

Towards resilience - identification of the characteristics required for an urban water supply business

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Abstract

Access to a safe and reliable water supply is a human right and is a pre-requisite for all other human rights. Communities in developed countries have an expectation of adequate high-quality water supplies being available to satisfy their demands and those expectations are continuing to change to match advancements in lifestyle patterns. Water service businesses have an obligation to manage the resources to safeguard the health of the community without causing environmental harm, whilst achieving this through efficient, effective and affordable processes.

The population living in urban areas is predicted to increase from a current global urbanisation figure of a little over 50% to an estimated 66% in 2050. The United Nations contends that careful planning will be necessary to ensure basic infrastructure is developed and essential services are provided to avoid exacerbating poverty and inequality or threatening the environment.

Researchers are advocating that climate change is now a real, pressing and global problem. Increasing evidence from the scientific community identifies that climate change should be considered irrevocable and will have a significant effect on water resources into the future. Thus, the combination of population growth and associated consumer demands, together with the likelihood of climate change reducing the limited resources, will pose challenges for water supply businesses. The businesses will be confronted with uncertainties and the likelihood of extremely disruptive events.

A primary objective of water businesses is to adopt risk mitigation strategies to enable the businesses to remain sustainable and to be resilient to disruptive events. The terms sustainable and resilient in the context of water supply businesses are a relatively recent adaptation of the original usage and understandings of the words. The derivation of the terms sustainable and resilient needs to be understood to drive the governance and management required to achieve the long-term goals.

The first objective of the research was to understand the nature of externally generated disruptive events and to identify the business elements needed and to manage uncertainties and impacts effecting the planning for the future provision of services to the stakeholders. A second objective required the identification and analysis of bridges and barriers that has the potential to enhance or frustrate the development of business

resilience. The research design provided a structured approach to enable the assembly and analysis of concepts leading to the development of the necessary characteristics required by urban water businesses to facilitate adaptive responses to disruptive events. A literature review determined current knowledge and approaches regarding the consideration of resilience and the development of definitions and understandings of resilience together with relationships in terms of sustainability, risk and vulnerability.

A case study was chosen as a pivotal part of the research to identify and demonstrate the complexities of the inter-relationships and interdependencies of business functions impacting on the success of governance and management models in urban water businesses subjected to a disruptive event. The South-East Region of Queensland, Australia was chosen for the case study as it was considered to have the elements and complexities enabling the critical analysis of the study criteria in relation to operational businesses suffering the effects of a significant disruptive event. The case study provided a context to identify and record historic data to lead to an understanding of the dynamics of reactions by government and water businesses during the period of a major disruption event in terms of extreme drought combined with major population growth. Reactive actions initiated legislation changes and industry restructures causing further business disruption to be experienced by the participants charged with the responsibility to action the changes and to continue the provision of water services to the community in accordance with the desired standards of service. A semi-structured survey recorded participant's observations of residual and imposed risks and uncertainties as the businesses transitioned through three discrete time-periods of various reactive initiatives and institutional restructure imposed by government legislation. The survey also provided the opportunity to explore social and cultural aspects to inform the assessment of the ability of the businesses to have adaptive capacity in each of the three time-periods.

Key findings from the literature review, case study and survey enabled the identification of the interaction and inter-relationships of critical factors leading to the ability of water businesses to be sustainable and enable transition to having adaptive capacity to become resilient to disruptive events. The terms: water security, reliability, sustainability and others were shown to be regularly confused with the description of resilience, which by definition, is a state of being adaptive and able to "bounce back" or to be reorganised, providing the system has not been taken beyond the point of failure. The study demonstrates that a pre-requisite for the achievement of resilience is

sustainability. The state of being sustainable implies balance and equilibrium, with the commonly accepted three-pillars of Social, Environmental and Economic attributes being in balance and interdependent. Being sustainable does not imply having resilience, however sustainability has been shown to be a prerequisite for resilience. The study argues that sustainability requires the technical, social and financial resources operating in harmony for a given outcome, whereas resilience requires the additional social and cultural characteristics to enable adaption to disruptions, to “bounce back”, or to reorganise.

Discussions in the study identified that sustainable water supply business needed long-term strategic plans to guide the continuing sustainability. The adopted definition of resilience identifies “anticipate trends and variability” as part of the criteria. To transition a sustainable business to one having resilience to overcome uncertainties and disruption, water supply businesses need the flexibility to identify uncertainties in association with their strategic goals to enable creative assessment of possible impacts that can be considered through scenario analysis. The study outlined that progression from sustainability to resilience requires the addition of social and cultural characteristics to develop institutional knowledge, critical reflection, learning, creativity, collaboration and fair governance.

Investment in technical, social and economic options to analyse uncertainties guided by long term strategic planning was shown to be necessary to understand possible reaction scenarios for responding to disruptive events. The study argues that pre-disruption investment of this type can ensure planned technical solutions are prudent and efficient to enable best value solutions to enable the continued delivery of desired standards of service to the stakeholders.

The case study discussions demonstrated that actions to provide adaptive capacity to counter disruptions having impacts on the key stakeholders must include an understanding of the community desires and behaviours. Any proposed behaviour modifications need to be approached through the establishment of the community’s trust in the messages being promoted by the water business. Results from the case study survey indicate that successful messaging can promote a sense of community ownership of the adopted reaction initiative. Community inclusion in development of solutions is an essential component of adaptive capacity for urban water businesses.

The analysis and key findings from the literature review, case study and survey established a set of characteristics and actions required to enable an urban water supply business to become resilient to disruptive events. The recommendations provide guidance for water supply businesses to identify governance and management procedures and behaviours driving the cultures required to enable the capacity to adapt to disruptive events and be deemed resilient. Primary cultures recommended are empowering continuous learning, establishment of trust and collaboration, critical reflection, capacity to change, adopting creative solutions, being visionary and having the ability to improvise. A further recommendation promotes collaborative relationships with stakeholders and customers to create understanding and trust of the initiatives promoted to effectively manage available water resources.

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List of Abbreviations

CEO	Chief Executive Officer
COAG	Council of Australian Governments
DEWS	Department of Energy and Water Supply
DNRMW	Department of Natural Resources, Mines and Water
D-R	Distributor-Retailer
ENSO	El Nino-Southern Oscillation
GCW	Gold Coast Water
GCWF	Gold Coast Water Future
IOD	Indian Ocean Dipole
IP	Intellectual Property
IPO	Indian Ocean Dipole
ITCZ	Intertropical Convergence zone
L/p/d	Litres per person per day
LGA	Local Government Authority
MJO	Madden-Julian oscillation
NWI	National Water Initiative
OUM	Office of Urban Management
QDC	Queensland Development Code
QUT	Queensland University of Technology
QUU	Queensland Urban Utilities
QWC	Queensland Water Commission
RCC	Regional Coordination Committee
RPAG	Regional Planning Advisory Group
SAM	Southern Annular Mode
SEQ	South East Queensland
SEQROC	South East Queensland Region of Councils
SEQWSS	South East Queensland Water Supply Strategy
SST	Sea Surface Temperature
STR	Sub-tropical ridge
ToR	Terms of Reference

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

QUT Verified Signature

Signature:

Date: 15th July 2018

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Chapter 1 Introduction

1.1 BACKGROUND

Access to a safe and reliable water supply is a human right and is a pre-requisite for all other human rights (Barraque, 2011). Communities in developed countries have an expectation of adequate high-quality water supplies being available to satisfy their demands and those expectations are continuing to change to match advancements in lifestyle patterns. Water service businesses have an obligation to manage the resources to safeguard the health of the community without causing environmental harm, whilst achieving this through efficient and effective processes.

Communities that are sufficiently fortunate to have access to reliable and safe reticulated supplies often take the services for granted and question the costs having to be paid for those services. There is a general lack of understanding why behaviours might need to change to permit the optimum management of a most precious resource to remain sustainable and to be resilient to disrupting events.

The population living in urban areas is predicted to increase from a current global urbanisation figure of a little over 50% to an estimated 66% in 2050 (United Nations, 2014). This trend together with overall global population increase will require careful management of finite resources as well as exploring the options for additional resources. The United Nations (2014) contends that careful planning will be necessary to ensure basic infrastructure is developed and essential services are provided to avoid exacerbating poverty and inequality or threatening the environment.

According to Shrestha, Babel, and Pandey (2014), climate change is now accepted as a real, pressing and global problem and scientific evidence shows global warming should be considered irrevocable. The reference authors contend that there is an increasing consensus among the scientific community that climate change will have a significant effect on water resources. Thus, the combination of population growth and associated consumer demands, together with the likelihood of climate change reducing the limited resources, will pose challenges for water supply businesses into the future.

Although climate change tends to be the prime focus of discussions for the future challenges of having available water resources, Vorosmarty et al. (2000) conclude that population growth and economic development over the next 25 years will have a greater

impact on water supply availability and consumer demand than will the effects of mean changes due to climate change. The authors highlight the need for an integrated approach bringing together the climate change, water resources, and socio-economic requirements of communities. To achieve this integration, water supply businesses will be faced with complex management challenges from a range of potentially disruptive events. Water UK (2015), a body representing all major statutory water and wastewater service supply organisations in England, Wales, Scotland and Northern Ireland, conclude that customers will have as their number one priority, a water supply that is safe and reliable at a price they can afford. It will therefore be critically important that the water industry plans for the long term to ensure decisions and investments made today can determine the level of service that the industry is required to provide well into the future.

The balance between supplied water quality, availability, affordability and agreed standards of provider/customer interaction form a basic framework for the future water supply planning for infrastructure and services. Water supply businesses having the responsibility for supply and management of potable water for urban communities have various ownership and governance structures and are in most cases, a monopoly supplier.

Management and operational procedures are essentially based on historical and predicted conditions of water demand and the availability of water sources. Technical data and methods for the development of infrastructure to service the consumer demands are readily available through skilled and experienced practitioners. Design standards and operational processes are generally well documented and understood. However, water businesses are faced with planning and operational uncertainties resulting from extremes in climatic conditions, unplanned population movements, regulation and stakeholder behaviour or expectations.

Therefore, a primary objective of water businesses is to adopt risk mitigation strategies to enable the businesses to remain sustainable and to be resilient to disruptive events. The terms sustainable and resilient in the context of water supply businesses are a relatively recent adaptation of the original usage and understandings of the words. The derivation of the terms sustainable and resilient needs to be understood to drive the governance and management required to achieve the long-term goals.

1.2 RESEARCH PROBLEM

A range of business models are adopted for organisations established to supply reliable and secure potable water to urban communities and to operate in highly regulated environments with regard to water quality and quantity. At the same time, stakeholders have expectations that the business remains financially viable while being affordable for consumers and the delivery of service standards is consistently maintained, including through conditions of disruptive extremes such as drought.

Water supply businesses are highly complex in all their facets of planning, infrastructure delivery, product delivery, systems operation, stakeholder communications and management. Businesses require insight into the probability of occurrence of factors and events which could lead to disruption and failure. Anticipated impacts of those disruptive events can then inform the organisation in adoption of mitigation measures necessary to enable a continued sustainable operation and have resilience to withstand disruptive events.

Disruptive influences can result from, for example:

- Future climatic conditions;
- Insufficient or inappropriate infrastructure;
- Unexpected population movements;
- Stakeholder group behaviour and expectations;
- Legislative changes;
- Inappropriate planning and judgement by business owners and management.

The research problem relates to the lack of understanding of how water supply businesses can develop adaptive capacity to remain sustainable and to have the ability to be resilient to disrupting influences. The adaptive capacity must be developed in a challenging environment of high stakeholder expectations and business regulation.

1.3 RESEARCH QUESTIONS

Urban water supply businesses operate under controlled and regulated regimes and are often subject to uncertainties and disruptions from external influences. They are at times impacted by extreme events which require a change to the mode of operation to

react to those events. A part of the response mechanism is controlled by the internal systems, business culture and effectiveness of the communication with stakeholders. The research questions are:

- What characteristics are required to ensure an urban water supply business can become resilient?
- What are the essential attributes to be maintained by governance and management groups to ensure urban water supply businesses can be resilient?
- What strategies are effective in obtaining community acceptance and support for initiatives to promote prudent management of water resources?

1.4 AIMS AND OBJECTIVE

The research questions highlighted the need for an understanding of resilience with a specific reference to urban water supply businesses. The understanding was needed to identify the key concepts that apply to a resilient business. The characteristics to support and maintain the continued state of resilience in the businesses needed to be developed to identify governance and management processes.

The research aimed to define resilience as applied to urban water supply businesses and to identify characteristics required to be developed by governance and management groups to support the establishment and maintenance of resilience to disruptive events in the businesses.

The initial objective of the research was to understand the nature of externally generated disruptive events and to identify the business elements needed and to manage uncertainties and impacts effecting the planning for the future provision of services to the stakeholders. A second objective required the identification and analysis of bridges and barriers that has the potential to enhance or frustrate the development of business resilience. The formulation of recommendations for the creation of appropriate governance and management characteristics and attributes required to support a resilient business was the third objective.

1.5 SIGNIFICANCE

Researchers considering the ability of water supply utilities to be resilient to disruptive events regularly focus on the technical aspects of infrastructure and the resource

capacity to continue to deliver the required standard of service during disruptions (Amarasinghe et al., 2017; Ashbolt, Maheepala, & Perera, 2015; Filippini & Silva, 2015; Jofreh, 2014; Turnquist & Vugrin, 2013; Wang & Blackmore, 2009). This study identified the essential link of technical capacity with socio-economic, environmental and legal considerations driving the ability to be resilient through suitable governance and management regimes enabling proactive strategies and business culture for mitigation of the effects of uncertainties. The importance of the study of the interdependence and interaction between the socio-economic, environmental, legal and technical aspects has been highlighted by Head (2010), while advocating the need for consideration of the competing broad and diverse issues in the review of reactions to a disruptive event. The development of key findings and conclusions of this study are significant not only for urban water supply businesses, but also for any public utility operating as a service provider to communities and being subject to significant uncertainties and disruptions.

1.6 STUDY SCOPE

The scope of the study was to define and understand the characteristics required for organisational resilience and to address the ability of urban water service businesses to adjust and adapt to the effects of disruptive influences through consideration of strategic approaches to governance, management, organisational culture, operational procedures and stakeholder communication. Although other sectors of water businesses (such as for irrigation, wastewater or recycled water) have some common organisational and business challenges, only the urban potable water supply sector has been the subject of specific attention in this study.

Detailed assessment of technical aspects of asset or system capacity was not analysed in the study. The study assumed that appropriate strategic asset management is practiced by the businesses. Relevant technical data to demonstrate impacts on business outcomes was taken from appropriate sources.

While system affordability impacts business strategies and decisions, options and processes for the financing of assets and operations were also not a part of the study. Where specific financial data was required, it was obtained from appropriate sources.

Finally, disruptive events considered in this study can result from uncertainty or unexpected events beyond the direct control of the relevant business. However, consideration of acts of terrorism was excluded from the scope of the study. Disruption as

a result of cyber-crime was not specifically addressed but was taken as posing similar business interruptions as others considered in the study.

1.7 OUTLINE OF THE THESIS

This thesis document consists of seven chapters, a list of references and three appendices. This introductory chapter has outlined the aim of the study, gives a description of the scope, outlines items excluded from the study and explains the study significance.

Chapter 2 introduces and defines the terms: risk, vulnerability, sustainability and resilience to enable an understanding of the concepts in relation to urban water businesses. The understanding of the terms leads to discussions regarding uncertainties faced by the water businesses in their role of delivering desired standards of water delivery services, particularly through times of disruptive events.

The research design and study method are presented in Chapter 3. The methodology has included a critical review of literature to probe the relative importance of the socio-cultural, economic and technical concepts discussed in the governance and management of urban water businesses. The chapter defines seven focus areas chosen to guide the literature review. A case study and survey are introduced to gain insight into how a selection of water businesses dealt with drought and unexpected population growth whilst continuing to respond to the expectations of delivery of water supply services.

Chapter 4 provides the philosophy behind the adoption of the case study and gives details of the study area to confirm its suitability to inform the outcomes of this thesis. The case study outlines the “base case” prior to business disruptions occurring, followed by the description of the water businesses’ journey from the pre-disruption conditions to the analysis of the disruptive event impacts and imposed reactions for resolution of the impacts. Actions to overcome the disruptions, including legislative reform, institutional restructure and water supply capacity and demand reviews are also described and analysed in Chapter 4.

Details of the survey associated with the case study are given in Chapter 5. The survey undertaken by the semi-structured questionnaire afforded the opportunity to record and understand the business risks and disruption experienced by the participants charged with the responsibility to action legislation and industry transformations whilst continuing the provision of water services to the community in accordance with the desired standards of service. The aim of the survey was to explore participants’ observations of residual and

imposed risks and uncertainties as the businesses transitioned through periods of various imposed reactive initiatives. The survey also provided the structure to explore social and cultural aspects to inform the assessment of the ability of the businesses to have adaptive capacity during the periods of transition and restructure. A further question requested opinions regarding the effectiveness of demand management initiatives adopted during the period of drought impact. Question responses and comments are discussed within this chapter, however the analysis of the responses, their overall relevance and links to the thesis questions occurs in Chapter 6.

Chapter 6 analyses the understanding of definitions of key concepts outlined in the literature review and the relationship with the learnings from the case study and survey questionnaire. The discussion aimed to describe the development of key findings from the literature review combined with the derived data from the case study and survey. The discussion produced answers to the study questions to present recommendations for development of adaptive capacity for urban water businesses to become resilient to disruptive events. Detailed discussion regarding effectiveness of demand management initiatives and observations of consumer behavioural change also occurs in Chapter 6.

Chapter 7 contains key findings from the study to inform the recommendations. The identification of future research to assist in the management of uncertainties regarding consumer behaviour and effectiveness of water demand initiatives is outlined.

Chapter 2 Literature Review

2.1 INTRODUCTION

The literature review for this study aimed to inform the identification and evaluation of the interdependence and interaction of social, economic and technical aspects of water supply businesses required to enable development of governance and management characteristics leading to adaptive and resilient businesses. The businesses can be subjected to uncertainties from potentially disruptive influences such as extreme climatic events; unexpected population increases and movements; changes in consumer behaviour; and expectations and changes in the legislation and regulation regimes. The critical review of research literature discusses the definitions of *Risk*, *Vulnerability*, *Resilience* and *Sustainability* as reviewed by other authors and informs the definitions adopted for this study. The discussion in the chapter then explores the relationship between those key concepts as defined and applied to a water utility business.

2.2 DEFINITIONS OF KEY CONCEPTS

To establish a base understanding of the inter-relationships between resilience, risk, vulnerability, sustainability, adaptability and reliability, it was considered essential that the terms were defined in the context of this study. The key definition required is that of *Resilience* and this needed to be explored through current understanding and usage.

2.2.1 Risk

SAI Global (2013) promotes risk as being the “effect of uncertainty on objectives” and gives associated explanatory notes:

- i. “An effect is a deviation from the expected — positive and/or negative;
- ii. Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organisation-wide, project, product and process);
- iii. Risk is often characterized by reference to potential events and consequences, or a combination of these;

- iv. Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence;
- v. Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of an event, its consequence, or likelihood.”

Haines (2011) takes the view that considering a systems-based philosophical and methodological approach, the risk to a system as well as its vulnerability and resilience, can be understood, defined, and possibly quantified most effectively. In a review of the work by Haines, Aven (2011) argues that risk is probability based, defined by the probability and severity of adverse effects, or the consequences, and suggests a rephrase of the definition by saying that risk associated with an activity is to be understood as uncertainty about and severity of the consequences of an activity. Aven (2011) also suggests the uncertainties relate to the events and consequences and the severity is just a way of characterising the consequences. Uncertainty meaning that it is not known whether the event will occur or not, and what the consequences (outcome) will be (how severe they will be) if the event does occur. Although the work by Haines (2011) and Aven (2011) considered mathematical derivation of risk events, it was considered that in relation to this study, the probability and severity of the disruptive event outcomes are predominately the consequences resulting from the accuracy of judgements made in relation to criteria for the future design and operational aspects of water services. Hence, a mathematical derivation of the likelihood of a disruptive event occurring does not greatly assist in the discussion.

The definitions and arguments promoted by Haines (2011) and Aven (2011) are covered by the SAI Global definition (SAI Global, 2009) with its accompanying notes. The SAI Global (2009) definition can be applied to the discussions on vulnerability, resilience and sustainability and was adopted for this study.

2.2.2 Vulnerability

Urban water utilities as a business entity, base their forward management and operating plans on “best available information” and judgements which include a forecast of events outside their control, such as climatic conditions. Hence the business is “at risk” of consequences from an uncertainty as described in the risk definition above.

Various authors have reviewed the definition of *Vulnerability* and the relationship between risk and vulnerability. Lei, Wang, Yue, Zhou, and Yin (2014) suggest that the word “vulnerability derives from the Latin word *vulnerare* (to be wounded) and describes the potential to be harmed, which means the sensitivity to a perturbation or stress.” Definitions have been proposed depending on the context of the subject and application. Downing, Ringius, Hulme, and Waughray (1997) suggest vulnerability be considered as environmental sensitivity. Various authors consider systems being exposed to stress or a hazard are considered vulnerable (Adger, 2006; B. L. Turner et al., 2003; Zhou, Wang, Wan, & Jia, 2010). Han (2011) promotes the definition of vulnerability as the result of interactive change of exposure and response activity.

Key words included by authors in their definitions of *vulnerability* are: exposure, sensitivity, susceptible, each of which could be considered as a state of being. On the other hand, *hazard* is an external effect creating a risk or as defined by SAI Global (2001), “a source or a situation with a potential for harm in terms of human injury or ill-health, damage to property, damage to the environment, or a combination of these”.

The definition of vulnerability proposed by The United Nations Office for Disaster Risk Reduction, UNISDR (2009), covers the focus and aspects of this study with its specific reference to community, systems and assets and encompasses the intent of the constructs from the other authors. This definition will be adopted for this study: “*Vulnerability, the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.*” (UNISDR, 2009). In their role to facilitate the implementation of the International Strategy for Disaster Reduction, UNISDR (2009) contend that there is no such thing as a “natural disaster”, only “natural hazards”.

2.2.3 Resilience

According to Brown and Williams (2015), “Among and even within disciplines, there are numerous definitions of resilience that focus on different attributes or different perspectives. The use of the term has grown over the past several decades, so that by now, many areas of research and application have their own definitions, metrics, and discipline-specific literature”. In the derivation of the definition of vulnerability, Kasperson, Kasperson, and Kasperson (2005), propose the definition as, “Vulnerability is the flip side of resilience: when a social or ecological system loses resilience, it becomes vulnerable

to change that previously could be absorbed.” (Kaspersen et al., 2005). Zhou et al. (2010) demonstrate the concepts with the figure as reproduced as Figure 2-1.

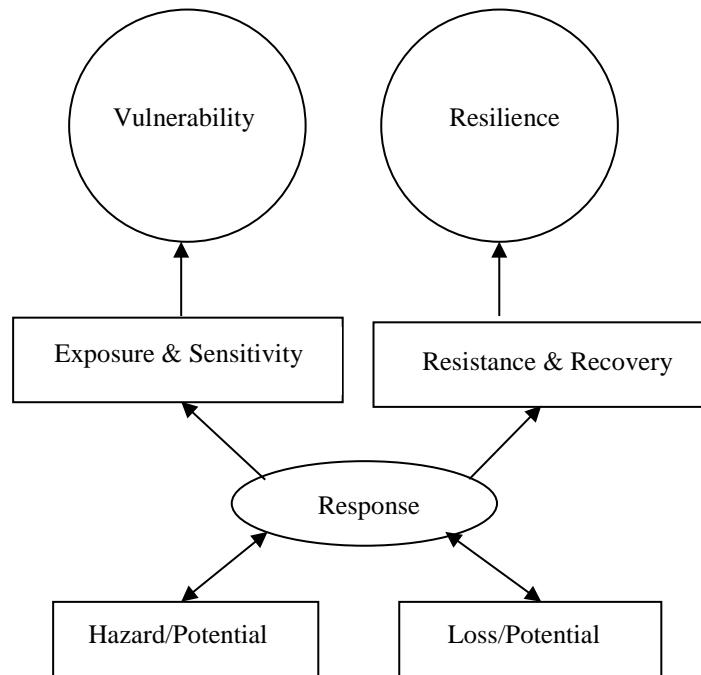


Figure 2-1. The relationship between vulnerability and resilience. Reproduced from “Resilience to natural hazards: a geographic perspective”, by Zhou et al., 2010. *Natural Hazards*, 53(1) p. 26.

There is common agreement between authors, Aven (2011), Haimen (2011) and Kjeldsen and Rosbjerg (2004) that resilience represents the ability of the system to withstand a major disruption within acceptable degradation parameters and to recover within an acceptable cost and time. Similarly, Collier et al. (2013) state that resilience simultaneously absorbs change and provides the capacity for change. Lei et al. (2014) suggests that “resilience is actually derived from the Latin word *resilio*, meaning ‘to jump back’, and that among social systems, resilience is determined by the capacity of reorganizing itself and the speed of recovery.” A review by Zhou et al. (2010) considers the relationship between Resilience and Vulnerability arguing that when discussing disaster resilience, it is a process of enhancing the capacity to resist and recover from loss caused by extreme natural events and is mainly focused on the stages of in- and post-disaster, thus helping to explore policy options for dealing with the hazards.

An analysis of the definitions shows that for the various applications of resilience, the common thread is that resilience is a state of being able or having capacity to recover from, accommodate, absorb, withstand, adapt, regenerate or reorganise as a result of the effects of a hazard or disturbance. Vurgin, Warren, Ehlen, and Camphouse (2010) described such capacities as being affected by resilience enhancement features: features of the system that can increase one or more of the system capacities and provided the graphical representation, see Figure 2-2.

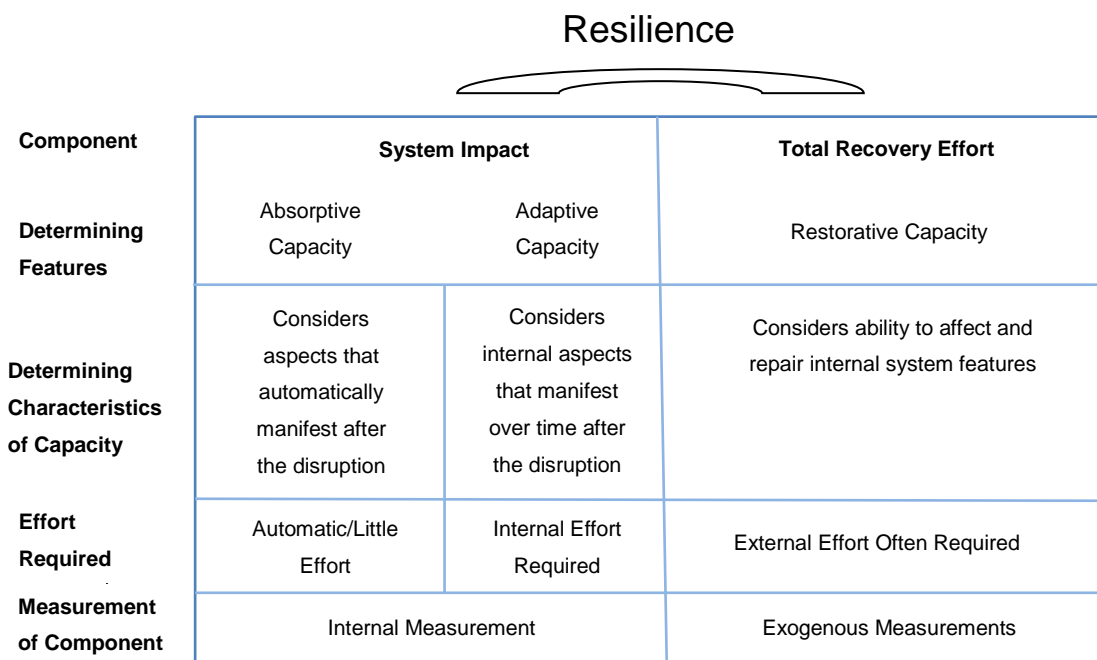


Figure 2-2. Resilience capacities of a system. Adapted from “A framework for assessing the resilience of infrastructure and economic systems”, by Vurgin et al., 2010. Springer: Berlin, Heidelberg, p.99.

A search of literature regarding the practices of current water businesses revealed a recommendation by the independent Task and Finish Group on Resilience, advising Ofwat - the Water Services Regulation Authority of England and Wales (Ofwat, 2015), provided a definition for the concept of resilience. The definition has been adapted for adoption in this study as: “Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability to enable the maintenance of services for people and protect the natural environment, now and in the future.” The definition foreshadows a risk management approach to anticipate trends and variability and hence have processes available to mitigate and adapt to the effects of disruption within known

limits. The definition is in agreement with the concepts of previous authors and has been adopted for the purpose of this study.

2.2.4 Sustainability

A group named “The Club of Rome” (Meadows, Randers, & Meadows, 1972) made a significant contribution to discussions during the 1980 to 1990 period regarding concerns for the long-term outlook for the social and environmental impacts from the increases in the world’s population. The Accademia dei Lincei in Rome (Meadows et al., 1972), convened to discuss “the present and future predicament of man”. The discussion was further developed with the involvement of numerous learned participants from many countries culminating in The Brundtland United Nations Commission (*Report of the World Commission on Environment and Development: Our Common Future*, 1987), where in Part 1, Chapter 2, sustainable development was defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This was further qualified by the statement that “it contains within it two key concepts, the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs”. The Brundtland United Nations Commission definition was identified as having significant merit and is often cited as the base understanding of sustainability. Common usage of *Sustainability* now recognises the three pillars of sustainability as Social, Environmental and Economic. The concept of the three-pillars being in balance with the interdependence of overlapping of the sectors is demonstrated as the diagram proposed by Bozza, Asprone, and Manfredi (2015), see Figure 2-3.

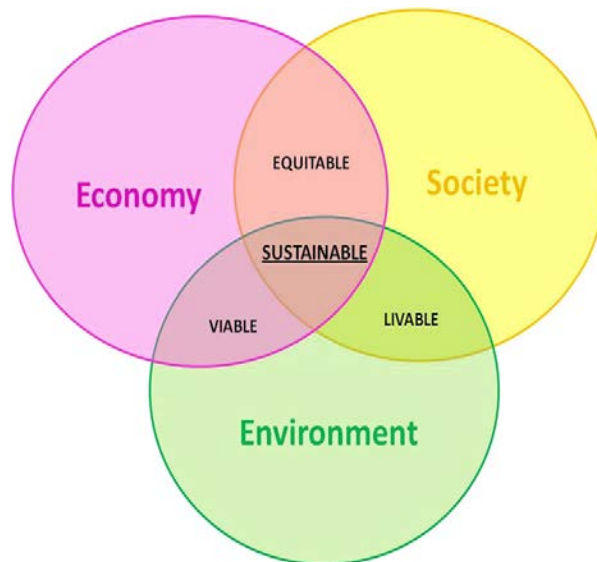


Figure 2-3. Sustainability dimensions. Reproduced from “Developing an integrated framework to quantify resilience of urban systems against disasters”, by Bozza et al., 2015. Natural Hazards, 78(3), p.1740

Definitions given by dictionaries follow the concept that being sustainable is the ability to continue a defined state or behaviour indefinitely: “to make or allow something to continue for a period of time” (Cambridge Dictionaries on Line, 2016); “able to last or continue for a long time” (Merriam-Webster's Learner's Dictionary, 2016); “able to be maintained at a certain rate or level” (“Oxford Dictionaries,” 2016). In complex systems it is necessary to define what is to be measured as being sustained and in the context of this study the focus of sustainability has been in relation to an urban water business maintaining its financial viability whilst meeting all environmental and social obligations and providing the agreed standards of service to its stakeholders.

2.3 FURTHER EXPLORATION OF THE RESILIENCE CONCEPTS

2.3.1 Concepts of resilience

The concepts of resilience are numerous among different disciplines and focus on various attributes or perspectives (Folke, 2006; Zhou et al., 2010). Management functions can also vary to achieve resilience for the different perspectives. As an example, Brown and Williams (2015) have given descriptions of resilience for ecological systems, social-ecological systems and disaster resilience with social focus or social–ecological focus as reproduced here, see Table 2-1.

Table 2-1

Comparison of the resilience concept among different disciplines (Brown & Williams, 2015)

	“Conceptual elements typically emphasised	Typical approach	Typical methods	Important research focus
Ecological resilience	Alternative stable states Thresholds Regime shift Critical transition Hysteresis Slow and fast variables Adaptive capacity	Natural sciences	Empirical observation Natural science methods including mathematical modelling and experimentation	Identification of alternative stable states Identification of key drivers and system response variables Early warning of approach to thresholds between alternative system states
Social-ecological system resilience	Ecological elements (as above) Adaptive cycle Transformability Social capital Social networks Learning Governance Vulnerability Panarchy	Social sciences Natural sciences	Empirical observation Natural science methods Social surveys, statistical analysis and other social science methods No social experimentation	Linkage of complex social and ecological systems, often emphasising either social entity or ecological entity Identification of key drivers and system response variables
Disaster resilience with social focus or social-ecological focus	Hazard Vulnerability Risk Preparedness Mitigation Socioeconomic attributes Social networks Institutions Infrastructure	Social sciences Natural sciences (for hazards) Engineering sciences (for infrastructure)	Empirical observation Natural science methods Social surveys, statistical analysis and other social science methods No social experimentation Civil engineering	Speed with which given social systems or sectors can return to normal function after a disturbance Magnitude of disturbance that infrastructure can resist”

The ability of a water supply business to adapt to and manage the disruptive events can be achieved by a combination of technical, economic and social measures. Gupta et al. (2010) have proposed that institutions need to analyse their inherent characteristics to empower social actors to respond to short and long-term impacts either through planned measures or through allowing and encouraging creative responses from

society. Sharpe (2016) argues that to engender adaptive capacity and achieve the ability to be resilient, systems and functions must reflect learning, flexibility to experiment and adopt novel solutions to broad classes of challenges.

A framework for achieving resilience is proposed by Brown and Williams (2015), describing a systems analytic context that includes the acts of decision making with the recognition of management objectives and specified in terms of system resilience, see Figure 2-4. The resource systems are influenced by management and other external drivers, as well as internal resource processes. In combination, these factors can inform management actions by adopting analysis through a feedback loop to define options to achieve sustainability and resilience.

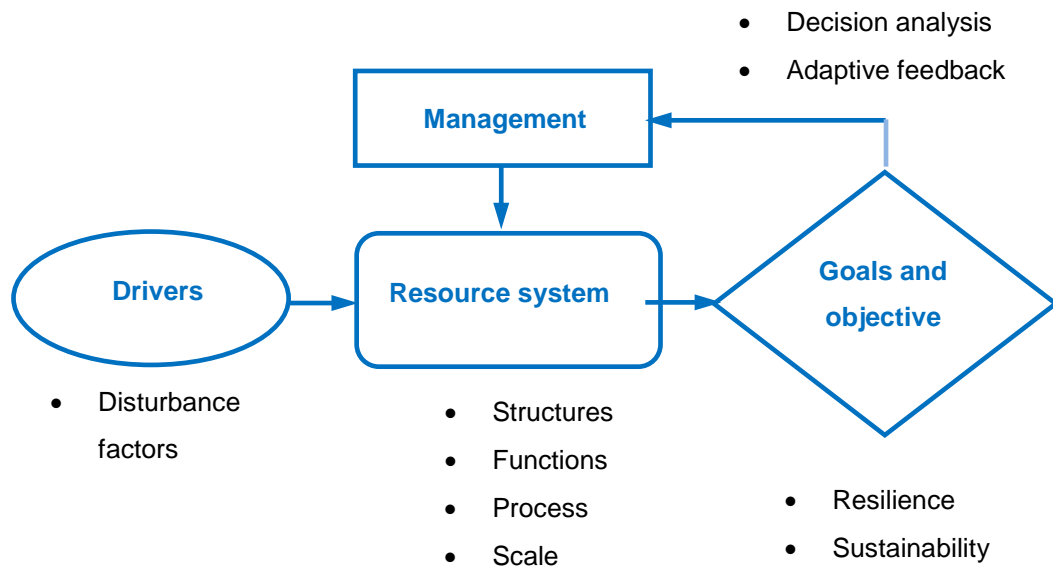


Figure 2-4. Framework for the management of resilience. Reproduced from “Resilience and Resource Management”, by Brown & Williams, 2015. *Environmental Management*, 56(6), p 1423.

Several elements are required for decision making to be based on more than intuition or chance and need to include some criterion measuring the relative value of decision alternatives with a mechanism for selecting among them (Brown & Williams, 2015). The framework can be used in the assessment of the impacts of disruptive events and the choices of adaptive strategy options driven by defined disturbance factors.

2.3.2 Capacity to adapt

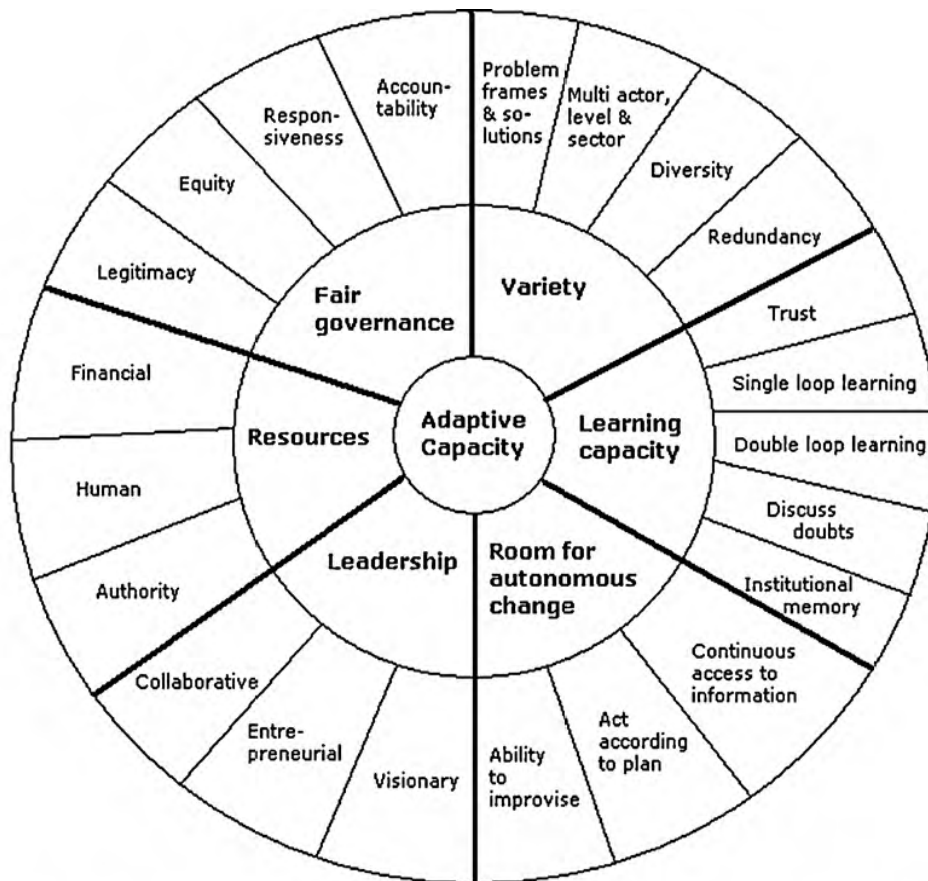
A key component of resilience is the ability to have the capacity to adapt to the response actions required following a disruptive event, see Figure 2-2. A tool to assess the adaptive capacity of institutions or societies has been proposed by Gupta et al. (2010) with an “Adaptive Capacity Wheel” to assess the adaptive capacity under six headings: “variety, learning capacity, room for autonomous change, leadership, resources and fair governance”, see Table 2-2 taken from Gupta et al. (2010). The Adaptive Capacity Wheel model, see Figure 2-5, enables the analysis of short and long-term impact scenarios and encourages creative responses from individuals and organisations to institute operational and cultural changes to cope with disruptive events.

Table 2-2
Adaptive capacity dimensions and criteria. (Gupta et al., 2010)

Dimension	Criteria	Definition
“Variety	Variety of problem frames	Room for multiple frames of references, opinions and problem definitions.
	Multi-actor, multi-level, multi-sector	Involvement of different actors and sectors in the governance sectors.
	Diversity of solutions	Availability of wide range of different policy options to tackle a problem.
	Redundancy (duplication)	Presence of overlapping measures and back-up systems; not cost effective.
Learning capacity	Trust	Presence of institutional patterns that promote mutual respect and trust.
	Single loop learning	Ability of institutional to learn from past experiences and improve their routines.
	Double loop learning	Evidence of changes in assumptions underlying institutional patterns.
	Discuss doubts	Institutional openness towards uncertainties
	Institutional memory	Institutional provision of monitoring and evaluation process of policy experiences.
Room for autonomous change	Continuous access to information	Accessibility of data within institutional memory and early warning systems to individuals.
	Act according to plan	Increasing the ability of individuals to act by providing

Dimension	Criteria	Definition
Leadership	Capacity to improvise	plans and scripts for action, especially in case of disasters. Increasing the capacity of individuals to self-organise and innovate; foster social capital.
	Visionary	Room for long term visions and reformist leaders
	Entrepreneurial	Room for leaders that stimulate actions and undertakings, leadership by example
Resources	Collaborative	Room for leaders who encourage collaboration between different actors; adaptive co-management
	Authority	Provision of accepted or legitimate forms of power; whether or not institutional rules are imbedded in constitutional laws
	Human resources	Availability of expertise, knowledge and human labour
Fair Governance	Financial resources	Availability of financial resources to support policy measures and financial incentives.
	Legitimacy	Whether there is public support for a specific institution
	Equity responsiveness	Whether or not institutional patterns show response to society
	Accountability	Whether or not institutional patterns provide accountability procedures”

Gupta et al. (2010) have an extensive outline to guide the use of the wheel through collecting the relevant data to analysing and presenting the results. Using colour coding of derived scores in the segments of the wheel, ready presentation of the adaptability of the subject institution or society highlights the segments needing attention are more obvious. The concept can be a useful tool to compare the adaptability of different institutions or societies or a single subject before and after management treatment.



Effect of institution on adaptive capacity	Score	Aggregated scores for dimensions and adaptive capacity as a whole
Positive effect	2	1.01 to 2.00
Slightly positive effect	1	0.01 to 1.00
Neutral or no effect	0	0
Slightly negative effect	-1	-0.01 to -1.00
Negative effect	-2	-1.01 to -2.00

Figure 2-5. The Adaptive Capacity Wheel and scoring scheme. Reproduced from “The Adaptive Capacity Wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society”, by Gupta et al., 2010. *Environmental Science and Policy*, 13(6), p. 464

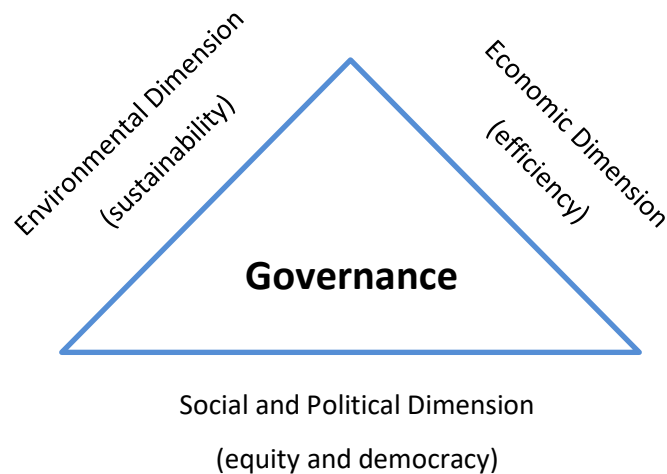
2.3.3 Institutional or social culture / behaviour

Many of the criteria used in the Adaptive Capacity Wheel concept can be observed as being derived from an adaptive institutional or social culture or behaviour. For example: learning, trust, capacity to change, collaborative, entrepreneurial, visionary and ability to improvise. Another approach was developed by Hill Clarvis and Engle (2015), wherein the concept of bridges and barriers to achieving resilience capacity was discussed. The

reference authors in a review of different institutional and governance studies highlighted “the importance of governance indicators such as information and knowledge, experience and expertise, networks, transparency, trust, commitment, leadership, legitimacy, accountability, connectivity and collaboration, iteratively, flexibility and leadership” to achieve or enhance adaptive capacity. Two case studies are used by Hill Clarvis and Engle (2015) to demonstrate how adaptive capacity should therefore contribute to enhancing resilience, rather than leading to adaptations that degrade resilience. Recent studies investigated by Hill Clarvis and Engle (2015) discuss examples of bridges and highlight a number of common barriers to adaptation processes: challenges in uncertainty and fragmentation of decision-making and information on disrupting influences; lack of resources and leadership; institutional management challenges; and contrasting risk perceptions and values. These barriers are listed by the authors as being under the broad headings of political, regulatory and legislative, and perception. As an example, a water supplier in one of the case studies had to defend why the strategies for longer-term resource planning and evaluation were useful and desirable, but contrary to the community perception as they “have only experienced abundant amounts of rainfall in their lifetimes, with droughts typically lasting a maximum of 3 years”. Hill Clarvis and Engle (2015) argue that using the bridges and barriers approach, researchers are able to identify key factors currently influencing adaptive capacity in water supply governance.

Agnew and Woodhouse (2010) contend that governance is a key concept in adaptation strategies and an observation is made that the meaning of governance can vary between having an emphasis on government as a centralised authority with its regulatory and financial instruments to that of the concepts of decision making by people and communities. The distinction is made between governance and management with the latter being focussed on operational procedures. The authors cite a depiction of water governance, see Figure 2-6 where the dimensions of water governance combine environmental, economic and social-political aspects and as good and effective governance is a pre-requisite for sustainability and resilience, the word in the centre of the diagram could be replaced by “sustainability” or “resilience”. In fostering adaptive capacity, Agnew and Woodhouse (2010) argue that while science and technology are necessary, they are insufficient on their own as they do not have the capacity to manage uncertainties that arise from economic and social matters. As a result of their research into building adaptive capacity, Keys, Bussey, Thomsen, Lynam, and Smith (2014), conclude

that “the major issue impacting adaptive capacity is not the availability of physical resources but the dominant social, political and institutional culture of the region.”



*Figure 2-6. Dimensions of Water Governance. Reproduced from “Climate Change Resilience and Adaptation: Perspectives from a Century of Water Resources Development”, by Agnew & Woodhouse, 2010. *Environment and Society*, 1(1), p.161.*

In a discussion on the achievement of resilience and adaptation to climate change, Sharpe (2016) argues that processes for flexibility and adjustment are needed. The author continues with the argument that limiting factors to a range of adaption techniques is associated with the capacity to learn and the superficiality of some learning. Sharpe (2016) contends that an incremental element of resilience of social-ecological systems is the learning, the flexibility to experiment and to adopt novel systems. This follows, in part, a similar argument supported by Gupta et al. (2010) in the analysis of adaptability capacity with the Adaptive Capacity Wheel. Sharpe (2016) promoted that transformative learning leads to a change in frames of reference that are cogitative building blocks and are central to the evolution of responses to disaster threats. A visual representation of the Transformative Learning Process is reproduced as Figure 2-7 and demonstrates how the development of new thoughts and beliefs are derived from critical reflection and consideration of past knowledge and experiences which are important in the understanding required to develop the adaptive capacity to respond to disruptive events. Again, this parallels the proposals forwarded by Gutpa et al. (2010).

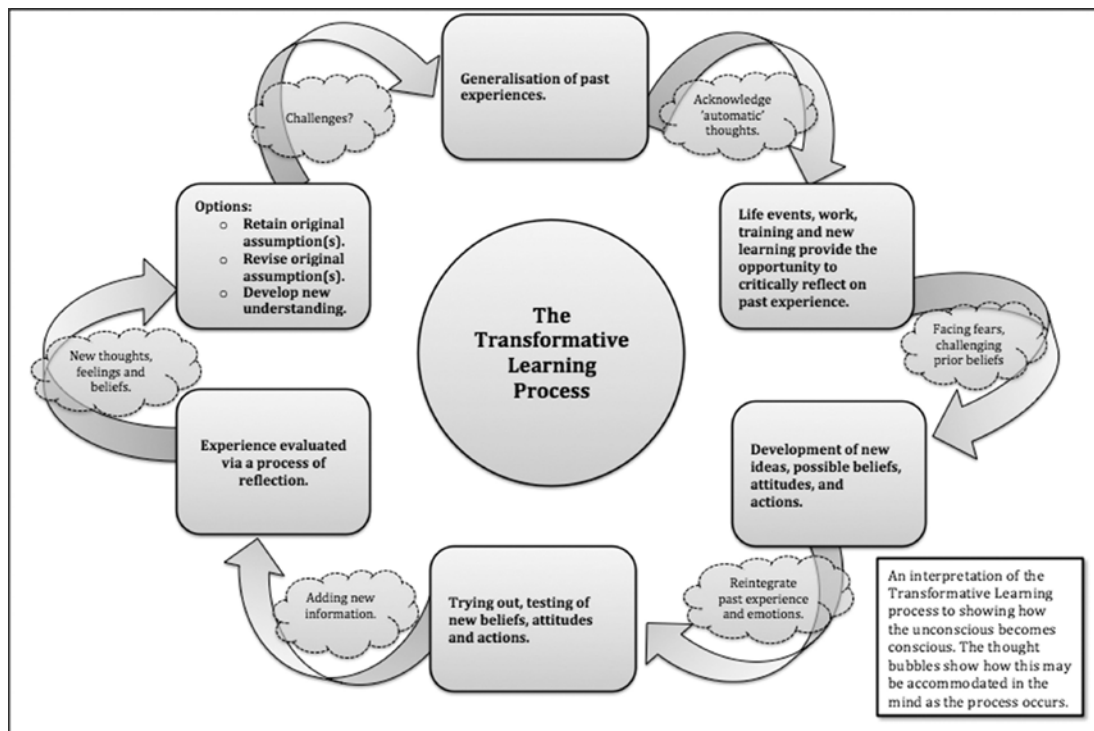


Figure 2-7. The transformational learning processes. Reproduced from “Understanding and unlocking transformative learning as a method for enabling behaviour change for adaptation and resilience to disaster threats” by J. Sharpe, 2016. *International Journal of Disaster Risk Reduction*, 17, p. 216.

Each of these authors, namely, Gupta et al. (2010), Hill Clarvis and Engle (2015) and Sharpe (2016), argues the importance of flexibility in decision making based on a culture or behaviour of leadership, learning, understanding of past events, visionary and collaboration.

2.4 RELATIONSHIP BETWEEN SUSTAINABILITY AND RESILIENCE

The relationship between sustainability and resilience in this study is in the context of the effects on urban communities in relation to achieving and maintaining service standards in the delivery of potable water supplies subject to disruptive influences. Bozza et al. (2015) argue that urban systems can be viewed as being composed of three main subsystems, “the infrastructural, the economic and the social, all mutually interacting through a dynamic network of relationships”. The reference authors suggest that in viewing the urban environment in such a way suggests a city as a complex system similar to an ecosystem, continuously varying, being at equilibrium at certain stages whilst having the ability to move to a new state of equilibrium (displaying resilience). By considering

this perspective in relation to an urban water service, the operation of the business is dynamic and aims to be in equilibrium and resilient to the effects of external influences such as changes in consumer demand for water quantity or quality, or the impacts of seasonal climatic change effecting available water volume in storages.

If sustainability is considered a form in which something can be at a certain level and remain for a long time, it is required to continue to be in a state of balance or equilibrium. To be sustainable and resilient, the water service business must firstly have all systems in balance (sustainable), and at the same time have the capacity to absorb or adapt to disrupting effects without failing (resilient) prior to returning to a state of equilibrium as soon as practicable.

A summary statement by Klein, Nicholls, and Thomalla (2003) suggests “A more resilient system can be less vulnerable to risk and, therefore, more sustainable.” If the statement having a “more resilient system” implies the need for higher financial investment or the application of additional resources, the question then is, does the increase in investment or resources continue to result in a sustainable system?

In its simplest form, the variables in the operation of a water supply system are the capacity to supply; the demands on the system; and the resultant cost of meeting demands and service standards, see Figure 2-8. This satisfies the concept of three pillars of sustainability.

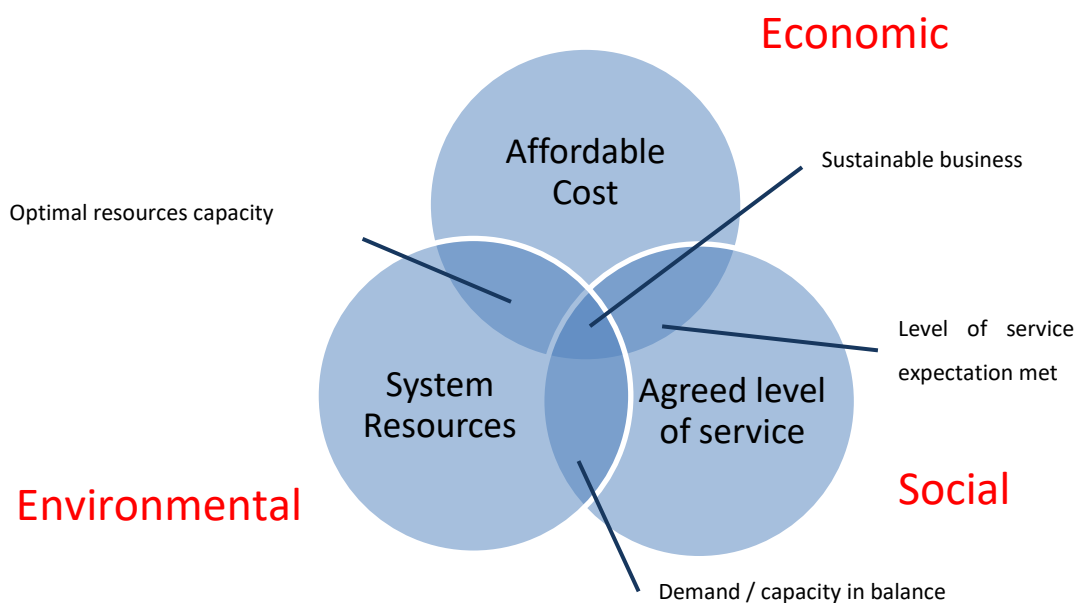


Figure 2-8. Water supply business - primary operational components in balance

At any point in time, a limiting value exists for each of the factors, which if exceeded, would cause a system failure. For example, if the system demand exhausted the capacity to supply then failure would occur. However, if the system demand could be reduced to suitable levels to meet reduced capacities to supply, then failure would be avoided, and the system deemed to be resilient. Similarly, if the increase in system demand could be met by favourable increase in capacity to supply, failure might be avoided. However, if the operating cost or investment in infrastructure required to achieve the additional capacity, the costs could possibly be prohibitive and result in failure to meet the accepted service standards of affordability.

Blackmore and Plant (2008) describe a range of desirable system attributes as an “umbrella concept” or an adaptor capacity, such that providing the amount of disturbance absorbed by a system remains within the limiting parameters; the system is capable of reorganisation. In comparing this argument with Figure 2-8, providing the disruptive influence allows each factor to adjust to a new level whilst remaining within the limiting values and maintains the balance between the three factors of cost, capacity and demand, the system has adaptive capacity and can be termed resilient. Thus, the system can be considered to have the capacity to adapt to and recover from the disruption, and be resilient to that disruption (Vugrin et al., 2010).

In the initial state of equilibrium or balance prior to the disruptive influence, the system is sustainable and if it has the ability to be resilient, it can return to a state of equilibrium after the adjustments are made following the disruptive event. Thus the inputs needed for resilience are dynamic whereas inputs to achieve sustainability are ones of balance and equilibrium. Holling (1973) argues that to remain in a state of being resilient, there is a limiting magnitude of disturbance able to be tolerated prior to the system failing to persist. Blockley (2015) argues that depending on the system being considered, sustainability might imply resilience. However, the interaction of other factors such as management of environment, financial or social aspects could impact the overall resilience. Blockley (2015) contends that resilience is necessary for, but not sufficient for sustainability, but sustainability is sufficient for resilience”. This statement appears to be at odds with the arguments of other authors and the outcomes of this thesis.

One of the factors in Figure 2-8 relates to affordable cost, a component of which is the investment needed to provide infrastructure and to operate the water supply systems. Higher investment in assets would be expected to provide a higher level of resilience by providing a greater system absorptive and adaptive capacity. In a complex system, such

as an urban water supply, a choice of the investment options could be made in relation to which components, or combination of components, result in the best opportunistic value for achieving an additional degree of resilience against disruptive events (Turnquist & Vugrin, 2013; Vugrin et al., 2010). A strategic decision is required to establish the optimum affordability and the degree of resilience provided against risk events. Turnquist and Vugrin (2013) demonstrated that consideration of the relationship between resilience enhancing investments made prior to or post disruption jointly informs the decision making process to identify a strategy best suited to the system being analysed. The reference authors sought to answer the question “What capabilities, resources, and/or network elements should be present to best provide network resilience against a variety of potential damage scenarios?”. In doing so, the reference authors presented a stochastic optimization model to enable consideration of combinations of investment and/or recovery options to minimise the overall cost for a network under various disruption scenarios. The model lends itself to an understanding of comparisons of resilience enhancement investment combined with recovery investments. A strategy can then be tested to consider scenarios with combinations of resilience enhancement investment and recovery investment providing least cost outcomes and smaller total impacts for a given system forecast risk event.

Vugrin et al. (2010) have developed a framework to choose recovery strategies by comparing the resilience costs under different recovery efforts. They describe how through the application of the resilience assessment framework a comprehensive evaluation of a system’s resilience can provide information on how to further enhance system resilience and provide a tool for a cost / benefit analysis. In working towards a strategic decision regarding the desirable extent of resilience against disruptive event scenarios, the cost of investment or resources can be evaluated to determine the actions creating best value.

2.5 IMPACT OF LEGISLATION AND REGULATION ON RESILIENCE

In the context of this study, legislation is considered as laws enacted to mitigate specified risks and regulation provides a control mechanism for a specified activity, usually in association with enabling legislation. Water supply businesses, whether they are public bodies or privately operated, are in most cases directly or indirectly controlled by a level of Government. Hence, they operate in a highly regulated environment and are

required to comply with disparate items of legislative frameworks, all presenting compliance as a degree of risk to the organisation. Allan, Jeffrey, Clarke, and Pollard (2013) highlight the need for consideration to be given to the risks from the impact of regulation, ownership and business culture on water utilities’ approaches to managing commercial, operational and systemic risks. The reference authors observe that “it is unusual that more attention has not been paid to exploring the associated ‘risk dynamic’ (taken to mean the interplay between (i) the risks associated with utility actions and (ii) the management strategies and interventions for coping with these risks).”

The prime operational revenue for water supply businesses is derived from tariffs applied to the consumers. Pinto and Marques (2016) note that tariffs have evolved significantly in varying fashions and models around the world, along with increasingly demanding requirements and objectives. The reference authors comment on the perception of water supply tariffs being adopted as powerful management tools and raise concerns on how utilities and regulators prioritise the objectives. They advocate the requirement for regulatory activities to be reviewed to enable evaluation of the suitable objectives together with the actual needs, in order to promote the desired outcomes in relation to social welfare.

Major water businesses in Australia are subject to regulatory control by the six states and two territory governments, with the controls primarily focused on cost structures. Reference to the details in Table 2-3 shows the non-uniformity of the responsibilities and systems for the regulation of water services across Australia.

Table 2-3
Governance at a glance – Water Pricing and Economic Regulation. (Australian Government, 2009)

“Economic regulator	Key responsibilities	Regulated services	Who sets water prices?
Australian Capital Territory			
Independent Competition and Regulatory Commission (ICRC).	Price determination & licensing, investigate competitive neutrality complaints.	Urban retail water, sewerage, waste water & bulk water, trade waste & water reuse.	ICRC.
New South Wales			
Independent Pricing and Regulatory Tribunal (IPART).	Price determination functions for the urban water sector & recommends licensing	Metropolitan bulk water, retail water, wastewater, stormwater, services & recycled water.	IPART – Metropolitan bulk & retail water, & rural bulk water.

“Economic regulator	Key responsibilities	Regulated services	Who sets water prices?
	guidelines to the Minister	Rural bulk water.	Local water utilities (106) – Non-metropolitan retail. Private Irrigation Companies (5) – Rural retail.
Northern Territory			
Utilities Commission	Monitor & enforce compliance with pricing determinations	Urban water supply & sewerage services.	Treasurer (Regulatory Minister).
Queensland			
Queensland Competition Authority (QCA)	Price recommendation, review of pricing policies, third party access & price monitoring	Not applicable	Local government councils (110) – Urban bulk & retail. SunWater – Rural bulk & retail for SunWater Water Supply Schemes. Seqwater – Rural bulk & retail for SeqWater Water Supply Schemes. Rural Water Boards (12) – Rural retail.
South Australia			
Essential Services Commission of South Australia (ESCOSA).	Review Government price-setting.	Not applicable.	SA Cabinet – Urban retail. Private irrigation trusts (27) – Rural retail
Tasmania			
Economic Regulator of Water and Sewerage (Commissioner of the Government Price Oversight Commission).	Regulate water and sewerage prices and licence industry participants. Monitor annual performance	Urban bulk water & retail water, sewerage services	Water Corporations (3) – Urban retail. Irrigation entities (5) – Rural retail
Victoria			
Essential Services Commission (ESC).	Price determination & service standards monitoring.	Urban bulk water & retail water, sewerage services, metropolitan drainage services, recycled water services. Rural bulk water, retail water &	ESC

“Economic regulator	Key responsibilities	Regulated services	Who sets water prices?
		irrigation drainage services.	
Western Australia			
Economic Regulation Authority (ERA).	Price recommendation. Oversight for urban & rural water pricing practices.	Not applicable.	Western Australia Cabinet – Urban bulk & retail. Irrigation Cooperatives (3) – Rural retail.”

Each of the Regulatory Authorities have the mandate to formulate Pricing Principles similar to the Queensland Competition Authority being given the authority to “seek to address the concerns which lead to the need for monopoly prices oversight and third party access” (Queensland Competition Authority, 2016). The regulators contend that their role is to reduce the possibility of some service providers charging consumers unfair prices or delivering inappropriate service standards. The aim is to promote pricing principles reflective of commercial markets taking into account matters of “relevant public interest”. The scope of the statement “relevant public interest” needs to be defined in relation to outcomes and the ability of the publicly owned businesses’ to mitigate risks, provide community accepted service standards, attain resilience and be sustainable. Grafton, Chu, and Kompas (2015) note that independent pricing regulators in each state and territory of Australia, as shown in Table 2-3, set prices for a ‘price determination period’ of between three to five years with an allowance for increases in line with consumer price index. Such pricing of water tariffs is not linked to efficiency of water delivery and poses a risk due to no provision being made for changed operational circumstances such as during a drought when additional investment in infrastructure might be prudent.

Although Pinto and Marques (2016) acknowledge the role of the independent regulator, they caution the potential for the regulators to be at risk of being too intrusive and rigid, thus lacking flexibility to target particular situations and objectives. Where the regulator operates in a rigid bureaucratic form, the outcomes might result in only short-term planning and investment being undertaken with no incentive for the water utility to be pro-active or have the adaptive capacity to be resilient against disruptions.

Pinto and Marques (2016) cite the reasoning of other authors and advocate the need to build a multi-objective analysis to allow the assessments of water tariff structures through a framework promoting the maximization of gains in terms of social welfare. The reference authors promote a hierarchical framework as in Figure 2-9, highlighting the importance of defining each criterion with its prescriptive principles. The development of a multi-objective model for the derivation of tariff structures could provide for the water supply businesses to be proactive with planning long term development and financing strategies and have the ability to achieve resilience against identified disruptive scenarios. Derivation of the prescriptive principles and weightings to be applied to satisfy particular conditions and circumstances is discussed by Pinto and Marques (2016). The reference authors advocate that it is not necessary to have an option that is the best in all criteria or is able to achieve the top overall score. Several objectives could be achieved by various options with no option necessarily being the best in achieving all objectives. A range of stakeholder inputs into the criteria and objectives selection is desirable to achieve optimal outcomes.

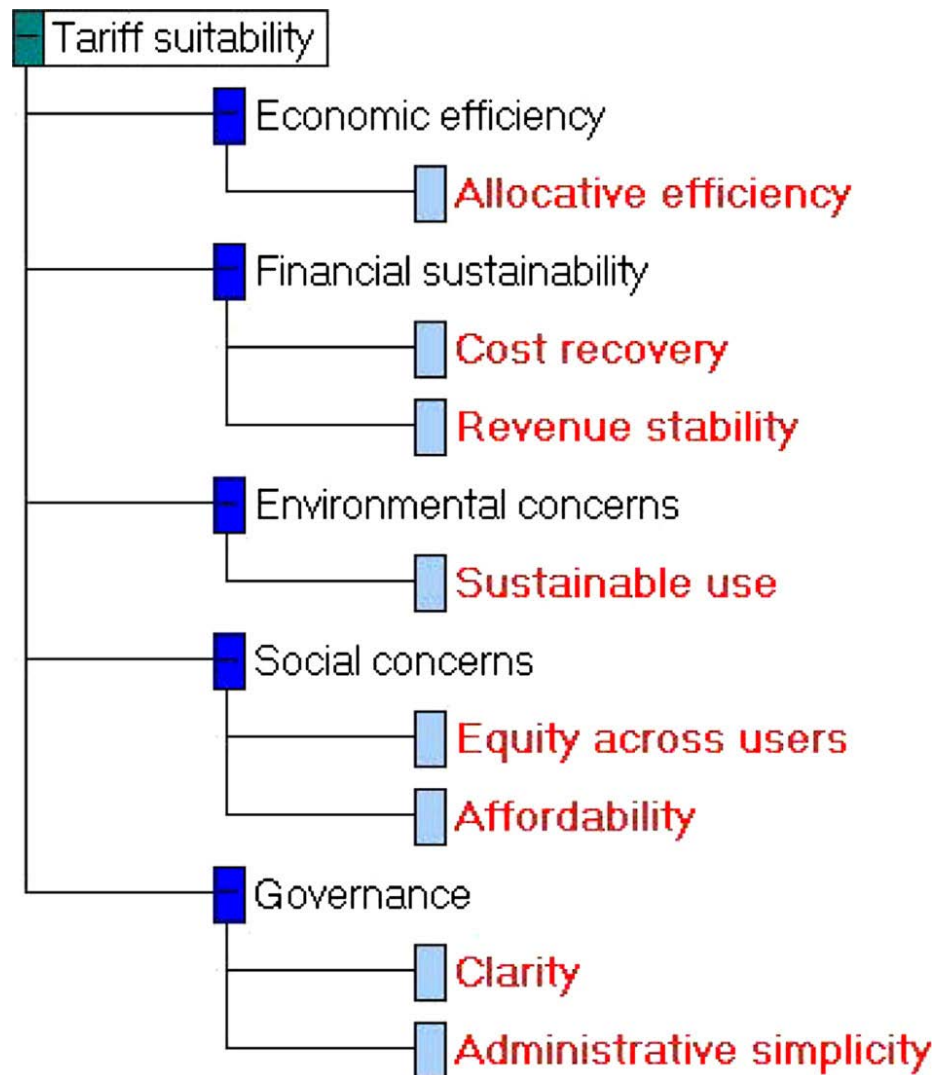


Figure 2-9. Dimensions and criteria for the tariff suitability regulatory tool. Reproduced from “Tariff Suitability Framework for Water Supply Services: Establishing a Regulatory Tool Linking Multiple Stakeholders’ Objectives” by F. Pinto and R. Marques, 2016. *Water Resources Management*, 30(6) p. 2040

Legislation for the control of social, economic, scientific or technical risks can vary over a range between being highly prescriptive in seeking to achieve outcomes, or as described by Haines (2011b), “problem focused” or “goal orientated”. The focus of this study relates to the characteristics for the water supply businesses to be resilient and hence an examination of the types of legislation and regulation causing a potential risk to the achievement of that goal has been explored. Allan et al. (2013) pose two critical questions: “what are the particular features of regulation, ownership and management culture which influence the risk dynamic, and what are the implications of these relationships in the context of ambitions for resilient organizations?” The reference authors explore the mindful choices and adjustments to be made to the business risk management strategy to

manage strategic tensions between efficiency, risk and resilience and conclude that a gap in the understanding within the water sector requires a paradigm shift from a re-active to a pro-active risk management culture. The need for a pro-active approach and culture is reflected in the Bonn Charter for Safe Drinking Water (International Water Association, 2004), which was prepared as a framework for institutions and regulators, enabling the achievement of safe and reliable water supplies across the world. The Charter emanated from the collaborative efforts of a number of peak body water organisations from many countries.

Items of reactive legislation are often drafted following an extreme damaging event and the stated political decree that “such devastation must never happen again” (Haines, 2011a), such that there is a learning from a current impact and suffering so future harm and suffering can be avoided. In these scenarios, the legislation is often drafted through the aspects of sociocultural and political interests with little input from the technical or science agencies. Haines (2013) contends that when emotions are less intense, questions need to be asked why certain paths were chosen and have the regulatory approaches accomplished the outcomes, followed by sustained reforms? In the case of extreme drought conditions in South Eastern Queensland (SEQ), Laves et al. (2014) argue that “the evaluation of applied adaptations (as a result of legislation) provide adequate evidence of frequent disparities between anticipated and actual outcomes”. Regulation introduced during an extreme event could introduce additional organisational compliance risks and impact on the resources required to achieve resilience. Laves et al. (2014) found that SEQ water businesses had undesirable consequences resulting from consumer water usage being substantially reduced (less income resulting from legislated restriction of use) and significant expenditure on additional supply capacity provisions resulting in the businesses facing undesirable debt levels associated with the investment in advanced supply capacity. Thus, the legislation achieved its socio-cultural aims in satisfying stakeholder expectations and political requirements of legitimate government, though failed through the creation of excessive debt levels. The SEQ system might be shown to have reacted adequately against the disruptive climatic event, however the sustainability of the businesses was compromised due to the excessive debt levels.

Climate change impacts are expected to occur at an increasing rate, result in greater impacts and scale of change, thus increasing uncertainty and driving the need for legal regimes to shift away from notions of “predictable uncertainty” (Clarvis, Allan, & Hannah, 2014). Socio-cultural expectations will drive risk mitigating legislation creating

further uncertainty for water supply businesses. Clarvis et al. (2014) have proposed a diagrammatic depiction of the shifting focus of water governance, see Figure 2-10. , moving from a condition of “Stationarity with predictable uncertainty” to a future phase under climate change and being non-stationary. The left hand and right-hand side heavy arrows depict the ranges of uncertainty and Clarvis et al. (2014) suggest a need for legal scholars to better understand adaptive processes that seek to embrace rather than control uncertainty, thus assist the aims to achieve resilience against disruptive climate change events rather than to be constantly reactive.

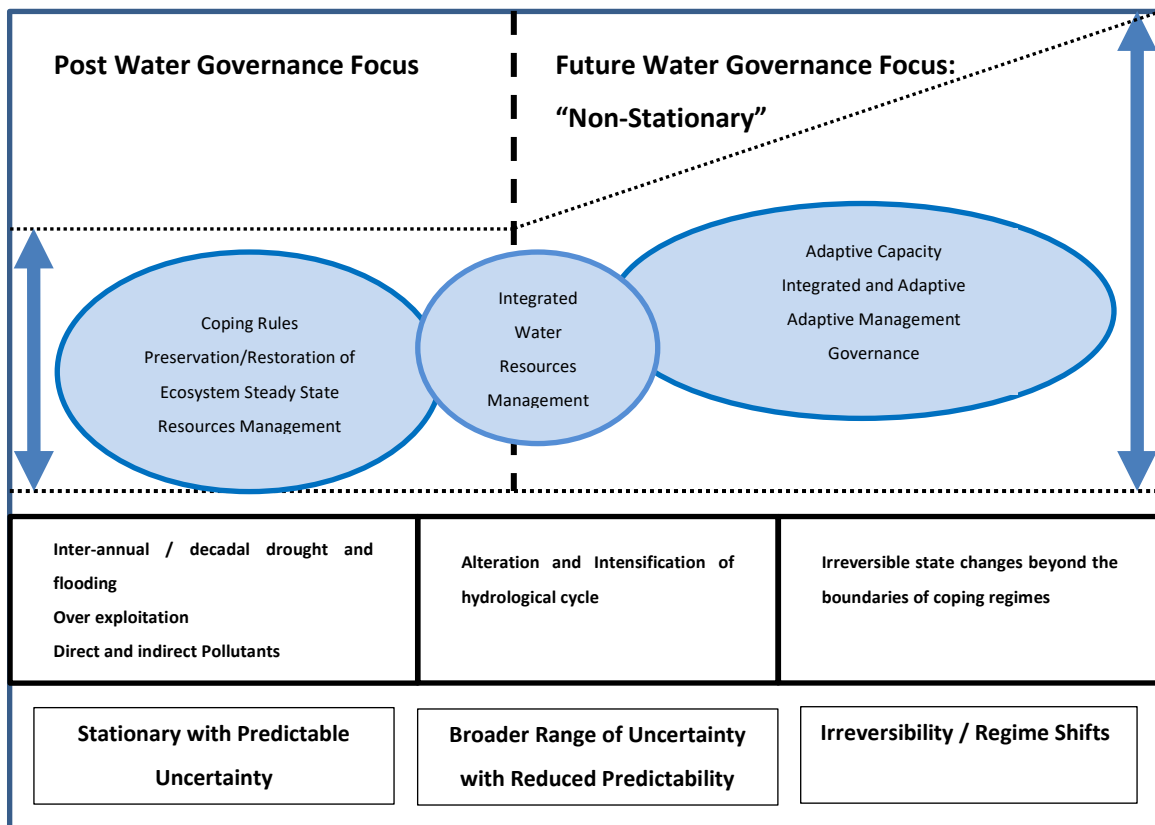


Figure 2-10. The shifting focus of water governance. Reproduced from "Water, resilience and the law: From general concepts and governance design principles to actionable mechanisms" by Clarvis et al., 2014. *Environmental Science & Policy*, 43, p.101.

2.6 MANAGEMENT OF STAKEHOLDER NEEDS AND EXPECTATIONS

Discussions by water supply businesses regarding stakeholder needs and expectations generally focus on conditions of water quality and quantity supplied and ways the consumption can be managed by the supply authority. Jorgensen, Graymore, and O'Toole (2009) identified that a number of studies consider water use behaviours from the aspects of internal dwelling use compared to external use, garden irrigation and swimming pools for example. The reference authors also observe that as outdoor use is considered to be more discretionary when compared to indoor use, it is often the first target for regulations to be applied through water use restrictions. A behavioural response to the restrictions applied to external use can be the installation of alternative supplies such as rainwater tanks or irrigation bores and Syme, Nancarrow, and Seligman (2000) question whether the resulting consumer response is motivated by reasons of conservation of water as good responsible citizens, or for securing an alternative independent household supply.

Blackmore and Plant (2008) observe that while the water utility has options to adjust operational technologies such as the application of pricing structures or regulation, consumers will only influence changes which are in the best interest of their family or their immediate environs. In commenting on the complexities of consumer behavioural responses, Syme et al. (2000) contend that during the formulation of water conservation strategies it is important for the water suppliers to understand the difference between likely outcomes from the promotion of habitual actions (taking shorter showers) and reasoned responses (purchase of water efficient appliances). Kahneman and Tversky (1979) observe that people are more sensitive to what they lose (reduced standard of service) rather than what they gain.

As customers focus on the level of service provided and have expectations regarding water quality, an important factor is reliability and security of supply. A. Turner et al. (2007) state that the prime requirement is to have sufficient level of service to satisfy the expectations for the provision of consumer needs such as hygiene, sanitation and landscaping. Thus, it is the social impacts of regulation of available water supply that need to be communicated and discussed. Water conservation campaigns need to be carefully informed to understand the likely potential consumer responses resulting from the range of regulations or incentives.

In testing the long-term effectiveness of strategies to promote household water savings, Fielding et al. (2013) found that if the regulation interventions cease and there are no environmental or contextual cues for water scarcity, water usage will eventually return to previous levels. The research by Jorgensen et al. (2009) revealed that many studies discover different factors acting on water use behaviour and not one study was able to attribute all of the variation in water use to the factors they examined, indicating that there may be other variables impacting on water use that are yet to be described. The reference authors suggest that trust may be an important factor that has not been fully explored and may be useful in the development of effective water demand strategies. Mis-trust in the way water authorities are managed, plan for adequate capacity and present information, (and the lack of trust of other consumers), are areas requiring further investigation. In a post-disruptive event review of water supply businesses, Head (2010) states that “the nature of the water policy challenge had broadened over time from being largely the province of engineers (hydrology and infrastructure construction) towards broader and diverse issues—environmental sustainability, the economics of water regulation, competing water uses, and shifts in consumer and industry behaviour”. Ampt, Neal,

MacKellar, and Davies (2014) report on the successes of campaigns of voluntary behaviour change designed to encourage the community to take responsibility for their own water saving initiatives by “helping people to help themselves”. The reference authors report that by building trust through targeted communication and the supply of accurate data, the community is able to achieve voluntary targets of reduced water use.

2.7 IDENTIFICATION OF UNCERTAINTIES AND DISRUPTIVE EVENTS

Potentially disruptive events in the context of this study of urban water supply businesses, are those resulting in a high consequence and uncertain likelihood of occurrence from a risk management perspective and having a severe impact on the ability to maintain expected levels of service. Water supply businesses suffer consequences through external influences such as climatic extremes and unanticipated demands on water resources, resulting in failure in the ability to maintain service standards due to insufficient resources or infrastructure capacity. The provision of infrastructure can involve long delivery times and thus the risk profile could substantially alter between the stage of initial planning strategies to the additional resource capacity being available.

Comes, Hiete, Wijngaards, and Schultmann (2011) discuss the development of scenarios to test severe uncertainties and analyse those through decision maps to challenge perceptions to aim for a better understanding of the future. Those reference authors argue that decision-making is particularly challenging when faced with severe uncertainties. They discuss the relevance and meanings of the terms: risk, uncertainty and ignorance in relation to decision making in scenario analysis and they adopt the definitions as:

- “In decisions under risk, the decision makers know the probability of the possible outcomes.
- In decisions under ignorance, these probabilities are either unknown or non-existent.
- Uncertainty is used as a broad term referring to both risk and ignorance.”

Comes et al. (2011) set out to distinguish principles for handling uncertainty through modelling and a Decision Plan using criterion under the headings of deterministic, probabilistic, fuzzy and limiting.

2.7.1 Uncertainties in forecasting climatic conditions

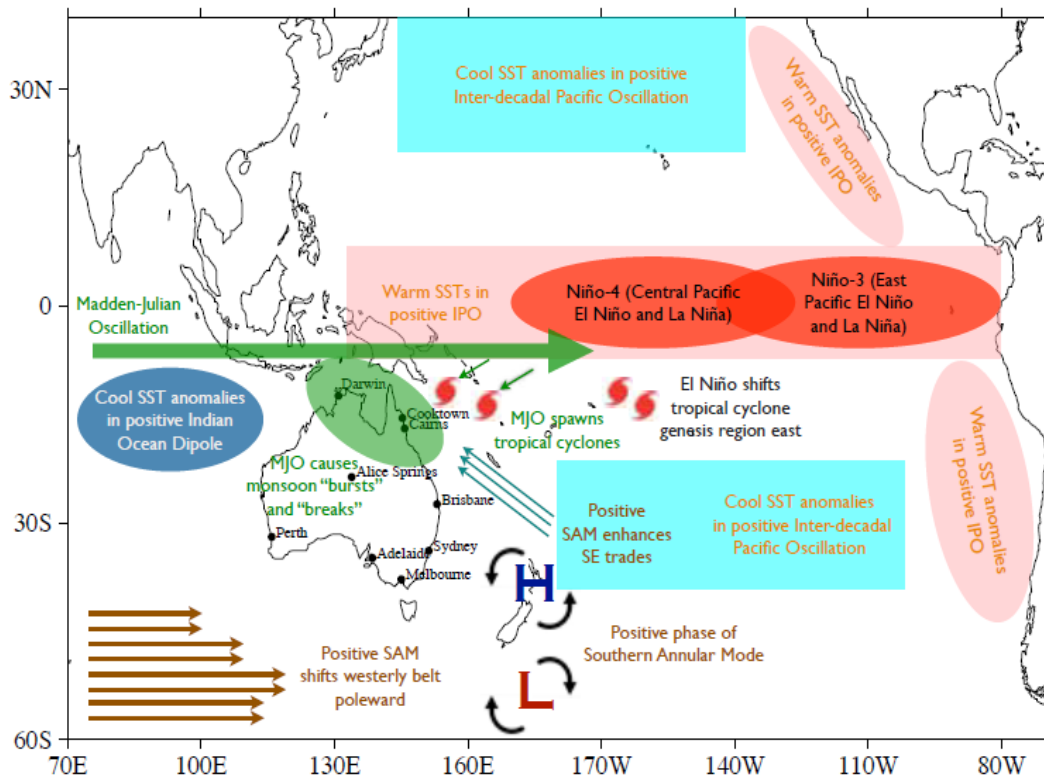
Forecast climatic conditions can be modelled based on historic patterns and measured data. Climatic conditions dictate the precipitation patterns providing water source yield and can have a significant effect on consumer water usage, particularly through external dwelling uses such as landscape irrigation and swimming pools. Arnell (1999) contends that restricted availability of accurate water use data constrains the estimation of impacts of climate change on global water resources as the calculations are very sensitive to results of water demand and evaporative quantities associated with higher temperatures.

In a discussion on three major drought periods in Australia between 1895 and the time of their research, Prowse and Brook (2011) predict projections of more frequent extremes of weather patterns, although they caution that additional understanding of relationships between large scale variations in precipitation scenarios is necessary before reliable forecasting can be achieved. To demonstrate the complexity and interaction of influences Prowse and Brook (2011) discussed and developed a table defining the major climate features influencing the Australian climate. See Table 2-4. The Walker Institute (2012) provides a graphical representation of the factors influencing climate drivers of rainfall in Queensland as an indication of the complexity of interactions between various natural occurrences causing modelling uncertainty in the forecast of rainfall patterns. See Figure 2-11. The reference authors discuss the significant decade to decade variability in rainfall patterns and the sensitivity to the climatic influences shown on their diagram.

Table 2-4
Major climate features influencing the Australian climate (Prowse & Brook, 2011)

“Climate feature	Acronym	Description/Effects
Intertropical Convergence zone	ITCZ	The ascending portion of the Hadley cell, where surface air originating from the subtropics is drawn in near the equator and rises due to convergence and convection, manifesting as an intense band of thunderstorms
Sub-tropical ridge	STR	The descending portion of the Hadley cell, where in warm, dry air sinks, forming a belt of high pressure and low rainfall at around 30 ^o latitudes.
El Nino-Southern Oscillation	ENSO	A coupled ocean-atmospheric variability whose oceanic component manifests as warm (El Nino) or cool (La Nina) sea surface temperatures of the tropical Pacific Ocean. The dry (El Nino) and wet (La Nina) phases of ENSO are predominately during winter and spring over eastern Australia

“Climate feature	Acronym	Description/Effects
Inter-decadal Pacific Oscillation	IPO	A low frequency variability, characterised by sea surface temperatures of the tropical and extra-tropical Pacific Ocean. Its positive phase is associated with more frequent El Nino events and suppressed impacts of La Nina. Conversely, its negative phase is linked to more frequent, wetter La Nina events.
Indian Ocean Dipole	IOD	A coupled ocean-atmosphere climate mode whose eastern pole manifests as variation in sea surface temperature off northwest Australia. During winter and spring, warm (cool) sea surface temperatures here result in wet (dry) phases, predominately throughout western to south-eastern Australia, partially due to their influence on the formation of the northwest cloud bands.
Southern Annular Mode	SAM	The dominant climate mode for southern Australia regions below 30° south, reflecting the difference in pressure between the mid and high latitudes. The positive phase of the SAM is associated with reduced rainfall over southern Australia during winter but increased rainfall in south eastern Australia (except Tasmania) during summer.”



Key climate drivers of rainfall in Queensland.

SST - Sea Surface Temperature
 SAM - Southern Annular Mode
 SE - South East
 MJO - Madden Julian Oscillation

Figure 2-11. Key climate drivers of rainfall in Queensland. Reproduced from “Queensland rainfall—past, present and future”, by Walker Institute, 2012. Department of Environment and Resource Management, Queensland Climate Change Centre of Excellence. p.7.

Sheffield, Wood, and Roderick (2012) caution that the simplicity of some forecast models might result in an overestimation of the severity of future droughts due to the interpretation of the effects of changes in available energy, humidity and wind speed. Each of the above researchers highlights the uncertainty of current forecast methods and models, indicating the difficulties and uncertainties water businesses face in predicting likelihood, severity and frequency of extreme climatic events.

2.7.2 Population uncertainties

Wilson and Rowe (2011) suggest the use of data produced by demographers should be clarified to be understood as “projections” or “forecasts” noting that when sets of curves for High, Mid and Low predictive bands are produced, users nearly always interpret the middle series projections as forecasts. Their paper demonstrates that the

assumption that projections are highly likely to eventuate is not supported by evidence. The accuracy of projections is dependent upon models used by demographers and by the assumptions and extrapolations made to inform those models. Wilson and Rowe (2011) argue that there are good reasons for demographers to study errors of past predictions, one being that users can be provided with estimates of uncertainty in current projections. A. Turner et al. (2007) demonstrate how changes to the base data over progressive time-periods together with assumptions for determining population predictions can produce different results and hence uncertainties in the forecasts for the future water supply demand. See Figure 2-12.

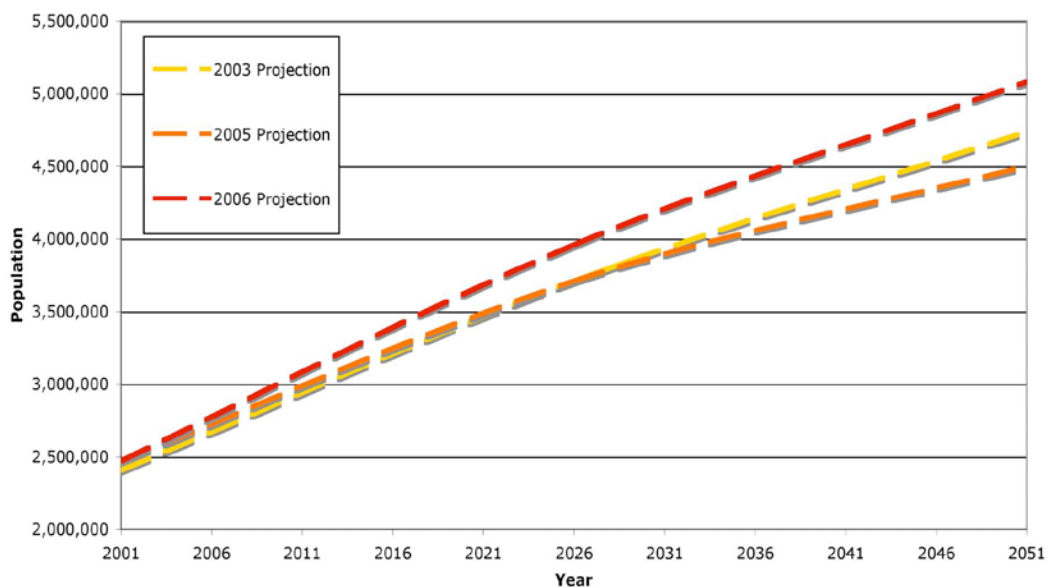


Figure 2-12. Variations in population projections. Reproduced from “Review of Water Supply-Demand Options for South East Queensland”, by Turner et al., 2007. *Institute for Sustainable Futures, Sydney and Cardno, Brisbane*, p.6.

Section 1.1 refers to the forecast that the percentage of the population living in urban areas is continuing to increase (United Nations, 2014). In response to social, economic and sustainability pressures being placed on cities as a result of the continued population increases, urban planning strategies to change previous land uses to provide for higher population densities are being adopted. Buxton and Tieman (2005) discuss how current Australian Governments are accelerating the population densities in urban areas through incremental, dispersed, market led redevelopment of existing land uses and

building conversions in cities. Their discussions in a case study highlight that the planning for higher densities in selected areas claims to be driven by economic and sustainability efficiencies and largely focus on the communities' access to transport and employment services. Whilst strategic development plans provide for the preferred development, the uptake of the opportunity for higher density development or redevelopment is market and community lifestyle driven. Generally, no consideration is included for the impact of redevelopment densities for provision of water and other utilities, thus creating significant uncertainties for the utility providers, firstly in the timing of increases in consumer demands and secondly in the adequacy of the capacity of existing assets to service demands from the higher density of population.

2.7.3 Legislation and regulation

Legislation and regulation of water resources and distribution is divided in a hierarchical three levels of regulatory systems between Federal, State and Local bodies in Australia, each having, at times, non-coordinated impacts on the governance of the businesses for responsible water management. The impacts are largely dependent upon the disparate needs and control of environmental outcomes linked to water usage by rural, industry or urban sectors. Each level of government has its own perspectives, often driven by local social, environmental or political agendas. Uncertainty can be driven by the urgent re-focusing of regulation of issues caused by natural hazard events and resulting social attitudes and behaviours. (Head, 2008, 2010).

2.7.4 Wicked uncertainties

Impacts on water businesses from types of uncertainties discussed in the foregoing parts of this Chapter are traditionally analysed from a technical base. However, problem analysis is increasingly having to be considered by engaging the broader community to assist in the understanding of the problem and in the identification of possible solutions (Head & Alford, 2015). Social uncertainties can result in multiple decision-making difficulties requiring collaboration, knowledge and solution acceptance from various sectors. Blockley (2015) considers that where problems are ill-defined, poorly understood or have changing requirements, they can be described as having "wicked uncertainties", resulting in problems that are difficult or impossible to solve. These problems pose

challenges to traditional approaches to finding solutions or to making governance policies. Horst and Webber (1973) argue that the problem-solving methods of science and engineering do not suit those required for the ill-defined and uncertain understanding of social problems or those arising from multiple sectors. The reference authors contend that “social problems are never solved - at best they are only re-solved, (possibly) over and over”. The search for a solution is halted when general acceptance of a result is established.

Urban water businesses are subject to policies of government, often developed from other than expert scientific and technical input. The policies can simply result from political expediency, and the possible introduction of a range of social, economic and environmental uncertainties for the water businesses. In a discussion on water policy and the governance of uncertainty, Head (2010) considers a scenario having a range of wicked problems stemming from unknowns about how consumers might react to the imposition of low water demand targets compared with the substitution of purified recycled water into the water system during periods of water scarcity. A range of solutions to accommodate the consumer reactions might develop further uncertainties for economic planning and consequential financial impacts on the community.

Such wicked problems can develop rapidly when stable business operation is disrupted by external influences such as unexpected climate events. The uncertainties might then introduce community reaction and political responses resulting in significant policy changes imposed on the water businesses (Head, 2010).

2.8 CONCLUSIONS

The concept of being *Resilient* should be considered in the context of the application whether it be, for example, technical, economic or social. The use of the term has acquired numerous definitions that focus on different attributes or different perspectives depending on the application. The definition should be linked to the ability to “bounce back”, recover or adapt to a disruption relative to the application being discussed. The inter-relationships between the terms: resilience, sustainability, vulnerability, risk and reliability have to be understood to avoid misuse of the terms and contexts. For the applications required for this study, definitions of risk, vulnerability, sustainability and resilience have been established with reference to the work of other researchers. The relationship between *sustainability* and *resilience* in this study has been adopted in the context of the effects on urban communities in relation to achieving and

maintaining service standards in the delivery of potable water supplies subject to disruptive influences such as drought or flood.

The understanding of the inter-relationship of sustainability and resilience has been assisted by the determination that sustainability is a state of balance between Social, Environmental and Economic factors with the ability to meet present and future needs, see Figure 2-3. Resilience is, by definition, ability to recover from a disruption and hence is dynamic. To remain in a state of being resilient, there is a limiting magnitude of disturbance able to be tolerated prior to the system failing to persist.

The ability of institutions, societies or assets to be resilient and adapt to disturbances needs to be based on frameworks having systems and functions that reflect learning, flexibility to experiment and the ability to adopt novel solutions to various classes of challenges. The frameworks can be used in the assessment of the impacts of disruptive events and the choices of adaptive strategy options driven by defined disturbance factors. Scenario testing allows strategies to be adopted to evaluate the cost of investment or resources to be employed to determine the actions creating best value and opportunity in the creation of a state of resilience against selected disturbance factors.

For an institution or society to be able to have the ability to adapt to a disturbance, or achieve resilience, it needs to adopt a culture or behaviour of learning, trust, capacity to change, collaborate, be entrepreneurial, visionary and have the ability to improvise. These elements can contribute to the development of the concept of bridges and barriers to achieving resilience and adaptive capacity. A number of common barriers to adaptation processes have been identified as: challenges in uncertainty and fragmentation of decision-making and information on disrupting influences; lack of resources and leadership; institutional management challenges; and contrasting risk perceptions and values. These barriers are listed under the broad headings of political, regulatory, legislative and perception.

As urban water supply businesses are in most cases directly or indirectly controlled by a level of Government, they operate in a highly regulated environment and are required to comply with disparate items of legislative frameworks, all presenting compliance as a degree of risk to the organisation. Where the businesses operate through a monopoly pricing arrangement, regulations for tariff structures must reflect long-term strategies for maintenance of service standards through a multi-objective model to have the ability to achieve resilience against identified disruptive scenarios. A range of

stakeholder contributions to the selection of criteria and objectives for the model input data is desirable to achieve optimal outcomes.

Standards for water utility service delivery are expected to satisfy consumer needs such as hygiene, sanitation and life-style. Management controls have proceeded beyond the technical and built asset aspects to the inclusion of an understanding of social impacts of the application of regulated water availability. The intent of the regulations need to be clearly communicated and discussed. Water conservation campaigns must be carefully informed to understand the likely potential consumer behaviours and responses resulting from the range of regulations or incentives.

An understanding of the type and nature of planning uncertainties likely to be faced by water business operations is necessary for the development of scenario plans for the analysis of possible disruptive events. Problem analysis is increasingly having to be considered by engaging the broader stakeholder and community group, and representatives of disparate discipline groups. Social uncertainties can result in multiple decision-making difficulties requiring collaboration, knowledge and solution acceptance from various sectors. Where uncertainties are ill-defined, poorly understood or have changing requirements, they can be described as being “wicked uncertainties”, resulting in problems that are difficult to solve or have a range of possible solutions. Deliberations on water policy and the governance of uncertainty need to consider a range of wicked problems stemming from unknowns, for example, about how consumers might react to the imposition to low water demand targets or the substitution of purified recycled water into the water system during periods of water scarcity. A range of solutions to accommodate the consumer reactions might develop further uncertainties for economic planning and consequential financial impacts on the community.

Chapter 3 Research Design and Methods

3.1 INTRODUCTION

The concept of resilience has grown over recent decades with various definitions and understandings within disciplines spanning a variety of sectors. (Brown & Williams, 2015). This study has a specific focus on the governance and management of urban water supply businesses achieving resilience against disruptive events. An understanding of the interrelationship and interaction of the concepts enabling water supply business to adapt to impacts of disruptive influences needed to be developed. A critical review of research literature was able to assess definitions of risk, vulnerability, sustainability and resilience as applied to urban water supply businesses. The development of the understanding of how business systems integrate with the concepts of resilience was supported by analysing a case study of businesses that have been subjected to disruptions. This included disruptions such as extreme climatic events, unexpected population increases and movements, changes in consumer behaviour and expectations and changes in the legislation and regulatory regimes.

3.2 RESEARCH DESIGN

The research design provided a structured approach to enable the assembly and analysis of concepts leading to the development of the necessary characteristics required by urban water businesses to facilitate adaptive responses to disruptive events. The steps in the development of the study were:

- A literature review to determine current knowledge and approaches regarding the consideration of resilience and the development of definitions and understandings of resilience together with relationships with sustainability, risk and vulnerability as outlined in Section 3.3.1. The literature review also considered social and regulatory impacts and uncertainties faced by urban water businesses.
- A determination of the key focus areas for the literature review, data collection and evaluation.

- Identification of the contributing factors to uncertainties faced by urban water businesses in their response to requirements for the delivery of water services at standards to satisfy their stakeholders.
- Selection and analysis of a case study to identify and demonstrate the inter-relationships and interdependency of concepts identified in the literature review.
- Assembly of details and documentation of governance and management of urban water supply businesses prior to, during and following disruptive events experienced in the case study geographic region.
- Design and undertaking of a survey by structured questionnaire to assemble data from respondents who were able to communicate their experience of impacts and remedial actions adopted to address disruptions to urban water businesses, with particular reference to the case study.
- Analysis of assembled data and literature to compare research findings with case study industry experience in relation to management of uncertainties and disruptive events.
- Assemble and discuss key findings to inform the recommendations from the study outcomes.

3.3 RESEARCH METHODS

3.3.1 Literature review and identification of key inter-related concepts

The critical review of literature probed the relative importance of the socio-cultural, economic and technical adequacy criteria to define the inter-relationship of inter-dependant aspects of urban water supply businesses. The definition and understanding of the key concepts to be applied in respect to water supply businesses was considered important to ensure the creation of a framework for discussion which captured the complexities of this business sector. The definitions of and relationships between risk, vulnerability, sustainability and resilience as applied to urban water supply businesses required clarification and certainty to inform a clear understanding of the key concepts.

The importance of the application of management strategies for the optimal investment of financial and human resources to mitigate impacts of disruptive events was

identified as a necessary part of the literature review. Consideration of options for investment to mitigate impacts from potential disruptions as an alternative to expenditure for the repair of damage post-disruption, was identified as key discussion item. As urban water supply businesses are subject to government regulation, it was important in the review to identify and analyse the forms of legislation and regulation applied and to review impacts on the ability of the businesses to be sustainable and to achieve resilience.

The requirement for suitable cultures to be developed within the businesses was highlighted in the literature review as being critical to the development of adaptive capacity. The review emphasised the importance of the appreciation of social behaviours both within the businesses and the stakeholder groups. The review provided an understanding of the likely behaviours and interaction between the businesses and consumer groups in the management of water conservation initiatives to assist in the mitigation of impacts of drought.

The literature review included the identification and discussion of uncertainties leading to potential disruptive events in the governance and management of water supply businesses. The review was used to consider how uncertainties could be analysed to build scenarios leading to strategies for adaptive management of potentially disruptive events. Areas of business vulnerability were classified to identify adaptive action to minimise management system stress and prevent failure.

3.3.2 Case study

The discussions from the literature review identified subjects for analysis in the case study to demonstrate the interaction and interdependence of the factors impacting on water businesses subject to disruptive events. The case study tasks were:

- a. Confirmation of selection of suitable study subject area with the scope to demonstrate the governance and management of business complexities associated with urban water supplies subject to disruptive events.
- b. Identification of external influences impacting the case study organisations and causing disruptive events to those organisations and their stakeholders.
- c. Identification of governance and management systems prevailing at the time of the disruptive events.
- d. Identification of actions taken by government and stakeholders in reacting to the disruptive events.

- e. Discussion detailing progressive impacts of reactive actions on water supply businesses in the case study area, for the period during and following the disruptive events.

The case study analysis informed discussion regarding industry experience resulting from the actions of a group of government policy makers and water supply businesses subject to disruptive events. The reactive management undertaken by policy makers and stakeholders highlighted various bridges and barriers either frustrating or assisting the building of capacity for the businesses to be adaptive when confronted by the disruptive events. Reports produced by stakeholders to detail proposed actions to react to the disruptive events highlighted the need for collaboration between all stakeholders and levels of government in order to achieve optimal outcomes. The data derived from the case study identified the outcomes of reactive decisions taken at relevant time-periods and enabled a critical review of the effectiveness of the decisions and implementation processes.

3.3.3 Stakeholder survey

A stakeholder survey using a semi-structured questionnaire was adopted to gain insight into opinions on how water businesses in SEQ dealt with drought and unexpected population growth whilst continuing to respond to the stakeholder expectations for delivery of water supply services. The semi-structured questionnaire was chosen to provide comparative data by enabling the respondents to give comments and opinions on nominated topics combined with providing a rating of importance for nominated outcomes. This approach was preferred over the use of a structured survey which would be adopted to test a hypothesis.

A copy of the survey questions is included in Appendix A. Representatives of organisations having a significant contribution to the governance, management and delivery of programs to counter the effects of the disruptive events were invited to respond to the questionnaires. Organisations represented were State and Local government departments and authorities. As state aligned respondents had roles relating to regulation and resource planning, scores were recorded separately to differentiate their perceptions from those from the local government sector whose prime responsibilities were water distribution and consumer interfaces. Aggregated scores for all respondents was also analysed.

The first part of the survey questions focussed on stakeholder perceptions of the high-level risks to the achievement of sustainability and resilience in their organisation and the SEQ region, to identify potential disruptive events and uncertainties. Respondents were requested to name their top three risks in each category for both their organisation and for the overall SEQ system. Each of the questions sought to define contributing conditions existing prior to disruption; after initial reactive actions; and ongoing mitigation measures through to the present time.

A further set of questions assisted in the understanding and assessment of the cultural and behavioural aspects of the organisations' progression through the same time periods. The assessment of the business culture and the adaptive capacity within the businesses was considered under six headings of: ability to consider problems from a variety of aspects; learning capacity; room for autonomous change; leadership; resources and fair governance. The final questions sought views on the effectiveness of water demand control measures and an assessment of consumer responses.

3.3.4 Data analysis

The case study and questionnaire provided base data for the analysis of risks and uncertainties encountered by the SEQ urban water businesses being subjected to major disruptive events. Both the case study and questionnaire highlighted the consequences of a failure to undertake strategic planning and to consider scenario treatment of uncertainties. Analysis of the assembled data from the case study and survey provided a critical review of the water businesses' journey from pre-disruption conditions to disruptive event impacts and reactions adopted for resolution of the impacts. Three defined time-periods were specified to ensure survey participants were able to refer their responses to a consistent base interval. The analysis identified contributing effects of barriers and bridges either frustrating or assisting enhancement of governance systems and management procedures required to establish a system to provide stable delivery of water to the desired standards of service to the region during the times of disruption.

Findings from the literature review informed the understanding of importance and relevance of criteria in discussions regarding the water businesses' ability to be sustainable and to achieve capacity to adapt and to counter disruptive events. The survey provided

data to identify the respondent's perceived importance of factors both for their organisation and for the total SEQ region businesses.

The risks to the attainment of sustainability and resilience as identified by the respondents were numerous and hence were grouped under themes for analysis. For Question 1, Sustainability Risks, the responses were grouped into thirteen themes, for example: "Financial impacts, Management of climate impacts, Management of assets, Governance and management, Lack of forward planning". The respondents used various descriptions for the risks and sorting into themes provided a system to capture the responses into a measurable set of data. The responses for Questions 2 and 3, identification of potential disruption events and identification of resilience risks respectively, were treated in a similar method. The aggregation of the number of recurrences of the themes given by the individual responses compared with the total responses provided an evaluation of the perceived importance of each theme.

Question 4 requested a rating of a set of nominated business uncertainties caused by external influences to gauge the perception of business vulnerability. Participants rated the risk factor of each uncertainty, the business opportunity to respond to the risk and the businesses' ability to provide an adequate response. Scales of 1 to 5 were used to rate the first two segments and a High, Medium, Low rating for the third segment. The assembled data was analysed by a series of weighted averages to provide a view of relative importance and opportunity to respond to uncertainties. Question 5 followed a similar format to rate internal business risks.

Question 6 was based on work by Gupta et al. (2010) and the "Adaptive Capacity Wheel". The question aimed to compare the adaptive capacity of the SEQ water businesses at the three time-periods and to gauge if the business transformations over the periods provided a benefit to the businesses and enabled the capacity to adapt to the disruptions. The responses to the first part of the question, "Is this criterion present in the business?", required a *Yes* or *No* reply for each time-period. The recurrence of positive scores compared to the total number of responses for each criterion was considered as a measure of the businesses' ability to display adaptive capacity. Further responses to the question nominated a numerical rating of the importance of each cultural or behavioural criteria for the businesses. Aggregated scores compared to the total number of responses, provided a measure of the level of development of cultural and behavioural competence to enable the capacity to adapt to disruptive events.

The role of the community in demand management initiatives was included in the survey. Participants provided a numerical rating for their view of the success of initiatives adopted during the period of the disruptive drought. Weighted averages of the aggregated scores was used to identify participants' perceptions of the success of the demand management initiatives. Comments to clarify the numerical ratings provided an enhanced response to the question.

The combination of understandings from the literature review, analysis of the case study and assembly of data from the survey identified the importance of the inter-relationship of technical, social and economic factors contributing to the ability of the businesses to adapt to disruptive events.

3.3.5 Study conclusions and recommendations

An analysis and discussion of the key findings from the literature review, case study and survey identified that although urban water businesses are highly dependent on technical aspects of governance and management, these are not sufficient for the achievement of sustainability or resilience. The literature review provided an understanding of definitions of the concepts of risk, vulnerability, sustainability and resilience. The understanding of the concepts was further developed through the case study and survey analysis. Cultures and behaviours leading to the capacity to be adaptive against disruptive events as identified in the literature review were compared with those analysed in the case study and survey.

The analysis of the case study and questionnaire data demonstrated the interaction and inter-relationships of risk factors and uncertainties to be managed by the water businesses. Consideration of the key findings from the literature review and the data derived from the case study and stakeholder survey enabled the identification of critical factors to lead the ability of water businesses to be sustainable and to transition to the acquisition of adaptive capacity to become resilient to disruptive events. The analysis of behavioural and cultural criteria identified in the literature review and considered in the responses to the survey produced a set of business characteristics required to enable the business capacity to be adaptive and to transition from sustainability to having resilience to disruptive events.

The combination of understandings from the literature review, analysis of the case study and assembly of data from the survey identified the importance of the inter-relationship of technical, social and economic factors contributing to the ability of the businesses to adapt to disruptive events. A summary of key findings from the study provided a set of recommendations.

3.4 ETHICAL CONSIDERATIONS

Assistance in the gathering of data for the case study was sought from a group of Local and State Government officers and stakeholders. The participants had made a significant contribution to the governance and management of the South East Queensland urban water businesses. The respondents' involvement had occurred over the whole or parts of the period prior to the disruptive events, during the time of institutional reform and after the transition to the current business ownership structures. The participants were invited to share their experience, knowledge and information regarding planning, financing, servicing expectations of stakeholders, legal aspects, business culture and system operation. All comments and responses were treated as anonymous and kept confidential. The names or affiliations of individual persons were not required in any of the responses. The participation and method of interaction and data gathering was subject to approval from the QUT Human Research and Ethics Committee under the approval number 160000121. Details of the approval are included in Appendix A.

3.5 SUMMARY

A critical review of research literature was used to inform the understanding of the definition of resilience and terms of sustainability, vulnerability and risk in the context of reacting to impacts from disruptions from extreme events as confronted by urban water supply businesses. Definitions of the terms were derived for adoption by the study. Research literature also assisted in the identification of focus areas for review of the relative importance of the socio-cultural, economic and technical adequacy aspects which need to be analysed in the assessment of water businesses' capacity to adapt to disruption.

A case study provided the opportunity to assess the interdependence and interaction of a complex set of governance and management activities for a set of urban water businesses that had to react to the impacts of severe drought and unplanned

population growth. A survey by semi-structured questionnaire for response by persons having a significant role in setting policy, planning and operation in the SEQ water businesses during the disruptive period, was constructed to elicit views of risks businesses faced with uncertainties and disruptive events. The survey also analysed cultural and behavioural criteria apparent in the businesses during the time-periods of prior to onset of drought, during the period of reaction to drought impact and after institutional reform. Results from the data analysed from the survey demonstrated the inter-dependence of technical, social and economic performance to enable the governance and management of urban water supply businesses to adapt to the disruptions.

The combination of the findings from the literature review, case study and survey provided a discussion to test the propositions by other authors from the literature review in relation to the experiences of a series of water businesses subject to disruptive events. The analysis produced a set of business characteristics required to enable adaptive capacity to transition from sustainability to having resilience to disruptive events. A concluding discussion of key findings from the study provided a set of recommendations to address the aims and objectives of the thesis.

Chapter 4 Case Study disruptions, challenges and responses

4.1 INTRODUCTION

A case study was chosen as a pivotal part of the research to identify and demonstrate the complexities of the inter-relationships and interdependencies of business functions impacting on the success of governance and management models in urban water businesses subjected to disruptive events. The area chosen for the case study was considered to have the elements and complexities enabling the critical analysis of the study criteria in relation to operational businesses suffering the effects of significant disruptive events. The case study provided a context to identify and record historic data to lead to an understanding of the dynamics of reactions by government and water businesses during the period of major disruption events of extreme drought and major population growth.

4.2 DESCRIPTION OF CASE STUDY ELEMENTS

The geographic area of the south-eastern corner of the State of Queensland, Australia, was nominated as the case study area as it suffered significant uncertainties in the management of impacts on the urban water supply systems resulting from a period of extreme climatic events combined with high population growth in the early to mid-2000s. Consequences of the events tested the capacity of the various water supply businesses to respond to the disruptions at that time.

The case study area characteristics of significance are:

- A range of urban, tourist, industrial and rural development subject to rapid regional population growth
- Increased urbanisation densities along the coastal areas
- Population of the region continued a rapid growth rate with an increase of approximately 29% for the decade prior to the commencement of the drought period taking effect in the early 2000s, see Figure 4-1. By 2015 the reported population had risen to 3.24 million (Australian Bureau of Statistics, 2016a), with

an expectation of growth to 4.4 million by 2031, (Department of Infrastructure and Planning, 2009)

- The governance at the local level was the responsibility of individual Local Government Authorities (LGAs), commencing with 17 at the beginning of the case study period, followed by a boundary change and amalgamation process being completed in March 2008, resulting in 11 LGAs as outlined on the map of the region, see Figure 4-2.

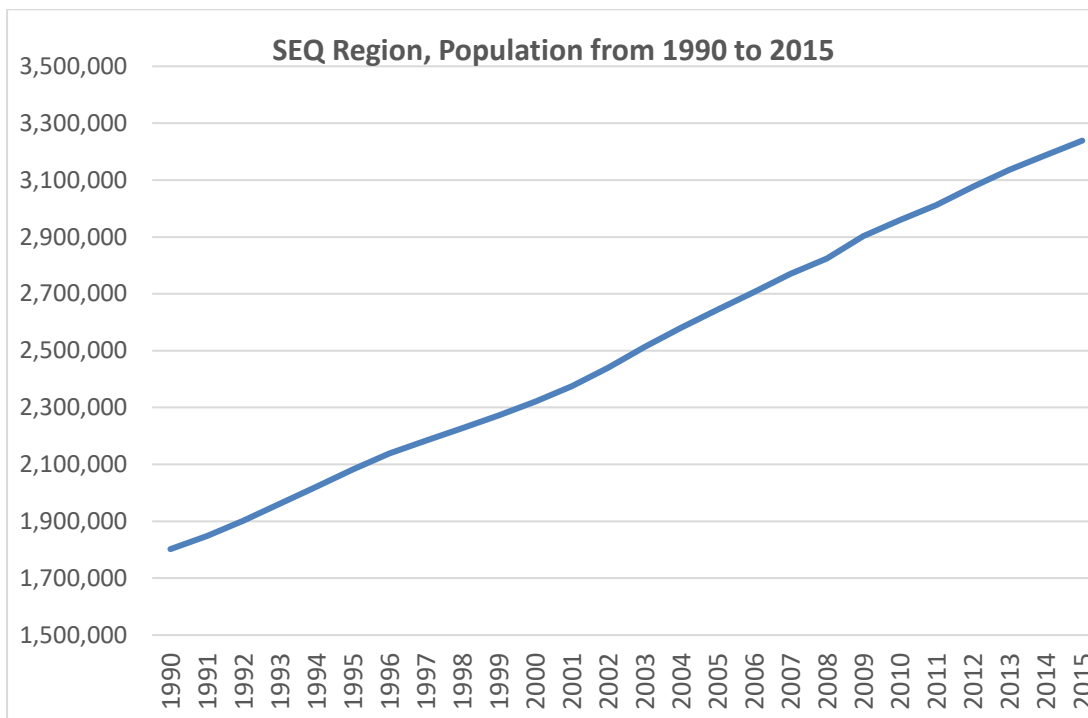


Figure 4-1 Population in the SEQ Region for period 1990 to 2015



Figure 4-2. South Eastern Queensland Local Authority Areas. Reproduced from “South East Queensland Regional Plan Review. Fact Sheet 3”, by Department of State Development, 2016. <http://www.dilgp.qld.gov.au/resources/plan/seq/regional-plan-2009/seq-regional-plan-2009.pdf>

- At the beginning of the extreme climatic event, named the “Millennium Drought”, the region was serviced by various water businesses operated through Local Authority ownership together with the State Government having responsibility for governance and management of water resources.
- Reactive actions to counter the drought conditions resulted in further disruptive actions. These included changes in institutional ownership; the operational management of water supply schemes becoming a shared responsibility between State and Local Governments; the introduction of new legislation to urgently

provide for changes in SEQ water governance and management; and major expenditure being incurred for the provision of additional resource and distribution capacity in the regional infrastructure.

- Intensive educational and regulatory actions were undertaken to alter consumer expectations and behaviours to achieve significantly reduced water demand.

4.3 PERIOD PRIOR TO DISRUPTIVE EVENTS

4.3.1 Regional water resources

Prior to the beginning of the drought conditions, the LGA water businesses had the planning and operational responsibility for the regional urban water resources with an overseeing and regulatory role by the Queensland State Government. Each LGA was focussed on the servicing of its own constituents and little coordination of resource planning occurred. Raw water storages and withdrawal infrastructure for water sources, including that for underground supplies, was the responsibility of LGAs except where the infrastructure was available for the dual purpose of urban and rural requirements, the latter being provided by the State Government. At that time, 19 major water storages were owned by 12 different entities (Department of Natural Resources and Mines, 2005). Most LGAs had no diversity available in their water supply sources.

Some of the small surface water storages had a dual purpose of providing source water for treatment and distribution to small urban communities in addition to the needs for rural supplies. The majority of the water sources in the region were from on-stream storages. A small number of groundwater extraction schemes were also utilised.

The Brisbane River catchment is the largest river system in the SEQ region. Figure 4-3 identifies the layout of the sub-catchments. The Lower Brisbane River catchment houses the largest urban developments of the SEQ region. The upper sub-catchments of the Brisbane River contain undulating areas with small townships, primary production activities and natural forest. Figure 4-4 shows the location of urban development in the Brisbane River catchment and along the coastal area of the SEQ region. The location of the urban water sources of the region are also indicated on Figure 4-4.

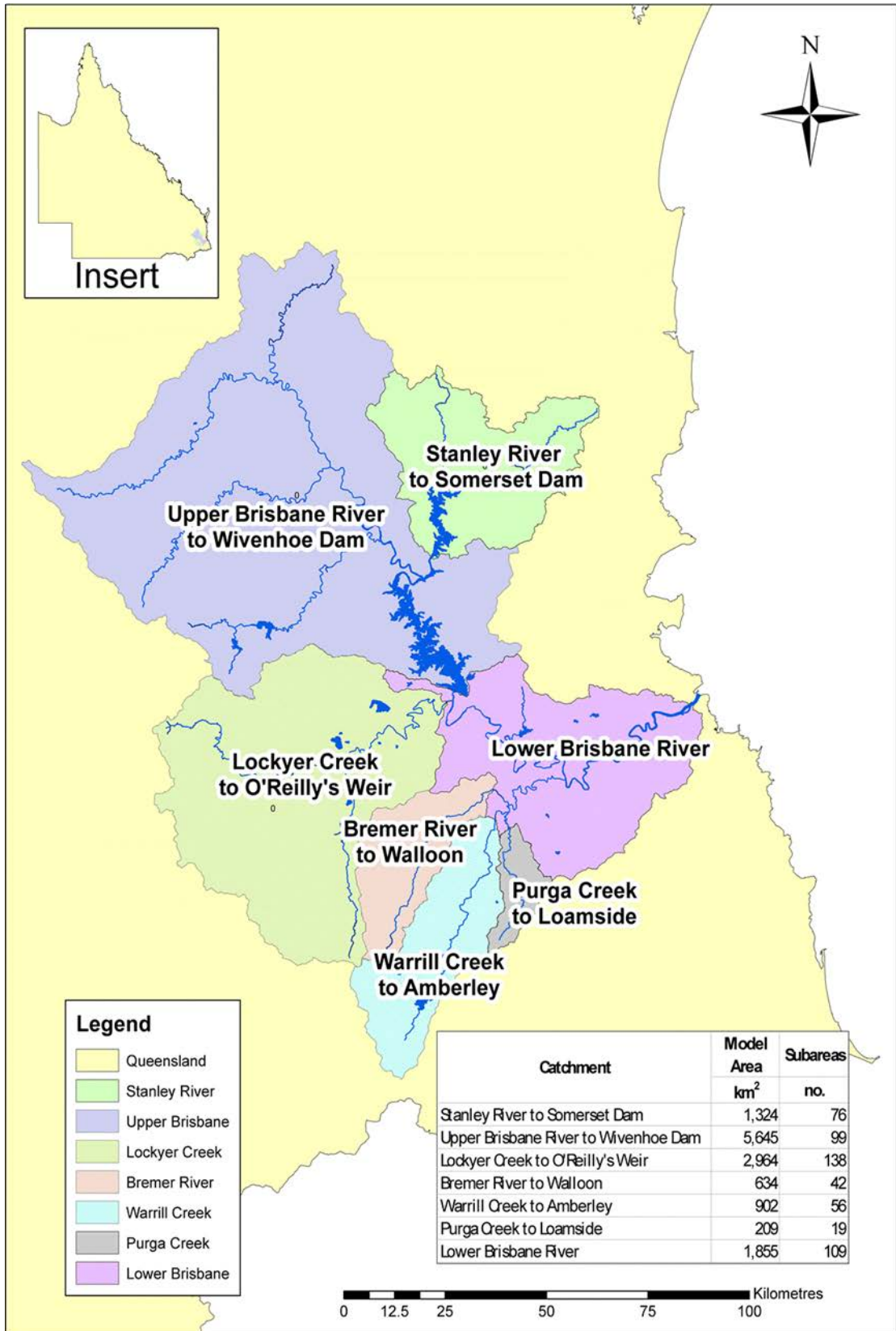


Figure 4-3. Brisbane River and sub-catchment details. Reproduced from “Brisbane River Catchment” by Department of Natural Resources and Mines, 2011



Figure 4-4. South East Queensland water supply sources and urban areas Reproduced from “Review of Water Supply-Demand Options for South East Queensland”, by Turner et al., 2007. *Institute for Sustainable Futures, Sydney and Cardno, Brisbane, p.14.*

River catchments serving the coastal developments of the north and south parts of the region are relatively small, short and steep systems having a rapid response to rainfall patterns. Thus, reliability of supplies drawn from those steams is more vulnerable to the

impacts of rainfall variability than the Brisbane River. The 2002 population reliant on the Brisbane intake system (Wivenhoe, Somerset and North Pine Dams) having a catchment area of 8708 km² (Seqwater, 2017a) was approximately 1.5 million (Australian Bureau of Statistics, 2016b), compared to the City of Gold Coast reliance on the Hinze Dam having a catchment area of 240 km² (Seqwater, 2017a). Gold Coast City housed a permanent population of 440,000 (Australian Bureau of Statistics, 2016b), plus high numbers of transient tourists. Hence the opportunity to have a secure and reliable water source is considerably reduced for those developments such as Gold Coast City serviced by the coastal streams when compared to the Brisbane River reliant communities.

4.3.2 Urban water business governance and management

Each of the 17 separate LGAs in the period prior to the drought had the responsibility to plan, manage and operate treatment, storage and delivery infrastructure to suit the demands of their individual communities. No water system interconnection was provided between LGAs across their boundaries, except where a neighbouring LGA was a customer. Brisbane Water, a government business enterprise of the Brisbane City Council and the largest water business in the region, was responsible for the distribution of reticulated potable water throughout Brisbane City, as well as for the treatment and transport of bulk water to the LGAs of Brisbane City, Ipswich City, Redcliffe City, parts of Pine Rivers Shire and Caboolture Shire. Water supplies to the remaining LGAs to the north, south and west in the region, were operated as separate systems. This water business ownership structure changed from time to time as amalgamation of LGAs occurred and business unit governance arrangements within the LGAs was revised.

Individual water businesses operated in each of the LGAs, either as a Council department or commercialised business unit. Each LGA applied their own water and wastewater tariffs and adopted an independent set of service standards. Thus, there was no consistency in service standards or pricing for consumers across the region. State Government legislation governing the operation and management of LGAs provided some consistency in engineering design standards for water supply services across the region.

Control of urban planning and development was the province of individual LGAs and each LGA prepared and administered its own urban land use zoning map, with little attention to strategic issues. No overall statutory development plan at a state or regional

level existed. As the location of LGA boundaries were determined independently from water catchment boundaries, LGA water businesses had little influence over the land use in water catchments outside their LGA area. Control of catchment use and runoff water quantity and quality was not available to the LGA water businesses outside their parent LGA geographical area.

4.3.3 Consumer water demand

Immediately prior to the onset of the drought impacts, LGAs had no consistent controls on consumer demand and other management interventions or initiatives had not been introduced. Thus the daily water consumption by the residential consumers and industry over the majority of the region was uncontrolled. Department of Natural Resources and Mines (2004) compiled a snapshot of urban water demand across the LGAs for the 2002 to 2003 period, see Figure 4-5. Notes on the figure list the assumptions used to compile the data. Using the assembled data, Department of Natural Resources and Mines (2004) calculated a weighted average of 300 L/p/d, 100 L/p/d and 50 L/p/d for residential, non-residential and non-revenue water demand respectively for the period thus giving a total average water demand of 450 L/p/d.

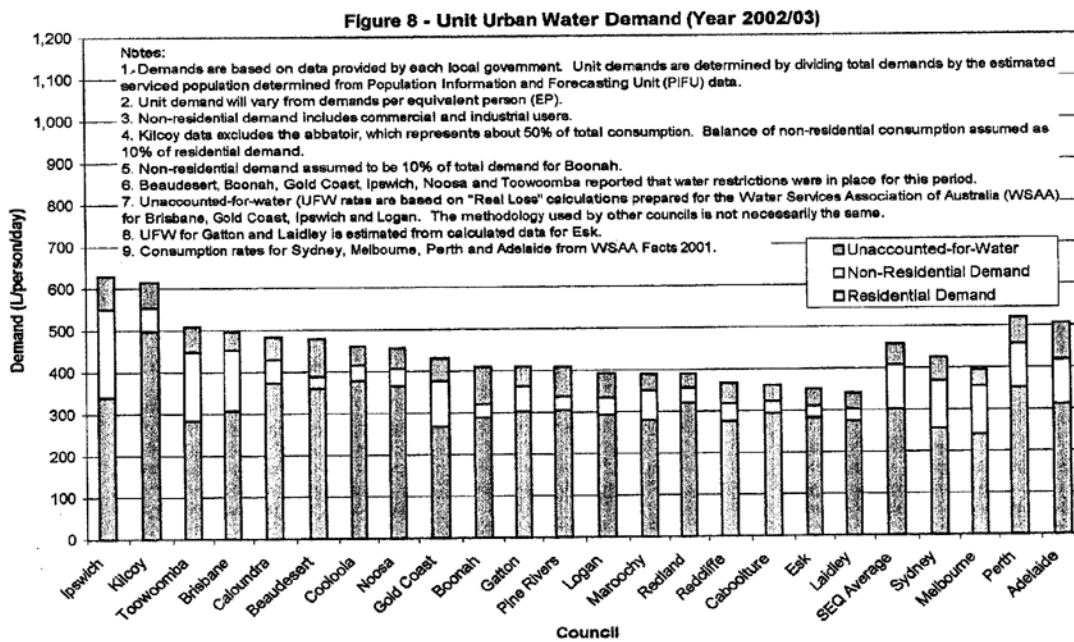


Figure 4-5. A snapshot of unit urban water demand – year 2002 to 2003. Reproduced from “South East Queensland Regional Water Supply Strategy - Stage 1 Report” by Department of Natural Resources and Mines, Brisbane, Queensland. p.34.

4.4 THE MILLENNIUM DROUGHT

An extended period of significant rainfall deficiency commenced in the SEQ region in the late 1990s period and continued through to 2009. The drought became known as the “Millennium Drought” and van Dijk et al. (2013) demonstrated that the event was the worst drought recorded in the eastern area of Australia. van Dijk et al. (2013) reported that consequences of the drought in east and south-east Australia impacted ecosystems, the economy and society. The reference authors found that as instrumental data was sparse prior to 1940 and few rainfall records were available prior to 1900, it was difficult to determine how the Millennium Drought compared in the long-term context. There is some evidence to suggest that the latest drought is the worst since European settlement in Australia, around 1783 (van Dijk et al., 2013). Verdon-Kidd and Kiem (2009) compared the drought for the period of 1895 to 1902, named the “Federation Drought”; the drought of 1937 to 1945 labelled as the “WWII drought”; and the Millennium Drought as the three longest drought periods in eastern Australia. The researchers found that although each drought had prolonged periods of rainfall deficiencies, other climatic factors contributed to their intensity and geographic and seasonal effects.

The Climate Change Centre of Excellence (2007) analysed the rainfall deficit during the Millennium Drought in the south-east Queensland region over the 70 month period from March 2001 when the Wivenhoe Dam (the largest storage in the region) was last at full supply level, through to the report date. When compared with an equivalent 70-month period of average rainfall from records available since 1903, the difference between the drought and historical average rainfall showed a deficit of 23.8%. A graphical representation of the rainfall deficit over the eight-year period 2001 to 2009 was shown by the Queensland Water Commission (2010), see Figure 4-6. The Commission included the trace of the rainfall deficit for the Federation Drought period in the figure for comparison. The reference authors define the accumulated rainfall deficit as the difference between rainfall over the drought period and the average rainfall.

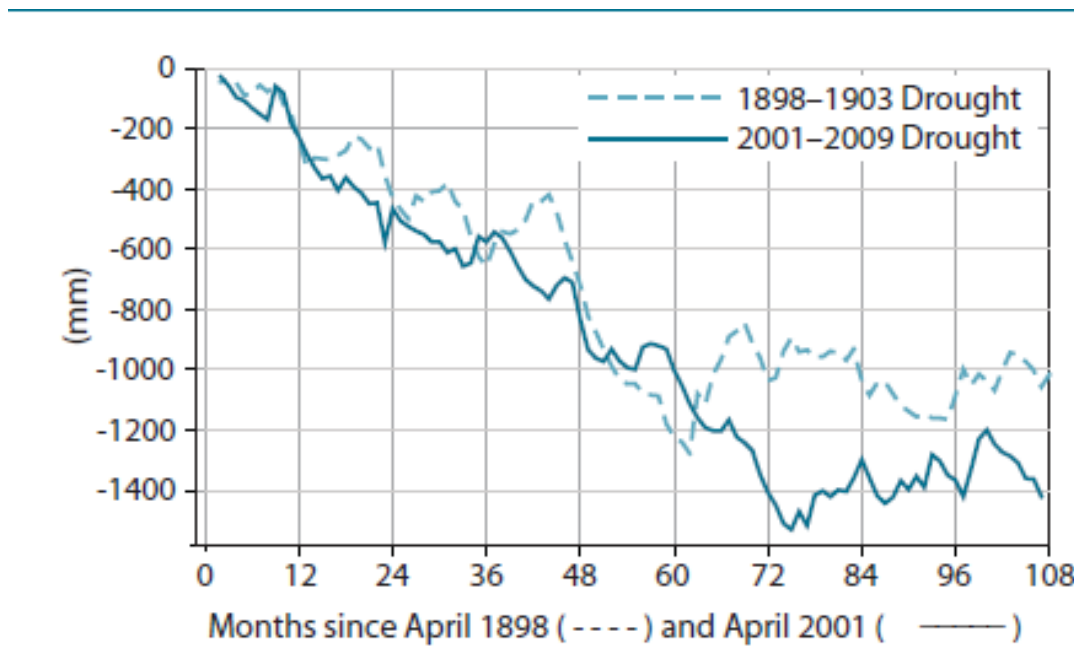


Figure 4-6. Accumulated rainfall deficit for the Federation and Millennium droughts. Reproduced from “South East Queensland Water Strategy”, by Queensland Water Commission, 2010. p.32.

The Australian Bureau of Meteorology (2015) records illustrate the extent of the prolonged rainfall deficit period and although the records show the commencement of rainfall deficiency in late 1996, it became more wide spread by 2001 as illustrated graphically, see Figure 4-7. The chart illustrates that for the period from 1 November 2001 to 31 October 2009, extensive areas were designated as having rainfall recordings as “Lowest on record” or “Very much below average”.

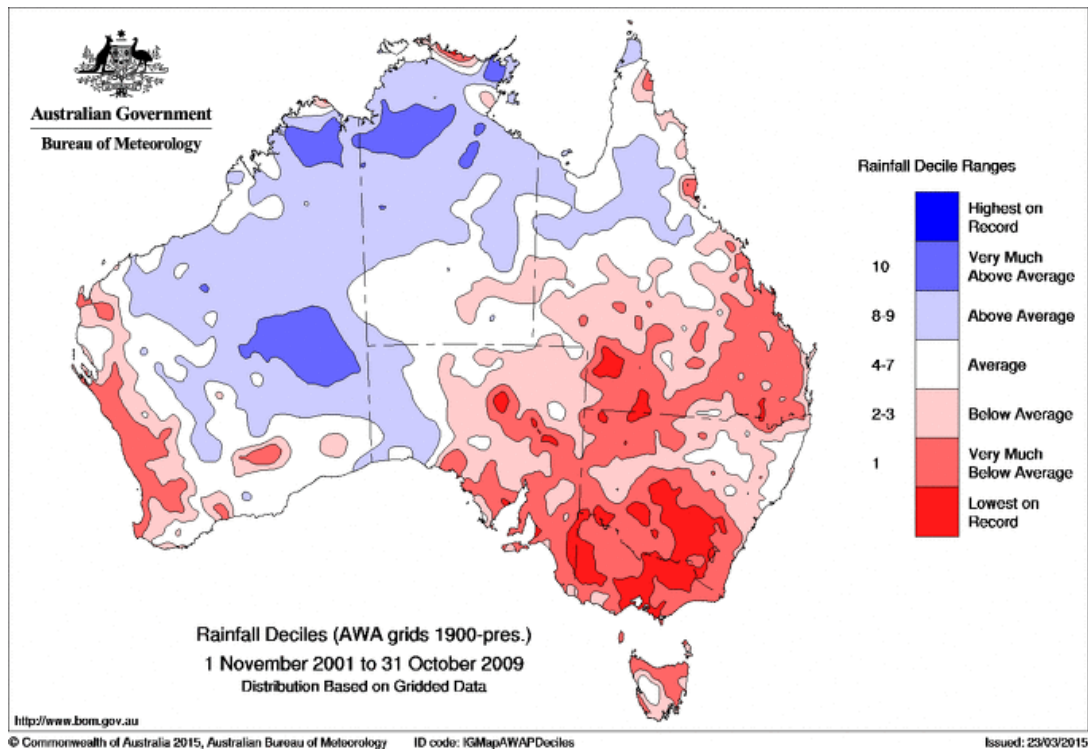


Figure 4-7. Rainfall Deciles 1 November 2001 to 31 October 2009. Reproduced from “Recent rainfall, drought and southern Australia’s long-term rainfall decline” by Australian Government Bureau of Meteorology, 2015

4.5 IMPACT ON RAW WATER STORAGE

The Climate Change Centre of Excellence (2007) reported that the Brisbane storages were full at the 2000-01 summer period and a steady decline of stored volume commenced at that time. The Department of Natural Resources and Mines (2004) note in the South East Queensland Water Supply Strategy – Stage 1 Report (SEQWSS 1) that the Hinze Dam received no rainfall runoff during the 2001-02 summer period, the first time in the history of that catchment. The timing of the impact of the rainfall deficit on the raw water storages was not consistent across the region. The Gold Coast City Hinze Dam catchment was first to be impacted by rainfall deficit and suffered significant storage drawdown from the beginning of 2001. The Hinze Dam has a small catchment area and storage volume compared to the relatively large serviced population resulting in concerns about the viability of the city’s water supply being voiced earlier than in other parts of the region.

The likely severity of the impact on the largest regional storage, Wivenhoe Dam, was not initially recognised as the rainfall characteristics and runoff being experienced at

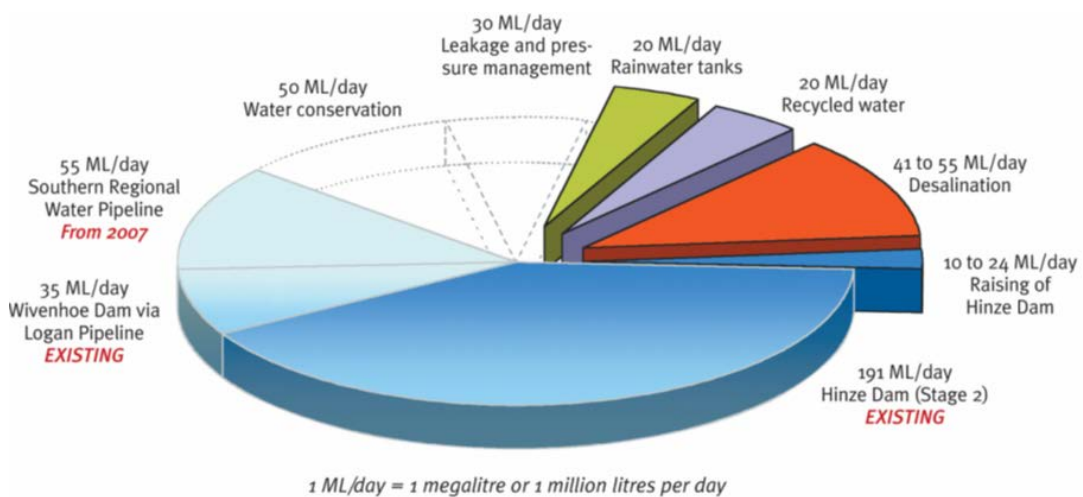
the time had not persisted for any extensive period in previous memory. Storages servicing the northern coastal areas benefited from regular rainfall events sufficient to achieve continued viable storage volumes.

4.6 GOLD COAST CITY AREA PLANNING

As the Gold Coast City water supply source was the first to be impacted by severe rainfall deficit, the City Council, through its commercialised water business unit, Gold Coast Water (GCW), commenced a detailed review of the immediate impacts and the development of long term strategies to service anticipated population increases. GCW identified that the continuing reliance on the strategy of having the Hinze Dam catchment as the sole water source for the City was not sustainable, partly because revised calculations had suggested that the dam safe yield should be revised from 245 ML/d to 191 ML/d (Capati, 2007). Additionally the City Council identified an impending impact of an unprecedented population increase. Capati (2007) reported that, on a population base of 450,000, it was expected an additional 15,000 persons per year would be migrating to the City, together with a visiting population of 10 million tourists per year. Considering the expectations of population increases, combined with the experience of the continuing rainfall deficit, GCW commenced the preparation of a strategic plan for delivery of water and wastewater services for the City for the next 50-year period. In April 2004, the Gold Coast City Council initiated a formal stakeholder engagement program, the Gold Coast Waterfutures Strategy Community Advisory Committee, to explore options for the development of a secure and reliable water delivery system over a 50-year horizon.

The Gold Coast Waterfutures Strategy Community Advisory Committee membership consisted of representatives from community and industry groups and State and Local Government representatives (Edwards, 2010; Gold Coast City Council, 2005). In October 2006, the Advisory Committee recommended a strategy to the Gold Coast City Council. The strategy included a combination of initiatives: a desalination plant, being the only non-climate dependant new source; raising of the Hinze Dam to increase the capacity of the current raw water source; a program of pressure management and leakage control to reduce water system losses; the introduction of non-potable recycled water use; encouragement of the uptake of rainwater tanks for both residential and non-residential use; and the construction of a regional pipeline to provide an interconnection with the Brisbane / Wivenhoe urban water system. Recommendations included in the strategy

were: undertaking investigations into the use of indirect potable reuse water; stormwater harvesting; and the use of grey water. The Gold Coast City Council (2005) report identified the preferred strategy to enable servicing of the City water supply demands to the year 2056, through a combination of existing and new sources together with substitution and efficiency measures, see Figure 4-8.



Note: Recent changes in dam safety requirements have meant final water supply contributions from Hinze Dam are undergoing investigation. This may alter both the raising of Hinze Dam yield and desalination capacity by approximately 14 ML/day.

Figure 4-8. Gold Coast City Preferred Long-term Water Supply Source Strategy. Reproduced from “Preferred Gold Coast Waterfuture Strategy Report – September 2005”, by Gold Coast City Council, 2005. Gold Coast City Council, Queensland.

A significant aspect of the preparation of the strategy for the future sustainable water provision for the Gold Coast City was the involvement of the community advisory committee and the wider community consultation by media reports and newsletters in the attempt to gain an educated community, community support for the strategy and develop community trust in the City Council (Edwards, 2010). In the preparation of the strategy the Gold Coast City Council (2005) set the targets for the strategy and reviews every four years, or at defined trigger events, to align with the criteria:

“By introducing a diverse range of water supply sources, it will ensure we improve the security of our water supply.

By embracing a balanced approach, we will create a more sustainable community by considering environmental, social and economic perspectives.

By being adaptable, the GCWF Strategy will have flexibility to respond to future changes in water supply requirements, technological advancements or

unexpected events.

By incorporating community input, we will create a feeling of joint ownership in the final Gold Coast Waterfuture (GCWF) Strategy decision”.

The Gold Coast Waterfuture source strategy adopted a continuum of the existing model of Local Government providing the needs of its own community and thus the strategy outcomes were confined to the needs of the Gold Coast City. However, at the same time, a significant proportion of the supply strategy was to rely on a part of the water allocation from the Brisbane urban system via a trunk pipeline, thus necessitating an initiation of region-wide planning for a future water supply strategy. The remainder of the regional water supply businesses and government were not accepting the signs of the risk of deepening drought and the planning by GCW forced attention onto regional-wide planning.

The strategic planning undertaken by GCW and its advisory committee demonstrated the benefits in generating trust and empowerment for community bodies to accept future planning actions likely to impact on their livelihoods. (Edwards, 2010). The concept of community engagement carried forward into the Regional Planning work as discussed in Section 4.7.

4.7 REGIONAL PLANNING IN SOUTH EAST QUEENSLAND

Urban and regional planning in Queensland was neglected by State Government until the 1990s as LGAs regarded local planning was their domain (Abbott, 1995). SEQ became the fastest urban growth area in Australia and communities separated by rural and forested areas began to expand to form contiguous urban developments. Concerns were raised by the community that growth in residential development was out of control. Areas of coastal environmental value, prime agricultural land and forested areas were being developed into an urban sprawl (Abbott, 1995). The concerns prompted a study to be commenced in 1990 as a collaborative effort between three levels of government, with community input. The study under the guidance of a Regional Planning Advisory Group (RPAG) consisting of representatives from three levels of government, professional and community members became known as the SEQ 2001 Project. Following various technical planning reports, the SEQ Regional Framework for Growth Management, 1995 (Regional Coordination Committee, 1995) was published as the first non-statutory regional plan for SEQ. A memorandum of agreement was signed by the Commonwealth

and State Governments and 17 LGAs in the region to recognise the plan as the primary regional planning strategy for SEQ (Abbot, 2012). Arising from the Regional Framework for Growth Management, scoping for a regional water strategy study was prepared and a report released in April 1999. The Growth Management report identified infrastructure required to satisfy water demands through to 2051 but did not consider any changes to institutional arrangements. Two yearly reviews of the regional growth framework were undertaken and generally only changed the priority actions (Abbot, 2012). A project to fully review all aspects of the Regional Framework for Growth commenced in 2000, to become known as SEQ 2021: A Sustainable Future. Eleven working groups were established to develop new and updated policy. It is noted that no working group was dedicated to water supply needs.

Abbot (2012), in his discussion on collaborative governance in the planning process identified discrete periods to study during the development of the SEQ regional planning as:

- “1990-1995: Initiating voluntary growth management;
- 1996-2000: Consolidating and implementing voluntary growth management;
- 2001-2003: A comprehensive review and agreeing to a statutory regional plan;
- 2004-2005: Preparing the SEQ Regional Plan; and
- 2006-2010: Implementing and reviewing the SEQ Regional Plan.”

The early regional planning activities that commenced in 1990 were undertaken through collaboration between the three levels of government. Successive changes in governments, political representatives and policies, priorities and ineffective commitment to the process, resulted in a loss of trust between state and local governments and by 2003 local government was voicing frustrations about lack of commitment and ineffective implementation of endorsed policies by the state representatives. LGAs were in agreement that to achieve effective regional planning, a statutory planning scheme that bound all levels of government and private sector developers was required. Such a plan should provide certainty of outcomes with implementation schedules and should align with provision of infrastructure. However, with the aim of continuing collaborative arrangements, the LGAs specified that there should be no Regional Planning Authority or Council (Abbot, 2012).

Following a state election in February 2004 (at the time the impact of the drought was becoming a focus for government and community), a new Office of Urban Management and Infrastructure Coordination (OUM) was established to report to the

Deputy Premier and Treasurer thus having a high-level commitment and responsibility. The new OUM was to identify the region's infrastructure needs, including transport, water and sewerage, for the next 20 years. After the preparation of a draft regional plan for public comment, the OUM released the South East Queensland Regional Plan 2005-2026 on 30 June 2005, this being the first statutory development plan for the region. The establishment of the OUM and its carriage of the statutory development plan initiated the state government as the dominant player for regional planning in SEQ. The LGAs were then required to align their planning schemes with the regional plan (Abbot, 2012; Harman & Wallington, 2010). Through periods of review and public consultation, a revised regional plan was released as the South East Regional Plan 2009-2031. Another major task for the OUM was the release of the South East Queensland Infrastructure Plan and Program 2005-2026 in May 2005. This was fundamentally a state government derived infrastructure plan to align with the requirements of the regional urban plan and detail the pricing and programs to inform the State Government budgets (Minnery, 2006). The infrastructure plan continued to be prepared annually in association with the state budget process from 2006 to 2010 (Abbot, 2012).

The establishment of the OUM in SEQ effectively established a separation of direction and administration for planning schemes for the SEQ area and for LGAs covering other sections of the state, although all were covered by the same legislation. In April 2008, the OUM was abolished and structural changes were made in the state system to introduce the Department of Infrastructure and Planning with the functions of the OUM dispersed amongst the new department or other departments or disbanded altogether. The changes further complicated relationships with LGAs and with community and industry groups (Abbot, 2012). In a discussion on the collaborative dynamics between state and local governments over the period of the regional planning in SEQ, Abbot (2012) noted drivers for collaboration between the two levels of government at this time were the need to provide acceptable statutory planning processes to control the rapid population growth and development. Abbot (2012) reports on some of the concerns aired as negative aspects of the relationships over the period of plan development as:

- “Amalgamations of local governments caused considerable temporary disruption of loss of capacity for joint action.

- The state government is perceived by local government to have taken some unilateral decisions about matters relating to the regional plan and this has reduced mutual trust and respect.
- Regular changes in regional planning ministers and thus regional coordination committee chairs have created a perceived lack of leadership.”

4.8 REGIONAL WATER STRATEGY PLANNING FOR SOUTH EAST QUEENSLAND

As a response to the Council of Australian Governments (COAG) 1994 initiative to reform the governance of water in Australia, the *Water Act 2000* was introduced by the Queensland parliament as the basis for the governance and management of all water resources in Queensland (Cox, 2008). The act preamble described it as “an Act to provide for the sustainable management of water and the management of impacts on underground water, and for other purposes”. The act introduced catchment-based resource planning and water service provider governance. Water resource planning was undertaken on a priority basis for catchments, followed by water resource operation plans. Early work in the preparation of the water resource plans gave priority to major rural catchments as these were considered to have the needs with highest priority at the time.

In 2004, as a response to wide spread drought impacts, the COAG introduced the National Water Initiative (NWI) for further reform in response to concerns that water allocations at that time were greater than sustainable quantities. The Queensland government introduced the *Queensland Water Plan 2005–2010* to identify strategies for improving water management and actions throughout the state for the next five years. The urban water sector also became a focus for the NWI in relation to the introduction of urban demand management and water sensitive urban design methods (Cox, 2008).

Section 4.7 outlined the introduction of regional development planning for SEQ with a study resulting in the first non-statutory regional plan for SEQ being published as the SEQ Regional Framework for Growth Management, 1995 (Regional Coordination Committee, 1995). The regional plan identified, as a priority action, the need for strategies to address water requirements resulting from the SEQ population growth. The action was addressed by a 1999 study labelled the South East Queensland Water and Wastewater Management and Infrastructure Study which was jointly funded by the State Government

and the LGA representatives through the South East Queensland Region of Councils (SEQROC). The study identified that further work was required to deliver a regional plan (Department of Natural Resources and Mines, 2004).

The Regional Coordination Committee (RCC) for the *SEQ 2021* Project requested in 2000 that work to produce a water supply regional plan be re-initiated. State government and SEQROC formed a steering committee to prepare Terms of Reference (ToR) for the development of a regional water supply strategy. The RCC and SEQROC approved the commencement of Stage 1 of a proposed three phase study to develop a regional strategy in May 2003. The ToR for Stage 1 required the identification of a strategy to ensure all LGAs in the region would be able to meet their water supply needs to the year 2020 and to identify the regional infrastructure required in the short to medium terms (Department of Natural Resources and Mines, 2004). The Stage 1 Report was completed in August 2004 and aligned with the SEQ Regional Plan with respect to population projections, the broader regional context and recommendations. The Stage 1 report (Department of Natural Resources and Mines, 2004) was essentially the results of a technical study outlining risks and opportunities within the infrastructure capacity as it existed at that time. However an important observation made in Stage 1 of the project was the identification of significantly improved communication between the State government, SEQROC and other stakeholders (Department of Natural Resources and Mines, 2004). Study recommendations included the continuation of the study to Phases 2 and 3 whilst retaining a similar project structure with a high level of interaction between the stakeholders.

A less technically focused report titled Stage 2 Interim Report was published in 2005 (Department of Natural Resources and Mines, 2005). The “Overall Purpose and Objectives” of the report were stated as providing advice to the Government and Council of Mayors (reconstituted from SEQROC), on strategies to augment the supply and distribution of water to meet future needs from 2005 to 2050. It was noted that due to the continuation of the drought period, a decision was made to publish the Interim Report prior to the completion of the Stage 2 report while continuing many of the short-term projects to refine actions “according to the needs as the drought either continues or breaks” (Department of Natural Resources and Mines, 2005). The stated objectives of the Interim Report were to recommend specific short-term actions and identify proposals for the medium-term which would lead to the long-term water security for the region.

The task of completion of the regional water strategy became the responsibility of a new government entity, Queensland Water Commission (QWC), formed under the *South East Queensland Water (Restructuring) Act 2007*. The South East Queensland Water Strategy (Queensland Water Commission, 2010) included in the *Context* statement: “the Millennium Drought is now behind us. Our water supply is now secure, due to SEQ dams currently at or near full capacity and due to the range of measures that were adopted as part of the drought response”. Further significant statements are: “The Strategy enhances the transparency of planning for, and operation of, the SEQ Water Grid. It delivers a Water Supply Guarantee, which ensures sufficient water is available to support a comfortable, sustainable and prosperous lifestyle while meeting the needs of urban, industrial and rural growth and the environment. This Guarantee will be delivered through a demand management framework, appropriate infrastructure investment and efficiencies gained through operation of the region-wide SEQ Water Grid”. (Queensland Water Commission, 2010). QWC provided an implementation plan for the achievement of the short and medium to long term strategies. The stated intention was a review of the Strategy every five years.

However, a change of political party at the next state election resulted in the proclamation of the *South East Queensland Water (Restructuring) and Other Legislation Amendment Act 2012* and the determination that QWC as a separate government agency ceased functioning in December 2012, with the QWC functions being divided and transferred to the Department of Energy and Water, Department of Natural Resources and Mines and Seqwater as a reconstituted statutory authority. Also at this time, with the same legislation, the *Permanent Water Conservation Measures across SEQ* which had been introduced by QWC in 2009, were abolished and the promotion of water use efficiency and conservation became the role of the LGA distribution and retail utilities.

4.9 LEGISLATION CHANGES

The period commencing at the late 1990s posed strategic and management disruption for the state government and LGAs coping with rapid population increases in SEQ combined with the impacts of extreme drought. Items of state government legislation to enable the achievement of planning controls and the desired infrastructure investment and management strategies were introduced progressively as outlined in Table 4-1. To differentiate between regional urban and water planning and legislation in the table, items

relating to regional planning are shown coloured green, and those for water planning are in a blue font. The water related legislation introduced governance structural reform and demand management controls together with operational reporting by new distribution and retailer groups to a state regulator department.

Table 4-1
Timing of regional planning and water supply related policy and legislation 1990 to 2015

Year	Regional and Water Planning	Planning or policy document	State Legislation, Governance	State legislation, planning	State legislation, security and management	Water entity governance structures
1990	Three levels of government, SEQ 2001 Growth Management Project started					
1999	SEQ Water and SEQROC, commenced water and wastewater management infrastructure study – further work required to formulate a regional plan	SEQ Regional Framework for Growth Management, 1995		<i>Integrated Planning Act 1997</i>		2 state entities and 17 local government
2000	June -RCC for SEQ 2021 project, requested regional water plan be re-initiated October – Water stakeholder workshop leading to establishment of Steering Committee				<i>Water Act 2000</i>	
2001						
2002						

Year	Regional and Water Planning	Planning or policy document	State Legislation, Governance	State legislation, planning	State legislation, security and management	Water entity governance structures
2003	May – RCC and SEQROC, approved commencement of Stage 1 water strategy report					
2004		SEQ Regional Water Supply Report Stage 1				
2005		<p>May – SEQ Infrastructure Plan and Program 2005-2026</p> <p>SEQ Regional Water Supply Strategy Stage 2 Interim Report</p> <p>August – Queensland Water Plan 2005-2010</p>		June – OUM, SEQ Regional Plan 2005-2026	<i>Water Efficiency Labelling and Standards (Queensland) Act 2005</i>	
2006		DNRMW, Water for South East Queensland: A Long Term Solution	<p><i>Water Amendment Regulation (No. 6) 2006 (made under Water Act 2000)</i></p> <p>Insert new Pt 8, w/s emergency</p> <p>Insert new schedules: 10A Service providers 10B Measures 10C Outcomes</p>			

Year	Regional and Water Planning	Planning or policy document	State Legislation, Governance	State legislation, planning	State legislation, security and management	Water entity governance structures
			10D Water supply emergency response for outcomes			
2007			<i>South East Queensland Water (Restructuring) Act 2007</i>	<i>Urban Land Development Act 2007</i>		
2008		March – QWC, Water for today, water for tomorrow	<i>Water Supply (Safety and Reliability) Act 2008</i>			March - Reform of the State's local government boundaries, hence reduction in SEQ LA water entities, from 17 to 10 July – All converted to state entities: QWC, Seqwater, LinkWater, Watersecure and WGM plus one retail entity
2009		Jan – Report on the Drought Contingency Projects June – DIP, South East Queensland Infrastructure Plan and Program 2009- 2026 July – DIP, South	<i>South-East Queensland Water (Distribution and Retail Restructuring) Act 2009</i>	<i>December – Sustainable Planning Act 2009</i>		

Year	Regional and Water Planning	Planning or policy document	State Legislation, Governance	State legislation, planning	State legislation, security and management	Water entity governance structures
		<p>East Queensland Regional Plan 2009-2031</p> <p>August – DERM, SEQ Natural Resource Management Plan 2009-2031</p> <p>Environmental Protection (Water) Policy 2009.</p> <p>December – Permanent water conservation measures</p>				
2010		<p>July – QWC, Water Strategy 2010</p>				<p>July – retail entity divided into three: Unity Water, QUU and Allconnex</p> <p>December – merge Seqwater and Watersecure</p>
2011			<p><i>South East Queensland (Restructuring) Regulation 2011</i></p> <p>April – repeal earlier retail entity legislation</p>			<p>July – Retail entities: Unity Water, QUU remain and Allconnex reverts to 3 LGA's ownership: Gold Coast, Logan and Redland</p>

Year	Regional and Water Planning	Planning or policy document	State Legislation, Governance	State legislation, planning	State legislation, security and management	Water entity governance structures
2012 March state election, change of ruling political party			<i>South East Queensland Water (Restructuring) and Other Legislation Amendment Act 2012</i>			July – Gold Coast, Logan and Redland= LGA business units
2013						Jan - LinkWater and Seqwater combined Water grid Manager and QWC moved to DEWS, DNRM, Seqwater
2014					<i>Water Amendment Regulation (No. 1) 2014 Amends Water Regulation 2002. Insert new Pt 8 Desired levels of service</i>	
2015						

4.10 INSTITUTIONAL RESTRUCTURE

Significant legislation introduced structural change in the responsibility for water management and delivery in SEQ with the state government retrieving the major role from the LGAs in mid-2008. Bulk water resources, treatment and trunk distribution through a new water grid became the responsibility of state statutory authorities and retail distribution remained with LGAs, either by way of LGA owned statutory authorities or LGA business units. Continual change in the structure occurred until early 2013 when a change in ruling political party reduced the number of state government statutory authorities to one and absorbed other responsibilities into government departments, see Figure 4-9.

The South East Queensland Regional Water Supply Strategy - Stage 2 Interim Report (Department of Natural Resources and Mines, 2005) highlighted the complications for management of the coordination of the numerous existing water supply schemes operated by the various water providers. The report noted the constraints placed on the equitable sharing and development of future resources across the region.

The purpose of the first item of legislation for institutional restructure, South East Queensland Water (Restructuring) Act 2007, stated “this Act is to facilitate a restructure of the water industry in south east Queensland to deliver significant benefits to the community, including—

- (a) improved regional coordination and management of water supply; and
- (b) more efficient delivery of water services; and
- (c) enhanced customer service for water consumers; and
- (d) a clearer accountability framework for water supply security.”

Subsequent variations of the determined institutional structure of organisations aimed to maintain the same outcomes.

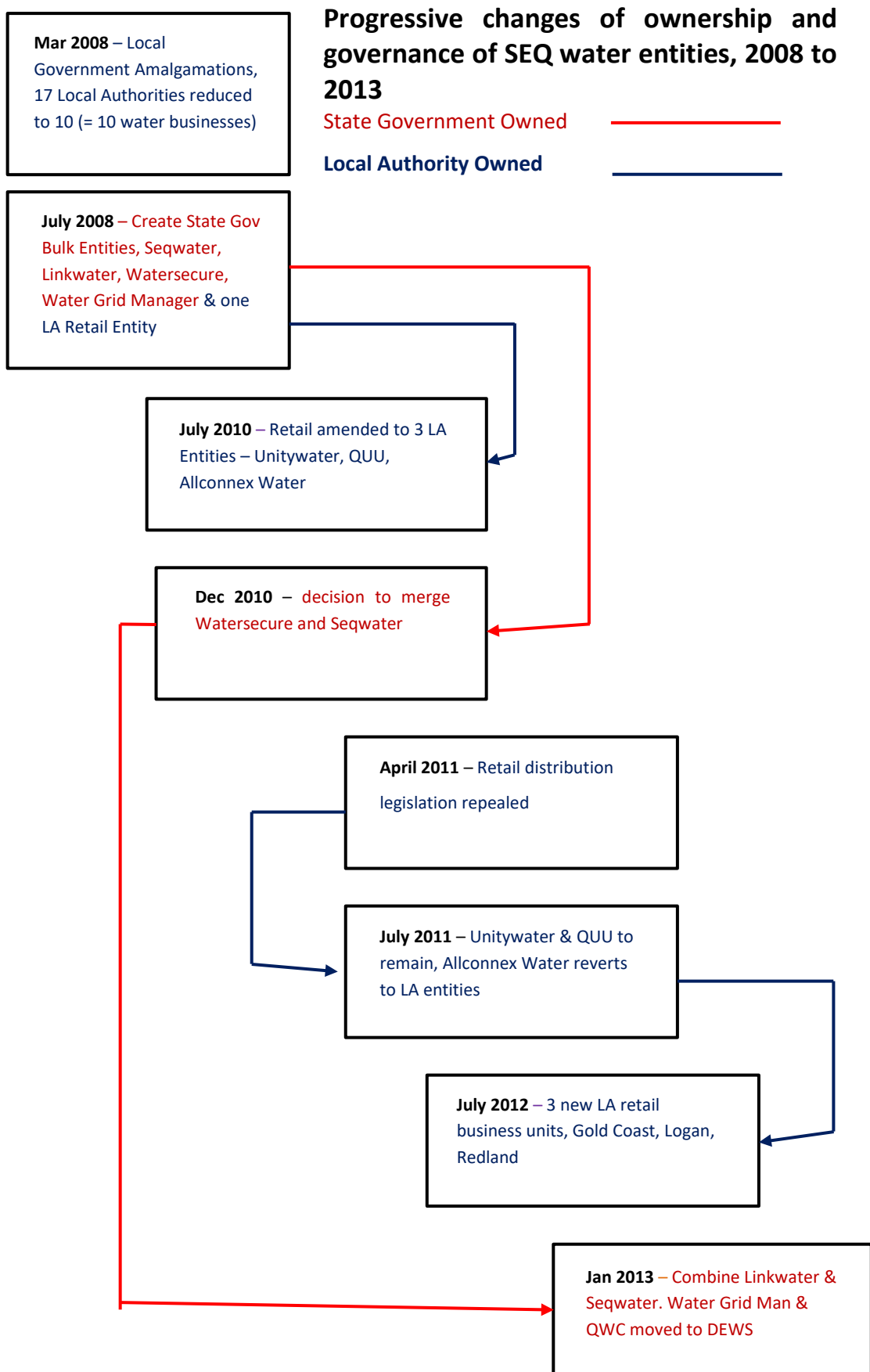


Figure 4-9. Progressive changes to ownership and governance of SEQ water entities 2008 to 2013.

4.11 WATER AVAILABILITY

A lack of consistency in design and operational standards existed across the SEQ region as a result of the existing resources being managed and operated by numerous independent authorities. These inconsistencies were addressed through the analysis of updated information and methods to reassess available yield from existing catchments. The work resulted in a downgrading of anticipated water yield from some catchments. The water availability from the catchments to satisfy identified needs, based on existing and forecast urban characteristics, was found to be sufficient to the year 2007 in the Gold Coast catchment or up to 2025 for those areas relying on the Wivenhoe / Somerset / North Pine system. One of the initial conclusions from the revised calculations was the need for a distribution system to share the available resources and balance the flows across the region, as recommended earlier by Gold Coast City Council. The studies culminated in the publication of the South East Queensland Regional Water Supply Strategy Stage 1 (Department of Natural Resources and Mines, 2004).

The South East Queensland Water Strategy (Queensland Water Commission, 2010) lists “be supply-ready” as one of the key features in the strategy. Options listed for investigation were: additional surface water storages, desalination facilities and recycled water purification.

4.12 WATER DEMAND MANAGEMENT

Attention to demand management was given in a general theme of “use less” in the South East Queensland Water Strategy (Queensland Water Commission, 2010). A range of initiatives were discussed including water efficient buildings and appliances, minimisation of system losses and supplementary supplies such as rainwater tanks. Short-term rebate schemes were introduced for household and business water efficiency initiatives. The then responsible State Government Minister gave an explanation of the rebates in answer to a question in parliament (The Minister for Natural Resources Mines and Energy and Minister for Trade (Mr Robertson), 2009).

As initial responses to the drought impacts, water use restrictions were intended to be applied progressively as water storage volumes reduced. QWC introduced a highly successful community engagement program “Target 140” to increase awareness of the need to reduce consumption throughout SEQ (Queensland Water Commission, 2007). The campaign aimed to reduce community water consumption to 140 L/p/d. QWC stated

an achievement of a reduction of 22.2% down to 126 L/p/d (Queensland Water Commission, 2007).

Seqwater (2017c) documents adaptive initiatives for the ongoing water security for SEQ, including demand control as a response to drought. Modelling of the on-stream storages informs the control measures required to respond to the progressive depletion of stored water due to inflow deficiency. Derivation of a model to identify response triggers as future drought conditions progress has been undertaken by Seqwater (2017c). The triggers are based on combined dam storage volumes remaining at progressive stages through the drought period and determines the supply side items, for example desalination and recycled water plants, to be deployed to balance the loss of security in the dam storages. A matching set of demand side triggers are detailed to provide for the progressive imposition of rules for restricted water use uniformly across the region.

4.13 SUMMARY

The south-east region of Queensland, with a particular focus on the water resources and distribution to urban communities, has been presented as being suitable for the case study. The area has varied geographical features and land uses and is of sufficient size to have significantly varied rainfall patterns over the water resource catchments of the area. Local governance was fragmented into numerous LGAs with standalone development and land use planning approaches. The LGAs have had State Government imposed boundary changes and area amalgamations which have also resulted in changes to the LGA groups managing the urban water supply systems. Water distribution standards were not consistent over the region and consumer demand and expectations varied. The diversity of characteristics across the region provided the opportunity to consider the vulnerabilities and risk impacts resulting from uncertainties and disruptions during the study period.

SEQ was subjected to two significant disruptions extending over a period of a decade from the early 2000s when the area experienced a higher than anticipated population expansion, combined with the onset of a severe drought. The drought was subsequently shown to be the worst since European settlement in Australia. Non-coordinated urban planning had prevailed across the region and fragmented ownership of water businesses resulted in critical disruptions to governance and management of community services.

Concerns were increasingly being raised by the community in the 1990s that growth in residential development was out of control and areas of environmental significance and rural areas were developing into an urban sprawl. Prior to that time, urban land use zoning was the province of LGAs and as no regional statutory control plans existed, lack of certainty in urban development intentions was an impediment to forward planning. The community concerns prompted a study which commenced in 1990 as a collaborative effort between the three levels of government, with community input. Following various technical planning reports, a document entitled, the SEQ Regional Framework for Growth Management was published in 1995. Continued work by working groups and advisory committees culminated in the first statutory SEQ Regional Plan being published in 2005 by a newly formed State Government Authority, The Office of Urban Management (OUM).

The drought conditions prevailing in SEQ in the early 2000s also occurred over large areas of eastern Australia prompting the Federal Government in partnership with the States and Territories to introduce The National Water Initiative (Commonwealth of Australia and the Governments of New South Wales, 2004), and the Queensland Government proclaimed the Water Act, 2000, both having significant compliance requirements for the SEQ water businesses.

The Hinze Dam servicing Gold Coast City at the south-eastern corner of the region was at full storage level in the summer of 2001 and the stored volume rapidly reduced to a critical stage after receiving no runoff into the storage in the following normal rain seasons. The Gold Coast City Council commenced urgent reactive planning to identify actions available to continue servicing its consumers. The City Council worked successfully with a community advisory committee to establish a strategic plan for actions to provide for sufficient supplies for a fifty-year horizon through a combination of existing and new sources together with substitution and efficiency measures. The continuing rainfall deficit impacts across the region prompted the state and combined local government groups to collaborate and to commence planning to provide infrastructure and system capacity for the immediate situation and for long term water security planning.

Similar to the new institutional arrangements for urban planning, a new State Government Authority, The Queensland Water Commission (QWC) was formed to take responsibility for the South East Queensland Water Supply Strategy intended to “ensure sufficient water is available to support a comfortable, sustainable and prosperous lifestyle while meeting the needs of urban, industrial and rural growth and the environment”.

Changes to ownership, governance, management and responsibilities for urban water delivery became a regular occurrence between the years 2007 and 2012, see Figure 4-9. A change of ruling political party in government made further institutional adjustments in 2013 and both OUM and QWC were abolished with their responsibilities being absorbed into other statutory authorities or state departments.

Progressive water demand control measures were introduced for industry and residential consumers as the impact of the drought conditions increased. Control initiatives included restricted flows, reticulation leakage and pressure control, rebates for rainwater tank installation, rebates for commercial user water efficiency programs and community education programs such as the highly successful “Target 140” campaign to reduce household consumption rates to 140 L/p/d. A number of control measures were relaxed or abandoned as the drought reduced its impact. SEQ received extreme rainfall in January and February 2011, resulting in devastating floods in the Brisbane River system. The federal government officially declared the drought in eastern Australia at an end in April 2012.

Chapter 5 Study Survey

5.1 SURVEY AIMS AND SCOPE

The case study discussion in Chapter 4 detailed the reactions by government and water businesses in response to the period of major disruptive events of extreme drought and major population growth in the SEQ region in the early 2000s period. An identified important aspect of the outcomes from the reactive actions initiated by legislation changes and industry restructures was the business disruption experienced by the participants charged with the responsibility to action the institutional changes and to continue the provision of water services to the community in accordance with the desired standards of service.

As witnesses to the processes adopted to react to the disruptions described in the case study, participants in the survey were able to provide expert commentary on the benefits or difficulties experienced as a result of the reactive processes. An aim of the survey was to explore participant's observations of residual and imposed risks and uncertainties as the businesses transitioned through the time-periods of the various reaction initiatives. The survey also afforded the opportunity to explore the participant's perceptions of the status of social and cultural aspects, as promoted by authors in the literature review as being necessary to provide the ability of the businesses to have adaptive capacity in each of three specified time-periods.

An important action to counter the drought disruption was the introduction of water demand initiatives. The survey participants were able to provide their understanding of the degree of success a range of the initiatives provided and to make comment from their knowledge and experience. The survey aimed to gather expert opinion to enhance the case study discussions and to provide a basis for the understanding required to satisfy the aims and objectives of the research study.

5.2 SURVEY STRUCTURE

A semi-structured survey by questionnaire was undertaken to consider the impacts from the disruptive events and the response actions taken by the various SEQ water businesses through and following the drought of the early 2000s period. Figure 5-1

displays the State Government initiated business transitions and restructures occurring during the time-periods. Three phases were considered in the survey to assess the state of the urban water businesses in the timeframes of:

- a. Time-period (A): Prior to the onset of the “millennium drought” – prior to 2002
- b. Time-period (B): After initial intervention by ownership and legislation changes together with the completion of augmentation of infrastructure and resources – 2003 to end of 2011.
- c. Time-period (C): Current day business structures and resources - after beginning of 2012.

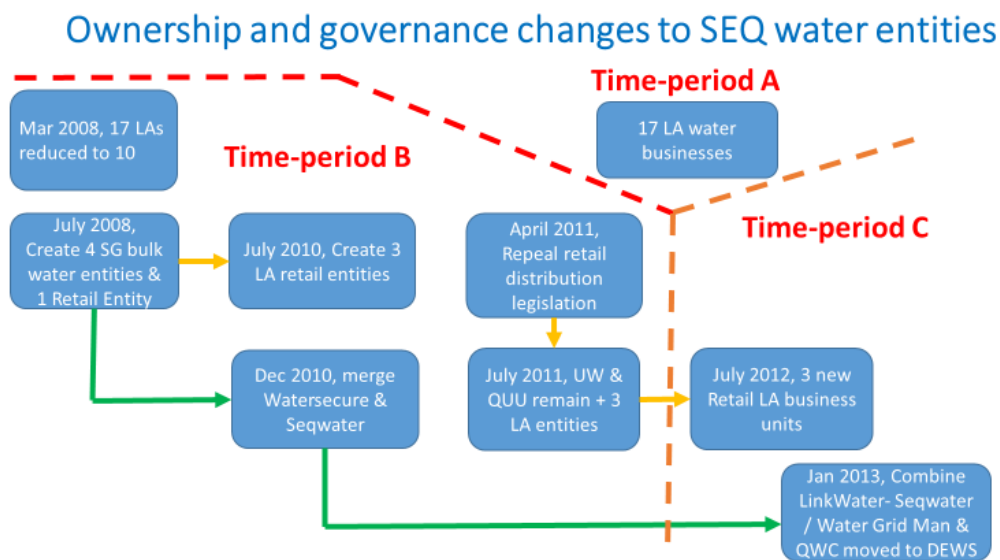


Figure 5-1. SEQ water business ownership and governance structure 2000 to 2013.

Participants for the survey were invited from a group of officers and stakeholders who had significant contribution to the governance and management of the Local and State Government owned SEQ urban water businesses during the above time periods. The participants in the survey were invited to share their experience, knowledge and information regarding planning, financing, servicing expectations of stakeholders, legal aspects and system operation. The participants were advised that although a response to each question or part was desirable, it was not obligatory as it was recognised that participants might have employment history in different businesses in relation to the three time-periods. It was also recognised that some businesses had not been in existence for

each period due to restructuring and institutional change continually occurring over the period, see Figure 5-1.

Many of the participants were employed in the SEQ water businesses during the Period A, both Local Government and State Government based, and then transitioned to reconstituted businesses or to the new organisations as institutional restructures occurred. Additionally, some respondents commenced in the businesses in Periods B and C thus limiting their comments to the later time-periods. The participants were requested to respond from the aspect of their knowledge and experience during the most relevant period or periods in each case. The responses were to be framed from an individual personal perspective and not designed to reflect the corporate views or strategies of the employing institution. Thus, the responses reflected the perceived priorities of the participant's roles and responsibilities in the institution of employment.

A group of thirty-one (31) persons were identified as being able to contribute to the survey intent as a result of the roles and responsibilities from the positions they occupied in the relevant businesses. Nineteen (19) responses were received with affiliations as shown in Table 5-1. Most of the participants contributed to all sections of the survey relevant to their knowledge, experience and time of involvement. The respondents provided a cross-section of views from experience and knowledge in both State and Local Government owned or operated businesses and departments. It was considered that the number of respondents was able to provide a reliable set of data due to the limited group having sufficient seniority, knowledge, responsibility and ability to contribute to the governance and management of the organisations over the designated time-periods.

Table 5-1
Number of survey respondents in each affiliation and time-period

Number of respondents	Period A	Period B	Period C
Local government employee	13	4	4
Local government owned corporation employee		7	8
Total local government focus	13	11	12
State government employee	2	2	2
State government owned corporation employee		4	4
Total state government focus	2	6	6

Number of respondents	Period A	Period B	Period C
Independent water business advisor		1	1
Total respondents	15	18	19

5.3 SURVEY QUESTIONS

The survey questions aimed to explore the urban water businesses' sustainability and resilience risks; potential extreme disruptive events; impacts of uncertainties; specified internal business risks; a characteristics assessment of the adaptive capacity of the business; and provide an opinion on the success of water demand management initiatives. Details of the questions are provided in Appendix B and outlined as follows:

Question 1: Identification of Sustainability Risks

- a. Response from participant's knowledge and observation of overall SEQ businesses.
- b. Response from participant's position of employment or influence in a particular SEQ water business.

Question 2: Identification of potential extreme disruptive events. Response from participant's knowledge and observation of overall SEQ businesses.

Question 3. Identification of Resilience Risks

- a. Response from participant's knowledge and observation of overall SEQ businesses.
- b. Response from participant's position of employment or influence in a particular SEQ water business.

Question 4. Identification of business uncertainties from external influences.

In this question, the uncertainties resulting from external influences, i.e. not under the direct control of the business, were nominated for evaluation. Responses were requested from the perspective of the participant's position of employment or influence in a SEQ water business.

Question 5. Identification of internal business risks and opportunities.

A list of internal business risks and opportunities were provided for assessment of risk rating; the business opportunity to manage the risk; and the ability to realise the

opportunity. Responses were requested from the perspective of the participant’s position of employment or influence in a SEQ water business.

Question 6. Identification and assessment of adaptive capacity within the businesses.

Responses were requested from the person’s observation of the businesses’ operations and from the participant’s position of employment or influence in an SEQ water business.

Question 7. Assessment of success of demand management initiatives.

Response from participant’s position of employment or influence in an SEQ water business or from general observation from involvement in the industry sector.

5.4 ANALYSIS OF SURVEY RESPONSES

Respondents used various descriptions of the risks and to provide a meaningful set of data, the risks were sorted and grouped under subject themes as in Table 5-2 to enable analysis of the survey participant’s perceived importance of the risks and events. Actual responses were chosen to form a narrative to highlight observations under the relevant themes. A further discussion in Chapter 6 analyses the relevance of the survey responses to the study questions.

In Questions 1, 2 and 3, survey participants were requested to nominate sustainability risks, potentially extreme disruptive events and resilience risks respectively. Numerous responses for each question were provided with varying detail and focus. A copy of the full responses is given in Appendix C.

Table 5-2
Grouping of responses under themes for risks and disruptive events

Question 1 - Sustainability Risks	Question 2 - Disruptive Events	Question 3 - Resilience risks
Financial Impacts	Non-acceptance of water pricing	Cost /finance/reprioritised budgets
Management of climate impacts	Un-expected climatic events	Insufficient flood immunity
Management of Assets	Major infrastructure failure	Poor asset management
Governance and management		Lack of coordination between businesses
		Loss of data/organisational memory

Question 1 - Sustainability Risks	Question 2 - Disruptive Events	Question 3 - Resilience risks
		Lack of sustainable business strategies
		Staff focus on restructure not operations
		No focus on water delivery as a business
		Lack of keeping up with technology
Lack of forward planning	Absence of long term planning	Lack of forward planning
Consumers / demand	Demand > capacity	
Water source management		Uncertain reliability/continuity of supply
Source diversity		Lack of acceptance of recycled water
Government intervention / institutional change	Continued institutional change	Government intervention/decisions
	Government policy / legislation/uncertainties	
	Local Government / State Government politics	Short term political views
Skills availability		Lack of governance/management skills
Population growth		No urban structure plan/out of sequence development
Community attitudes	Community concerns / outrage	Community influence/demands
Water quality	Unacceptable water quality / health alerts	Lack of catchment management - water quality

5.4.1 Question 1- Sustainability Risks

This question explored risks impacting the ability of SEQ urban water businesses to achieve continuing sustainability. Additionally, identified risks could provide an understanding of any differences between State and Local Government perspectives of the business management and operations. The response to the question of identification of sustainability risks resulted in an extensive list with the risks being described in varying detail. Participants were requested to list the top three risks for each time-period; from the perspective of the overall SEQ businesses; and for the individual business having most

relevance to the participant. Respondents, although providing varying detail of the risk description, were consistent in their description format across the three time-periods. The risks were able to be clearly identified under the themes as listed in Table 5-2. Table 5-1 indicates the number of respondents for each time-period is not consistent due to the migration of participants through various businesses as a result of the institutional reform and business transitions. For each time-period, the relative importance of the risk theme as perceived by the group of respondents has been established by calculating the number of recurrences of the risk theme as a percentage of all risk responses relative to a time-period. Figure 5-2 shows a comparative representation of the risks identified under each theme and for each time-period.

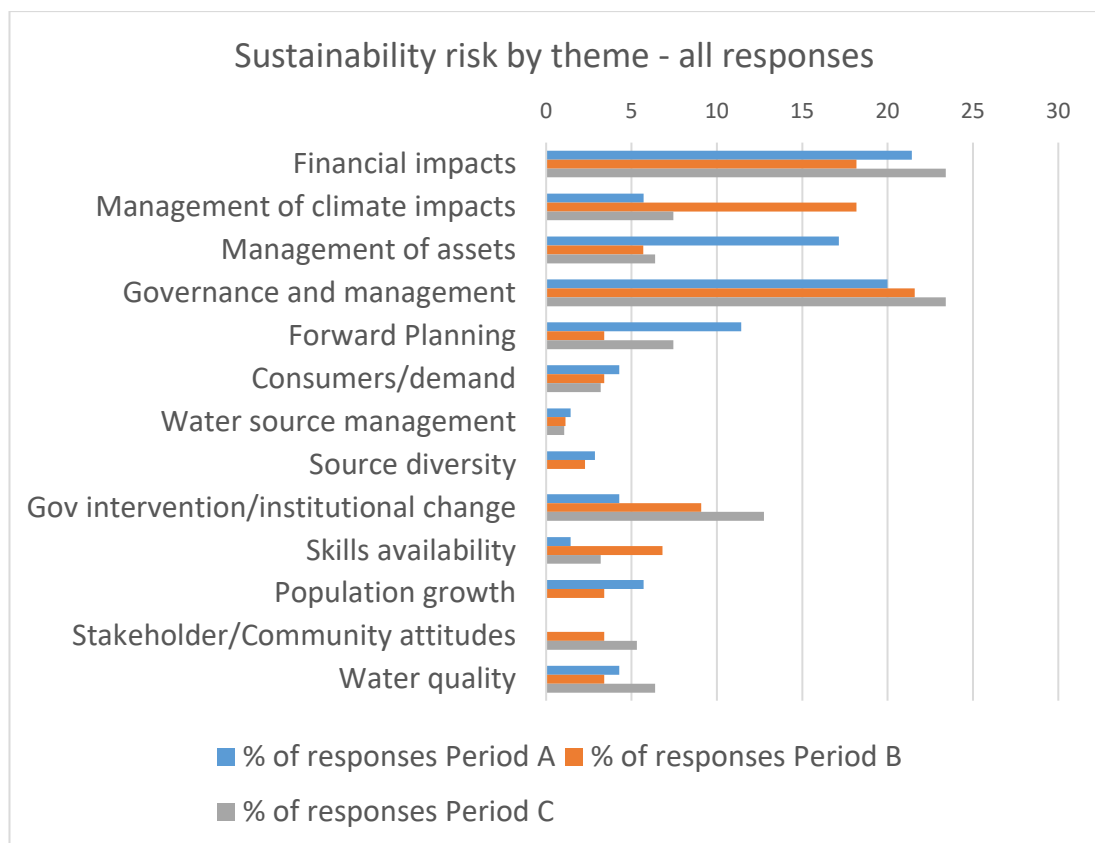


Figure 5-2. Graphical representation of sustainability risks identified for each period A, B and C.

Although the risks identified cover a range of business functions, the impact on the water businesses varies over the transition through the time periods as in the following discussion. Direct quotations referenced from the survey responses are shown in *italics*. A listing of responses to identify sustainability risks for the relevant time-periods is given in Appendix C.

Financial risks continue to be identified at a similar importance level for each time-period, although the detail of the risks vary over the time-periods as shown in the lists of typical responses. During Period A when most responsibility for water provision lay with Local Authorities, the identified risks related to *Council's reliance on water revenue with subsidisation of other activities and pricing not fully linked to service or cost in all entities*. With the restructuring and amalgamation of the water business into larger organisations under different ownership and governance in Period B, as well as large capital expenditures by government to counter the impacts of the drought, the identified risks changed to *funding constraints; significant investment decisions made with water price impacts way beyond (likely) drought period; separation of decisions of drought response and customer bill impacts* combined with the commencement of *pressure to keep costs down*. Period B also saw the introduction of bulk water pricing separated from retail servicing at a time when severe restrictions were imposed with an identified risk being *loss of revenue (consumption reduction) with increased operating costs (bulk water pricing)*. The Period C businesses were developing some commercial maturity and commencing a focus of value for money and charging the true cost of water to the customer. While identified risks continued to be *funding constraints and limited access to resources and budget, affordability of water to the community, return on investment*, one respondent stated that *cost to customer is the highest risk to the present model of bulk supply, distribution and retail water supply services. While the distribution retail services are managing to reduce the cost to serve, the bulk supply price is rising. Given the cost of living is increasing and utility costs are a significant proportion of these costs, water utilities must be structured financially to realise decreases in the cost to serve to be sustainable into the future*.

The management of climate impacts received little attention in Period A. During this period, water authorities used ad hoc control through restriction of consumer's water usage as a response to short term low rainfall events, and risks for this period were *lack of public awareness regarding water conservation* and the authorities having a *reactive approach to drought circumstances*. A risk was observed due to *State Government did not recognise the seriousness of the drought conditions*. Realisation of a major impact of rainfall deficit in Period B brought identified risks as *ability to deal with drought and the reactive approach to drought circumstances*. Risks were identified as resulting from *lack of water security planning* and the need for attention to *water supply security (drought management) - investment decisions*. Figure 5-2 demonstrates that the anticipation of

climate induced sustainability risks in Period B was significantly greater than in Periods A and C. As Period C followed the time of major infrastructure development to provide water security, concerns regarding water provision appear to have introduced a change of risk focus away from water supply security to administrative and management matters of *tension between utility focus on water provision versus natural resource/environmental management focus*.

Management of assets was considered as having the highest risk profile for this theme in Period A with *ageing infrastructure - reliability and renewals* being impacted by *funding constraints* and *lack of long term planning (political cycles 3 years not planning cycles 20 years plus)*. Period B risk profile increased with the *transition of ageing and somewhat disparate infrastructure and systems, and the implementation of risk controls* as the systems previously operated as individual systems with various protocols and operational expectations were combined to operate together. Respondents identified that there was a *low level of captured IP and asset information* to assist in the management of the transition of the assets to the new responsible entities. This risk was restated in the responses for Period C as *continued loss of IP and systems through rapid industry amalgamation process*.

Governance and management risks featured in a significant number of the responses as shown in Figure 5-2. These risks changed in focus as the businesses were restructured and institutional reform was introduced. The Phase A risks focused on the structure of *the water entities of SEQ were owned by around a dozen councils and State Government departments, so common agreement on the problems was difficult with water only one of Councils' concerns – difficult to get necessary executive attention*. There was an *internal focus – not wider region co-operation* leading to *no coordinated planning across SEQ*. Period B was the most significant in the change process as demonstrated in Figure 5-1 and in respondents identified risks resulting from a *reactive approach to drought circumstances through Government intervention* resulting in *the SEQ industry structure spread responsibilities and liabilities through unworkable organisational structures and 'contractual arrangements' with duplication of corporate and management structures within the bulk water industry*. This produced a *lack of alignment between commercial operating expectations and government ownership/stakeholder/shareholder* with the *changing operating and regulatory environment leading to confusion in the roles and responsibilities outside the water sector*. Risk resulting from the *separation of bulk and retail functions* and *SEQ businesses not*

working together for common good were identified for Period C. Technical and operational risks such as *continued loss of IP and systems through rapid industry amalgamation process* leading to *lack of IP and knowledge to support quality decision making* were also identified for this period.

Lack of forward planning featured more in Period A than in the periods after restructures, with statements of *lack of long term planning (political cycles 3 years not planning cycles 20 years plus)* and *no coordinated planning across SEQ*. After the impact of the drought was experienced in Period B, the risks associated with continuity and reliability of supply highlighted that the *rapidly growing population is increasing demand on existing raw water sources*. The *SEQ Water Security Plan* indicates how supply will be augmented but implementation is not clear. Risk remains high until detailed infrastructure plans are developed and adopted by the State Government, and a further risk of government lack of focus on water policy issues in the absence of public interest. Additionally, it was highlighted that a risk in Period B was *transitional arrangements: This focus on institutional arrangements distracted people and diverted scarce resources from core business of delivering safe and reliable services*. This combined with local government amalgamations in 2008 was a significant risk to water business sustainability from 2006.

A participant gave a detailed response for Period C in relation to a risk under Continuity and Reliability of Supply – *notwithstanding the planning set-out in the SEQ Water Security Plan to maintain adequate supply there remains significant detail planning work to implement the high-level planning*. This gives rise to the following risks: a). *The detail planning work has the potential to overwhelm business as usual arrangements and divert resources at a time when significant resources to undertake planning for large tracts of green-field development area*. This could impact on the prudence and efficiency of infrastructure and the development industry if adequate resources are not available for green-field planning and b) *Planning may be accomplished but the state may not be able to afford implementation which will place continuity and reliability of supply at risk*. This statement is supported by the lack of planning as highlighted in the case study.

Skills availability and retention was listed as a risk, particularly in Period B when most of the business restructure occurred and new businesses having new governance arrangements were formed. Risks were stated as *the SEQ industry structure spread responsibilities and liabilities through unworkable organisational structures and*

'contractual arrangements', with duplication of corporate and management structures within the bulk water industry. New corporate structures resulted in a lack of experienced senior managers and suitable board members.

Participants listed various risks under government intervention and institutional change commencing with Local Government amalgamations and boundary changes in Period A to continual policy changes and uncertainties in the later periods. The risk of further political interference in decision making and political instability and unpredictability (further water institutional reform) theme is repeated in various forms in the responses.

The remaining themes of customer/demand, stakeholder/community attitudes, population growth and water quality, while a lesser number of reoccurrences, were of sufficient importance to be listed by some participants. Water quality risks were identified as arising from lack of catchment control and for later years, the ability to control disinfection over the larger network. The risks relating to water source diversity referred to the non-acceptance of the use recycled water.

5.4.2 Question 2 - Potential extreme disruptive events

This question requested the participants to identify the high priority disruptive events potentially impacting on the businesses to enable consideration of strategies needed to react or adapt to those events. The response to this question of identification of potential extreme disruptive events resulted in an extensive list with items in varying detail. Participants were requested to list the top three events for each time-period. As shown in Table 5-2, the potential disruptive events have been grouped under themes coordinated with those identified in Question 1 responses as sustainability risks. The recurrence of identified disruptive events under each of the themes is shown graphically in Figure 5-3. The percentage shown represents the repetition of responses under each theme and is calculated recognising the different response groups for the three time-periods. The method of calculation follows that used for Question 1.

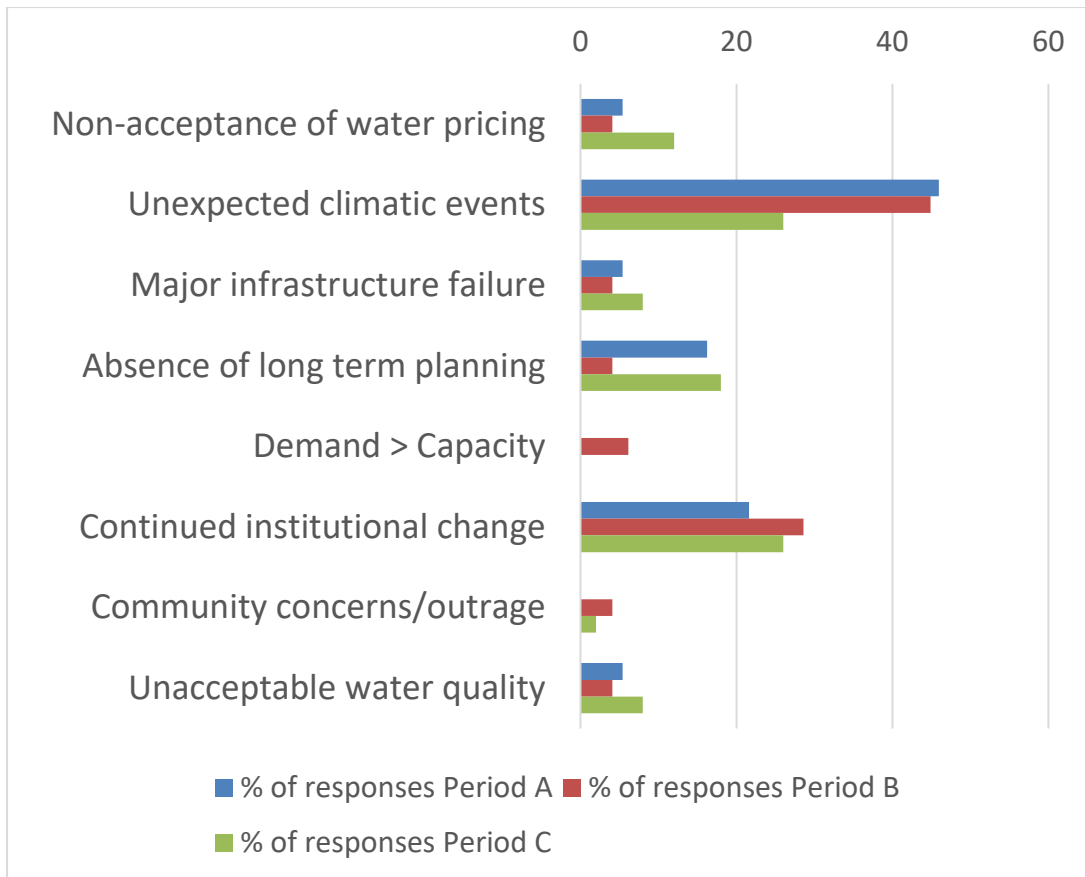


Figure 5-3. Potential extreme disruptive events.

As shown in Figure 5-3, responses from participants identified unexpected climatic events as the most often nominated disruptive influence for Periods A and B, and still a significant event in Period C. Both drought and flood feature under this theme with near to equal prominence. Continued institutional change or government intervention through policy or legislative change is identified as significant disruptive events in all three periods by both State Government (SG) and Local Government (LG) participants, see Figure 5-3 and Figure 5-4. While there are some differences in the number of times the events were identified by the participants, there is nothing of major significance to observe between the responses from the two sectors of businesses or departments. All detailed responses to Question 2, identification of potential extreme disruptive events, are shown under the themes in Appendix C for each time-period.

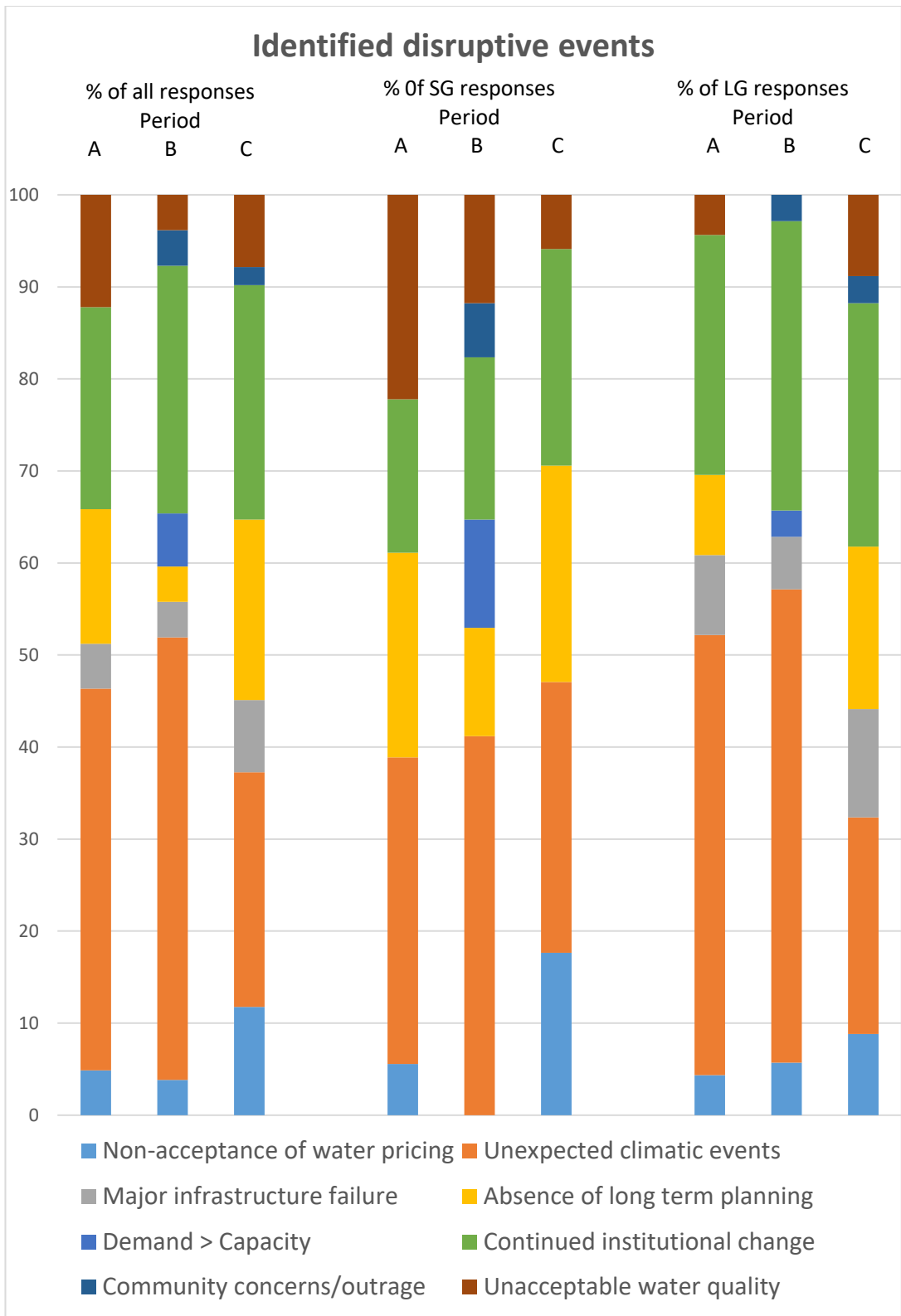


Figure 5-4. Disruptive event identified by representatives from each level of government

5.4.3 Question 3 - Risks impacting ability to be resilient

This question aimed to differentiate the participant’s nomination of risks impacting the achievement of resilience compared to those identified as associated with sustainability. Although there was some variation in the responses between Question 1 and Question 3, the responses fell generally under the same themes, indicating an absence of consideration to cultural and non-technical aspects. This bias is possibly explained by the fact that most respondents were the technically focused parts of the businesses.

As with the responses to Questions 1 and 2, this question for the identification of resilience risks resulted in the respondents providing an extensive list of risks with items in varying detail. Participants were requested to list the top three risks emanating from the disruptive events in Question 2, as listed for each time-period. The potential resilience risks have been grouped under themes which coordinate with disruptive events as shown in Table 5-2. For each time-period, the relative importance of the risk theme as perceived by the group of respondents has been established by calculating the number of recurrences of the risk theme as a percentage of all risk responses relative to the time-period. Figure 5-5 represents the prevalence of the responses relating to the relevant theme and time-period.

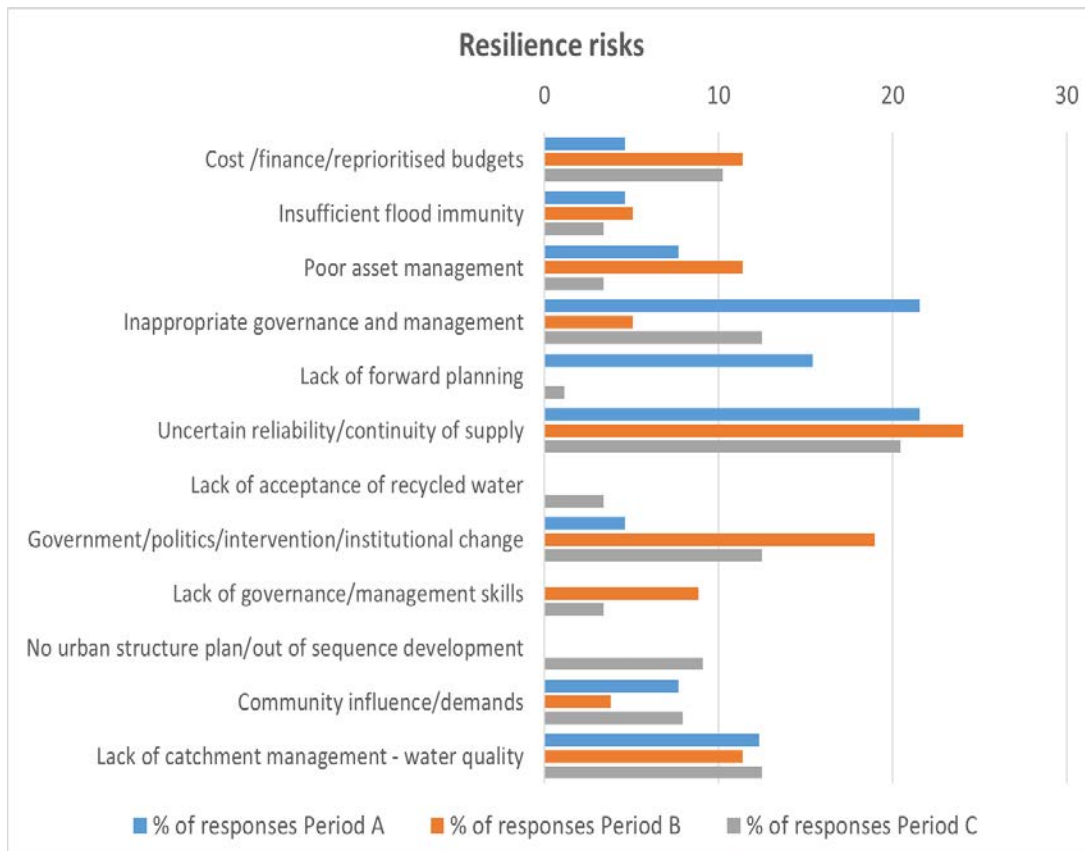


Figure 5-5. Risks effecting the achievement of a resilient water business.

A full list of participant's responses to the question are shown in Appendix C and the following commentary discusses the prime risks raised. All risks under the themes outlined, whilst not stated as frequently as others are sufficiently important to be raised by the respondents. Risk statements from the respondents are shown in italics.

Uncertain reliability / continuity of supply resulted in the highest number of responses for each time-period for the identified risks effecting the achievement of a resilient water business. For each period, respondents identified a high risk as *loss of water supply to some or all of SEQ region, or similar statements, and inability to meet demand through lack of sufficient contingency supply infrastructure or prolonged failure to supply core services due to single point failure in a supply chain being observed* in Period C.

Inappropriate governance and management featured highly for Period A when the Local Authorities managed the majority of the water businesses. A typical response to the identification of risks under this heading was: *the water entities of SEQ were owned by around a dozen councils and State Government departments, so common agreement on the problems difficult with unconnected supplies and major risk of failure to supply demand during drought – vulnerability of isolated water supply schemes* being highlighted. Period B was a time of substantial change in institutional arrangements and management and identified the risk of being unable to provide business resilience as *people disruption was the big one, continued changes hampered a maturity in systems and focus on the main games. Much navel gazing and in fighting over perceived turf wars.* Also identified was a situation of *inadequate services due to high demand on staff to undertake their day jobs in addition to providing input into complex institutional reform and the focus taken away from operations to restructuring.* A further risk identified through the transition period was the *loss of historical information and data through reform politics influencing infrastructure operations and the difficulties in rebuilding organisational capacity.*

The risks identified from government/politics/intervention/institutional change were greatest in Periods B and C when the substantial transitional institutional changes were occurring. A typical response was the situation of *a large number of new organisations / institutional forms as well as numerous regular changes in institutional structures.* This resulted in the *SEQ industry structure spread responsibilities and liabilities through unworkable organisational structures and 'contractual arrangements',* coupled with *reactive response leading to ad hoc decision making responding to short term political perspectives at all levels of government.*

Lack of catchment control leading to water quality issues has been identified as a risk affecting the achievement of a resilient business across each of the time-periods with *flood impact on raw water quality/capability of water treatment plant to treat poor quality source water* being the primary concern. A respondent raised under Period C, the comment - *present approach to catchment management has high probability of adverse raw water quality outcomes in the future.*

5.4.4 Question 4 - Identification of business uncertainties from external influences

The aim of this question was to evaluate the impacts on urban water business due to uncertainties posed by external influences from a nominated list. Observations and industry knowledge of occurrences during the period of drought and disruption were used to formulate the list of external influences on the businesses to be evaluated in the questionnaire. Participants were requested to provide ratings on a scale of 1 – 5, with 5 being the highest rating for:

- The risk posed to the management of the business from the nominated uncertainty
- The opportunity to respond to the uncertainty
- The ability of the business to provide adaptive actions in its response to the uncertainties.

Not all participants provided complete responses to all parts of this question and analysis was undertaken by normalising each set of responses to the total number of responses for each nominated uncertainty and applying a weighted average approach to provide a rating for each segment. Figure 5-6 shows the risk ratings (in the range of 1–5) as determined by:

- Complete group of respondents (G)
- Respondents from the State Government sector (SG)
- Respondents from the Local Government sector (LG)

The risks from climatic uncertainties were identified by the respondents as having a higher rating by the State Government participants compared to the Local Government participants; slightly less for legislative and institutional changes; and of similar rating for the remaining uncertainties. These differences between State and Local government

responses is possibly due to the division in responsibility for the provision of bulk water by the state government group compared to retail sales and distribution being the responsibility of the local government participants.

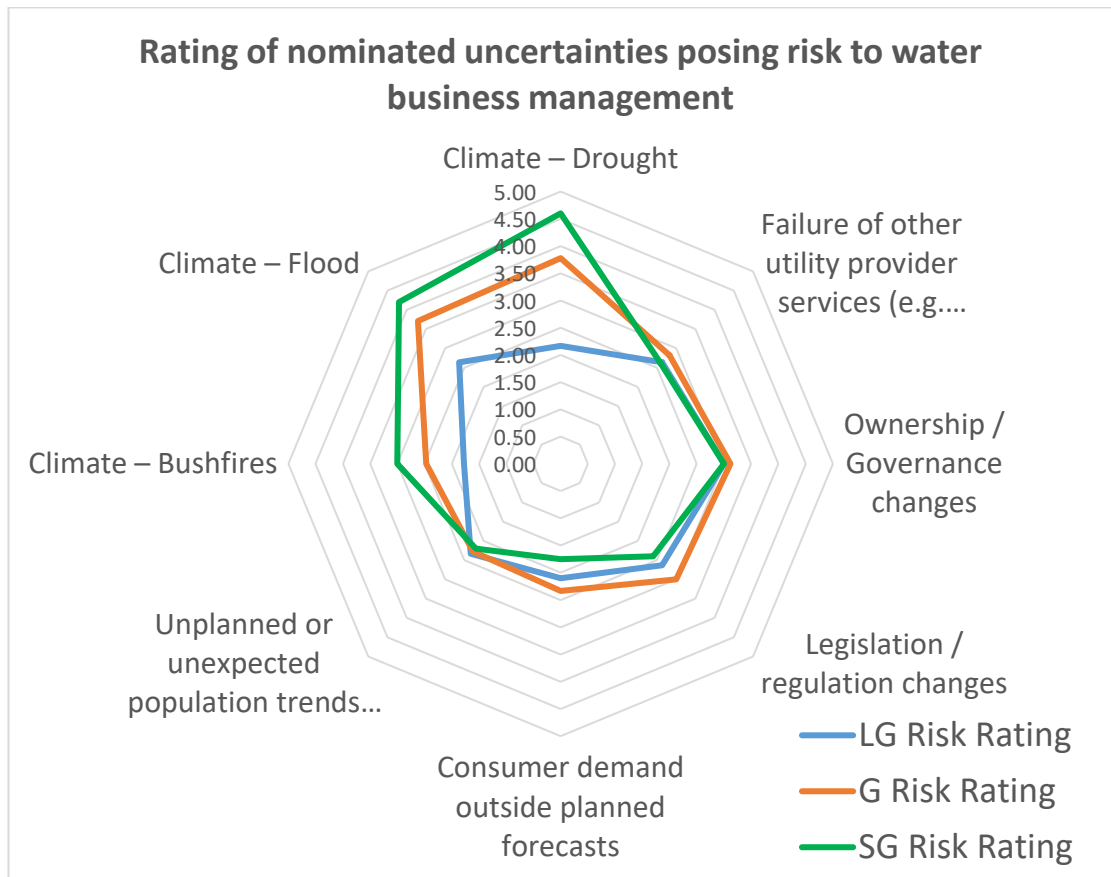


Figure 5-6. Rating of nominated uncertainties posing risk to water business management.

The respondents’ perceptions of how their organization has an opportunity to respond to the listed uncertainties and the businesses’ ability to apply adequate adaptive responses are shown in Figure 5-7. The ability to respond to uncertainties received medium to high ratings for all headings except “Ownership and governance changes”.

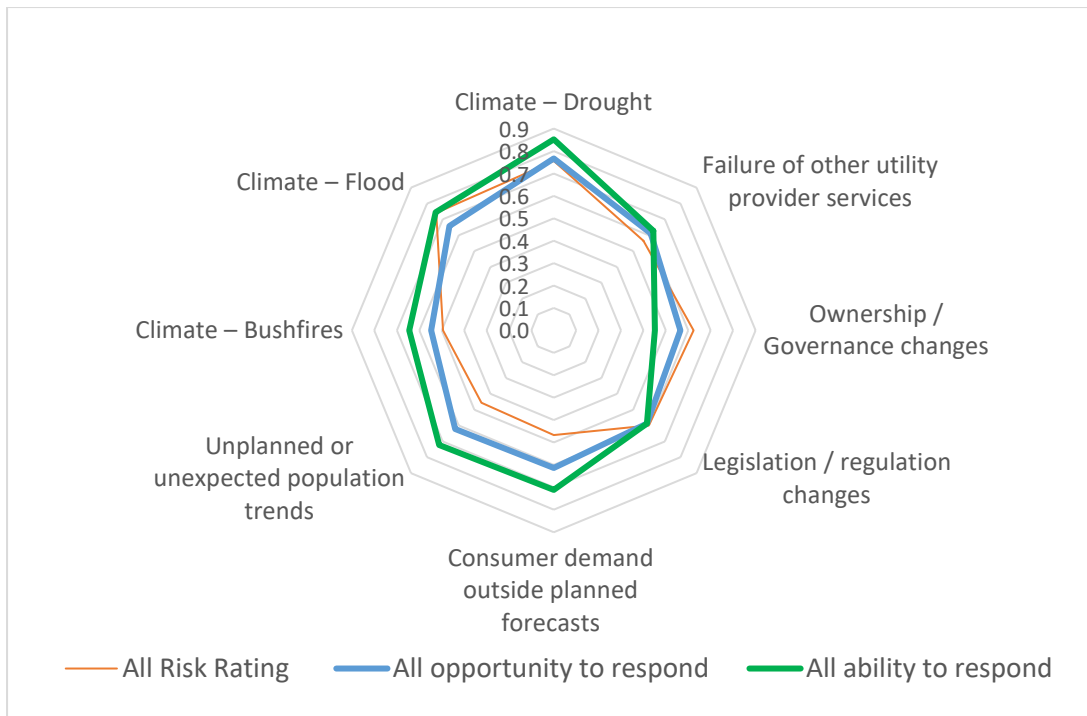


Figure 5-7. Weighted average of responses for risk, opportunity and ability to respond to uncertainties.

5.4.5 Question 5 - Identification of internal business risks and opportunities

Responses to this question followed a similar format to the previous question and aimed to assess the impact of listed internal risks fundamentally under control of the business. For the graphical representation of all responses see Figure 5-8. The ratings of the internal business risks are lower than the external uncertainties with an overall higher (positive/beneficial) score for the opportunity to respond and for the business management system allowing the ability to respond. Risks identified as having a comparatively higher impact were lack of:

- Long term strategic asset management
- Sustainable long-term investment
- Skills availability
- System and business knowledge
- Stakeholder acceptance of levels of service
- Optimum business and staff culture

The least level of opportunity to respond to the risks were identified as:

- Control of consumer demand
- Finance – income / debt affordability
- Stakeholder acceptance of levels of service

Participants indicated that the organisations had the least ability to respond to:

- Control of consumer demand
- Finance - security of income
- Stakeholder acceptance of levels of service

The risks listed in the question were referred to a “internal risks”. However, each had a degree of external influence to impact the outcomes and businesses were seen as having some difficulty in the application of suitable adaptive actions. Those respondents with a technical background might not have appreciated other tactics such as financial or social awareness programs available to control or mitigate those risks.

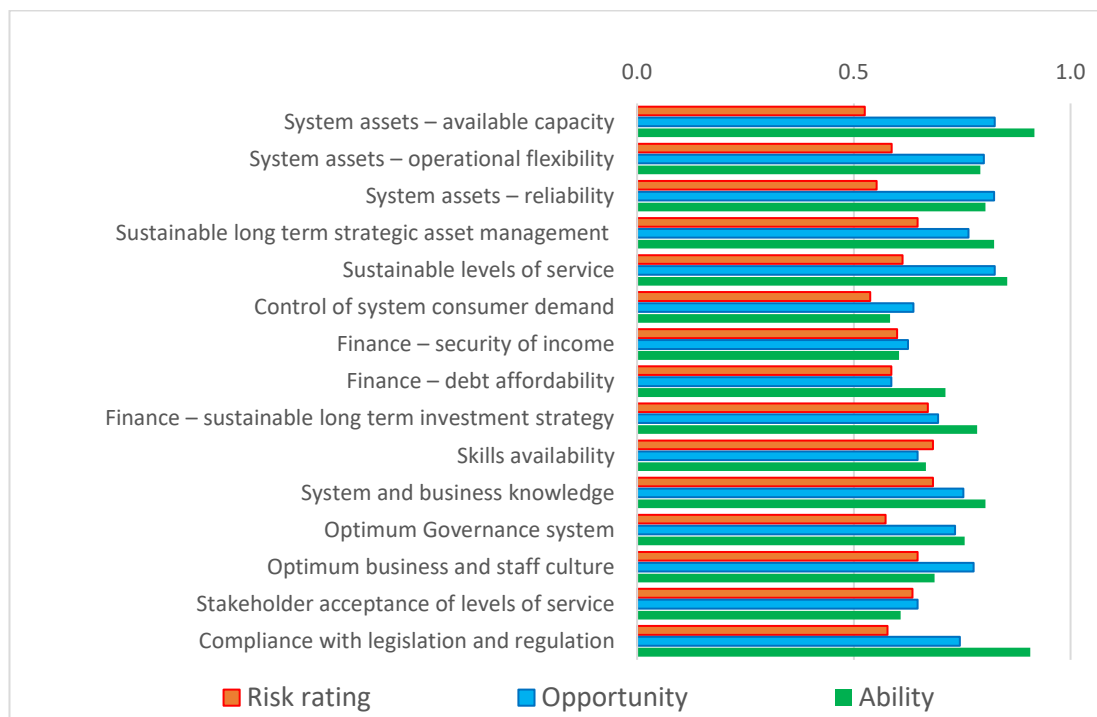


Figure 5-8. Evaluation of internal business risks, opportunities and ability to apply adequate response.

5.4.6 Question 6 - Identification and assessment of adaptive capacity within the business.

Head (2008) suggests that in the development of adaptive capacity in water supply businesses, the institutions must be cognisant of: science and technology; social aspects;

capability of management; and the ability to recognise and coordinate inter-related issues and uncertainties. Gupta et al. (2010) have proposed that institutions need to analyse their inherent characteristics to empower social participants to respond to short and long-term impacts either through planned measures or through allowing and encouraging creative responses from society. Sharpe (2016) argues that to engender adaptive capacity and achieve the ability to be resilient, systems and functions must reflect learning, flexibility to experiment and adopt novel solutions to broad classes of challenges.

The aim of Question 6 was to test the propositions as they might apply to the SEQ water businesses, with the assessment of the business culture and the existence of adaptive capacity under six dimensions: variety, learning capacity, room for autonomous change, leadership, resources and fair governance as proposed by Gupta et al. (2010). Definitions to be adopted for each of the terms for the dimensions and criteria were given in the preamble to Question 6, see Appendix B.

The majority of respondents completed all parts of this question. The question of a nominated criterion and dimension being present in a business at each of the time periods required a YES or NO response. The result gave an indication of the respondent's opinions of the criteria being present in the business at a time-period nominated. The score was calculated by a numerical count of the recurrence of the positive responses and converted to represent a percentage of all responses received for a particular criterion. The question was designed to test the respondent's perception of the SEQ water businesses having adaptive capacity and to compare the results for three time-periods. Each criterion was assessed for each of the three time-periods. The percentage of respondents considering the presence of the criterion being present in the business was calculated by dividing the number of "Yes" nominations by the number of responses. An averaging of the scores followed to establish the overall scores under the six dimensions (segments) and a further averaging provided an indicator of the businesses having systems and culture to encourage adaptive capacity. The latter scores provided an indication of the effect the business transformations in governance and management had in providing a benefit to the businesses to adapt to the disruptions over the successive time-periods A, B and C. No weightings were applied to any of the criterion, that is, each criterion was viewed as having equal importance for the assessment. As in the method used by Gupta et al. (2010) to provide a visual structure to the information, a colour system was adopted to distinguish the percentage of positive responses for each of the criterion followed by the assembly into "dimensions" and to the summary representing the perceived presence of adaptive

capacity. Colours represented five bands of results each representing intervals of 20% as shown in the legend for Figure 5-9. The colour legend on Figure 5-9 follows the concept proposed by Gupta et al. (2010) with the scores from the questionnaire responses indicating a progressive improvement in the “effect of the institution on adaptive capacity”.

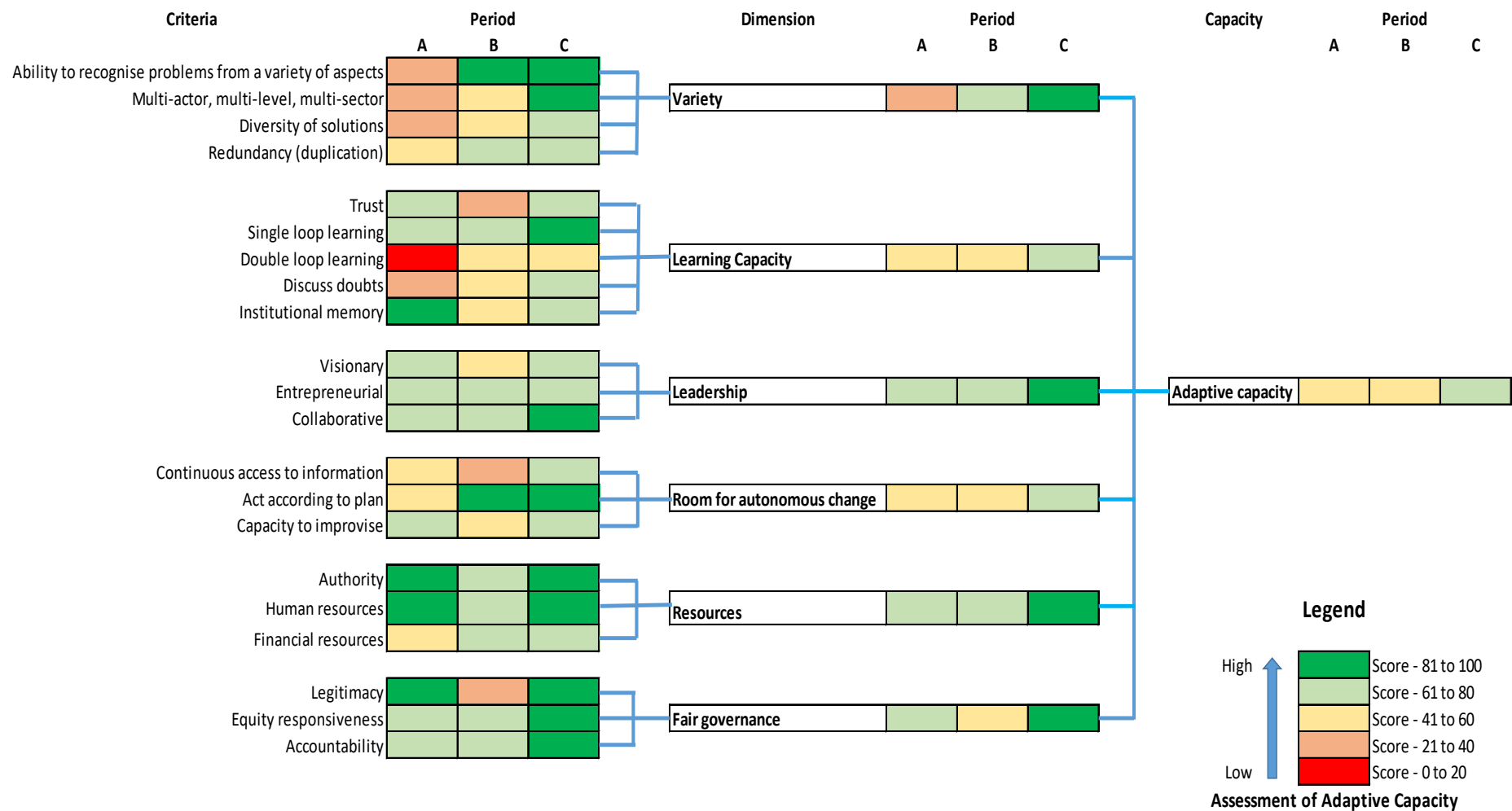


Figure 5-9. Assessment of the social and cultural characteristics of adaptive capacity of the SEQ water businesses over three nominated time-periods.

The following discussion considers the scores for each of the criterion in association with the business transition activities occurring in the time-periods as detailed in Figure 5-1, and with the risks and uncertainties identified in the previous questions of the survey. *Variety* in this context questions whether the business has the flexibility to recognise that there can be multiple inputs to arrive at solutions to problem solving through the interaction of multi-actor, multi-level and multi-sector. The criteria redundancy or duplication can refer to solutions being “more of the same” or a statement often heard to legitimise a certain line of action, “this is the way we have always done it”. Thus, this criterion must be analysed from the aspect of having a positive or negative quality towards the ability to achieve desired positive outcomes. The scores generated from survey responses provided an assessment of adaptive capacity over the three time-periods. The colour coding and descriptions in *Figure 5-10* are as the same as for Figure 5-9.

During the Period A when the governance and management of the water businesses was mostly the responsibility of Local Governments, the perception by respondents appears to be a simplified and restricted approach to problem solving through multiple but non-connected entities. For example, statements from the responses to sustainability risks were: *internal focus – not wider region co-operation and water only one of Councils’ concerns – difficult to get necessary executive attention*. Sufficient change in governance and management resulting from fewer and larger entities having more and varied resources through the Periods B and C appears to have encouraged the perception of greater potential to achieve adaptive capacity from the criterion listed under the dimension of *Variety*

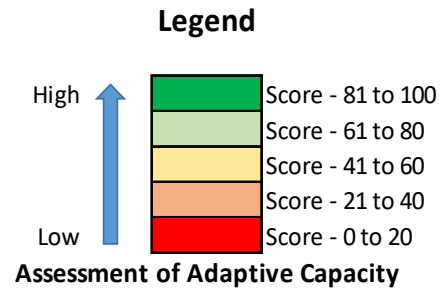
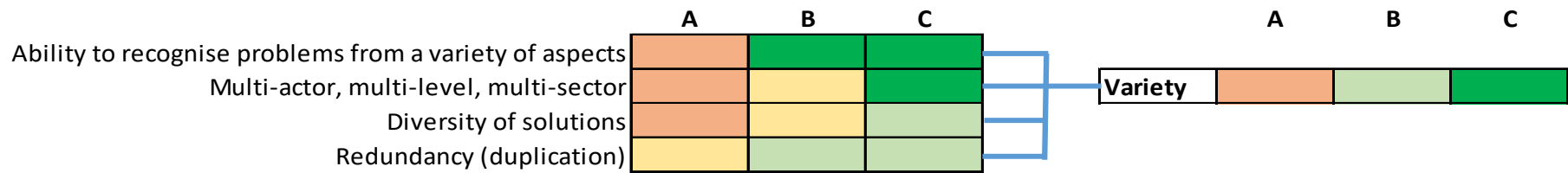


Figure 5-10. Assessment of adaptive capacity under the dimension of Variety

The assessment of *Learning Capacity* shows a similar improvement in the capacity to adapt through the time-periods as shown in

Figure 5-11. Keys et al. (2014) suggest that the implementation of adaptive capacity must be a negotiated process of social reasoning, values, politics and interplay between stakeholders. Gupta et al. (2010) argue that adaptive institutions encourage learning and questioning of assumptions and doubts. A part of the learning is the encouragement of new understanding from experiences. Reliance must be based on trust between actors and the development and use of institutional memory.

The institutional arrangements in Period A produced a long period of stable operation with well-developed institutional memory managed by relatively few people in each of the entities. However little coordination of learnings occurred across the multiple entities. Respondents perceived that for Period A, trust and single loop learning (learning from experiences) were highly developed whilst the entities had not matured in their strategic development to include double loop learning (“are we asking the correct question?”) or being able to discuss doubts or assumptions. The transition to a reduced number of new entities in Period B led to new teams derived from personnel from numerous unconnected entities, thus resulting in loss of trust and institutional memory. Respondents recorded an improvement in scores for these criteria into Period C although double loop learning remained at a low level. Overall, it was perceived that the dimension of *Learning Capacity* improved in Period C.

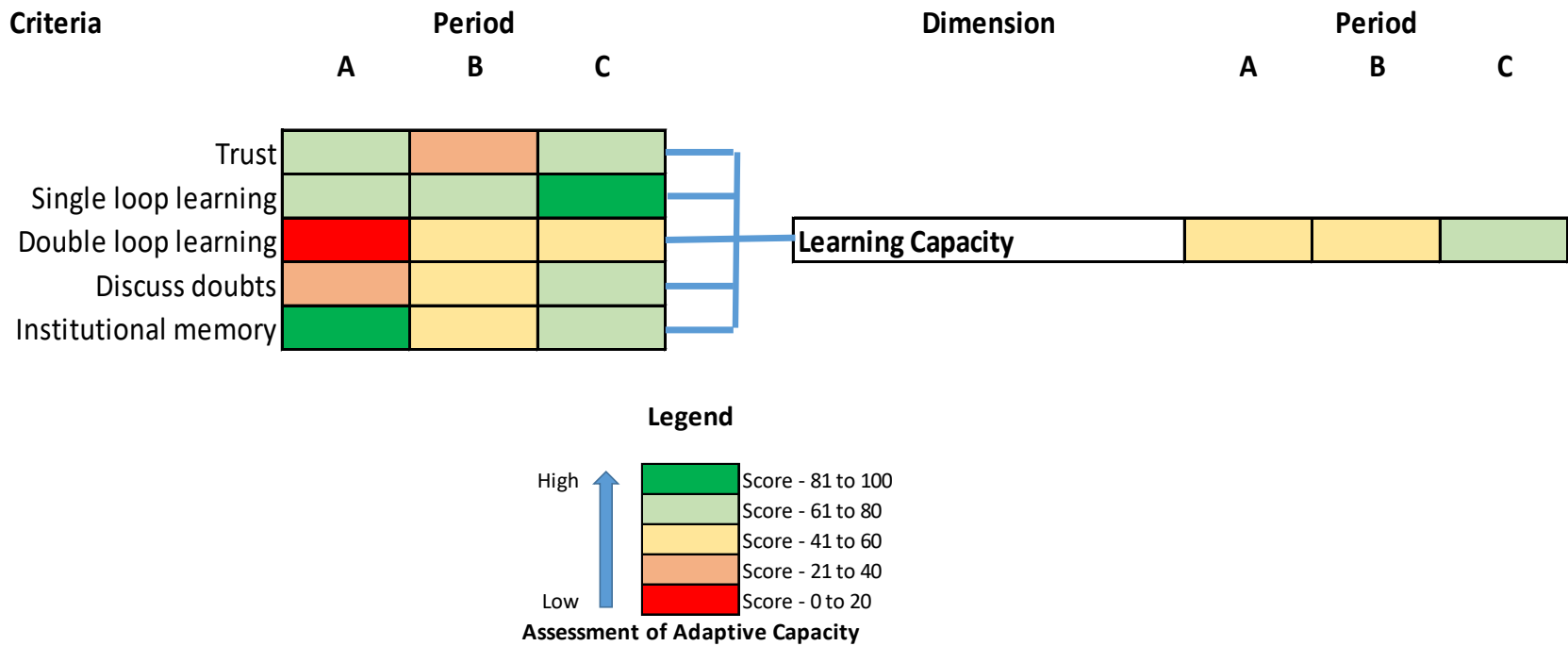


Figure 5-11. Assessment of adaptive capacity under the dimension of learning capacity

Leadership was seen by the respondents, refer Figure 5-12, as being highly developed through each period, although in the mid period, the criteria *Visionary* was observed to have a lesser score, possibly due to transitions to new institutional governance and management causing attention to be diverted away from any strategic planning or visionary actions. A comment from one of the respondents to Question 3 regarding resilience risks in Period B was: *people disruption was the big one, continued changes hampered a maturity in systems and focus on the main games. Much navel gazing and in-fighting over perceived turf wars.* Collaboration between and within entities was encouraged by expectations and regulations developed for the performance of the new businesses and is likely to be the reason for the high score under Period C.

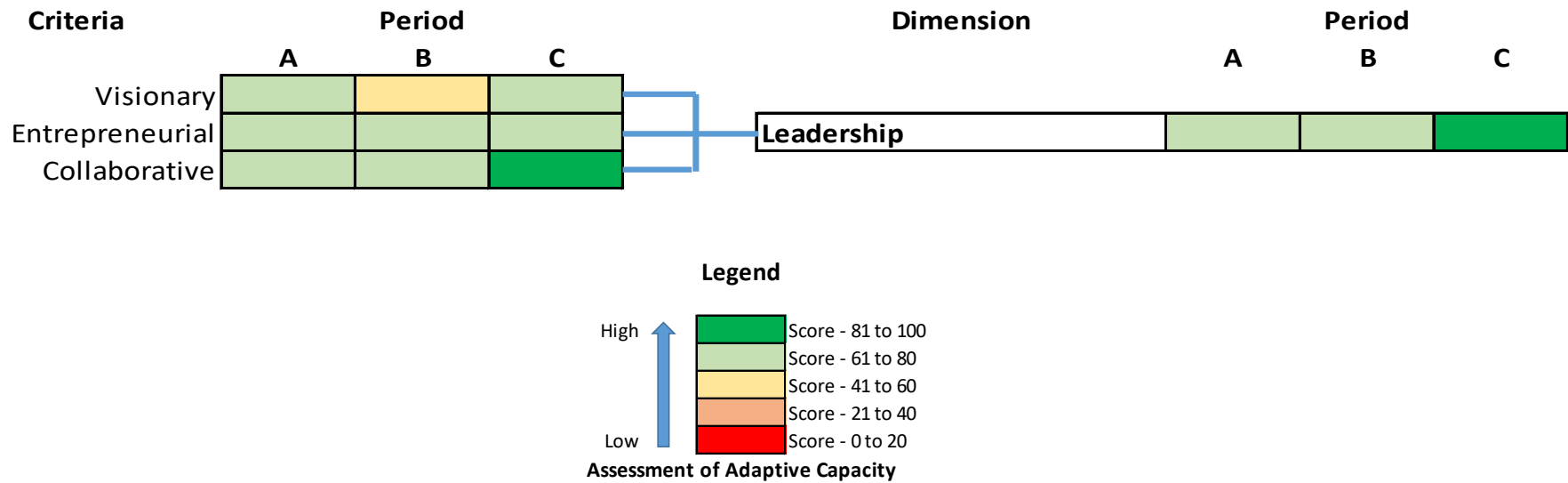


Figure 5-12. Assessment of adaptive capacity under the dimension of leadership

Gupta et al. (2010) argue that for an institution to be adaptive, the actors must have the ability to adjust their behaviours to suit the changing circumstances faced by the institution, enabling planned actions based on appropriate information and resources.

Figure 5-13 represents the perceptions of respondents regarding the dimension of *Room for Autonomous Change* over the three time-periods. In Period A, the access to information and acting according to plan were given a low score although capacity to improvise was scored reasonable highly. As under the dimension of variety, the low score might be due to the effect of the multiple businesses having no coordination or information sharing. The access to information was scored lower in Period B than in Period A, possibly due to a major realignment of businesses and systems hindering access to necessary information. The criteria of acting according to plan was highly scored in both Periods B and C, possibly due to plans for the new businesses being determined by new regulations and systems and could account for the low score for capacity to improvise in the middle years.

Figure 5-13 indicates that the criteria of acting according to plan was shown to be scored the highest in both the importance of the criteria for the development of resilience capacity and for the opportunity for the business to achieve high ability to foster adaptive capacity. Capacity to improvise was hindered during Period B when the development of governance and management in new entities was taking precedent over operational processes. Overall the scores for the dimension of *Room for Automotous Change* was shown to improve over the successive time-periods.

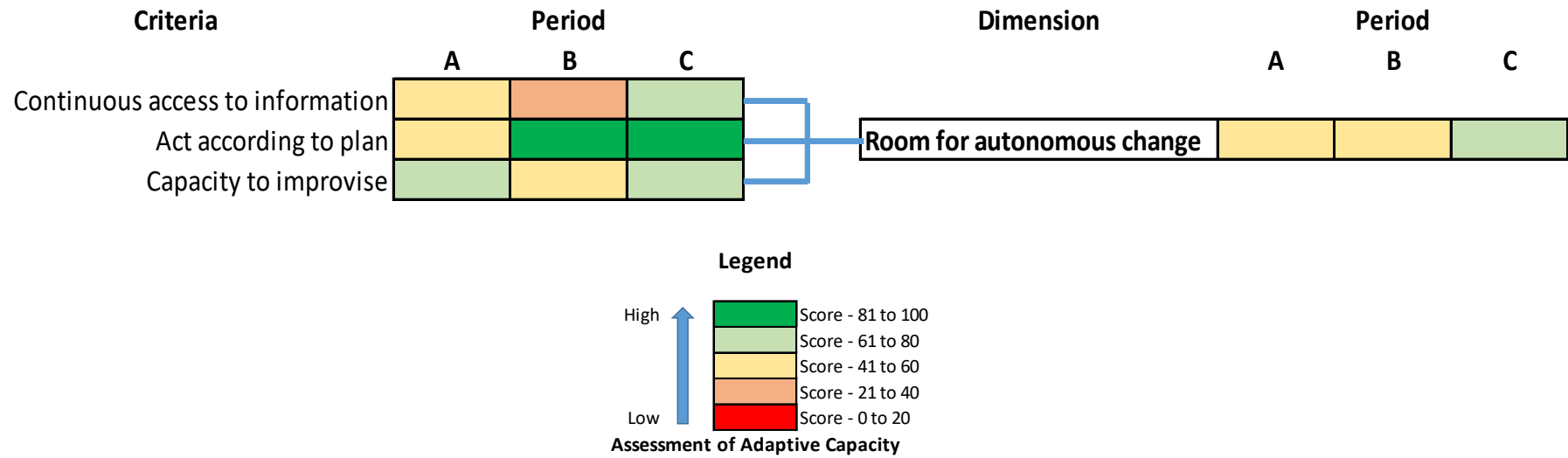


Figure 5-13. Assessment of adaptive capacity under the dimension of room for autonomous change

The dimension of *Resources* as shown in Figure 5-14 indicates a high rating for all criteria over the time-periods except for the criteria of financial resources in Period A. Respondents identifying sustainability risks at Question 3, stated that financial resources in the Period A were subject to the risk of *Council reliance on water revenue but underinvestment in infrastructure* and funds being used for *subsidisation of other council activities*. It was noted that ratings for Authority and Human Resources were lower in Period B, possibly due to the continual organisational change in the governance and management of the businesses during that period. Respondents indicated that the overall dimension of *Resources* was high for each time-period and especially so in Period C.

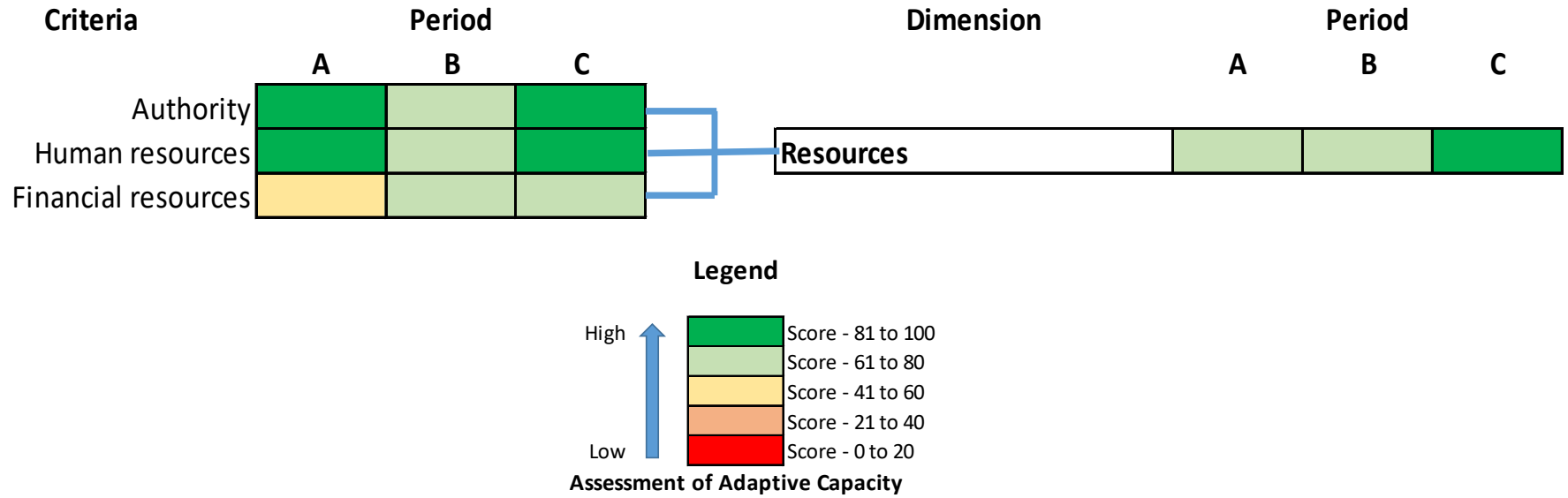


Figure 5-14. Assessment of adaptive capacity under the dimension of resources

An assessment of the dimension of *Fair Governance*, see Figure 5-15, over the three time-periods indicates that the survey participants considered the water businesses had a high ability to foster adaptive capacity except for the criteria Legitimacy during Period B. Although the businesses were owned by a number of separate and non-connected entities in the first period, local governments were seen by the community as stable and legitimate forms of entities to deliver water utility services. In the second period, the community was confused about the ownership and responsibilities of the new reconstituted businesses, particularly from the question of whether the businesses had been privatised and effectively taken out of community ownership. Risks identified by respondents for the mid time-period demonstrate the concerns about the institutional changes and apparent lack of legitimacy for fair governance, for example, statements of *institutional instability - changing water reform and local government reform and changing operating and regulatory environment leading to confusion in the roles and responsibilities outside the water sector*. After the initial business transitions into Period C, respondents perceived a return to stability and improved ability to develop adaptive capacity through legitimacy, equity responsiveness and accountability.

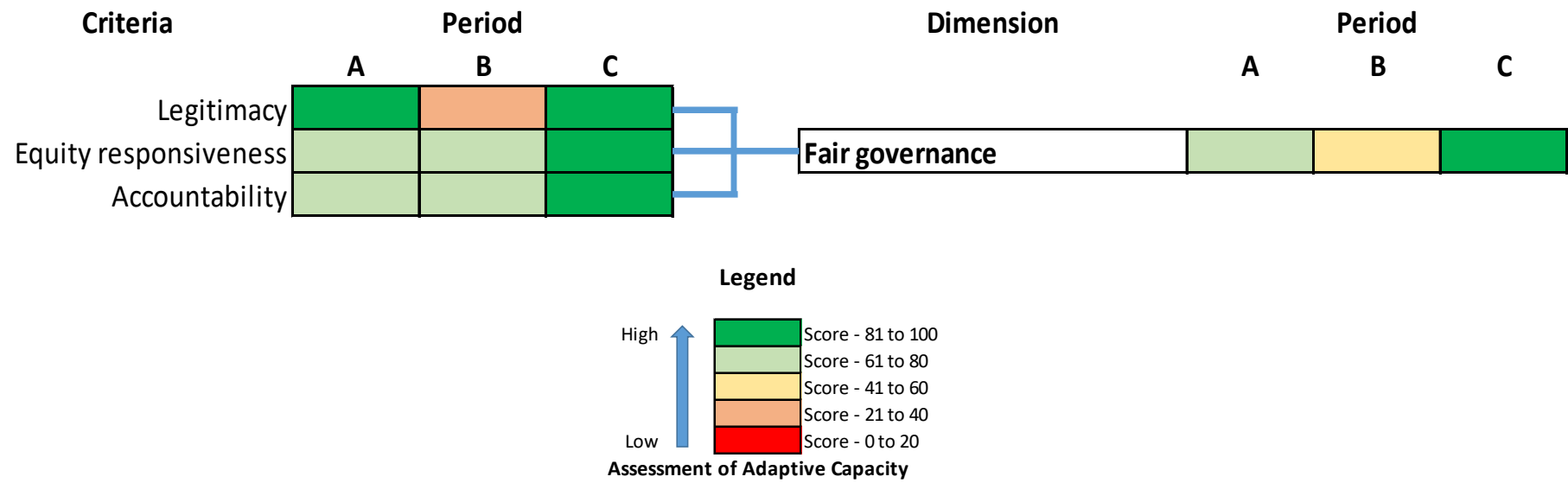


Figure 5-15. Assessment of adaptive capacity under the dimension of fair governance

Comments by one of the participants from the local government owned retail/distribution entities at the end of Question 6 summarises thoughts on some of the dimensions outlined in the question:

Variety and Learning - Under the current model the organisation benefits from a skills-based Board. This enables many different views to be gathered, viewing issues through a variety of prisms. This enhances discussion around risk to ensure those discussions are not solely asset focused but are really customer orientated. Little opportunity for full redundancy within the water industry. More important to have a measure of criticality to service and then contingency planning. Double loop learning – has been improved by a mature approach to risk and opportunity assessment and management. This commences at the Board and works down. Institutional memory is relatively short, or perhaps geographically patchy. That said the reduction in memory has produced alternative thinking, plus the patterns of customer behaviour have not returned or repeated that which was experienced pre-millennium drought. There certainly has been a change in the demand for ‘softer skills’, especially leadership that was never apparent pre-drought. This has enabled the D-Rs [Distributers-Retailers] (QUU and Unitywater) to look for positive non-regulated income opportunities, innovation and a direct customer focus instead of asset manager focus. Governance - Public support has been won, however it can be fickle. The business is in a far better position than 5 years ago, which is a tribute to those managing the messages and political interactions. Overall this might be a topic best discussed to capture the nuances of a D-R [Distributers-Retailers] when compared to a council business.

Another view from a state government participant highlights the need for effort to be applied to educate the public on: the status of the new entities; their roles and responsibilities; the aims of the businesses to provide high standards of service; and how resilience might be achieved in the event of disruptions.

SEQ water businesses have limited legitimacy with the public compared to the former council businesses. Many members of the

public still believe that the DRs [Distributors Retailers] and Seqwater are privately owned and complain regularly about the lack of accountability of senior executives and board members. There are also some indications that the DRs, in particular, have expanded beyond the economies of scale tipping point for a natural monopoly". The same participant continues with the observation that *"there has been substantial organisational turmoil in the state-owned bulk sector, with rapidly changing organisational structures, geographic relocations, and short-tenure CEOs leading to dysfunctional organisational culture at some periods.*

Another state-government based respondent suggests – *While there may be high opportunity present, it may come at a high cost (resources or effort) which may or may not be worthwhile to achieve the objective.*

Survey participants were asked to rate the importance of each of the criteria in the development of resilience capacity and rate to what extent the businesses had opportunity to foster adaptive capacity. The response to the question was by the nomination of a score from 1 to 5 for each of the criterion with 5 representing the highest importance or opportunity. Figure 5-16 illustrates the derived scores resulting from the calculation of weighted averages of the ratings given by respondents. The criterion rated most highly for both the importance of the specified criteria and the opportunity for the business to achieve high likelihood of adaptive capacity was "act according to plan" under the dimension "room for autonomous change". The questionnaire defined this criterion as "increasing the ability of individuals to act by providing plans and scripts for action, especially in case of disruption or disasters". The resultant rating suggests that respondents identified the need for planning for scenarios and strategies in the event of disruptions is a necessary action to allow the actors to be prepared for independent responsive thought in undertaking adaptive action.

The score for both the importance and opportunity to develop resilience capacity through suitable human resources having the skills and knowledge to contribute to the solving of problems likely to be encountered, received the second highest rating by the survey respondents. Risks identified in Question 1 included *retention of skilled staff and lack of IP and knowledge to support quality decision making*, thus highlighting the need for the suitable human resources to be available.

The least rating for the importance of criteria required the development of resilience capacity was given to “equity responsiveness” under the dimension of “fair governance”. This criterion was defined in the questionnaire as “whether or not institutional patterns show response to society”. The low rating given by the respondents for the importance of the criterion could possibly result from the perception that the actions would be undertaken by a regulated entity, hence not providing the ability to respond to society needs rather than institutional requirements. This criterion was also given a relatively low rating for the opportunity for the business to have the ability to foster adaptive capacity. The same observation regarding societal needs and institutional requirements might also be an explanation of the rating given. The lowest rating for the opportunity to foster adaptive capacity was nominated for “multi-actor, multi-level, multi-sector,” defined in the questionnaire as “involvement of different actors and sectors in the organisational governance”. The low rating in this instance might result from the respondent’s perception of low opportunity to achieve the criterion through the current levels of institutional maturity and management restrictions.

The discussion above identifies the high and low rating given for the criterion. The variation between the high and low ratings represents the averages of scores being in the range of mostly 3 to 4 in the scale 1 to 5 with 5 being the highest rating. Thus the differences between the perceived importance and opportunity to achieve the various dimensions are not major.

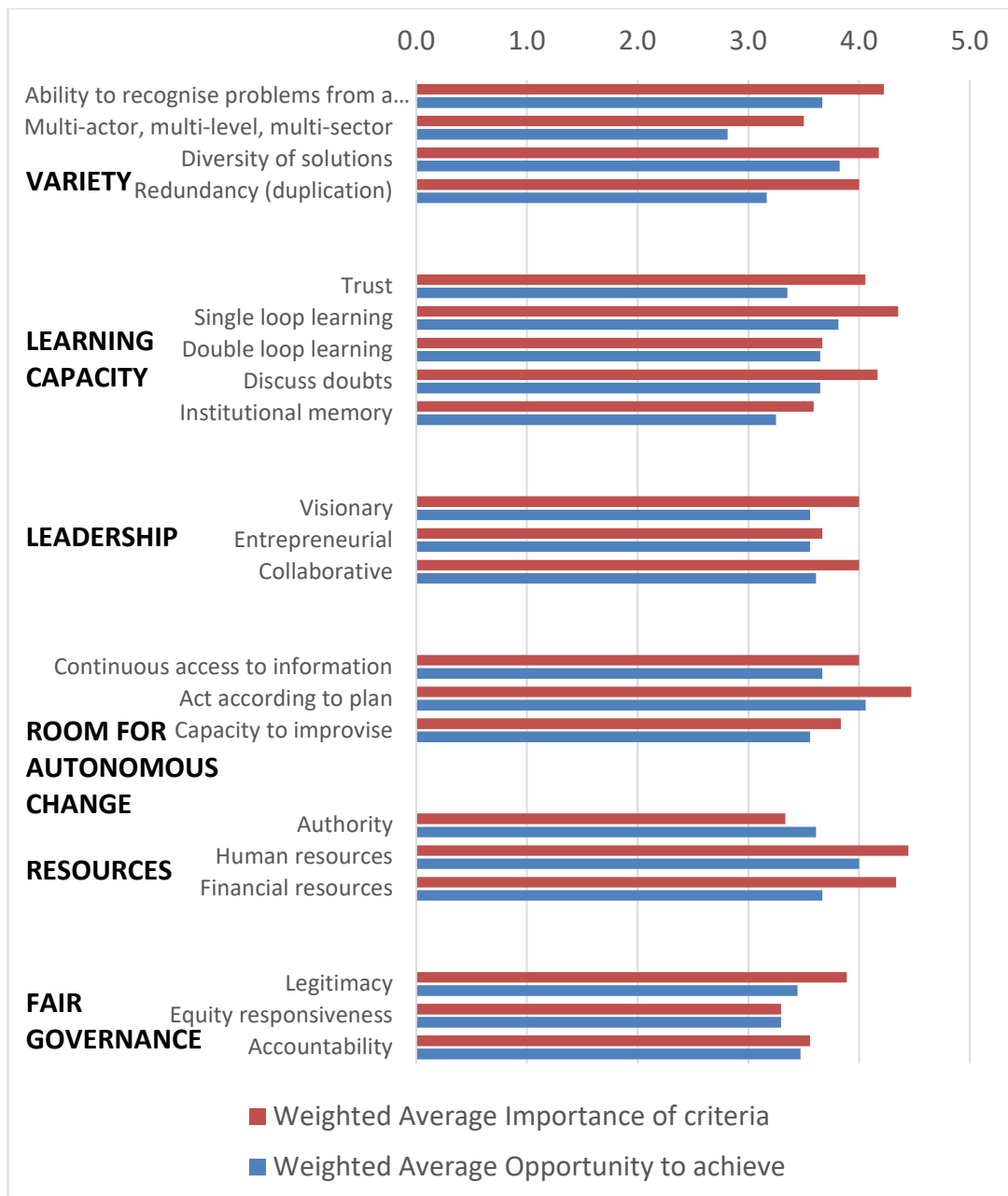


Figure 5-16. Assessment of importance of and opportunity to achieve high likelihood of adaptive capacity under specified criteria.

5.4.7 Question 7 - Identification and assessment of impact of consumer behaviours

The question aimed to evaluate the participant’s observations of the effectiveness of water demand initiatives introduced during the drought period, Period B. The question requested a score rating of 1 to 5, with a score of 5 being the highest rating of likely success for a series of nominated initiatives. The initiatives were used by all or various of the water

businesses during the drought period, Period B. Comments were also invited against each of the listed initiatives.

Figure 5-17 gives a graphical representation of the weighted average of the scores of initiatives effectiveness allocated by the survey participants to the list of demand management initiatives. Table 5-3 gives a list of the comments on the individual initiatives showing the diversity of views and responses from the participants. The figures in parenthesis at the end of each comment represent the effectiveness rating given to that initiative by the individual respondent who made the comment.

A comparison between scores given and the comments made by the respondents indicated no consistency in the perceptions of effectiveness of the initiatives and provided no definitive data for analysis. The comments provided were considered to provide a better insight into the perceived effectiveness of the initiatives rather than the numerical ratings in this case. The information given in Figure 5-17 is assembled from the responses received, although it has not been relied upon to inform the conclusions or the recommendations derived for this thesis, except from the aspect of the importance of excellent interaction with the community and other stakeholders. A more detailed survey would be recommended should an investigation into this subject be undertaken in the future.

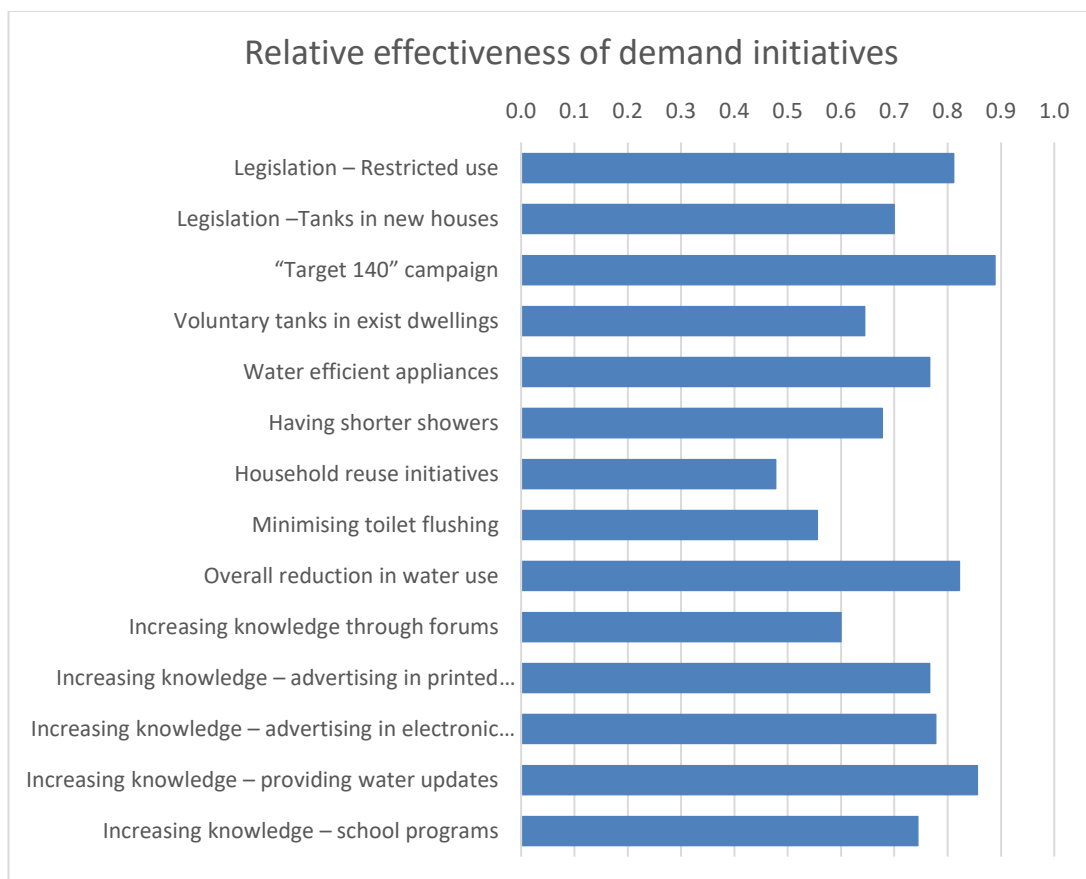


Figure 5-17. Respondents view of relative effectiveness of demand initiatives.

Table 5-3

Respondents comments on the effectiveness of the demand initiatives.

Demand reduction initiative	Comment
Legislation – Restricted use of water	<p><i>Communication and community engagement was more effective than regulation (3)</i></p> <p><i>The applications of water restrictions have led to a sustained change in societal behaviours that will likely never revert (5)</i></p> <p><i>People accepted, supported and abided by the restrictions (5)</i></p> <p><i>Ensuring powers of enforcement are available (5)</i></p> <p><i>People could see practical sense in this approach during the millennium drought (5)</i></p> <p><i>Overall, I don't believe the legislation itself made the biggest contribution to water use reduction. However, it provided a necessary 'stick' to some consumers and underpinned the "voluntary" measures that were promoted throughout the drought (e.g. provided an incentive to providers for support) (4)</i></p> <p><i>Restrictions seems only to have been useful as a companion to the Target 140 campaign. Don't believe there were more than a handful of prosecutions (if any) (1)</i></p> <p><i>Not community lead (3)</i></p>

Demand reduction initiative	Comment
Legislation – Rain water tanks in new houses	<i>Reduction of outdoor usage had major impact (4)</i>
	<i>Legislated (5)</i>
	<i>Not really effective (3)</i>
	<i>Not much traction for rainwater tanks new dwellings (1)</i>
	<i>Supported building community resilience to not only drought but future water supply disruptions (4)</i>
	<i>Mandatory requirement hence rating of 5 (5)</i>
	<i>Subsequent impacts in prolonged dry period when tanks go dry and customers switch back to the network supply (3)</i>
	<i>QDC Code was effective (5)</i>
	<i>The longevity of rain tanks needs to be addressed – ie maintenance. During drought, it provides an ‘additional’ water source and therefore doesn’t significantly reduce water use from the reticulated network. (3)</i>
	<i>Most new houses have limited outdoor watering areas (2)</i>
Promotion of “Target 140” campaign	<i>Understanding the best use for installation (4)</i>
	<i>Strong communication messages (5)</i>
	<i>Supported building community resilience to not only drought but future water supply disruptions (4)</i>
	<i>Supported the change in behaviour previously mentioned (4)</i>
	<i>People responded and supported the campaign (5)</i>
	<i>People could see practical sense in this approach during the millennium drought. (4)</i>
	<i>Unfortunately, this was extremely successful. And almost impossible to get consumption to increase to cover the debt (5)</i>
Voluntary uptake – Rain water tanks in existing dwellings	<i>Not community lead (3)</i>
	<i>The most resonant message of the drought and with specific target to be achieved gave a metric for all in society (5)</i>
	<i>Minimal incentives eg. No rebate (2)</i>
	<i>High uptake with subsidy (4)</i>
	<i>Significant take-up over \$60M in Brisbane (4)</i>
	<i>Supported building community resilience to not only drought but future water supply disruptions (4)</i>

Demand reduction initiative	Comment
Voluntary uptake – Installation of water efficient appliances	<i>Good response but I think mostly by gardeners needing an alternative source in restrictions rather than water conscious trying to make indoor use savings (3)</i>
	<i>Small lot development does not favour installation of rainwater tanks (2)</i>
	<i>The voluntary measures empowered people to feel like they were making a positive difference which, while directly may not lead to a significant water use reduction, indirectly can change lifestyle and behaviours to make significant difference (3)</i>
	<i>Although not cost-effective in strict terms, substantial reductions in outdoor watering demand for potable water (4)</i>
	<i>Initial costs were subsidised (4)</i>
	<i>Rebates provided (4)</i>
	<i>High uptake (4)</i>
	<i>Added to supporting the behavioural change, and customer taking accountability for their own water use management (3)</i>
	<i>I think subsidised plumbing service assisted with a good response (4)</i>
	<i>Free home efficiency visits assisted (3)</i>
Voluntary uptake – Having shorter showers	<i>Saw only minor evidence of prolonged adoption (3)</i>
	<i>This was made easier by manufactures and suppliers shifting to these devices as the lowest cost items on the shelf (5)</i>
	<i>As an adjunct to other measures, very effective (4)</i>
	<i>Initial costs were subsidised (4)</i>
	<i>Difficult to assess individual initiative (4)</i>
	<i>Added to supporting the behavioural change, and customer taking accountability for their own water use management (3)</i>
Voluntary uptake – Household reuse initiatives	<i>Could have been promoted more (3)</i>
	<i>This a hard one for most people but shower timers helped (3)</i>
	<i>Some of the voluntary measures sparked a lot of community conversation leading to broad scale lifestyle changes which made potentially significant difference in water use (5)</i>
	<i>A tangible reminder to be water smart in all areas of activity (4)</i>
<i>Generally accepted but unmeasurable (3)</i>	
<i>Difficult to assess individual initiative (3)</i>	

Demand reduction initiative	Comment
Voluntary uptake – Minimising toilet flushing	<i>Added to supporting the behavioural change, and customer taking accountability for their own water use management (3)</i>
	<i>Mostly informal reuse like bucketing from washing machine and shower rather than formal reuse systems (2)</i>
	<i>Costly exercise (2)</i>
	<i>Not much opportunity on a small suburban lot or in an apartment/townhouse (2)</i>
	<i>Not much saving involved (2)</i>
	<i>Generally accepted but unmeasurable (3)</i>
	<i>Difficult to assess individual initiative (3)</i>
	<i>Added to supporting the behavioural change, and customer taking accountability for their own water use management (3)</i>
	<i>Not really sure about people’s response to this – don’t think it’s a good idea though (3)</i>
	<i>Cannot recall this being actively promoted (1)</i>
Voluntary uptake – Overall reduction in water use	<i>This was made easier by manufactures and suppliers shifting to dual flush and selling at reasonable cost (4)</i>
	<i>Unfortunately, part of too little water flowing through the sewerage network to transport the solids (3)</i>
	<i>Generally accepted but unmeasurable (3)</i>
	<i>Strong evidence of results (5)</i>
	<i>Added to supporting the behavioural change, and customer taking accountability for their own water use management (3)</i>
Increasing consumer knowledge and understanding – through community forums	<i>Data shows lower per capita consumption. However, this may be related to changes in external or discretionary use (5)</i>
	<i>Water consumption remains relatively low compared to pre-2002 (4)</i>
	<i>Measured response indicated an acceptance (4)</i>
	<i>Large effort – little return (3)</i>
	<i>Less of an effective process (3)</i>
	<i>Supported driving behavioural change (3)</i>
<i>Do not recall physical community forums (1)</i>	
<i>Not sure of the reach of this approach (2)</i>	
<i>Communities have changed (and new ones exist now that didn’t before) (3)</i>	

Demand reduction initiative	Comment
	<i>People have little time to spend in community meetings. They just want action (2)</i>
	<i>Very proactive in early period of 2000 (5)</i>
Increasing consumer knowledge and understanding – advertising in printed media	<i>Newspaper distribution diminishing (2)</i>
	<i>Key elements (4)</i>
	<i>Supported driving behavioural change (3)</i>
	<i>Again, probably limited reach (2)</i>
	<i>But fewer example so printer media exist now. On line is the new communication route (3)</i>
	<i>Not effective – gets lost in advertising. People also get tired of being pounded by a depressing message through their mail box, community notice boards, local and national newspapers, etc. (2)</i>
	<i>Some confusion due to number of service providers and regional effect of drought (3)</i>
Increasing consumer knowledge and understanding – advertising in electronic media	<i>Key element of strategy (5)</i>
	<i>Electronic media not prevalent during time of the drought (1)</i>
	<i>Supported driving behavioural change (3)</i>
	<i>Maybe higher in today's society with the greater use of social media (2)</i>
	<i>Will be far more effective now (2)</i>
	<i>Some confusion due to number of service providers and regional effect of drought (3)</i>
Increasing consumer knowledge and understanding – providing regular water resources situation updates	<i>People become interested (4)</i>
	<i>Critical part of message (5)</i>
	<i>Supported driving behavioural change (3)</i>
	<i>Regular water usage and overall dam levels and communicated well (4)</i>
	<i>I think the reporting of dam levels was very influential (4)</i>
	<i>Context is important – talking about return periods is difficult and generalising with a regional percentage of capacity available risks a north v south debate (3)</i>
	<i>This is most effective on TV news. Particularly when they show cracking mud and dead fish...under a blazing sun (5)</i>
	<i>A stark contrast to messaging in Canberra, which had most retail businesses displaying their exemption from restrictions (5)</i>

Demand reduction initiative	Comment
Increasing consumer knowledge and understanding – providing school programs interaction	<p data-bbox="576 286 983 313"><i>Strong commitment and campaign (4)</i></p> <p data-bbox="576 349 1193 405"><i>Imagery of low water levels and impacts was a lasting impression whether through print or electronic media (5)</i></p> <p data-bbox="576 441 1171 468"><i>Works well and should be formalised and continued (4)</i></p> <p data-bbox="576 504 858 530"><i>General reinforcement (3)</i></p> <p data-bbox="576 566 1251 651"><i>By far the best avenue is through building behaviours through younger generations who then support changing behaviours in older generations. (4)</i></p> <p data-bbox="576 687 1059 714"><i>Some limited advice, knowledge provided (2)</i></p> <p data-bbox="576 750 1262 777"><i>Has some longer lasting impacts and messages go home too (4)</i></p> <p data-bbox="576 813 1198 869"><i>Children are often effective in modifying the behaviour of parents and other adults. (4)</i></p> <p data-bbox="576 904 1267 990"><i>Existed prior to drought and still continues today. Would be one of the longest running programs and commitments to educating the next generation (5)</i></p>

5.5 SUMMARY

The findings from the survey provided a pivotal set of data for the research. The survey was structured to provide observations of risk, uncertainty, potentially disruptive events, adaptive capacity and opinions on the likely success of water demand initiatives. The expert opinions and commentary provided by the respondents enabled an understanding of the impacts of the initial disruptive events resulting from occurrences external to the businesses. The comments from the respondents also included descriptions of impacts from business disruption resulting from remedial actions imposed by new government policy and legislation. Responses to the questions from both State and Local Government based representatives provided the opportunity to compare perceived priorities of managers from the two responsible government sectors. The comments from state government participants tended to be biased towards a legislative and authoritative focus whilst those from local government emphasised items relating to issues imposed by the higher level of government, such as institutional reforms, together with those relating to the management of water distribution assets and community services. Some migration of participants from one level of government to the other during the time-periods and

structural reforms had some effect of normalising the responses. Having knowledge of the varied subject interests between the groups guides consideration of options to be followed by regulators and businesses in establishing capacity to be adaptive to the disruptive events.

During the Period A, the state-government representatives had the role of regulator while local-government was responsible for system operations and management. In Periods B and C, the local-governments continued as operators/managers, although with considerably different business structures, whilst the state-government continued as regulator and expanded their responsibility to be the resource manager and bulk water provider.

Chapter 6 Discussion of key findings

6.1 INTRODUCTION

The analysis and discussion regarding urban water businesses achieving a state of being resilient to disruptions is based on the understanding of applicable definitions of key concepts outlined in Section 2.2, the critical review of research literature and the analysis of the learnings from the Case Study and Survey Questionnaire. A review of the data from the case study and survey has been used to test the arguments proposed by authors from the critical review of literature and has enabled the preparation of a summary of characteristics required for urban water businesses to achieve adaptive capacity when faced with disruptive events.

The definition of *Resilience* is stated in different forms depending on the application being debated, as outlined in Section 2.2.3. In the context of urban water businesses, the statements of long term viability, reliability, sustainability, security or resilience are often mixed or confused (Brown & Williams, 2015). The definition of resilience for this study was adapted from that published by Ofwat (2015) and states: “Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability to enable the maintenance of services for people and protect the natural environment, now and in the future”, see Section 2.2.3. In the context of urban water businesses, the reaction to a disruption is one of being capable of reorganisation or having the ability to “bounce back” from an adverse situation, thus suggesting the need for a dynamic reaction. For each application, a limiting condition of acceptable degradation of parameters exists, beyond which recovery is not possible without some change of elementary structure. The inherent characteristics for a resilient system are learning, flexibility and being adaptive (Sharpe, 2016). By contrast, sustainability infers all elements are in balance, and for an urban water business, relates to the maintenance of its financial viability whilst meeting all environmental and social obligations and having the resources and assets to provide the agreed standards of service to its stakeholders, see Figure 2-3.

Achieving the characteristics to be considered resilient suggests also as a prerequisite, a state of sustainability. However, sustainability does not infer resilience. Sustainability, see Section 2.2.4 and Figure 2-3, has the features of all elements being in

balance and having the ability to remain in that state. Sustainability requires the technical, social and financial resources operating in harmony for a given outcome. Resilience requires the additional characteristics to enable adaption to disruptions, to “bounce back”, or to reorganise. In a business sense, the enabling characteristics must be provided by the culture of the organisation driven by the governance, management and social strategies. Without the characteristics for adaptivity being available to transition to a state of resilience, the business can be sustainable, although not necessarily capable of withstanding a disruption.

6.2 DISRUPTION AND ADAPTIVE CAPACITY

A discussion describing opportunities and mechanisms for achieving adaptive capacity was included in Section 2.3.3 where the concept of “bridges and barriers” was defined by Hill Clarvis and Engle (2015), with examples of a number of common barriers to adaptation processes as: “challenges in uncertainty and fragmentation of decision-making and information on disrupting influences; lack of resources and leadership; institutional management challenges; and contrasting risk perceptions and values”. Examples of such barriers to the ability to adapt were observed in the case study and survey as outlined in the text and listed in Table 6-1.

Consideration of the disruptions to the SEQ region in the case study and particularly to the water businesses in the early 2000s, reveals a willingness at a technical level to have collaboration between the various governing authorities at two levels of government as a positive bridge to achieving adaption. However, the same collaboration was not available at a political level and decision-making interaction with the community was minimal.

Table 6-1. *Barriers to adaptive capacity in SEQ at time of population and drought disruptions in the early 2000s.*

Barriers to adaptive capacity	Section Ref	Discussion and survey quotations
The region was serviced by numerous disparate systems of governance and management	4.2 5.4.1 5.4.3	“Each of the 17 separate LGAs had the responsibility to plan, manage and operate treatment, storage and delivery infrastructure to suit the demands of their individual communities.”
No common leadership or common ownership of the problem	5.4.1	“common agreement on the problems was difficult” “no coordinated planning across SEQ”

Barriers to adaptive capacity	Section Ref	Discussion and survey quotations
No sharing of knowledge	5.4.1	“internal focus – not wider region co-operation”
No common forward planning strategies	4.7 4.8	“the SEQ Regional Framework for Growth Management, 1995 (Regional Coordination Committee, 1995) was published as the first non-statutory regional plan for SEQ.” Early water planning commenced in 1999 had lapsed. “the SEQ 2021 Project requested in 2000 that work to produce a water supply regional plan be re-initiated.”
Lack of collaboration and trust	4.7	“Successive changes in governments, political representatives and policies, priorities and ineffective commitment to the process, resulted in a loss of trust between state and local governments”
Lack of leadership	4.7	“Regular changes in regional planning ministers and thus regional coordination committee chairs have created a perceived lack of leadership”
Lack of broad stakeholder interaction	4.7	“Concerns were raised by the community that growth in residential development was out of control.” The community concerns were a much-needed catalyst for the commencement for the problem to be addressed.

The primary disruptions to the SEQ region resulted from extreme climate changes and greater than expected population growth. Both impacted the businesses’ ability to continue to deliver expected standards of service to the stakeholders in the region. Each of the disruptive factors impacted areas of the region to a greater or lesser extent and at varying times.

Turnquist and Vugrin (2013) demonstrated that consideration of the relationship between resilience enhancing investments made prior to or post disruption jointly informs the decision-making process to identify a strategy best suited to the system being analysed. With reference to the discussion in Section 2.4 “The relationship between sustainability and resilience”, and in the context of urban water supply, it can be argued that investment in preparation of strategies tested by scenario analysis of uncertainties can provide the business with capacity to adapt to identified disruptions. As observed in the case study Sections 4.7 and 4.8, no investment had been made to test uncertainties or assumptions to prepare for impacts possible from extreme events such as from high population growth or extreme drought. No regional urban or water supply strategic planning had been completed prior to the impacts being experienced in the early 2000s. Reactions to the impacts were initiated under a program of urgent decision making without the assistance

of tested base knowledge. The remedial actions introduced significant institutional change throughout the region as described in Section 4.10, as well as requiring major expenditure on infrastructure development to be undertaken as an urgent response. Section 4.5 describes how raw water resources of parts of the SEQ region were not initially impacted by drought conditions and could have been described as being sustainable at that time. However, as the drought progressed, the impact became region wide and options available to counter the effects could not be taken in some areas in isolation and hence had to be performed in a coordinated manner across the region. Drought conditions progressed to having precipitation significantly less than in recent history and the climate induced uncertainty increased to extreme. Without the benefit of investment in strategic planning, uncertainties with the potential to influence the long-term development had not been identified or addressed.

Rather than relying on numerous disconnected small LGA water providers, the State Government took a more responsible role and a regional approach was initiated. New water businesses were created with changed governance and management roles and responsibilities. The business structural changes brought about secondary disruption through administrative and social uncertainties. Survey respondents highlighted that water business personnel were diverted from their core tasks and instead were occupied in responding to demands from new organisational and regulatory structures rather than undertaking governance and management operational tasks to deliver services to the consumers, see Section 5.4.3. The actions taken were essential to repair a system failure, beyond what could be considered as a simple reorganisation or “bouncing back after the disruption”. Thus, the SEQ urban water businesses could not be considered sustainable nor resilient.

6.3 SURVEY RESPONDENT’S VIEW OF INSTITUTIONAL REFORM

The Queensland state government was under pressure to mitigate the impacts of the drought and new legislation was progressively promulgated to introduce institutional reform and to regulate the operation of new water supply entities. The period from 2004 to 2013 witnessed continual legislation and regulatory change resulting in further disruption to the governance and management of the water businesses, see Figure 4-9 and Figure 5-1. Responses from survey participants show in Section 5.4.2, that the highest risks of occurrence of disruption in the businesses were continued climate uncertainty,

further institutional change and the absence of suitable long-term planning and resource development strategies. From their experience over the case study period, the survey respondents identified risks impacting on the sustainability of the businesses as discussed in Section 5.4.1. Similar themes continued in Section 5.4.3 discussing the ability to be adaptive leading to resilience. The primary themes were:

- Water resources – uncertain reliability and capacity to supply
- Lack of governance / management / skills
- Instability – institutional change, political intervention, unsuitable organisational structures
- Non-strategic decisions – lack of strategic planning, reactive responses leading to ad hoc decision making

The responses to the questions for sustainability and resilience risks covered the same themes and demonstrated that the understanding of the definitions of sustainability and resilience might be mixed. Although not specifically sought in the survey, responses and comments indicate that the perception of the participants could suggest that the SEQ urban water supply businesses could not be considered to be sustainable over the time-periods considered in the survey.

Arguments in Section 2.3.2 to consider characteristics to differentiate the understanding of sustainability compared to having the capacity to adapt have been discussed by authors Gupta et al. (2010); Brown and Williams (2015); Sharpe (2016). In fostering adaptive capacity in urban water supply businesses, Agnew and Woodhouse (2010) argue that while science and technology are necessary, they are insufficient on their own as they do not have the capacity to manage uncertainties that arise from economic and social matters. Keys et al. (2014) concluded in their research that “the major issue impacting adaptive capacity is not the availability of physical resources but the dominant social, political and institutional culture of the region”.

Survey participants were requested to indicate their perceptions of the display of the nominated adaptive characteristics as displayed by the SEQ water businesses over the three time-periods of institutional reform displayed in Figure 5-1. The responses as shown in Figure 5-9 provide a view of the perceived achievement of adaptive capacity for each of the criteria nominated. The colour coded scores indicate that the survey respondents considered significant progress towards adaptive capacity had occurred as a result of the reforms over the time-periods. However, the overall assessment indicates further

progression of some characteristics is required for the urban water supply businesses to achieve adaptive capacity and to be deemed resilient.

6.4 TRANSITION FROM BUSINESS SUSTAINABILITY TO RESILIENCE

An evaluation of the barriers constraining adaptive capacity outlined in Table 6-1 and the Question 6 responses and comments, see Section 5.4.6, together with the arguments expressed by authors from the literature reviews, has set a framework for the development of characteristics needed to transition a sustainable urban water business to one having resilience to disruptive events. As suggested by Agnew and Woodhouse (2010), the attributes for a sustainable water business are necessarily technically dependant, whilst the characteristics for adaptability are primarily socially and culturally focused.

The resources needed for sustainability of an urban water supply business are optimal physical and financial assets together with well trained and knowledgeable human resources operating with good governance and management systems in a stable business environment. The sustainable business is able to provide its stakeholders with an agreed standard of service to align with expected operational conditions.

To enable the business to transition to one having adaptive capacity and the ability to achieve resilience to disruptive events, additional characteristics are required to react to uncertainties as promoted by authors such as Gupta et al. (2010); Brown and Williams (2015); Sharpe (2016). The reference authors argue that adaptive concepts can be derived from an institutional or social culture or behaviour to include: “learning, trust, capacity to change, collaborative, entrepreneurial, visionary and ability to improvise”.

Figure 6-1 has been derived from the characteristics promoted by the above authors and from observations from the case study and responses to the survey, particularly in relation to the identification of risks impacting the achievement of sustainability and resilience and the responses to Question 6 - Identification and assessment of adaptive capacity within the business. Figure 6-1 describes the characteristics to enable a sustainable urban water supply business to transition to one having the capacity to be dynamic and have the tools and capability available to react to disruptive events.

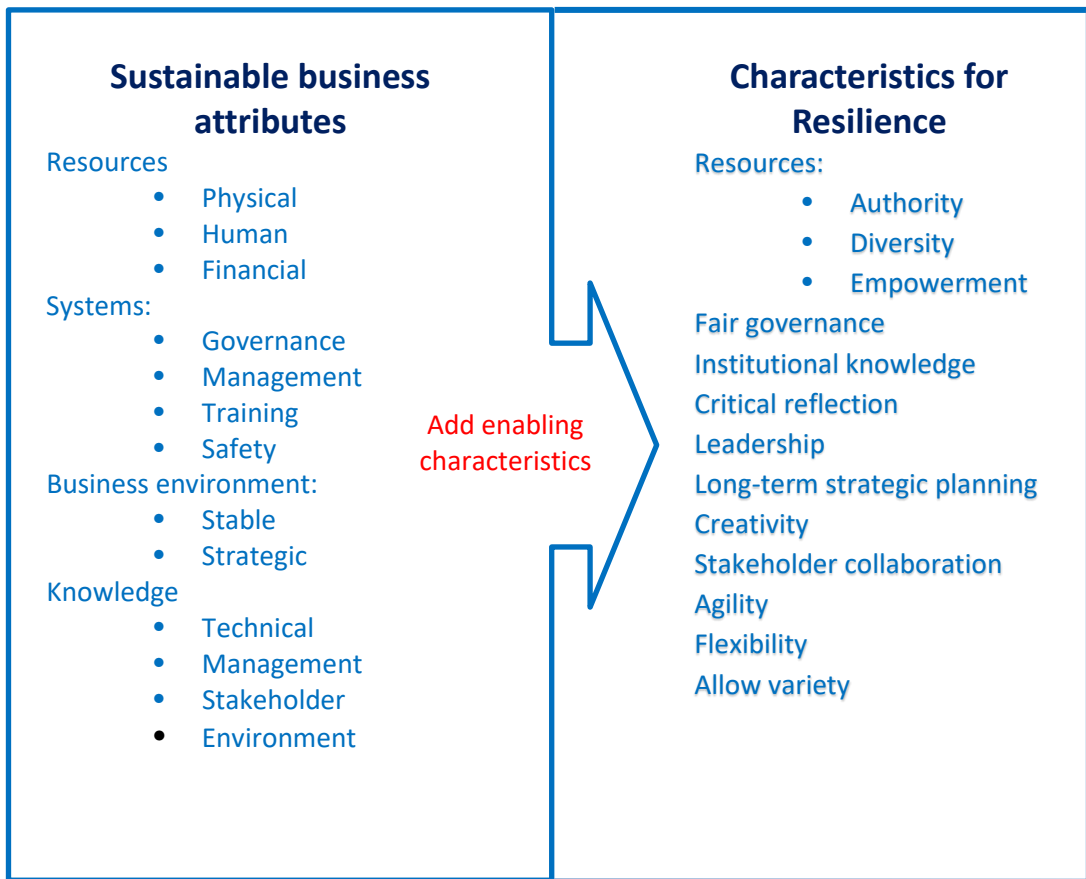


Figure 6-1. Characteristics required to take sustainable water business to a resilient state

6.5 DEMAND MANAGEMENT THROUGH BEHAVIOURAL CHANGE

An important aspect of the reaction tactics to control the drought impact in SEQ was management of consumer demand. Question 7 of the study survey see Section 5.4.7, explores the success of various demand management strategies adopted during the drought period. The initiatives could be categorised as: regulation, behaviour modification and physical.

Survey respondents considered that the imposition of restriction on use of water, while being partially successful, needs to be underpinned by an understanding by the consumers of the reasons behind the restrictions, as discussed in Section 5.4.7. As suggested by Jorgensen et al. (2009), development of consumer's trust of the reasons being used for the imposition of the restricted water use is an important factor that is useful in the development of effective water demand strategies. In SEQ, the critical need for demand reduction was conveyed through various forms of media, particularly the highly

successful “Target 140” campaign, (Queensland Water Commission, 2007), which fostered consumer understanding and trust of the information being conveyed. An opinion from a survey respondent stated, *continuous reporting of results against target gave the community a sense of ownership*. The campaign aimed to reduce urban water consumption to 140 L/p/d. QWC stated an achievement of a reduction down to 126 L/p/d. Reference to Figure 5-17 shows that survey respondents judged the “Target 140” campaign the most successful of all demand management initiatives. From the survey, opinions of usefulness of the different media forms for conveying the messages tended towards favouring electronic methods where images of severely drought effected locations and low water storage areas were graphically displayed.

The onset of drought over extensive areas of eastern Australia promoted the introduction of nation-wide scheme for the identification of water-use efficiency in domestic appliances with each state introducing their own Act (Queensland Government, 2005). The *Water Efficiency Labelling and Standards (Queensland) Act 2005* required mandatory efficiency labelling of appliances but options for purchase and use of appliances was still the consumer’s choice, although for a period of time, a government rebate was available to encourage the purchase of efficient appliances. A rebate was also provided to offset the cost of the installation of rainwater tanks, available for external use water or for toilet flushing and laundries (The Minister for Natural Resources Mines and Energy and Minister for Trade (Mr Robertson), 2009). The installation of rainwater tanks was mandatory for all new dwellings in the SEQ region from early 2005 until the end of 2012, whilst rainwater storage tanks could be installed voluntarily at existing dwellings at a subsidised cost. Respondents from the survey reported a good uptake of opportunities for the installation of rainwater tanks. The rapid rate of installation of rainwater tanks did not continue after the completion of the time for rebates. Syme et al. (2000) and some respondents from the survey, question whether the resulting consumer response is motivated by reasons of conservation of water as good responsible citizens, or for securing an alternative independent household supply for their benefit. Blackmore and Plant (2008) observed that consumers will only influence changes which are in the best interest of their family or their immediate environs.

Research was undertaken to establish the behavioural water usage patterns by a selected sample of rainwater tank owners, both those who had mandated tanks in new dwellings and those who had undertaken voluntary installations (Coombes, 2012; Gardiner, 2009; Gardiner, Gardner, & Skoien, 2008; Gardner et al., 2013). Behavioural

patterns of use by the two groups and by age groups were found to vary with no conclusive patterns.

The behavioural change of consumers through the variety of initiatives to reduce water demand led to a reduction of consumption by an average domestic dwelling from 300 L/p/d at the beginning of the drought (Department of Natural Resources and Mines, 2004), to 126 L/p/d through the Target 140 campaign (Queensland Water Commission, 2007). The reduced consumption was generally maintained for almost a decade through to the beginning of 2017. Less than average rainfall was experienced through the summer, autumn and winter of 2017 causing significant drawdown in raw water storages to a level near the first alert to be given under the drought response plan recently established by Seqwater (2017c). Domestic water consumption increased to an average of over 200L/p/d, prompting Seqwater (2017b) to begin community awareness messages of an impending demand control period. Early spring rainfall over most of the region provided minor runoff into some storages and delayed the initiation of drought response activities.

The urban water businesses had been comfortable with the prolonged reduction in demand and apparent maintenance of consumer behaviour. Fielding et al. (2013) found that if the regulation interventions cease and there are no environmental or contextual cues for water scarcity, water usage will eventually return to previous levels. SEQ consumers were beginning to observe water scarcity cues and the behavioural changes established during the “drought campaigns” were beginning to reverse. The long-term effects of some of the previous initiatives such as water efficient appliances and installation of rain-water tanks might have had a long-term mitigating effect although the latter needs to be qualified. In the 2017 period, the below average rainfall was causing the storage in the rain-water tanks installed during the drought to be depleted. This might result in consumers substituting reticulated potable water for the loss of availability of stored rainwater for their individual uses. Rather than changing their water use behaviour to reduce consumption, those consumers might be exacerbating the trend of increasing per person average consumption and the stress on the raw water supplies across the region during rainfall deficiencies. Kahneman and Tversky (1979) noted that people are more sensitive to what they lose, in this case the loss of availability of rainwater storage for various household uses. The tendency to substitute the loss of stored water with reticulated supply might then be adopted rather than consider the resulting impact (additional cost or adverse impact on the community water availability) from the substitution of the reticulated source. New research to document behaviour patterns to compare with those

of the earlier research (Coombes, 2012; Gardiner, 2009; Gardiner et al., 2008; Gardner et al., 2013) would be beneficial data for the understanding of value derived from the imposed installation of rainwater tanks as a strategy to offset the use of reticulated potable water in periods of rainfall deficiency. Whilst the installation of domestic rainwater tanks, both mandated and voluntarily, might be of benefit during average rainfall periods when all water storages are replenished, consumer behaviour patterns might negate those benefits in times of rainfall deficiency. The establishment of long-term behavioural trends building on the initial data would inform consideration of outcomes from significant uncertainties.

Chapter 7 Conclusions and recommendation for future research

7.1 KEY FINDINGS

This study developed an understanding of the characteristics required for an urban water supply business to be resilient against disruptive events. The terms: water security, reliability, sustainability and others are often confused with the description of resilience, which by definition, is a state of being adaptive and able to “bounce back” or to be reorganised, providing the system has not been taken beyond the point of failure. As demonstrated in Section 2.4 a pre-requisite for the achievement of resilience is sustainability. Dictionary definitions for *Sustainability* are: “to make or allow something to continue for a period of time” and “able to be maintained at a certain rate or level”. See Section 2.2.4. The state of being sustainable implies balance, equilibrium. Common usage of *Sustainability* now recognises the three pillars of sustainability as Social, Environmental and Economic, with the three-pillars being in balance and having the interdependence of overlapping of the sectors, see Figure 2-3. Being sustainable does not imply having resilience, however sustainability is a prerequisite for resilience.

The definition of *Resilience* for this study has been adapted from the water industry body Ofwat (2015) as “Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability to enable the maintenance of services for people and protect the natural environment, now and in the future”. See Section 2.2.3. In the context of urban water businesses, the reaction to a disruption is one of being capable of reorganisation or having the ability to “bounce back” from an adverse situation, thus suggesting a dynamic reaction.

Sustainability requires the technical, social and financial resources operating in harmony for a given outcome. Resilience requires the additional social and cultural characteristics to enable adaption to disruptions, to “bounce back”, or to reorganise.

A sustainable water supply business needs long-term strategic plans to guide the continuing sustainability. The Ofwat (2015) definition of resilience identifies “anticipate trends and variability” as part of the criteria. To transition a sustainable business to one having resilience to overcome uncertainties and disruption, water supply businesses need

the flexibility to identify uncertainties in association with their strategic goals to enable creative assessment of possible impacts that can be considered through scenario analysis. The progression from sustainability to resilience requires the addition of social and cultural characteristics to develop institutional knowledge, critical reflection, learning, creativity, collaboration and fair governance. Investment in the analysis of uncertainties guided by long term strategic planning is necessary to understand possible reaction scenarios for responding to disruptive events. Pre-disruption investment of this type can ensure planned technical solutions are prudent and efficient to enable best value solutions to deliver the desired standards of service to the stakeholders.

The outcomes of disruptions to urban water businesses impact directly on the stakeholders, especially the consumers. Actions to provide adaptive capacity to counter the disruption must include and understand community desires and behaviours. Any proposed behaviour modifications need to be approached through the establishment of the community's trust in the messages being promoted by the water business. Results from the case study survey indicate that successful messaging can promote a sense of community ownership of the initiative. Community inclusion in development of solutions is an essential component of adaptive capacity for urban water businesses.

7.2 STUDY RECOMMENDATIONS

The analysis and key findings from the literature review, case study and survey have established a set of characteristics and actions required to enable an urban water supply business to become resilient to disruptive events. The recommendations that follow respond to the study questions, aims and study objective stated in Sections 1.3 and 1.4. As sustainability is a prerequisite for a water business to become adaptive and achieve resilience, recommendation "a" is the first priority to allow the remaining recommendations to realise the full opportunity for the businesses to become resilient.

Recommendations:

- a. The water supply business attains sustainability, recognising the three pillars of Economic, Social and Environmental and delivers the desired standards of service to its stakeholders.
- b. The business governance and management group lead a culture of empowering continuous learning, establishment of trust and collaboration,

critical reflection, capacity to change, adopting creative solutions, being visionary and having the ability to improvise.

- c. The business governance and management group lead processes for the establishment of strategic goals with analysis of uncertainties through scenario testing to establish institutional knowledge for informed management of possible disruptive events.
- d. The business governance and management group develop collaborative relationships with stakeholders and customers to create understanding and trust of the initiatives promoted to effectively manage available water resources. The relationships need to encourage and recognise stakeholder input to the development of resource management initiatives.

7.3 RECOMMENDATION FOR FURTHER RESEARCH

This study has discussed water demand initiatives adopted by the urban water businesses reviewed in the case study. Likely consumer behaviour in response to water demand management initiatives can create a significant uncertainty for urban water supply business. Little research considering long-term usage patterns spanning over a number of successive climatic seasons has been recorded. A significant uncertainty for urban water businesses is the understanding of consumer's behaviour in response to the need for reductions in water demand from the reticulation systems in times of rainfall deficit.

Initiatives adopted during the drought period in the early 2000s in the SEQ region were a combination of regulation, behaviour modification and physical. The physical initiatives refer to the requirement for water efficient domestic appliances and business equipment which are planned to result in long term reductions in water usage. Installation of rainwater tanks was adopted as another physical initiative intended to be an additional or alternative water source. However, rainwater tank storage is subject to having sufficient rainfall to replenish the supplies and hence are advantageous in "normal" or better rainfall periods. Regulation and behaviour modification require social interaction to achieve a water demand reduction, often as a short-term reaction to adverse climatic conditions. Prior understanding of the likely community response to water use demand measures by regulation or calls for consumer restraint is uncertain. Characteristics identified to foster adaptive capacity leading to resilience include continuous learning and attainment of knowledge to overcome uncertainties.

A research project is recommended to review the consumer's behavioural patterns through the seasonal rainfall variations experienced in SEQ from the drought period up to late 2017 and their response to the consequential availability of rainwater for their household use. The scope of the project would include the differentiation of behavioural patterns and consumer's aspirations between those householders with either mandated or voluntary installations.

Various research projects undertaken during the early 2000s drought period could provide a suitable base for new research into the understanding of consumer behaviour through periods of drought, plentiful rainfall and a return to sparse rainfall as occurred to the end of 2017 in the SEQ region. A critical review of the long-term effectiveness of initiatives introducing alternative water sources to reduce demand from urban reticulation during the critical early 2000s period would add value to the understanding of suitable demand management options.

Section 6.5 discusses the circumstances around the installation of household rainwater storage tanks as mitigation measures during the times of extreme rainfall deficiency in SEQ. Case studies of consumer behaviour were undertaken during and immediately following the drought period when replenishing rainfall occurred.

Further research into the continued behavioural patterns when reduced rainfall caused depletion of the stored water in rainwater tanks could reveal if the consumers then reverted to an increased draw on the reticulated supplies to replace flows previously being available from the storage tanks, thus exacerbating the overall increase in system water demand. The significance of the behavioural pattern would depend on the historic uptake of rainwater tank installation opportunities across a region. In SEQ, the installation of rainwater tanks for new houses was mandated for the period of early 2005 to the end of 2012 and subsidised voluntary installation in existing dwellings was promoted during the same period.

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Appendix A

Questions for the semi-structured survey

Survey Questions in relation to a research study entitled:

EVALUATION OF THE CHARACTERISTICS REQUIRED FOR A RESILIENT URBAN WATER BUSINESS

Research Problem: The research problem relates to the establishment of best practice methods to enable urban water supply businesses to develop adaptive capacity to remain sustainable and to enable resilience to disrupting influences. The adaptive capacity must be developed in a challenging environment of high stakeholder expectations and business regulation.

The scope of the research is restricted to urban water provision and does not include collection, treatment or reuse of wastewater.

A case study has been included in the scope of the research and the urban water businesses of South East Queensland (SEQ) have been adopted as being appropriate in this instance.

The survey questions are framed to assess the state of the businesses in the timeframes of:

- a. Time period (a): Prior to the onset of the “millennium drought” – prior to 2002
- b. Time period (b): After initial intervention by ownership and legislation changes together with the completion of augmentation of infrastructure and resources – 2003 to end of 2011.
- c. Time period (c): Current day business structures and resources - after beginning of 2012.

For some questions, the survey participant will be requested to respond from knowledge and observation of the overall SEQ businesses and additionally from a position of employment or influence in a particular SEQ water business. Participants might have employment history in different

businesses in relation to the three time-periods. It is also recognised that some businesses have not been in existence for each period. Please respond from the aspect of your knowledge and experience during the most relevant time periods in each case.

You are encouraged to add extension or clarification comments for each question.

Question 1a. Identification of Sustainability Risks. *Response from participant’s knowledge and/or observation of overall SEQ businesses.*

List top three risks, in order of importance, within all SEQ urban water businesses relating to achieving the continuing sustainability of the businesses.

	Risks relevant to achieving Sustainability At period (a)	Risks relevant to achieving Sustainability At period (b)	Risks relevant to achieving Sustainability At period (c)
1			
2			
3			

Comments:

Question 1b. Identification of Sustainability Risks. *Response from participant's position of employment or influence in a particular SEQ water business.*

List top three risks, in order of importance, within your SEQ urban water business relating to achieving the continuing sustainability of the business.

	Risks relevant to achieving Sustainability At period (a)	Risks relevant to achieving Sustainability At period (b)	Risks relevant to achieving Sustainability At period (c)
1			
2			
3			

Comments:

Question 2. Identification of potential extreme disruptive events. *Response from participant's knowledge and observation of overall SEQ businesses.*

List top three extreme events, in order of importance, with the potential to cause major disruption to SEQ urban water businesses.

	Potential extreme disruptive events At period (a)	Potential extreme disruptive events At period (b)	Potential extreme disruptive events At period (c)
1			
2			
3			

Comments:

Question 3a. Identification of Resilience Risks. *Response from participant's knowledge and observation of overall SEQ businesses.*

List top three risks emanating from the events in Question 2, in order of importance, with the potential to cause major disruption to SEQ urban water businesses.

	Risks relevant to achieving capacity to be Resilient At period (a)	Risks relevant to achieving capacity to be Resilient At period (b)	Risks relevant to achieving capacity to be Resilient At period (c)
1			
2			
3			

Comments:

Question 3b. Identification of Resilience Risks. *Response from participant's position of employment or influence in a particular SEQ water business.*

List top five risks emanating from the events in Question 2, in order of importance, with the potential to cause major disruption to your SEQ urban water business.

	Risks relevant to achieving capacity to be Resilient At period (a)	Risks relevant to achieving capacity to be Resilient At period (b)	Risks relevant to achieving capacity to be Resilient At period (c)
1			
2			
3			

Comments:

Question 4. Identification of business uncertainties from external influences. *In this question the impacts are seen as a result of external influences i.e. not under the direct control of the business. Response from participant's position of employment or influence in a SEQ water business*

Apply numerical rating of importance for the items causing a risk to the business and a rating of opportunity potential for responding to the resultant uncertainty. Rate as 1 to 5 with the highest risk or opportunity scoring 5. A third column requires an assessment of the confidence rating (High, Medium, Low) in the business being able to forecast impacts and apply suitable adaptive responses to the disruptive events i.e. being resilient to those events.

Business uncertainties caused by external influences	Numerical Risk Rating of uncertainty 1 to 5	Numerical rating for response opportunity 1 to 5	Ability to apply adequate adaptive response (H, M or L)
Climate – Drought			
Climate – Flood			
Climate – Bushfires			
Unplanned or unexpected population trends or movements			
Consumer demand outside planned forecasts (e.g. climate induced?)			
Legislation / regulation changes			
Ownership / Governance changes			
Failure of other utility provider services (e.g. energy)			
Other-----			

Comments:

Question 5. Identification of internal business risks and opportunities *Response from participant's position of employment or influence in a SEO water business.*

Apply numerical rating of importance for the items causing a risk to the business and a rating of opportunity potential for responding to the resultant uncertainty. Rate as 1 to 5 with the highest risk or opportunity scoring 5. A third column requires an assessment of the confidence rating (High, Medium, Low) in the business being able to forecast impacts and apply suitable adaptive responses to the disruptive events i.e. having resilient to those events.

Internal business risk/opportunity	Numerical Risk Rating 1 to 5	Numerical rating for opportunity to respond to risk 1 to 5	Ability to apply adequate response to opportunity (H, M or L)
System assets – available capacity			
System assets – operational flexibility			
System assets – reliability			
Sustainable long term strategic asset management planning			
Sustainable levels of service			
Control of system consumer demand			
Finance – security of income			
Finance – debt affordability			
Finance – sustainable long term investment strategy			
Skills availability			
System and business knowledge			
Optimum Governance system			
Optimum business and staff culture			
Stakeholder acceptance of levels of service			
Compliance with legislation and regulation			
Other:			

Comments:

Question 6. Identification and assessment of adaptive capacity within the business. *Response from participant's position of employment or influence in a SEQ water business.*

Various researchers have argued that the ability of a water supply business to adapt to and manage disruptive events can be achieved by a combination of technical, economic and social measures. Gupta et al. (2010) have proposed that institutions need to analyse their inherent characteristics to empower social participants to respond to short and long-term impacts either through planned measures or through allowing and encouraging creative responses from society. Sharpe (2016) argues that to engender adaptive capacity and achieve the ability to be resilient, systems and functions must reflect learning, flexibility to experiment and adopt novel solutions to broad classes of challenges.

The aim of this question is to test the propositions as they might apply to the SEQ businesses, with the assessment of the business culture and the adaptive capacity under six headings: *variety, learning capacity, room for autonomous change, leadership, resources and fair governance* as outlined by Gupta et al. (2010). Your answers will assist in informing an understanding of the importance of the criteria and their contribution to development of resilience to disruptive events in the water businesses. The answers relative to the time periods will assist in the understanding and assessment of the cultural aspects of the organisations' progression through the disruptive events.

Dimension	Criteria	Definition	Is this criterion present in business? Time period (a) <i>Y or N</i>	Is this criterion present in business? Time period (b) <i>Y or N</i>	Is this criterion present in business? Time period (c) <i>Y or N</i>	Importance of this criteria to development of resilience capacity. <i>Score 1 to 5</i>	Opportunity for business to achieve high likelihood of adaptive capacity. <i>Score 1 to 5</i>
Variety	Ability to recognise problems from a variety of aspects	Room for multiple frames of references, opinions and problem definitions.					
	Multi-actor, multi-level, multi-sector	Involvement of different actors and sectors in the organisational governance.					
	Diversity of solutions	Availability of wide range of different policy options to tackle a problem					
	Redundancy (duplication)	Presence of overlapping measures and back-up systems; not cost effective?					

Dimension	Criteria	Definition	Is this criterion present in business? Time period (a) <i>Y or N</i>	Is this criterion present in business? Time period (b) <i>Y or N</i>	Is this criterion present in business? Time period (c) <i>Y or N</i>	Importance of this criteria to development of resilience capacity. <i>Score 1 to 5</i>	Opportunity for business to achieve high likelihood of adaptive capacity. <i>Score 1 to 5</i>
Learning capacity	Trust	Presence of institutional patterns that promote mutual respect and trust					
	Single loop learning	Ability of institution to learn from past experiences and improve its routines					
	Double loop learning	Evidence of flexibility and changes in assumptions underlying institutional patterns					
	Discuss doubts	Institutional openness towards uncertainties					
Leadership	Visionary	Room for long term visions and reformist leaders					

Dimension	Criteria	Definition	Is this criterion present in business? Time period (a) Y or N	Is this criterion present in business? Time period (b) Y or N	Is this criterion present in business? Time period (c) Y or N	Importance of this criteria to development of resilience capacity. Score 1 to 5	Opportunity for business to achieve high likelihood of adaptive capacity. Score 1 to 5
	Entrepreneurial	Room for leaders that stimulate actions and undertakings, leadership by example					
	Collaborative	Room for leaders who encourage collaboration between different actors; adaptive co-management					
Room for autonomous change	Continuous access to information	Accessibility of data within institutional memory and early warning systems to individuals					
	Act according to plan	Increasing the ability of individuals to act by providing plans and scripts for action, especially in case of disruptions or disasters					

Dimension	Criteria	Definition	Is this criterion present in business? Time period (a) Y or N	Is this criterion present in business? Time period (b) Y or N	Is this criterion present in business? Time period (c) Y or N	Importance of this criteria to development of resilience capacity. Score 1 to 5	Opportunity for business to achieve high likelihood of adaptive capacity. Score 1 to 5
	Capacity to improvise	Increasing the capacity of individuals to self-organise and innovate; foster social capital.					
Resources	Authority	Provision of accepted or legitimate forms of power; whether or not institutional rules are imbedded in constitutional laws - empowerment					
	Human resources	Availability of expertise, knowledge and human labour					
	Financial resources	Availability of financial resources to support policy measures and financial incentives.					
Fair Governance	Legitimacy	Whether there is public support for a specific institution					

Dimension	Criteria	Definition	Is this criterion present in business? Time period (a) <i>Y or N</i>	Is this criterion present in business? Time period (b) <i>Y or N</i>	Is this criterion present in business? Time period (c) <i>Y or N</i>	Importance of this criteria to development of resilience capacity. <i>Score 1 to 5</i>	Opportunity for business to achieve high likelihood of adaptive capacity. <i>Score 1 to 5</i>
	Equity responsiveness	Whether or not institutional patterns show response to society					
	Accountability	Whether or not institutional patterns provide accountability procedures					

Comments:

Question 7. Identification and assessment of impact of consumer behaviours. *Response from participant's position of employment or influence in a SEQ water business or from general observation from involvement in this industry sector.*

This section is aiming to explore the impact of consumer behaviours relating to water demand reduction during the drought period. The scores are to evaluate your observation of consumers' responses to initiatives introduced by the State Government and water businesses. The score ratings are to be 1 to 5 with a rating of 5 being the highest rating of success for that initiative. Comments regarding these initiatives are welcomed.

Demand reduction imitative	Success rating for imitative 1 to 5	Comments
Legislation – Restricted use of water		
Legislation – Rain water tanks in new houses		
Promotion of “Target 140” campaign		
Voluntary uptake – Rain water tanks in existing dwellings		
Voluntary uptake – Installation of water efficient appliances		
Voluntary uptake – Having shorter showers		
Voluntary uptake – Household reuse initiatives		
Voluntary uptake – Minimising toilet flushing		
Voluntary uptake – Overall reduction in water use		
Increasing consumer knowledge and understanding – through community forums		
Increasing consumer knowledge and understanding – advertising in printed media		
Increasing consumer knowledge and understanding – advertising in electronic media		

Increasing consumer knowledge and understanding – providing regular water resources situation updates		
Increasing consumer knowledge and understanding – providing school programs interaction		

Definitions:

The geographical area for the case study is that covered by the Local Governments of Brisbane, Gold Coast, Ipswich, Lockyer, Logan, Moreton Bay, Noosa, Redland, Scenic Rim, Somerset and Sunshine Coast.

Definitions in the context of the study:

Sustainable development – *“development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”* (Report of the World Commission on Environment and Development: Our Common Future, 1987)

Resilience - *“resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment, now and in the future.”* (Ofwat, 2015)

Appendix B

QUT Ethics Approval Number 1600001216

Dear Prof Ashantha Goonetilleke and Mr Graham Thomsen

Project Title: Evaluation of the characteristics required for a resilient urban water business

Ethics Category: Human - Low Risk

Approval Number: 1600001216

Approved Until: 20/06/2019

(subject to receipt of satisfactory progress reports)

We are pleased to advise that your application has been reviewed and confirmed as meeting the requirements of the National Statement on Ethical Conduct in Human Research.

I can therefore confirm that your application is APPROVED.

If you require a formal approval certificate please advise via reply email.

CONDITIONS OF APPROVAL

Please ensure you and all other team members read through and understand all UHREC conditions of approval prior to commencing any data collection:

- > Standard: <http://www.orei.qut.edu.au/human/manage/conditions.jsp>
- > Specific: None apply

Decisions related to low risk ethical review are subject to ratification at the next available UHREC meeting. You will only be contacted again in relation to this matter if UHREC raises any additional questions or concerns.

Whilst the data collection of your project has received QUT ethical clearance, the decision to commence and authority to commence may be dependent on factors beyond the remit of the QUT ethics review process. For example, your research may need ethics clearance from other organisations or permissions from other organisations to access staff. Therefore the proposed data collection should not commence until you have satisfied these

requirements.

Please don't hesitate to contact us if you have any queries.

We wish you all the best with your research.

Kind regards

Janette Lamb / Debbie Smith

on behalf of Chair UHREC

Office of Research Ethics & Integrity

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<http://www.orei.qut.edu.au>



PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT
– Survey –

**Evaluation of the Characteristics required for
a Resilient Urban Water Business**

QUT Ethics Approval Number 1600001216

RESEARCH TEAM

Principal Researcher:	Graham Thomsen Research Student	Masters
Associate Researchers:	Professor Ashantha Goonetilleke Supervisor Dr Timothy Rose Supervisor	Principal Associate

**Science and Engineering
Faculty
Queensland University of Technology (QUT)**

DESCRIPTION

This project is being undertaken as part of a Masters by Research Study by Graham Thomsen

The purpose of this project is to provide a contribution to knowledge and understanding of governance and management methods to secure social and individual wellbeing through the provision of urban water services which are affordable, meet service expectations and are resilient to disruptive events. Adaptive capacity has to be developed by urban water supply businesses in a challenging environment of high stakeholder expectations and business regulation.

The research will include a Case Study of the impacts and outcomes of extreme climatic conditions prevailing in the south-eastern area of Queensland (SEQ) in the early to mid-2000s.

As you belong to a group of officers and stakeholders who had significant contribution to the governance and management of the Local and State Government owned SEQ urban water businesses operating prior to the disruptive events through to those involved in the current business ownership structures, you are invited to participate in this project to share your experience, knowledge and information regarding planning, financing, servicing expectations of stakeholders, legal aspects and system operation.

PARTICIPATION

Participation will involve completing a structured and confidential survey with Likert scale answers (rating from 1 to 5 in scale of importance) that will take approximately 30 minutes of your time.

Questions are expected to include:

- (a) List top three risks, in order of importance, within SEQ urban water businesses relating to achieving the continuing sustainability of the businesses.
- (b) Apply numerical rating of importance for the items (8 items listed) causing a risk to the business and a rating of opportunity potential for responding to the resultant uncertainty. Rate as 1 to 5 with the highest risk or opportunity scoring 5. A third column requires an assessment of the confidence rating (High, Medium, Low) in the business being able to forecast impacts and apply suitable adaptive responses to the disruptive events i.e. being resilient to those events.
- (c) This section is aiming to explore the impact of consumer behaviours relating to water demand reduction during the drought period. The scores are to evaluate the consumers' responses to initiatives (14 initiatives listed) introduced by the State Government and water businesses. The score ratings are to be 1 to 5 with a rating of 5 being the highest rating of success for that initiative. Comments regarding these initiatives are welcomed.

Although a response to each question or part is desirable, it is not obligatory as it is recognised that participants might not have had involvement with the subject water business sector over the total period covered by the survey.

Your participation in this project is entirely voluntary. If you agree to participate you do not have to complete any question you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT. If you do agree to participate you can withdraw from the project during your participation without comment or penalty. Any identifiable information already obtained from you will be destroyed. However, as the survey is anonymous, once it has been submitted it will be expected that your non-identifiable responses can be used in the research. All communication with you will be on a negotiated and agreed basis regarding method and timing. Data handling and storage processes will be established to ensure that you cannot be identified.

At the completion of the sector of the research, feedback along with the research results in the form of an executive summary will be offered to you. The summary will include the aggregated results of data collected from the survey in order to share the knowledge.

EXPECTED BENEFITS

It is expected that this project will not provide a direct individual benefit. However, the research is designed to have an industry benefit to assist with the understanding of how water supply businesses can develop adaptive capacity to remain sustainable and to

have the ability to be resilient to disrupting influences, such as drought, in a challenging environment of high stakeholder expectations and business regulation. The research will contribute to knowledge and understanding of governance and management strategies for all urban water supply businesses in the provision of reliable and safe water services to secure continued social and individual wellbeing for the communities they serve.

RISKS

Your participation in this project will not subject you to risks beyond those encountered in your day to day routine, other than possible inconvenience. The risk of inconvenience to you will be minimised by allowing you to nominate the location and timing for the response to the survey. All communications will be on a negotiated and agreed basis.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated as anonymous and will be confidential unless required by law. The names or affiliations of individual persons are not required in any of the responses.

Any data collected as part of this project will be stored securely in accordance with QUT's Management of Research Data policy.

Please note that non-identifiable data from this project may be used as comparative data in future projects or stored on an open access database for secondary analysis.

CONSENT TO PARTICIPATE

The return of the completed survey is accepted as an indication of your consent to participate in this project.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If you have any questions or require further information, please contact one of the researchers listed below.

Graham Thomsen	graham.thomsen@hdr.qut.edu.au	0411 776 958
Ashantha Goonetilleke	a.goonetilleke@qut.edu.au	07 3138 1539

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Advisory Team on 07 3138 5123 or email humenethics@qut.edu.au. The QUT Research Ethics Advisory Team is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Appendix C

Individual responses to survey questions

The responses listed below are direct quotations from the participants. No corrections have been made to grammar or spelling.

Question 1 Sustainability Risks - Survey participant's responses

Theme	Period A	Period B	Period C
Financial impacts	Affordability – budget cycles – Short horizons max 5 years	Funding constraints	Growth management - long term water security uncertainty
	Pricing was not fully linked to service or cost in all entities	Funding infrastructure for population growth	Funding constraints
	Council reliance on water revenue but underinvestment in infrastructure	Affordability – long term financial commitment (50-year commitment)	Limited access to resources and budget, affordability of water to the community, return on investment
	Subsidisation of other council activities	Market-based model implemented for non-market businesses	Financial sustainability – bulk water charge
	Pressure to keep costs down	Significant investment decisions made with water price impacts way beyond (likely) drought period	Contrast between variable price structure and fixed cost structure
	Cost efficiency and effectiveness of service delivery	Economic viability of region	Debt servicing vs revenue limiting the ability to invest in assets and business systems
		Loss of revenue (consumption reduction) with increased operating costs (bulk water pricing)	Financial sustainability in the form of certainty of income for a business that can occasionally ask its customers to

Theme	Period A	Period B	Period C
		<p>Pressure to keep costs down</p> <p>Separation of decisions of drought response and customer bill impacts</p>	<p>use less of its product thereby reducing its revenue</p> <p>Recovery of Drought Infrastructure Investment</p> <p>Pressure to keep costs down Cost to Customer is the highest risk to the present model of bulk supply, distribution and retail water supply services. While the distribution retail services are managing to reduce the cost to serve the bulk supply price is rising. Given the cost of living is increasing and utility costs are a significant proportion of these costs, water utilities must be structured financially to realise decreases in the cost to serve to be sustainable into the future.</p> <p>Fixed costs of manufactured water assets vs revenue</p> <p>Seqwater - Debt structure is the worst of any water business in the country. Adequate capital should have been</p>

Theme	Period A	Period B	Period C
Management of climate impacts	<p>State Government did not recognise the seriousness of the drought conditions</p> <p>Not looking at potential risks (e.g. only look at historical records not considering worse than historical)</p> <p>Reactive approach to drought circumstances</p>	<p>Water supply security (drought management) - investment decisions</p> <p>Drought and lack of water security planning</p> <p>Reactive approach to drought circumstances</p> <p>Ability to deal with drought</p>	<p>provided to the organisation to prevent huge interest bills.</p>
Management of assets	<p>Management of assets</p> <p>Ageing infrastructure – reliability, renewals</p> <p>Funding constraints</p>	<p>Managing and maintaining ageing infrastructure</p> <p>Low level of captured IP and asset information</p> <p>Transition of ageing and somewhat disparate infrastructure and systems, and the implementation of risk controls</p>	<p>Continued loss of IP and systems through rapid industry amalgamation process</p> <p>Corporate procurement has constrained capital, operational and maintenance procurement options.</p>
Governance and management	<p>The water entities of SEQ were owned by around a dozen councils and State</p>	<p>The SEQ industry structure spread responsibilities and liabilities through</p>	<p>Open to private sector water providers without proper regulation in place.</p>

Theme	Period A	Period B	Period C
Government departments, so common agreement on the problems difficult.	unworkable organisational structures and ‘contractual arrangements’.	Delays in ability to standardise business processes and systems	
Local councils operating as sole entities in managing water	Duplication of corporate and management structures within the bulk water industry	Complex operational and regulatory environment as a statutory authority (eg Council Shareholders, State Government, Water Commission, Grid Manager, DEWS)	
Internal focus – not wider region co-operation	Lack of alignment between commercial operating expectations and government ownership/stakeholder/shareholder	Separation of bulk and retail operations	
Water only one of Councils’ concerns – difficult to get necessary executive attention	Complex and top heavy bulk water industry structure	Different agenda between State and Council manifesting in relationship between Seqwater and Distributor/Retailers	
		SEQ businesses not working together for common good	
		Government lack of focus on water policy issues in the absence of public interest	
		Tension between utility focus on water provision versus natural resource/environmental management focus	

Theme	Period A	Period B	Period C
Lack of forward planning	<p data-bbox="443 759 920 863">Lack of long term planning (political cycles 3 years not planning cycles 20 years plus)</p> <p data-bbox="443 906 904 1046">Assignment of responsibility for planning and delivery of bulk water supply (lack of focus/priority by the State Government)</p> <p data-bbox="443 1090 920 1121">No coordinated planning across SEQ</p> <p data-bbox="443 1165 943 1382">Continuity and Reliability of Supply – Prior to 2002 the assignment of responsibility for planning and delivery of adequate bulk treated water supply at State Government was not effective and this caused significant</p>		<p data-bbox="1518 427 1973 491">Competition – emerging alternative service providers</p> <p data-bbox="1518 534 1973 715">Supply chain disruptions across the SEQ water sector due to multiple agency asset operation and management and external interdependencies</p> <p data-bbox="1518 759 1995 791">Continuity and Reliability of Supply.</p> <p data-bbox="1518 834 2029 1121">Rapidly growing population is increasing demand on existing raw water sources. The SEQ Water Security Plan indicates how supply will be augmented but implementation is not clear. Risk remains high until detailed infrastructure plans are developed and adopted by the State Government.</p> <p data-bbox="1518 1165 2029 1230">Greenfield development - as opposed to infill to increase connection/km density</p>

Theme	Period A	Period B	Period C
Consumers / demand	<p>uncertainty for local government water businesses in planning and delivery of adequate supply for future populations</p> <p>Customer expectations</p> <p>Lack of public awareness regarding water conservation</p>		Stakeholder expectations in regards to minimising price increases
Water source management		<p>Continuity and Reliability of Supply. During this period water supply security planning was evolving at State Government (regional) level and in the earlier years rapid roll-out of infrastructure was occurring with low and rapidly declining storage levels. There was risk that water storages may fail and desalination as a source of water would not be delivered in time to maintain basic levels of service.</p>	
Source diversity		<p>Diversity of supply – belief of traditional sources</p> <p>Poor community and stakeholder engagement about recycled water use in the drinking water cycle.</p>	Community acceptance of drought infrastructure (built assets – Western corridor & desal)

Theme	Period A	Period B	Period C
Government intervention / institutional change		<p>Transitional Arrangements: This focus on institutional arrangements distracted people and diverted scarce resources from core business of delivering safe and reliable services. This combined with local government amalgamations in 2008 was a significant risk to water business sustainability from 2006.</p> <p>Government intervention</p> <p>The SEQ industry structure spread responsibilities and liabilities through unworkable organisational structures and ‘contractual arrangements’.</p> <p>Institutional instability - changing water reform and local government reform</p> <p>Changing operating and regulatory environment leading to confusion in the roles and responsibilities outside the water sector</p> <p>Political instability and unpredictability (further water institutional reform)</p>	<p>Continuing institutional uncertainty (confused role as Local Government/ Local Government Water Service</p> <p>Provider and SEQ Distributor/Retailer</p> <p>Continuing institutional uncertainty/ unsustainable long term model</p> <p>Government intervention</p> <p>Political interference</p> <p>Institutional Change</p> <p>Continuing institutional uncertainty/ unsustainable long term model</p> <p>State Government Water Reform still initially bedding in</p> <p>Degree of concern with the potential politic interference when reaching decisions</p>

Theme	Period A	Period B	Period C
Skills availability		<p>The intervention was sold on the basis of less confusion (less players involved) however the initial model resulted in a whole different range of confusion and inefficiency both at state govt level and local government level. The politics involved again produced sub optimal outcomes</p>	<p>Changes of government between political parties. differences in policy position cause a three-yearly redirection especially on things like the desal and western corridor assets.</p>
		Retention of skilled staff	Operational expertise and knowledge of new assets, still reliant on 3rd resources
		Aging workforce	Key staff / knowledge loss during business transition
		Workforce insecurity	Lack of IP and knowledge to support quality decision making
		The new entities had insufficient experienced senior managers.	Reliance on external service contractors
	<p>Again the people risk over this period was manifested in new businesses were established, peoples careers severely impacted, and the industry is still going through the shake out of these decisions. All this happened while there were council restructures, mining boom, drought, fluoride, floods. Some</p>		

Theme	Period A	Period B	Period C
Population growth	Growth - lack of water security (regional water strategy)	Increasing Population	people thrived but many were displaced many times
Community attitudes			Inelastic customer behaviour Community perceived value of water Community knowledge and acceptance of alternate water sources including recycled water
Water quality			Water Quality: a. The power to manage water supply catchments is effectively in the provisions of town planning schemes which are administered by local governments with competing priorities. b. Impacts on raw water quality by flooding remains a high risk for SEQ until Mount Crosby WTPs are upgraded. (Somerset and Wivenhoe Dams being the major supply sources and Mount Crosby treating water from these sources.)

Theme	Period A	Period B	Period C
			<p data-bbox="1518 387 1980 456">Water Quality – maintaining a good quality product to customers</p> <p data-bbox="1518 496 2011 935">Water Quality Disinfection residual remains a significant issue particularly in water supplied from the water grid into distribution networks. Age and disinfection residual at offtakes is critical to the cost of maintaining safe water quality at the extremities of the distribution networks. Significant expenditure is needed to address this problem and the level of necessary expenditure may not be affordable to Seqwater.</p> <p data-bbox="1518 975 2018 1267">Seqwater – lack of ability to influence planning in SEQ. nor formal powers were handed to the organisation as part of the restructure. We don't have protected drinking water catchments, we don't have referral or compliance powers to prevent inappropriate use of the drinking water catchments</p>

Question 2. Disruptive events - Survey participant's responses

Where identified events were essentially the same or near the same wording, for example “drought” or “local drought” only one instance has been listed in the table.

Theme	Period A	Period B	Period C
Non-acceptance of water pricing	Water & Wastewater billing (user pays)	Qld Water Commission – attempting to transfer electricity experience to water	Affordability – water bills – community & political influence
	Significant economic contraction causes customers inability to pay their bills	Economic disruption Economic growth	Significant economic contraction causes customers inability to pay their bills and income shrinks
	Draconian political Price regulation		Price shock
	Water business commercialisation		Politicised Price regulation for all SEQ water entities Collapse of national electricity market model Water price
Unexpected climatic events	Extreme weather events (drought/flood)	Extreme weather events (drought/flood)	Extreme weather events (drought/flood)
	Drought: Drought was a major risk because of the low level of inter-connectivity of water supply sources.	Long term regional drought Major flood, bush fire or extreme weather event	Drought Until climate independent water sources are established at an affordable lifecycle cost the

Theme	Period A	Period B	Period C
Hence, individual water supply schemes were vulnerable to localised drought conditions	Long term regional drought	Disruption to water supply (water quality or operational issue)	sustainability of present water supply businesses is at risk.
Major flood, bush fire or extreme weather event	Weather events / storms	Legislative change	Local and regional drought
Flood: Flood was a constant risk because of the impact on raw water quality. WTPs had been in operation for decades and were configured with conventional treatment processes that have limited capacity to treat highly turbid waters that flow from catchments disturbed by erosion and/or bushfire.	Cyclones (Destructive Winds) In the later part of last century many reservoirs were constructed with roofs that were vulnerable to damage by cyclonic winds which was a major risk	Local drought	Flood
		Flood	
		Earthquake	

Theme	Period A	Period B	Period C
	<p>to treated water quality supplied to the customer.</p> <p>Local Drought</p> <p>Flood</p>		
Major infrastructure failure	<p>Major Infrastructure Failure</p> <p>Aging infrastructure</p>	<p>Ageing infrastructure</p> <p>Major infrastructure failure</p>	<p>Power failure – more reliance on pumping to move water around and “manufactured water” now that a failure in the power system can results in disruption to the ability of the water business to supply its services</p> <p>Major supply chain failure due to increased reliance on external providers and supply chain partners</p> <p>Blockages to roads and loss of communications</p>
Absence of long term planning	<p>Business knowledge and performance (national standards and benchmarking) – impact on strategies and structures</p> <p>Population Growth</p>	<p>Prolong period of drought – lack of contingency beyond traditionally supply sources</p> <p>Technological change</p>	<p>Urban / regional development. The influence of water sensitive design and over development in catchments impacting raw water quality and cost to deliver water</p>

Theme	Period A	Period B	Period C
<p>Technological change</p> <p>Lack of proper planning for water grid</p>	<p>Planning & constructability of significant assets – desal, recycled water, pipelines, regional supply of water</p>	<p>No suitable land for future supply augmentation</p> <p>Manufactured water assets not available when required</p> <p>Water security plan - no clear policy on use of recycled water scheme</p> <p>EDQ - developer-led urban planning New technologies that allow customers to manage services beyond current water business operating models</p>	
<p>Demand greater than capacity</p>	<p>Significant increase in water demand by community</p> <p>Prolong period of drought – lack of contingency beyond traditionally supply sources</p> <p>Water restrictions and water efficiency management programs</p>	<p>Manufactured water assets not available when required</p> <p>Water security plan - no clear policy on use of recycled water scheme</p>	

Theme	Period A	Period B	Period C
Continued institutional change Government policy / legislation uncertainties Local / State government politics	Significant changes to local government boundaries National Water Initiative/Competition Policy Government policy changes Council politics COAG reform NCP reforms (1997/98) Politically driven restructuring of industry/governance interventions	Transitional Arrangements: Council political power vs State political power Political interference Local government reforms - infrastructure funding changes Merging of water businesses from local councils Legislative change Transitional Arrangements Water Reform Local government reforms - infrastructure funding changes 2010 SEQ Water Reforms Merging of water businesses from local councils	Revisioning of water businesses Institutional reform – uncertainty Change in State government Further changes to current structure – single bulk with 2 DRs and 3 Councils operations does not seem stable. Politicised Price regulation for all SEQ water entities. Political interference QCA regulation – uncertainty Regulation; The present approach to regulation of water businesses in the SEQ Water (Distribution Retail Restructuring) Act places their ability to lower the cost to serve at a high level of risk. Particularly, the provisions in relation to imposition of infrastructure charges that are commensurate with actual cost of provision of trunk infrastructure to serve emerging green-

Theme	Period A	Period B	Period C
		<p>Further restructuring as the original one was not correct</p> <p>Changes to the SEQ model as its being deployed</p>	<p>field development areas. In addition, legislation to enable third party service provision and the aspect of the service provider of last resort has the potential to be a major risk to the sustainability of existing water utilities.</p> <p>Consolidation of resources and budget as a result of various water reform</p> <p>Further restructuring as govts look for more efficiencies and control over businesses</p>
Community concerns / outrage		<p>Drought extends and recycled water is introduced causing community outrage</p> <p>Stickiness of consumer behaviours</p>	<p>Public distrust of microeconomic reforms and commercialization / privatisation.</p> <p>Power of customer</p>
Unacceptable water quality	<p>Disruption to water supply (water quality or operational issue)</p> <p>Crypto giardia threat</p> <p>Water & wastewater quality and environmental spills</p>	<p>Sub-regional water quality incident</p> <p>Water quality risk especially from the lack of catchment management and combination of unsophisticated treatment plants and processes</p>	<p>Health scare outrage with drinking water supply believed to be the source</p> <p>Water Quality failures</p> <p>Water quality risk especially from the lack of catchment management and</p>

Theme	Period A	Period B	Period C
Sub-regional water quality incident	Water quality risk especially from the lack of catchment management and combination of unsophisticated treatment plants and processes		combination of unsophisticated treatment plants and processes Catchment Management Density of development is increasing and catchment management provisions have not progressed. More effective management of catchments is essential to protect raw water quality.

Question 3. Risks impacting resilience - Survey participant's responses

Theme	Period A	Period B	Period C
Cost / finance / reprioritised budgets	Cost impacts	Cost impacts	Cost impacts
	Financial management capability	Mobility of resources and increase costs in a heated market for infrastructure projects	Increasing cost of services
	Reprioritisation of budgets		Changes to tariff structure
		Failure of market model	Financial Impacts
		Financial Impacts	Potential loss of customers and associated revenues
		Increase in operating costs with reduced revenue	Conflict in decision making / inability to fund required infrastructure due to Return on Investment concerns
		Negative budget impacts	
		Reprioritisation of budgets	Loss of revenue in cost regulated business
		Financial Impacts	Introduction of third party supply arrangements which expose existing utilities and ultimately customers to increased costs
		Unforeseen budget impacts	
			Financial Impacts

Theme	Period A	Period B	Period C
Insufficient flood immunity	<p>Electrical Equipment located below flood level</p> <p>Loss of power to mechanical and electrical assets</p>	<p>Electrical Equipment located below flood level</p> <p>Flood impact on raw water quality/capability of water treatment plant to treat poor quality source water We started to get ready during this period mostly for drought not flood and we started to do the planning but it was not very sophisticated</p>	<p>Electrical Equipment located below flood level</p> <p>Flood</p>
Poor asset management	<p>Renewals</p> <p>Significant asset damage sufficient to limit the safe supply of water</p> <p>Major risk of failure to supply flowing destructive winds due to contamination of treated water supply at reservoirs with damaged roofs.</p>	<p>Renewals</p> <p>Additional infrastructure</p> <p>Lack of systems investment</p> <p>Technology embedded to identify trends and respond earlier</p> <p>Renewals, Technology use</p> <p>Loss of life or significant community health impact</p> <p>Time required to restore assets to normal operating condition</p>	<p>Decrease in level of services leads to more asset failures</p> <p>Significant asset damage sufficient to limit the safe supply of water</p>

Theme	Period A	Period B	Period C
Governance and management	<p data-bbox="472 427 797 451">Silo'd response to events</p> <p data-bbox="472 499 931 675">The water entities of SEQ were owned by around a dozen councils and State Government departments, so common agreement on the problems difficult</p> <p data-bbox="472 722 707 746">Bulk water supply</p> <p data-bbox="472 794 752 818">Unconnected supplies</p> <p data-bbox="472 866 943 1010">The restructure was not planned, costed or focused correctly, the timing was less than optimal with all the other things going on at the time</p> <p data-bbox="472 1058 954 1193">Major risk of failure to supply demand during drought – vulnerability of isolated water supply schemes</p> <p data-bbox="472 1241 842 1265">Reputation of water business</p> <p data-bbox="472 1313 819 1337">Local government capacity</p>	<p data-bbox="981 427 1480 603">People disruption was the big one, continued changes hampered a maturity in systems and focus on the main games. Much navel gazing and in fighting over perceived turf wars</p> <p data-bbox="981 651 1480 786">Inadequate services due to high demand on staff to undertake their day jobs in addition to providing input into complex institutional reform</p> <p data-bbox="981 834 1458 898">Poor people and change management through times of transition</p> <p data-bbox="981 946 1458 1010">Focus taken away from operations to restructuring</p> <p data-bbox="981 1058 1480 1121">Loss of historical information and data through reform</p>	<p data-bbox="1518 427 1787 451">Lack of coordination</p> <p data-bbox="1518 499 2029 643">The water entities of SEQ are owned by some councils and State Government departments, so common agreement on the problems difficult</p> <p data-bbox="1518 691 2018 786">Still a lack of awareness but not as bad as the region has gone through both drought and flood in this period</p> <p data-bbox="1518 834 1951 898">Politics influencing infrastructure operations</p> <p data-bbox="1518 946 1995 1010">Very thin organisational memory and capacity</p> <p data-bbox="1518 1058 1771 1082">Business Continuity</p> <p data-bbox="1518 1129 1962 1153">Rebuilding organisational capacity</p> <p data-bbox="1518 1201 1995 1265">Ability to achieve a sustainable water business</p> <p data-bbox="1518 1313 1906 1377">Potential change to SEQ water business's operating model</p>

Theme	Period A	Period B	Period C
Lack of forward planning	Lack of focus on water business		
	Business Continuity		
	Business uptake of technology		
	Lack of adopted technology		
	Lack of knowledge and impact on future performance and ability to respond and fund changes		Reluctance to identify next bulk water supply (and therefore not identify suitable land parcel)
	Growth planning		
	Inadequate planning		
Capacity to meet development requirements			
Uncertainty re: capacity to manage growth			
Lack of future planning			
Development			

Theme	Period A	Period B	Period C
	Lack of sufficient contingency supply infrastructure		
Uncertain reliability / continuity of supply	No adequate 'back ups' or contingencies	Service disruption	Service disruption
	Service disruption	Ability to meet level of service and quality	Increase in the cost of treating and supplying reliable and safe water to the community
	Reliability and continuity of supply	Dam failure – running out of water	Storage within bulk and distribution retailer networks
	Loss of water supply to some or all of SEQ region	Reliability and continuity of supply	Ability to move resources effectively around the region and monitor outcomes
	Capacity to service	Bulk water supply	Reliability and continuity of supply
	Uncertainty re: water security	Loss of water supply to some or all of SEQ region	Loss of water supply to some or all of SEQ region
	Lack of sufficient contingency supply infrastructure	Inability to meet demand	Failure of disinfection secondary – safe drinking water
	Loss of operation of water and wastewater active assets	Inability to supply safe drinking water	Inability to meet demand
	Lack of alternative/back up water supply	Alternate water supplies	Capacity to service
		Capacity to service	Lack of sufficient contingency supply infrastructure

Theme	Period A	Period B	Period C
Lack of acceptance of recycled water	Major risk to public health as development was occurring at the fringe of water supply schemes and local government water supply businesses were not equipped to develop and implement solutions	Loss of water supply Major risk of failure to supply demand during drought – vulnerability of isolated water supply schemes.	Prolonged failure to supply core services due to single point failure in a supply chain Incident management response in conjunction with Seqwater and Local Disaster Committees Ability to mobilise and use generators on sites such as STP Loss of water supply to some or all of SEQ region Inability to meet demand Lack of systems after period of disruption Supply chain risks not well understood across water business and the sector
	Major risk of inefficient and/or underutilised infrastructure due to legacy of rapid urban development 1980s and 1990s combined with inefficiencies imposed by standalone water supply scheme within local government boundaries	Major risk of inefficient and/or underutilised infrastructure due to legacy of rapid urban development 1980s and 1990s combined with inefficiencies imposed by standalone water supply scheme within local government boundaries.	Poor community and stakeholder engagement about recycled water use in the drinking water cycle

Theme	Period A	Period B	Period C
Government / politics / intervention / institutional change	State Government intervention	The SEQ industry structure spread responsibilities and liabilities through unworkable organisational structures and ‘contractual arrangements’	Acceptance of manufactured water
	COAG reform		Ownership
			Change Governance
			Regulatory uncertainty
			Political interference
			Still talk of mergers going on and changes. Melbourne just restructured what was perceived to be a long running successful model. Mergers of the power companies is still clear in people’s minds as a further threat to the water industry
			Risk averse policy process
			Politics
			Short term political perspective
			Short term political perspectives at all levels of government
	Ownership		
	Organisational restructures		
	Inconsistent government policy		
	Poor decisions are made		
	Changing governance /regulatory framework		
	Large number of new organisations / institutional forms as well as numerous regular changes in institutional structures		
	Experimental institutional model		
	Rapid onset of change to business and operating models		

Theme	Period A	Period B	Period C
Lack of governance / management skills		<p>Inappropriate decisions</p> <p>Reactive response leading to ad hoc decision making</p> <p>Government intervention</p> <p>Ownership</p> <p>Operating models not prepared for potential sustained / slow burn impacts</p>	<p>Loss of technical expertise</p> <p>Staff and business capability that is not prepared for responding to disruption and rapid change</p> <p>Resilience not considered as an outcome when making holistic business change decisions</p>

Theme	Period A	Period B	Period C
No urban structure plan/out of sequence develop		<p>The new entities had insufficient water industry experienced Board members</p> <p>Staff and capability pressures</p> <p>Business capability not prepared for coordinating major response and recovery</p>	<p>Growth planning</p> <p>Lack of regional and long term planning</p> <p>Early release of greenfield development areas without adequate detailed planning and establishment of funding mechanisms within accepted price path</p> <p>Major risk of inefficient and/or underutilised infrastructure due to shift of population to greenfield areas prior to planned density of occupation of brownfield areas occurring</p>

Theme	Period A	Period B	Period C
Community influence/demands	<p data-bbox="472 943 763 967">Customer expectations</p> <p data-bbox="472 1015 943 1086">Change / customers belief that water was free – part of the rates bill</p> <p data-bbox="472 1126 734 1150">Community Impacts</p> <p data-bbox="472 1198 943 1342">Lack of focus or importance on the risks was the biggest manifestation. It wasn't really on people's radar when I came up here – lack of focus</p>	<p data-bbox="981 943 1272 967">Customer expectations</p> <p data-bbox="981 1015 1245 1038">Community Impacts</p>	<p data-bbox="1518 392 2029 600">Increasing demand on resources of water business to participate in detailed planning for climate independent water sources which will have implications to support services planning for greenfield areas.</p> <p data-bbox="1518 647 1693 671">Development</p> <p data-bbox="1518 719 1917 791">Lack of regional and long term planning</p> <p data-bbox="1518 831 2007 903">Ability to manage growth - challenges of working with EDQ model</p> <p data-bbox="1518 943 1995 1007">Small community groups influencing decisions</p> <p data-bbox="1518 1054 1809 1078">Customer expectations</p> <p data-bbox="1518 1126 1783 1150">Community Impacts</p> <p data-bbox="1518 1198 1928 1222">Lack of proper public education</p> <p data-bbox="1518 1270 1704 1294">Public inquiry</p>

Theme	Period A	Period B	Period C
	An assumption that ‘water is innocent until proven guilty’ because its water and you don’t get sick from the water was evident. – lack of education		Instantaneous information availability to customers, social media interference in event response Community Impacts
Lack of catchment management - water quality	<p data-bbox="472 608 658 639">Water Quality</p> <p data-bbox="472 683 875 715">Contamination of water supply</p> <p data-bbox="472 758 949 826">Loss of life or significant community health impact</p> <p data-bbox="472 869 663 901">Crypto giardia</p> <p data-bbox="472 944 949 1082">Flood impact on raw water quality/capability of water treatment plant to treat poor quality source water</p> <p data-bbox="472 1125 949 1262">Major risk of failure to supply demand during flooding and or blue-green algae blooms because of inadequate treatment technology</p> <p data-bbox="472 1305 837 1342">Water Quality/Public Safety</p>	<p data-bbox="983 608 1169 639">Water Quality</p> <p data-bbox="983 683 1460 751">Loss of life or significant community health impact</p> <p data-bbox="983 794 1460 975">Poor catchment and water quality outcomes remain one of the biggest risks and the region seriously needs to look at planning controls and integrated planning</p> <p data-bbox="983 1018 1460 1305">Major risk of failure to supply demand during flooding and or blue-green/filter blocking algae blooms because of inadequate treatment technology Increasing risk of poor raw water quality due increasing density and expansion of development in water supply catchments</p> <p data-bbox="983 1348 1346 1380">Water Quality/Public Safety</p>	<p data-bbox="1516 608 2018 746">Present approach to catchment management has high probability of adverse raw water quality outcomes in the future</p> <p data-bbox="1516 790 2018 858">Health scare outrage with drinking water supply believed to be the source</p> <p data-bbox="1516 901 2018 970">Disabled water supply, impact to health of community</p> <p data-bbox="1516 1013 2018 1082">Higher organics in raw water including precursors to DBPs</p> <p data-bbox="1516 1125 2018 1230">Flood impact on raw water quality/capability of water treatment plant to treat poor quality source water</p>

Theme	Period A	Period B	Period C
		Higher organics in raw water including precursors to DBPs Flood impact on raw water quality/capability of water treatment plant to treat poor quality source water	
