952	.198
Saturated model	.000	1.000		
Independence model	.570	.528	.214	.317

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.989	.966	1.002	1.008	1.000
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.333	.330	.333
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	.000	.000	6.986
Saturated model	.000	.000	.000
Independence model	139.500	103.875	182.554

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.019	.000	.000	.080
Saturated model	.000	.000	.000	.000
Independence model	1.672	1.603	1.194	2.098

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.000	.000	.200	.514
Independence model	.517	.446	.591	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	17.643	18.618	37.461	45.461
Saturated model	20.000	21.220	44.773	54.773
Independence model	153.500	153.988	163.410	167.410

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.203	.207	.287	.214
Saturated model	.230	.230	.230	.244
Independence model	1.764	1.355	2.259	1.770

2. Ridgewood

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Where4_1	<---	BI_RGD	.403	.062	6.538	***	
Stay3_1	<---	BI_RGD	.966	.142	6.787	***	
Moving2	<---	BI_RGD	1.133	.105	10.839	***	
Recom1	<---	BI_RGD	.340	.081	4.190	***	

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Where4_1	<---	BI_RGD	.687
Stay3_1	<---	BI_RGD	.709
Moving2	<---	BI_RGD	.999
Recom1	<---	BI_RGD	.465

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
e4	<-->	e1	-.107	.036	-2.966	.003	

Correlations: (Group number 1 - Default model)

			Estimate
e4	<-->	e1	-.388

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
BI_RGD	1.000				
e4	.181	.033	5.544	***	
e3	.926	.171	5.420	***	
e2	.003	.109	.027	.979	
e1	.420	.069	6.058	***	

Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
Recom1	.216
Moving2	.998
Stay3_1	.502
Where4_1	.472

Matrices (Group number 1 - Default model)

Factor Score Weights (Group number 1 - Default model)

	Recom1	Moving2	Stay3_1	Where4_1
BI_RGD	.004	.875	.002	.007

Total Effects and standardized total effects

	BI_RGD	
	Total effects	Standardized effects
Recom1	.340	.465
Moving2	1.133	.999
Stay3_1	.966	.709
Where4_1	.403	.687

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	9	2.061	1	.151	2.061
Saturated model	10	.000	0		
Independence model	4	132.338	6	.000	22.056

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.034	.987	.866	.099
Saturated model	.000	1.000		
Independence model	.430	.563	.271	.338

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.984	.907	.992	.950	.992
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.167	.164	.165
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	1.061	.000	9.489
Saturated model	.000	.000	.000
Independence model	126.338	92.568	167.538

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.027	.014	.000	.127
Saturated model	.000	.000	.000	.000
Independence model	1.765	1.685	1.234	2.234

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.119	.000	.356	.189
Independence model	.530	.454	.610	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	20.061	21.347	41.038	50.038
Saturated model	20.000	21.429	43.307	53.307
Independence model	140.338	140.909	149.661	153.661

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.267	.253	.380	.285
Saturated model	.267	.267	.267	.286
Independence model	1.871	1.421	2.421	1.879

B. Output files of Path analysis to test the relationship of residential satisfaction with behavioural intention in "The Green", Ridgewood and in overall

1. The Green

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Recom1	<---	BI_Green	1.000				
Moving2	<---	BI_Green	3.572	.615	5.805	***	par_1
Stay3_1	<---	BI_Green	3.071	.560	5.487	***	par_2
Where4_1	<---	BI_Green	1.463	.298	4.906	***	par_3
NBSat	<---	BI_Green	-3.097	.575	-5.383	***	par_4
HomeSat	<---	BI_Green	-1.404	.709	-1.981	.048	par_5

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Recom1	<---	BI_Green	.576
Moving2	<---	BI_Green	.994
Stay3_1	<---	BI_Green	.737
Where4_1	<---	BI_Green	.625
NBSat	<---	BI_Green	-.488
HomeSat	<---	BI_Green	-.219

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
e5	<-->	e6	1.532	.463	3.310	***	par_6
e1	<-->	e6	-.450	.117	-3.848	***	par_7

Correlations: (Group number 1 - Default model)

			Estimate
e5	<-->	e6	.341
e1	<-->	e6	-.443

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
BI_Green	.129	.045	2.857	.004	par_8
e1	.260	.041	6.360	***	par_9
e2	.022	.132	.164	.870	par_10
e3	1.028	.184	5.573	***	par_11
e4	.431	.069	6.228	***	par_12
e5	5.079	.771	6.589	***	par_13
e6	3.973	.596	6.666	***	par_14

Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
NBSat	.238
HomeSat	.048
Where4_1	.391
Stay3_1	.543
Moving2	.987

	Estimate
Recom1	.332

Matrices (Group number 1 - Default model)

Factor Score Weights (Group number 1 - Default model)

	NBSat	HomeSat	Where4_1	Stay3_1	Moving2	Recom1
BI_Green	-.001	.000	.006	.005	.268	.005

Total Effects and standardized total effects

	BI_Green	
	Total effects	Standard effects
NBSat	-3.097	-.488
HomeSat	-1.404	-.219
Where4_1	1.463	.625
Stay3_1	3.071	.737
Moving2	3.572	.994
Recom1	1.000	.576

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	14	6.683	7	.463	.955
Saturated model	21	.000	0		
Independence model	6	213.317	15	.000	14.221

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.101	.975	.925	.325
Saturated model	.000	1.000		
Independence model	.821	.508	.312	.363

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.969	.933	1.002	1.003	1.000
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.467	.452	.467
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	.000	.000	10.008
Saturated model	.000	.000	.000
Independence model	198.317	154.786	249.293

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.077	.000	.000	.115
Saturated model	.000	.000	.000	.000
Independence model	2.452	2.280	1.779	2.865

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.000	.000	.128	.605
Independence model	.390	.344	.437	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	34.683	37.133	69.366	83.366
Saturated model	42.000	45.675	94.024	115.024
Independence model	225.317	226.367	240.181	246.181

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.399	.402	.517	.427
Saturated model	.483	.483	.483	.525
Independence model	2.590	2.089	3.176	2.602

2. Ridgewood

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Recom1	<---	BI_RGD	1.000				
Moving2	<---	BI_RGD	2.812	.693	4.059	***	
Stay3_1	<---	BI_RGD	2.794	.654	4.274	***	
F1HomeSat	<---	BI_RGD	-1.836	.734	-2.501	.012	
F2NBSat	<---	BI_RGD	-1.444	.366	-3.950	***	

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Recom1	<---	BI_RGD	.510
Moving2	<---	BI_RGD	.926
Stay3_1	<---	BI_RGD	.765
F1HomeSat	<---	BI_RGD	-.338
F2NBSat	<---	BI_RGD	-.401

Intercepts: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
Recom1	1.434	.084	16.979	***	
Moving2	2.053	.131	15.671	***	
Stay3_1	3.329	.157	21.145	***	
F1HomeSat	11.672	.234	49.861	***	
F2NBSat	7.065	.155	45.533	***	

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
e1	<-->	e7	-.383	.106	-3.623	***	

Correlations: (Group number 1 - Default model)

	Estimate
e1 <--> e7	-.495

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
BI_RGD	.139	.064	2.195	.028	
e1	.396	.069	5.743	***	
e2	.184	.172	1.068	.286	
e3	.770	.210	3.664	***	
e7	1.515	.255	5.937	***	
e6	3.640	.606	6.010	***	

Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
F1HomeSat	.114
F2NBSat	.161
Stay3_1	.586
Moving2	.857
Recom1	.261

Matrices (Group number 1 - Default model)

Factor Score Weights (Group number 1 - Default model)

	F1HomeSat	F2NBSat	Stay3_1	Moving2	Recom1
BI_RGD	-.008	-.007	.057	.239	.033

Total Effects and standardized total effects

	BI_RGD	
	Total effect	Standardized effect
F1HomeSat	-1.836	-.338
F2NBSat	-1.444	-.401
Stay3_1	2.794	.765
Moving2	2.812	.926
Recom1	1.000	.510

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	16	1.234	4	.872	.309
Saturated model	20	.000	0		
Independence model	10	115.051	10	.000	11.505

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.989	.973	1.025	1.066	1.000
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.400	.396	.400
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	.000	.000	2.313
Saturated model	.000	.000	.000
Independence model	105.051	74.192	143.367

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.016	.000	.000	.031
Saturated model	.000	.000	.000	.000
Independence model	1.534	1.401	.989	1.912

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.000	.000	.088	.906
Independence model	.374	.315	.437	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	33.234	36.017		
Saturated model	40.000	43.478		
Independence model	135.051	136.791		

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.443	.480	.511	.480
Saturated model	.533	.533	.533	.580
Independence model	1.801	1.389	2.312	1.824