

Risky Environments: Governance and Adaptation for Future Flood Risk

Rhiannon Niven

BSoc Sc (Psych) – The University of Adelaide, South Australia

BEnv St – The University of Adelaide, South Australia

BEnv Policy Mgt (Hons) – The University of Adelaide, South Australia

Department of Geography, Environment and Population

School of Social Sciences

Faculty of Arts

University of Adelaide

Thesis submitted for the Degree of Doctor of Philosophy

July 2017

Table of Contents

Table of Contents	ii
List of Tables	i
List of Figures	ii
Abstract	iii
Declaration	iv
Acknowledgements	v
Acronyms and Abbreviations	vi
Chapter 1: Introduction	1
1.1 Challenges for flood management	1
1.2 Theoretical framework	3
1.3 Purpose and scope	3
1.3.1 Research context	3
1.3.2 Research aim	4
1.3.3 Research significance	4
1.4 Thesis structure	5
1.5 Chapter summary	5
Chapter 2: Conceptualising flood risk	6
2.1 Introduction	6
2.2 Defining key concepts	6
2.2.1 What is a flood?	6
2.2.2 Types of flooding	7
2.2.3 Definition of risk and hazard	8
2.2.4 Risk theory	9
2.2.5 Resilience and vulnerability	14
2.2.6 Mitigation and adaptation	15
2.3 The history of management of flooding	18
2.3.1 Flood defence through to flood risk management: a risk based approach	18
2.4 Governance of flood risk	22
2.4.1 Government and governance	22
2.4.2 Governance across scales	24
2.5 Risk perception	25
2.6 Key issues for management: failure of the current paradigm?	27

2.6.1 Climate change	27
2.6.2 Urbanisation.....	29
2.7 Study rationale.....	30
2.8 Chapter summary	31
Chapter 3: Research design and methods.....	32
3.1 Introduction	32
3.2 Research design.....	32
3.2.1 Qualitative research	32
3.3 Methodology	33
3.3.1 Grounded theory	33
3.3.2 Case studies	34
3.4 Methods and data collection.....	39
3.4.1 Interviews	39
3.4.2 Document analysis.....	44
3.4.3 Data analysis.....	45
3.5 Triangulation and validity	46
3.6 Limitations	46
3.6.1 Potential bias.....	47
3.7 Chapter summary	47
Chapter 4: South Australia and the Brown Hill and Keswick Creek Experience	49
4.1 Introduction	49
4.2 Local context: case study background	49
4.2.1 The BHKC catchment	50
4.3 Governance of flood risk management in the BHKC catchment.....	54
4.3.1 Governance framework for BHKC.....	57
4.3.2 Development of the BHKC SMP	60
4.3.3 Challenges for effective flood management: governance and implementation	66
4.4 Adaptation in the BHKC catchment.....	70
4.4.1 Risk perception	71
4.4.2 Adaptation for urbanisation and infrastructure.....	71
4.4.3 Relocation policies	72
4.5 Key findings	74
4.6 Key themes and chapter summary	75
Chapter 5: 2011 Queensland flood event.....	77
5.1 Introduction	77

5.2 Local context: SE QLD flood history	78
5.2.1 The 2011 flood event.....	80
5.2.2 The flood event impacts	84
5.3 Issues and lessons learned from the 2011 SE QLD flood event	86
5.3.1 Resulting reviews and inquiries.....	87
5.3.2 QLD flood governance framework.....	91
5.3.3 Mapping and data	98
5.3.4 Knowledge and perception of flood risk	100
5.3.5 Rebuilding post-flood.....	103
5.4 SE QLD and relocation policies.....	105
5.4.1 Grantham and relocation	105
5.4.2 Brisbane and the Voluntary Home Purchase Scheme	107
5.5 Challenges for flood management.....	110
5.5.1 Climate change	110
5.5.2 Urbanisation.....	112
5.5.3 Adaptation for future risk in SE QLD	112
5.6 Key findings	118
5.7 Key themes and chapter summary	118
Chapter 6: Scotland and the United Kingdom.....	119
6.1 Introduction	119
6.2 Local context: history of flooding in the UK	120
6.3 UK flood risk management governance framework	122
6.4 A UK perception of contemporary issues	124
6.4.1 Key challenges.....	124
6.5 Response and adaptation to increasing flood risk.....	131
6.5.1 The role of insurance	132
6.5.2 Sustainable flood risk management.....	135
6.6 Key findings	148
6.7 Key themes and chapter summary	149
Chapter 7: Adaptation to future flood risk: challenges and opportunities.....	150
7.1 Introduction	150
7.2 Comparative analysis of case study results.....	150
7.3 Risk perception.....	151
7.4 Governance frameworks and challenges for flood management	153
7.4.1 Governance: responsibilities and influences	153

7.4.2 Challenge of political boundaries	157
7.4.3 Public policy	158
7.5 Adaptive management for flood risk.....	175
7.5.1 Landscape management.....	175
7.5.2 Insurance.....	184
7.6 Key themes and chapter summary	186
Chapter 8: Summation and conclusions	189
8.1 Introduction	189
8.2 Research summary	189
8.3 Key findings	191
8.3.1 Challenges for flood management.....	191
8.3.2 Adaptive management options for flood risk	194
8.3.3 Limitations for future adaptation to increased flood risk	196
8.4 Theoretical and policy implications	197
8.5 Key research challenges	198
8.6 Knowledge contribution and future research directions	199
8.6.1 Final conclusions: a balance of localism in a federalist system	200
Appendices.....	203
Appendix A – Examples of natural flood risk management projects in the UK.....	204
Appendix B - Summary of recurrent themes across case studies	207
Reference list	210

List of Tables

Table 1 Basic governance types.....	23
Table 2 Justification of case study sites with similarities and differences	36
Table 3 Organisations represented by interview participants	41
Table 4 Interview schedule	43
Table 5 Validity assumptions and procedures	46
Table 6 Government agencies responsible for flood management in the BHKC catchment ...	56
Table 7 Properties affected by flooding for existing conditions in the BHKC catchment	62
Table 8 SMA involvement in 2017 BHKC SMP	63
Table 9 Proposed share of Local government costs.....	69
Table 10 QLD flood governance framework.....	93
Table 11 Research locations and primary flood policy documents	94
Table 12 Key themes from interviews	125
Table 13 Comparison of flood-related legislation across case studies	163
Table 14 Comparison of flood-related policy tools and regulations.....	164
Table 15 Comparison of climate change adaptation policy tools	169
Table 16 Comparison of climate change mitigation policy tools and regulations.....	170

List of Figures

Figure 1 Location of Brown Hill Keswick Creek catchment.	51
Figure 2 Map of Brown Hill Keswick Creek catchment	52
Figure 3 Peak levels for selected flood events.....	78
Figure 4 Historic flood peaks at the Brisbane River city gauge	79
Figure 5 Historic flood peaks at the Bremer River Ipswich gauge.....	79
Figure 6 Map of Brisbane River catchment.....	80
Figure 7 Major urban centres impacted	82
Figure 8 Map of flood impacted areas in SEQ 8 – 12 th January 2011	83
Figure 9 Affected areas in SE QLD.....	85
Figure 10 Key themes from interviews.....	86
Figure 11 Extracts from the EU Floods Directive relating to natural flood management	140
Figure 12 Extracts from <i>FRM Act</i> relating to natural flood management	141
Figure 13 Extracts from England and Wales <i>FWM Act</i> relating to natural flood management	141

Abstract

Modern environments are becoming increasingly risky. Climate change, population growth and the spread of urbanisation have increased flood risks, such that the vulnerability of populations to the natural hazard, and the financial cost of response and recovery have increased in association. In response, flood governance is changing. This study presents the results of a comparative case study of flood risk governance and management that aimed to address two research questions, (i) what are the key challenges of flood management in consideration of the role of the governance framework, local context and stakeholder perception and acceptance of risk at multiple scales and (ii) what are the options for an adaptive management approach to flood?

The research design employed components of grounded theory and a comparative case study methodology to explore approaches to flood management in three different case studies across local, regional and national scales: 1) The development of the Brownhill and Keswick Creek Stormwater Management Plan in South Australia; 2) The governance response to the 2011 floods in south-east Queensland, and; 3) the implementation of the *Flood Risk Management (Scotland) Act 2009* in Scotland, United Kingdom. Ulrich Beck's Risk Society (1992) was applied as a philosophical lens to construct the conceptual understanding of 'risk'.

Findings reveal a diversity of approaches to the management of future flood risk across scales. Each case study and scale (local, regional and national) highlighted different aspects and challenges of flood management around the themes of governance (e.g. diffused and unclear responsibilities and accountabilities), adaptation (e.g. relocation, natural flood management and use of landscape) and underlying risk perception. The three case studies together provide a critical comparative analysis of the key challenges faced by managers of flood risk.

Concluding recommendations highlight that common challenges for flood management are constructed around: urbanisation; climate change; governance of systems; risk perception; and uncertainty from increased flood risk. The case studies demonstrated that the link between a new framing of risk and the practical consequences for implementation need to be strengthened for effective community empowerment and resilience. Increased community resilience requires multi-disciplinary, cross-scale understanding, where local communities can imprint their values and risk perceptions on the decision-making process. A transition towards a sustainable flood risk management paradigm will be required for communities to adapt to their new risky environments.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

I give consent to this copy of my thesis when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968. The author acknowledges that copyright of published works contained within this thesis resides with the copyright holder(s) of those works.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

Rhiannon Niven

8 November 2017

Acknowledgements

First and foremost, I would like to thank my supervisors, Dr Douglas Bardsley and Dr Melissa Nursey-Bray for their valuable guidance, patience and support throughout this thesis. I am extremely grateful for their time, comments, and many discussions without which this thesis would not exist. I am especially grateful for their advice and the final push to the finishing line.

I would like to acknowledge Dr Dianne Rudd for her extra advice and support throughout my years in the Department of Geography, Environment and Population. I would also especially like to thank those at the Flood Hazard Research Centre, Middlesex University for hosting me during my time in London – you welcomed me as one of your own and provided new perspectives. A special thank you goes to Dr Sally Priest, Dr Meghan Alexander, and Dr Thomas Thaler for sending me care packages and continued debate from the other side of the world.

To all the individuals and organisations that gave their time and shared insights into participating in my research, this thesis would not have been possible without you.

A special mention to my fellow postgraduates, who provided much needed support, advice, conversation, and laughter – especially to Romy, Nicole, Cathy, Simon, George, Michael, Prae, and Anne. I look forward to maintaining lifelong friendships.

To my work managers and colleagues – thank you for allowing me flexibility and continuously pushing me to finish. I couldn't have done it without your support behind me.

A very big thank you goes to my Dad, Nicole and Romy who spent many hours reading and providing last minute comments on my thesis in such a short time frame, and to Gaby and Michael who created my maps. I don't know what I would've done without their contribution and this thesis is significantly better for it. I am forever grateful.

And finally, to Mat – who showed immense patience, support, provided me with food and made me laugh – you went beyond what I would have ever expected; I know it wasn't easy. But now it is time to adventure!

Acronyms and Abbreviations

ABI – Association of British Insurers

AEP – Annual Exceedance Probability

AHD – Australian Height Datum

ARI – Average Recurrence Interval

BHKC – Brown Hill and Keswick Creeks

The Bureau – Bureau of Meteorology (Australia)

CBD – Central Business District

CEO – Chief Executive Officer

CRESS – Centre for River EcoSystem Science (University of Stirling, Scotland)

COSLA – Convention of Scottish Local Authorities

CPI – Consumer Price Index

DEFRA - Department for the Environment, Food, and Rural Affairs (England and Wales)

DEWNR – Department of Environment, Water, and Natural Resources (South Australia)

DFL – Defined Flood Level

DPTI – Department of Planning, Transport and Infrastructure (South Australia)

EU – European Union

***Floods Directive** - Directive 2007/60/EC on the assessment and management of flood risks*

***FRM Act 2009** – Flood Risk Management (Scotland) Act 2009*

***FWM Act 2010** – Flood and Water Management Act 2010*

GB – Great Britain

ICA – Insurance Council of Australia

Inquiry – Queensland Floods Commission of Inquiry

IPCC – Intergovernmental Panel on Climate Change

ISO – International Organisation for Standardisation

LVRC – Lockyer Valley Regional Council

NGO – Non-government organisation

NR AMLR - Natural Resource Adelaide and Mount Lofty Ranges

NSW – New South Wales

OECD - Organisation for Economic Co-operation and Development

PCWMB - Patawalonga Catchment Water Management Board

PMF – Probable Maximum Flood

PPRR – Prevention, Preparedness, Response and Recovery

QLD – Queensland

QRA – Queensland Reconstruction Authority

Review - Natural Disaster Insurance Review: Inquiry into flood insurance and related matters.

RSPB – The Royal Society for the Protection of Birds (United Kingdom)

SA – South Australia

SAFECOM – South Australian Fire and Emergency Services Commission

SAIFF – Scottish Advisory and Implementation Forum for Flooding

SE – South east

SEQ - South east Queensland

SES - State Emergency Service

SEPA – Scottish Environment Protection Agency

SMA – Stormwater Management Authority (South Australia)

SMP – Stormwater Management Plan

SNH – Scotland Natural Heritage

SPP – State Planning Policy

SNIFFER – Scotland & Northern Ireland Forum for Environmental Research

SUDS – Sustainable Urban Drainage Systems

UK – United Kingdom

UNISDR - United Nations Office for Disaster Risk Reduction

USA – United States of America

WSUD – Water Sensitive Urban Design

Chapter 1: Introduction

Floods are a naturally occurring hazard, but the fatalities, injuries, damages and other impacts which follow are a human construct; the consequence of actions and decisions made by past and present individuals, governments and other actors (The World Bank and The United Nations 2010). Floods are proven to be one of the most regular and expensive economic disasters world-wide. Approximately 500 million people are affected every year and annual flood insurance claims have increased from USD 1–2 billion in the 1970s to insured flood losses of USD 15 billion in 2011 (Swiss Re 2012). Furthermore, floods can have a devastating effect on communities, leaving lasting impacts far beyond the end of the flood itself. The continuously increasing tangible and intangible impacts of flooding indicate that the current management system paradigm is not coping with modern systems.

As populations grow, urban density and built environments increase, and factors such as changes in climate all combine to increase flood risk in these communities, adaptation responses to these new levels of flood risk are required. Of particular importance is the impact of climate change, which is increasing the intensity and likelihood of flooding globally. The Intergovernmental Panel on Climate Change (IPCC) report (2014a) states that in locations such as Europe, riverine flooding will be one of the most significant and overwhelming consequences of climate change. Impacts are particularly acute in urban areas, as towns and cities are often established near rivers and coasts.

Adaptation to increased levels of flood risk due to climate change and urban development factors will involve a complex range of responses outside the current management paradigm of a mixture of flood defence and flood risk management, which has been unable to effectively conceptualise and respond to present levels of risk.

1.1 Challenges for flood management

Challenges for appropriate flood management are most complex in urban areas, which have historically been built along or near coastal or river systems and were utilised for many conflicting uses, such as sources of drinking water, irrigation for agriculture, trade routes, and political boundaries (Zevenbergen *et al.* 2008). Furthermore, soils and topography on coastal or river floodplains are also generally productive agricultural lands, thus promoting higher settlement densities. However, as Tempels and Hartmann (2014) neatly explain, a substantial problem for floodplain and river system management is that urban development diminishes the space for the river to behave naturally and its capacity to absorb extra flows.

As settlements have become more permanent, the physical and governance boundaries have become disconnected from the land and water creating the need for physical, or ‘hard’, flood defences. These types of static, structural solutions were the dominant global approach to flood management until the 1990s (Tempels & Hartmann 2014). There has been significant investment in flood mitigation infrastructure that focuses on protection, such as levee banks and dams (Cook *et al.* 2016). Despite such investment, annual damage costs are continuing to increase worldwide (Munich Re 2010), demonstrating changing levels of risk exposure and increasing vulnerability of infrastructure and communities as the flood management system is unable to cope.

As the global population increases and further development is required, towns and cities continue to grow, intensifying the disconnect between rivers and floodplains and generating the wicked problem of flood management as defined by Rittel and Webber (Head & Alford 2015; Rittel & Webber 1973).

In addition to the twin pressures of increasing urban development and climate change impacts, the need to manage the inequality of vulnerable populations is significant. Not all members of an urban area will be impacted by or exposed to flood hazards in the same manner. Low socio-economic populations are often exposed to higher levels of flood risk, and are also the most vulnerable to the impacts of floods. This adds to the challenge of flood management and governance (Johnson *et al.* 2007a; Johnson *et al.* 2007b). Equality and resilience are also linked to the ability to adapt. As Adger (2013a) discusses, adaptation strategies can reduce the resilience of communities and cultures if they are not well-considered and implemented in a thoughtful manner. A reduction in resilience is more likely to occur when adaptation strategies focus on private interests and investments without the consideration of cultural and community factors and values. An important consideration for this thesis is that if *‘cultural dimensions of climate change [or hazard management] are ignored, it is likely that both adaptation and mitigation responses will fail to be effective because they simply do not connect with what matters to individuals and communities’* (Adger *et al.* 2013a, p. 116).

More recently, recognising the need to look beyond flood mitigation infrastructure and its failings, much flood policy has shifted from decades of an ingrained focus on flood defence to a more adaptive approach to flood risk management (Hartmann & Jeupner 2014; Tempels & Hartmann 2014; Werritty 2006). However, despite some academic and practical support for adaptive approaches there remains significant resistance to widespread implementation on the ground. This change in the requirements and considerations for managing flood risks is also challenging how and at what scale flood governance is structured (Adger *et al.* 2013b).

1.2 Theoretical framework

This project has been designed to explore challenges to flood hazard management through a social science lens, to provide a complementary viewpoint to more traditional approaches historically dominated by hydrologists, water resource engineers, economists and statisticians. While these technical disciplines have been extremely beneficial for understanding many aspects of flood hazards and their management, they offer a relatively narrow lens for exploring this multi-dimensional and complex issue (Merz *et al.* 2014). Rather, to address the growing perception of unprecedented levels of flood risk and the variety of social, economic, cultural, environmental, and infrastructure-related impacts, trans-disciplinary research crossing natural and social sciences is necessary in order to understand the challenges faced by contemporary hazard managers and therefore progress adaptation (Hulme 2010).

Lupton's (1999a; 1999b) typology of risk provides context and framing of risk from three different sociological theory perspectives for understanding the multi-discipline and complexity around risk theory, and examination and application throughout this thesis. These are the 'risk society', 'cultural/symbolic' and 'governmentality' perspectives. To help understand the multi-disciplined current world state of risk more generally, the study will frame risk through reflexivity and the current risk modernity described in Beck's (1992) Risk Society theory in the context of flood risk management.

A period of new governance is being undertaken to manage contemporary risk with difficult challenges to manage both people and land in an ever-growing and high pressure, short-term focused, political environment. As Beck (2013, p. 2) highlights, factors such as increasing urbanisation and climate change require '*a globalised change of consciousness and practice*' and the development of '*cosmopolitan communities of climate risk*'. The following chapters will examine the need for changes in the culture surrounding flood risk management to accommodate new approaches and epistemology for adaptation to the new prevalent risk environment. The purpose and scope of the thesis along with the research aims and objectives will be described in the next sections, providing context for the remainder of the thesis discussion.

1.3 Purpose and scope

1.3.1 Research context

This study was devised in the wake of several major flood events having record high impacts (Munich Re 2010; Swiss Re 2012), highlighting the current paradigm is struggling and the need

for a review of contemporary policies and planning for flood and hazard management. The flood events across Europe, Canada and New Orleans in the United States of America (USA) in 2005, the United Kingdom (UK) in 2007, 2009, 2010, and 2012, and China, Thailand, Brazil, Australia and the Mississippi River in USA in 2011 demonstrated increasing flood damages and a continuing rise in global flood risk. As a result of these notable flood events, several reviews were conducted, such as the *Queensland Floods Commission of Inquiry (Inquiry)* (Queensland Floods Commission of Inquiry 2012), which provided a useful tool for analysis and examining change in governance, policy and implementation approaches. The aims and objectives of this study are set out below.

1.3.2 Research aim

A comparative case study of approaches to flood hazard management is presented so that practitioners and policy makers can examine a range of adaptation measures undertaken in three different contexts and governance scales: the Brownhill and Keswick Creek (BHKC) catchment in South Australia (SA); south-east Queensland (SE QLD), Australia; and, Scotland, UK. In each case study, the practical risk mitigation approaches that have been employed and the associated implementation of flood management policy are critically evaluated. The diversity in location and scale enables the exploration of a variety of challenges surrounding political cultures and governance of flood risk. Thus, by examining the three case studies with different geographical and political scales and contexts, this thesis aims to address the following research questions:

- What are the key challenges for flood management in the context of the:
 - Governance framework
 - Local context of the case study site
 - Stakeholders' perceptions and acceptance of risk?
- What are the options for an adaptive management approach to flood risk?

1.3.3 Research significance

As mentioned in section 1.2, there is a need for trans-disciplinary research crossing natural and social sciences. This thesis has attempted to incorporate aspects from across the natural, technical and social sciences through a high-level analysis and focus on how people and populations will be impacted through a change in flood risk. The research is significant as the high-level approach has facilitated an examination and greater understanding of how people and governance systems are navigating contemporary risk management and the transformation

to an era of risk awareness and increasing complexity. Such improved understanding has implications for decision-making around the policy and governance for flood hazard, as an example of a complex risk problem.

1.4 Thesis structure

To address the research aims mentioned above, the thesis examines the complex, interconnected topics presenting challenges for flood management and the use of adaptive management approach to flood risk by discussing three in-depth case studies within the context of a critical Risk Society theoretical lens as discussed by Beck. Chapter Two reviews the literature of flood management approaches in a global context, highlighting the growing risk of floods. Chapter Three explains the research design and methodology undertaken to meet the aim of this thesis. Chapters Four, Five and Six present the results of the three case studies. Each case study chapter will discuss the local climate change impacts for the region, cognisant of many of the emerging risks of climate change. The local climate impacts will be discussed in the context of a range of risks influencing greater flood hazard. Key findings from the three case studies are compared and synthesised with the literature in Chapter Seven to provide an overall summary of the contemporary challenges for flood management, including similarities between the case studies and ways forward. Chapter Eight delivers the final conclusions and the implications of the research for future flood risk management.

1.5 Chapter summary

Increasing flood risk due to growing urban development and climate change is providing new challenges for flood management. Different approaches to the management of flood risk are needed to address this increased risk as traditional flood protection measures are no longer coping as demonstrated by the continuous increase in response, recovery and damage. This chapter provided an introduction to the study premise. The following chapter presents a review of the literature around risk, adaptation, flood management paradigms, governance and key issues for management which led to the development of the study rationale.

Chapter 2: Conceptualising flood risk

2.1 Introduction

Chapter Two defines the key terms and concepts relevant to this research, and presents the theories of risk and adaptation which inform the study premise and serve to frame the research approach. In addition, the chapter reviews the literature on the history of flood management approaches, governance and considers the implications of two of the main factors driving increases in flood risk – climate change and urbanisation – in order to provide the rationale for this study’s exploration of governance challenges for flood management.

2.2 Defining key concepts

2.2.1 What is a flood?

Floods can be defined generally as ‘*water in a place that is normally dry*’ (Arnell 2002, p. 112). The European Union (EU) defines floods as a ‘*temporary covering by water of land not normally covered by water*’ (European Union 2007, p. 3). The Australian Government provided a more detailed definition of flooding in response to the recommendations in the *Natural Disaster Resilience Review*:

The covering of normally dry land by water that has escaped or been released from the normal confines of: any lake, or any river, creek or other natural watercourse, whether or not altered or modified; or any reservoir, canal, or dam (Commonwealth Treasury 2011).

Petts and Amoros (1996, p. 2) provide a more technical definition, where floods are described as, ‘*hydrological events characterized by high discharges and/or water levels leading to inundation of land adjacent to streams, rivers, lakes and other water bodies*’.

However, Walker and Burningham (2011) argue that the experience of being flooded is much more complex than these definitions depict, as flooding involves a mix of natural, social and technological factors. The multiple causes and consequences of flooding result from human-environment interactions in the complex social-ecological systems. Floods, while fundamentally natural phenomena, are exacerbated by environmental impacts of human activity, such as for example, modification of waterways, deforestation of catchments, and development on floodplains. Floods become a social issue when nature moves from the wild outside, to the controlled and domestic domain, threatening the normal way of life (Walker *et al.* 2011).

The multifarious nature of flooding is reflected in the conceptualisation applied by the EU, which refers to the importance of human-environment interactions:

Floods are natural phenomena which cannot be prevented. However, some human activities (such as increasing human settlements and economic assets in floodplains and the reduction of the natural water retention by land use) and climate change contribute to an increase in the likelihood and adverse impacts of flood events (European Union 2007).

Due to the importance of the social component, this broader conceptualisation of flooding has been applied in this study.

2.2.2 Types of flooding

There are several types and sources of flooding. These include flash flooding, stormwater, coastal, riverine flooding, as well as flooding resulting from snow melt and infrastructure breaching or failure. These different types and sources of flooding will be briefly described below.

Infrastructure breaching or failure occurs when mitigation structures such as dams, levees and pipes fail during a specific event due to damage, age, poor design, or operation. An example of dam failure was when a tailings dam operated by Brazilian mining company Samarco in the town of Bento Rodriguez collapsed in November 2015; the result was disastrous with villages destroyed, 19 fatalities and catastrophic environmental damage (Phillips 2016).

Snow melt flooding occurs when snow melts faster than the soil or watercourse can absorb it. The excess water acts similarly to rainfall runoff. Snow melt flooding is particularly dangerous when rainfall is occurring onto melting snow, resulting in faster movement. Snow melt flooding is common in areas such as on the Israel River in New Hampshire, USA (National Weather Service 2017).

Coastal flooding generally occurs with storm surges and significant tidal events, such as king tide events. Coastal flooding is projected to increase with climate change induced sea level rise and cause significant inundation of new areas (IPCC 2014a). Hurricane Katrina is one recent significant example where New Orleans experienced catastrophic flooding on August 29, 2005.

Stormwater and riverine flooding are the focus of this thesis due to their common occurrence and prevalence through urban areas. Stormwater (pluvial, surface water or overland flow) flooding occurs due to heavy rainfall generally occurring over a short period. Stormwater flooding can occur in almost any location where there has been an intense amount of rainfall and drainage systems cannot manage the amount of runoff from the rainfall (Geoscience

Australia 2017). Stormwater flooding mostly occurs as flash flooding (within six hours of the rainfall event) and predominately in urban areas. Natural watercourses and catchments may also experience flash flooding due to the intense rainfall breaching the limited capacity of the watercourse and the catchment's inability to absorb the excess water. Flash flooding can cause considerable damage because of the high velocity and speed of the moving water. Due to the rapid onset, there is also limited time to provide emergency warnings or engage any protective measures.

Riverine flooding (fluvial) can be much slower moving and takes longer than six hours to occur. Riverine flooding occurs when the capacity of the watercourse has been reached, often due to significant levels of rainfall in the upper reaches of the catchment (Smith 1998). Riverine flooding can also be caused by snow melt. The floodwaters of riverine flooding can also take much longer to recede than a flash flood. A key example of this was the Thailand flooding in 2011, which spread through Bangkok and surrounding areas for months (Gale & Saunders 2013).

2.2.3 Definition of risk and hazard

The key, inter-connected terms used throughout this thesis: 'risk', 'hazard', 'vulnerability', 'adaptation', 'mitigation' and 'resilience' vary across different fields in the social and physical sciences (Brooks 2003; Weichselgartner & Bertens 2000). Weichselgartner (2000) argues that variances in the definition and application of these concepts exists due to people's differing perspectives towards risk mitigation, and their underlying approaches to, conceptualisation of, and attitudes towards scientific, social and political influences between stakeholders, civil protection practitioners, and social and physical scientists. Brooks (2003) suggests that the natural disaster and hazard community focuses on 'risk', whereas social and climate scientists tend to refer to 'vulnerability'. Therefore, a discussion around the conceptualisation and use of these terms follows.

Throughout history, the definition of the term 'risk' has altered and has been used in a variety of different contexts. Originally, many researchers deemed a risk to be from a natural hazard event without human intervention; for example, storms, disease epidemics and floods. Over time, the causes of these 'risks' or 'natural disasters' have also changed; from the supernatural, to nature, and more recently to humans (or society) responsible for erroneous risk management decisions (Weichselgartner & Bertens 2000). When risks are conceptualised as a result of the supernatural, hazard events cannot be pre-empted by society and implies that little can be done to reduce their impact (Lupton 1999a). Lupton (1999a) suggests that the

contemporary meaning of risk changed with the development of the period of modernity, which began in the 17th century.

The International Organisation for Standardisation (ISO) defines risk as the '*effect of uncertainty on objectives*' (International Standards Organisation 2009, online). Risk can also be understood as the combination of a hazard and its consequences, and is often expressed as:

'Risk = hazard x exposure x vulnerability' (Kron 2002, p. 60).

Risk can be generally conceptualised as something that is not in the process of happening; rather it is something that *may* happen (Adam *et al.* 2000). Cutter (1993) suggests that risk is the measure of the probability of a hazard occurring; therefore, 'hazard' is a considerably broader concept that encapsulates the magnitude of an event on society, the environment and socio-political contexts. McGuire *et al.* (2002) define natural hazards as extreme natural events that threaten people, their property and possessions. Such natural hazards are termed natural disasters when the event occurs. Examples include: geological hazards, such as earthquakes and atmospheric hazards including temperature and lightning; and hydrological hazards, such as floods (McGuire *et al.* 2002). The context in which the risk is apparent determines the perceived severity of the natural hazard. The environmental or other processes that drive these hazards occur on a global scale and have regional impacts (Cutter 1993). Risk can also have significant political influence, as it is conceptualised by who is defining the risk, and how and why (Cutter 1993).

Considering these conceptualisations, 'flood risk' can then be described as the function of hazard; this encapsulates the probability of any flood event, the exposure of the population, infrastructure and assets, and the vulnerability of the community in terms of their capacity to respond to and cope with the event (IPCC 2012; Koks *et al.* 2015; Kron 2005; Thaler 2015). The vulnerability and resilience of a community are the most significant factors determining capacity to manage flood risk.

This thesis prefers to use the term 'risk', as it is more commonly used and understood by hazard management practitioners.

2.2.4 Risk theory

There is much debate in the theoretical discussions regarding the concepts of risk, hazard and uncertainty (Caplan 2000). According to Davies *et al.* (2012), since the 1960s, risk has become a central ideology for both the social and natural sciences. Authors such as Beck (1992, 1999), Giddens (1991, 2009), Slovic (2000), Castree (2001), Lupton (1999a, 1999b) and many others have written extensively on the subject of risk and society. Further detailed discussion will be

presented on Beck's Risk Society in Section 2.2.4.1 to provide understanding of the framing of risk throughout this thesis.

Lupton (1999a) and Fox (1999) identify the various theorists of risk, and categorise them into different perspectives. The realist and social constructionism perspectives are identified as the most common in the social sciences. These two perspectives contrast between those focussed on the technical and scientific approach, such as that used in engineering and mathematics (realist), and the social, psychological, and cultural features of risk (social constructionism) (Lupton 1999a). These perspectives can be scaled between weak and strong with those in the 'weak' constructivist camp recognising that there is a realist influence on a constructivist approach. Fox defines realists as those for whom '*risk maps directly onto the underlying hazard*' (Fox 1999, p. 16). This understanding allows for risk assessments and strategies to be implemented, reducing the likelihood of a negative outcome (Fox 1999).

Fox (1999) also describes the postmodern model, where hazard events are a social creation developed from outcomes of decisions made by humans. Fox (1999, p. 29) states that both risks and hazards are '*constructed through the lens of culture*'. Likewise, Cutter's (1993) expanded natural hazards theory was one of the first to theorise that risk was a socially constructed concept which demonstrated the relationship between people and the environment. Cutter expands on the theory originally developed by White *et al.* (1968), demonstrating that the human-environment relationship is viewed as part of a system where hazards are connected to both human use of the environment, and natural events, such as earthquakes and floods. Cutter (1993) explains that such hazards are social constructs because they often result from failures of systems, whether these systems be political, technological, or economic. Bogard (1989) also discusses the concept of risk as a social construct, with an increase in hazardous environments and an increase in the vulnerability of disadvantaged populations to hazards. The increase in the vulnerability to such hazards is theorised to be as a direct result of the increase in technology usage and development, and the false perception of technology to have fail-safe protective operative features.

Fox (1999) also identifies the culturalist or constructionist perspective, whereby risk is determined to be constructs of people with the hazard as a natural event. Douglas (1992; 1982) and Slovic (2000) support such a viewpoint, focusing on the perception and concept of risk as subjective. Adams (1995) also suggests that Beck (1992, 1996, 2006, 2010), Giddens (1991, 2009), and Wildavsky (1986) sit within the cultural theorists category. Wildavsky uses a political science and individualist approach, and Beck and Giddens use the sociology and egalitarian perspective.

Beck (1992) defines risk as a systematic method of coping with the hazards and insecurities provoked and developed by modernisation. Both Beck and Giddens see societal risks as increasing and of different types. Giddens (1991) defines his modern world of high modernity as post-feudal Europe, and argues that modernity is time where difference, exclusion and marginalisation are cultivated and the stand-out social form is the nation state (Giddens 1991). As Giddens (1999, p. 3) states,

Risk was supposed to be a way of regulating the future, of normalising it and bringing it under our dominion. Things haven't turned out that way. Our very attempts to control the future tend to rebound upon us, forcing us to look for different ways of relating to uncertainty.

Giddens' view is particularly relevant to the idea of 'natural' risks. Giddens (1991, 1999, 2009) theorises that 'natural' risks, such as floods, storms, and other events, are now at unprecedented levels. The increasing nature of urbanisation and globalisation has exacerbated these events and now cause undue disruption to societies.

Instead, Beck suggests that risk itself is related to the notion of reflexive modernisation; a transition has occurred from the modern concept of risk (where it is no longer a natural phenomenon that cannot be avoided) to one where risk may be a result of human activities. It is here that we are introduced to Beck's (1992) 'Risk Society' theory. Slovic (1994, p. 66) supports Beck's viewpoint and states:

There may be real changes in the nature of today's risks. For example, there may be greater potential for catastrophe than there was in the past, due to the complexity, potency, and the interconnectedness of technological systems and the widespread exposure of millions of people to new technologies and substances.

Further to this, it is important to differentiate between 'uncertainty' and 'risk'. Adams (1995) defines uncertainty as where the probability of an event is unknown, whereas risk infers at least limited knowledge regarding an event or hazard. Brown and Damery (2009) recognise how uncertainty has become a critical factor in environmental debates, especially for global hazards such as climate change. Such global hazards can be differentiated from traditional environmental hazards, such as extreme events seen as natural occurrence, or isolated technological hazards, due to their widespread impacts and their cumulative nature (Cutter 1993).

However, many risk theorists agree that risk has developed into a concept of human creation and subjectivity, and can therefore be managed and controlled through engineered solutions. Westernised countries such as Australia and the UK have traditionally held the viewpoint of being able to predominantly control nature, despite these locations being vulnerable to climatic

extremes and future changes, providing the basis for a flood defence paradigm (Zander *et al.* 2013).

Risk is also connected to the concepts of choice, responsibility and blame. These are major factors in the risk management regime for various natural hazards such as floods and bushfires, where communities and governments look to those responsible for management and provide blame for losses. According to Caplan (2000), Beck and Giddens both agree that societal trust in science has declined, with knowledge challenged by the audience. The publicised case of earthquake management in Italy, L'Aquila is one example, where the seismic scientists faced charges of manslaughter for incorrect advice, and ineffective risk assessments and communication (Cartlidge 2014). A similar experience was also faced by the scientists in New Zealand after the Christchurch earthquake (Marzocchi & Cocco 2013).

Countries around the world are attempting to address growing flood risk by implementing various risk mitigation and adaptation measures to address community vulnerability and increase resilience. These measures will be discussed in section 2.2.6. First, a more detailed description of Beck's Risk Society theory is provided in order to frame this research project.

2.2.4.1 Ulrich Beck's Risk Society

This research study employs Ulrich Beck's *Risikogesellschaft* (Risk Society) theory (Beck 1992) as a philosophical lens to understand the environment in which flood risk and flood management is occurring.

Risk Society theory (Beck 1992) conceptualises how current processes of modern development generate or accentuate risks, and argues that society needs to respond by transforming into a reflexive society, constantly learning how to adjust to societal risk. In such a transformation to a reflexive society or second modernity, society would be defined by its capacity to monitor, reflect upon and respond to risks (Beck *et al.* 2003). Furthermore, Adam *et al.* (2000) expand on Beck's original theory by suggesting that all elements of societal risk have hidden political, ethical and moral agenda.

Risk Society theory developed from a left-wing political perspective with a combination of debates regarding Marxist, constructionist, modernist and realist epistemologies shown to influence the theory (Benton & Craib 2001; Mythen 2004; Turner 2009). Beck therefore identifies as a weak constructivist and stated, '[i]t is not clear whether it is the risks that have intensified, or our view of them. Both sides converge, condition each other, strengthen each other' (Beck 1992, p. 55). It can be seen that both risk perception and the risk itself are inter-linked (Sørensen 2017). Beck therefore disagrees with a stronger constructivist approach

promoted by theorists such as Douglas and Wildavsky (1982) (Sørensen 2017). Beck (2009, p. 84) argues they disregard that, *'people in the Stone Age did not have the capacity for nuclear and ecological self-destruction and that the threats posed by lurking demons did not exhibit the same political dynamic as the man-made risks of climate change'*.

Applications of Risk Society differ from the dominant environmental management paradigm of weak ecological modernisation, currently being applied in most western societies. Ecological modernisation presumes that environmental risks can be controlled by advancements within current management systems; thus, technological progress for managing such risks is promoted. This is particularly the case in the field of flood risk management, as explained by Mol and others (Mol & Sonnenfeld 2000; Mol *et al.* 2010; Mol & Spaargaren 1993, 2000, 2009).

Similar to constructivism, ecological modernisation can be experienced across a spectrum. Ivan (2011) provides some differentiation between weak and strong interpretations of ecological modernisation. A 'weak' perspective is defined as focussed on technical solutions to environmental issues through the elitist corporate policy cycle, whereas strong or 'reflexive' ecological modernisation consists of a much broader, consultative and democratic approach to environmental problems with international considerations (Ivan 2011).

Mol and Spaargaren (1993, 2000, 2009) identify similarities between the two paradigms, including the identification of a need for transformation of old political systems and institutions, and the role of markets and associated economic pressures to catalyse environmental reform. Yet, it can be argued that the ecological modernisation approach (Mol & Sonnenfeld 2000; Mol *et al.* 2010; Mol & Spaargaren 1993, 2000, 2009) will fail to fully encapsulate the needs of society to manage the challenges ahead, and generate the socio-ecological transformations that reflect the emerging Risk Society. For that reason, stronger targeted interventions by the state, in association with cultural and economic systems, will be required to respond to the increasing levels of risk.

For example, since climate change is being generated by societal development itself, climatic change will continue unless society fundamentally transforms. Climatic and other socio-ecological risks will define the relationship between society and the natural environment this century, and generate new risks to governance. The creation of a path to reflexive modernisation is a significant governance challenge. Garnaut (2008) has noted that, without a consensus on climate change and the impacts, management will continue to remain reactive and segregated instead of comprehensively applying the Precautionary Principle in a proactive integrated manner to plan for a sustainable future.

Ecological modernisation alone will never be able to fully frame responses to the major challenges of consumption and risk that societies face, because modernisation generates risk by encouraging the continuation of industrial development (Blowers 1997). In comparison, reflexive modernisation allows society to continually reconceptualise risk, and introduce ongoing changes to adapt broadly across all forms of production, institutions and lifestyles (Blowers 1997). Therefore, in this thesis, reference to the ecological modernisation paradigm typically includes approaches to flood management that are reliant on technological solutions to reduce risk. These approaches continue to encourage the perception that engineered solutions can protect the community from all hazards. By contrast, a Risk Society approach acknowledges that risk is a social construct and demands a holistic approach for disaster and natural hazard management.

2.2.5 Resilience and vulnerability

Disaster and natural hazard management aims to address the resilience and vulnerability of communities who are exposed to risk. The next section defines the key concepts of resilience and vulnerability in relation to hazard management. It is noted there is a substantial amount of multi-disciplinary literature addressing the concepts of resilience and vulnerability, with each concept worthy of its own literature review. Instead, the following section serves to provide a brief overview of each key concept as applied in this thesis.

The IPCC (2012, p. 5) defines resilience as:

The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

Douglas (1982, p. 196) provides an alternative definition, '*resilience is the capacity to use change to better cope with the unknown; it is learning to bounce back*'. Ribot (2010) and Paton (2001) expand on these definitions, arguing that community resilience can be described across several scales, utilising personal and environmental resources and systems. In this sense, resilience is the ability of a community to recover using its own resources. Resilience requires both protection of the physical integrity of the built environment (e.g. building codes, retrofitting buildings) and governance systems, ensuring economic, business and administrative continuity (including emergency management and social institutions). Resilience also requires the community to have the resources, capacity, and capability to utilise physical and economic resources which will reduce disruption to the community's functions and enable improvement.

The partner concept to resilience is vulnerability, which can be defined as ‘*the propensity or predisposition to be adversely affected*’ (IPCC 2012, p. 5). Weichselgartner (2001) provides further review of the various nuances in ‘vulnerability’ definitions, and Cutter (1993, 1996) explores themes around risk and hazard exposure, vulnerability as social response, and the vulnerability of places. In this context, vulnerability has relevance for emergency and hazard management planning through the understanding of place and local value.

While vulnerability and resilience co-exist at both the individual and community scale, the focus is often on resilience (King *et al.* 2014). A resilience focus has significant influence on policy and legislative direction, as it changes the emphasis towards mitigation of flood risk or adaptation to new levels of risk. Applications of this notion of resilience include options such as a relocation or retreat policy, which directly addresses vulnerability to a hazard.

Castree and Braun (2001) suggest that flood hazards have the highest impact of all hazards on the most disadvantaged communities. Adger (2002; Adger *et al.* 2016) agrees, arguing that rising economic inequality is changing risk distribution and the level of social resilience. In general, wealthy individuals and communities have an ability to mitigate or adapt to hazards, because they can afford to invest in insulating mechanisms to increase their resilience against hazards. For example, this can occur either economically in the form of appropriate insurance, or physically in the form of resilient buildings. In contrast, disadvantaged populations are often found residing behind collective protective structures that may generate the perception of safety and promote further development, such as levees and below dams. However, any subsequent failure of these structures then results in significant and sudden disasters costlier than before the structure construction. This is well-known as the levee paradox (Baldassarre *et al.* 2016; Kates *et al.* 2006; Montz & Tobin 2008; Smith 1998; Viglione *et al.* 2014; White 1945).

2.2.6 Mitigation and adaptation

There is significant literature relating to mitigation and adaptation, predominately from a climate change perspective. However, this section clarifies the use of the terms mitigation and adaptation in reference to hazard management as applied in this thesis. Broadly, mitigation and adaptation methods increase resilience and decrease vulnerability to hazards. Bracken (2012) states that some risks can be reduced or avoided through protection, defence, and prevention (mitigation), but others we must need to learn to live with (adaptation). This research adopts Bracken’s (2012) conceptualisation of adaptation as communities will need to learn to live with increased flood risk.

In reference to climate change, the IPCC (2012, p. 5) defines adaptation as follows:

In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to the expected climate.

To address one of the research aims, this thesis will focus on exploring some of the adaptation methods available to individuals and communities to increase their resilience to living with increased flood risk. Jonkman and Dawson (2012, p. 789) highlight a key influencing factor in managing flood risk, that, '*people respond and adapt their behaviour to the conditions to which they are exposed (i.e., they are the reflexive systems)*'.

A focus on adaptation facilitates a greater awareness of the limitations of the current flood management paradigm where risk assessments, design, and planning is based on the assumption of a steady state of previous levels of risk (Keskitalo 2010). As the previous level of risk is exceeded, flood mitigation measures are not as effective, leaving residual risk. To address the residual risk, or replace traditional mitigation structures such as dams and levees, some examples of some possible tools include:

- Relocation (retreat) policies – movement of communities or individual properties away from the risk source. Relocation is often discussed as a viable adaptation solution for sea level rise and coastal flooding in particular (Kates 2007; King *et al.* 2014; Perry & Lindell 1997; Petz 2015).
- Water Sensitive Urban Design (WSUD) - a multi-disciplined approach for integrated water cycle management that aims to reflect environmental, social, and economic water management requirements and strategies. WSUD measures are used to improve water quality and retain or slow the flow of stormwater to reduce low hazard urban flooding, for example, the use of green infrastructure or rain gardens (Salinas Rodriguez *et al.* 2014).
- Sustainable Urban Drainage Systems (SUDS) – can be used to reduce or limit inflow at the minor drainage system level; using measures to infiltrate flow locally, or to store and reuse it. Other options are to divert or disconnect flows to alternative systems or outfalls via overland flow paths (Djordjevic *et al.* 2011; White & Howe 2005).
- Ecosystem services - such as purposeful use of wetlands and floodplains to store flood waters and slow the movement of floodwater, for example 'natural flood management' (in Scotland) (Boyd & Banzhaf 2007; Luisetti *et al.* 2011).
- Financial measures, such as flood insurance – uses a risk-based pricing model to promote policyholder adaptation to flood risk and improving resilience through

recovery to events (Hudson *et al.* 2016; Lo 2013a, 2013b; Penning-Rowsell *et al.* 2014; Rufat *et al.* 2015; Surminski & Oramas-Dorta 2014).

- Building styles, controls, and materials – the use of certain materials and designs can increase resilience of buildings, such as allowing for a waterproof lower level, installation of flood barriers, raising the building on stilts, raising of electrical wiring, dry-proofing and shielding (Australian Building Codes Board 2012; Djordjevic *et al.* 2011; Moore 2012).
- Land use planning - involves consideration of the drainage ‘major system’ (i.e., the above ground flow pathways such as creeks, rivers, swales, instead of the underground piped system) at the planning stage, and its integration into the development planning system. Also includes the restriction of certain categories of development and land uses in accordance to risk exposure (Burby *et al.* 2000; Hegger *et al.* 2016; Howe & White 2004; White & Richards 2007b).

The following section will expand on the adaptation approach of relocation and retreat, since these policies will be explored in some detail in this thesis.

2.2.6.1 Relocation or retreat policies

Relocation (or retreat) policies are analogous to the ‘flight’ from the ‘fight or flight’ response to impending risk and hazards. Relocation policies also allow ecosystem processes to occur with minimal interference. Relocation may or may not be voluntary; some governments have forcefully removed residents for safety reasons, for example in response to a nuclear disaster, volcano, or earthquake (Arnall *et al.* 2013; Badri *et al.* 2006; King *et al.* 2014; Oliver-Smith 1991). This type of relocation may be a temporary solution until the danger of the hazard has disappeared, or may become permanent. Relocation policies also allow ecosystem processes to occur with minimal interference but have potential to increase vulnerabilities and insecurities as experienced in the case of Alexandria, Egypt (Nurse-Bray 2017; Zografos *et al.* 2014). Petz (2015, p. 1) provides the following definition of planned relocation:

Planned relocation is a process in which persons or groups of persons move or are moved away from their homes, settled in a new location, and provided with the conditions for rebuilding their lives. Planned relocation is carried out under the jurisdiction of the state, takes place within national borders, and is undertaken in order to mitigate risk and impacts related to disasters, including the effects of climate change.

Relocation is also discussed in the context of planned migration as an adaptation response to risk (Bardsley & Hugo 2010; Hugo 2011). Relocation has mostly been discussed as an adaptation method in response to climate change where mass planned migration is being

considered; for example, in island nations, such as Kiribati and Tuvalu, or low-lying delta regions of developing countries, such as Egypt (Badri *et al.* 2006; Bogardi & Warner 2009). Relocation policies are already enforced by national law in Italy in response to landslides, mudflow and flood hazards (Menoni & Pesaro 2008, p. 36). Other international examples of relocation policies include in response to flooding in Allenville, USA (Perry & Lindell 1997), and Pune, India (Cronin & Guthrie 2015). Petz (2015) provides a review of further examples from 1950 to 2015. Petz (2015) analyses 38 papers, 17 (covering 24 case studies) categorised as pre-emptive or anticipatory relocation (before the hazard event) and 21 (covering 25 case studies) categorised as reactive relocation (after the hazard event).

Relocation from flood-devastated settlements has also taken place in Australia in the past, for example in the towns of Bega, Moama, Gundagai and Maitland, New South Wales (NSW) (Keys 1995). A relocation policy has been implemented recently in response to flood risk in Grantham, QLD. Grantham's relocation is one reason SE QLD has been targeted as a case study in this research.

While small, rural communities experiencing significant or frequent flood events are more likely to be relocated because of the risks of hazard and the feasibility of movement, relocation policies are now also being considered for larger populations to address flood hazard where it is impractical to remain in place (Petz 2015).

2.3 The history of management of flooding

2.3.1 Flood defence through to flood risk management: a risk based approach

The perception of risk and flooding has altered throughout history as different social and technological paradigms have dominated. Originally, as Samuels *et al.* (2006) outline, flood events were deemed an 'Act of God' and were accepted as part of nature. As the Enlightenment and the Technological Age became dominant in the 18th and 19th centuries, the ideology that humanity could dominate and control nature, and thereby prevent hazards, appeared (Samuels *et al.* 2006). The concepts of flood response, flood defence and flood protection and prevention predominated (Samuels *et al.* 2006), consistent with the description of ecological modernisation (Macnaghten & Urry 1998; Mol & Sonnenfeld 2000; Mol *et al.* 2010; Wisner *et al.* 2004).

In the flood defence and prevention paradigm, key interventions include the conversion of watercourses to concrete channels, the clearing of vegetation, and the building of hard structural defences such as flood mitigation dams, detention basins, walls and levees. While such engineering methods are often successful to their designated design limits, floods exceeding

those thresholds can have catastrophic results. Likewise, as Douglas and Wildavsky (1982, p. 197) warn, as an example of a strong constructivist viewpoint, *'if some degree of risk is inevitable, suppressing it in one place merely moves it to another'*. This can be seen to have eventuated in the catastrophic flood event in New Orleans, USA due to Hurricane Katrina, where the complex Mississippi River levee systems were breached.

Large-scale technological failures, such as experienced in the New Orleans disaster, also demonstrate the isolation of flood defence structures from their landscape with any potential for technological or systemic multi-functionality often not taken into consideration (Jonkman & Dawson 2012). As greater understanding of hydrological, landscape, and social systems occurs, the need for integrated water cycle management has become clearer. Such an approach would frame flood risk management systems and infrastructure as part of greater, increasingly interdependent system spanning across water and the landscape.

Following on from increased understanding of these systems, there is growing recognition that long-term use of flood defence mechanisms is unsustainable, considering increasing risk from climate change impacts, changing land use, and population pressure (Evans *et al.* 2004; Treby *et al.* 2006). The recognition that flood management requires consideration of environmental sustainability and social responsibility is characterised by the challenges of Beck's Risk Society.

2.3.1.1 A Transition to Sustainable Flood Risk Management

From the early 1990s, there has been a recognised shift away from a flood defence and flood protection paradigm to a flood risk management paradigm (Schanze 2006). Many Organisation for Economic Co-operation and Development (OECD) countries and the academic literature (e.g. Brown & Damery 2002; Bubeck *et al.* 2015; Challies *et al.* 2016; Hall *et al.* 2003; Hillman 2009; Hochrainer-Stigler *et al.* 2013; Johnson & Priest 2008; Penning-Rowsell *et al.* 2006) policy discussions have recognised the shift to a risk-based approach. Flood risk management aims to integrate structural defensive and protection measures with non-structural measures, reducing the impact of flooding through land use planning, education and awareness programs, emergency warnings and insurance programs. Flood risk management is grounded in risk-based decision-making, integrative management and stakeholder engagement (Challies *et al.* 2016; Huitema *et al.* 2009; Ward *et al.* 2013). The move to flood risk management has occurred in response to increased risk (Butler & Pidgeon 2011; Johnson & Priest 2008) and recognition of limits to the flood defence and prevention paradigm.

Butler (2011) and Johnson and Priest (2008) explain how the shift to a flood risk management paradigm is linked to sustainable development principles and government rationalities associated with advanced liberalism. Following this viewpoint, the focus of management has switched from the flood water itself, to the exposed communities and those agencies with roles and responsibilities for flood management. Butler (2011) examines how floods were once deemed as a natural threat (in the flood defence paradigm) and have transitioned into the social dimension that can be governed through government infrastructure and processes, like the non-coercive rationalities of advanced liberalism.

Transition towards a flood risk management framework integrating sustainable and natural flood risk management approaches also makes economic sense. As Salzman *et al.* (2001) point out, '*the economics of 'natural' solutions to flood control would seem to favour such methods over engineering approaches*' (Salzman *et al.* 2001, p. 320). There have also been many reports in the European context, criticising the focus on hard technological 'solutions' to flood hazard across the government, non-government and academic sectors (e.g. Cook *et al.* 2013; Dawson *et al.* 2011; Holstead *et al.* 2015; Johnson & Priest 2008; Lane 2008b; Lane *et al.* 2003; Lane *et al.* 2011; Pitt 2008; Rouillard *et al.* 2013; Scottish Government 2011; Werritty 2002, 2006). Jonkman and Dawson (2012) discuss the vulnerability of hard flood defence systems and their impact on the social and ecological systems that they influence, highlighting the need for accurate flood modelling, data and mapping to better understand and manage informed decision-making.

Sustainable flood risk management is a contemporary component of flood risk management and considers floods as providing an 'ecosystem service' while the landscape provides a role in reducing risk (e.g. Boyd & Banzhaf 2007; Chan *et al.* 2006; Farber *et al.* 2002; Salzman *et al.* 2001; Swallow *et al.* 2009; Tomich *et al.* 2004). Ecosystem services indicate the value that is allocated to an ecosystem function, thus recognising the benefits that the processes provide to human systems (Constanza *et al.* 1997; Department of the Environment 2009). The use of landscape function is an example of this; for example, natural flood management methods follow sustainable development principles, such as reforestation to moderate water flows and wetlands to hold and slow the flow of water (Salzman *et al.* 2001). The use of landscape function demonstrates how a natural system can provide an economic viability for operating in a natural manner. Salzman *et al.* (2001) provide many other examples of how the use of natural processes for flood management have successfully mitigated and decreased the vulnerability of the affected communities to flood hazard.

Farber *et al.* (2002) discuss the ecological thresholds for ecosystem services, and the value of vegetation and flood mitigation. Farber *et al.* (2002) recognise that there is often conflict

between ecological and economic values, which becomes apparent in the management of flood risk. Using a flood risk management approach, it is up to communities and decision-makers to decide the values for implementation. However, acknowledging the value environmental services provide allows justification of non-structural approaches for flood risk management, whilst also recognising ecological benefits which flooding produces, such as fertility for agriculture or wetlands or the disturbance of forested areas.

The value of a sustainable flood risk management approach encompassing natural flood management has been supported across Europe, led by the EU Directive in flood risk (European Union 2007) which will be discussed further in Chapter Six. Scotland is a world leader in the sustainable flood management approach, where flood risk schemes:

Must be developed with consideration of catchment processes and characteristics, making all reasonable and practical efforts to enhance the (urban and rural) landscapes' natural ability to slow and store flood water (Scottish Government 2009b).

The leadership of Scotland for sustainable flood risk management provides the rationale for the third case study presented in this research.

Countries such as The Netherlands and Germany are also transitioning to sustainable flood management, with policies like '*Making Room for Rivers*' and '*Slowing the Flow*' being promoted and implemented (Biron *et al.* 2014; Bubeck *et al.* 2015; Hartmann & Spit 2016). These countries have also progressed along the risk theory continuum by removing historical significant levee systems, examples of an ecological modernisation approach in the first modernity, to returning and rezoning areas of land for designated flood areas, in line with the Risk Society paradigm. These approaches are attempting to transform and return some of the balance between nature and society, in accordance with a reflexive or second modernity in a Risk Society. Sustainable flood management also recognises the need for an integrated water cycle management approach, which considers flood issues and solutions to stormwater in relation to water quality and biodiversity benefits.

According to Cook (2016) and Werrity (2006), despite these transitions of policy and legislation to a sustainable flood management approach, the previous cultural framing of flood defence has endured in Scotland and remains a challenge for practitioners as they attempt to reconcile traditional approaches with the emerging, critical alternative.

On a global scale, while countries vary in their approach to flood management, there is a common reliance on the ecological modernisation approach of attempting to control and contain a natural process using traditional hard engineering methods. With the onset of climate change and the predicted exacerbation of flooding frequency and magnitude in some areas, the

epistemological approach of sustainable flood risk management will become vital if successful management methods and governance systems are to adapt to the new conditions.

2.4 Governance of flood risk

2.4.1 Government and governance

Government policy and decision-making in liberal democracies such as Australia follow a ‘rationalist’ model (Head 2008; Head & Alford 2015; Heazle *et al.* 2013; Marston & Watts 2003; Sanderson 2002). A rationalist approach implies that policy objectives are well defined, understood and government decisions are objectively evaluated using accurate assessments of costs and benefits (Heazle *et al.* 2013). Flood risk management rarely depicts this kind of clarity because of a lack of knowledge and data, competing goals, and a lack of in-depth cost-benefit analysis of the full range of management possibilities (Heazle *et al.* 2013, p. 163). There are also several players influencing management of flood risk, resulting in flood risk becoming an issue of ‘governance’ rather than ‘government’.

Governments are no longer seen as single sources of authority around decision-making in resource policy and management. Instead, a multi-scale, polycentric approach to governance has taken over, whereby the contribution of many stakeholders from various institutions is recognised (Pahl-Wostl *et al.* 2008). Jordan *et al.* (2005) provide some significant discussion around the definition of ‘government’ and ‘governance’ across various disciplines, and the types of governance (Table 1). In the context of flood management, Pierre and Peters’ (2000, p. 1) description of ‘governance’ is apt, in that the term ‘governance’ has the ‘*capacity – unlike that of the narrower term ‘government’ – to cover the whole range of institutions and relationships involved in the process of governing*’. Driessen *et al.* (2012) agree that governance consists of an arrangement of public and/or private actors from different institutions, with a specific approach to managing the issue, i.e. flood risk. This process of governing utilises an entire range of legislation and policy tools (Jordan *et al.* 2005), some of which are discussed throughout this thesis.

Table 1 Basic governance types

	<i>Government Determines Societal Goals (Ends)</i>	<i>Society Determines Societal Goals (Ends)</i>
<i>Government selects the means of policy</i>	STRONG GOVERNMENT: hierarchical steering from the centre	HYBRID TYPES
<i>Society selects the means of policy</i>	HYBRID TYPES	STRONG GOVERNANCE: society is 'self-steering' and 'self-organising'

Reproduced from Jordan *et al.* (2005), p. 484

The main players, or 'risk practitioners' in the governance of flood risk include different political and geographic scales of government across various government departments (typically relating to infrastructure, planning, environmental, social inclusion, and safety), emergency services, meteorology services, community groups, non-government organisations, insurance industry bodies and private companies, and industry specialists such as engineering and hydrology consultants. In Australia, these practitioners fall under the emergency management 'prevention, preparedness, response and recovery' (PPRR) organisational framework. These management bodies can all have involvement in the formation and implementation of public policy through formal and informal engagement processes.

The UK provides an example of complex formal governance, where the Environment Agency, Department for Environment, Food and Rural Affairs (DEFRA), emergency services and Met Office, together with non-government organisations such as the National Flood Forum, Association of British Insurers (ABI), community groups, local flood action groups, private consultants, private citizens and businesses, play a role as part of partnership-funding agreements. Across these groups there are a range of traditional command-type, regulatory policy tools, as well as softer policies to provide guidance (Jordan *et al.* 2005). The governance framework defined throughout this thesis includes (but not exclusively) the use of:

- Various legislative, regulatory and policy tools across disciplines
- Flood hazard mapping and flood risk assessment used for planning
- Development, land use planning and building policies, codes and guidelines
- Any other governmental decision-making tools and processes.

Since the popular movement for an inclusive governance system continues, social learning needs to be a significant part of policy development and implementation (Folke *et al.* 2005; Pahl-Wostl *et al.* 2007; Pahl-Wostl *et al.* 2008). Social learning in governance is important when considering socio-ecological systems such as flood management and catchments, as the impacts of flooding are a social problem. A significant problem is a 'lack of understanding of

the governance and cultural systems and how they are structured and managed and interact with ecological systems, and how we produce science and knowledge for policy' (Pahl-Wostl *et al.* 2008, online). Successful governance requires new ways of conceptualising institutional arrangements based on the adjusted framing of issues (Pahl-Wostl *et al.* 2008), including the large influence of the awareness and perception of flood risk (Daniell *et al.* 2011).

2.4.2 Governance across scales

The scales at which the governance of floods occurs is fundamental to this research as flood risk is both experienced and governed cross- and within- scales. Cash *et al.* (2006, online) define cross- scale as, *'interactions across different scales, for example, between spatial domains and jurisdictions'*. The understanding of how the concept of scale is framed is important as, *'complex policy processes increasingly play out in multi-level and multi-scale contexts; this means that actors and processes operating on different scales and levels are involved'* (van Lieshout *et al.* 2011, p. 1). The three case studies have been analysed across political jurisdictions and geographic scales to provide deeper insights of actual or perceived challenges, and opportunities and barriers for adaptation to future risk. The scale rationale will be discussed further in Chapter Three.

The complexity of policy and scale is particularly relevant for flood management and has implications for decision-making. Cash *et al.* (2006) determined that decision-making as part of the policy process fails when the cross-scale dynamics of complex human-environment systems are not taken into account. Kok and Veldkamp (2011, online) suggest that preventing process failure requires, *'a transdisciplinary arena is required where the concepts of scale and governance are framed such that a broad variety of stakeholders can join the debate and/or the decision-making process'*.

Multi-level governance is defined as a decision-making process that occurs across public and private institutions, and across multiple political and geographic scale levels and sectors (Boland 1999; Daniell *et al.* 2011; Hooghe & Marks 2003; Keskitalo 2010). The majority of studies relating to adaptation examine either/both flood risk or climate change, and adaptation at a singular scale (predominately local or national) (Keskitalo 2010). This is despite adaptation to flood risk occurring through changes at local, regional, national and even international levels (Keskitalo 2010). Therefore, it is exceedingly unlikely that any one government agency, non-government organisation, industry, or private individual will have the resources or political power to make or implement decisions without the support of other entities (Daniell *et al.* 2011). Multi-level governance also becomes increasingly complex as often catchment and water

resource management are considered within administrative boundaries instead of physical or catchment boundaries. Boundaries can become of significant importance if limited or ineffective collaboration between governance agencies occurs, resulting in poor outcomes (Zevenbergen *et al.* 2013). The design of successful governance frameworks and processes is a challenge, and full of practically and politically complex factors (Adger *et al.* 2005; Adger *et al.* 2004; Daniell *et al.* 2011; Olsson *et al.* 2004).

In consideration of the complexity involved in the governance of flood risk, Rittel and Webber's (1973) conceptualisation of 'wicked problems' is adopted to provide a greater understanding of governance practices as the involved parties the high stakes (people and property), with a high degree of uncertainty (increasing flood risk) and the diverging perspectives on values and facts (risk perception) (Funtowicz & Ravetz 1993; Mazzega *et al.* 2014). Wicked problems are those which cannot be described easily, and the search for a technical or scientific solution will fail (Rittel & Webber 1973). Head (2008, p. 102) has argued that, *'technical approaches are bound to overlook the values, perspectives and lived experience of the stakeholders and citizens who are directly or indirectly assisted or involved in these interventions'*. Head (2008) goes on to state that addressing wicked problems, such as flood management, requires *'deliberation and debate concerning the nature of the issues and exploring alternative ways forward'* (Head 2008, p. 102). This reflects Beck's (1992) idea that government institutions that were developed in the nineteenth century do not have the capacity in their current format to manage complex environmental issues and wicked problems. For example, the earliest of climate change agencies were not introduced until the late 1980s. Howes *et al.* (2012) agree with Beck, and say that policy-making processes were not designed to address wicked problems such as flood management, and suggest a sequential or iterative decision-making approach to policy-making.

The next section will examine how risk perception is interrelated with the governance and decision-making process, impacting on actual responses for flood management.

2.5 Risk perception

Risk perception is a key concept in this research, since the perceived level of flood risk significantly influences the management approach undertaken through the level of awareness, preparedness, and response by individuals and governance organisations (Djordjevic *et al.* 2011). How risk perception applies to management will be explored across the three case studies and discussed further in Chapter Seven.

There are many influences on how risk is perceived by individuals, groups, and societies (Cutter 1993). As Davies *et al.* (2012) state, risk has become a significant factor in our daily lives. Wilkinson (2001) suggests that modern society has become more preoccupied with risk than historical societies, and an increased awareness of environmental risks has arisen because of mainstream media coverage of high profile events. Slovic (1994) agrees, and highlights that risk is perceived to be at a greater level despite society having a higher standard of living, with safety and health levels increased. Several factors may influence this, such as improved technology increasing our awareness and knowledge of possible dangers and hazards, and our reliance on such technologies to manage these identified risks (Slovic 1994). Additionally, adding to the complexity of how risk is interpreted is related to a reliance on technology and potential litigation involved when mistakes are made, or the technology fails (Slovic 1994). An example of this is the well-publicised perceived failure of the Wivenhoe Dam in the 2011 QLD floods. The role of perception in the QLD floods will be discussed further in Chapter Five.

Certain cultures perceive the world to have certain hazards and danger, whereas others may perceive there to be minimal concern (Adams 1995). For example, communities in Bangladesh who accept floods as a part of life and have adapted to live with floods would have different risk perceptions compared to those in many Western societies where restraint and control of flood waters is a historic dominant management paradigm.

The main factors influencing risk perception and acceptance include the experiences of those affected, personalities, social and cultural influences, philosophies and politics (Cutter 1993). As Brown and Damery (2009) suggest, the perception of risk depends on awareness or recognition of a problem, the importance of that risk, and the perceived ability for a positive outcome or resolution. The way in which these psychological, social and cultural perceptions interact with awareness results in the level of confidence surrounding the identified risk (Brown & Damery 2009). It has also been determined that an individual perceives risk in accordance to their experiences and personality in conjunction with the cognitive structures of the brain itself (Brown & Damery 2009). Douglas (1982, p. 194) states:

Acceptable risk is a matter of judgement and nowadays judgements differ.
Between private, subjective perception and public, physical science there lies
culture, a middle area of shared beliefs and values.

Community responses to flood risk and how decision makers develop policy, planning and legislation is impacted by risk perception and what is deemed to be an acceptable level of risk. For example, if residing on a floodplain with built flood defences, the assumed exposure to flood hazard by residents is low (White, 1942; cited in Lane 2012; Ludy & Kondolf 2012). A resident of such an area may decide that the benefits of living in the area, such as infrastructure, resources and fertile soils, outweigh the negative impacts of floods themselves. However, Lane

(2012) suggests that personal experiences, such as an extreme flood, can alter people's likelihood to take risks and their perception of danger; this is also discussed by theorists such as Cutter (1993) and Slovic (2000). In addition, the likelihood to take risks is characterised by others who make statutory arrangements regarding the flood risk, and therefore development and its protection (Lane 2012). This concept indicates the importance of having strong, evidence-based policies and legislation in place as part of governance process to manage the key issues for flood management.

2.6 Key issues for management: failure of the current paradigm?

Increasing populations and settlements with a growing number of assets and value, compounded by climate change, all add to the rising costs of flood damage in risk exposed areas. The increasing tangible and intangible flood impacts creates challenges for insurability (Swiss Re 2012). The challenges posed by climate change and urbanisation will be discussed in more detail below and adaptation to the new levels of uncertainty and risk they pose will be examined throughout the remaining chapters.

2.6.1 Climate change

Anthropogenic climate change will have many impacts world-wide. The IPCC reports provide a thorough synthesis of impacts and evidence (IPCC 2013, 2014a, 2014b). Arnell and Gosling (2016) provide a recent review and global analysis under several modelling scenarios of the impact of changes in flood risk. While many issues from increasing temperature are expected, the changes to extreme weather patterns may have the most significant impact on society. Climate is likely to become increasingly variable, with a change in frequency and intensity of extreme weather events (IPCC 2014a). The hydrological cycle is likely to become more intense and the *'frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century over many areas of the globe'* (IPCC 2012, p. 13). There is also *'medium confidence that, in some regions, increases in heavy precipitation will occur despite projected decreases in total precipitation in those regions'* (IPCC 2012, p. 13). As evidence continues to mount, confidence in predictions is becoming more certain.

The changes in precipitation levels and behaviour, coupled with the increase in temperature, will lead to changes in flooding frequencies, behaviour and intensity. However, the IPCC states that there is:

Currently limited to medium evidence available to assess climate-driven observed changes in the magnitude and frequency of floods at regional scales

because the available instrumental records of floods at gauge stations are limited in space and time, and because of confounding effects of changes in land use and engineering. Furthermore, there is low agreement in this evidence, and thus overall low confidence at the global scale regarding even the sign of these changes (IPCC 2012, p. 13).

However, there is strong evidence and consensus that sea level rise, tropical cyclones, heat waves, glacial retreat, and permafrost degradation are occurring, thus increasing the likelihood of coastal, glacial and mountain flooding (IPCC 2012, 2013, 2014a, 2014b).

van Aalst (2006) provides a review into climate change and natural disasters, and highlights some of the issues around managing the growing uncertainty related to the impact of climate change on flooding. Based on a synthesis of global research, van Aalst (2006) concludes there is a consensus for increased flood risk, where the greater impacts will likely be felt due to new levels and frequencies of extreme events rather than from manageable events. It is important that regional influences such as landscape changes, population growth and urbanisation are also taken into consideration when considering floods and climate change (van Aalst 2006).

Supporting the IPCC research and van Aalst (2006), Arnell and Gosling (2016, p. 392) state that, *'the effects of climate change on flood characteristics therefore vary across space, depending on flood generating mechanism'*. Arnell and Gosling (2016) found that intense rainfall and the resulting saturation changes are particularly important in certain landscapes. Changes in temperature and rainfall will have significant influence on snowmelt floods depending on whether snow accumulation increases, or there are changes in timing or the amount of snow falling returns to precipitation. In relation to snowmelt floods, the flood regime may change from spring snowmelt flooding to rainfall-based floods in winter.

Overall, climate change will alter the global exposure to flood hazard, but this will change across regions with some areas experiencing an increase and others a decrease in risk. Climate change is likely to transform the current regimes of floods, but there is still much uncertainty in the magnitude of impacts worldwide. Climate change will proffer new opportunities and challenges, resulting in new forms of power, inequality and insecurity – together with new ways of developing cooperation and solidarity. Additionally, since jurisdictional boundaries do not limit climate change, local responses will become increasingly insufficient (Becker *et al.* 2013). Thus, partnership approaches need to be considered to manage flood risk, and this will bring further political challenges. Castree (2010, p. 2) summarises the management challenge presented by climate change and to a lesser extent hazard management:

Geopolitical tensions bubble under the surface where they are not already made manifest. Virtually all the world's problems have an international dimension to them, yet cross-governmental efforts to enact joined-up policy – such as the Kyoto Protocol – are routinely foiled or attenuated. But like any

crisis moment, the late naughties are at a crossroads, a crucial interregnum of immense opportunity and new possibilities.

The uncertainty around climate change needs to be considered together with other factors which will increase the impacts of floods, such as growing urbanisation and populations exposed in flood risk areas.

2.6.2 Urbanisation

The environmental pressures of growing populations, urban sprawl and development infill will have the most compounding influence on flood regimes. Recent predictions suggest that urban areas exposed to flood risk will increase by a magnitude of 2.7 by 2030 (Rojas *et al.* 2017).

The effect of urban development has been well documented and quantified in the literature and applied practice (e.g. Hollis 1975; Huong & Pathirana 2013; Nirupama & Simonovic 2007; Schultz 2006; Smith *et al.* 2001; Wright 2001a; Zhu *et al.* 2007). Urban development is changing fluvial morphology and hydraulic geometry by decreasing the permeable surface area, dredging and digging out watercourse channels and generally changing the landscape for construction (Rojas *et al.* 2017). These cumulative impacts are increasing the level of runoff, in turn increasing the likelihood of localised urban flooding.

The effect presents a significant management challenge in urban areas, as intense rainfall is placing pressure on often aging drainage systems above their design capacity, increasing the volume of runoff entering rivers or urban watercourses. The removal of suburban gardens and park areas, the sub-division of blocks and rural areas serves to exacerbate these issues, with peak flow increases up to an estimated 300% (Hollis 1975; Huong & Pathirana 2013; Kemp & Myers 2015; Miller *et al.* 2014; Nigussie & Altunkaynak 2016).

Prevailing governance challenges are around how to manage increasing levels of flood risk with the needs for new development and economies. Menoni (2008, p. 34) indicates that, *'stressing this point again and again is important because, despite the advancement in legislation and normative rules, urban development is still driven more by real estate market pressures than by safety considerations'*.

Brogan also describes the severity of the impact of urbanisation and flooding:

The work of urbanisation goes on but we are unwilling to face its implications and, less and less does the traditional view that the city appears and grows in response to favourable geographic conditions, describe the realities of modern urban growth (Brogan 1963, p. 161).

The large influence of urbanisation reinforces the importance of smart urban planning and consideration of geography and proximity to floodplains, as *'the urbanisation process tends to be definitive and in general terms irreversible'* (Menoni & Pesaro 2008, p. 34). As Menoni (2008, p. 34) points out, *'wrong siting decisions are still being made, creating the ground for very high collective costs: the cost of today's urbanisation, the cost of tomorrow's first attempt to mitigate risk once a disaster occurs, and finally the cost of relocation'*.

2.7 Study rationale

There is evidence that modern societies are managing flood risk, however escalating costs and worldwide concern indicate that there is significant room for improvement. The 2015 United Nations Office for Disaster Risk Reduction (UNISDR) (2015) report stated that the economic losses from natural disasters, including flooding, is approximately US\$250 billion to US\$300 billion annually. The costs of tangible and intangible flood damages are only increasing (Swiss Re 2017); influenced by the combined impacts of urbanisation from growing populations and a changing climate creating an unprecedented 'risky environment'. The increasing impact and frequency of natural disasters worldwide presents a need for greater understanding of how we manage flood risk (White & Haughton 2017).

Flood management is a complex, multi-dimensional, or 'wicked' problem (Rittel & Webber 1973) with interested parties across many economic, social, cultural, political and environmental systems. As such, the governance, planning and risk perception of flood risk is also increasingly complex.

A flood defence paradigm has been historically dominant, with an evidence-base from engineering and modelled solutions. However, residual risk is increasing, and the complex human factors (social, cultural, economic, and perception) contributing to flood risk require a more holistic flood risk management response. Current governments are seemingly struggling with modern levels of risk as determined by the increasing damages. There is a current apparent lack of motivation and support for preparedness in comparison to funding and attention provided to response and recovery (Simpson *et al.* 2016). Decision-making processes for hazard management are made in an environment of uncertainty, resulting in trade-offs between objectives, values, and actors. More informed and improved decision-making will result in reduced risk, increased resilience, effective resource allocation, and a holistic approach with multiple benefits (Simpson *et al.* 2016). Thus, by examining the three case studies with different geographical and political scales and contexts, this thesis aims to address the following research questions:

- What are the key challenges for flood management in the context of the:
 - Governance framework
 - Local context of the case study site
 - Stakeholders' perceptions and acceptance of risk?
- What are the options for an adaptive management approach to flood risk?

The different perspectives framed within the context of the three case studies will enhance the understanding of flood risk adaptation measures. Therefore, the results and learning from the case studies at the different geographic and political scales will help to facilitate a greater frequency and confidence in the implementation of alternative flood management practices.

2.8 Chapter summary

This chapter defined the key concepts and terms used throughout this thesis, and framed the study with a discussion themed around 'risk', 'risk perception', 'governance', and 'adaptation'. The transition of flood management across the spectrum of approaches from flood defence to sustainable flood risk management reflects a change in social, political, and cultural systems, and how they address flood hazard. These systems are being continually threatened and exposed to conflict by two of the main factors increasing flood risk – climate change and urbanisation. Beck's Risk Society provides a philosophical lens for exploring these issues, together with the importance of how risk is perceived. Within this context, the next chapter outlines the research design and methods employed to fulfil the aim of this study.

Chapter 3: Research design and methods

3.1 Introduction

Chapter Three describes the research design employed to meet the aim of the research: to identify challenges influencing flood risk management approaches across the three case study sites across governance, local context and the risk perception; and the examine options for adaptation to flood risk. A review of the literature led to the rationale that current governance and flood management systems are complex and require a deeper understanding for analysis. For this reason, a qualitative approach was undertaken to identify any recurrent themes for examination in more detail. The chapter concludes with an outline of the scope and limitations of this study.

3.2 Research design

3.2.1 Qualitative research

Qualitative research is generally conducted through intense or sustained contact between the researcher and the research participants, in order to investigate their perceptions of an issue. The methodology in this study was designed to analyse differences between flood management approaches. Qualitative research was used as adaptation, flood management and other ‘wicked’ problems are complicated and nuanced, and a quantitative approach would trivialise the results (Radhakrishnan *et al.* 2017). Baxter and Eyles (1999) provide a review and further justification for the use of qualitative research for hazard and risk research.

The use of qualitative methods has many advantages, despite criticisms largely associated with the lack of replicable methodology from researchers who prescribe to quantitative research methods. For example, qualitative data can provide a snapshot of ‘real life’ and ‘groundedness’ within the local context, allowing for in-depth understanding of underlying and implicit factors relating to the issue at hand (Waller *et al.* 2016). Qualitative research facilitates the ‘*exploration of the ways in which meanings, emotions and values come to constitute our world*’ (Anderson 2004, p. 254).

The flexibility in the qualitative approach generates improved comprehension and an ability for respondents to provide their own assessment of causation, which quantitative approaches may not have the capacity to achieve. Furthermore, qualitative research is acknowledged to be a valuable strategy for exploring new areas, discovering new findings, and creating hypotheses or generating theories (Miles *et al.* 2014).

3.3 Methodology

The methodology for this study was based on elements of grounded theory and a case study approach. The following sections outline these two approaches, including key reasons these methodologies were selected for this research.

3.3.1 Grounded theory

Grounded theory involves continuous interplay between the data collection process and the data analysis to develop a theory (Bowen 2006). Grounded theory was introduced by Glaser and Strauss (1965, 1967) who presented systematic methodological strategies and approaches for developing complex theories from qualitative data, as opposed to testing pre-existing hypotheses (Charmaz 2014).

Grounded theory is embraced by postpositivists (or systematic) researchers, who recognised the validity of the approach when used following specific protocols (Creswell & Miller 2000). Charmaz (2014) and Mills *et al.* (2006) advocate the constructivist approach to grounded theory, which includes a more inductive, comparative, emergent, and open-ended approach in comparison to the grounded theory methodology developed by pioneers Glaser and Strauss. Constructivists generally believe in interpretive, open-ended, and contextualised perspectives (Creswell & Miller 2000). The constructivist position of grounded theory acknowledges the ‘construction’ of research and bias that may be applied, despite the attempted neutrality of the researcher. This position allows for significant researcher reflexivity in the process of analysis. Hall and Callery (2001) explain that such reflexivity acknowledges the researcher influence over the researcher-participant interactions. Furthermore, relationality notes the effect of power and trust on the researcher-participant relationship. Reflexivity together with relationality serve to increase the validity of the findings in grounded theory studies.

The validity of the approach is further enhanced by demonstrating trustworthiness and authenticity (Creswell & Miller 2000). Validity can be enhanced by sourcing data from various locations and using triangulation to verify the information obtained (Bryman 2008; Thomas 2009). Appropriate sources include interviews, observations, government publications, published media, videos, academic articles, correspondence, and books (Corbin & Strauss 1990).

One critique of grounded theory is the amount of data that can be collected. While noting that a lack of repetition can be an issue, there is recognition that small samples and limited cases are not an issue if thick, rich descriptive information is collected (Charmaz 2014; Creswell & Miller 2000; Glaser 1998). In other words, despite appearing low in quantity, the high quality

of the data still allows for analytical methods and concepts to be developed, and for categories to be defined and interrogated by the researcher.

According to Charmaz (2010, 2014) and Glaser (1967), a grounded theory study involves:

- Simultaneous involvement in the data collection and analysis
- Analysis of actions and processes instead of the themes and structure
- Constructing codes from the data, not from pre-conceived hypotheses
- The use of comparative methods
- Advancing theory development during data collection and analysis
- Conducting a literature review after independent analysis
- Theoretical sampling, not sampling for population representativeness
- Note-taking to develop categories, their properties and defining relationships between categories and identifying any gaps and differences.

This study utilises grounded theory methodology to explore and understand the viewpoints of a variety of stakeholders, and synthesises this with data obtained through document analysis. In line with grounded theory methodology, this research employed theoretical sampling and semi-structured interview techniques to create rich data sets, from which themes (or codes) were developed. As Charmaz (2014, p. 23) explains, rich data are '*detailed, focussed, and full. They reveal participant's views, feelings, intentions, and actions as well as the contexts and structures of their lives*'.

3.3.2 Case studies

Case studies allow for an exploratory approach enabling greater understanding of a problem or phenomenon (Eisenhardt 1989). As Yin (2004; 2009) argues, the advantage of case studies is that they allow for the demonstration of a phenomenon in its context, a process which is unable to be replicated through wider quantitative research methodologies. Case studies are often used to explore in-depth hazard management scenarios (Badri *et al.* 2006; Department for Environment Food & Rural Affairs 2014a; Krol 2014; Lopez Marrero 2009; Mathew *et al.* 2012; von der Dunk *et al.* 2011).

A multi-case study approach was employed in this study to gain an overview of how the challenge of managing flood risk is being addressed in Australia and internationally (Hay 2010). Furthermore, comparison of multiple case studies increases the robustness of the research method and the validity and reliability of the results (Eisenhardt 1989; Yin 2004, 2009).

3.3.2.1 Selection of case studies

The three case study locations share comparable environmental features despite their different socio-political contexts. The criteria used for selecting case study sites for this research were, broadly:

- An exposure to significant flood risk
- Urban characteristics
- A use of alternative and innovative approaches to managing perceived flood risk.

The selection process involved screening for case study sites with similar social, political, cultural, and economic characteristics, while offering a range of other variables to aid comparison including across scales. The use of case studies across different scales is reflective of the governance of flood risk. Flood risk is both experienced and governed across and within multiple scales as discussed in Chapter Two. Therefore, the framing of results from multiple perspectives of geographical and political scales will enhance the understanding of key challenges to allow for increased facilitation of adaptation options to increased flood risk (Radhakrishnan *et al.* 2017).

Table 2 depicts variables taken into account to justify case study site selection. These variables will be expanded on in the discussion below.

Table 2 Justification of case study sites with similarities and differences

	CASE STUDIES		
	SA (Brown Hill Keswick Creek (BHKC)) (Australia)	SE QLD (Australia)	SCOTLAND (UK)
Multi-tiered political system	Three-tiered government: local, state, federal	Three-tiered government: local, state, federal	Four-tiered government: EU, UK, Country, Municipality
Governance scale focus	Local/Municipality (third tier)	State (second tier) and Local/Municipality (third tier)	Country (third tier)
Community influence	✓		✓
Poor historical planning	✓	✓	✓
Historical approaches to flood risk management	✓	✓	✓
Current approaches to flood risk management	Community participation	Relocation and Structural mitigation	Natural and Sustainable
Economy	OECD	OECD	OECD
Flood history	✓	✓	✓
Type of flood risk	Pluvial (stormwater) Fluvial (riverine) Flash flooding	Pluvial (stormwater) Fluvial (riverine) Flash flooding	Pluvial (stormwater) Fluvial (riverine) Coastal Flash flooding
Landscape use	Urban	Rural and urban	Rural and urban
Growing populations	✓	✓	✓
Increased risk from climate change	✓	✓	✓
Mitigation/Adaptation focus	Mitigation	Adaptation	Adaptation

Two countries, Australia and the UK, were selected. Australia and the UK are both OECD member countries, and have highly developed democratic systems with high standards of living. Although their governance systems have very strong historical and contemporary similarities, the two countries have slightly different political systems that influence the development and implementation of flood management policies. The federated system of Australia enables parallels to be explored with the supra-state governance framework of the EU.

The UK is a member country of the EU¹, and adheres to the European Directives, including those relating to flood management (for example, the *Directive 2007/60/EC on the assessment and management of flood risks (Floods Directive)* (European Union 2007). England, Scotland, Wales and Northern Ireland have their own national policies and planning systems. Scotland introduced legislation specific to flood management, with the *FRM Act 2009*. Significantly for this research, this legislation adopts a sustainable flood risk management approach. The legislation also compels individual local authorities in Scotland to take jurisdictional responsibility for the management of flood risk in their area.

Australia is a federation operating with three levels of government: Federal, State and Local. In terms of flood risk management, the State and Local governments maintain the majority of responsibility. In SA, relevant State government legislation includes the *Natural Resource Management (NRM) Act 2004* and *Local Government Act 1999*; in QLD, the *Planning Act 2016*. The Federal government provides general overall guidance through policy, and influences implementation through funding.

Both countries experience significant – occasionally catastrophic – and, in certain areas – frequent flooding. Recent flood events include the 2011 SE QLD floods, and the 2007 and 2015/16 flood events in the UK. Although both countries have sophisticated governance arrangements, they are still struggling with the challenge of managing flood risk in the face of population growth, urbanisation and climate change. These challenges are continuing, despite several decades of institutionalised and applied flood risk management. Perceived system failures have resulted in a number of formal reviews in both jurisdictions (Grantham Floods Commission of Inquiry 2015; Pitt 2008).

The three case studies selected for this research present snapshots of alternative approaches to management of perceived flood risk:

¹ At the time of the research (2011-2017), the United Kingdom was a member of the EU.

- Case Study One – study of the approval process for BHKC Stormwater Management Plan (SMP) in SA
- Case Study Two – study of the governance response to the 2011 flood event in SE QLD
- Case Study Three – study of the implementation of the *FRM Act 2009* in Scotland, UK.

The case studies will be presented in scalar order, demonstrating how risk perception may influence at local, regional and national scales.

The SA case study of BHKC catchment was selected to study the local scale, where the community's influence on the development of the SMP was explored due to the change of strategic direction away from structural mitigation. The case was highly politicised in nature, and valuable for demonstrating the influence of local scale politics on the governance of flood risk management. The SMP was being finalised by the five local councils within the catchment, and was formally approved by the State Stormwater Management Authority (SMA) during the fieldwork period of this case study.

SE QLD was chosen as a case study site due to the timing and catastrophic size of the 2011 flood event. The timing of this event provided the researcher with the opportunity to monitor changes and reactions to flood management, perceptions of flood risk, and to determine what lessons were learnt and applied after this significant flood event. SE QLD also provided the opportunity to examine the risk perception and flood management at the regional scale. Significantly, the 2011 event resulted in numerous inquiries, including the *Inquiry* (Grantham Floods Commission of Inquiry 2015; Queensland Floods Commission of Inquiry 2012) and the *Natural Disaster Insurance Review: Inquiry into flood insurance and related matters (Review)* (The Australian Government: The Treasury 2011).

Reforms to planning and guidelines were also made (Brisbane City Council 2012d; Queensland Reconstruction Authority 2011b). These changes imply that an over-reliance on mitigation infrastructure may have contributed to the flood event. The governance response to the 2011 flood event also provided the opportunity to explore an alternative method for flood adaptation; the application of a relocation policy for the town of Grantham (Lockyer Valley Regional Council 2011a; NCCARF 2011; Queensland Reconstruction Authority 2011a).

The UK case study focusses on Scotland and draws on further details, additional learning and comparisons from England. These locations in the UK provided an opportunity to examine approaches to flood risk management at the national scale, through Scotland's introduction of the *FRM Act 2009*. The opinions of the relevant stakeholders were sought on the impact of this legislation, as well as on the governance arrangements with re-focussed responsibility for flood management by local governments. This case study also provided an opportunity to explore an

alternative approach to flood management; the use of landscape and natural flood management elements in contrast to structural mitigation.

The results of the individual case studies will be presented in detail in the following chapters: Chapter Four (BHKC, SA), Chapter Five (SE QLD), and Chapter Six (Scotland, UK), while Chapter Seven will provide an integrated, cross-case comparison, as described by Yin (2004). Chapter Seven will also identify any recurrent themes that influence the ways that flood risk is experienced and governed.

3.4 Methods and data collection

The use and integration of different research methods results in a more in-depth understanding of the research topic and, thus increasing the validity of the research findings. In this study, interviews and document analysis were used because they allow for the examination of flood management issues from a variety of relevant perspectives. The following sections describe the techniques employed in this research, from conducting interviews to document analysis, as well as analysis of the collected data.

3.4.1 Interviews

Interviews are commonly employed in grounded theory research, and are seen to be the start of the research journey where unique, contextual experiences are captured to explore a research topic (Charmaz 2014). Grounded theorists utilise several interview techniques, such as intensive, informational, and investigative interview strategies. This study utilised intensive interview techniques, which comprise a guided conversation on participants' personal experiences. This strategy allows stakeholders to raise and emphasise issues that they perceive are most relevant to the topic. Semi-structured interviews are also useful for exploring consistent themes and concepts in each interview (Corbin & Strauss 2015). Valentine (1997, p. 126) identifies the aim of an interview '*is . . . to understand how individual people experience and make sense of their own lives. The emphasis is on considering the meanings people attribute to their own lives and the processes which operate in particular contexts*'.

A constructivist approach to interviewing was undertaken in this research, whereby the researcher and the participant interact with each other to explore the complexities of the area of interest and 'construct' knowledge demonstrating significant depth and reflexive thought (Guba & Lincoln 1989; Hand 2003; Mills *et al.* 2006). The interview approach undertaken by the researcher reflected this approach by engaging with participants to understand responses and to

generate data by creating mutual meaning of the interview topic (Mills *et al.* 2006). For example, during the interviews the researcher regularly summarised and clarified responses where necessary to ensure the key meanings were interpreted correctly.

3.4.1.1 Participant recruitment

In the first instance, potential interview participants from each case study were identified using a purposive sampling method (Thomas 2009). Key stakeholder organisations were collated from a desktop study of the relevant documents and websites relating to flood management in the three case study sites:

- BHKC, SA
- SE QLD, QLD
- Scotland, UK.

The focus was initially on the second and third tiers of government, due to the active role that public servants play in decision-making regarding flood management. A small number of key informants were also targeted at higher executive levels of organisations including, for example, Chief Executive Officers (CEO), Mayors, General Managers of Planning and Development (or similar), and Principal Engineers. State Government representatives included the General Manager/Manager of various departments relating to infrastructure, environmental policy, and planning. Industry, academic and community representatives were also interviewed to gain alternative perspectives on flood management approaches and to explore their perceptions of flood risk and how the perception of risk may be influencing flood management.

Once initial telephone or email contact had been made with the key informants, a snowball sampling technique was used by asking each interview participant to suggest other relevant contacts and further participants for inclusion (Bryman 2016; Thomas 2009). Once no further key contacts were suggested by participants, the sample was deemed sufficient for the case study. Table 3 provides the breakdown of organisations involved across the BHKC, SE QLD, and UK case studies, with positions and names removed to maintain the anonymity of the participants.

Table 3 Organisations represented by interview participants

		Second Tier Government ²	Third Tier Government ³	Insurance ⁴	Academia and Research	Non-Government ⁵
CASE STUDY	BHKC (SA) (16 participants from 12 interviews)	Natural Resources Adelaide and Mount Lofty Ranges (NR AMLR)	City of Mitcham			No Dam Community Action Group
		Stormwater Management Authority (SMA)	City of West Torrens			
		South Australian Fire and Emergency Services Commission (SAFECOM)	City of Unley			
		Department of Environment, Water and Natural Resources (DEWNR)	Adelaide City Council			
		Department of Planning, Transport and Infrastructure (DPTI)				
	SE QLD (19 participants from 16 interviews)	Department of Local Government and Planning	Lockyer Valley Regional Council	Insurance Australia Group	University of Queensland	SEQ Catchments
		Queensland Reconstruction Authority (QRA)	Toowoomba Regional Council	ICA	Risk Frontiers	AECOM
		Department of Environment and Resource Management	Ipswich Regional Council	Swiss Re-Insurance		
		Department of Community Safety	Brisbane City Council			
	UK (15 participants from 15 interviews)	Scottish Environment Protection Agency (SEPA)	Convention of Scottish Local Authorities (COSLA)	British Insurance Association	University of Lausanne (Switzerland)	AECOM
		Scottish Water	Angus Council	AVIVA	University of Dundee	National Flood Forum
		Scottish Government		Independent Insurance Consultant	University of Oxford/Flood Hazard Research Centre	
Environment Agency (England)						

² Second tier government refers to the Australian State governments, and Scottish and English governments

³ Local council/municipality governments

⁴ Includes insurance industry organisations and private insurance companies

⁵ Includes private consultancies, community, and non-government organisations

3.4.1.2 Interview process and structure

In-depth, semi-structured interviews were undertaken with representatives of key stakeholder organisations. An interview schedule that included a series of key questions allowed for significant flexibility in interview discussions. The semi-structured nature of the interviews enabled consistency in the topics covered in the interviews across the three case studies, while still allowing for free-flowing discussion around issues the interview participants deemed important or most relevant to their roles (Dunn 2010; Hay 2010). Such an approach was useful to identify relevant issues, such as key risks and opportunities, consequently enabling lines of inquiry to be followed.

In total, 43 interviews were undertaken with 50 participants across the three case studies. Most of the interviews were completed in a one-on-one format, but five interviews were conducted as a small group discussion where multiple participants within an organisation were interviewed together. The interviews generally occurred at, or near, the participants' workplace or home ranging in duration from 30 minutes up to three hours.

Interview participants were provided with a consent form and the interview schedule before the agreed interview time, to allow them to prepare and bring any documents or supplementary information to the interview. Most the interviews were audio-recorded to allow the researcher to focus on developing the conversation. Three of the interviewees requested not to be recorded, and one of the interviewees elected to answer the questions in written format instead of a face-to-face or telephone interview. Where necessary, the researcher contacted the interview participants after the initial interview by telephone or email to gain further clarification and information.

Interviewees represented various key planning and operational decision-making levels within the relevant stakeholder groups. Each respondent was targeted for their ability to provide information on at least one aspect of the complex and interacting issues affecting the management of flood risk. Some spoke strongly from both their local context as well as from the broader perspective of paradigmatic positions on flood management, others were more focused on broader policy directions. Questions were asked about the respective stakeholders' involvement, understanding, current and future planning and adaptation responses to flood risk, and the possibility of relocation or retreat policies in each case study region. Table 4 shows the key questions in the interview schedule. The order of the questions varied to maintain conversational flow, and some were excluded if they were deemed irrelevant or the interviewee had already addressed the topic in a previous response.

In each case study region, sites of significant interest were visited to generate a visual and more in-depth understanding of issues and places. The interview participants were often keen

to use key locations as talking points, to provide greater context for their narratives. As examples, the researcher visited Adelaide and Brown Hill Creek Recreation Park in SA, Brisbane, Grantham and Wivenhoe Dam in SE QLD, and relevant sites around Perth in Scotland.

Table 4 Interview schedule

1. What does your role entail regarding flood management?
2. How do you feel your organisation performs regarding flood management?
3. What are the main issues you and your organisation face for flood management?
4. What is your opinion on the current flood management systems?
5. Do you have any suggestions for future improvements for flood management in Australia/Scotland?
6. Thinking more generally about the governance of floods, are there any changes you would like to see in the future? If so, what and why?
7. What are the barriers you believe that different levels of governments will face with future flood management?
8. What do you feel are the most important issues currently facing flood management locally and on an international scale?
9. What do you see the future trends/methods used to be for flood management in Australia/Scotland and internationally?
10. There is evidence that climate change has the potential to alter the weather patterns and result in an increase in both frequency and intensity of flooding. Do you believe that the current flood management approach will be adequate to deal with changing weather patterns?
11. Given projections of climate change are you allowing for these in planning? If yes, how? Or if no, why not?
12. What do you believe are the benefits of sustainable or more planning focused in comparison to protective engineering flood risk reduction solutions?
13. Considering increasing populations, should there be more designated areas where development is prohibited and/ or removed? If yes, which areas and why?
14. What role do you feel that relocation/realignment/retreat policies have in the future to address exposure to risk?
15. How do you think a relocation/realignment/retreat policy could be implemented in Australia/Scotland?
16. What role do you believe insurance and reinsurance currently/should play in flood management?
17. Any other issues/comments?

3.4.1.3 Fieldwork schedule

The first case study fieldwork was undertaken over a three-month period, including a two-week on-site visit in November 2011, in SE QLD. The visit was planned in November due to the beginning of the wet season, so that flood preparedness was a prominent issue. The fieldwork for this case study took place in Brisbane and surrounding areas severely impacted by the 2011 floods. The researcher also travelled to Sydney as a part of the SE QLD case study research, to

interview key industry representatives. Initial contacts made prior to arrival in Brisbane, were supplemented through snowballing during the fieldwork process, leading to the recruitment of 19 participants for 16 interviews in total.

The BHKC case study fieldwork was undertaken over a 10-month period, from June 2012 to March 2013 in Adelaide, SA. Participants were recruited through the targeting of initial key stakeholders, and supplemented by snowballing. Further correspondence was undertaken with participants post-interview in order to gather updated information as the BHKC SMP process progressed. A total of 12 interviews with 16 participants were completed. No interviews were undertaken with insurance companies in SA due to the previous interviews with insurance representatives from a national perspective in Sydney, NSW during the SE QLD case study fieldwork period. One request for an interview was declined from a third tier government representative due to the political pressures of case study.

The UK case study was undertaken over three-month period from October to December 2012. Again, initial participants were targeted and recruited via email, then supplemented by snowballing on arrival in London. The locations of these interviews varied, with the researcher visiting sites in England, Scotland and Switzerland to meet with key individuals. A total of 15 interviews were completed with 15 participants.

3.4.2 Document analysis

Document analysis is a systematic procedure for reviewing or evaluating documents, similar to analysing interview transcripts (Bowen 2009). Documents comprise text which contain content, purpose, visibility, legitimacy, and can have significant consequences (Charmaz 2014). Document analysis is a key component of qualitative research, with grounded theorists looking at the construct as well as the content and source of documents (Bowen 2009). Documents are also seen to be more objective than interviews, as they are generally without influence by the researcher (Charmaz 2014). Document analysis is also useful for cross-reference with other sources of qualitative data, to increase the validity of a study. Documents generally present the cultural, social, historical, and situational context of data, and represent a published discourse – particularly when they are strategic and technical plans with a purpose to guide the management process.

Due to the contemporary nature of the case studies undertaken, and their continuously updating content, most of the documents analysed to explore the broad topic of flood risk were media reports and ‘grey’ literature. Documents analysed included relevant government policies, plans, and reports; industry publications; and, non-government organisation reports. Bryman

(2016) notes that government documents are extremely valuable to researchers as they generally meet Scott's (1990, p. 6) four criteria for assessing documents: '*authenticity*', '*credibility*', '*representativeness*', and '*meaning*'. Documents from some organisations may seem authentic and meaningful, but credibility and representativeness are often harder to assess as they may be promoting a certain agenda or subject to external influence. For example, credibility and authenticity can be an issue for media reports and websites, despite still being a valuable source of data for assessment (Bryman 2016). As Merriam (1988, p. 118) states, '*documents of all types can help the researcher uncover meaning, develop understanding, and discover insights relevant to the research problem*'.

The BHKC case study uses data predominantly from interview transcripts, media, technical reports, and the SMP itself for document analysis. Because of its local and contemporary nature, there was a limited amount of other published literature.

3.4.3 Data analysis

The audio-recorded interviews were transcribed for analysis. Where the interview participant had opted out of audio-recording, the researcher's notes were clarified with the participant to ensure their accuracy.

In line with grounded theory, a critical meta-analysis of interview transcripts was undertaken manually using inductive thematic analysis and selective coding (Corbin & Strauss 2015; Morse & Field 1995; Urquhart 2013). According to Morse and Field (1995, p. 139), '*thematic analysis involves the search for and identification of common threads that extend throughout an entire interview or set of interviews*'. These significant concepts and influencers, which link interviews together (Morse & Field 1995), are subsequently selectively coded as themes. Selective coding limits data to the core prevalent concepts, thus filtering the results (Urquhart 2013).

Whilst undertaking the thematic analysis and selective coding, attention was also paid to areas of agreement and disparity between participants' perceptions, within and between the case study regions. The focus of the analysis and coding was on the narrative and meaning behind the results to identify themes. Quotations from the interviews are used extensively throughout this thesis to provide thick and rich description of the prevalent themes. The interview participants are cited using the case study abbreviation, a de-identified number, and the year the interview took place; for example, 'UK1 2012'. At times, prominent themes are quantified as percentages to show the weighting of particular results. These interview results have been

integrated with documentary evidence to demonstrate key relationships and concepts important to flood management planning and processes.

3.5 Triangulation and validity

Triangulation is a well-established method used in grounded theory research to increase validity (Urquhart 2013). Within a positivist, grounded theory paradigm, triangulation involves the use of two or more methods, theories, data types, or researchers to collect data on a particular issue (Charmaz 2010; Denzin 2001; Miles *et al.* 2014; Urquhart 2013). Creswell and Miller (2000) describe how triangulation is a systematic process undertaken through the researcher’s lens, searching for common themes and categories from multiple methods. Triangulation is a useful process to examine the complex themes in risk management.

As shown in Table 5, this research has used both data source and method triangulation. Data triangulation occurred with data collected from different sources, including interviews and various documents from a range of governance and geographical scales and locations. Method triangulation was applied by using semi-structured interviews, literature review and document analysis.

Table 5 Validity assumptions and procedures

		PARADIGM	
		Positivist Or Systematic	Constructivist
LENS	Researcher	Triangulation via data sources and methods (interviews and document analysis)	
	External audience	Audit trail	Thick, rich description

Source: Adapted from Creswell and Miller (2000)

3.6 Limitations

The qualitative approach undertaken in this research has some limitations. For example, qualitative research methods do not generally include large and randomised samples, which can make it difficult generalise conclusions. Standard mean qualitative sample sizes have been

identified to be approximately 30 per study (Mason 2010). Qualitative research may also be criticized for not generating robust and representative data for analysis. However, it has been deemed that the research is satisfactory if the saturation principle defined by Glaser and Strauss (1967) is followed as the exploratory and in-depth nature of qualitative research enhances the validity and reliability of the approach to allow for local analyses that triangulate to guide wider claims. In the case of this research, despite the possibility of further identification of participants, repetition in narratives from the current interview participants indicated that the saturation point for each case study was reached and that further interviews would not necessarily result in improved data (Mason 2010).

This research often encountered contentious and emotive circumstances resulting in interview participants' responses being restricted, as they were not prepared to discuss certain topics due to extensive media campaigns that had occurred. In the case of SE QLD, much information was sub-judice from the *Inquiry* (Queensland Floods Commission of Inquiry 2012), restricting some participants' responses. This may also have been the reason for several stakeholders declining to participate.

3.6.1 Potential bias

Qualitative research has potential for the researcher to apply intentional and unintentional bias to the results through ontological and epistemological assumptions. For this research, an 'outsider' position bias was applied during the interview and data analysis process to allow for neutrality. This research also applies a social science philosophical lens (Blaikie 1993) to consider flood management, which is primarily approached from an engineering or ecological, positivist ontology and epistemologies. The application of a social science lens is important to examine the complex themes around governance, political influences, and challenges relating to adaptation to risk, which all have social influences.

There was also the possibility of self-selection bias from those interviewed as explained by Collier and Mahoney (1996) where participants may have wanted to participate to promote specific messages or provide socially accepted answers. It was deemed that the de-identification and confidentiality of responses and participants minimised the impact of this bias.

3.7 Chapter summary

This chapter has detailed the research design employed to meet the aim, and provided justification for exploring case studies of flood risk management in SE QLD, SA and the UK.

A brief description of the case studies chosen to examine flood risk management was provided. This research employs a qualitative approach integrating semi-structured in-depth interviews and documentary analysis. The key qualitative methods used in this research study are document analysis and interviews. The participants were recruited using a desktop study of relevant published literature, and by snowballing from other participants. These participants represented the different tiers of governance, including representatives from government, industry, community, and non-government organisations.

Data and method triangulation was employed to increase the validity and reliability of the results.

The findings of the individual case studies will be presented in Chapters Four (BHKC, SA), Chapter Five (SE QLD) and Chapter Six (UK). Chapter Seven will provide an integrated, cross-case comparison of the three case studies, while Chapter Eight will summarise the major findings.

Chapter 4: South Australia and the Brown Hill and Keswick Creek Experience

4.1 Introduction

Chapter Four will explore flood risk management at the local scale, through a case study of the development of the BHKC SMP in SA. In this context, the chapter addresses the objectives of this research project: to identify challenges for flood management in the context of current governance framework for flood risk management, and; to examine options for adaptive flood risk management. These objectives will be considered in the context of how flood risk is perceived in this specific case study. Due to the local scale of this case study, the focus of this chapter will be on the governance framework and adaptation to future risk.

The chapter begins by providing background to the BHKC case study, describing the geographical context and the level of flood risk experienced in the catchment – in particular, the impact of urbanisation. Following this, the governance of the BHKC catchment is explored through an examination of the development of the SMP. Barriers to effective flood risk management are presented, followed by options for alternative approaches to risk management.

The chapter concludes by examining stakeholder perceptions of flood risk management in the BHKC catchment, and discusses the impact of these on governance outcomes.

4.2 Local context: case study background

The development of the BHKC SMP was a highly political process, and the topic of much local public debate. During the process, there was inter- and intra- agency conflict between State government and Local governments, as well as with the public. A significant amount of discussion surrounded the proposed flood detention dams in Brown Hill Conservation Park; widening of stormwater drainage culverts in the City of Unley; and, increasing flow capacity in sections of upper Brown Hill creek in Local Government Areas of Mitcham and Unley.

The opinions and perceptions of stakeholders from key governing bodies were sought, regarding their experience with the BHKC SMP as well as the history of BHKC's management⁶. The case study will focus on issues occurring between 2012 and 2014. The Plan

⁶ Due to the time lag between fieldwork and thesis submission, the results presented in this chapter do not necessarily reflect current opinions and perceptions of the BHKC SMP. However, the results presented do serve to demonstrate the complexities and high level of emotion involved local flood risk management.

was being finalised by the five Local governments within the catchment, and was formally approved by the SMA during the fieldwork period of this case study.

4.2.1 The BHKC catchment

SA is the driest state within the driest continent of Australia (Smith 1998). Away from the southern coastal fringe, the predominant state of dryness and frequent droughts has implications for flood risk perceptions within both the general public and governing bodies. Flood risk is perceived to be low, despite the Adelaide metropolitan area featuring multiple small river and creek systems. Most of these are naturally ephemeral, including the BHKC catchment (Daniels & Tait 2005). Despite their generally dry state or low flow, these watercourses still experience significant flood events.

The BHKC catchment (Figures 1 and 2) has headwaters in the Mount Lofty Ranges, and flows across the Adelaide Plains before discharging into Gulf St Vincent via the Barcoo Outlet from Patawalonga Lake. The catchment is a part of the greater Patawalonga catchment, which also includes the Sturt River, and has an area of 235 km² (Daniels & Tait 2005). The BHKC catchment is made up of several smaller creeks and sub-catchments, namely the Brown Hill, Keswick, Glen Osmond, and Parkland Creeks.

The Brown Hill Creek sub-catchment of the greater BHKC catchment has an area of 32 km², and travels through the metropolitan suburbs of Mitcham, Westbourne Park, Millswood, Ashford, Kurralta Park, and Netley. The upper reaches of the catchment also include a semi-rural area in the Hills Face Zone (Department of Transport Planning and Infrastructure 2014). This region is mostly used for grazing, biodiversity conservation, or bushland on lifestyle blocks. The creek is an unlined channel until Unley Park, and is concrete-lined for the rest of the watercourse (Hydro Tasmania Consulting 2006)

Figure 1 Location of Brown Hill Keswick Creek catchment.

Compiled by G. Eckert (2017).

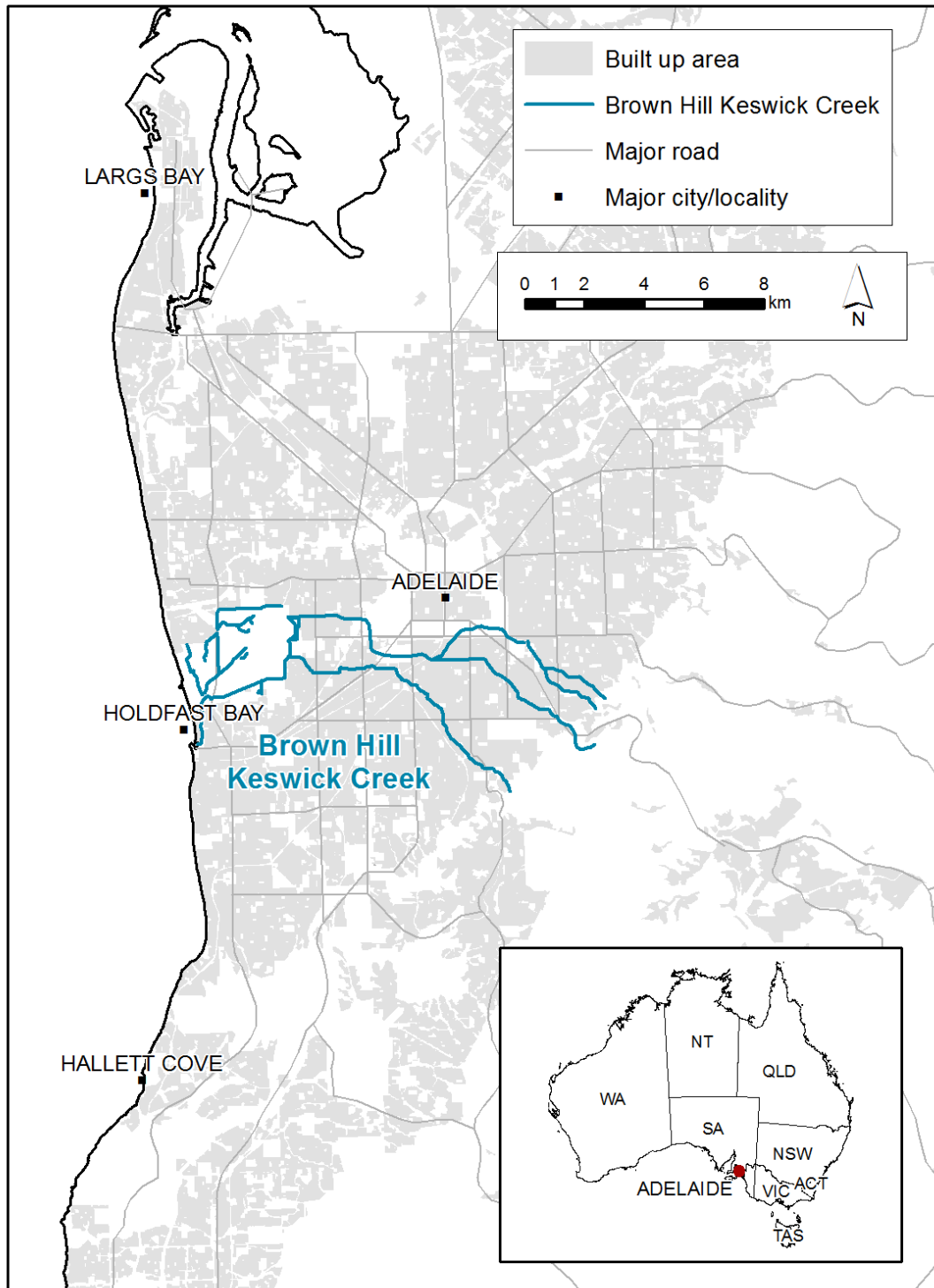
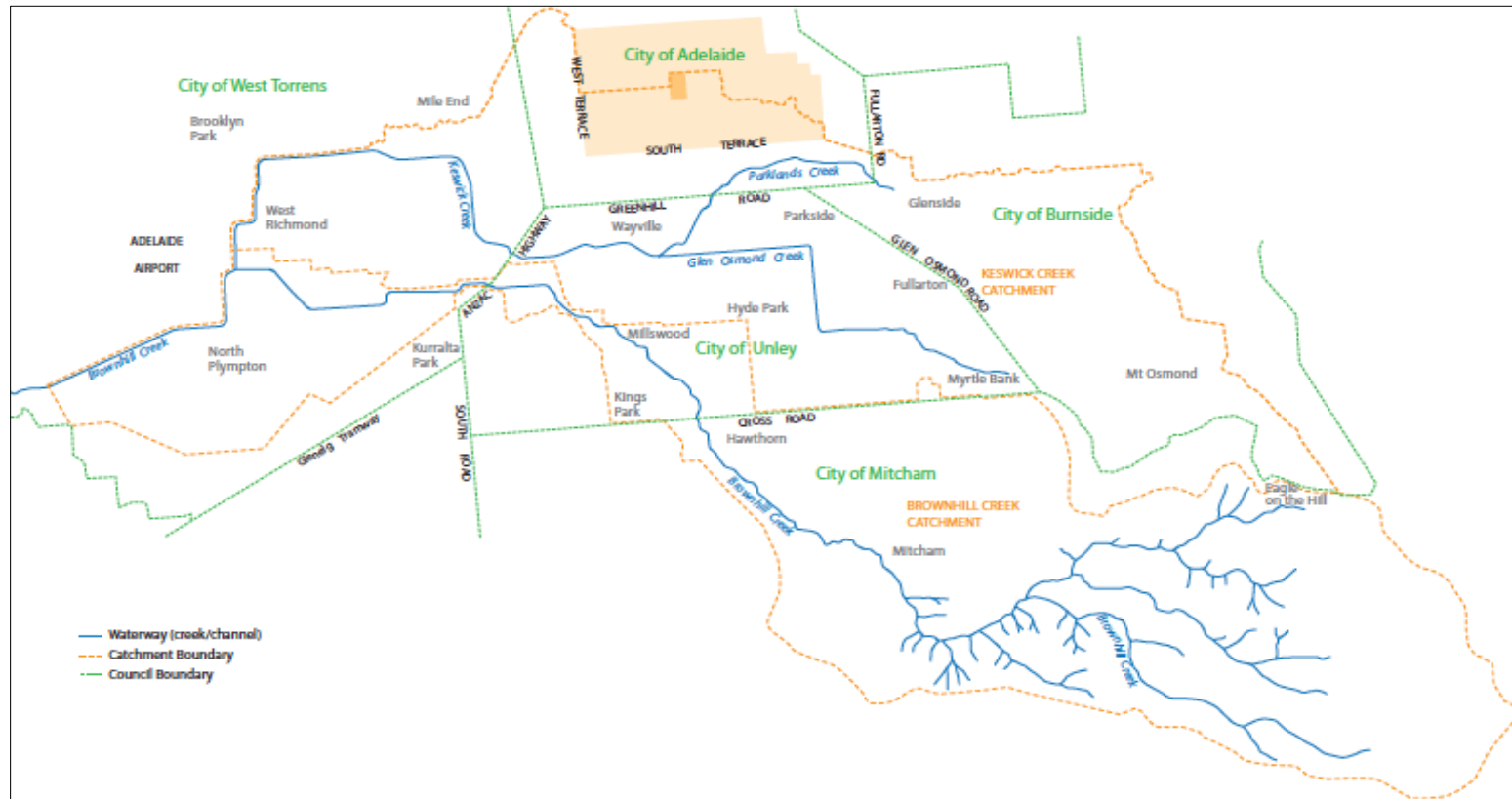


Figure 2 Map of Brown Hill Keswick Creek catchment

Source: Brown Hill Keswick Creek Stormwater Project (2011, p. 1)



The Keswick creek sub-catchment has an area of 36.7 km², and is fed by the Glen Osmond and Parklands Creeks. These creeks flow through the metropolitan areas of Leawood Gardens, Highgate, Parkside, Unley, Wayville, Glen Osmond, Glenunga, Glenside, and Goodwood. The creeks have mostly been converted to concrete channels and culverts.

Flash floods are the main flooding concern within the BHKC catchment (McCarthy *et al.* 2006). The Parklands, Glen Osmond and Keswick Creeks respond more quickly to rainfall than Brown Hill Creek, which has a much slower flood response time before it joins with Keswick Creek (Hydro Tasmania Consulting 2006). A recent assessment suggests that currently the BHKC catchment has a low level of flood protection, with a high level of flood risk to property (WorleyParsons Services Pty Ltd 2012).

4.2.1.1 Impact of urbanisation

The BHKC catchment has largely urbanised since European migrants began inhabiting the region in the mid-1800s (WorleyParsons Services Pty Ltd 2012). Subdivision of older properties has escalated significantly in the last decade, most recently in response to the *30 Year Plan for Greater Adelaide* (Department of Planning and Local Government 2010), which aims to increase development density in metropolitan areas. Infill development has led to more impervious roads and pavements, and consequently increased flood risk to properties and assets in the catchment (Wright 1999, 2001b). The removal of gardens and lawns in favour of impervious concreted surfaces and paving has also increased run-off to the stormwater drains (WorleyParsons Services Pty Ltd 2012). It is projected that infill development will continue to increase flood risk in the greater catchment area over the coming decades (Kemp & Myers 2015).

The *30 Year Plan for Greater Adelaide* (Department of Planning and Local Government 2010) also encourages urban densification and at a greater scale in the catchment area.

Flood risk in the catchment has been documented since the 1930s. After the implementation of the *Metropolitan Drainage Act 1935*, the common flood management approaches along BHKC have been defensive structures (Read 2006). As a result, in much of its urban areas, the BHKC catchment has been converted to an urban drainage system comprising various engineered solutions (Hydro Tasmania Consulting 2006). Much of the flow is directed through concrete underground drains, often from water running off hardened bitumen or concrete surfaces (Daniels & Tait 2005; Read 2006). As WorleyParsons (2012) identify in their report, the highly urbanised nature of the catchment will restrict and continue to reduce the performance level of any structural flood mitigation works.

As Daniels and Tait (2005, p. 261) note:

Flooding has become an acute problem since residential and industrial developments have been (and continue to be) situated in areas that were historically floodplains and wetlands. Consequently, there are now very few feasible locations for the water to be diverted, and the greater coverage of hard surfaces has led to less opportunity for rain to be absorbed into the soil, therefore a higher volume of stormwater is flowing into the rivers.

Specific flood mitigation works were undertaken in response to the 1925 and 1930 floods, and major flooding again occurred in 1992 (Attorney General's Department 1992; Hughes 1992), 2005 (Johnston *et al.* 2007), and 2016 (Jones 2016). Other major flood events occurred in 1875, and 1981 with damages to railway lines and surrounding houses (McCarthy *et al.* 2006).

The remainder of this chapter portrays and discusses the management challenges faced by at the local scale using the development of a case study to identify challenges for flood management in the context of the governance framework of the SMP; and barriers for flood management, and; adaptation options for future risk. Risk perception of the research participants will be integrated throughout the chapter reflecting the implicit and explicit influence on all aspects of the Prevention, Preparedness, Response and Recovery (PPRR) emergency management framework. Comments by the research participants will be integrated with document analysis to provide the overall results from the case study.

4.3 Governance of flood risk management in the BHKC catchment

The governance framework for the management of flood risk in the BHKC catchment involves both State and Local governments. Therefore, the roles and responsibilities of State and Local government agencies is worth examining in detail, as it demonstrates the complex processes involved in local-scale flood management.

Historically, management of the flood risk in the catchment was undertaken by the local councils in conjunction with the State government and the Patawalonga Catchment Water Management Board (PCWMB). The PCWMB was created in 1995 in response to the *Catchment Management Act 1995* introduced by the SA government. This formative legislation was replaced by the *Water Resources Act 1997*. Later, legislation and various Boards were amalgamated into the broader remit of the *NRM Act 2004*. As part of the *NRM Act 2004*, the governance responsibilities of the PCWMB was absorbed by the NR AMLR. With respect to the BHKC SMP, NR AMLR provides advice to local government on environmental principles

and has some responsibilities around watercourse quality. Table 6 shows the main government agencies and their various responsibilities for aspects of flood risk management.

Thus, current arrangements for governance of flood risk in the BHKC catchment are convoluted. As one participant stated:

If you look at flooding it's very, very diffuse. So, we have one agency, which is the SES who go out and do their best to deal with the flood. You've got local councils who own most of the flood mitigating infrastructure, which obviously has a big effect on how good your flood mitigation is in the first place. Depending on where you are you've got State and Local governments doing land use planning, which can affect who's in the way of the water. It's very easy for different players to point the finger at each other and that's kind of where we are now. So, we've got a tiny little catchment of 32 km², but because we're talking about fundamentally an infrastructure issue, the councils are supposed to be the ones who fix it, but they don't have the money. It's a State level risk but the State says, "*Well it's the councils' problem*". The Commonwealth government often funds these things but are basically saying, "*We don't have any money and by the way natural disasters are a State problem anyway*". So, everyone's pointing the finger at each other and that's sort of allowed this to just go on in emergency management generally, because it's not a crisis you have to fix right now, it means it's a much harder sell (SA7 2013).

Governance for flood management in the BHKC catchment is further complicated by the involvement of private companies and community groups. The privately-owned Adelaide Airport undertakes their own flood risk management activities to protect their infrastructure and business (Adelaide Airport 2009), while three community groups (Save Our Streets Community Action Group, No Dam in Brown Hill Creek Community Action Group and Save Our Creek Environs Trees) have formed in response to the proposed options for the SMP. These community groups have significant community support, and have been successful in influencing catchment managers, this adding to the diffuse governance of flood risk in the BHKC catchment. As SA7 (2013) mentions, '*six State ministers, three levels of government, and about ten different agencies have responsibility for flooding in SA, depending on where you are and what the issue is*'.

Table 6 Government agencies responsible for flood management in the BHKC catchment

Local government - City of Mitcham, City of Unley, City of Burnside, Adelaide City Council, City of West Torrens	Lead bodies for stormwater management in their area under the <i>Local Government Act 1999</i> ; responsible for local development planning and decision-making under the <i>Development Act 1994</i> .
SMA	Provides funding and authority for stormwater management and urban flooding in SA, as well as approving any SMPs. The SMA came into being in 2007 with the introduction of the <i>Local Government (Stormwater Management) Amendment Act 2007</i> . The SMA has an annual budget of \$4 million (indexed to the Consumer Price Index (CPI)) to manage stormwater, including urban flooding, across SA.
SA Government - DEWNR	Flood Hazard Leader in SA – overarching coordination and leadership role for flood management.
SA Government - DPTI	Provides technical advice to the SMA on SMPs.
SA Government - the State Emergency Service (SES)	SA Flood Control Agency; responds to emergency flood events and involved in emergency management planning.
SA Government - SAFECOM	Administers the <i>Emergency Management Act 2004</i> and <i>Fire and Emergency Service Act 2005</i> .
SA Government - NR AMLR Board, (a division of DEWNR) SA government	Responsible under the <i>NRM Act 2004</i> for maintenance of watercourses, and provides advice on SMPs through the SMA.
Australian Federal government - Bureau of Meteorology (The Bureau)	Responsible for providing flood warning and monitoring along the BHKC watercourses and providing flood warnings with the SES.

4.3.1 Governance framework for BHKC

The governance framework in place for the development of the SMP is two-tiered. A project Steering Group includes the CEOs of the five relevant councils, and a Study Steering Committee. The Study Steering Committee consists of representatives from the state government agencies NR AMLR and DPTI (as the technical advisory agency for the SMA), as well as technical representatives from the Mitcham, West Torrens and Unley City Councils (WorleyParsons Services Pty Ltd 2012).

The number of stakeholders involved in the development process of the BHKC SMP has resulted in a highly-politicised discourse, strongly influencing the progress and final version of the SMP. The collaboration between the five councils and state government deteriorated after the creation of a proposed 2006 plan, when Mitcham Council pulled out of the process and, *'it wasn't particularly friendly'* (SA11 2013). All participants noted the development of the BHKC SMP had become toxic at that point. SA16 (2013) agreed that the promoted perception of flood risk was politically motivated:

The whole project is being driven by politics. Flooding in BHKC is nothing like the sort of flooding in eastern Australia – in Adelaide, the inconvenience caused by 100 mm of water in the streets is portrayed as a major calamity.

Governance has been the main challenge for the development and implementation of the BHKC SMP, as there has been a need to manage equity across the region and different levels of risk exposure across the catchment. The governance struggle has been highlighted by SA11 (2013), who stated that:

For me, the whole thing is about governance here because it's the fact that it crosses five council boundaries, the fact that in SA all stormwater is the responsibility of councils, which isn't the case everywhere. The fact it floods West Torrens and rains in Mitcham, so why we would pay for money to fix that up?

This statement highlights the cause of the conflict surrounding the governance of flood risk in the catchment: the question of who should pay. This reflects the challenges of managing environmental risks that do not conform to administrative boundaries:

I certainly hold the view that the most logical council boundaries are actually a catchment. If you went with water catchments as your council boundary, all others are just, you can draw a line there or there, that's a main road, that's not. But the catchment actually makes some sense (SA11 2013).

There has also been resentment regarding the perceived lack of equity in terms of decisions made by a council in one part of the catchment, where the main impacts were felt by a council in another part of the catchment. This controversy was exacerbated by residents who were

frustrated with the lack of action to address their personal flood risk, pending decisions made by Local government. Elected Local government councillors, SA government ministers and residents created substantial public discourse, contributing significant emotive commentary broadcasted in the local media (Abraham 2008; Goldsmith 2008; Higgins 2009; Whiting 2008, 2009; Williams 2009) and State Parliament (Parliament of South Australia 2005, 2008). As two of the participants stated,

West Torrens and Mitcham, it's been a lot more contentious for them and the politics which have been played weren't particularly nice insofar as they did start playing the man a little bit more and not playing the issue. That's a bit of a symptom of modern day politics, which is a real tragedy because it stymies the debate (SA5 2013).

As an exercise in Local government, I think the Mitcham Council was absolutely pulled through the mud. The councillors were verbally abused, not in the chamber but in the press. Criticised, told that we were risking flooding for the entire community, other councils. We were being held to ransom individually, almost blood on our hands, etcetera, etcetera, and etcetera. This was all because we were asking the questions and finding out the truth I think, of what was trying to be proposed, why it was trying to be proposed, what it actually meant (SA2 2012).

Don't they realise that we're the seventh highest out of 10 in Australia, that the Adelaide Airport is going to be totally flooded, that the rail systems, and the economic outcome of all of this, they are putting the State at risk? That is, this council [Mitcham Council]. It was awful (SA2 2013).

Internal politics, between elected members and council staff, was also an issue within some councils. As SA4 (2013) mentioned,

There's been some internal politics between all the councils as well... so there's a lot of politics involved. There's been a lot of navigating through the politics. Some of the councils [elected councillors] have a fair bit of trust in their administration [paid staff] in terms of what's being done and it's fair to say that some don't for whatever reason.

The development of the SMP was delayed due the politics described above. The SMA continued to issue orders to complete the SMP collaboratively. As noted by SA11 (2013),

It's really interesting from a [Local] government's point of view whether they could force us to or not. There are various bits of legal advice around and it gets back to the [State] constitution and the power of the State government to, for example, or Mitcham, to spend money in Unley for the benefit of West Torrens. Can they [SMA and State government] actually force us to do that under the constitution?

Another participant concluded, *'I'd say the story that you're looking at here is very much about disparate Local governments trying to work together with a supportive but not particularly active State government in this particular case. So, it's small jurisdictions'* (SA6 2013).

Hence, it is worth analysing the perceptions of State and Local government participants regarding which responsibilities should be shared, and which should be controlled by another level of government. Opinions on State government involvement were reflected upon by the Local government participants in particular, where 75% (12 of 16) believed that the project could have been undertaken at the State level to avoid the cross-jurisdictional issues between Local councils. There was consensus among Local government representatives that the State government should have been more supportive with the development of the SMP. As one participant stated,

To tell you the truth, the State government really didn't want to buy into it. One, the State didn't want to take it over, because once you stick up your hand say, "Ok, we'll do it", councils will just push everything your way, so it will be a precedent for a whole lot of flicking back flooding responsibilities. Two, the State really didn't initiate this thing... they didn't have any real ownership of it (SA6 2013).

Nevertheless, 50% (8 of 16) of the participants also stated that because of their strong involvement, Local councils were able to develop a more holistic SMP which better reflected local values. SA4 (2013) suggested the BHKC SMP exercise has increased Local government collaboration and has generated the positively externality of generating improvements in cooperation across other projects. In other words, despite the politicisation of the development of the SMP, stronger relationships have been built between the councils with broad positive results:

There have been a whole range of other issues that have been unearthed within the five councils and it's been five councils now at the CEO level working much, much better together. So that's been a huge positive and so that's been a good exercise. That the work that's been undertaken I think has contributed towards a much, much better plan (SA2 2012).

Most councils have a better approach I think to dealing with their communities than the current State government. Their [State government] 'announce and defend' approach where they say they're doing something and then that's it, and then they just defend the criticism that comes their way and get on and build it. Councils are a bit more in tune with their communities and a bit more receptive to what they've got to say so that's how we're dealing with it (SA4 2013).

The strong politicisation of the flood mitigation planning observed in this case study will most likely continue to affect the SMP during implementation. As SA16 (2013) states, *'trying*

to avoid adverse political impact when the catchment rules are enforced will be one of the key future issues. Such barriers will be discussed in detail in section 4.3.3.

During the development of the SMP, the five councils were able to consider the community opinion in opposition to the dam, and negotiate an agreement:

The real breakthrough came for the councils when we, through the CEOs, we were able to get a bit of a feel that it was just like any other negotiation, that instead of us focusing on what we didn't agree on, we had to focus on what we did agree on and get that sorted, and out of that has come the Part A, Part B. We now know all the things we agree on and the things we don't and even on the dam, no dam issue, the West Torrens couldn't really care if there's a dam or no dam, as long as it doesn't cost any more. If you say, "Ok, West Torrens, it's not going to cost you any more", they don't care whether there's a dam or no dam. Burnside doesn't care if there's a dam or no dam, nor do Adelaide. The only one who cares is Unley. Unley and Mitcham care because the alternative to the dam is more culverts in the City of Unley. We're the only two that actually care, but that took us quite a while and it's all around the governance. Because you've got these CEOs who get their jobs from councils, the councillors who are at the meetings are very worried and concerned and don't really know what's going on, they're afraid that they're going to be duped or something's going to happen (SA11 2013).

The rights and opinions of private property owners present another challenge for the governance of flood risk in the catchment. This is because, with the exception of the City of Burnside, most of the watercourses that currently run through suburban areas remain under private ownership. In contrast, the City of Burnside regained control of their watercourses in response to the 1971 report recommendations (BC Tonkin and Associates 1971). Private ownership of the watercourses adds a further political dimension to the governance of the BHKC catchment, and raises questions regarding equity for hazard management. These significant issues will be discussed in more detail in section 4.3.3.

4.3.2 Development of the BHKC SMP

The BHKC catchment was identified as being at significant flood risk in the early 1930s with the introduction of the *Metropolitan Drainage Act 1935*. Following this, the five catchment councils began a joint process to manage the flood risk. Since that time, there have been several major engineering reports produced, with the most significant being the 1971 (BC Tonkin and Associates 1971), 1984 (Wood Bromley and Carruthers & Mitchell 1984), and the 2006 (Hydro Tasmania Consulting 2006) reports. These reports were the catalysts for the development of the 2012 (WorleyParsons Services Pty Ltd 2012) draft SMP, the subsequent 2014 Part B report (Brown Hill Keswick Creek Stormwater Project 2014), and the final 2016 SMP (Brown Hill Keswick Creek Stormwater Project 2016). The development of the SMP has been a contentious

and drawn out process, and is worth examining as it explores the impact of community influence on the management of risk and the decision-making that leads to policy generation. The following discussion will examine the key milestones across the decades of governance preceding development of the SMP.

Numerous studies, reviews, and draft management plans have been undertaken since the area was identified as at risk to flooding. There have been improvements in science and technology, and changes in local politics (Adelaide and Mount Lofty Ranges Natural Resources Management Board 2010; Australian Water Environments 2008; BC Tonkin and Associates 1971, 1996; Collins & Wilson 2009; GHD Pty Ltd 2008; Hydro Tasmania Consulting 2005, 2006; Kemp 1998; QED Pty Ltd 2005; VDM Consulting 2010; Wood Bromley and Carruthers & Mitchell 1984; Wright 1999, 2001a, 2001b, 2006). The culmination of these studies led to the development of the final BHKC SMP (Brown Hill Keswick Creek Stormwater Project 2016) to manage the flood risk.

The management and development of the BHKC SMP did not progress significantly until the above mentioned 1984 (Wood Bromley and Carruthers & Mitchell 1984) report. The Wood Bromley and Carruthers & Mitchell (1984) report highlighted that non-structural measures (such as flood warning systems, flood-proofing of properties, and land use zoning) were not going to be sufficient to manage the risk. Furthermore, the report recommended that structural mitigation measures (such as detention storage, channel improvements, and the diversion of surplus flows) were going to be necessary, and offered the cost-effective solution to the flood risk. SA6 (2013) discussed the importance of the 1984 report, stating that,

Essentially it was a huge leap forward... they started to actually define which areas would be flooded and it was quite revealing in that significant areas were flooded. Some councils, I know for a fact, didn't share that information with their elected members. Because once you tell your elected members, "*Look at the flooding*", they say, "*What are we going to do about it?*" and clearly there wasn't a co-ordinated plan, or at least there wasn't commitment to a co-ordinated plan.

The 2006 report (Hydro Tasmania Consulting 2006) was also a significant milestone as it estimated damages for a 1% annual exceedance probability (AEP) (or 1 in 100 average recurrence interval (ARI)) flood. This placed BHKC in the top 10 catchments at risk in Australia, and the most 'at risk' catchment in SA (Table 7). The identification of this high-risk level provided a catalyst for renewed interest in flood management of BHKC, leading to the development of the SMP.

Table 7 Properties affected by flooding for existing conditions in the BHKC catchment

Source: WorleyParsons Services Pty Ltd (2012, p. 35).

DESIGN FLOOD EVENT	NUMBER OF FLOOD AFFECTED PROPERTIES		
	OVER-FLOOR FLOODING	UNDER-FLOOR FLOODING	TOTAL
10 Year ARI	151	1001	1152
20 Year ARI	805	3059	3864
50 Year ARI	1513	4199	5712
100 Year ARI	1712	5209	6921
500 Year ARI	2440	7806	10246
Probable Maximum Flood	~10000	10000+	20000+

The 2006 version of the SMP proposed two flood control dams (Hydro Tasmania Consulting 2006), which were a major cause of emotional debate and community dissatisfaction. This Master Plan was never endorsed by the City of Mitcham council (City of Mitcham 2013); *‘That’s when the thing hit the fan because Mitcham said, “we don’t want flood control dams”’* (SA6 2013). Mitcham Council pulled out of the SMP Study Steering Committee, escalating the governance issues detailed above in section 4.3.1.

You had the well-meaning local members of Mitcham being actively knocking, *“No we don’t want flood control dams here, they’re ugly, it will wreck our whole area”*, and it started from there and also the Mitcham council turned on their CEO. It turned out to be the ‘little p’ politics of Local government, particularly Mitcham, white-anting the 2006 plan because of the flood control dams and they insisted that, *“No, we don’t need them”* (SA6 2013).

After Mitcham council ceased to participate in the 2006 Plan, the SMA exercised its statutory powers and directives, as outlined in Table 8.

Table 8 SMA involvement in 2017 BHKC SMP

Source: Stormwater Management Authority (2015, 2017).

Timeline	Process
2006	Hydro Tasmania report (Hydro Tasmania Consulting 2005, 2006) proposed two dams as mitigation options
May 2010	SMA issued 'notice' for a completed SMP in 90 days
August 2010	SMA issued an 'order' for a completed SMP by April 2011
May 2011	SMA issued an 'order' for the SMP to be completed by March 2012
May 2012	SMA endorsed two-part approach
March 2013	Part A Gazetted
March 2017	Part B (and final version) Gazetted

Eventually the five councils came back together and developed the draft 2012 BHKC SMP (WorleyParsons Services Pty Ltd 2012). This Plan was separated into two parts; Part A, comprising proposed flood mitigation works, was approved by the SMA in February 2013, and the Part B was published in September 2014 (Brown Hill Keswick Creek Stormwater Project 2014). The SMP was completed in 2016 and finally gazetted in 2017 (Brown Hill Keswick Creek Stormwater Project 2016). The final SMP was significantly different from the SMP originally proposed, and is an interesting case study because the major difference was generated through the incorporation of community input and values. The influence of the community discourse is detailed in section 4.3.2.1 below.

The final BHKC SMP has identified a range of structural and non-structural flood mitigation options to address the current flood risk and reduce risk into the future applying a flood risk management paradigm. The range of structures for construction and implementation include:

- On-site storage through detention basins and artificial wetlands
- WSUD – such as the use of rain gardens
- Stormwater harvesting and reuse infrastructure
- Creek maintenance and rehabilitation
- Widening of creek capacity in some areas
- Culverts
- Improvements in development planning
- Easements over private land to ensure standardised creek maintenance.

The identification of these measures demonstrates a significant move away from the planned structural mitigation dam, towards a prominent use of landscape and non-structural approaches, complemented with softer structural approaches to mitigate the flood risk.

4.3.2.1 Community discourse and its influence on approaches to flood mitigation

As described above, a proposed dam in the Brown Hill Creek Recreation Park generated the greatest political controversy in the generation of the BHKC SMP, resulting in significant delays in its development. Considerable community backlash, including a ‘no dam’ petition of over 7,000 signatures and prolonged community lobbying, significantly influenced the decision-making of the governing agencies:

There’s a lot of emotion connected with the idea of a dam and people get really fired up about the thought of building a dam in a pristine environment... The political sensitivities are so difficult to manage because people are interested in now, and now it’s not flooding and now we’re trying to build this horrible structure and have bulldozers all over the place and we’re squashing trees and wrens and things (SA1 2012).

And:

“*No dam in Brown Hill Creek*” should have another banner underneath, “*Let the bastards in West Torrens drown*” ... The opposition is fundamentally emotional, aesthetic, and “We don’t like the idea of a dam.” Dams in general. Dams and engineers are a bit on the nose these days because of the major projects that we’ve engineered over the years that now have been shown to have detrimental effects on the environment (SA1 2012).

From the interviews, State government representatives were supportive of a flood retention dam to mitigate the flood risk for the BHKC catchment, despite the community dissent. SA11 (2013) provides insight as to potential reasons why, *‘I think the State took a position, some key people in the State took a position many years ago and they’re still trying to defend that, and they’re still trying to defend the 2006 report with its two dams’*. In contrast, the Local councils

put forward the official position that they prefer a ‘no dam’ option, involving the enlargement of culverts throughout the City of Unley council area (Brown Hill Keswick Creek Stormwater Project 2014).

This significant divergence in goals between the two levels of government raises questions about the importance of community values, how they might balance with broader government ideas, and how communities can be effectively involved in emergency management. The discord between the values and wishes of government and community reflects the findings of Rubin (1991) and Pearce (2003), who identified that communities are often frustrated at not being included in their local disaster management planning. In support, SA11 (2013) stated, *‘the community reaction needed to be considered and I think that’s been completely ignored. And I think the State government has thought, “There’s a few loonies in Mitcham Council, that’s all it is”’*. According to Pearce (2003, p. 212), *‘it is recognised that while a top-down policy is needed, it is really the local-level bottom-up policy that provides the impetus for the implementation of mitigation strategies and a successful disaster management process’*.

Recognising the value of bottom-up policy, the BHKC SMP project transformed from a typical State government ‘announce and defend’ style, to a project where the SMP and flood risk more generally were about:

Really understanding what the community needs, what the community wants, what their aspirations are, not what we need to build. It’s moving from big government to small community to big community to small government, which is unique and should happen. The reality is the community should be the driver and what we should be doing is facilitating, enabling, and servicing the community instead of big government telling you, *“This is what we’re going to do and this is what you’re going to get”* (SA13 2013).

The emotion evident in the commentary of community members regarding the proposed dam in Brown Hill Creek Recreation Park is neatly reflected in this broader observation by Myers (1997, p. 1):

People who work to manage natural hazards must repackage themselves and what they know from the local community’s viewpoint, across adjustments and across hazards, but in context of non-hazards community goals. Our research is telling us that local stakeholders’ capacity to manage their own environment, resources, and hazards must be increased, and that it is the locals who must decide what they are willing to lose in future disasters.

The cost implications of appropriate community engagement to determine local values and priorities is often listed as a barrier to more extensive community involvement local decision-making. Often, the level of funding that is available and the priorities for that funding are

inconsistent with this goal. In terms of the BHKC SMP project, specific barriers are discussed in more detail in the following section.

4.3.3 Challenges for effective flood management: governance and implementation

Several barriers and challenges were identified by the research participants for the management of flood risk and development of the BHKC SMP. The main two challenges from the perspective of Local government representatives were:

- Private ownership of sections of the creeks
- Funding arrangements for the implementation of the SMP.

These issues will be described in the following sections.

4.3.3.1 The private ownership of watercourses

A major issue identified by the research participants was regarding how to deal with the creeks under private ownership, common across the Cities of Mitcham, Unley and parts of West Torrens. It is challenging for the State government to address under current legislation, mainly due to the lack of clarity in responsibilities and access to land for Local and State governments under the *Local Government Act 1999* and the *NRM Act 2004*. As SA4 (2013) emphasised, *'the issue of trying to sort out creeks in private ownership, that's a bigger elephant in the room to us than the dam or no dam'*. Watercourses are usually considered public land and are managed by governments or other public custodians. As SA1 (2012) mentions,

It's fine, it's lovely, it's an amenity, have a creek running through and you can do what you like, and the kids can play in the creek. It's a resource, but it's also a conveyor of stormwater and a potential serious risk to the community.

The challenge for the governance and implementation of the SMP regarding the private ownership of the waterways in the above-mentioned areas is a result of the legacy of past laissez faire planning decisions. Those decisions allowed the construction and installation (either with or without Council approval) of tennis courts, gazebos, garden benches and similar. SA4 (2013) discussed the challenge of this, stating,

There are large areas, lengths of the creek that are in private ownership, which means it is very difficult for the councils to do things in there. Especially when you get up in the leafier suburbs where they're quite large allotments that back onto the creek. They have tennis courts, swimming pools that have been built, not over the creek but into the creek..... we've still got to make sure that the creeks, the system works well but of course there are lots of

points where it's constricted because it's in private ownership and so how do we deal with that?

SA 11 (2013) agreed:

Massive issue. Not just now but ongoing. People have done all sorts of things to the creek and will continue to do so. It's really interesting. If you're in a million-dollar home in Unley and I'm going to take out the last five metres of your back garden and preclude you from doing a whole lot of things in it, you're going to say, "*Well, you need to pay me for that*". I'm on my own [in Council], I'd just sit here and say, "*No, I'm sorry, you can either make it [the easement] go through or we're going to sue you when it floods. If you want I'll come and do the work for you, but why should I pay you for five metres that was never really yours because you're just causing your neighbours to flood*".

The above statements demonstrate the challenges posed for management of environmental hazards which cross both jurisdictional and public-private boundaries. The responsibility of governments to 'protect' their rate-payers is also discussed by Vari *et al.* (2003) in a Turkish context where there is still a strong demand for central government control whilst taking into account social and ecological considerations despite private ownership, demonstrating that similar problems are being experienced across the world by risk practitioners.

To address historical challenges as the SMP moves into the implementation phase, Local councils and other State government stakeholders will review their legislative powers and their roles and responsibilities for watercourses. With the introduction of easements and allowing non-possessive access to the creek and immediately adjacent land, Local governments will have to manage politically and economically powerful residents, further adding to the complex governance issues (Brown Hill Keswick Creek Stormwater Project 2016), and pressure of liability for decision-making (Nurse-Bray 2010). Many residents previously protested the introduction of easements in the mid-2000s (Goldsmith 2008; Parliament of South Australia 2005):

It caused a lot of stink because, not widespread, but there were a few people that lived along the creek who wanted to redevelop and they got very shitty understandably, and they put a lot of pressure on Trish White, the Minister who eventually resigned... and that whole planning control thing sort of fell away (SA6 2013).

As noted, the previous protests against the easements were successful and were retracted due to the community backlash by the Minister of Planning, preceding her resignation (Guardian Messenger 2005).

Authorities will again have to work with residents to determine if the relevant legislation requires the residents to maintain their section of the creek for safety, biodiversity, and flood

conveyance for the catchment. This will require clear guidance on private responsibilities, as SA6 (2013) notes:

When it comes to local residents, I think personally, and it's a policy position we've put up, that urban watercourses should be under public ownership or public control because you can't expect the private people to maintain them and when there is a flood, there's going to be all sorts of stuff to clean up. We've seen that in the 2005 floods where people haven't been able to clean up and they've expected councils to come in and clean up. So, I think the community have got to realise that private watercourses are really not going to be around for too long and that probably some sort of easement or access is the way to go.

This change in roles and responsibilities will require a management of expectations and significant funding to implement. Funding of the project was another barrier to successful governance identified by the research participants in this case study; this will be addressed in the following section.

4.3.3.2 Funding the BHKC SMP

At the time of the research (2012-2013), a key governance challenge and source of debate between the State and Local governments related to the funding arrangements for implementation of the BHKC SMP. With the project expected to cost approximately \$140 million (Brown Hill Keswick Creek Stormwater Project 2016; Department of Environment Water and Natural Resources 2017), there is considerable financial pressure on all levels of governance involved. As of February 2017, the State government and Local councils agreed to a 50% funding co-contribution (Department of Environment Water and Natural Resources 2017). The limited budget for the SMA (\$4 million annually indexed to CPI) will make it difficult for the State to meet their funding commitments under the partnership agreement. As SA11 (2013) states,

We're unlikely to get any money from the Feds so at the moment we've costed \$150 million. The State gets \$4 million a year for the whole state! So, they can't afford their share of the project and you've still got this cost boundary issue. Why would West Torrens pay money for a project in Unley that doesn't help flooding in West Torrens unless there's an agreement that the whole thing is going to be built? West Torrens has to take a chance of putting money into other council projects and that will be a big issue for them.

SA13 (2013) stated that, *'Our council, as have the other four councils, have categorically put money into a long term financial plans for 10 years to deliver 50% of this... The councils can't afford to do it 100% it's a fact. Fact. It would be unheard of as well'*.

SA14 (2013) also highlights the equity issue presented by funding contributions, stating, ‘*I think the State and Federal government contributing is a way of creating greater equity across the catchment.*’ The attempt to address the variance between flood risks across the catchment between the jurisdictions is reflected in Table 9, where West Torrens is responsible for the majority of the Local government costs. This funding arrangement also had implications for the ‘dam versus no dam’ debate, as ‘*The City of West Torrens is covering 49% of the cost of the Plan. The SMA is the people’s money. It is a huge political battle. Why should they [West Torrens] have to pay for something for Mitcham?*’ (SA3 2013).

Table 9 Proposed share of Local government costs

Source: adapted from WorleyParsons Services Pty Ltd (2012, p. 43;147).

COUNCIL AREA	NUMBER OF TOTAL FLOOD AFFECTED PROPERTIES (1% AEP EVENT)	PERCENTAGE SHARE OF COSTS (Construction and Maintenance)	PERCENTAGE SHARE OF COSTS (Administration)
Burnside	59	12%	20%
Adelaide	18	8%	20%
Unley	2722	21%	20%
Mitcham	105	10%	20%
West Torrens	4017	49%	20%

A further issue around equity across the catchment was raised as the broader community will be paying for the project through council rates and the tax-payer funded SMA, and yet many will not be benefiting from the mitigation results as they are removed from the risk zone. Residents will also be inconvenienced from the installation of the infrastructure. This payment challenge reflects the broader global-scale climatic change management issues as described as part of a Risk Society with the local community paying for risk experienced elsewhere. As SA5 (2013) stated:

Flooding is not a particularly sexy issue, but there’s a lot of money that we’re going to be investing into it and throwing into it. People just won’t really see the benefits of it so it’s not like building a nice basketball stadium or an underpass or something that people are really going to see and get a lot of use or enjoyment out of. The recurrent costs are going to be a bit of an issue for councils as well, the life cycles of these assets, I think it was between 50 and 70 years and they have got to be done all over again.

The maintenance and cost lifecycle of mitigation provides support for the need for adaptation for future risk and the need to consider alternative approaches to manage flood risk despite the prioritisation for flood mitigation across SA (Stormwater Management Authority 2016).

4.3.3.3 Climate change

Although the research participants did not identify climate change impacts as one of the case study's key challenges, climate change is a significant issue for the management of floods in the catchment and has been recognised as a key challenge for SA (Bardsley 2006). Charles and Fu (2014) determined that climate change projections for the NR AMLR region include:

- Decreases in rainfall are projected for all seasons, with the greatest decreases in spring
- Average temperatures (maximum and minimum) are projected to increase for all seasons. Slightly larger increases in maximum temperature occur for the spring season
- Continued sea level rise
- Increase in extreme weather events.

SA has recognised the threat of ignoring climate risk and been a leader in climate adaptation since the introduction of the Coastal Protection Board's (1991) *Policy on coast protection and new coastal development*, which included considerations for sea level rise. The South Australian Government (2012; 2015) has also introduced the *Climate Change and Greenhouse Emissions Reduction Act 2007*, and introduced the guiding policy documents; *Prospering in a changing climate: A Climate Change Adaptation Framework for South Australia 2012* and *South Australia's Climate Change Strategy 2015-2050* which highlight action and policy options needed to address climate change.

Possible adaptation options for flood were explored with the research participants in more detail in the next section.

4.4 Adaptation in the BHKC catchment

The BHKC catchment is the most 'at risk' catchment in metropolitan Adelaide (Department of Environment Water and Natural Resources 2017). Therefore, the Local and State government flood risk practitioners including must address the flood risk in the catchment, along with perceived flood risk, flood awareness and education, and explore adaptation options in addition to the implementation of the SMP. The following section discusses ways that flood risk

practitioners in the BHKC catchment are, and could continue to, manage increased risk, and the possibilities for implementation of alternative solutions such as relocation or retreat policies.

4.4.1 Risk perception

The examination of flood risk at a local scale indicated the risk perception in BHKC catchment is causing many challenges to address and adapt to urban flood risk. The initial low prioritisation of the flood risk in the catchment demonstrated a complacency and low motivation to resolve key governance issues causing delays in development of the BHKC SMP.

The risk perception experienced by the practitioners and community reflects how practitioners are also looking into the future to managing the increased risk from urbanisation and climate change. The participants discussed adaptation in the context of urbanisation, and relocation in the form of easements on privately owned land. The results will be discussed in the next sections.

4.4.2 Adaptation for urbanisation and infrastructure

Urban flood risk is the greatest management challenge for Local governments in the BHKC catchment, especially in the face of greater uncertainty around the frequency and intensity of rainfall events due to climate change. Many of the participants discussed the issue of increasing urban infill and the legacy of past planning decisions with respect to the management of stormwater flooding. SA2 (2012) highlights the problem of ageing infrastructure, unable to cope with increased volumes of water created by increased urbanisation in the catchment:

I think the huge factor in all of this is the density of development and the urbanisation, because you can regularly look at new homes being built with impervious surfaces, front and back, with a little token something, which might be one tree, but the whole run off is being directed into gutters that are unable [to cope], either in width, or height. Importantly in our patch, we're the second oldest council in South Australia, so the pipes themselves often are too small to take this volume of water.

SA1 (2012) discussed the hydrological impacts of increased urbanisation, and how the current capacity of the urban creeks is exceeded with the greater loads and velocities:

The urbanisation process has affected the hydrology in two ways. Probably the lesser impact but still a major one is the use of ground water, bores, particularly through the Hills, people pumping out water for their gardens and what have you, we've reduced the ground water flows, the subterranean water is limited. With a double whammy, we've put impervious surfaces over the urban areas so we've prevent recharge of groundwater systems so that the

natural recharge and the ongoing flows through the summer that would have occurred in the past no longer occur and secondly when it does rain, the discharges that the tunnels have to carry will be two, three, four times what they would have.

To counter this, impervious surfaces within the BHKC catchment could be minimised with new methods and infrastructure to handle the increased runoff. As SA6 (2013) suggests:

Rather than concentrating on individual house blocks and trying to put detention in there or at least permeable pavement, I think we should take a bigger leap and create some permeable paths and road infrastructure and try to maximise the amount of moisture that we get from our roaded catchments because in a sense that's where a lot of the run off comes from.

Increasing urbanisation and increases flood risk. The feasibility of alternative adaptation policies, such as relocation type policies, are discussed below.

4.4.3 Relocation policies

The use of buy-back schemes and the introduction of easements over properties at flood risk was discussed at some length by the stakeholders interviewed. Such policy actions can be broadly categorised into the relocation policy category discussed in Chapter Two, as they result in distancing property owners from the risk source. However, they are often politically unpopular and expensive to implement.

The SA Planning Policy; the *30 Year Plan* (Department of Planning and Local Government 2010), needs to consider stormwater management issues to keep urban flooding under control. According to SA6 (2013), the current SA planning policies are too lenient:

If you have a look at our planning policies, they all say the right sort of things but there are no hooks, there's no commitment and often there's no funding to it. So, I'm a great sceptic of our planning policies because they say all the right things but they don't achieve anything. It's only until people make a commitment to fund something or to implement a program where things are done, so I'd say, generally, the planning of Adelaide has been dispersed amongst local councils who are self-serving and inwardly looking. These sorts of issues where you need to rise above individual councils, you need a strong visionary planning council or planning body.

However, SA13 (2013) notes that managing urban flooding goes further than planning policies:

I think the first question you should come back to is not about the urbanisation, it's not about the *30 Year Plan*, it's about actually building in flood zones and the reality is there needs to be either a change or an acknowledgement if properties are going in there [thought needs to be given] in regard to the risk potential, and with regards to how they're built, the built form, how they mitigate themselves, all of those things. That's important.

Relocation policies were considered in the early stages of the development of the BHKC SMP. There was an opportunity to purchase an at-risk property, but this was deemed unfeasible:

We had an opportunity with the City of Unley to buy out somebody down on one of those streets, Jocelyn Street I think it was. And there was a huge reluctance because people say, "*If you do it for that, you set a precedent*" (SA6 2013).

SA4 (2013) agreed, stating:

At that time, it was identified that there was likely to be property acquisition as part of the flood strategy and the risk strategy for it. That got too much of a hot potato for the government so they more or less, not walked away, but they said, "*We've done this much, now councils it's over to you*".

In considering relocation as a possible planning policy in the BHKC catchment, there was overall agreement that a strong relocation policy would not work:

It's publicly and politically not acceptable because there's no money and people don't like it. An option is to buy back properties along Brown Hill Creek over a 50-year period as they come up for sale, buy them, move whatever you have to away from the creek and rebuild it. They tried it earlier on in the piece. It's not politically acceptable. The disruption is enormous (SA1 2012).

The purchase of entire properties to completely remove residents from flood risk was discussed by the participants with strong consensus around the significant political and economic barriers, '*it was talked about for a little while and it [the cost] was just going to be astronomical*' (SA10 2013). This viewpoint of the cost as a barrier was supported by SA5 (2013), who stated, '*I mean, if we were to try to buy them back we'd go bankrupt. We can't do that. It's just too expensive, especially when you're talking through Unley Park and some of those places*'. SA12 (2013) agreed:

I think moving people out of the flood plains is just economically not feasible. You're talking about purchasing people's homes, you've got to start with half a million dollars each for a home and keep going from there and there's certainly not the money for that. Traditionally the approach has been, in terms of least sort of political disruption if I can use that word, it is to do works. Now, that works fine when it's just building culverts or upgrading drains and putting down the roads and you just dig up the road and the disruption are for the individual for a few weeks and it's gone and then it's forgotten about and

it works away quietly, people don't seem to mind that. Now we're proposing different solutions in terms of flood control dams, albeit flood control dams have been, they're new in Adelaide, but there's quite a number around, we are now seeming to be getting this hysterical reaction from people and deliberate misunderstanding and deliberate misinformation.

While buy-back schemes were ruled out, easements will be used to address both the private ownership of the creeks and reduce the risk to people and property. The use of easements was initially identified and communicated to residents through the Part B report (Brown Hill Keswick Creek Stormwater Project 2014).

When questioned how the Local governments could go about introducing easements over the impacted properties, or full acquisition for a relocation policy, SA5 (2013) mentioned that it would be undertaken more easily by a Local compared to a State government because '*they can have that discussion and can get that sense that they have dealt with their local representative more so than just a bureaucratic office in North Terrace [SA State Parliament] or in Canberra [Australian Federal Parliament] that's made a decision and that they've got no recourse to*'.

Despite Local government identified as the best option to implement a relocation policy, the legacy of past planning decisions and the private ownership of the watercourses will make it very difficult to regain land back into public ownership. As SA7 (2013) notes:

Legally, you are, if you regulate to say, "*You may not do this*", they legally have a right to sue you, which is as it should be. If a government makes a law that impacts on you directly you should have recourse for that. If they're going to affect the price of your land or anything else, if it's been given to you and it's your asset and you own it then you have recourse, you have a right to be compensated, or the right to force them to compensate you. The trick is in places like Unley there's a lot of very well heeled, very well-educated people who know that and can afford to do it.

Whilst it will be extremely difficult to implement a relocation policy by way of using easements over 'at risk' properties, it will be necessary for implementation of the SMP and for attempting to manage the balance between, '*risk to people and property*' (SA13 2013). Using easements will also address the governance issue surrounding the private ownership of the creeks in the system, and will enable Local government to manage, clear and potentially deepen the drainage system, thus reducing flood risk and increasing public safety.

4.5 Key findings

The development of the BHKC SMP has been a highly political process, with conflict between governing bodies. Substantial challenges for flood management have been governance related,

and included the private ownership of the creeks, lack of clear roles and responsibilities for State and Local government, and the proposed funding arrangements between State and Local government and the five local councils.

The influence of the community also provided interesting learnings for governance of flood risk. Pressure from wealthy, well-educated, politically powerful citizens drove debate surrounding the highly-opposed flood retention dam in the Brown Hill Creek Recreation Park. The high level of community pressure and persistent lobbying forced a change in risk management approach, whereby community values were incorporated into the SMP. In this sense, the final version of the BHKC SMP demonstrated a move to a more reflexive society, in accordance with Beck's (1992) Risk Society.

Further to this, the results from this case study provide support for more sophisticated approach utilising a flood risk management paradigm, where local consultation and engagement is prioritised and solutions reflect the various interests across a broad range of stakeholder viewpoints. This approach places a stronger emphasis on risk as a social construct and the need for social solutions to manage natural hazards. In the development of the BHKC SMP, a considered, holistic process provided a stronger opportunity for a multi-beneficial solution, where an adaptive management approach has integrated technical solutions with landscape management to 'slow the flow' through a highly urbanised environment. The results indicate that communities value ecological factors and these factors need to be considered for any adaptation approach.

4.6 Key themes and chapter summary

Chapter Four has explored flood risk management at the local scale, through a case study of the development of the BHKC SMP in SA. The governance framework for flood risk management in the BHKC catchment are convoluted. This contributed to the development of the BHKC SMP being a highly political process, dominated by inter- and intra- agency conflict between State government and Local governments and heavily influenced by the local community. The main challenges for flood risk management identified in this case study relate to problematic governance: the private ownership of watercourses and the funding arrangements for SMP implementation. The issue of equity – across public-private and jurisdictional boundaries, was a recurrent theme underpinning these barriers. The final version of the BHKC SMP has identified a range of structural and non-structural flood mitigation options, demonstrating a significant move towards an adaptive flood risk management paradigm.

The implications of the results from this case study will be examined in relation to the other case studies in Chapter Seven. First, Chapters Five and Six will present the results of the SE QLD and UK case studies, respectively.

Chapter 5: 2011 Queensland flood event

5.1 Introduction

The 2011 flood event in SE QLD, Australia had catastrophic impacts across the state. The flood event resulted in multiple injuries and 24 fatalities, over 200,000 people directly impacted with over 2.5 million people affected in total, an estimated 28,000 homes rebuilt with approximately 56,200 insurance claims received, total tangible costs estimated at \$6.7 billion and intangible costs approximately \$7.4 billion, and the declaration of a state of major emergency (van den Honert & McAneney 2011; Queensland Floods Commission of Inquiry 2012; Deloitte Access Economic 2016). The event prompted several inquiries and broader national discussion about flood management. Indeed, it is important to examine this event in relation to the governance of and adaptation to risk because it was a catalyst for major changes in the management of flood risk in QLD and across Australia. The Grantham relocation, for example, is often highlighted as an example of an alternative flood risk management approach. Chapter Five will use the 2011 SE QLD flood as a case study to address a key aim of this study: ‘to investigate the challenges of flood management’ and ‘examine options for an adaptive management approach to flood risk’.

This chapter begins with a brief history of major floods in SE QLD that have had governance implications, followed by a short summary of the 2011 flood event and a description of the governance arrangements in place during the research period. Planned relocation as an adaptation response for flood risk will then be examined in detail using the township of Grantham as an example, and is followed by a review of further adaptation options for flood risk management.

The following analysis uses data from interviews conducted in November 2011, as well as a document analysis of media reports, government policy tools and relevant academic literature. Targeted follow-up phone interviews were undertaken in 2012 to clarify progress made in the implementation of changes from the *Inquiry* (Queensland Floods Commission of Inquiry 2012) and the *Review* (The Australian Government: The Treasury 2011). Although the broader implication of the interview results is discussed in Chapter Seven, key points raised in relation to developing alternative management responses to flood risk are introduced in this chapter.

It is important to note the post-flood event and Wivenhoe dam operation analyses by the media and the *Inquiry*. According to the ICA reviews, the dam releases from the Wivenhoe and Somerset Dams impacted heavily on the flooding throughout Brisbane and Ipswich (Insurance

Council of Australia 2011a). However, the dam operations, policies and manuals will not be explored as they are outside the focus of this thesis.

There were also multiple emergency response policies and plans which impacted on the flood event, but these were also deemed to be out of the scope of this thesis, which does not address emergency management response and recovery planning.

5.2 Local context: SE QLD flood history

QLD has a long history of large-scale flooding from intense rainfall events which are often associated with tropical cyclones. In the case study region of SE QLD, catastrophic floods occurred in 1841, 1893, 1974, and 2011 (Figures 3, 4, and 5), with major and minor flooding occurring frequently between these events, including in 2001 and 2004 (Bureau of Meteorology 2013).

The 1974 event occurred during Tropical Cyclone *Wanda* and caused catastrophic flood damage in the capital city of Brisbane. Indeed, the 1974 event remains the most severe case of urban flooding in Australia. It resulted in many flood risk mitigation and management steps being taken in SE QLD, including the construction of the Wivenhoe Dam and Lake Complex, which was designed to protect the increasing value of the downstream urban assets from flooding. Thus, the 1974 event altered the Brisbane River catchment management (Figure 6) considerably and had important implications for the events that took place in 2011.

Figure 3 Peak levels for selected flood events.

Source: Brisbane City Council Inquiry Board (2011, p. 18)

River Height Station (m Australian Height Datum (AHD))	Feb 1893	Feb 1931	Jan 1974	Jan 2011
Gatton (Lockyer)	16.33	9.14	14.63	>16
Ipswich (Bremer)	24.50	15.50	20.70	19.25
Mt Crosby	32.00	21.78	26.74	n/a
Moggill	24.50	15.40	19.93	17.86
Jindalee	17.90	9.60	14.10	12.86
Brisbane City Gauge	8.35	3.32	5.45	4.46

Figure 4 Historic flood peaks at the Brisbane River city gauge

Source: Bureau of Meteorology (2014, online).

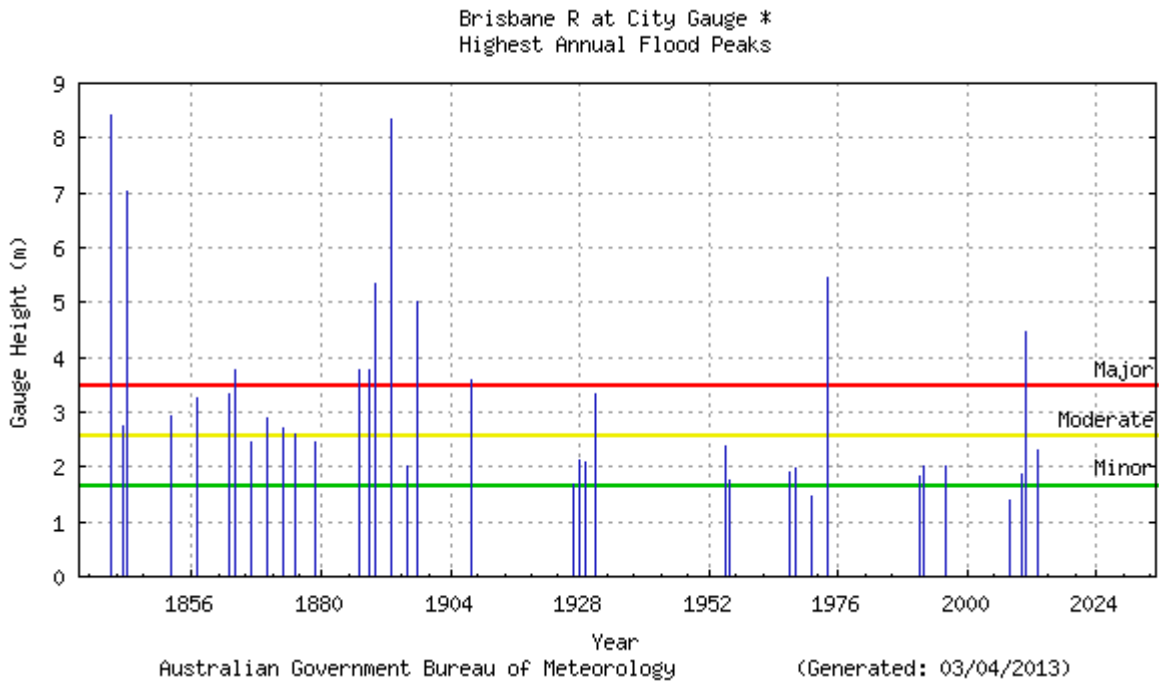


Figure 5 Historic flood peaks at the Bremer River Ipswich gauge

Source: Bureau of Meteorology 2014, online)

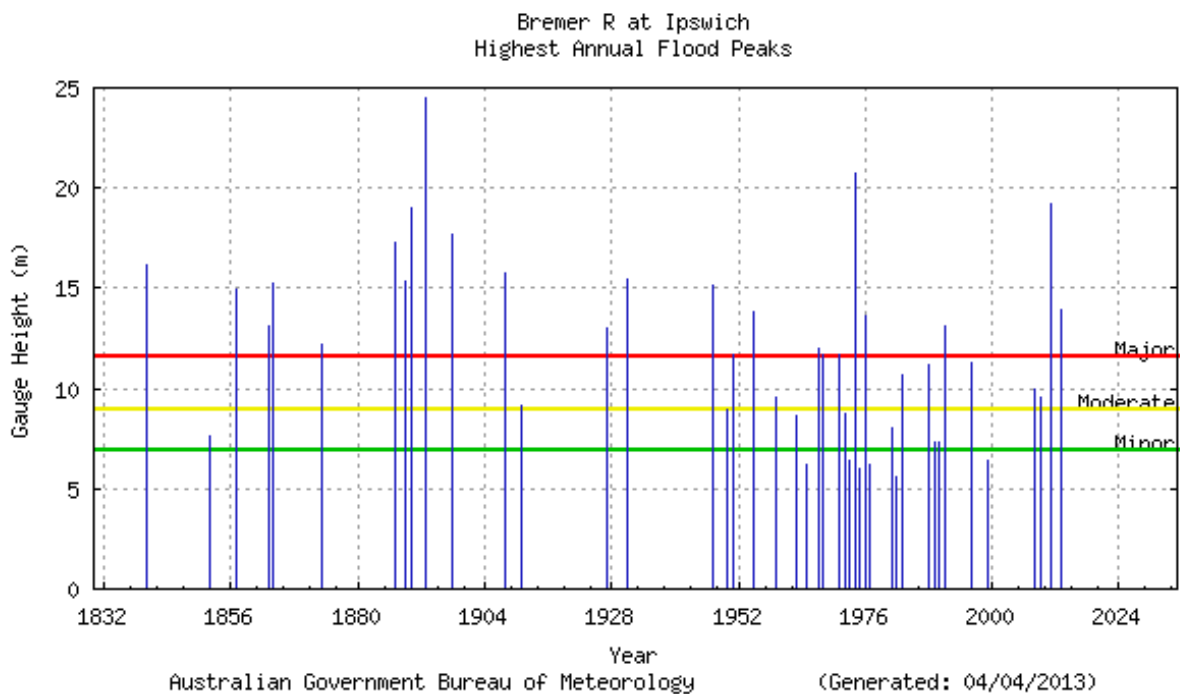
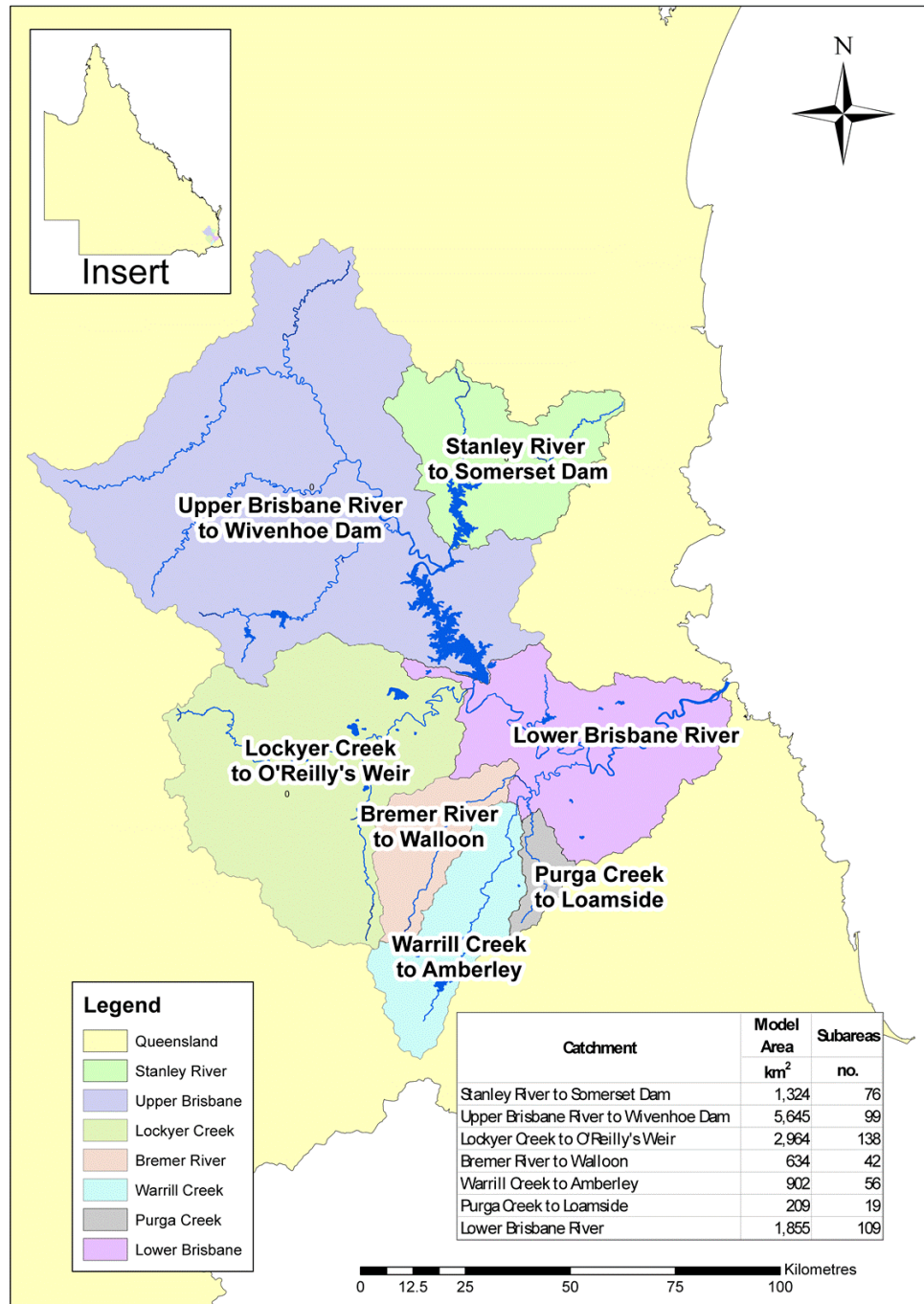


Figure 6 Map of Brisbane River catchment

Source: Department of Natural Resources and Mines (2014, online)



5.2.1 The 2011 flood event

5.2.1.1 Brisbane River catchment description

The Brisbane River catchment is in SE QLD and consists of the Brisbane and Bremer Rivers, the Lockyer Creek, and other small creeks (Figure 6). The catchment is approximately 13,570 km². It is predominantly a rural catchment which includes many small towns, including

Grantham, although it also contains the major metropolitan areas of Brisbane, Ipswich and Toowoomba (van den Honert & McAneney 2011). The catchment has experienced significant development in recent history and many of the watercourses within the catchment significantly modified through the construction of dams and weirs, most notably Wivenhoe and Somerset Dams (Seqwater 2013).

The Wivenhoe and Somerset Dams were designed to both store water and mitigate flood risk. The total capacities of the dams allocated for flood mitigation purposes are 1.45 million mL and 0.52 million mL respectively (Joint Flood Taskforce 2011; Seqwater 2013; van den Honert & McAneney 2011). It is important to note the potentially contradictory purposes of both dams, as much of the controversy around the management of the 2011 flood centred on this issue.

5.2.1.2 Weather conditions for the 2011 event

Before the 2011 flood, QLD experienced a decade of severe drought. These conditions were followed in 2010 by a year of record rainfall, in response to strong La Nina conditions, which leading to a saturation of catchments (Brisbane City Council Board of Inquiry 2011; Bureau of Meteorology 2013). The earlier drought conditions had important implications for flood preparedness.

From the 7th to the 12th January 2011, there was very heavy rainfall over the Brisbane River catchment. 370 mm was recorded at Wivenhoe Dam, 223 mm recorded at Bremer River, and 268mm over the Lockyer Creek catchment. It has been estimated that higher levels of rainfall were also experienced outside the area of the existing rain gauges (Brisbane City Council Board of Inquiry 2011).

The highly developed cities of Brisbane, Ipswich, and Toowoomba and surrounding regions were affected (Brisbane City Council Board of Inquiry 2011) (Figure 7). Together, flood conditions in the Brisbane River catchment and the catastrophic impact throughout QLD of Tropical Cyclone *Yasi* on February 3rd, led to 99% of Queensland being declared a disaster zone. This reflects the scale of the challenge for governmental and humanitarian response systems (Figure 8).

Figure 7 Major urban centres impacted

Compiled by G. Eckert 2017

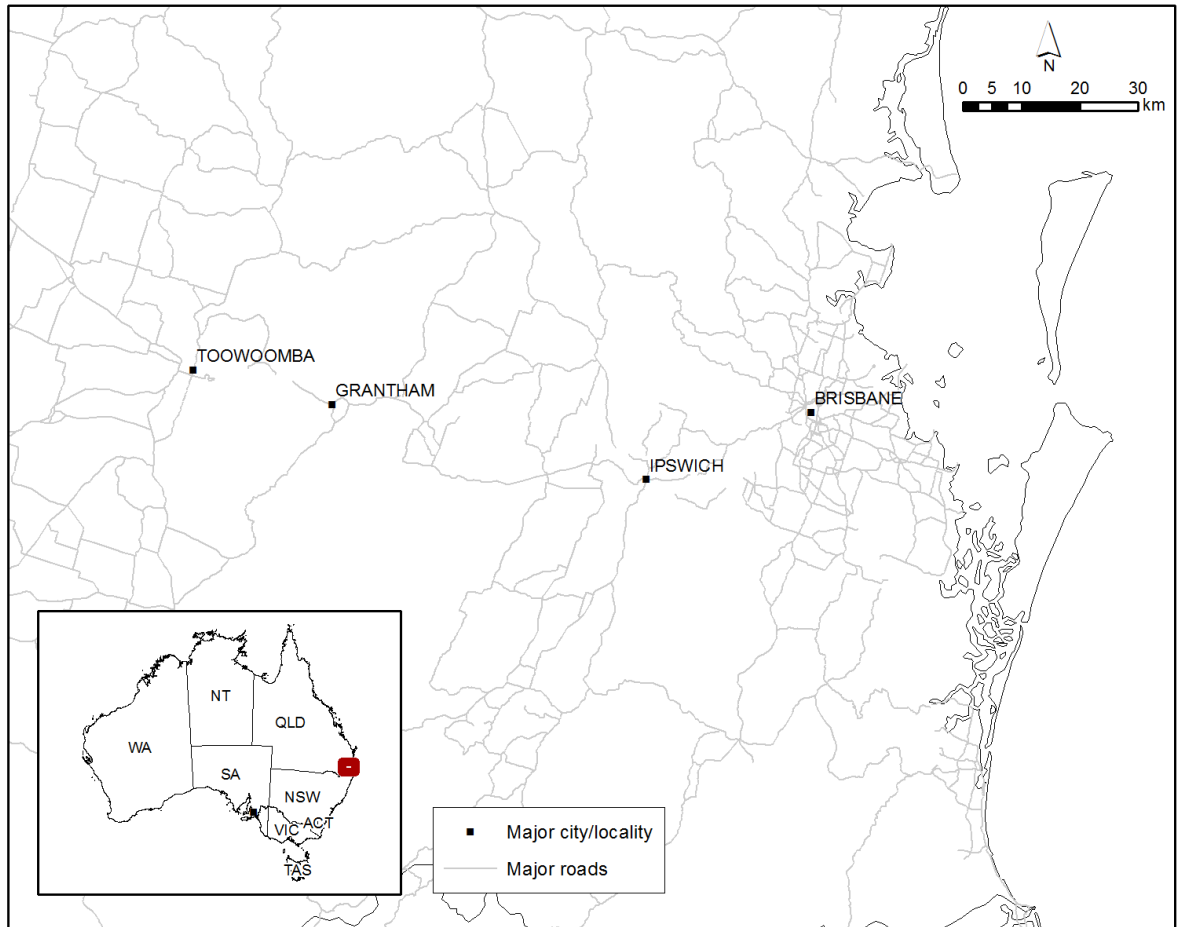
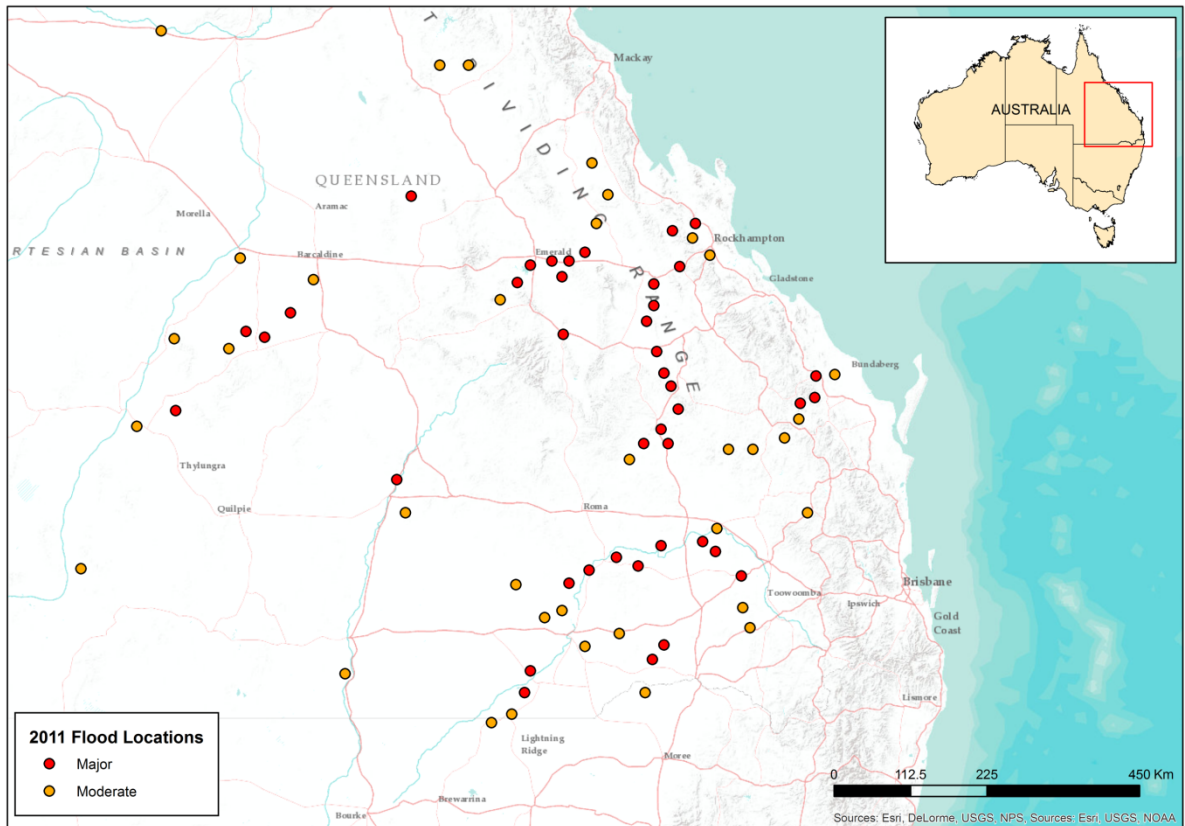


Figure 8 Map of flood impacted areas in SEQ 8 – 12th January 2011

Source: Adapted from Bureau of Meteorology (2011), compiled by M. Chadbourne 2015



The Brisbane city area maintained major flood status for an overall period of 32 hours because of the high river level during the flood event (van den Honert & McAneney 2011). In fact, floods and high flows in the Lockyer and Bremer Rivers added flows to the Brisbane River downstream of the Wivenhoe Dam. This additional water resulted in a peak flood level of 17.86 m AHD at the Moggill flood gauge. Three different high tides also occurred in the major flood timeframe, further exacerbating the flood peaks in Brisbane.

In the Toowoomba and Lockyer Valley regions, flash flooding was caused by a series of intense storm periods during which 40-50 mm of rainfall occurred within a 30 minute period. Runoff into already saturated watercourses within the catchment resulted in creeks overflowing and 11 m of high velocity water gushing through Toowoomba city centre on the 10th January (van den Honert & McAneney 2011).

In the lower Lockyer Valley region, the Lockyer Valley Creek continued to flood with 7 m of water inundating the settlements of Grantham, Murphy's Creek and Postmans Ridge. Flooding in these areas peaked at a water depth of 15.38 m at Gatton in the Lockyer Valley on

the 11th of January. The flood peak at Helidon was 6 m higher than the previous 1974 maximum peak of 7.55 m (Bureau of Meteorology 2011a).

5.2.2 The flood event impacts

Throughout QLD, more than 200,000 people were directly impacted by the 2011 flooding, with over 12,000 of them relied on official evacuation centres (van den Honert & McAneney 2011). The widespread impact was represented by the community clean-up in the aftermath of the flood with over 55,000 registered volunteers assisting with the clean-up and many thousands more unregistered, colloquially known as the ‘mud army’. The Australian Defence Force was also engaged to assist with the recovery process (van den Honert & McAneney 2011). The high involvement of volunteers from the community is important to note as the involvement demonstrates the importance of social capital in building resilience. The next sections will provide a brief overview of the impacts of the floods in the case study townships.

5.2.2.1 Brisbane and Ipswich

The rainfall and flood events described above had a catastrophic impact on SE QLD. In Brisbane, 22,097 residential properties were impacted by flooding and over 3,600 of these houses were evacuated (Brisbane City Council Board of Inquiry 2011; van den Honert & McAneney 2011). A further 7,671 non-residential properties were inundated, 6,680 of those properties were in the Central Business District (CBD) and surrounding suburbs (Brisbane City Council Board of Inquiry 2011). Interestingly, many of the areas that were inundated in 1974 were flooded again in 2011 (van den Honert & McAneney 2011).

Ipswich experienced similar levels of damage, with the suburb of Goodna heavily impacted (City of Ipswich 2011). Approximately 10,000 residential properties were inundated with flood waters in the Ipswich region, including double-story houses that were completely submerged (SEQ8 2011). In contrast to Brisbane, minimal damage occurred to public infrastructure in Ipswich where flood resilience measures such as removing portable buildings and preparing fences were taken (SEQ8 2011).

5.2.2.2 Toowoomba and the Lockyer Valley Region

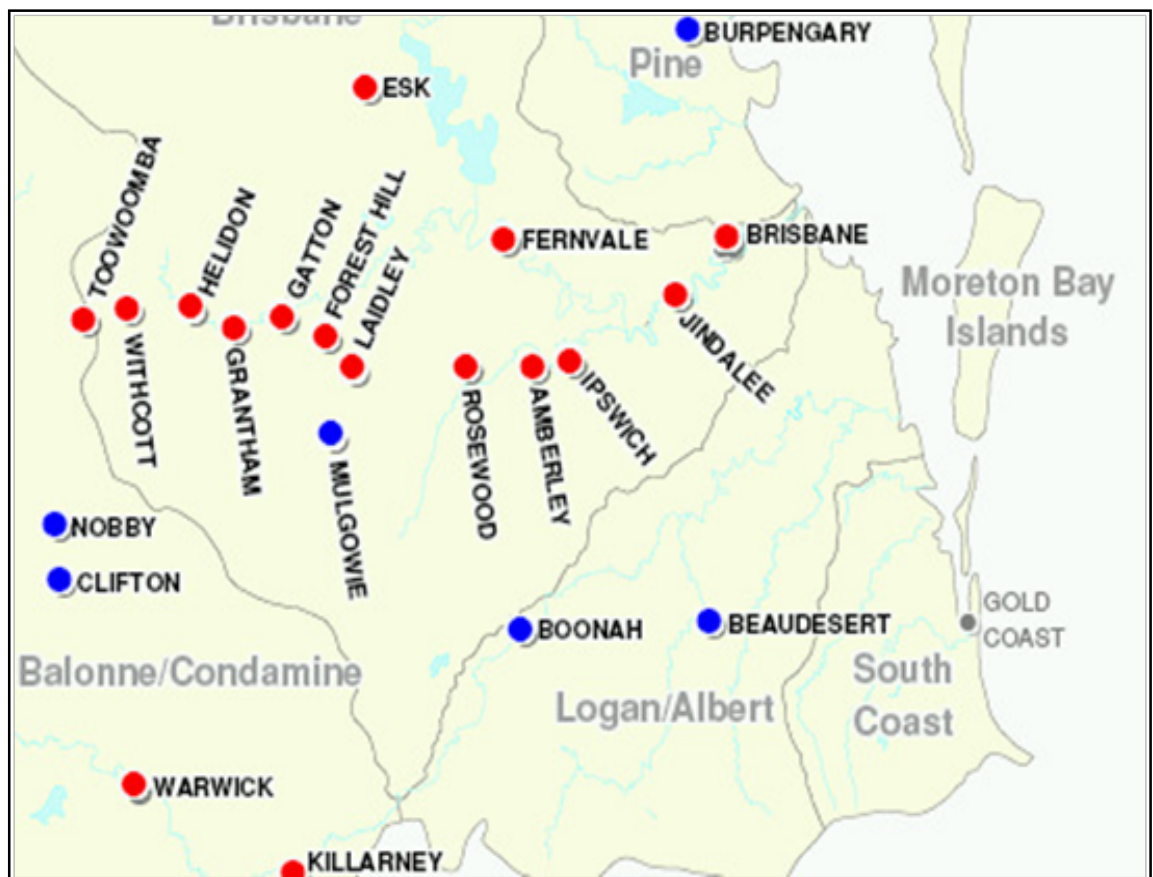
According to the Bureau, the most destructive floods during the period of disaster were flash flooding in the Lockyer and Bremer catchments, and in the Toowoomba township (Bureau of

Meteorology 2011b). Affected towns in these catchments were Murphy’s Creek, Postmans Ridge and Grantham, and Toowoomba (refer Figures 7, 8 and 9). During these flash flooding events, 25 people were drowned; with nine others missing, presumed dead (van den Honert & McAneney 2011). Significant property damage also occurred, with the majority of houses in the floodplain area of Grantham either completely destroyed or suffering severe structural damage (Coates 2012; van den Honert & McAneney 2011). Major infrastructure in the region, including roads, railway lines and bridges, also sustained severe damage. In Toowoomba, the majority of damage was to vehicles, commercial property and local public infrastructure (SEQ4 2011).

As a result of the catastrophic damage in Grantham and surrounding areas, the Lockyer Valley Regional Council (LVRC) offered residents in affected areas relocation to higher land within the town area after the event, an initiative discussed in detail in section 5.4.1.

Figure 9 Affected areas in SE QLD.

Red dots are flood inundated towns/cities, and blue dots are flood affected towns/cities
 Source: NCCARF (2011, online).



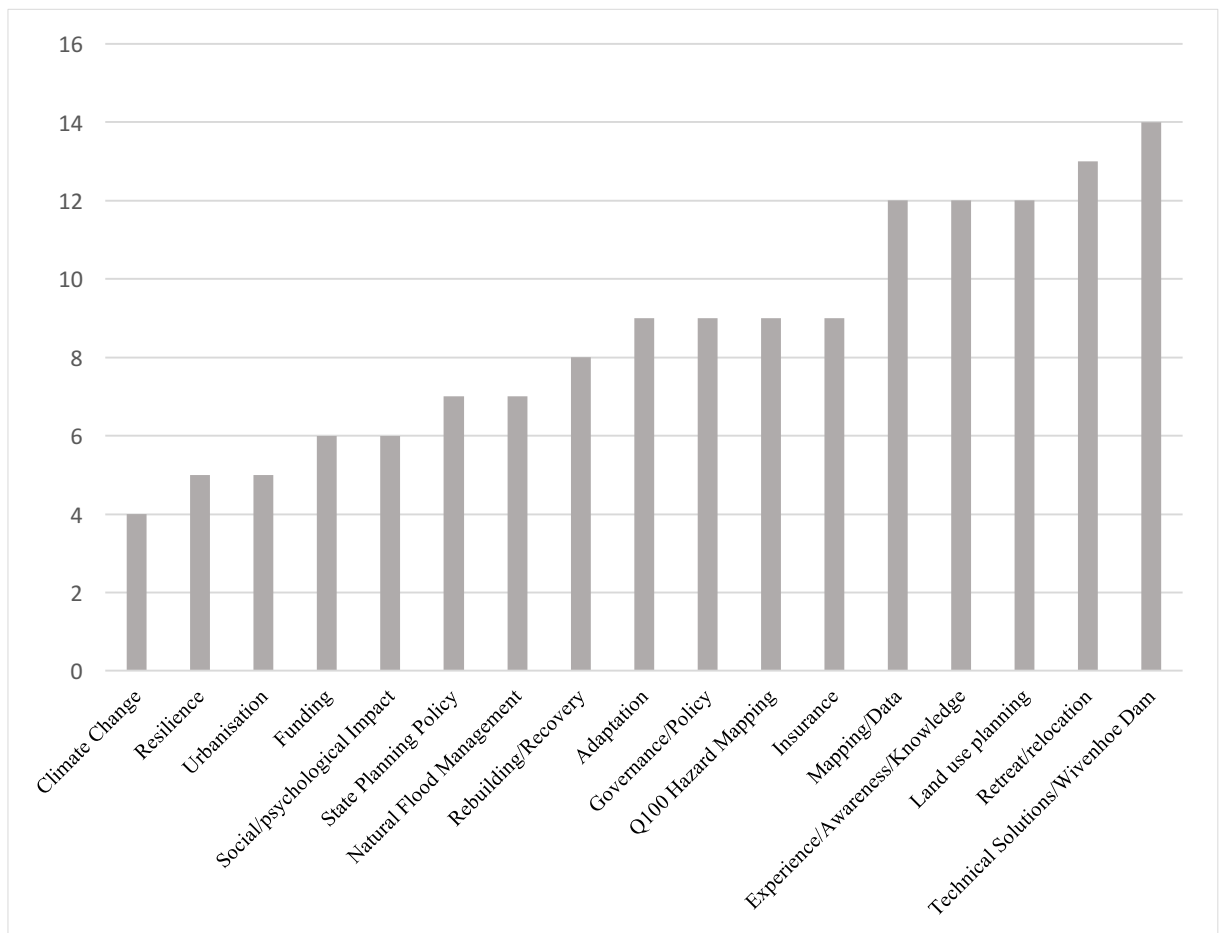
5.3 Issues and lessons learned from the 2011 SE QLD flood event

Analyses of interviews conducted for this study and findings from government inquiries into the 2011 flood revealed common themes in the aftermath of the 2011 flood event (Figure 10).

Interviews highlighted:

- Mapping and data to support flood management
- A low level of experience of previous flood events and awareness of flood risk and consequences by practitioners and the public
- Land use planning legacies
- Insurance uptake
- The influence of risk perception – i.e. that technological structures, such as the construction of the Wivenhoe Dam would protect the city of Brisbane from any future flooding.

Figure 10 Key themes from interviews



5.3.1 Resulting reviews and inquiries

Because of the scale and catastrophic nature of the 2011 flood event, multiple formal inquiries across industries were conducted with a view to understand what occurred, assess the performance of agencies involved, and make recommendations for future actions. All the reviews recognised there was a systematic failure of governance arrangements at the time of the flood, which has had a significant influence on implementation of existing policies and plans. As such, it is useful to understand the background of each review, its scope of reference, and how interview participants perceived them.

The main review relevant to this thesis is the *Inquiry* (Queensland Floods Commission of Inquiry 2012). The Queensland Government's response to the *Inquiry* Final Report was, '*the Queensland Government supports all of the final report's recommendations*' (Department of Premier and Cabinet 2012, p. 4). The Final Report made 177 recommendations in total, with:

- 123 of those relating to the responsibility of the State government
- 56 to Local government
- Eight to the Commonwealth government
- Seven to private organisations

(Department of Premier and Cabinet 2012).

The second major review pertinent to this study is the *Review* (The Australian Government: The Treasury 2011), because it addresses conflicts in how flood and hazard are defined, as well as discussing the concept of market-based risk. The full terms of reference of each inquiry can be found in the final reports (Queensland Floods Commission of Inquiry 2012; The Australian Government: The Treasury 2011).

5.3.1.1 Queensland Floods Commission of Inquiry

Significantly, some interview participants in this study contributed to the *Inquiry* via written submissions or formal evidence, so the *Inquiry* was of particular interest to them.

The *Inquiry* was set up to examine seven issues that arose from the 2010/11 flood events. These were:

1. Preparation and planning for the floods by governments
2. Agencies and the community
3. The adequacy of the response to the floods
4. Management of essential services

5. The adequacy of forecasts and early warning systems
6. Insurers' performance of their responsibilities
7. The operation of dams
8. Land use planning to minimise flood impacts

(Queensland Floods Commission of Inquiry 2012, p. 30).

Themes one, six, and eight are significant to this research and key points to come out of the *Inquiry* (Queensland Floods Commission of Inquiry 2012, p. 31 [emphasis is author's own]) include:

In land use planning, attention to flood risk has been ad hoc. The recommendations made are designed to insert into the land use planning system uniform controls which will ensure that flood risk is consistently recognised and planning assessments are made with regard to it.

Queensland also lacks a coherent approach to floodplain management; a number of recommendations have been made relating to the need for current and comprehensive flood studies and flood mapping, particularly in urban areas.

While interview participants were mostly satisfied with the terms of scope and conduct of the *Inquiry*, SEQ6 (2011) felt it missed two vital components which lead to a more holistic view of the environment: how natural resource management is involved in flood risk management and how the urban environment interacts with the natural environment in floodplains. They said:

People are going to build on floodplains in the future. How they build on floodplains and where they build on floodplains, and what impact that might have on how the floods work and all that kind of stuff hasn't really been looked at. The land planning thing is a bit on the edge. Natural resource management planning and resilience floodplain management in that regard I don't think really has captured their attention (SEQ6 2011).

SEQ9 (2011) criticised the second part of the *Inquiry*, stating:

I think it's turned into a criminal trial. I don't think the way the back end has been delivered has been responsive. I understood the first part of the *Inquiry* because that was realistically about lives lost, emergency management response, how did we respond and all those things. This back end has been very much putting planners on the stand about decisions they made five years ago and how that decision was impacted by the most recent event.

The *Inquiry* report also focussed on insurance, examining the insurer's performance when they were responsible for meeting claims lodged (Queensland Floods Commission of Inquiry 2012). However, there were limited public or professional submissions made to the *Inquiry*

regarding insurance and so the Commission did not come to any substantial conclusions. Five recommendations were offered relating to the methods and communications used when involved in the claims process. The insurance industry was examined in further detail in the *Review*.

5.3.1.2 Insurance and the Natural Disaster Insurance Review

The *Review* (The Australian Government: The Treasury 2011) provided an in-depth examination of the insurance industry in response to the 2011 flood event. The *Review* made four pivotal recommendations, and 47 other recommendations. It was undertaken in response to the low uptake of flood insurance by homeowners, and confusion surrounding the distinction between flood and storm damage (The Australian Government: The Treasury 2011). Recommendations relating to floods, from this report, revolved around availability, affordability, funding, communication, information, definition clarity, and operations (The Australian Government: The Treasury 2011). Of particular relevance here is the standard adoption of a ‘flood’ definition and insurance cover as proposed in the *Clearing the Waters* report (Commonwealth Treasury 2011; The Australian Government: The Treasury 2011). The recommendations correspond with the issues highlighted by the interviewee participants regarding insurance as examined further below. In response to the recommendations proposed, SEQ18 (2011) mentions:

With regard to all of the other recommendations that were in there, there were really only a core set of them that really all hung together. None of those have been implemented, primarily because the insurance industry pushed back on them fairly strongly and said these were quite ill-conceived (SEQ18 2011).

The *Clearing the Waters* report (Commonwealth Treasury 2011) focuses on insurance reform after 2011. For the most part, the consultation paper addresses the need for a standard definition of flood (which has been implemented) and the need for clearer and simpler communication of the policy inclusions and exclusions (which has also now been implemented through publications). However, SEQ18 (2011) questioned the importance of a definition, ‘*had we had a standard flood definition in place for all policies for 2010/2011, would it have made a difference? Not a zack, it really wouldn’t. Because fundamentally people still have to buy the product*’.

As the *Review* (The Australian Government: The Treasury 2011, p. 2) determined, there is ‘*a serious community issue around the availability and affordability of flood insurance. It is essentially a coverage issue*’. This issue was highly publicised in the media post-event (e.g. Ryan 2011; Templeton 2011; Thompson 2013), and was raised again after the 2017 flooding

that followed Cyclone Debbie (Farrow-Smith & Harper 2017; O'Brien 2017). In fact, the *Review* reported that the lack of uptake of property insurance in Australia, especially in high risk locations such as SE QLD, resulted in economic and social losses and will hinder personal and community recovery (The Australian Government: The Treasury 2011). As SEQ18 (2011) stated, '*back in 2006 nobody covered riverine flood in the residential space*'.

Section 5.3.3 further discusses that the lack of coverage by insurance companies was connected to a lack of flood mapping and data for many areas as noted in the *Inquiry* and *Review*. In addition, when flood data is available and properties are categorised as high risk, insurance premium costs significantly increase and can be prohibitive for those who need flood insurance the most (The Australian Government: The Treasury 2011). As SEQ19 (2011) discusses:

I think that the market, the insurance industry will come up with a relatively sustainable flood insurance solution if left to its own devices. My prediction is what we will see is a pool of very high-risk people or policy holders or the community that won't be able to economically fund their insurance purchase. That's where the mechanism falls down. *There's nothing that we can really do about that because that's a result of houses being built in the wrong place in the first place* [emphasis author's own].

The role of insurance as a market-based adaptation approach for informing decisions surrounding risk/market based retreat as a mitigation measure will be discussed more broadly in Chapter Seven. That said, 84% (17 of 19) SEQ participants discussed the role of insurance in flood risk management. Key issues related to definition confusion, performance and risk management.

The performance of many individual insurance companies regarding private residential insurance was heavily criticised in the public forum, with significant coverage in the media. The insurance industry was also covered in the *Inquiry* (Queensland Floods Commission of Inquiry 2012), the *Review* (The Australian Government: The Treasury 2011), and reviews by the Commonwealth Treasury (2011) and the House of Representatives Standing Committee on Social Policy and Legal Affairs (2012). Likewise, SEQ15 (2011) commented on the negative publicity:

Obviously companies that offered flood cover like Suncorp came out of it very well because they paid claims and the rest of the industry, essentially most others who did not offer flood came off very badly, so the reputation was affected by the majority of insurers who did not offer flood cover and the response for that was to implement a whole lot of reviews and find out why there wasn't flood cover and how could insurers be persuaded to offer flood cover, how could it be made more affordable. Because the issue is that flood is, particularly in SE QLD and parts of coastal NSW, are very high flood risk areas and the whole principle of insurance is that you price for that risk and

as you price for high risks it becomes quite expensive and flood risk areas, for instance the annual premium could be many thousands of dollars (SEQ15 2011).

Lo (2013a, 2013b) highlights the fact that many residents in flood-prone areas do not have flood insurance – either because it is not available or they can't afford it, or social influence from individual social circles or general society, among other reasons. Lo (2013a 2013b), therefore sees a need for education to change the perception of flood risk. SEQ18 (2011) also discussed the need for more education,

Government and insurers need to focus on making sure that people have got the right information in front of them to make a decision that's correct for them. The worst case is, when I wander around a flood zone and after the flood waters have receded and people go, "*I didn't buy flood cover*", or, "*I didn't buy any cover because I didn't know I had a flood risk*". That's tragic. But for the right information having been presented to them, they would have protected themselves and that's what we all need to focus on in a regulation sense.

This observation was supported by the ICA (2011b), who demonstrated that only approximately half of insurance policies purchased within Australia covered flood hazard. However, as Lo (2013a) points out, by correctly pricing risk, insurance companies provide an incentive to reduce the purchaser's risk exposure. Flood insurance can provide financial protection to events, therefore increasing resilience (Carter 2012; Priest *et al.* 2005). As Burby (2001) indicates, flood insurance can also influence decision-making for planning and development in flood risk areas, with pricing reflecting floodplain management techniques. SEQ15 (2011) made the same observation:

The crux of the issue is your question around the price signal. And a lot of it hinges on having the appropriate data, which is why we weren't able to provide flood cover in QLD or Victoria. But once you've got the right data and you can price the risk then that price sends the signal to those people that they live in a high-risk area and irrespective of whether its flood or crime or whatever it is, it's a signal that they'd need to change either their location or their behaviours.

These comments highlight the role that insurance can play in flood risk management, both increasing flood risk awareness and as a tool to increase resilience

5.3.2 QLD flood governance framework

Floodplain management arrangements in QLD are '*complex, with responsibility for key activities spread across a range of entities and levels of government*' (PricewaterhouseCoopers

2015, p. 22). Legislation covers the PPRR framework (Office of the Inspector-General Emergency Management 2015), with the primary governance arrangements noted in Table 10.

The QLD State government plays a key role in providing over-arching guidance and coordination for flood management through emergency response, recovery and, most significantly, through administering the *State Planning Policy* (Table 10). This is despite local government having primary responsibility for disaster management in their area under section 4A of the *Disaster Management Act 2003*. In 2011, the scale of the flood event provided a significant challenge for the governance arrangements in QLD. The perceived failure of capacity to effectively govern the implications of the flood event was recognised by the creation of the QRA - a new State government department. The QRA was created to develop efficiencies in the clean-up and rebuilding of infrastructure and communities impacted by the natural disasters from November 2010 to April 2011, but has continued to operate in a smaller capacity since the completion of major projects to assist managing future natural disasters and to complete on-going reconstruction projects (Queensland Reconstruction Authority 2013).

Many local governments have a suite of policy documents that refer to floods, which reflects the fact disaster management falls within their respective jurisdictions and the localist approach presented by QLD. Certainly, as Table 11 shows, this is the case for the local government areas that fall within the case study site.

Indeed, Brisbane, Ipswich and Toowoomba Councils have each developed a significant number of strategies, plans and policies to manage flood risk, with many developed in direct response to the recent significant flood events. The reactive nature of flood risk planning and the political motivation of 'being seen to be doing something' may have strongly influenced creation of policies and plans. The reactive nature of flood policy, planning, and prioritising is supported by SEQ6 (2011), '*one of the things that is clear in QLD is that floodplains and flood mitigation were not really as high priority as they should have been*'.

Table 10 QLD flood governance framework

Legislation	Policy	Agencies/Organisations
<p><i>Disaster Management Act 2003</i></p> <p><i>Sustainable Planning Act 2009</i>⁷</p> <p><i>Local Government Act 2009</i></p>	<p>Emergency Management Assurance Framework</p> <p>State Disaster Management Plan</p> <p>Disaster Management Strategic Policy Framework.</p> <p>State Planning Policy</p> <p>South East Queensland Regional Plan 2009-2031⁸</p> <p>Queensland Local Disaster Management Guidelines</p>	<p>QRA</p> <p>Department of Infrastructure, Local Government and Planning</p> <p>Department of Natural Resources and Mines</p> <p>Department of Energy and Water Supply</p> <p>Department of Science, Information Technology and Innovation</p> <p>Queensland Fire and Emergency Service</p> <p>Office of the Inspector-General Emergency Management</p> <p>Department of Communities, Child Safety and Disability Service</p> <p>Local government</p> <p>Local Disaster Management Groups</p> <p>District Disaster Management Groups</p> <p>NRM organisations, e.g. <i>Healthy Waterways and Catchments</i> for SEQ.</p>

⁷ The *Planning Act 2016* has since come into operation

⁸ The South East Queensland Regional Plan 2017 has since come into operation

Table 11 Research locations and primary flood policy documents

Location	Policy Document
Brisbane City Council	<p>Brisbane FloodSmart Future Strategy (Brisbane City Council 2012a)</p> <p>The Lord Mayor’s Taskforce on Flooding (Brisbane City Council 2005)</p> <p>Flood Action Plan (Brisbane City Council 2012b) – completed 31 October 2016</p> <p>Brisbane City Plan 2014 (Brisbane City Council 2014a)</p> <p>Catchment Floodplain Management Plans (in progress)</p> <p>Brisbane Long Term Infrastructure Plan 2012-2031 (Brisbane City Council 2012c)</p>
Ipswich City Council	<p>Ipswich Planning Scheme (City of Ipswich 2006)</p> <p>Corporate Plan 2012-2017 (City of Ipswich 2012)</p> <p>Advance Ipswich 2015 (City of Ipswich 2015a)</p> <p>Integrated Water Strategy 2015-2031 (City of Ipswich 2015c)</p> <p>Floodplain Management Strategy (City of Ipswich 2015b)</p> <p>Waterway Health Strategy (City of Ipswich 2009)</p>
Lockyer Valley Regional Council	<p>Temporary Local Planning Instrument (TLPI 01/2017) (Lockyer Valley Regional Council 2017)</p> <p>Lockyer Valley: A Growing Lifestyle:2012 – 2022 Community Plan (Lockyer Valley Regional Council 2011c)</p> <p>Corporate Plan (Lockyer Valley Regional Council 2012a)</p>
Toowoomba Regional Council	<p>Toowoomba Planning Scheme (Toowoomba Regional Council 2012b)</p> <p>Toowoomba Regional Planning Project Flood Study Final Report (Toowoomba Regional Council 2009)</p> <p>Corporate Plan 2014-2019 (Toowoomba Regional Council 2014)</p> <p>Toowoomba Regional Community Regional Plan (Toowoomba Regional Council 2012a)</p> <p>Floodplain Risk Management Plans - Yarraman, Maclagan, Quinalow, Cooyar, Crows Nest, Jondaryan and Oakey (in process) (Toowoomba Regional Council 2017)</p>

To provide better flood risk management, some local government areas are focussing on a catchment management approach, some of which require cross-border partnerships. The Toowoomba Regional Council, for example, is a member of the Condamine Alliance (Condamine Alliance 2014), which works in conjunction with local government to develop a flood risk assessment using a catchment based approach (Toowoomba Regional Council 2013). Several interview participants highlighted the need for more partnerships like this. SEQ4 (2011) said:

It should be done on a regional and catchment basis which goes beyond boundaries. QLD is moving into that space now. It's been unable to for a long time, but is starting to move into that space because it is the appropriate level to be looking at, the region wide catchment type approach to water management, to drainage management on a catchment wide basis because it goes beyond councils. The only alternative if the State wishes to remain on holidays is the Councils have to get together; the Councils of the various boundaries have to get together and work. So, in our case probably five councils would get together because we are the headwaters of the Murray-Darling. It would be difficult, and doable but far better to be done at State level and at the higher level (SEQ4 2011).

Similarly, SEQ9 (2011) said that local government partnerships are important because, *'when flooding occurs, it doesn't yet stop at a local government boundary, nor does it stop at a planning scheme boundary'*. It is important to note that partnership planning at catchment level was also raised in the BHKC case study discussed in Chapter Four.

However, the creation of the QRA reflects a broad acknowledgement that there was a governance and prioritisation failure from the localist approach, with the previously existing agencies and governance arrangements unable to cope during the large flood event, potentially due to an implementation gap.

The influence of the local focus on flood management is often represented through planning schemes. Planning schemes in SEQ will now be discussed in the following section.

5.3.2.1 QLD planning schemes to increase

The key *State Planning Policy (SPP)* before and during the time this study was conducted was the *SPP1/03 Mitigating the adverse impacts of flood, bushfire and landslide* (Queensland Government 2003b). The *SPP1/03* policy document was governed by the *Sustainable Planning Act 2009* (Queensland Government 2009). The *Temporary SPP 2/11: Planning for Stronger More Resilient Floodplains* (Queensland Reconstruction Authority 2011b) was introduced after the flood event, and recognised that the *SPP1/03* was inadequate because it failed to successfully reduce flood risk for communities. The *State Planning Policy* replaced the

Temporary SPP 2/11 in 2013. This policy was updated again in 2016 (The State of Queensland 2016).

The original *SPP1/03* and historical land use planning was criticised by interview participants, chiefly because there was a lack of enforcement of the guidelines in the planning policy; responsibility of floodplain management resided with local government; the prohibitive cost of research into floods, and because of the reliance on the Q100 planning line.

The Q100 is a planning tool that indicates the 1 in 100 ARI, or 1% AEP flood hazard boundary on a map. Brisbane City Council defines this as a ‘medium risk area’ (Brisbane City Council 2014b). Q100 values vary with each location and are often used as the defining measurement for planning schemes by local governments.

SEQ6 (2011) described the *SPP1/03* as,

It [SPP1/03] basically set an environment where the State said it was up to local governments who may, in inverted commas, make local rules with the associated management with the floodplain... The *State Planning Policy* says its local government, but local governments say, “well, we don’t have the expertise or the resources to be able to manage that”. So, there’s this sort of gap.

SEQ9 (2011) provided further explanation on the poor implementation of the *SPP1/03*:

At the time that the *State Planning Policy* came in, the State was in drought and no one was getting money for flood studies so we have put it on record with the Commission that we recognise some of those challenges that Local government have faced.

The challenges in implementation of the *State Planning Policy* reflect a top-down bureaucratic approach, with State government seeming to dictate to Local governments, without provision of adequate support or resources, highlighting an implementation gap which will be discussed further in Chapter Seven.

A document analysis shows that QLD is mitigating levels of flood risk through land use planning, despite the significant installation of structural defences across the state. The City of Ipswich is employing a weak relocation policy promoting adaptation through the ‘*transition of existing flood affected residential areas to low impact, non-residential uses*’ (City of Ipswich 2013, p. 2). Their planning policy recognises the need to apply gradual land-use change rather than an abrupt abandonment of a location, thus recognising psycho-social attachments people have to place and community, as well as the significant economic and political impacts of such moves. This land use policy change requires a series of hazard maps, showing various risk levels, beyond only the Q100 flood hazard line.

Previously, QLD planning policy *SPP1/03* (Queensland Government 2003b) only noted that floor levels should be above the Q100, not the need for a whole hazard mapping spectrum. Unfortunately, the focus on this measurement resulted in the '*Q100 [going] into the folklore as being, "If I'm above the Q100, I'm safe"*' (SEQ12 2011). The focus on Q100 and the false belief of safety can be linked back a constructivist approach and how risk is conceptualised and what level of risk is deemed acceptable as discussed in section 2.2.4.

The *Inquiry* put forward the following recommendation (Queensland Floods Commission of Inquiry 2012, p. 63):

This focus on the Q100 and one defined flood event should not continue. Q100 represents only one possible flood. Reliance on a single defined flood event contains this limitation: there are only two areas by reference to which planning controls relevant to flood can be set – the area inside, and the area outside the line depicting the extent of the flood. Restricting development within the extent of the 1% AEP flood will manage a portion of the risk, but it does not deal with the risk of floods that are less frequent, but more severe, or those that will occur more often, but with less damaging consequences. Instead, the various areas to which planning controls apply should be selected having regard to the likelihood, behaviour and consequences of the full range of possible floods, up to and including the probable maximum flood.

There was consensus among interview participants that dependence on the Q100 line should not continue, with many of the interviewees agreeing with the need for a graduated system of hazard event lines. SEQ12 (2011) suggests the following to demonstrate and clearly communicate levels of risk:

You should use Q50, Q100, Q200, Q500, and even PMF (Probable Maximum Flood), so that you can see the shape of your flood risk and people understand that Q100 isn't the end of it. If you only put a single line down they think, "If I'm over the line I'm all right", whereas, "*Oh, there's more lines and more lines and there's this funny line that hasn't got a number, it's got letters, that's safety up there and these are all relative levels of risk*".

This viewpoint was also presented in the *Inquiry* (Queensland Floods Commission of Inquiry 2012, p. 68) which recommended:

2.13 For urban areas or areas where development is expected to occur:

- a) Councils with the requisite resources should develop a flood map which shows 'zones of risk' (at least three) derived from information about the likelihood and behaviour of flooding
- b) Councils without the requisite resources to produce a flood behaviour map should develop a flood map which shows the extent of floods of a range of likelihoods (at least three).

The introduction of such measures will have a range of flow-on effects including being able to make informed decisions about new developments. As one participant noted, *'before you can decide to stop making bad decisions you need to know where those places are that you shouldn't be making those decisions in'* (SEQ7 2011). SEQ7 (2011) goes on to mention:

We've been to some degree merrily filling in floodplains and doing all that sort of stuff, at least up until the last 10 or 15 years anyway but now that's starting to be realised that we have to stop doing that and they're now getting the capability to stop doing it. It's all very well to know you shouldn't do it but if you don't know where you shouldn't be doing it then that makes life a bit tough.

A legacy of many old developments has been the infill of floodplains, although this has also been a hallmark of some new developments. As SEQ12 (2011) noted, *'In January 2011, there were very large parts of the housing stock, including in Brisbane and Ipswich, which went under and recently built houses too, after the State Planning Policy had come into place'*. Recent flooding of new houses indicates that there will always be areas at flood risk over the Q100 (1% AEP). Although flood mapping is available to councils, they continue to put people and property unnecessarily at risk for a range of reasons, including pressure from developers, political motivations and the incorrect assumption that the level of risk is eliminated by mitigation infrastructure such as the Wivenhoe dam, where it is only reduced. SEQ14 (2011) highlights the issue of residual risk, and the conundrum that planners and governments face dealing with flood risk and development:

The issue is that we just had an event larger than the DFL (Defined Flood Level) is and I think that raises the issue, what do you do with this residual risk? I think that's the question that really needs to be looked at. Do you change your level higher or do you actually start to manage that residual risk better and give people the choice or more information about what that is and that's really the big lesson that comes out of this. You're always going to get an event bigger than whatever line you put, so you have to advise the public about that residual risk and make sure that you're planning and managing that and if it is a really high-risk area and that residual risk is quite significant then you need to manage that and do something about it (SEQ14 2011).

These results suggest there needs to be a reduced reliance on the Q100 or 1% AEP event for development decisions. Rather, a gradient of risk will better serve communities, helping them to understand their exposure to flood risk and supporting smarter land-use planning.

5.3.3 Mapping and data

Appropriate and successful communication of flood risk is extremely important for best practice flood management. Although some government authorities had access hazard mapping

using gradient lines such as the Q100 (1% AEP), many local councils either had insufficient or no flood mapping completed for their region (Queensland Floods Commission of Inquiry 2012). SEQ4 (2011) highlighted this:

One of the difficulties in QLD is that there has not been a lot of flood mapping or flood work done, unlike maybe in Victoria or NSW where extensive work has been done. Gold Coast has done a lot of flood mapping work, but Toowoomba has done very little. Brisbane has done some, but not enough, and Sunshine Coast has certainly done more than Toowoomba, because Toowoomba has done very little, but the State's done even less.

A lack of flood mapping makes it difficult for people living in areas that do not flood frequently to identify the flood risk to their properties. Likewise, planners face challenges identifying the risk to infrastructure in unmapped areas. A lack of information about flood risk may lead property owners to underinsure their assets or not insure them at all, with obvious negative ramifications in the event of flood. It can also mean missed opportunities for better planning and preparation for floods by both local Councils and property owners. SEQ4 (2011) commented on the poor state of mapping in QLD:

The QLD Government has been very slack in the past in terms of getting just base mapping, just getting basic maps out there that have reasonably accurate topographic information. It just hasn't existed. When I first came to here three years ago, the base maps being used out in the Boonies were army ordinances maps. So, you know, that's how accurate they are. Yeah, they were done during the war, the Second World War.

Recommendation 2.4 from the *Inquiry* states that, '*a recent flood study should be available for use in floodplain management for every urban area in QLD. Where no recent study exists, one should be initiated*' (Queensland Floods Commission of Inquiry 2012, p. 54). However, the *Inquiry* does not specify who should fund these studies, although it is known that financial resources are the main barrier to undertaking flood studies, which generate the necessary mapping. The *Inquiry* also suggests flood studies should, where possible, involve collaboration between neighbouring local governments so whole catchments are investigated and mapped allowing for greater understanding of flood water behaviours and impacts (Queensland Floods Commission of Inquiry 2012). More detailed mapping also strongly influences insurance premiums and land use planning and development as discussed in above sections.

Basic flood maps known as 'Interim Floodplain Assessment Overlays' have since been provided by the State to the public and Local governments (Queensland Floods Commission of Inquiry 2012; Queensland Reconstruction Authority 2013). These maps have been developed for councils to use as a resource in their planning schemes, and, according to SEQ7 (2011), they

'will make all the difference to people's appreciation of what it is that's there. It's so much harder for people to ignore I suppose'.

As SEQ7 (2011) said, even with sufficient flood maps, the misuse or lack of understanding of hazard mapping caused confusion:

There's a lot of commentary you might have heard coming out of the *Inquiry* about people who were flooded saying, "*Oh but I was above the flood line*". Yeah, I know. But it doesn't mean you're not going to get flooded and that brings much bigger questions about the fact that in riverine flooding you going to have major landscape changes through urban development. And, the ways the water flows through the changed landscape can mean that it may not be a very big effect but you might still get flooded anyway. Even though when it was initially identified [at flood risk], you might have been above it. But it's the way hydrological forces work, that you might get flooded anyway (SEQ7 2011).

The importance of effective communication of flood risk was stressed by several interview participants. SEQ14 (2011) said, *'we put a lot of effort into putting more information out. But the flood information and the way that flood information is communicated is one of the big outcomes or the big learnings of this event'*. Clearly, the accumulation of knowledge about flood risk and the effective communication of this information is essential for community to form a view on their flood risk and can also be used to influence formal risk assessments and technical analyses (Plattner *et al.* 2006).

5.3.4 Knowledge and perception of flood risk

Realistic and accurate knowledge and perception of flood risk can have a significant influence on the importance placed on flood risk management. 32% (6 of 19) of interview participants discussed how the experience of drought conditions for the previous decade and lack of serious flooding in the area since 1974 influenced emergency management operations, urban planning, public perception, and professional knowledge. SEQ13 (2011), for example, said, *'like anything like a flood like this, when you get a big event that hasn't occurred for a while, things can be a bit rusty. People have left, people have changed, and people haven't been through floods before'*. SEQ13 (2011) continued, *'while you can do preparedness training and things like that, none of it actually necessarily prepares you for the real thing, so in any emergency response you've got that challenge in front of you'*.

Arguably, a significant and enduring legacy of the sustained drought conditions was the false perception held by the public and many professionals that the Wivenhoe and Somerset

Dams would prevent further flooding in Ipswich and Brisbane. SEQ19 (2011) explains the mechanism of Wivenhoe Dam and its operations,

Wivenhoe Dam is meant to be water storage and it's also meant to be a flood mitigation mechanism. So, from a water storage perspective you want to keep the dam levels as high as you can in case we run into a 10-year drought and need to draw down on it or in the case of La Nina year you want to keep the dam levels as low as possible so you can fill it up with flood water and protect the city. So, they've got two competing priorities there that will never sit comfortably with each other. In a way, it dumbs down the role that dams like that have to play in active, effective flood mitigation.

The competing priorities described here added to the widespread belief that Wivenhoe and Somerset Dams would protect Brisbane, which was discussed by 37% (7 of the 19) of participants. It is possible that this also impacted on the perception that the dams were mismanaged (see Madigan 2013), despite the *Inquiry* determining this was not the case (Queensland Floods Commission of Inquiry 2012). SEQ1 (2011) discussed the role of political pressure in the management of the dams, particularly how years of drought conditions impacted decision-making and risk perception of the consequences in this regard:

People were being flooded by the releases and they were questioning, you know is this necessary or not? So, there was a lot of political pressure to keep the release levels minimal until the end. And then they were like "GASP" and let it out. There was this political pressure not to release because we had had such a huge drought.

SEQ14 (2011) said, *'I think there's a lot of misunderstanding about what Wivenhoe can do in the community... definitely there are a lot of urban myths about what Wivenhoe does and doesn't do'*. This point was reiterated by SEQ1 (2011) who felt that despite the knowledge of the flooding upstream, *'there was an unbelievable level of denial'*. SEQ1 (2011) went on to say, *'I think a lot of the public had always thought for decades, "Oh Wivenhoe Dam will protect us". There was a very misplaced belief that the Dam would protect everybody, that there would never be a flood like '74''*.

Interview data therefore suggests that the perception that dams would protect the cities and surrounding areas led to an environment where misinformation and, or, a lack of information was the norm for areas at risk of flooding, indicating the influence and danger of a false perception. As SEQ1 (2011) said,

Oh, nobody would tell you; no if you were going to buy a house then they wouldn't say, *"Oh by the way this is in a flood-prone area"*. The real estate agent wouldn't tell you that it is in a flood prone area. I think when you are looking at buying a house, the vendor wants to sell it, and the real estate agent wants you to buy it. The neighbours aren't going to come out and say, *"oh yeah"*. If the neighbours know, they probably live with the risk. But you

know, it's been 35 years since it last happened and people get into a mind-set where they think "*oh well*".

Similarly, SEQ6 (2011) said:

There was this sort of myth that Wivenhoe Dam would somehow stop a flood. You don't have to be Einstein to work out that it's not going to stop a flood, especially if that flood is not up there, the floods down here. I think the other thing is I think people actually had this expectation, and it was a common myth that people actually went with. I mean it suited people; it suited developers to sell a piece of land and say no, "*it's ok, even though it's on a floodplain, we built Wivenhoe*". So, Wivenhoe is going to protect you. It was easy. People said, "*oh yeah ok, I want this block of land anyhow, so in the back of my mind I will reason that Wivenhoe is going to protect us*". The fact is that if the Bremer floods, the Bremer floods. It's got no Wivenhoe between you and it. If the Lockyer floods, it's got no Wivenhoe between you and that as well. And if Wivenhoe is full, then it can't help you anymore. And if Wivenhoe breaks, then we all go out to sea. So, there were a lot of false senses of securities and misinformation. And there were a lot of things that went on in relation to, "*oh look it won't happen again, that was a freak event*" (SEQ6 2011).

The *Inquiry* considered the general misperceptions around Brisbane's flood risk and the notion that dams would provide adequate protection (Queensland Floods Commission of Inquiry 2012). As SEQ5 (2011) reflected,

Well in the *Inquiry* there's been a lot of debate around that as to who ever claimed that and how was that a commonly held view, and why wasn't that more rationally debated and understood. But again, remember we'd been in drought for 10 years.

Similarly, SEQ1 (2011) mentions the lack of community knowledge about Brisbane's landscape and that residents believed that if their property was some distance from the river, they would be unaffected:

Brisbane is hilly, so the water just goes around like all the lower levels of an egg carton. So, you might be 2km away from the river but if your street goes like that then you are at the low part of the dip and get flooded and that's what happened (SEQ1 2011).

Perceptions such as this indicate a need for greater education, awareness and communication of the flood risk in Brisbane and surrounding areas in SE QLD. SEQ1 (2011) asks the important question, '*how do you communicate even better and get through to the public through all those levels of denial*'? SEQ5 (2011) agrees emphasising the need to remove '*any doubt that Brisbane's a river city and will continue to flood*'. SEQ7 (2011) also indicated a need to improve flood risk education and effectively communicate information that is available:

I don't think there's a very good understanding of what risk is. People equate flooding maps and other biophysical mapping as zones. They don't understand the difference between a map showing different land use zones and map showing vegetation or anything really. It's just so enamoured of the whole zoning concept that as soon as they see a map with colours on it they think the lines at the edge are hard lines, and one side you're fine and the other side you're not or whatever way it is. So, I think there's a fair bit of education in making people understand the nature of risk and how you respond to risk in different ways (SEQ7 2011).

However, the *Inquiry* does not list communication recommendations beyond increasing general knowledge about flood risk and creating a public acceptance of the flood risk exposure.

Yet knowledge and acceptance of vulnerability to flood risk may lead to increased resilience to future flood events by urban and regional populations, as demonstrated by the local farming community:

The farmers were very philosophical about it, very resilient. 'Hey, we live on a floodplain, it's going to flood'. So, we build our houses in a certain sort of way and we expect to have those losses. But hey next season is going to be a ripper because we've got all this water, we've got a good water table, and all sorts. There are some good things out of this flood. Right next door is a group of people going why did the government let this happen? We should've been protected from this flood, you know? These were all the type of people who had come out there for the lifestyle but didn't want what went with it (SEQ6 2011).

However, SEQ6 (2011) believes that:

You'll never get urban communities to ever live with floods. I think you need to get them to understand them more. They need to understand what impact they might have. It's been one of those things where we had a drought for so long in QLD, it's been so long, since '74 when they had a last real flood of any real major scale (SEQ6 2011).

The extended time between events meant knowledge and skills deteriorated, while misconceptions about the protective capacity of mitigation measures, like the Wivenhoe Dam, flourished among both the public and risk practitioners. SEQ9 (2011) summarised this: '*I think there were some lessons that were learned (in the '74 flood) but then lost, and now they're being learned again*'. The misperception of risk and a loss of knowledge occurred in many areas, including planning and building codes.

5.3.5 Rebuilding post-flood

The recovery phase of a flood typically involves rebuilding property and infrastructure, activities that should be undertaken in a planned and considered manner. Building codes were

reviewed in Chapter Nine of the *Inquiry* (Queensland Floods Commission of Inquiry 2012), and *Temporary Planning Instruments* were applied across local governments in the aftermath of the 2011 flood event to guide rebuilding (i.e. Brisbane City Council (Brisbane City Council 2012d)). As SEQ7 (2011) mentions, *‘for example, here in Brisbane the council quickly introduced interim planning law that basically took away the height limit’*.

This new interim planning measures increased the height restriction to 9.5 m, and resulted in renewed popularity of a modern version of the traditional Queenslander-style home allowing for housing on stilts. Indeed, 211 applications were submitted to rebuild properties at a higher level (MacDonald 2013; Madigan 2011; Moore 2011, 2012). Significantly, a main reason Queenslander-style homes were built was to reduce the impact of flood. The resurgence of houses built this way signals a return to building adaptation methods in order to increase resilience to flood. Further methods of risk adaptation and resilience will be discussed in the following section.

However, despite recognition of the need to improve building codes and designs for adaptation, thereby reducing vulnerability to flood hazard through the use of flood-resilient building codes and materials, the majority of houses rebuilt after the floods were built in the image of those damaged in the flood. SEQ13 (2011) discussed possible reasons for the trend to rebuild like-for-like, and suggests psychological impacts and cost limitations of implementing change.

They weren't insured but they still put it back, the gyprock went back, floorboards went down exactly that it was. It was like-for-like. It was like, *“I want to just get back to the way I was and pretend it didn't happen”* almost because it's a bit hard. That's something that should be thought about (building like-for-like), whether its cost for cost or it's just too hard (SEQ13 2011).

SEQ9 (2011) acknowledges the greater trend to build like-for-like, and the need for a bigger focus on betterment. It is arguably a lost opportunity for adaptation and increased resilience:

I think betterment is a must. I think there is potentially lot of people just doing a like-for-like because its' easier, but I think the rules at the moment also are a little bit restricting in that respect (SEQ9 2011).

An excellent example of people rebuilding in the same way as before the flood was the return to using slab-on-ground housing. As SEQ7 (2011) mentions, slab-on-ground housing should not be used in high risk flood areas, rather a return to Queenslander-style housing should be encouraged:

Certainly, a building response in terms of what sort of buildings are you building. So, redevelopment in these areas and taking proper account of the risk in doing so. We know places that flood regularly and people still build slab-on-ground houses, they're still allowed to build slab-on-ground houses. Why do it? (SEQ7 2011).

SEQ14 (2011) agrees there is a need to build to a greater resilience level, so that post-event recovery is easier:

You should be encouraging to have building resilience and resistant materials or something like that above that line as well so that when it does happen you can cope with that and it's easy and your building doesn't fall over and you can just hose everything out (SEQ14 2011).

SEQ5 (2011) also agrees there is a need for improved building design and materials as an adaptation method. Such adaptation techniques are necessary:

Because we've got a legacy of existing urban areas in areas of risk. And given much of it, the risk is still relatively low and you could live through it you're prepared, I think really in many cases, that's the response (SEQ7 2011).

Flood risk mitigation and adaptation responses to increase resilience to flood hazards will be discussed in the next section of this chapter.

5.4 SE QLD and relocation policies

5.4.1 Grantham and relocation

On the 11th of January, an '*inland tsunami*' went through the Lockyer Valley region (NCCARF 2011, p. 1). This caused severe devastation both psychologically and physically to those impacted by the flood. The *Grantham Floods Commission of Inquiry Report* (Grantham Floods Commission of Inquiry 2015) provides a timeline, and engineering and hydrological analysis of the flood event in detail.

To address the need to rebuild the town, the LVRC relocated the township to a higher tract of land in the Grantham area (Lockyer Valley Regional Council 2011a).

After the flood, the Mayor sort of had a look around and thought well we could spend \$100 million rebuilding these people's lives in the same spot they were to perhaps have another flood maybe next year, maybe never who knows? But it just seems a bit silly to rebuild it in that spot. Because you are just putting people back at risk. The problem was a lot of people weren't going to ever go back there. People who were on their roofs or lost family weren't going to live back there. So, what you end up with is basically a ghost town. That was what council was kind of facing after the event. Basically, you could go spend a lot of money there to rebuild, with most of the people

they aren't going to come back and you end up with a bit of a ghost town on a major road in the region. So, would obviously be an eyesore SEQ3 (2011).

As SEQ3 (2011) stated, the rationale for the relocation policy was to reduce risk exposure, and increase resilience for the area:

It's much more of a sort of a community resilience type thing to get people out of harm's way. Because that's what we really care about at the end of the day. I mean we can lose a few bridges here and there, but you don't want people dying.

The *Grantham Relocation Policy* (Lockyer Valley Regional Council 2011a), presented an opportunity for a land swap for affected property owners in the towns of Grantham, Murphy's Creek, Postman's Ridge, Withcott and Helidon. The relocation policy was voluntary, and completed in stages, with over 70 families moving into new homes by December 2011 (Lockyer Valley Regional Council 2011a; Rowland 2011).

The relocation and redevelopment of the new site for the town was undertaken in partnership with the QRA and Commonwealth National Disaster Levy funding. The State declared a 'Reconstruction Zone' to achieve the building of new dwellings in the short timeframe (Queensland Reconstruction Authority 2011a), which allowed the QRA to fast-track development administration, such as planning permissions, and cut 'red-tape'.

The 'land swap' relocation process occurred using a ballot, which was organised by the property developers involved in the project (SEQ3 2011). Owners of the new properties numbered their preferences in block designs ranging in sizes from 1,000 m² to 10,000 m². The participants were then allocated their new block and transferred their existing land into Council ownership (Lockyer Valley Regional Council 2011a, 2011b; Queensland Reconstruction Authority 2011a).

During the fieldwork phase of this study, the overwhelming response to the Grantham relocation initiative was very positive. As SEQ3 (2011) stated, *'99% of the community is absolutely rapt, and they should be really'*.

SEQ9 (2011) highlighted that the reconstruction project demonstrated the ability of governments to collaborate across levels and business areas to deliver successful adaptation projects. They said:

And what this exercise showed me was there was a level of collaboration between Local, State, and Federal to deliver on something that needed to be done at a really quick timeframe, but we didn't let the quality of the work slip at the same time. We just went and we had this really focussed in attitude of well how are we going to do this? What do we need to do? And literally cut what would have been a three year timeframe into four months. And our mandate was we want to see people in their homes by Christmas.

SEQ9 (2011) also viewed the process as positive overall, and thought it was great to be involved in a community restoration project:

But it's also then about how can we look at ways to strengthen the community as well. So, one of the things we really like doing as planners, is we want to work out in two years' time, what Grantham would look like and have a vision. And work out from a land-use planning point of view, if you want to achieve that vision, how do you go about doing it? So, you say for any new commercial, they shouldn't go through the planning process, so let's just get the new shops up and running. So, it's really bust through that red tape and make sure it happens. One of the stuff we really enjoyed doing, it sounds a little bit nerdy, but we went back and we got in touch with the local historian, and we went right back to when Grantham was really founded, and we went on this sort of amazing journey of what was Grantham. And that helped inform well what were Grantham's previous strengths, how can we bring that back in to a community who was just left unbelievably devastated (SEQ9 2011).

Nevertheless, concern remained about the ongoing psychological wellbeing of the community. As discussed in Chapter Two, relocation can have unexpected negative results from the displacement. Potential negative impacts can be overlooked during implementation because, *'it's been done after the flood and it's been done in that space, which is full of emotion and all those sorts of things'* (SEQ6 2011).

Grantham's relocation experience is an important example of an alternative flood risk management approach. Interview participants were questioned on the likelihood of further implementation of relocation policies, with 58% (11 of 19) indicating they were supportive of the concept of relocation policies, although they acknowledged the difficulty of applying the policy in practice. SEQ1 (2011), considered there may be, *'different ways of conceptualising the idea of retreat'*. This concept is discussed further in Chapter Seven.

5.4.2 Brisbane and the Voluntary Home Purchase Scheme

Brisbane City Council also has a relocation policy, known as the Voluntary Home Purchase Scheme (Brisbane City Council 2005, 2010). The Scheme operates by Council and resident agreeing for the Council to purchase their flood affected property at a determined price. The scheme is described as an, *'opportunity for those affected to remove their families from flood risks, while also contributing to the restoration of natural waterways'* (Brisbane City Council 2010, p. 1). There policy has specific criteria, all of which must be met to participate (Brisbane City Council 2010, p. 1):

1. The property must be flooded during a two-year ARI (50% AEP) flood event.
2. The property must be in a residential zone.
3. Flood waters must inundate the residential dwelling on the property.
4. There is no other viable infrastructure solution (such as pipes) available to remove the flooding problem.

The program began in 2006, and as at 31 October 2011, the Council had approached approximately 240 home owners, and had purchased roughly 55 properties with the median price around half a million dollars each (SEQ14 2011)⁹. SEQ14 (2011) noted that in Brisbane there are approximately 400 residential properties that are impacted by a 39% AEP event. Residents often reject purchase offers, reflecting the lack of desire by people to move from their homes and communities. However, after each flood event, the willingness to leave increases, reflecting the reactive nature of flood risk mitigation/adaptation and how psychological impacts and experience of a disaster can change property owners' perception of risk. As SEQ14 (2011) said,

During the flood event we actually got, it was actually getting quite difficult. We only had a 20% or 30% response rate, now we're up in the 80 to 90% response rate. That's just life. Community being aware and understanding and accepting that there actually is risk there and it'll drop off again, if we don't get another event it'll drop off again. But yeah, we definitely do notice a spike of activity for the Voluntary Home Purchase scheme after an event, for sure (SEQ14 2011).

Once properties have been acquired under the Scheme, the houses are removed and '*assigned an appropriate non-residential use which has a range of environmental and social benefits. The land may be used for conservation, drainage easements or parklands*' (Brisbane City Council 2010, p. 2).

Measures such as the Voluntary Home Purchase Scheme by Brisbane City Council help to address the legacy of existing development and past planning decisions, and are supported by the findings from the *Inquiry* (Queensland Floods Commission of Inquiry 2012). Recommendation 11.1 from the *Inquiry*, states:

Councils should consider implementing a property buy-back program in areas that are particularly vulnerable to regular flooding, as part of a broader floodplain management strategy, where possible obtaining funding from the Natural Disaster Resilience Program for this purpose (Queensland Floods Commission of Inquiry 2012, p. 275).

⁹ The Brisbane City Council declined to provide updated information at the time of thesis submission.

The use of voluntary relocation schemes was also supported as a positive policy mechanism by other interview participants:

Well I think, voluntary purchase in high risk areas is a useful measure and you know is an obvious one where there is sufficient funding to actually get people out of a dangerous situation. It's not the only solution, and it's not the silver bullet (SEQ5 2011).

I think they're [voluntary purchase schemes] fantastic! I mean, it's always going to come at a cost. I think Brisbane City Council, I think that's great, and they've had it in place for a while, I think the Council, like a lot of other councils need to actively work through this new cycle to undertake some very serious land use transitions (SEQ9 2011).

The *Inquiry* also identified some of the possible negative impacts that interview participants raised. It concluded that the removal of properties may render the land 'sterilised' if proper land-use planning is not applied and considered (Queensland Floods Commission of Inquiry 2012), but did not explicitly recognise any of the psychological, economic, environmental or social impacts suggested by the interview participants as barriers to implementation of relocation (Queensland Floods Commission of Inquiry 2012). The *Inquiry* considers that the successful relocation of Grantham can be used as a template for other local governments provided the specific circumstances of each region are taken into account in each relocation case (Queensland Floods Commission of Inquiry 2012). Suggested factors for consideration in applying relocation policies, include:

- The opinions of the local community
- Whether the residents see the value in retreat
- Availability of land to relocate to
- Financial resources
- If the consideration of the floodplain management best practice principles justifies development of the relevant land

(Queensland Floods Commission of Inquiry 2012).

Relocation policies are contentious and their inherent complexity make them difficult to implement. There are many social barriers that make relocation an undesirable prospect for people, but future flood events may determine that relocation will become the only long-term feasible option for some communities. Grantham is an example of this.

5.5 Challenges for flood management

The data sources analysed here - formal inquiries, media and primary interviews - identified an array of complex issues around the 2011 flood event. Similar, and bigger, flood events are expected to occur again, like the flooding that occurred across QLD and NSW in 2017 (Australian Broadcasting Corporation (ABC) News 2017). The last section of this chapter analyses interview participants' views on the factors likely to increase flood risk in SE QLD in the future, followed by a discussion of flood risk adaptation and mitigation methods they suggest to increase resilience to flood hazards.

5.5.1 Climate change

SE QLD is predicted to experience increases in extreme rainfall and variability, and a change in cyclonic patterns from climate change (IPCC 2012, 2014a). The *Inquiry* does not make any specific recommendations regarding planning and preparing for climate change, but it does mention the need to include the impact of climate change in flood studies, proposing the use of the Monte Carlo modelling techniques (Queensland Floods Commission of Inquiry 2012).

SEQ5 (2011) draws on the *Increasing Queensland's resilience to inland flooding in a changing climate: Final report on the Inland Flooding Study* which made 12 recommendations regarding planning and preparation (Department of Environment and Resource Management *et al.* 2010), and states that the report, '*has actually been quite a useful and often referenced study in terms of providing an alternative approach to both flood mapping and risk management*' (SEQ5 2011). Recommendations relevant to this study include:

1. Local governments should factor for a 5% increase in rainfall intensity per degree of global warming into the 1 per cent (Q100), 0.5% (Q200) and 0.2% (Q500) AEP flood hazard events recommended in *SPP 1/03* (now superseded by the *State Planning Policy* (The State of Queensland 2016) for new developments.
2. The following temperatures and timeframes should be used for the purposes of applying the climate change factor in Recommendation 1: 2°C by 2050, 3°C by 2070, and 4°C by 2100.
3. The Queensland Government will review and update this climate change factor when a national position on how to factor climate change into flood studies is finalised as part of the current review of Australian Rainfall and Runoff by Engineers Australia.

4. The review of *SPP 1/03* should develop criteria that outline the circumstances where a DFE higher or lower than the 1% AEP (Q100) is appropriate for residential land use planning.
5. The review of *SPP 1/03* should consider how to improve the integration of land use planning and disaster management planning.
6. The review of *SPP 1/03* (now superseded by the *State Planning Policy* (The State of Queensland 2016)) should consider issues concerning coincident flooding including: the results of any research into the potential impacts; the extent to which coincident flooding is already covered in flood studies conducted by local governments; and the most appropriate planning instrument to address coincident flooding in the future.
7. Working through the national Building Ministers' Forum and the Australian Building Codes Board, support the development of a national code for the design and construction of new building work in areas designated as flood prone in local planning schemes

(Department of Environment and Resource Management *et al.* 2010, pp. 2-3).

Many of these recommendations have been addressed in the updated *State Planning Policy* (The State of Queensland 2016), and also in the updated National Construction Code Series (Australian Building Codes Board 2012, 2014a, 2014b, 2014c). However, despite these measures to prepare for climate change in SE QLD, SEQ9 (2011) states that, '*I think there is a real lack of understanding of realistically what is climate change as it results on a flood*'. SEQ4 (2011) agrees, '*it's arrogance for us to think we can ever get a handle on what flooding patterns and rain patterns will take place, particularly going forward and with the increase of carbon in our atmosphere, who knows?!*' Importantly, the 2016 update also re-introduced a sea level rise allowance of 0.8 m by 2100, which was controversially removed in the 2013 iteration by the Minister for Planning under the Liberal National Party coalition Queensland Government in power from 2012-2015 (Bell-James 2014; Engineers Australia 2015).

The uncertainty around future understanding of risk including the impact of climate change, is difficult for those in politics and policy who rely on certainty for decision-making. The precautionary principle approach can be useful for managing uncertainty in risk, especially with the addition of increasing population, and urbanisation.

5.5.2 Urbanisation

Brisbane and the surrounding areas in SE QLD are experiencing high population growth rates. A larger population requires additional infrastructure and housing, resulting in increasing urban infill, decreasing the capacity of built and natural systems to cope with flood events.

SEQ5 (2011) highlights this issue well, describing how flood risk grows as we:

Increase development of our urban areas, so intruding into more hazardous areas or indeed intensifying in existing hazardous areas. So, I think that's an issue and a challenge. And then the increasing inter-linkedness between infrastructure and communities. So, what might've been bearable in the past, now because everything is linked and so connected can have enormous consequences. One part of the city being badly affected could quickly impact upon the rest of the city in ways that weren't the same 20 or 30 years ago.

SEQ18 (2011) also stated that urbanisation is a significant issue that needs to be considered.

We had a piece of analysis done by Risk Frontiers in fact that did a normalisation on that curve [extreme events and time], that cost curve taking out population increases, building code changes, building cost changes. And essentially it normalised it right out, and what you saw straight away was that there has been no change in frequency of extreme weather apart from the standard 11-year cycle that we deal with. And there's been no realistic change in the intensity of events. What's changed and this is why I quite liked it, because it really elegantly demonstrated that what in fact has changed is what we're building, and where we're building it, and how we're building, and funnily enough those are the things that we can actually really influence quickly and effectively (SEQ18 2011).

This participant clearly illustrates how building materials, and planning (or lack of) influences the economic cost of extreme events on communities and how increasingly urbanised locations amplify risk exposure.

SEQ5 (2011) look at how such urban flood risks can be managed, *'in terms of where you've got urban areas, the key issue is I guess, protecting people and protecting property, controlling the water, containing it directly as much as possible'*. The next section will examine how various mitigation and adaptation responses to increase the resilience to flood hazards could be applied in SE QLD.

5.5.3 Adaptation for future risk in SE QLD

The management of flood risk in SE QLD has historically favoured structural risk mitigation (Agriculture and Resource Management Council of Australia and New Zealand Standing Committee on Agriculture and Resource Management 2000). The new levels of risk and uncertainty facing policy makers requires the inclusion of adaptation approaches within the

landscape. Australia and SE QLD are moving towards floodplain management techniques which consider the social, economic, and ecological factors in an area (Agriculture and Resource Management Council of Australia and New Zealand Standing Committee on Agriculture and Resource Management 2000; Department of Infrastructure Planning and Natural Resources 2005; Emergency Management Australia 1999). Floodplain management controls are being developed around mitigation structures, land use planning, building controls and flood emergency measures (Australian Emergency Management Institute 2013, 2014). All interviewees discussed the value and implementation of different mitigation and adaptation approaches for flood risk.

In SE QLD, a lot of the mitigation structures were implemented after the catastrophic 1974 flood event. As SEQ14 (2011) explains:

They spent a lot of time and money ripping up a lot of the creeks and concreting them basically, and a huge amount of work that was done there. It was, from a flood mitigation perspective, very successful. It always interests me, because Council actually produced this document going, “*Aren’t we amazing?*” They took this beautiful little creek and they ripped it up and put this concrete channel in it. You look at it now and you’re like, that would be considered a disaster these days. But then it was cutting edge, the best thing that you could do. So, people’s values change as well. I think that’s something you need to be mindful of. People’s values do change and what worked before and was really successful before, might not continue to work (SEQ14 2011).

After the 1974 flood event, structures such as Wivenhoe Dam and levees were constructed in locations across SE QLD. Overconfidence in and a false perception of the protection provided by hard structural-engineered solutions then dominated the following decades. SEQ14 (2011) mentioned the role of the natural environment and its systems were disregarded in that time period with hard engineered solutions considered best practice:

I’m sure what we’re doing now will be seen as being old-fashioned in the future as well. That’s just the nature of things. But you do the best that you can with the new emerging technologies and those sorts of things. After all of those works that were done in the 80s, the late 80s because they were completed late 80s/early 90s, I think it wasn’t until 2000 that they still sort of realised, “*Hold on, we’ve still got a problem. We haven’t fixed it. Oh my God, we need to do something else*” (SEQ14 2011).

It was around the late 1990s and early 2000s that hard structures were initially found to be an incomplete solution and floodplain management techniques were developed taking into consideration the natural features of the environment and the ecological impacts (Agriculture and Resource Management Council of Australia and New Zealand Standing Committee on Agriculture and Resource Management 2000; Department of Infrastructure Planning and Natural Resources 2005; Emergency Management Australia 1999). However, it was difficult

for government bodies to implement floodplain management techniques or develop floodplain management plans, (Agriculture and Resource Management Council of Australia and New Zealand Standing Committee on Agriculture and Resource Management 2000; Department of Infrastructure Planning and Natural Resources 2005; Emergency Management Australia 1999), particularly as the areas of risk were not identified until significant flood studies and mapping in QLD appeared.

As SEQ6 (2011) mentions, *'I think that message is starting to happen that it's not all about an engineering solution. And engineering solutions sometimes actually make things worse rather than better. All the old heads unfortunately [think], engineering solves everything'*.

SEQ6 (2011) acknowledges that engineering solutions can potentially worsen flood impacts in some locations. The levee paradox is one such scenario. When a levee is overtopped, the flood impact will be significantly worse than without a levee. The same situation can occur if a dam breaks or water is released at short notice (Smith 1998). In either of these scenarios, often the only available option for residents is to evacuate the area. The risk perception of communities believing themselves to be protected by physical structures can also be misplaced, as demonstrated in section 5.3.4 with the perception that Wivenhoe would protect Brisbane and Ipswich no matter the severity of the event. SEQ14 (2011) highlights the need to communicate the role of structural measures and the level of risk that they can manage, stating, *'I think it's important to be able to communicate what those structural measures do as well, so that the community understand, "ok, well, this has got us this level of safety but there's still this much to go"'*. SEQ13 (2011) agrees, stating the expansion of, *'levees and flood mitigation structure provide protection up to threshold and when a threshold gets exceeded, how do you manage that risk expectation in consequence with it? So, that is a challenge'*.

Mitigation measures don't have to involve hard structural engineering approaches, they can also use surrounding natural environment to lessen the exposure to flood hazards. These types of approaches form part of current national best practice, as described in the *Floodplain Management in Australia: Best practice principles and guidelines* (Agriculture and Resource Management Council of Australia and New Zealand Standing Committee on Agriculture and Resource Management 2000). Examples include appropriate land use and involve integrated catchment management. As SEQ6 (2011) said with regards to natural mitigation approaches:

We've got to get consistent veg. along our stream banks to mitigate the floods. And there were people who were actually saying that they could actually start to measure what impact that would have on flood resilience, slowing the peaks down, meaning that the water is moving through more slowly, and meaning that the water can get away quicker so actually having an impact in places like Brisbane about the level of the flood. It won't stop floods, but

because it slows the water down, you've got an opportunity to actually get the water away (SEQ6 2011).

SEQ4 (2011) explains how developers are addressing flood risk and incorporating sustainable development into new estates using environmental features, or so-called 'soft' engineering approaches:

They're planning about how they can control the water, how they can slow it down, through different techniques – vegetation, topography, you know changing the topography a bit through drainage trains, just to direct, slow down and clean it up, and mitigate the effects of the hardening on each site where possible, and outside the site if possible. And to take that into account what you can't do on-site, you do off-site (SEQ4 2011).

The use of natural mitigation approaches such as using vegetation to slow the flow and velocity of water or using natural landforms to absorb the impacts of floods can be difficult to implement in historically hardened urban settings such as Brisbane, Ipswich and Toowoomba. They may be more appropriate in regional or peri-urban locations. This dilemma will only become more pressing in the future as flood risk increases due to urbanisation and urban infill from growing populations. SEQ4 and SEQ13 (2011) discuss this problem:

I think in terms of an urban setting, it's more difficult to be trying to find an ecological solution to it. There's just not enough room. We're dealing with a situation which is man-made and there's not a lot you can do about it (SEQ4 2011).

It's about when flows happen letting them through and making and letting the system respond to it, not about artificially storing and making releases when they didn't naturally occur. That's the general philosophy (SEQ13 2011).

Despite the use of more natural flood mitigation techniques, land use planning, and building and development controls, some of the participants believed there continues to be a place for hard flood mitigation structures. One participant mentioned that residents in one community were concerned that the trees had caused the significant flood impacts, indicating a lack of knowledge and communication of the behaviour of floods and their impacts on the natural as well as the built environment. As SEQ6 (2011) mentions:

They saw all the rubbish and the trees going down and where there'd be one tree left on the bank, of course it had dug out on the bank. So, they'd blame the tree for the fact that the bank got dug out. I mean what we have now is have people actually starting to accept that vegetation along the streams actually has a mitigation effect. And even the report that was released by the QLD government by the Chief Scientist and whatever they are now actually saying yes, our stream vegetation, stream bank and floodplain vegetation is important for flood mitigation (SEQ6 2011).

Many of the interviewees acknowledged the need for a balance of hard and soft engineering, land use planning, and building and development control mitigation measures to address flood risk. As SEQ14 and SEQ9 (2011) state:

We will do hard engineering. I don't think you can ever move away from hard engineering. I think you always need to have it there. It's always going to be important. But probably before there was just hard engineering, whereas now we're actually looking at a range of different solutions and in some places you just can't engineer it out without billions of dollars of structural work (SEQ14 2011).

I think there's always got to be a balance between planned and engineered solutions. There is always going to be a role, particularly for townships like Goondiwindi, for you know the urban levee. No doubt about it. In terms of reducing, but also at the same time there needs to be a planning solution there in the event that that dam actually, or the failure of the levee. So, I think very much they go side by side (SEQ9 2011).

Structural and non-structural adaptation approaches can play a role in addressing residual risk from the failure of structural mitigation measures. Adaptation options can be useful to complement current built structures as their design levels are limited in the context of new, higher levels of risk. This study has defined a risk adaptation measure as one that does not attempt to mitigate the flood risk, but instead allows communities or individuals to live with the level of risk. Such measures are generally non-structural.

SE QLD used adaptation measures, as defined in Chapter Two, in response to the 2011 flood event in several ways:

- Change in behaviour, including building different styles of houses, with alternative materials. For example, the redeveloped Queenslander-style house as opposed to slab-on-ground housing
- Retreat/relocation policies as demonstrated by Grantham and the LVRC
- Appropriate land use planning.

SEQ14 (2011) said, '*generally with the structural measures you can never completely remove the risk. You need to always have a suite of actions*'. Other interview participants also indicated support for integration of adaptation in SE QLD. SEQ12 (2011) justified this approach in this way,

The answer to it, in QLD, the simple answer is adaptation strategies. We must adapt. What does that mean? Well, fundamentally it means we defend or we retreat. Either we put up barriers, or lift everybody's house up on stilts by an enormous degree or we say, "*No, this is all too difficult, too expensive, we cannot*", and there are some small townships that have no land above Q100 so they flood pretty frequently now. They're going to flood much more

frequently in the future too so then perhaps we should just say we abandon them. And that's a very, very difficult socio-political decision to make.

Adaptation approaches allow continued use of high risk areas, and provide the opportunity to work with the natural environment. The need to work with nature will require stronger policies and approaches to increase resilience to a hazard such as flooding. Grantham's relocation is an example of a strong adaptation policy to counter increased flood risk.

In addition, adaptation methods are often more financially viable than large mitigation structures. As SEQ5 (2011) found:

A levee bank completely surrounding a hazard area would be enormously expensive to build and maintain. As a planner you would say if that cost x million how much would it cost just to buy all the properties anyway? If it's cheaper to buy all the properties you'd want a really good reason why you're doing the other one.

The need for stronger policy and implementation of adaptation approaches such as Grantham is again demonstrated by SEQ7 (2011) who states:

I think it's probably pretty clear that we need to do a lot more work in terms of identifying those areas at risk that we're prepared to put up with as a society and taking action to deal with it in terms of built responses or whatever it might be, adaptive responses of some sort.

Catastrophic events, such as the 2011 floods can be used as a catalyst to implement new policies and restrictions in terms of risk management responses. As SEQ13 (2011) considers:

After a big flood event like this you've got some impetus and you've got some goodwill amongst people, but they're looking for some solutions too. You don't just want to say to someone, "*You made a bad decision when you bought there, too bad.*" They're looking for a little bit. There's not just technical stuff, there's a lot of emotive pull out there. It would be silly to ignore that and treat it as a technical exercise because a lot of it is about, how do you build a case for change? How do you bring people along with you? Because if you don't, then you're going to get fought at every turn. And ultimately once you get further enough away from an event, it's very hard to do [implement change] (SEQ13 2011).

SEQ13 (2011) highlights the importance of planning in advance to implement change immediately after a flood event when political and public support is high. The quick timing provides opportunities to increase prevention and preparedness and ultimately increase resilience to future floods.

5.6 Key findings

The findings from this chapter tell us about governance, key challenges, risk perception and adaptation at a regional scale. Key challenges were shown to exist around governance, insurance, land use planning, mapping and data, supporting appropriate perceptions of risk, and rebuilding post-flood event.

A key issue linking across the key findings is an implementation gap between policies and expectations in place at or between the State or Local government level and delivery of outcomes, such as adequate, standardised flood mapping. The implementation gap was potentially a product of an enforced localist approach without adequate governance systematic support and resourcing. The lack of adequate mapping across QLD was found to have related impacts on insurance, land use planning, rebuilding post-flood, and risk perception. The broad flow on affects indicate the importance of having a strong scientific evidence-base underpinning decision-making. In turn, this allows for a more informed approach for adaptation for the future.

The dangers of inaccurate risk perception was also a key issue throughout this chapter. The false belief and trust in Wivenhoe and other flood mitigation structures had a strong influence of flood practitioners' and the communities' preparedness and response to the flood event. The results demonstrated that complacency occurred around the possible impacts of large-scale floods and potentially resulted in unnecessary lives and properties put at risk, highlighting the need for a strong focus on education and awareness in at risk communities.

5.7 Key themes and chapter summary

This chapter has addressed the research aims by describing the catastrophic flood event of 2011 in SE QLD, with a focus on Brisbane and the surrounding region, to determine key challenges for flood management. The chapter has tried to provide an overview of the complex setting and strategic discussions around the 2011 event and draw out the lessons learned from some of the key topics around governance, risk perception and adaptation to future risk, which have a much broader influence across the PPRR spectrum. Relocation policies were explored in detail using Grantham in the LVRC as a snapshot for adaptation to new levels of risk. The chapter then examined broad adaptation options in response to increased flood risk from climate change and urbanisation to prevent catastrophic flooding impacts.

Chapter 6: Scotland and the United Kingdom

6.1 Introduction

Chapter Six will explore flood risk management at the national scale through a case study of the implementation of the *Floods Directive* in the UK, and the introduction and application of the *FRM Act 2009*. The examination of the *Floods Directive* and the *FRM Act* were chosen to provide examples of and the emphasis placed on the influence of policy and legislation as key components in a flood governance framework. The research findings will also focus on an analysis of the *Floods Directive*, *FRM Act*, and the philosophical change in the flood management approach to exploring adaptation options for managing flood risk. These themes will be understood in the context of key stakeholder perception of the management of flood risk.

First, a brief overview of the local context of the case study will be provided by describing major flood events in the UK and the governance framework for flood management across Scotland and the UK. The contemporary issues and challenges faced by flood risk practitioners will then be analysed and understood through the lens of the local risk perception. The chapter will conclude by investigating the use and implementation of sustainable and natural flood management approaches as adaptation approaches.

This case study also provides an important learning comparison due to its national scale in comparison to the local and regional scale cases studies presented in Chapters Four and Five. The international context also provides an important learning comparison for understanding flood risk management more broadly.

The analysis of the impact of the *Floods Directive* and *FRM Act* presented here draws from data obtained from interviews conducted between November 2012 and January 2013, and relevant academic literature, technical reports, government publications, policies and plans, and media publications.

Although flood management in Scotland is the focus of this chapter and the fieldwork, examples from England and Wales are also included. There are many overarching policies and agreements that apply not only to Scotland but also to the UK as a whole¹⁰.

¹⁰ The research is of a dynamic nature and policies and practices have progressed since the fieldwork period. Therefore, some comments and policies may no longer be directly applicable. Yet the information obtained is still highly relevant to a comparison between case studies and generates arguments for principles and goals for broader application of the principles and goals outlined.

6.2 Local context: history of flooding in the UK

Flooding represents a major environmental hazard across contemporary northwest Europe, Ireland and the UK. The prevalence of flooding is exacerbated by a combination of settlement history on coasts, estuaries and navigable rivers and is accompanied by recent continued urban development on floodplains, high population density in areas prone to flooding, and changing land use patterns in the UK and Ireland (Adger *et al.* 2016).

The UK has historically been prone to flooding from both coastal and fluvial sources with major impacts on settlements being recorded for hundreds of years (Brown & Damery 2002; Handmer 1986). Flood risk is exacerbated by land sinkage in large parts of south-east of England of approximately 30 cm per century (Handmer 1986).

There is an acceptance that flood risk is increasing due to other factors such as increasing population, urbanisation, and climate change (Brown & Damery 2002), resulting in severe pluvial flooding. Many different approaches to flood management have been developed throughout Great Britain, with a current push towards sustainable flood management methods including the use of natural flood management.

Recent major flooding in the UK has acted as a catalyst for significant policy and management change. The most significant policy change came as a result of floods which include the 1947 riverine flood, 1953 East Coast flood, 1998 Easter flood, 2000 autumn floods, and the 2007 summer floods (Blackburn *et al.* 2008; Chatterton *et al.* 2010; Coulthard & Frostick 2010a; Johnson *et al.* 2005; Lane 2008a; Marsh 2008; Paranjothy *et al.* 2011; Pitt 2008; Posthumus *et al.* 2009). There was also widespread flooding across the UK during the winter of 2013-2014 (Met Office 2014; Reuben 2014; Rodgers & Bryson 2014), and 2015-2016 (BBC News 2015, 2016b; Met Office 2015) but it is yet to be determined if these floods will result in significant changes in policy (HM Government 2014), and are thus outside the scope of this research. A brief overview of the floods and how they impacted on flood management is presented below.

In 1947 over 40 counties across England were flooded by snow melt and significant rainfall. Flood protection structures failed, with levee and river banks broken and overtopped, and general widespread saturation and long-term flooding (Johnson *et al.* 2005). These floods occurred during the severe economic depression after World War II, so what minimal flood prevention and protection measures there were, were not effectively enabled. However, this flooding resulted in policy implementation from the *Land Drainage Act 1930* being accelerated by the Ministry of Agriculture and Fisheries (Johnson *et al.* 2005).

One of the most devastating floods in north-east Europe was experienced in 1953, impacting most heavily on the Netherlands (Penning-Rowsell & Handmer 1988). Referred to as the East Coast floods in the UK, 300 people drowned due to the failure of sea walls and other protective structures (Handmer 1986). These floods also affected both Scotland and England on a dramatic scale and resulted in 1200 breaches of flood defences, 160,000 acres of inundated farmland, and the flooding of 24,000 houses (Johnson *et al.* 2005). The scale of this flood event resulted in the introduction of new coastal protection standards, the creation of an emergency warning system, a greater research investment, and a storm tide warning system. This event was also seen to be the stimulus for the development of the Thames Barrier in London (Johnson *et al.* 2005) and resulted in a significant level of investment in structured flood defences.

The severe 1998 Easter flood across the midlands of England and Wales (Horner & Walsh 2007; Met Office 2012a) resulted in five deaths and thousands evacuated (Bye & Horner 1998). As a consequence of the 1998 flooding and resulting formal reviews (Bye & Horner 1998; House of Commons Select Committee on Agriculture's Special Session on Flood and Coastal Defence, 2001), warning systems and public awareness were improved (Johnson *et al.* 2005).

The 2000 flooding was the most extensive event since 1947 with over 10,000 homes and 700 locations impacted (Met Office 2012d). Five major rivers - the Thames, Trent, Severn, Wharfe and Dee peaked at their highest levels for sixty years, and the River Ouse in Yorkshire reached its highest level since the 1600s. Multiple catchments experienced several consecutive flood events, especially in south-east England (Met Office 2012d). The 2000 flood event was important for policy development in the UK; the *Planning Policy Guideline 25 on Development and Flood Risk* in July 2001 was introduced after significant levels of public consultation and government review (Johnson *et al.* 2005; Kelman 2001). This flood event triggered the transition from traditional structural flood defences to an emphasis on the need for stronger development and planning controls, and led to the policy- *Making Space for Water* (Department for Environment Food and Rural Affairs 2005).

The flooding in June/July of 2007 was widespread across much of Wales, the Midlands, Northern England, Northern Ireland and parts of Scotland and South-west England (Blackburn *et al.* 2008; Chatterton *et al.* 2010; Coulthard & Frostick 2010b; Lane 2008a; Met Office 2012b, 2012c; Pitt 2008; Wilby *et al.* 2008). These floods significantly raised the profile of the impact of climate change on flooding, and resulted in the Pitt Review (Pitt 2008). The Pitt Review was the catalysed significant legislation and policy change across the UK. One example is the *Flood and Water Management Act 2010 (FWM Act)* in England (Department for Environment Food and Rural Affairs 2010), which sets out a clear governance framework for flood and coastal risk management and legislates the *Floods Directive*.

The winter of 2015/16 also resulted in further significant flooding in the UK and the 2016 *National Flood Resilience Review* to, ‘better protect the country from future flooding and increasingly extreme weather events’ (Environment Agency 2015). For the first time, climate change was identified as a factor in the extremity of these floods (Vidal 2015a, 2015b). Following the 2015-16 floods, there was an announcement of an additional £2.3 billion of investment in 1,400 new flood defence schemes to improve protection for 300,000 additional homes (Environment Agency 2015). The perceived inequity in solutions and funding response by the Government resulted in significant criticism on the level of action and the previous and committed defence mitigation infrastructure in some regions (BBC News 2016a; Environment Agency 2015; Ruz & Kelly 2015; Shukman 2015). Despite the significance of the 2015-16 flooding and possible reform, they are largely beyond the scope of this thesis due to their timing prior to thesis submission.

The above summaries provide examples of where flood events have catalysed policy and legislative changes for flood management in the UK. The next section will examine the current governance framework for the UK. This includes the influence of the introduction of the *Floods Directive* in 2007 which was a significant catalyst for policy development, planning and action (Alexander *et al.* 2016; European Union 2007).

6.3 UK flood risk management governance framework

EU members, such as the UK, are accountable to the Directives imposed by the European Parliament. There are two European Parliament and Council Directives which are relevant to flooding policy and legislation in the UK. The most relevant is the previously mentioned Floods Directive. Of less relevance is the *Directive 2000/60/EC establishing a framework for the Community action in the field of water policy* (European Union 2000), which is more commonly referred to as *The Water Framework Directive*. The *Habitats Directive*, and the *Environmental Impact Assessment and Strategic Environmental Assessment Directive* are also of some relevance (European Commission 2014).

The EU Directives were developed to inform member countries on best practice flood management and to create consistency across political borders. The current flood management arrangement in the UK is governed between DEFRA (Department for Environment Food and Rural Affairs 2005), and the individual Environmental Agencies of England and Wales, Northern Ireland, and Scotland (Lane *et al.* 2011). Current practices in England and Wales are guided by the *FWM Act*, and the *FRM Act* in Scotland. UK15 (2013) stated that the legislation isn’t strong enough, ‘everything in my opinion has always fallen a little bit short in terms of

when it comes to legislation. [There is a need] to be hard and fast and say, “We should be doing this”’.

DEFRA devolved flooding responsibilities to the Scottish Government. UK8 (2012) criticised the devolution of responsibilities across governments with, ‘*there’s quite a lot of people that don’t recognise the devolved aspect, and then that devolution means that there’s no links*’.

As mentioned, the Scottish Government’s powers over flood management are upheld through the *FRM Act*. SEPA is responsible for national flood forecasting and flood warning, as well as coordinating strategic flood risk management, and community education and awareness (Scottish Environment Protection Agency 2016b). The *FRM Act* (and *FWM Act* in England) also provides a localist focus; designating responsibilities and accountability for on-ground planning and implementation to Local government (Thaler & Priest 2014). Local government are responsible for managing and maintaining flood defences and watercourses, and other flood risk management measures within their relevant counties (Scottish Environment Protection Agency 2016b). In Scotland, the Convention of Scottish Local Authorities (COSLA) represents Local government and helps to negotiate funding. The Local governments have accountability and responsibility for producing Scotland’s first ‘Local Flood Risk Management Plans’ in partnership with SEPA, Scottish Water and other responsible authorities. Local governments also consult with local organisations through flood risk management local advisory groups to raise awareness, capture local knowledge and share information about flooding (Scottish Environment Protection Agency 2016b).

UK3 (2012) criticises flood management responsibility designated to Local government, stating, ‘*having 32 delivery bodies for a lot of the schemes is a real issue, [along with] expecting them to all have the capacity and the expertise to take forward investing in measures*’. This criticism links back to the previous quote regarding the devolved responsibility by UK8 (2012).

Local governments are also expected to partner with relevant stakeholders including; independent government bodies, such as Scottish Water; non-government organisations (NGOs); and the ABI; creating a complex governance framework. While this can have benefits for ensuring a holistic approach which encompasses local values, it also provides significant challenges.

Alexander *et al.* (2016) provides an excellent overview of how the administrative and governance arrangements influence the management of flood risk. It is clear that flood risk governance across the UK has been influenced by external factors, such as political ideology (centralisation, privatisation, and localism) and the *Floods Directive*, and factors internal to the

traditional flood policy domain, such as ‘catalyst’ flood events which drive the incremental changes.

The incremental approach to changing flood risk management in the UK is a fundamental strength and allows for gradual maturation of the governance system (Alexander *et al.* 2016) enabling adaptation to be positioned at the forefront of a response to increased risk. This maturing of the governance framework reflects the complex needs to be addressed across disciplines, the growing number of stakeholders demanding a voice, and the changing perception of risk and how it is constructed. An incremental approach from a changing risk perception and construction is reflective of Beck’s Risk Society recognising constructivism of risk.

6.4 A UK perception of contemporary issues

6.4.1 Key challenges

Interviews were undertaken with 15 key stakeholders involved in the governance of flood management across England (five) and Scotland (10). Identification and analysis of the key themes around the challenges and issues in the UK have been drawn from those interviews and from documentary analysis. Unprompted examples of the most important themes identified by the stakeholders are shown in Table 12.

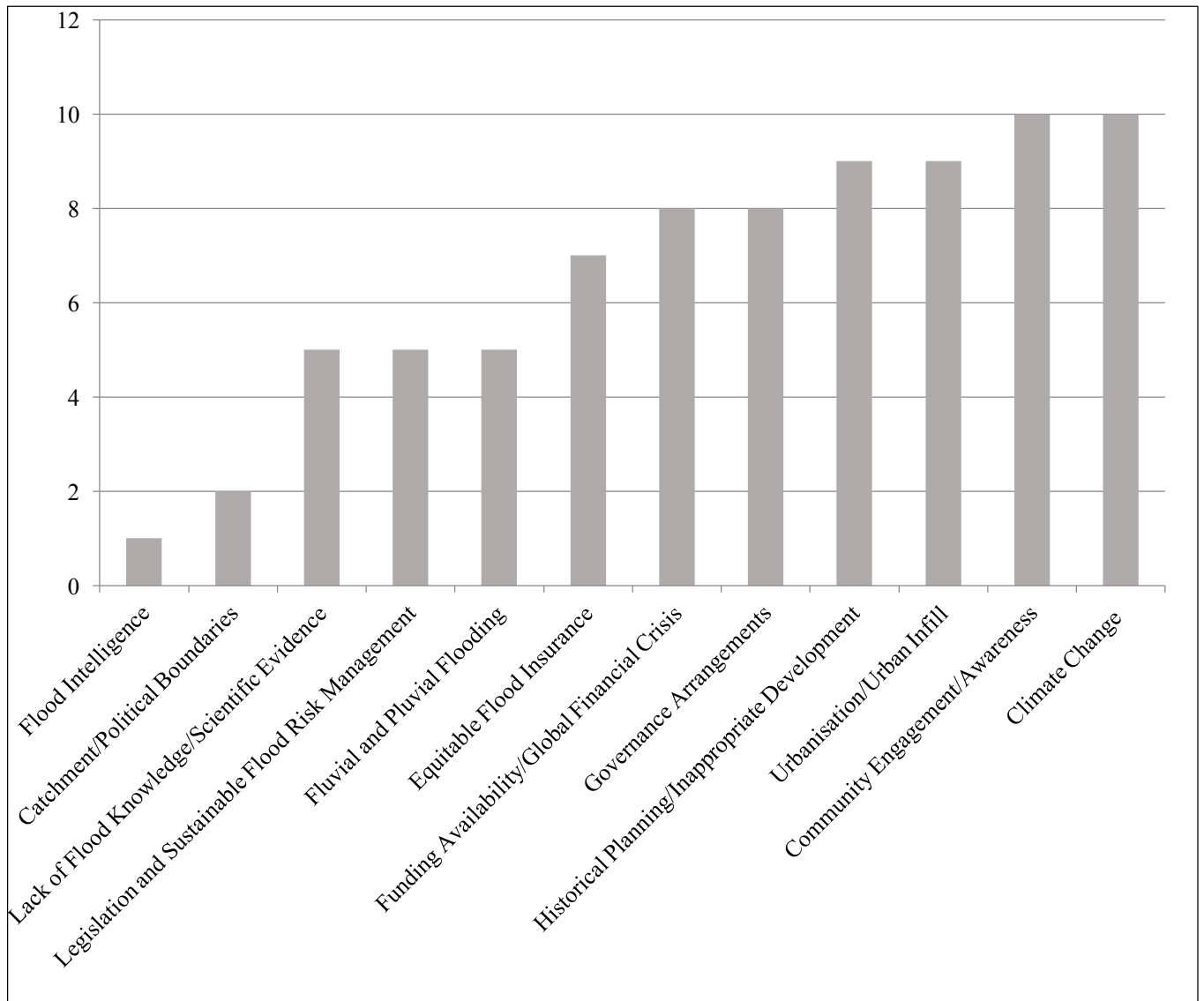
The following sections examine some of the issues emphasised by the interviewees as the most important – the impact of climate change, urbanisation and urban infill, land use, planning/development, governance, insurance, and exploring sustainable flood risk management together with the *FRM Act*. The other frequently mentioned barriers include funding for flood management and the impact of the Global Financial Crisis, and community engagement/awareness for flood risk. These two factors have not been examined in detail as they are deemed to be outside the scope of this thesis. These are similar findings to Waylen *et al.* (2017) who found that key barriers for sustainable flood management in Scotland were:

- Funding and resources
- Constraints of place
- Evidence-base on NFM has gaps and uncertainties
- Formal and informal expertise
- Discomfort with new measures
- Potential mismatches between statutory processes, planning and appraisal systems

- Challenges of collaboration and communication.

The similarity and consistency of key findings across studies provides support for improvement in these areas. The next section will explore the challenges of addressing two of the highest ranking key themes (besides community engagement/awareness which is not in the scope of this thesis) of urbanisation (including planning and development) and climate change.

Table 12 Key themes from interviews



6.4.1.1 Addressing climate change

Research into the impact of climate change and flooding suggests potential for significant risk increase from climate impacts in the UK, in addition to increases in populations and urbanisation (e.g. Hall *et al.* 2003; Harries & Penning-Rowsell 2011; IPCC 2014a; Lane 2008a; Lane *et al.* 2007; Oven *et al.* 2012; Wilby *et al.* 2008). Consequently, climate change is being

seriously considered within the UK (e.g. Charlton & Arnell 2011; Few *et al.* 2007; Hall *et al.* 2003; Hall *et al.* 2005; Hall *et al.* 2006; Lane 2008a; Lane *et al.* 2007; Mansell 1997; Oven *et al.* 2012; Tompkins *et al.* 2010; Werritty 2002; Wilby *et al.* 2008), and mitigation and adaptation is generally accommodated in policies and planning guidelines (e.g. Adaptation Scotland 2014a; Department for Environment Food and Rural Affairs 2005, 2010; Department for Environment Food and Rural Affairs & Environment Agency 2013; Department of Energy and Climate Change 2011; HM Government 2008, 2012, 2013; Scotland Environment Protection Agency 2014a, 2014b; Scottish Government 2009a, 2009b, 2009c, 2014a). The acceptance and inclusion of climate change into policy and planning as a common part of the governance framework is of importance as it contrasts with the two previous Australian case studies.

The Scottish Government has already acknowledged that the climate has changed and is continuing to change. There is awareness that climate change will mean ‘*an increase in river and coastal flooding*’, ‘*changes to biodiversity and landscapes*’, and ‘*an increased frequency and intensity of storms that may cause disruption and threaten life and property*’ (Scotland Environment Protection Agency 2014b, p. 4). Further details on Scotland and the UK’s climate change impacts and how it relates to flood risk can be found in the UK Climate Impact Program data (United Kingdom Climate Impact Program 2014), Foresight Futures reports on future flooding (Flood and Coastal Defence 2004a, 2004b, 2004c, 2004d, 2004e) and the latest IPCC report (IPCC 2013, 2014a, 2014b). The changes to flood risk, landscapes, and storm events have increased the flood risk in many locations, and has implications for change in the current land use. As the European Commission notes, ‘*coastal and urban areas and densely populated floodplains are facing particular problems*’ (European Commission 2009, p. 1).

The *FRM Act*, *FWM Act*, and the *Floods Directive* promote adaptation options, such as natural flood management, for increased flood risk induced by climate change and other factors such as urbanisation. Only 20% (3 of 15) of the interview participants supported the EU in describing the use of natural flood management (refer section 6.5.2.2) as a suitable tool for addressing residual risk, especially in relation to climate change impacts, indicating a discord between policy and culture. Supportive comments include:

Our challenge for climate change will be natural flood risk management techniques, because the timescales are going to align with each other. And I think that’s what we’ve got to do, we’ve got to get the research and data so that as the climate changes practitioners will have the evidence to go and apply techniques which are much more cost effective and beneficial to mitigate the effects of climate change (UK8 2012).

Evidence suggests that working with nature's capacity to absorb or control impact in urban and rural areas can be *a more efficient way of adapting than simply focusing on physical infrastructure*. Green Infrastructure can play a crucial role in adaptation in providing essential resources for social and economic purposes under extreme climatic conditions. Examples include improving the soil's carbon and water storage capacity, and conserving water in natural systems to alleviate the effect of droughts and to prevent floods, soil erosion and desertification. Some examples of this 'mal-adaptation' are sea level rise or flood protection infrastructure that may disturb the natural dynamic nature of coastal and river systems (European Commission 2009, p. 1) (emphasis author's own).

The interview participants agreed that climate change is a challenge for policy and management both currently and for in the future. As UK2 (2012) highlighted, '*we actually don't know the effect of climate change on fluvial flood risk. We know sea levels are rising, that's absolutely clear. But fluvial risk is by no means clear*'. Generally, however, practitioners are applying the Precautionary Principle and planning for adaptation. As UK7 (2012) noted:

Climate change is an issue the European Parliament takes very seriously; there is no particularly strong climate change denial culture in Europe... obviously for some people it still seems to be an issue, but it isn't here, and it certainly isn't in the UK, or Scotland. People get it. They want to be able to mitigate and be able to deal with it and ensure that everyone is not burdened too much by it and disadvantaged by it.

UK3 (2012) supported UK7 (2012) that climate change is considered during decision-making processes but believed the impact of climate change, together with other major challenges such as urbanisation, were difficult to quantify during application:

It's something you always have to give a nod to in terms of, "*We need to take account of long term development and climate change*", but how you do it in practice is proving to be quite difficult. There's a few reasons for that:

- 1) The uncertainty of all the different scenarios. Emission scenarios; you can look at which ones you choose for flood risk management so you can err on the side of caution and choose quite an unlikely scenario that is going to give you larger impacts but translating that into rainfall and into run off and into river flows is technically quite challenging to do.
- 2) Also, linking it to changes in patterns in social and economic activity, because of course, all the major climate change impacts over a 50, 60-year planning horizon are meaningful only in terms of where people are living and working over similar horizons.
- 3) If you factor into that the economics of decision-making, where actually it's benefits in the next five or 10 years that really drive decisions, because you're discounting all the benefits into the future.

It's really hard in practice to really take account of things like climate change in the decision-making. So, the way we were trying to do it is to highlight areas that are likely to be highly sensitive to climate change and then making sure we're assessing measures for all those sensitive areas. It's also taking into account how adaptable they're likely to be to climate change. It's really through assessing the adaptability of measures in sensitive areas (UK3 2012).

UK12 (2012) states that despite current policies and planning, there is still room for improvement and education, *'you've got some very good policies coming forward into core planning structure and so on and through the infrastructure plan, they're beginning to get there, but in terms of the day to day work of somebody doing something, it's not there'*.

Despite this acknowledgement that climate change increases the flood risk experienced in the UK, there are other issues which are seen to also add to flood risk. UK14 (2012) states:

The real driver of future flood risk is vulnerability, changes in infrastructure, buildings and content, urbanisation etc. That's the rain, climate change driven rainfall, and that's the coast. In other words, what it shows you - I call it the elephant in the room - that worrying about climate change impacts upon rainfall in the UK flood context is not a good idea, the real issues are:

1) Changing ways we use the landscape, which means people are living more and more in flood prone areas and,

2) Risk from the coast and sea level, which is pretty serious.

I am worried that climate change has hijacked the flood risk agenda and again, if you're the Environment Agency, to blame climate change is a much easier blame thing, it's out there, it's in the sky, it's well away, than actually saying, *"Is it our policies that have made things worse? Is it our failure to take a strong stance in respect to planning, for instance, that's made things worse?"*

UK4 (2012) agreed with this idea, and stated that the major issue for future flood risk management will be urbanisation, which is strongly recognised throughout literature.

6.4.1.2 Urbanisation and planning for the future

There has been a long history of urban development in high flood risk regions in the UK, with widespread development on the floodplains occurring in the 19th and early 20th centuries. The impact of urbanisation, 'urban creep', and aging infrastructure is of significant concern to many of the practitioners managing infrastructure (e.g. Scottish Water), such as sewers and stormwater drainage systems. The age of and history around the settlements in Britain is such that much of the flood defence infrastructure is reaching its performance capacity and will be unable to cope as urbanisation increases.

The Pitt Review (Pitt 2008) highlighted the issues that urban creep presents, especially during the 2007 floods where pluvial stormwater flooding was identified as a main cause. Recommendations nine and 10 (Pitt 2008, pp. 72-73) relate to the need to increase pervious surfaces and reduce loads in the urban drainage systems. UK4 (2012) also highlighted this problem:

In the UK, the biggest impact is going to be urbanisation, urban creep. So, what we're trying to do is to encourage people to basically treat rainwater and deal with rainwater at source. So, by building retention storage and porous surfaces and all that kind of stuff. But again, that's not our responsibility in terms of maintaining those systems. So, it becomes difficult if you are trying to get people to do the right thing.

As UK5 (2012) mentions, one of the challenges to dealing with urban flood risk is that:

A lot of the inland flooding that we get is not just water escaping from rivers, it's the inability of the land to cope with very heavy and sudden downpours. Particularly because of increased urbanisation, concreting over towns, inadequate drainage systems to cope with that. And the predicted rainfall pattern that we'll get in the UK is we'll get more sudden heavy rainfalls and heavy downpours. So, I guess the change in climate and the increase urbanisation, lack of adequate planning decisions in the past, which also means exposure to flood properties in floodplains and possibly without defences, or with defences that might have been adequate in the past.

Approaches such as 'green infrastructure', WSUD, and SUDS are beginning to be utilised to address the increasing urban flood risk as mentioned above. As UK8 (2012) stated:

WSUD is going to ride on the back of flood risk management because that's where the funding is, it's where the political agenda, the need is at this time. So, it will be around SUDS, it will be around drainage. To get WSUD we have to look at the drainage and add on these added benefits. We've put in drainage schemes; we've put in surface water management schemes we need to as a community work with our clients to demonstrate that we can do something that's a little bit different. We need to work with water bodies and say we're going to put these in so many houses and they're going to benefit from it.

The use of methods such as these are however only appropriate for smaller AEP floods that are a product of surface water flooding. Urban flood risk is identified as the most pressing issue for the UK, including Scotland. This flood risk is being exacerbated by the increased level of urban development within the UK, especially in England. In part, this urban flood risk is a result of lack of land use planning and development controls.

33% (Five out of 15) of the interview participants specifically noted the conundrum relating to monitoring planning and increasing development and the rising population across the UK:

You could say there's still cases of floodplain development, which perhaps is unwise but we are a small and crowded island and you have to develop somewhere. If you are not going to develop in the green belt or in national parks or in areas of outstanding natural beauty, then sometimes there are not many areas left. There are local authorities like Hull and like Tower Hamlets in London, the whole thing is floodplains, do you expect them not to do anything? No. So, you've got to have a balanced approach and say the local economy is important and the risk can be very low, in Tower Hamlets, the standard of protection of the Thames barriers is 1 in 5000 years [ARI]. Are you saying we shouldn't develop there? No. Ok, is there a risk? Yes. It is a very small risk and a risk we can probably deal with. But you shouldn't embargo development, you shouldn't sterilise the floodplain (UK2 2012).

UK1 (2012) goes on and mentions the developers are also a part of the problem of increasing urban flood risk.

One of the issues is developers don't really give a shit if they develop a flood risk area because as soon as they've sold it to some, what's the word, gullible sort of home buyer that hasn't bothered to check if they're at flood risk or not. They buy the property and then they flood two years later, you know the developer has got off scot free really.

One method of managing increasing populations and urban creep is placing restrictions on land use. Scotland's land use policy (Scottish Government 2011) signifies the need to control and prepare for increasingly risky environments for a sustainable future and indicated the importance of developing 'partnerships with nature'. The land use policy highlights the need to take into consideration factors such as climate change and urban creep, and to apply 'River Basin Management Plans' and 'Flood Risk Management Plan's to deliver the *Principles for Sustainable Land Use* (Scottish Government 2011). Measures such as these aim to restrict inappropriate land use and development and to manage the, '*multiple and growing demands we make on land*' (Foresight Land Use Futures Project 2010, p. 18). UK14 (2012) supported the results of the Foresight Land Use Futures Project (2010) and noted that improvements need to be made to the planning system:

I don't think planners are particularly good at understanding really what makes flood risk and it can occur from scales down to individual houses up to whole spatial units. It can involve individual properties, large numbers of properties. Its silly rules like in the UK where if there are fewer than 10 properties at flood risk, the developer doesn't have to worry about it. The Environment Agency has no role. That's wrong. One property being made worse from a development is no different to 10 properties. So no, I don't think the planning system has any idea of how to handle flooding, if I'm honest.

The flood risk is not just where houses are, it's where houses are in relation to all the other things that we do geographically. Where we work, where our families are and it's always interesting to me when you see flood victims say, "*I couldn't get to my daughter's birthday party*", or, "*I missed my son's graduation because of the flood*". You can't really talk about this rural/urban

separation anymore in flood risk management. The network of movement of people and goods and so on is too distributed to say that the UK is anything other than a great big city.

The Foresight Land Use Futures Project noted that it is imperative that stricter controls are applied to floodplains and that, '*more proactive flood plain zoning can help to reduce future exposure to flooding in the built environment, using flood corridors in urban areas to help deal with peak flows*' (Foresight Land Use Futures Project 2010, p. 22). Growing population density, the spread of urban areas and hence a reduction in permeable surfaces is resulting in increasing pressure on the landscape, which will only increase flood risk in the future.

The challenge of development on floodplains is one that will only become greater as hydrological systems become more sensitive and management failures (perceived or real) continue. The challenge and management of development is closely related to governance systems and is part of the debate between flood risk management as a public or private good (Geaves & Penning-Rowsell 2016). The governance of flood risk in the UK and what that means for its management, will be explored in the next section.

6.5 Response and adaptation to increasing flood risk

The research results have found that two of the key challenges for managing flood risk was the combination of climate change and urbanisation increasing flood risk aligning with the research aims. The *Floods Directive* was introduced to push for equality in response to historically reduced government budgets. There is a need for a more comprehensive and multi-beneficial approach to flood management, along with a, '*desperate call to finally take phrases like adaptation and climate change seriously*' (Wiering *et al.* 2017, p. 15). Recently, there have been increasing levels of interest in the literature exploring how the UK and Europe are implementing flood risk more broadly and incorporating adaptation into their strategies (Bubeck *et al.* 2015; Driessen *et al.* 2016; Geaves & Penning-Rowsell 2016; Gralépois *et al.* 2016; Hegger *et al.* 2016; Kaufmann & Wiering 2017; Wiering *et al.* 2017).

Scotland and the UK have been leaders in implementing the *Floods Directive* and adapting to a higher risk level. Modern flood risk management in the UK is adapting to include the following:

- Managing all sizes of flood events – encompassing a ‘room for rivers’ and ‘natural flood management’ paradigms.
- Risk-informed, evidence-based decision-making – basing decision-making on the estimates of the flood risk, the costs of all structural and non-structural options, and any other (tangible and intangible) costs and benefits.
- Integrated systems approach – traditional technical flood defences are being complemented or replaced by measures for reducing effects of flooding, such as emergency warning systems, emergency response, land use planning regulations, building adaptation and protection, or insurance solutions (Merz *et al.* 2010).

The role of insurance as a financial adaptation option to increase resilience to flood risk, and the implementation of sustainable flood risk management encompassing the management of different sized flood events and alternative options such as natural flood management and relocation of communities, will be discussed in more detail in the following sections.

6.5.1 The role of insurance

Insurance is a key part of the flood risk management portfolio in the integrated systems approach used in the UK; reflecting risk exposure. 93% (14 of the 15) of the UK participants noted the importance of equitable flood insurance. There is high uptake of flood insurance policies in Britain with, ‘*the coverage of domestic properties for flooding is about 90%*’ (UK2 2012).

The previous ‘Statement of Principles’ insurance agreement between the ABI and the Government resulted in the high uptake of flood insurance. This previous agreement has now been replaced by the new model ‘Flood Re’. The new Flood Re framework stipulates:

- Flood Re will be run and financed by insurers as a not-for-profit fund which will cover the cost of flood claims from high risk homes.
- Insurers will pass the flood risk element from those households deemed at high risk of flooding, to the fund. Premiums for the flood risk will be calculated based on council tax banding, up to a maximum limit depending on the Band.
- Flood Re would charge member firms an annual charge of £180 million. This equates to a levy of £10.50 on annual household premiums and represents the estimated level of cross-subsidy that already exists between lower and higher flood risk premiums, and;

- Flood Re will be designed to fully deal with at least 99.5% of years. Even in the worst half a per cent of years, Flood Re will cover losses up to those expected in a 1 in 200 year – a year six times worse than 2007 – with Government taking primary responsibility – working with the industry and Flood Re – for distributing any available resources to Flood Re policy holders should claims exceed that level

(Association of British Insurers 2013a, 2013b, 2013c).

One participant noted that insurance is, *'the elephant in the room in that we don't often get the chance to discuss, but it is really very critical'* (UK10 2012). During the research period between October and December 2012, the Statement of Principles was near expiry. Flood Re was activated on April 4, 2016 (Association of British Insurers 2017).

To highlight the role that insurance can play in flood risk management and risk awareness, Flood Re will not apply insurance to any homes built after the 1st January 2009 *'to avoid incentivising unwise building in flood risk areas'* (Association of British Insurers 2013b, p. 1) demonstrating how insurance can play a key role in flood governance. Homes built during or after 2009 will be subject to individual insurance company costing, allowing market prices to influence development, potentially leading to an ad hoc retreat. UK3 (2012), and UK8 (2012) go on to discuss how insurance, resilience, and development are related and if flood risk continues to increase it would *'naturally form managed retreat. But again, it comes back down to people's house prices would be devalued, and therefore it would come back to the private person eventually'* (UK8 2012). As UK3 (2012) notes:

It's a really difficult problem because you could just let market forces work and over time people would take that into account in their decision-making when moving into high risk areas, the fact that they may not be able to get insurance for those damages. It doesn't help the people that are there at the moment but I think over time it would also put more pressure on the land use planning system because flood risk would be a much more important component of deciding whether or not to build in a particular location, if the availability of insurance was a real issue for the developments themselves (UK3 2012).

This commentary indicates that, despite often being treated separately, insurance has a significant mitigation and adaptation role amongst other non-structural risk management measures, and provides resilience for recovery. UK3 (2012) supports this idea with:

The government could look at it as investment in any of the other measures they invest in, whether it's flood warning or structural defences or awareness-raising or grant schemes. They could also look at investing and supporting and subsidising insurance but it's a very difficult issue to solve. Certainly, insurance companies- you can see why they shouldn't be responsible for subsidising or underwriting those risks and those impacts.

However, 27% (four of 15) of participants indicated that there needs to be a greater acknowledgement of individual resilience measures by insurance companies. This critique has been accepted by the insurance industry representatives interviewed in the UK (UK 2012), and UK5 (2012) stated, *'it's difficult for us to justify the expense assessing each risk individually, yet there's a minority that we need to do that to - and take account of what they've done on the individual property'*. UK5 (2012) highlights how assessing properties on an individual level requires an increase in resources and expense – potentially hindering the application process and discouraging take up.

The UK participants noted that insurance is a complex tool and operations have been under some debate. Insurance cost, and the 'fairness' of any subsidies are major issues. As UK12 (2012) mentioned, *'insurance has got to be accessible to all because it's the single biggest thing and most effective thing that people as individuals can do to protect themselves'*. UK12 (2012) also mentioned the need to be socially just in implementing an insurance scheme; *'it's got to be affordable, so accessible... it's got to be socially just, in the sense that vulnerable groups in society or other groups for that matter shouldn't be excluded so it's got to have that availability'*.

The issue of 'fairness' was also considered by UK2 (2012) with:

If you were to criticise the insurance regime, you would say that the people who live on the tops of hills are subsidising the people who are at flood risk to a massive extent. It's a massive cross-subsidy, which the people who live on the tops of hills don't know about. It's about a billion pounds a year. That's the criticism you could put to insurance.

However, despite these criticisms, UK1 (2012) highlighted that, *'I think it is kind of inevitable that we're living in a world where flood risk is only going to get worse in the UK'*. UK3 (2012) addressed the necessary role that insurance needs to play in such a risky environment with, *'I think insurance has a really important role to play in terms of helping people to recover from flooding and recognizing that we've got an endemic problem that we can't stop happening, people do need the assistance in recovering'*. UK11 (2012) agreed, stating:

If insurance companies withdrew insurance for flooding, I think that would make a lot of people very, very nervous because there are some places which flood for a hobby really. The same images flash up every time there is a flood, certain towns where they always get it and if they haven't got insurance that's a massive blow.

These results indicate the important role that the insurance industry has within flood risk management in the UK. The insurance industry has the, *'fantastic capacity to be able to*

influence what happens and by looking at things in a holistic way and strategic way to actually shape change, which would result in fewer claims from that point of view, but would also be a public benefit' (UK12 2012).

6.5.2 Sustainable flood risk management

Scotland has focussed on a sustainable flood risk management approach to address a changing risk environment since 2009. Scotland has arguably taken the implementation of the *Floods Directive* further than England/Wales and so will be examined in further detail. Scotland is using sustainable and natural flood management to transition from technocratic flood risk management to a more sustainable governance and management approach (e.g. Cook *et al.* 2016; Spray *et al.* 2009; Stirling 2008; Waylen *et al.* 2017; Werritty 2006). The following section discusses the policy and implementation of the *FRM Act*.

6.5.2.1 The influence of the *Floods Directive* and the *FRM Act 2009* on sustainable flood management

The *Floods Directive* has greatly influenced the management of flood risk in the UK and Scotland especially. The implementation of the *FRM Act* on June 16, 2009, forced a change in culture in flood management. Since 2009, Scotland has concentrated on sustainable flood risk management.

The *FRM Act* has increased responsibility on the main bodies who manage flood - local authorities, SEPA, the Scottish Government, and Scottish Water. The creation of both the Scottish Advisory and Implementation Forum for Flooding (SAIFF) and associated local advisory groups were also developed to be an interface with the community, and within and between the governing bodies, signifying the importance of a local approach. SAIFF is responsible for ensuring the flood management approaches used meet the EU guidelines.

Interview participants discussed the changes in Scotland's flood management since the implementation of the *FRM Act* and considered the performance of the legislation. All (15 of 15) the participants were in favour of the changes and the resulting new direction supporting the need for a strong top-down approach.

UK3 (2012) discussed the introduction of the *Floods Directive* and its role in developing the new *FRM Act*:

That [*Floods Directive*] was one of the key drivers behind the new legislation in Scotland. It has really modernised how we're managing flooding. So, it was the key reason we got a new piece of legislation and new roles and responsibilities for different public bodies. It was something the Scottish Government recognised it had to do anyway but the *Floods Directive* really helped focus their minds in terms of needing to reorganise how we manage flooding. I'd say it was quite an important bit of legislation.

The *Floods Directive* and the *FRM Act* in Scotland, which followed that, has set it up in a much better risk-based, plan-led approach where we'd work out just the spread of the problem across Scotland and really develop our understanding and then work out the best way of managing the flooding problem. It's set up the framework. That's great in theory and what we're busy struggling with, is then implementing it, particularly the partnership working aspect.

UK12 (2012) mentions the importance of the EU policy, with, '*EU environmental policy is what has driven most environmental policy in Britain over the last 20 years in reality. The government won't admit that, but it's true*'. UK7 (2012) supports this with:

Everything to do with the environment in the UK ultimately comes from the EU, because environmental issues don't respect national boundaries, they cut across it. So, it's a clear prerogative of the EU, and the role in the UK, and the Scottish government, and local authorities is to implement and respond to those EU directives.

The participants noted the significant impact that the *Floods Directive* and the *FRM Act* had on changing the culture of the approach undertaken in Scotland. UK8 (2012) highlighted this change, and mentioned how the culture has progressed along a spectrum from flood prevention, to flood protection/alleviation, to flood risk management:

The *FRM Act* has definitely changed context... the culture has become much more around being aware of what risk really is. The Act is really good because it is responding to the legislation and looking at social and cultural heritage and environmental and then economic risks.

This new risk culture being presented in Scotland reflects the transition described in the Risk Society theory (Beck 1992, 1999, 2006) to a reflexive modernity where there is a '*general sense of a shift towards a more uncertain and insecure society*' (Sørensen 2017, p. 2), and the acknowledgement that living with risk is inevitable. A '*concept of a zero Risk Society has been superseded*' (Gralepois et al. 2016, p. 1). As UK10 (2012) acknowledges, '*water will find its way back to its natural course, and whilst an engineer will try and persuade it otherwise, it will always find its way back*'. UK7 (2012) also supports the observation of the new risk culture:

The *FRM Act* is all about looking at it [floods] in terms of risk. It's not looking at it in terms of the most suitable political or other structure, you're actually homing in on what to politicians is important, risk to people, risk to land, buildings, assets and all the rest of it and risk to economies.

However, UK13 (2012) feels that Scotland would have reached the same sustainable flood management culture without the introduction of the *Floods Directive*. *'All it did was give us a specific timetable for doing certain aspects of it. We were already on that path. I don't think it made a huge difference'*.

One of the key changes resulting from the introduction of the *FRM Act* is the increased collaboration between the governing bodies. As UK10 (2012) states:

The *FRM 2009* is very much a partnership, has a partnership ethos within it, the need for cooperation is set down in statute but it is actually happening and I think it does bode well for local authorities with a different interest to be able to work together on things that are regional and certainly on a national level.

There has, however, been some criticism regarding the *FRM Act*, with UK8 (2012) comparing it to England and Wales who have developed a *FWM Act* (Department for Environment Food and Rural Affairs 2010). The *FWM Act* integrated both flood and water management so the interconnected *Floods* and *Water Framework* Directives can be addressed together (European Union 2000, 2007). As UK8 (2012) mentions, *'So now we're sitting here and we've got a FRM Act; our capability is now constrained by a bit of legislation that is silo thinking. The community is broken because we now have two different Acts'*.

UK4 (2012) also criticises the implementation and the lead coming from SEPA where they may not have the expertise required for practical solutions:

I think the SEPA are very good as an advisory body, they're very good with the science. But I am a bit uncomfortable with how far they're taking the implementation of the [FRM] Act because they're going to come up with preferred measures to address flooding. I hope and certainly, I'm sure they will, they have to take a lot of advice from the authorities and Scottish Water because SEPA are not engineers. So, while the science might be good, the practicalities will be different... SEPA are going to have to be very careful how they manage this because I don't think, both in terms of the engineering capability to understand whether it's actually a practical solution but also in terms of money. Because they might come up with solutions that are very expensive and nobody can deliver. And that's just because they haven't got the expertise, that's all. They weren't set up to do that. They are scientists, so I think maybe the Act went a bit far in terms of giving SEPA all this responsibility to that level. But as I said, they have a good opportunity to manage it in terms of actually using the local authorities and Scottish Water to get most information and listening to what they're saying. Listening is very important (UK4 2012).

There is still a level of apprehension and cynicism regarding the prioritising of natural flood management demonstrating a discord between policy and practice. However, despite this, 53% (eight of 15) of the participants were very positive regarding the new approach and that the

FRM Act has been successful thus far in meeting the time constraints and requirements needed. Waylen et al (2017, p. 5) determined similar results with their participants demonstrating widely positive views towards sustainable and natural flood management. UK13 (2012) stated a reason for the support:

I think it has focused practitioners on the need to be, the need to work together more collaboratively. That's been one of the major gains from it. It has also meant that because we now have legislation in place, to deliver it, it makes it, it gives them an incentive to look at more sustainable approaches. It can sometimes be too easy to do what you have always done. Because we have legislative requirements in place now to take a more sustainable approach I think that local authorities and others are certainly doing that.

The change in direction has been welcomed, and the benefits from the cooperation between all parties and the community have been appreciated despite the initial challenges.

The following section explores and focuses on the actions undertaken/needed to use natural flood management approaches and the critique of these techniques.

6.5.2.2 'Natural' flood management approaches

A key finding from the Pitt Review (Pitt 2008) recommended that a more sustainable approach towards flood risk management should be undertaken. The policy of *Making Space for Water* (Department for Environment Food and Rural Affairs 2005) in England/Wales outlined the need for the implementation of a further balance between structural and non-structural approaches - including the need to work with natural processes. The Pitt Review Recommendation 27 (Pitt 2008, p. 130) also promoted a greater need to work with natural resources. The Pitt Review coincided with the introduction of the *Floods Directive* in 2007; justifying a change in policy direction for flood management to include natural flood management.

SAIFF defines natural flood management as:

Techniques that aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters. These techniques include the restoration, enhancement and alteration of natural features and characteristics, but exclude traditional flood defence engineering that works against or disrupts these natural processes (SAIFF 2011; cited in Nutt 2012, online).

DEFRA (2013) also notes that the use of natural flood management approaches has wider benefits than reducing flood risk, with possible higher biodiversity levels in wildlife habitats, reducing carbon emissions, and an improvement in water quality and pollution reduction. The

National Flood Forum (2016b, p. 1) discusses some of the benefits of using natural flood management whilst recognising that *‘on its own, it won’t solve a communities’ flooding problems, but that it can make up one part of the flood risk management jigsaw’*:

Natural flood management is about how we delay and speed up water flow through a catchment to reduce the peaks of water that often cause flooding. We are seeing growing interest in it amongst our Flood Action Groups because it is often more affordable than hard-engineered defences and it gives people a sense of ownership, purpose and practical involvement in reducing their flood risk.

The push for an increase in natural flood management techniques to develop a holistic approach for managing flood risk in conjunction with flood defence mechanisms is also apparent within the legislation at various government levels as demonstrated in Figures 11, 12 and 13.

The *Floods Directive* (Figure 11), the *FRM Act* (Figure 12), and to a less extent, *FWM Act* in England/Wales (Figure 13) have signalled for the need to use natural flood management techniques. From comparison of these three sources, it clear Scotland has taken a stronger policy alignment towards supporting sustainable, nature-focused land use practices than England/Wales despite both being derived from the EU *Floods Directive*.

In the 2007 *Floods Directive* (European Union 2007), the EU has indicated the need for an integration and increased usage of natural flood management techniques stating, *‘flood risk management should work with nature, rather than against it’* (European Commission Directorate-General Environment 2011, p. 1). The European Commission suggests the rationale behind the use of natural approaches includes a focus on water retention capacities which can reduce the impacts of floods (European Commission 2014). The European Commission (2014) suggests that the best place to apply natural flood management is in a holistic context, either across a catchment of a river or along a length of coastline.

Figure 11 Extracts from the EU Floods Directive relating to natural flood management

‘With a view to giving rivers more space, they should consider where possible the maintenance and/or restoration of floodplains, as well as measures to prevent and reduce damage to human health, the environment, cultural heritage and economic activity’
(European Union 2007, p. 2).

‘Flood risk management plans shall take into account relevant aspects such as costs and benefits, flood extent and flood conveyance routes and areas which have the potential to retain flood water, such as natural floodplains, the environmental objectives of Article 4 of Directive 2000/60/EC, soil and water management, land use planning, land use, nature conservation, navigation and port infrastructure’ (European Union 2007, p. 5).

‘Flood risk management plans may also include the promotion of sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event’ (European Union 2007, p. 5).

Figure 12 Extracts from *FRM Act* relating to natural flood management

'Act in the way best calculated to manage flood risk in a sustainable way, promote sustainable flood risk management'.

'In considering structural measures under subsection (1)(b), SEPA must consider measures that seek to reduce, slow or otherwise manage flood water by altering (including enhancing) or restoring natural features and characteristics. The measures considered in pursuance of subsection (3) must include measures that consist of carrying out any alteration or restoration of natural features and characteristics identified as being capable of contributing to the management of flood risk in an assessment done under section 20 in relation to the district' (Scottish Government 2009b, p. 17).

“flood protection work” means any operation on land for the purpose of protecting any land from flooding including—

- any work of construction, alteration, restoration, enhancement, improvement, repair, maintenance, demolition or removal,*
- any work that involves the alteration (including enhancement) or restoration of natural features and characteristics of any river basin or coastal area,*
- the sowing or planting of vegetation or forestry' (Scottish Government 2009b, p. 95).*

Figure 13 Extracts from England and Wales *FWM Act* relating to natural flood management

'The following are examples of things that might be done in the course of flood or coastal erosion risk management:

- planning, erecting, maintaining, altering or removing buildings or other structures (including structures built or used for flood defence purposes),*
- maintaining or restoring natural processes' (Department for Environment Food and Rural Affairs 2010, p. 2)*

'In this section “flood risk management work” means anything done for the purpose of maintaining or restoring natural processes' (Department for Environment Food and Rural Affairs 2010, p. 45)

The EU Commission goes on to provide examples of natural flood management techniques:

- Restoring natural flows by realignment of coastal areas, or re-connection of rivers with their floodplain,
- Restoration of wetlands which can store flood water and help “slow the flow” of flood waters,
- Reservoirs in agricultural areas which can store flood water during flood events, and otherwise be high nature value areas, and;
- Urban ‘green infrastructure’ such as green spaces, sustainable urban drainage and green roofs, SUDS, and WSUD

(European Commission Directorate-General Environment 2011, p. 1).

However, when questioned regarding the implementation of natural approaches and how they are being integrated into practice, the participants agreed that while such approaches were beneficial, they were difficult to introduce. UK (2013) was particularly interested in the use of natural approaches but highlighted the barriers for any level of commonplace implementation. Their key barriers to implementation included:

- Lack of evidence
- Lack of funding
- Lack of Stakeholder engagement
- Governance framework - including policy and legislation
- An embedded hard structural engineering culture

(UK15 2013).

These barriers are similar to those mentioned in the 2008 Pitt Review where the funding appraisal and prioritisation system using cost benefit analyses were noted to favour traditional concrete engineering structures (Pitt 2008). The Pitt Report also noted the significant lack of incentive for the application of natural approaches in practice, especially in a rural setting where farmers felt that they were disadvantaged and without support (Pitt 2008). Waylen *et al.* (2017) again found similar barriers for the implementation of natural flood management:

- Difficulties allocating resources
- Challenges in using evidence and handling uncertainty
- Complexities of coordination (governance and inclusion of stakeholders).

The strong correlation between these results establishes the validity of the issues found and demonstrates significant support for further work in these areas. UK10 (2012) agreed with culture and engagement of the community as barriers:

I think that's the difficulty with natural flood management, I'm more naturally a sceptic of it, because there's got to be sufficient endorsement of it, but also support of it by the landowners, from the farming community. It's very much a case of engaging directly with the farming community so they understand that there could be some mutual benefits at that level. And I think the best way to do that is at a very local level, is trying to get some of these projects on the ground so we can actually get some case studies that then can be presented more nationally in terms of putting national flood management on a regional, rather than a national level. It's very difficult to persuade people to give up land and turn that over to floodplains.

However, natural approaches often take long time-frames to assemble sufficient scientific evidence. As UK8 (2012) noted when considering the actual usage of natural techniques:

You're asking me to come along and you want me to protect three houses using natural flood management techniques and put my professional indemnity insurance on the line. I would walk away from it. Because we do not have the science. I cannot defend our decisions if somebody said we'd done something wrong.

The lack of implementation of the legislated requirements for natural management techniques indicates there is a significant deficiency in the translation of policy into practice. Across the UK there are minimal examples of where natural approaches have been applied, with a list of some pilot studies found in Appendix A. However, DEFRA has coordinated three major pilot studies in England which started in 2009. These projects have yet to provide final results. Scotland has also undertaken pilot studies, which are also yet to provide final outcomes. It will be of interest to note of natural flood management is used on a wider scale when more comprehensive evidence is available.

The use of pilot studies indicate that the government is attempting to overcome one of the barriers to support the rationale for implementation of natural flood risk management techniques, but it is still unclear whether a large enough shift in culture has occurred to allow natural approaches to become more frequently used. There is also still much scepticism surrounding the use of natural approaches and an acknowledgement of the limitations of implementation. As Smith (2016) and Alexander *et al.* (2016) discuss, DEFRA's flood policy of discouraging 'hard' engineering solutions was criticized during the winter of 2013/2014. With an extremely wet winter and severe and sustained flooding experienced in the Somerset Levels and Moors area, more than 115 km² of land was inundated. For several months, roads were inaccessible, businesses ceased operation, villages were abandoned, and residents

evacuated (House of Commons Environment Food and Rural Affairs Committee 2014). The extent of the flooding resulted in considerable media attention, with the British Prime Minister stating, ‘we cannot let this happen again’ (Dominiczak 2014, online) (despite the unrealistic expectation). The research results supported such popular sentiment, for example, UK13 (2012) mentions natural approaches:

Will never provide the protection that a wall or barrier or traditional scheme could provide if you’re looking for protection from the 1 in 200 [ARI] flood protection. But what it can do is provide an additional level of protection for levels of climate change or top up for traditional schemes.

UK5 (2012) agreed, and stated:

A lot of these measures are absolutely necessary. And I think we need to live with the fact that it’s better for water to permeate slowly into the ground and released into river systems slowly, rather than going into drainage systems and separating out the stormwater drains from foul water drains. And one of the things that’s commented on is that drains are only designed to cope with a one in 30 year return period rainfall and yet we’re saying that we need properties defended to a minimum standard of 1 in 100 or one in 200 years ARI. And that’s just not compatible with the way that we design drains.

As UK15 (2013) notes, whilst natural approaches are beneficial and should be considered, they are not appropriate for every circumstance, season and location.

So, what seemed a good flood risk management measure in terms of working from a natural process, doesn't seem to have the longevity that some of the others may have as well. Although it's very good from a water quality point of view to re-establish these areas and very good from a biodiversity point of view, it's not been the complete solution we were all hoping for.

Those who have experienced flooding find it difficult to rely on natural approaches. UK15 (2013) elaborates:

You've got to convince people on the ground as well that these kinds of things work. Again, we were listening to a chap in a place called Morpeth, which is near Newcastle. And they looked a scheme where they couldn't fund any defences to a 100 years [ARI] standard but they got one to a 50 year [ARI] standard. And they put in some storage in some fields upstream of the town and that's going to give them 100 year [ARI] protection overall. And speaking to an outsider and saying, “*How do you feel about that?*”? And he said, “*Still a little bit anxious that those fields aren't going to hold that water back?*”. So, there's still an element of distrust within people on the ground as well. There's an argument between people who've actually flooded and people who are at flood risk. The people who are at flood risk and haven't been flooded, say, “*I don't want that wall there, I want it prettier or something much more in keeping with the environment?*”. People who've actually been flooded and have had various bodies of water in their house say, “*Just stick a wall there and I don't care how you do it, just put me a wall up?*”, and you can understand there are people that get very anxious when it rains and they want something hard and fast there and they don't want somebody like me saying, “*I'll put a nice*

wetland and trees”, and they're going, “*I don't know if I can trust you on that*”. Again, it comes down to a lot of science and evidence and more examples and we'll be able to prove that.

UK3 (2012) debates the applicability of natural management approaches when dealing with communities:

It is very much a hierarchy in thinking through the measures. There will always be significant flooding problems where you get down to the bottom of that list and be looking at built defences. It's a probably the last option you'd get to quite quickly and quite obviously in many circumstances, but I think if you can, particularly if you can avoid it through looking at natural flood management, catchment management, then I think that's the right approach.

As UK3 (2012) states that the likelihood of natural approaches becoming a major tool for managing flood risk is limited; built defences will remain heavily used. UK8 (2012) goes on and states that, ‘*I think natural flood risk management; it has to be in the toolbox for England and Wales, but it will be a smaller tool. Its potential opportunity is smaller than what we've got in Scotland*’; referring to the challenges to apply natural approaches in more populated and urban areas. This statement by UK8 (2012) supports the argument that Scotland has the potential to be a global leader in new adaptation approaches for managing flood risk.

Gralepois *et al.* (2016) explored the challenge of natural flood management implementation and the reliance of flood defence in England and elsewhere in Europe. They determined that the, ‘*strongly established actor coalitions, a solid institutional design centred around flood defence, and sunk costs of flood defence investments made in the past, hamper a radical shift toward new flood risk strategies*’ (Gralepois *et al.* 2016, p. 9). It was proposed that a change towards adaptation and resilience for integrated flood management will help with the transition to include approaches such as natural flood management in the ‘toolkit’ for sustainable flood management, along with concepts such as retreat/relocation policies.

6.5.2.3 Relocation

Relocation policies have long been undertaken in the UK at various scales; managed realignment and managed retreat have been used with salt marshes reinstated to manage coastal erosion (e.g. Esteves 2013; Luisetti *et al.* 2011; Turner *et al.* 2007). The 2005 *Making Space for Water* (Department for Environment Food and Rural Affairs 2005) policy document was a key driver in broader application of these actions, but relocation has previously been implemented on a more localised scale.

Relocation is a likely strategy to complement natural flood management to reduce risk exposure and vulnerability. Therefore, as part of the research undertaken, the interview participants were questioned on the possibility and likelihood of introducing relocation policies as an integrated measure for sustainable flood risk management, with nine of the 15 participants stating that they could see the benefits of such a policy.

Despite the positive inclinations for a relocation policy, when application was considered, the policy direction was generally thought to be politically and socio-economically unpopular. UK7 (2012) states the difficulties of a scenario, '*where you say to a town on the Essex marshes, "Forget it, you've got to move somewhere else". That would be a very tricky decision because they don't like that*'. UK8 (2012) agreed; '*in terms of managed retreat, it's a really, really interesting one. I think human nature is that we would try and engineer a solution. There will be places that will be blighted*'. Such comments are consistent with the data presented in the previous case studies.

The feasibility of a relocation policy was noted to be more favourable if the flood risk was extreme. UK13 (2012) supported the possibility of relocation policies being implemented at a wider scale; '*managed retreat is something that has been piloted in Scotland*'. Legislation including property acquisition also supports the capability of retreat to be used more broadly (Department for Environment Food and Rural Affairs 2010; Scottish Government 2009b). As UK4 (2012) demonstrates the legislative support,

I think that the *FRM Act* recognises that and the approach that SEPA took, in agreement with the local authorities, [that retreat] is amongst a basket of things you can do that is also an opportunity. Whether it will be done is a different kettle of fish because it's difficult. And people have been living in their homes forever and a day and all that kind of stuff. But yes, it can be done and it should be done when it's necessary. There was an example where it was mentioned - there was this small hamlet and it's in an estuary and it's getting flooded from coastal flooding, and it will get washed away. It's too expensive; the cost/benefit is not there. You can't spend the money and you would have to build a wall around it kind of New Orleans style. It's crazy and so the best way to do it would just be to relocate people.

However, it is unlikely that relocation would occur without significant community consultation and an in-depth cost-benefit analysis for the specific location at risk. UK10 (2012) explains this process for considering retreat and how community engagement would be needed:

We would consider it, and we have considered it. I shan't say the location, but we had gone to the idea that existing properties, dwellings, industrial areas, a ledger of facilities that were at flood risk, and therefore could we relocate? Could we actually turn that area to a functioning floodplain and take the properties away from there and actually breaking the pathway to flooding? And we had considered that and in terms of the costs, which was

fundamentally what this decision came down to, but costs would not allow it. In terms of it was better, there was a better cost-benefit analysis to protect the properties than it would've been to purchase and relocate. We had considered that, whether it would have been politically sanctioned or not, I don't know. The public perception of that, whether we had wanted to go along that route, is a difficult one.

I think if we were to go about doing that it would be very much a case of community engagement to actively demonstrate that it was absolutely needed so that the actual science and the engineering behind it was robust and that was communicated well so that they realise the severity of the problem that we had. And once you've got that understanding, or at least the willingness to try and understand that, the problem has been explained, we're then looking at solutions. If it's purely down to money as to why you can't protect a property, then that becomes more of a difficulty and I think the way around that would be to demonstrate that this was the safest, the best option for the individuals affected. But more importantly that there was some betterment out of that. We're freeing up areas that would be turned over for amenity use.

Increased risk is reflected in cost/benefit analyses for assessing appropriate flood risk management options, indicating a lack of viability for flood defence in some areas. UK14 (2012) explores this possibility and the political challenges during flood events:

It won't be a retreat of people, it will be the retreat of management, which is a very interesting thing to do. How long that remains sustainable for is a very interesting question indeed. I don't see how any government could defend management retreat during a crisis. I think it would be a catastrophe for whoever's advocated that.

UK1 (2012) contradicts with:

Why should we be overly sentimental and keeping whole towns protected when there's no economic benefit for keeping them and the town there? Think we'd certainly say if there's places that are uninsurable, and there are places that are uninsurable [now], that are economically just not viable to insure, then it's probably a very sensible idea not to live in them as well.

It is increasingly possible that more locations will become economically unviable to continue to insure with increased risk and uncertainty, and residents and governments will face the challenge of '*you have to accept that you'll live with the risk, or move away*' (UK9 2012). Such a statement supports future flood management including localised adaptation methods and/or a relocation of populations.

6.6 Key findings

The UK has a long history of experiencing large-scale flooding. Two of the key challenges examined in further detail were deemed to be managing the increased risk from climate change and growing urbanisation.

The examination of the key policy and legislation to manage flood risk has provided learnings around the governance of flood risk. The *Floods Directive* was a catalyst for a philosophical change in management approaches across the UK (and the EU more broadly) with the introduction of the *FRM Act* in Scotland and the *FWM Act* in England and Wales. The *Floods Directive*, *FWM Act* and *FRM Act* were found to provide the base for a strong governance framework which thus lead to clear devolution of roles and responsibilities for flood management. A clear governance framework has significant reflection on the perception of the importance (and hence perception of level of risk experienced) of flood management. In addition, the governance framework clearly communicated the prioritisation and expectations of approaches used to manage flooding, and the focus on adaptation to future flood risk.

The focus on different adaptation approaches to address future flood risk provided key learnings for implementation around sustainable flood risk management approaches, such as natural flood management and relocation policies. Key barriers found to implementing natural flood management and relocation policies were very similar to other academic studies, validating the results. The barriers found to implementing natural flood were around:

- Appropriate resourcing
- Evidence and certainty in results
- Embedded culture legacy
- Difficulties engaging and coordinating across stakeholders.

The identified barriers above, in addition to the perception of risk in the community and value of socio-environmental systems experienced, will have strong implications for the successful application of sustainable flood risk management. The criticism given to the UK government agencies regarding the various flood defences and adaptation approaches used (or lack of) in the 2013/14 floods and the 2015/16 flooding provides further justification for an increased evidence-base of adaptation approaches for sustainable flood risk management for use in the decision-making process.

6.7 Key themes and chapter summary

Chapter Six has provided a learning experience from examining flood risk at the UK national scale. The UK has a significant history of large scale flooding providing evidence for the importance of risk-appropriate flood management. Key challenges for flood management were found to be around the increased risk from climate change and urbanisation. As a result of increased risk and uncertainty around flood hazard, the focus of this chapter was around the governance framework facilitating flood risk management, and the adaptation to future levels of flood risk and the residual risk from existing flood mitigation structures as design levels are potentially exceeded.

The Scottish sustainable flood risk management philosophy as an adaptation response was then explored further. Natural flood management and relocation was focussed on as key alternatives to flood defences for use as part of wider sustainable flood management.

The following chapter of this thesis will draw together the three case studies and consider the issues raised and methods to address increasing future flood risk.

Chapter 7: Adaptation to future flood risk: challenges and opportunities

7.1 Introduction

The preceding three chapters examined case studies of flood governance frameworks at three different contexts and scales. Specific examples of alternative policy approaches for addressing current, future and residual flood risk were identified. The case studies have presented a snapshot of some of the myriad of interconnected themes relevant to, and influencing the governance and outcomes of flood management. The purpose of Chapter Seven is to compare and contrast the key recurring themes across the three case studies relating to flood governance framework, in order to determine key challenges and opportunities for learning.

Specifically, this chapter critically analyses how risk perception can influence options for an adaptive management approach to flood risk. The chapter delineates the various central challenges presented by the current governance frameworks, and some key barriers to and opportunities for the uptake of adaptive measures in flood risk management in the face of increased flooding risk and impacts.

7.2 Comparative analysis of case study results

The three previous chapters have examined three case studies:

- Case Study One (SA) – development of the BHKC SMP, where a preference for a structural mitigation response was replaced by an integrated approach with a stronger landscape focus in response to community pressure
- Case Study Two (SE QLD) – The 2011 flood event as a catalyst for change, and a focus on the relocation of Grantham township in response to catastrophic flooding
- Case Study Three (UK) – The introduction of the *FRM Act 2009*, with a focus on the implementation of sustainable and natural flood risk management.

These three case studies have similar social, political, cultural, and economic characteristics and examine governance across a local, regional, and national scale. The use of case studies across local, regional and national scales provides examples of the risks to governance across those same scales. The recurrent themes identified that influence the ways that flood risk is experienced and governed include the following:

- Risk perception – the influence of community and practitioner response and in decision-making processes
- Increasing urbanisation and changes in land use – how governments are balancing requirements for development, aging infrastructure, increasing populations and resultant higher levels of run-off
- Climate change – how to plan for the uncertainty and the change in frequency and magnitude of extreme events
- Established governance frameworks – including localism, and policies and planning
- Adaptation options - including landscape management, feasibility of alternative options in urban environments.

These themes are summarised in Appendix B, with key quotes from the results to demonstrate each theme. Here, each theme is discussed in detail to outline the key influences that each element has over evolving governance arrangements, with the theme of ‘risk perception’ examined first.

7.3 Risk perception

‘Risk perception’ is of particular significance due to the research aim to identify challenges for flood management in the context of stakeholders’ perceptions and acceptance of risk. This aim is important to examine in more detail as there is a recognised need for a greater understanding of risk perception in flood management (Birkholz *et al.* 2014). Chapters Four, Five and Six examined how risk perceptions influenced flood risk management approaches.

Flood risk perceptions are a long-acknowledged influence on community resilience and acceptable levels of risk at a certain location are often socially constructed and understood through either a rationalist or a constructivist paradigm (Birkholz *et al.* 2014). The findings from Birkholz *et al.* (2014) can be linked back to Beck who had a similar view and deemed risk to be in-between a realism and constructivism ontology (Sørensen 2017). The trust (or lack of) by the community in the ‘experts’ in charge of governing the risk has the most substantial influence on individual/community risk perception (Wachinger *et al.* 2013). Risk perception also has a significant influence in how risk practitioners govern risk.

According to Slovic and Weber (2002, p. 2), risk perception can have an explicit and implicit role in decision-making as, ‘*differences in risk perception lie at the heart of disagreements about the best course of action between technical experts and members of the general public*’. This statement is particularly evident in the case study of the development of

the BHKC SMP. Risk perceptions are strongly influenced by the frequency of experienced events (Slovic et al. 1980; Wachinger et al. 2013). However, the management of flood hazards often involves planning for events that have not yet happened, for example a 1% ARI event or higher, as in the BHKC catchment. As Richard A. Clarke, former White House counter-terrorism chief has stated, '*democracies don't prepare well for things that have never happened before*' (Slovic & Weber 2002, p. 18).

Emotion also influences risk perception, and provides a social amplification of risk (Kasperson *et al.* 1988; Slovic 2000). The concept of social amplification highlights the complex interactions around emotion and logical thinking, often in conflict in discussions of flood risk management. Emotion was particularly apparent in the SE QLD case study, especially in relation to the perceived low level of risk portrayed by the installation of Wivenhoe Dam to protect Brisbane from flooding. This false perception, in combination with a large time period between major flood events, led to a dangerous culture of complacency on the part of the public and some risk practitioners.

The social amplification of risk was also demonstrated in the UK, where UK4 (2012) highlighted the need for a shift in thinking about risk, if landscape management options are to be part of future flood risk planning (see Appendix B). This shift will need to entail:

- Identification of the risk acceptance of this level of risk in a specific location
- A change in the perception of what a technological solution to risk looks like.

A review article by Birkholz *et al.* (2014, p. 18) supported these results from the UK case study, finding that, '*the extent to which people feel responsible for taking protective actions is closely related to their belief in the effectiveness of 'public' protective measures*'. This finding by Birkholz *et al.* (2014) is particularly relevant for implementation of adaptation measures, such as natural flood management, which are employed as part of a sustainable flood risk management paradigm involving a strong emphasis on community consultation and engagement, and inclusion of local values which reflects an argument for localism. To implement alternative approaches there needs to be an '*understand[ing] and value [of] personal protection vs. public protective measures, as well as how public measures might be valued against other societal objectives (e.g. economic growth)*' (Birkholz *et al.* 2014, p. 18).

In terms of adaptation, risks such as floods can also be perceived as failures of systems in modern society, and are constructed by those who experience them – they are not just 'natural' hazards (Castree & Braun 2001). The actions of government will frame how adaptation to climate change unfolds (Adger *et al.* 2016). Hence, an explicit decision to change management approaches is needed with clear leadership from those governing of risk management. The

following section addresses the research objective to ‘identify challenges for flood management in the context of the governance arrangements’ by comparing and contrasting specific governance challenges observed across the three case studies.

7.4 Governance frameworks and challenges for flood management

The focus of this study was on governance of flood risk via the systems responsible for flood management; these systems include:

- Governing, government and political arrangements – including industry and other non-government organisations and representative groups where relevant.
- Public policy and legislation, including land use planning policy.

The following sections discuss the governance challenges for flood risk management, identifying commonalities and discordances across the three case study sites.

7.4.1 Governance: responsibilities and influences

Beck (2009) and Butler and Pidgeon (2011) postulate that governance of flood risk is currently based on three labels: cause, blame, and accountability, while a questioning of progress is lacking, and that a broader focus on the societal change needed for sustainable flood risk management is absent. Recent formal assessments of governance performance across the context of the three case studies (Office of the Inspector-General Emergency Management 2015; Pitt 2008; Queensland Floods Commission of Inquiry 2012; Teague *et al.* 2009) investigate the justification of cause, blame, and accountability in the context of governance for specific events in the case studies, and have suggested that levels of preparedness, and hence community resilience to flood hazards, is inadequate (Lindell & Whitney 2000; Paton & Johnston 2001). The results of this research support this contention; there is often a significant disconnect between accountability and responsibility for flood and natural hazard management. There is also a concentration on the cause and blame of events as seen particularly in the SE QLD case study with the dam operators.

The failings within the governance framework for the four PPRR sectors of flood management was one of the key issues identified in all case studies. Almost half (48%, or 24 of 50) of the interview participants identified an inadequate governance framework as a barrier to effective flood management. Diffuse and unclear governance arrangements are a particular issue, as noted by 32% (16 of 50) participants. Diffuse responsibilities were particularly important in the two Australian case studies, perhaps reflecting the Federal political system and

emergency management statutory requirements that themselves have unclear multi-agency, multi-level devolutions of roles and responsibilities. The varied, unclear and inter-governmental nature of governance responsibilities can result in ineffective and inefficient management. For example, reflecting the disparity in policy development versus implementation, SEQ6 (2011) notes, *'there's not proper engagement between the National government and the Local and State agencies, or even Local government'*. Reflecting on the 2011 flood event, SEQ5 (2011) highlights the complexity of roles and responsibilities in terms of flood management, and the need for better intergovernmental relationships:

I think Local government is best placed to understand the needs of its particular community, and should be the first port of call for information, advice and support. State government has to be ready to deploy its resources on the one hand in terms of emergency response, and on the other hand in terms of a standardised and co-ordinated framework for development and emergency governance in the State. And National government needs to provide both, and funding for an integrated national approach. Because, as we saw, an event of the severity of the QLD flood involved the Federal government, the Army, State government and all its departments and resources, and a continual list of Local governments, you know Mayors appearing in the media speaking for the community what their needs are and marshalling those.

In contrast, the UK presents a localism approach through, for example, community-based Local Flood Action Groups formed through the National Flood Forum (National Flood Forum 2016a). However, UK8 (2012) opined that, *'local authorities have the biggest problem of trying to deliver stuff for the public'* supporting findings by Thaler and Priest (2014). Thaler and Priest (2014) determined six key issues arising from the adoption of localism for flood management in England including:

1. Only a (re-)imagination process of sharing risk burdens
2. A shadow of more democratic processes
3. Insufficient balance of power between the different stakeholder groups (Allen & Cochrane 2010)
4. Potential 'hollowing out' of the government because of downscaling responsibilities to local actors
5. The creation of a gap in the transfer of power, resources and capacities with the result that local authorities are not able to handle all their new tasks (McCarthy & Prudham 2004), and finally
6. Unresolved conflicts between different actors, citizens and stakeholders (Thaler & Priest 2014, p. 419).

Furthermore, a key influence in management directions made by Local government can be fear of litigation by community members (Nursey-Bray 2017). The closer connection between Local government and their communities increases a community's level of influence; this can have a significant impact on the direction of flood risk management and the policy positions developed by Local government.

Althaus *et al.* (2013) highlight the significance of the political influence to which the presiding government is subject to. The BHKC case study demonstrated the influence that external factors have on governance arrangements; local politics and community groups heavily influenced the development of the BHKC SMP. The design of the SMP was significantly altered due to the petitioning of politically-powerful residents and three active community groups, which were also in conflict with one another. One of the main issues was regarding private ownership of creeks in some of the most affluent neighbourhoods in Adelaide; attempts at introducing easements through properties for Local councils to gain ownership of these watercourses had failed previously due to pressure applied by the residents.

The political discourse from the UK has promoted localism since the introduction of the *FWM Act 2010* and *FRM Act 2009*. This legislation provided Local governments with the lead responsibility for coordination of flood management (Smith *et al.* 2016). The focus on localism allows those impacted by flood risk to have a greater and more formal influence on how their local flood risk is managed (Begg *et al.* 2015). According to Begg *et al.* (2015), consideration of the local context and community needs improved democratic decision-making processes. Similarly, Adger *et al.* (2016) contends that if government agencies are to uphold legitimacy and trust to encourage adaptive and resilient behaviour, they need to engage in deliberative planning which includes a strong focus on community input.

As detailed in Chapter Six, an example of localism in practice is the use of partnership funding for flood management in England. While the incorporation of local values is necessary as part of a flood risk management program, a local approach may impede uniformity in best-practice due to large variations in local communities' abilities to organise or to raise funds. In contrast to a risk prioritisation approach undertaken at the national scale, the local scale may be unable to adequately prioritise risk for hazard management and vulnerability. UK2 (2012) discusses these shortfalls:

Partnership funding – let's go through the measures. There is a danger, actually there is a real danger, that the government sees the initial success in partnership funding, which there has been apparently there's 120 million pounds being put on the table by various local authorities. They haven't agreed to it yet, but they are putting it forward. There is a real danger that they see such success here that they push it a lot further so that the ratio of government money to local money being something like 5:1, 500 million to 100 million say, 500 million from DEFRA and 100 million partnership funding. It becomes 300:300 or 250:350 or 150:450. Now the effect that would have is that it would become very idiosyncratic where you actually got your flood schemes. You'll get it where people are rich and are able to raise the necessary local money. And you won't get it where the poor communities in the north of Britain [are] because they can't raise the money. So, the national perspective is lost. That would be a danger.

Likewise, Rietig (2014) warns of the limited effectiveness of local solutions for wicked problems. Local community-focused projects, developed and controlled at the local level, are unable to take into consideration a range of important, larger scale factors, such as risk sharing or equality in vulnerability. An example of a poor outcome due to liberalism of governance can be found in a case study of coastal planning at Byron Bay, NSW, where powerful and wealthy citizens changed the Local government policies and approach to strategic risk management through constant legal challenges against the local council which they perceived challenged their lifestyle and land (Niven & Bardsley 2013). In this example, an implemented policy of planned retreat was challenged by local residents, resulting in a weaker policy and removing the strong stance supporting natural coastal processes. The protection of the environmental system and processes was thereby reduced and a people and property-centric focus returned. Considering these examples in combination with the results of the BHKC case study, there is a need for strong public policy which incorporates community values while maintaining broader goals of sustainability. A solution may be to undertake a high-level flood risk assessment to prioritise at risk areas, and empower local communities in the approach taken to address the risk.

It was clear from the results of this research that complex and convoluted governance arrangements – in particular, lacking clear, articulated organisational responsibilities with associated budgets – generates confusion and inefficiency. Ultimately, this results in various interpretations of policy and ineffective legislative implementation for flood and natural hazard management potentially resulting in poorer outcomes for communities at risk.

7.4.2 Challenge of political boundaries

Political, administrative boundaries are closely linked to planning policy and dictate how flood risk is managed. Boundaries can be across each government tier divide, from local/state across to national/international levels. Addressing risks that run across political boundaries is difficult, not in the least because it requires inter-governmental and often multi-scalar cooperation. As the development of the BHKC SMP has demonstrated, this can be a challenging, time-consuming process where the agendas of each political entity are compromised to some extent. To demonstrate this issue regarding the BHKC SMP, SA11 (2013) states,

You've got to question not just the politics. You've got to question the ability of organisations to partner with each other... Given that you've got this quite difficult technical issue, are five councils with all different agendas; are they the right body to run that technical exercise? I say, "No way!" (SA11 2013).

Despite SA11's (2013) concerns, there are successful cases of multi-authority flood management projects; for example, the development of the Gawler River Floodplain Management Authority (The Town of Gawler 2014) also in SA, and the Glasgow MGSDP Partnership (The Metropolitan Glasgow Strategic Drainage Partnership 2011) in Scotland. However, SA11 (2013) stated that factors relating to the success of the Gawler River Floodplain Management Authority were dependent on external factors, '*they never got the funding agreement together until it flooded and it created the drama to do that*'. To overcome the issue of political boundaries, SA11 (2013) argues for council boundaries to be based on catchments:

I certainly hold the view that the most logical council boundaries are actually a catchment. If you went with water catchments as your council boundary, all others are just; you can draw a line there or there. That's a main road, that's not. But the catchment actually makes some sense.

Similarly, the UK case study results also demonstrated that different political agendas are an issue. UK14 (2012) highlighted some of the problems associated with the discordance between political and geographical boundaries:

One of the problems long known in all river basin management is that the geographical jurisdictions of democratically accountable bodies don't match the geographical jurisdictions of the river, the river basin, so you always have this problem that there is a mismatch. And of course, one of the things you see particularly in a UK setting is that the administrative organisation of the UK is very much urban/rural.

In addition to the divergence between political and geographical boundaries, the management of flood risk across the urban/rural interface is also challenging. At the peri-urban interface, there are significant changes in land use and geomorphology, which alter communities' risk perception, vulnerability, connection to place, and values (Eakin *et al.* 2010).

Peri-urban areas may also experience a separation from the landscape, interpreting flood risk as an agricultural problem and does not reflect the increasing role of urbanisation (Eakin *et al.* 2010).

The urban/rural conflict influences how the landscape is managed globally. However, if used cleverly, the management of peri-urban areas can provide opportunities for reducing exposure to flood risk in the urban areas by utilising measures such as wetlands, vegetation, and other natural flood management techniques.

7.4.3 Public policy

As Althaus *et al.* (2013, p. 1) contend, '*we shape our world through public policy*'. Policy guides our response to complex issues such as flood risk and flooding. As articulated by Donaldson *et al.* (2013) and others (Butler & Pidgeon 2011; Smith *et al.* 2016; Walker *et al.* 2011), the importance of flood events are continuously defined by the politics of the time and location; subsequently, management approaches are transposed into public policy within those political frameworks.

In Australia, the UK, and most other Western governments, policy and decision-making follows a linear, rationalist model (Heazle *et al.* 2013). Consequently, government departments and politicians are charged with, and/or coordinate various types of problem solving and service provision, often quite efficiently and effectively from top-down or bottom-up perspectives. However, Kettl (2009) argues that governments are less able to deliver adequate solutions for wicked problems as often the development of policy and plans is much simpler than the implementation, coined the 'implementation gap' (Nurse-Bray *et al.* 2012; Pelton 2016; White & Richards 2007a) as noted throughout each case study to some extent.

In both Australia and Great Britain, flood policy implementation mostly falls to Local government and then to second tier governments – State governments in Australia and National governments of Scotland, Wales and England in UK. The disparity between responsibilities (and capacity) of different levels of government for policy-making versus implementation requires further research, especially in regard to inter-government relations and the provision of resources.

The implications of the results from the public policy document analyses undertaken in this study should be considered for the development of new public policy in the future. Flood risk practitioners can examine the examples of various policy tools available to determine the best fit for their location, drawing on the case study experiences of different management measures

presented here. The following three sections critique the most significant types of interconnected contemporary policy and legislation for a flood risk management paradigm across the three case studies: flood management policy; climate change policy; and, land use planning policy.

7.4.3.1 Flood management policy and legislation

Policy tools and legislation relating explicitly to flood management were analysed from the three case studies (Tables 13 and 14). The results showed that government departments are often constrained and limited in their policy and management solutions. For example, SEQ12 (2011) stated:

Australia has an acute problem of flood, what are we going to do about it? This is a difficult problem already and it is going to get substantially worse over time and governments are appalling at aiming for situations which are beyond the lifespans of their government. But over time it is getting worse and worse.

Supporting SEQ12 (2011) and Kettl (2009), Head and Alford (2015) are critical of governments' ability to deliver on wicked problems. Providing a critique of systems theory, values perspectives, and expert-driven, rational comprehensive planning through an engineered approach, Head and Alford (2015) suggest that government decision-makers need to go beyond technical and rational thinking, and work collaboratively to deliver actions for wicked problems and alternative solutions.

In their analysis of the 2011 Brisbane flood, Heazle *et al.* (2013) argue that one criticism of the rationalist policy model is an over-reliance on structural engineering, and as a result, the increasingly unrealistic demands are made of those with technical knowledge. According to Heazle *et al.* (2013), rationalist governments allow and encourage the public opinion that structural engineering flood defence mechanisms, such as dams and levees, either completely eliminate or significantly reduce the risk of damage from extreme flood events. Complete elimination is unlikely. The separation of communities from the risk source (e.g. river) or hazard (e.g. flood) can have severe consequences for resilience. This concept was neatly encapsulated in this comment from UK14 (2012):

What that means for risk is the vulnerability is increased, so you may have reduced the hazard by making it flood less, but you've increased the vulnerability. Because one of the things that reduces vulnerability and increases resilience, is your ability to know what to do both when there is a flood and in the future to prepare yourself for a future flood. But that's all gone so we have these landscapes now; we have communities living in risk sanitised landscapes where they're divorced from the environmental

processes that we need them to experience in order to know how to live with them. It leads into a whole different set of theories under the heading 'living with risk'. That actually some of the most resilient communities, in whatever risk terms you're talking about, are those who've learnt to live with risk and therefore that's the challenge to the engineering paradigm, because what engineering does, is it gets rid of the little risks that really, perhaps we should be having in our landscape and it would be better if there were some small floods that came close but didn't quite make it.

The same sentiment is found in comments from the SE QLD case study, for example SEQ9 (2011) who stated, *'I think a lot of people had assumed that Brisbane would always be protected by Wivenhoe, that there would be no more '74'*. Furthermore, the BHKC case study found that governing authorities were more concerned about the approval of the BHKC SMP and the required solutions, than applying progressive thinking for adapting for future risk; the BHKC councils were focused on standard structural solutions before being challenged to produce alternative methods by the community. The final outcome was an integrated approach utilising a flood risk management paradigm which combined structural and landscape mitigation methods.

The results of the three case studies demonstrate that communities in flood risk areas would benefit from a mix of risk management approaches. Rouillard (2013) contends that governments must enact strong public policy to manage complex issues like flood risk. Howes *et al.* (2012) suggest that, in order to manage the interlinked challenges of natural disasters and climate change, there needs to be a rethink of the prioritisation of the traditional PPRR model on which emergency hazard management policy is commonly based where significant funds are channels at response and recovery. Instead, prioritisation needs to go towards prevention and preparedness to allow for proactive planning.

As part of the re-prioritisation, a reframing of risk governance and policy needs to focus on improving community engagement and communication; re-focus attention on community resilience; improve interagency communication and collaboration; and, create institutional arrangements that support continual improvement and policy learning (Bardsley & Rogers 2011; Howes *et al.* 2012). Of the three case studies undertaken in this research, each demonstrated aspects of this approach: the development of the BHKC SMP (noted this was not the initial aim of policy; rather, it was a result of community backlash to proposed plans and pressure from community advocacy groups); on-ground implementation of the *FRM Act 2009* through local 'Flood Risk Management Strategies' (Scotland Environment Protection Agency 2015); and the Grantham relocation. However, these examples were not reflective of broader experience.

Comprehensive and clear public policy for flood management is vital for successful management of flood risk. Public policy should clarify roles and responsibilities; provide direction for management priorities and guide how various tools will be utilised; and, ultimately, lead to action and positive outcomes for communities diminishing the implementation gap.

Policy also dictates which paradigmatic direction will be taken for flood management. For example, different policy frameworks prioritise protection, and prevention or adaptation strategies, as well as what methods will be used, and whether community empowerment or top-down leadership will be emphasised. The results have demonstrated a need for both public and internal policy documents should clearly articulate and communicate strategic directions and priorities. For example, in the Scotland case study, national and EU policies provided significantly more clarity than policy documents from the Australian case studies; as a result, a clear message was sent to decision-makers and communities regarding actions to be taken, the reasoning behind these actions, and the decision-making processes that should be employed.

Finally, policy should lead to action. Policy which does not have any ‘hooks’ or legislative requirements to encourage or enforce compliance is often ineffective. SEQ6 (2011) criticises the current public policy processes in QLD and the implementation gap experienced without enforced compliance:

I think part of the problem with policy is this sort of “*Yes, Minister*”. Trying to make it someone else’s problem. But generally, the intent of the policy, I’m not trying to fault that. They’re trying to actually build resilience back into landscapes. But because government is very process driven instead of outcome driven, it means the process becomes more important than the outcome. And that means you’ve got to hope that all these processes working together somehow by some sort of miracle, get a good result. And government is so big and so complicated these days that sort of concept doesn’t work anymore because there’s too many things working in parallel that are actually incompatible.

As demonstrated in both the SE QLD and the UK case studies and supported by Althaus *et al.* (2013), public policy can be highly influenced by, and formed in response to, extreme flood events. During times of crisis, Althaus *et al.* (2013, p. 219) recommend a continued focus on the policy cycle process acknowledging the need to provide, ‘*a sense of calm and order again into the community*’ and ‘*provide some sense of explanation to tragedy and chaos*’. This supports Kingdon’s (1995) Multiple Streams Framework theory, which posits that major crises open ‘windows of opportunity’ to allow new ideas, or existing ones, to move up the policy agenda in three streams:

- Defining the problem
- Identifying policy responses
- The politics of the situation.

For example, in the UK case study, document analysis revealed a strong history of altering their public policy direction after major flood events. SE QLD also has a history of responding to extreme flood events with new/revised policy, often as a result of formal inquiries documenting perceived governance failures (Donaldson *et al.* 2013). These inquiries deem flooding to be a man-made hazard, with those impacted upon searching for someone to blame and seeking a change in governance response (Harries 2013).

As Wilkins (2000), Penning-Rowsell *et al.* (2006), Emery and Hannah (2014), and Smith *et al.* (2016) – among others – argue, flood policy adapts ‘catalytically’ during times of flood ‘crisis’. Instead of new ideas and directions, the catalytic changes are generally based on the quickening and magnification of ideas that already exist in the political ideology (Emery & Hannah 2014; Penning-Rowsell *et al.* 2006). However, such reactive policy changes may not always have the most beneficial outcomes due to their emotive and politically popular aims. Furthermore, such reactive policies often don’t change regulatory legislation, thus maintaining compliance rather than anticipating future needs.

Examples of reactive policy changes after major flood events include England reinstating the drainage of moorlands to manage flood risk in response to the 2014 flooding. SEQ9 (2011) also discussed how SE QLD used the 2011 flood event as a catalyst to change policy:

Unfortunately, it did take a summer of what we’ve seen to see a fairly radical push in policy and in some respects, that is unfortunate, but you look at the Victorian bushfires, you look at Cyclone Tracy, you look at those sorts of elements, and that saw the revolution and I don’t think anyone wasn’t understanding of flood risk, I think everyone is. It was probably more done at such a micro scale that what really needed to be done was more of a macro, holistic scale and I think all councils have been dealing with it on every application that’s coming through and the like. But what we’re seeing is the shift to save from a micro level; we’re going to provide you with some better guidance of how you need to do it at that macro level.

Table 13 and Table 14 present a comparison of flood and disaster related legislation and public policy and strategy documents across the three case studies. The next section examines the level of success with which current policies are received and implemented across the three case studies.

Table 13 Comparison of flood-related legislation across case studies

SA	QLD	EU and UK
<i>Natural Resource Management Act 2004</i>	<i>Disaster Management Act 2003</i>	<i>European Union Civil Protection Mechanism</i>
<i>River Murray 2009</i>	<i>Sustainable Planning Act 2009¹¹</i>	<i>Civil Contingencies Act</i> <ul style="list-style-type: none"> - <i>Emergency Response and Recovery guidance</i> - <i>Emergency preparedness guidance</i>
<i>Local government Act 1999</i>	<i>Water Supply (Safety and Reliability) Act 2008</i>	<i>Flood and Water Management Act 2010 (England and Wales)</i>
<i>Emergency Management Act 2004</i>	<i>Water Act 2000</i>	<i>Land Drainage Act 1991</i>
<i>Metropolitan Drainage Act 1935</i>	<i>Water Reform and Other Legislation Amendment Act 2014</i>	<i>Water Resources Act 1991</i>
<i>South-western Suburbs Drainage Act 1959</i>		<i>Water Act 2014</i>
<i>Planning, Development and Infrastructure Act 2016</i>		<i>Flood Risk Regulations 2009</i> <i>Environment Act 1999</i> <i>Coast Protection Act 1949</i> <i>Flood Risk Management (Scotland) Act 2009</i> <i>Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks</i> <i>Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy</i>

¹¹ The *Planning Act 2016* has since come into operation

Table 14 Comparison of flood-related policy tools and regulations

SA	QLD	Australia (national)	EU and UK	International
State Emergency Management Plan	State Disaster Management Plan	Investing in a Safer Future: a Disaster Risk Reduction policy for the Australian aid program	Flood Risk Management Plan for Scotland (Scotland)	Hyogo Framework for Disaster Reduction
Water for Good Strategy	Disaster Management Strategic Policy Framework	National Strategy for Disaster Resilience	Flood Risk Management Planning in Scotland: Arrangements for 2012-2016 – Guidance (Scotland)	Sendai Framework for Disaster Risk Reduction 2015-2030
Stormwater Strategy: The Future of Stormwater Management	Queensland's Emergency Management Assurance Framework	National Land Use Planning Guidelines for Disaster Resilient Communities	Project Appraisal for Flood Protection Schemes – Guidance (England and Wales)	UN Plan of Action on Disaster Risk Reduction for Resilience: Towards a Risk informed and Integrated Approach to Sustainable Development
Planning Policy Library	Standard for Disaster Management in Queensland		National flood and coastal erosion risk management strategy (England)	Geneva Mandate on Disaster Reduction
State NRM Plan	State Planning Policy		The National Flood Emergency Framework for England (England)	
Regional NRM plans	Various Local government policies, strategies and guidelines		Flooding and coastal change 2010-2015 (England and Wales)	Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation and Recovery
Various Local government policies, strategies and guidelines			'Policy statement on partnership funding' (England and Wales)	
			Principles for Implementing Flood and Coastal Resilience Funding Partnerships (England and Wales)	
			Various Local government policies, strategies and guidelines (England, Wales and Scotland)	

Firstly, in the UK, document analysis revealed that Scotland and England, strongly influenced by EU directives, has developed significant and clear public policy tools to address flood risk. These were the most developed and established flood management policies and legislation out of the three case studies examined. The UK also successfully linked public policy with compliance through legislation; this was absent in the SA and QLD case studies. Scotland has 14 localised flood management strategies and management plans which are enforced through legislation (Scotland Environment Protection Agency 2015; Scottish Environment Protection Agency 2016b). In both Scotland and England/Wales, flood risk management has also been integrated with related policies such as water management (Department for Environment Food and Rural Affairs 2005, 2010, 2013; Department for Environment Food and Rural Affairs & Environment Agency 2013; Scottish Government 2009a, 2009b, 2009c, 2011).

However, despite the UK strong plans, policies, and related legislation, some stakeholders remained cynical, questioning whether natural flood management was being implemented effectively. The specific merits of the approach are discussed further in section 7.5.1.1. In general however, the findings suggest progressive policies, such as the landscape-focused policy tools, were implemented due to a strong, top-down push from the EU via their Directives. Local perceptions and experiences of higher flood risk could also drive clear, effective, progressive policies. However, the irregular nature of the flood hazard in Australia could limit a political commitment to such holistic policy.

SE QLD has a history of significant flooding, and has flood management policies and strategic documents at the local level – including strategic plans, strategy documents, and corporate plans – to manage flood hazards (e.g. Brisbane City Council 2005, 2007, 2012a, 2013a, 2013b; City of Ipswich 2012; Toowoomba Regional Council 2009, 2013). The 2011 floods also resulted in Grantham utilising a planned relocation policy to manage their exposure to high flood risk (Lockyer Valley Regional Council 2011a, 2011b; Queensland Reconstruction Authority 2011a). It remains to be seen if a relocation approach will become more widely used in QLD or elsewhere in Australia.

In this case, the strong local policy governance, in QLD was not provided with strong direction at the State level prior to the 2011 floods. This resulted in minimal compliance with recommended policy guidelines, perhaps reflecting the absence of ‘hooks’ or enforceable legal requirements. Currently, state management of flood risk is mostly reflected in QLD *State Planning Policy* (The State of Queensland 2016), focusing on resilience using building and planning measures, and development plans (e.g. Brisbane City Council 2014a; City of Ipswich 2013; Department of Housing and Public Works 2012, 2013; Lockyer Valley Regional Council

2012b; Queensland Reconstruction Authority 2011a; The State of Queensland 2016; Toowoomba Regional Council 2012b).

The stronger focus on policy at the Local government level in QLD is a reflection of legislative arrangements specific to QLD; the *Disaster Management Act 2003* delegates principal responsibilities for management of flood hazards to Local government. The absence of strong State level guidance was criticised by SEQ5 (2011), because reliance on Local government to implement State policy isn't always effective:

There's a tendency within government now to have no capacity to deliver anything at all, it's all about policy. So, when they actually make policy they just impose that upon one another or Local government who have somehow got to find the resources to make that policy work in a realistic sense in their space. We've actually got to the ridiculous circumstance in QLD where some of the people within State agencies don't even know the regulatory regimes they're working in. They know the Act that they're working in, but they don't know the relationship that Act to things like the Regional Plan, which overrides their Act, the regulations, or the State policies.

This statement highlights the issue of policy development versus implementation, and calls into questions which level of government should be responsible for each. Except for QLD, where strong policy was created and implemented at the Local government level, policy tools have primarily been developed by the first tier (Australian national or EU) or second tier (e.g. SA, or Scotland/England), while implementation is predominately by Local government. The UK attempted to address this policy development and implementation disparity by introducing local partnership approaches which allows local communities and businesses to drive their own flood management (Department for Environment Food & Rural Affairs 2014b). However, such locally-driven flood management models can have equality problems, and can deviate from a strategic risk prioritisation model. For example, where an overarching risk assessment is completed, such as in Scotland (Scottish Environment Protection Agency 2016a) and England (Environment Agency 2009), the most vulnerable communities and areas at highest risk can be prioritised for various management approaches from a national perspective.

Another issue regarding policy development and implementation is that, in practice, local governments are often lacking in resourcing, capacity, and capability to fully address flood risk. The influence of local politics and vocal (but not necessarily the majority) residents may also result in skewed priorities or a less effective outcome.

In the BHKC case study in SA, the State government had no single public policy in place solely dedicated to the management of flood risk. Instead, the State government made reference to flood and stormwater management throughout various legislation and policy documents. While this approach, if integrated and thorough, could manage flood risk as part of a holistic

water cycle management approach, the diffuse governance system provides a lack of clarity on roles and responsibilities, as well as minimal strategic direction. Instead, the Local government SMPs are used as policy tools to dictate the direction of flood management within a catchment without any enforced compliance for implementation.

While the *Planning Policy Library* (Department of Planning and Local Government 2011) provides a range of regulations for integration into local development planning, the BHKC case study exhibited a community-driven policy response in recognition of the apparent failure of top-down policy to manage flood risk in the area (Brown Hill Keswick Creek Stormwater Project 2014).

The significant community backlash to the originally proposed structural solution of a retention dam forced a change in strategic direction for flood risk management within the catchment, with the final plan taking community values into account. In this example, the rejection of the rationalist policy approach and the development of a unique, reflexive management system could be seen as an example of a governance transition (Beck 1992, 2006, 2010), from the first to the second modernity. The challenge now surrounds the implementation of such an alternative, less invasive, landscape and risk awareness-driven approach. In particular, the lack of an effective floodplain management or flood risk policy at the State government level could be seen as a problem in the BHKC catchment, as there are minimal top-down drivers for a consistent and strong policy solution.

In general, across all case studies, public policies are often not well linked to each other, and operate in 'silos'. SEQ5 (2011) describes the negative impact this can have:

Why in the Infrastructure Plan is there no reference to the NRM Plan? Just a reference would be nice! Oh no, there's another Plan for that. But you're failing to recognise that in your infrastructure has an impact on natural resources and vice versa. If you could recognise that in your Infrastructure Plan, then the linkage would become more obvious to you and you would actually be able to use it to your advantage.

This isolation can be a particular issue in hazard management policy because of the interconnected nature influencing development and implementation, which if certain factors aren't considered can generate barriers to success.

7.4.3.2 Climate change policy

Climate change adaptation policy is increasingly linked to flood and disaster management policy and legislation, and was discussed by many interview participants during this research. Many of the principles which underpin climate change adaptation either relate to, or are very similar to, disaster and hazard management policy. The relationship between hazards and climate change is particularly relevant in light of the predicted impact of climate change in terms of increasing flood risk. Recent climate predictions show an increased likelihood of severe weather events including large downpours which may result in flooding in the case study regions (IPCC 2012, 2014a).

Krol (2014) describes the close relationship between flood and climate change policy in Wales, and determines that a series of flood events can influence climate change policy if they are linked together by a high-level narrative. Frequent flood events can provide opportunities for such narratives, hence enabling social learning.

A comparison of government statutory measures related to climate change adaptation and mitigation are presented in Table 15 and Table 16. Based on the document analysis conducted across the three case studies, there is a large variation in policy development and compliance requirements, and an assumption of related performance.

Across both flood and climate change policy, the EU and the UK are considerably more progressive and advanced in terms of formalisation of their management. Greater investment has also driven clearer governance structures with compliance linkages. One explanation for this may be that the EU, acting as equivalent the Australian 'Federal' level, generates strong and explicit top-down directives. Further to this, climate change has been accepted as a key component of the challenge by those in Britain. In contrast, the two Australian case studies showed that these communities seemed less prepared and most held the view that climate change would not have a significant impact on flood risk. This lack of acknowledgment seemed particularly prevalent in the BHKC case study.

The range of policy tools and legislation developed to manage flood risk and climate change through the three case studies demonstrate the difficulties of managing flood risk and the different approaches available. Participants acknowledge that there needs to be an improvement in policy tools and legislation. Across the three case studies, only the UK example exhibited flood and climate change related policy tools, which enable best practice. Despite these presence of these tools, implementation is not always occurring. It may be that these policy tools are not being transferred into practice due to a disconnect between legislation, the policy-makers and the real challenges that practitioners face to implement change. Further research

needs to be undertaken on 1) the structure of policy, 2) governance of policy and legislation at the national level, and 3) the empowerment of those bodies to make policies and tools.

Table 15 Comparison of climate change adaptation policy tools

SA	QLD	Australia (national)	UK	EU
Prospering in Changing Climate: A Climate Change Adaptation Framework for South Australia	Advancing Climate Action in Queensland Making the transition to a low carbon future	National Climate Resilience and Adaptation Strategy	Scottish Climate Change Adaptation Programme Scotland’s Climate Change Adaptation Framework	EU Adaptation strategy EU Adaptation Strategy Package
South Australia’s Strategic Plan Target 62	Coastal hazards adaptation program—QCoast2100		Adapting to climate change: National Adaptation Programme (England and Wales)	
Resilient South Adaptation Plan (Includes part of BHKC region)	Queensland Climate Adaptation Strategy (Q-CAS)			
The 30 Year Plan for Greater Adelaide: A volume of the South Australian Planning Strategy				
Our Place Our Future: State Natural Resources Management Plan South Australia 2012 – 2017				

Table 16 Comparison of climate change mitigation policy tools and regulations

SA	QLD	Australia (national)	UK	EU	International
South Australia's Climate Change Strategy 2015-2050 – Towards a Low Carbon Economy	A Solar Future	Emission Reduction Fund	<i>Climate Change (Scotland) Act</i> (and associated regulations and orders) ¹²	<i>Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community</i>	UNFCCC COP21 Paris Agreement
South Australia's climate change vision: Pathways to 2050.		National Emergency Productivity Plan	Scottish emissions targets 2028-2032.	<i>Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources</i>	Subnational Global Climate Leadership Memorandum of Understanding
<i>Climate Change and Greenhouse Emissions Reduction Act 2007</i>		Ozone and HFC measures	Climate Challenge Fund	<i>Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency</i>	
South Australia's Strategic Plan (SASP) as Target 64			UK CRC Energy Efficiency Scheme	<i>Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide</i>	
Carbon Neutral Adelaide: A shared vision for the world's first carbon neutral city			UK Climate Change Levy	EU Climate and Energy Framework	
Tackling Climate Change: South Australia's Greenhouse Strategy 2007 – 2020			Climate resilient infrastructure: preparing for a changing climate (England and Wales)	EU Emissions Trading System The Energy Savings Opportunity Scheme Regulations 2014 European Climate Change Programme 2020 Climate and Energy Package 2030 Climate and Energy Framework	

¹² The Climate Change (Annual Targets) (Scotland) Order 2010; The Climate Change (Limit on Carbon Units) (Scotland) Order 2010; The Carbon Accounting Scheme (Scotland) Regulations 2010; The Climate Change (International Aviation and Shipping) (Scotland) Order 2010; The Climate Change (Annual Targets) (Scotland) Order 2011; The Climate Change (Limit on Carbon Units) (Scotland) Order 2011; The Climate Change (Duties of Public Bodies: Reporting Requirements) (Scotland) Order 2015; The Climate Change (Additional Greenhouse Gas) (Scotland) Order 2015; The Carbon Accounting Scheme (Scotland) Amendment Regulations 2015; The Carbon Accounting Scheme (Scotland) Amendment Regulations 2016.

7.4.3.3 Land use planning policy

As identified by Burby and French (1981) and White (1975, p. 89) decades ago, land use planning is, *'the single adjustment most likely to lead to a decline in national flood losses.'* Land use planning guidelines remain a powerful policy tool which can have significant implications for vulnerability of the community, despite increases in mitigation infrastructure and sophisticated flood warning systems. Planning policy is strongly influenced by the availability and knowledge of risk as well as the perception of what is an acceptable level of risk (Birkholz *et al.* 2014). Complementary planning zones, building requirements, and restrictions reflect accurate hazard mapping. Incorrectly applied land use policy poses liability risks for governing bodies if residents are unduly exposed to hazards (Glavovic *et al.* 2010). There has been a push for educational tools, such as CoastAdapt (NCCARF 2017), developed in Australia to assist both communities and local councils to understand their risks to inform planning and to reduce poor decision-making. Inappropriate decisions have significant long-term consequences and are extremely difficult, if not impossible, to reverse.

The importance of land use planning in flood management was discussed by 48% (24 of 50) of interview participants across the three case studies. It was particularly relevant in the UK and SE QLD case studies, where it was noted that different land use planning approaches need to apply to urban and rural settings to achieve desired outcomes.

Historically, changes in land use have had significant impacts on flood risk and will continue to do so into the future as populations increase and community needs change. Additionally, as discussed throughout the thesis, a number of factors, including increasing urbanisation and aging infrastructure; a change in frequency and magnitude of extreme weather events induced by climate change; growing populations; and, shifting demographics, *'call for a reconsideration of how built-up areas are designed, and are already forcing incremental adaptation of existing cities, neighbourhoods and properties'* (Veerbeek *et al.* 2016, p. 5). A reconsideration of urban design also must also include new land use planning approaches to respond to increased flood risk.

Land use planning guidelines are closely linked to, and influenced by public policy directions. For example, in the SA case study, *The 30 Year Plan* and the *Planning Policy Library* (Department of Planning and Local Government 2010, 2011) dictate land use planning and guide Local development plans. However, these policies and plans can lack important spatial and systemic details. Therefore, it is important that robust and enforceable public planning policies are developed, in order to balance hazard exposure and appropriate development.

This research focused on the impacts of flood on urban and peri-urban areas. Interview participants discussed relevant planning policies and a lack of quality flood intelligence, risk assessments, mapping, and land use planning. In all case studies, stricter planning controls were called for to mitigate flood risk. It was also apparent that, in specific locations addressed in the case studies, land use planning guidelines were not being applied in a consistent and tightly controlled manner. Many inappropriate planning decisions have been made in the past that are yet to be rectified. Many of these decisions may have been influenced by economic incentives for developers to build on flood prone land due to land availability and potentially cheaper costs. Economic drivers can then translate into political pressures on local governments who may be influenced by economic growth. In addition, other motivations have been identified around reducing risk perception of a location by enticing development of that space (Messner & Meyer 2006). SE QLD participants were critical of the quality, and historical application, of their planning policy, recognising significant high risk development has occurred. SEQ7 (2011) was particularly critical of QLD's land use planning:

I think there'll be some interesting judgements coming out of the inquiries as to whether the *State Planning Policy*, which is now nearly 10 years old dealing with riverine flooding, has been adequate... It will probably be a demonstration that the pick-up rate hasn't been all that terrific. And I think it's fair to say on the coastal side too that councils traditionally didn't do the work that was necessary to actually map the areas of hazards.

The State has had these policies but they've not been required, councils haven't been required to apply them strictly. So, it's a bit of a 'here's the policy, off you go' sort of thing.

SA participants also voiced concerns regarding land use planning, with SA6 (2013) stating,

I'm a great sceptic of our planning policies, because they say all of the right things but they don't achieve anything. If you have a look at our planning policies, they all say the right sort of things but there are no hooks, there's no commitment and often there's no funding to it.

One of the main concerns has been a decrease in permeable areas as a result of growing urbanisation in combination with aging infrastructure, particularly in the UK. This has had a significant impact on local flood risk, and provides the greatest challenge for Local government in control of stormwater runoff, and often drainage systems. Pluvial type flooding is the greatest hazard faced by Local governments in urban areas. UK5 (2012) highlights this challenge:

Drains are only designed to cope with a 1 in 30-year return period rainfall and yet we're saying that we need properties defended to a minimum standard of 1 in 100 or 1 in 200 years. And that's just not compatible with the way that we design drains.

Additional challenges were noted in the two Australian case studies, mostly in relation to a lack of risk data and mapping. The lack of data is particularly relevant regarding pluvial flooding, thus hindering responsible decision-making, which should be implemented through the planning system across a spectrum of risk - as demonstrated in the UK. Of the three case studies, the strongest, most descriptive, and most established land use planning guidelines were the *Scottish Planning Policy* (Scottish Government 2014b). Most importantly, flood risk is addressed across a spectrum of risk, with 0.1% to 0.5% hazard development guidelines. This risk spectrum is important for both development and risk education and acknowledgement. In contrast, SEQ12 (2011) describes QLD's *State Planning Policy*:

Our policy was to say basically, "Ok Local government, go away and do a flood study and then you put your floor levels above that by 30 cm". But we didn't mandate it, we didn't say, "and all of you are to have done your flood studies in two years' time", we didn't. And so many of them just put them off and off and off. So, it didn't happen because there's been periods of drought and "the 1974 flood, that's never going to come again because we've got these dams now protecting Brisbane". And Q100 went into folklore as being, "if I'm above the Q100, I'm safe". The uptake of our planning policy SPP/103 over the eight years that it's been in place has been poor, chiefly because of the costs and difficulties for small councils of doing a flood study. Because without a flood study you can't put in your controls.

Your current regime is based upon a single line Q100, and they're saying no, that's not really right. You should use Q50, Q100, Q200, Q500 and even the PMF; so that you can see the shape of your flood risk and people understand that Q100 isn't the end of it. If you only put down a single line they think, "*If I'm over the line, I'm all right*".

Despite the UK employing the best practice approach of the risk spectrum in their planning policy, UK8 (2012) made the point that there still improvements needed for a holistic approach to land use and planning policy:

We've not really got there with that kind of thing yet, we're still thinking about "*oh floods go to a certain place*", and we're not really nailing this vulnerability of land use. We've got some really good processes there for mapping hazards which is, that's what we've done, it's been there for years, and people know how to do that. Looking at velocities and depth and all that kind of stuff which is about knocking people over and getting them washed away and killing them. But we've not really looked at the impact on land. And the *Act* is really good because it is responding to the legislation and looking at social and cultural heritage and environmental and then economic risks.

UK2 (2012) agreed, stating,

The land use planning critique would be that there is some development going ahead that shouldn't. But the counterargument is that it's local people making local decisions. What is not acceptable is to say we will develop our floodplain and then ask the national taxpayers to bail us out. That is not on, as far as I am concerned. In the same way that my criticism of the insurance industry is that there is major cross-subsidy, would be that if you don't have a national cross-subsidy it is going to cost people who live in serious flood risk areas such a lot of money to insure, that they won't insure. Are we better off with that? No, we're not.

These critiques demonstrate that land use planning in urban areas is of extreme importance. The need to discuss and improve planning controls for existing and new developments has been highlighted in various reviews and inquiries undertaken in recent years in Australia and internationally (e.g. Department of Transport and Regional Services 2004; Brisbane City Council Board of Inquiry 2011; Catastrophic Disasters Emergency Management Capability Working Group 2005; COAG 2011; Comrie 2011; Environment and Natural Resources Committee 2012; Goode *et al.* 2011; Hussey & Pittock 2013; Norman *et al.* 2014; Queensland Floods Commission of Inquiry 2012; Wenger *et al.* 2013). Climate change risks, changing demographic distribution, and the need for management of areas with high hazard exposure and biodiversity values will all exacerbate these hazard challenges.

Furthermore, the academic literature also espouses the need for improved land use planning for emergency and disaster management. Also relevant to flood hazard management, Norman *et al.* (2014) discuss how planning measures are critical in reducing risk and increasing resilience for communities in the context of bushfire hazard. Land use planning measures need to be kept up-to-date with the latest scientific and technical knowledge, and must also be inclusive of other risk and climate change impact data (Norman *et al.* 2014). Norman *et al.* (2014) also stipulate that risk mitigation measures (such as hazard reduction burning in the case of bushfires) should not be over-utilised; a reliance on built mitigation measures may encourage new development and intensification of existing residential land use in areas of high risk. In contrast, UK2 (2012) argues for a balanced approach, integrating mitigation infrastructure to support development:

You've got to have a balanced approach and say the local economy is important and the risk can be very low. In Tower Hamlets, the standard of protection of the Thames barriers is 1 in 5000 years. Are you saying we shouldn't develop there? No. Ok is there a risk? Yes. Is it a very small risk and a risk we can probably deal with but you shouldn't embargo development, you shouldn't sterilise the floodplain, a phrase that I think is quite useful, because there is some risk.

The challenge of balancing economic development and socio-cultural factors with flood risk must be considered by planning practitioners in the development of strategic planning policy.

The case study findings from this research suggest that currently, the imbalance remains due to a prioritisation of economic development and other competing planning requirements.

7.5 Adaptive management for flood risk

This section addresses the research objective to examine options for an adaptive management approach to flood risk in each context. Each case study exhibited a particular adaptation approach to flood risk despite specific local challenges; these included:

- BHKC SMP – Community rejection of structural mitigation and pressure to transition to integrated structural and landscape management approaches for management of flood risk
- SE QLD – Relocation of Grantham township away from the flood risk area
- UK – Implementation of the *Floods Directive*, the *FRM Act 2009* and the introduction of sustainable and natural flood risk management methods across the UK to adapt to changing levels of flood risk.

These adaptation measures can be broadly categorised under the theme of ‘landscape management’ to address flood risk. The evaluation of their implementation has implications for future adaptation to flood risk, and for decision-makers in determining future directions.

Insurance will also be discussed due to the high weighting given in the results and impact that fiscal resilience has on communities post-flood.

7.5.1 Landscape management

The nature of the landscape significantly influences flood behaviour, and is strongly linked to land use and development planning. The deliberate control of landscape function and design can be used to manage flood risk, and can aid the transition from protection to prevention, to adaptation, and resilience to flood hazard. The deliberate use of landscape is especially important within peri-urban areas where conflict between economic and ecological values generates acute challenges.

The utilisation of landscape management reflects Beck’s Risk Society discourse of a second modernity and broad limitations for the structural control of risk. The use of landscape is an adaptation measure, and recognises a more holistic approach to managing risk and the value of natural processes. Landscape measures are also important to complement mitigation structures in addressing residual risk; acknowledging design level limitations.

Managing the landscape is a technique that is being increasingly used as an alternative to, or to complement, structural engineering; examples include planting of forests and vegetation to slow flows and incorporating swales, channels, and wetlands into the landscape (Adaptation Scotland 2014b; AECOM 2012; CRESS 2011; Holstead *et al.* 2015; Howgate & Kenyon 2009; Nutt 2012; Richardson 2014; Van den Hoek *et al.* 2012; Wahren *et al.* 2012; Wilkinson 2013).

As examples, the integration and recognition of the ‘*Making room for rivers*’ and ‘*Saving space for water*’ policy themes in the UK showed that the concept of returning natural floodplains is becoming more prominent across Europe as ways to manage flood (e.g. Biron *et al.* 2014; Hooijer *et al.* 2004; Hudson *et al.* 2008; Moors for the Future Partnership 2012; van Stokkom *et al.* 2005; Wilkinson 2013; World Wildlife Fund 2005). Throughout the EU, landscape management is being employed in many countries with a traditional reliance on protection structures or in densely populated areas, such as in the Netherlands (Hudson *et al.* 2008; Luger *et al.* 2010; Silva *et al.* 2004; van Stokkom *et al.* 2005). However, as Potter (2008) states, ‘*the practice of floodplain restoration remains in its infancy and is not keeping pace with the policy rhetoric*’ (Potter 2008, p. 16).

The results from this research support Potter’s findings, as there was minimal large-scale usage of floodplains to mitigate flood risk in the three case studies. UK10 (2012) discussed the changes in floodplain management and transition in approach:

I think the first measures that we would look to implement have often been protection measures and prevention measures. I think even the change from prevention schemes from protection schemes is a change. The availability of large funding for these schemes is no longer there and we accept that and therefore we have to implement a range of different measures to deal with flooding. Historically we’ve dealt with it in a very draconian measure in a council sense. We turn up and fix the problem. What we’re finding now is that it is a greater acceptance from the public and the communities is that they have to participate in this. And that is what is changing the mindset of the council. We do need to find smaller, more local tailored solutions to deal with flooding at an appropriate level. We can’t necessarily have the large capital-intensive schemes that would prevent flooding. We very much need to protect ourselves and make ourselves more resilient to flooding.

This comment by UK10 (2012) accurately reflects the challenge faced by councils explored in the SA BHKC catchment, indicating that the same issues are being faced by a range of OECD governments. Further examples from the UK case study results support this finding:

It’s a long road because it involves changing the culture, it’s a long road. It’s not just a question of what’s the best solution, it’s a question of thinking differently, it’s a question of being willing to take a bit more risk on and so it’s going to take a little while to get there (UK4 2012).

It's a long, long term view and it's a long, long term strategy and it's particularly challenging for local authorities because the political view might change and all that changes on a regular basis. So, to keep to that kind of approach requires the whole mentality to change, but we will get there. We will definitely get there. There is a real push, certainly from the government, from SEPA and ourselves, and a lot of the local authorities are on board as well because they also understand that. I mean I work with a lot of them and they do understand that we can't just put this water in the sewer system, it just doesn't work and they see it. It might work today but in ten years' time with climate change and increased urbanisation, it's not going to work and it's still going to flood. I don't see any other way of doing it anyway so we're going to have to or we'll be under water (UK2 2012).

Further, initiatives in rural areas across the UK demonstrate that controlled landscape measures are mostly being employed to mitigate the impact of flooding in rural environments, where more space is available to incorporate larger risk mitigation schemes or specific natural flood management approaches (Adaptation Scotland 2014b; Holstead *et al.* 2015). There were small localised examples – such as Pickering, North Yorkshire – where landscaping was also used to manage flood impacts and reduce runoff. The use of land such as recreation parks to mitigate flood waters is reasonably common in high flood risk areas (Murray 2017).

All three case studies highlighted the need to use landscape measures to increase societal resilience to floods. However, schemes which include large scale revegetation and forestry require large amounts of land to have any impact. Structural engineering measures such as dams and significant drainage systems also require large amounts of land. The multiple-use nature of such land use has the potential to generate conflict between farmers and other users, as they may feel the land is being wasted and the economic value reduced, especially if the acquisition of productive land is required to develop schemes. These socio-economic factors need to be considered when flood risk management projects are being undertaken in an area.

7.5.1.1 Natural flood management

There has been a significant push from EU policy and academic literature for a move for increased utilisation of natural flood management. According to SEQ6 (2011), the use of natural flood management as an adaptation to rising flood risk offers a conceptual discourse:

You can think that you can beat nature, but that's on the basis that nature actually behaves itself, and because it's nature, it doesn't behave itself. So, because it works on totally different timeframes to us, you get fooled into the false sense of securities that we get until we change the order of things. I think there's a better understanding now that the old sorts of things that our grandfathers and great-grandfathers used to say; is nature is a power resource, and if you work against it, it will crush you. If you work with it, it will support you type of thing. I think we're coming back to an understanding of that,

particularly with climate change. We're going to have to work with it, and adapt, rather than saying we can stop it.

The Queensland Government also conducted a thorough review into natural flood management as part of the *Inquiry* (2012), but there has yet to be any significant implementation of natural approaches.

The use of natural flood management techniques is being promoted especially in Scotland. This is a response to the acknowledgement that structural mitigation is not always the solution and to gain greater ecological benefits. Drawing from the results to validate these findings, UK14 (2012) considered the difficulties that had been faced in changing the culture from protection and prevention to adaptation using natural flood management:

I also have a lot of sympathy that they have an institutional legacy that comes out of civil engineering, which is a good legacy to have because a lot of these solutions can be dealt with through civil engineering. But civil engineering is not the solution to flood risk management because most civil engineers only do hazard. They have absolutely no understanding of what vulnerability and resilience is. They have absolutely no understanding of what democratic accountability might mean. What engineers do well is they build things and they build things in common, common resources like dykes and so on. What they don't do very well is, all of the other areas of flood risk management that are quite important.

Similarly, Cook (2016), who also conducted a qualitative study examining differences in flood management paradigms, found that natural flood management is also gaining momentum in the USA. This demonstrates a worldwide trend in line with Beck's strong but reflexive responses to risk. The use of natural flood management was supported by those who raised the issue in this research: 20% (10 of 50), with 6% (3 of 50) against the idea. The growing discourse in support of natural and sustainable flood management is re-framing flood management, supporting Werrity's (2006) earlier analysis indicating a 'seismic shift' in approach, and as Cook (2016) stated, questions the predominant understanding of what flood management should be, how it should be measured, and, therefore, how it should be implemented.

SEQ7 (2011) acknowledged a lack of consideration of natural approaches in Australia:

You would hope it means that future decision-making takes account of that and you retain those things rather than knock them over. I don't think we really have, I know this thinking is much more advanced in other places such as Mississippi and Louisiana and places like that where they're actively reinstating the coastal wetlands and that sort of stuff. To a degree we're still at the opposite end of the spectrum at the moment, still pulling them out. But Moreton Bay [QLD], for example, could be a good example of where you could in fact maintain or enhance the ecosystems to provide that mitigation response.

While there is a notable lack of non-structural natural flood management methods implemented on a wide scale in Australia, there are some examples. The largest scale example of the formal utilisation of floodplains for flood mitigation is throughout the Murray-Darling Basin. This very large catchment runs across several States and flows predominately through rural areas, allowing for agricultural and conservation land-uses when not in flood. Other small-scale examples include the response of BHKC SMP and Grantham in SE QLD, which utilised non-structural components in their responses to flood risk.

Besides the dominance of a structural engineering culture in flood management, the results demonstrate that one of the major barriers to implementing natural flood methods on a larger scale is the lack of data supporting such approaches. Demonstrating this, UK8 (2012) discusses:

The biggest constraint we have at the moment is looking at doing it that there isn't enough science to back it up. So, we did this pilot study in South Lancashire Council [England] and they went, "*oh this is great*". We can look at this, we can look at doing catchment, we can develop the hydrological, the roots in hydrological model, looking at all the catchment contributions and then how we can change all those parameters of the hydrological models reflecting the planting of trees or putting in big woodlands. Put woodlands in so getting the catchment operates like big sponges. But I said as a consultant you're asking me to come along and you want me to protect three houses using natural flood management techniques and put my professional indemnity insurance on the line - I would walk away from it. Because we do not have the science. I cannot defend our decisions, if somebody said we'd done something wrong.

Knowledge on possible opportunities will continue to increase as more research is conducted and results become available.

Criticisms such as those mentioned by UK8 (2012) highlight that, despite England having the legislation and public policy to support natural approaches, their application as a preferred response has been difficult. Cook's (2016, p. 320) findings also show that natural flood management is a '*good, but contested idea*', but may remain a '*socio-political concept*' unless complex landscape science accompanies the policy.

As seen in BHKC, there is public support to consider alternative approaches like natural flood management. Further research is needed if natural flood management is to become a standard tool, to reduce the reliance on structural flood defences as in the current mainstream flood management paradigm. Techniques such as WSUD and SUDs, mentioned in Chapter Two, can be used to complement and transition to larger-scale management techniques, especially in urban areas. UK (2012) stated, '*It's more sustainable ways of managing flood are definitely more important. It can't all be concrete flood defences, and yet in a coastal town which is below sea level, it's got to be concrete defences*'.

Despite the positive attributes for natural flood management discussed above, a significant disadvantage includes the large amounts of land required to implement. Therefore, it is often unsuitable for urban spaces. As UK10 (2012) stated, '*It's very difficult in terms of to persuade people to give up land and turn that over to floodplains. That's quite challenging, a challenging thing to do*'. These results support Cook's (2016) and Smith's (2016) discussion that the consistent preference for technical approaches over natural or sustainable flood management is due to a failure to recognise and plan early enough for alternate measures as legitimate options. There is somewhat of a cultural resistance to understand the definition of what natural flood management is, how it is practised, and the measurement of effectiveness – despite questions over the long-term effectiveness of technical, hard engineering solutions in the face of increasing risk. However, the short-term, political inconvenience and lack of popular support for natural flood management should not be used as a deterrent for implementation if expert advice suggests otherwise (Smith *et al.* 2016).

The case study results were similar to Waylen *et al.* (2017), and highlighted key barriers to the implementation of natural flood risk management:

- Lack of evidence
- Lack of funding
- Lack of stakeholder engagement
- Governance framework - including policy and legislation
- An embedded hard structural engineering culture.

These categories and associated results provide useful learning for practitioners, policy makers across government scales, and practising consultants; especially in managing residual flood risk to complement new or existing mitigation methods that aim to reflect the fact that floods can and do exceed design levels with catastrophic consequences. By recognising these identified constraints on effective use of landscape to mitigate flood risk, each barrier can be specifically acknowledged and responses generated.

7.5.1.2 Planned relocation

The concept of post-disaster relocation is not a new alternative to structural mitigation. However, it is generally implemented only where an area is considered uninhabitable.

The use of relocation policies to adapt to flood risk and hence reduce vulnerability by retreating from the risk zone itself, is one that was considered to be extremely difficult to implement by the research participants despite not being a new concept. These findings are

consistent with those in the literature (e.g. Arnall *et al.* 2013; Badri *et al.* 2006; Hurlimann & Dolnicar 2011; King *et al.* 2014; Menoni & Pesaro 2008; Oliver-Smith 1991; Perry & Lindell 1997; Zander *et al.* 2013). Many potentially negative social impacts of relocation have been documented, such as loss of social connections. A major barrier to implementation is the cost in moving people and the connected social and economic perspectives because of the ‘*interdependence between urban functions and a given territory*’ (Menoni & Pesaro 2008, p. 51).

However, despite the negative impacts that have been described, relocation can also be seen to have many positive results, as demonstrated by the Grantham example presented in SE QLD. There are a growing number of contemporary examples which highlight how relocation can be used to increase hazard resilience in high vulnerable areas and be useful for adaptation to the increasing risk (e.g. Arnall *et al.* 2013; Badri *et al.* 2006; Hurlimann & Dolnicar 2011; King *et al.* 2014; Menoni & Pesaro 2008; Okada *et al.* 2014; Oliver-Smith 1991; Perry & Lindell 1997). According to UK5 (2012), relocation is likely to be implemented more frequently: ‘*ultimately, I think we need to face up to the fact that there are very, very small minorities that are living in places that can’t be economically defended*’.

Chapter Five presented the motivations (safety, vulnerability, economics, and trauma) behind Grantham’s relocation policy, giving some indication of how relocation can occur successfully. Likewise, Okada *et al.* (2014) state that the positive implementation of the relocation policy in Grantham was as a result of situational and local political influences, and strong levels of community engagement despite initial State and Federal government opposition. Voluntary implementation of Grantham added to its success, since a lack of government support is one of the major reasons for the perceived failure of relocation as a management response (Arnall *et al.* 2013).

As Zander *et al.* (2013) and Oliver-Smith (1991) also found, forced relocation should be avoided where possible. Those who choose not to relocate when a policy is implemented in response to the risk of a hazard, may not have a realistic alternatives due to finances, employment, social/family commitments or age (Arnall *et al.* 2013; King *et al.* 2014).

The experience of Grantham supported this idea, with some residents choosing to remain in their existing homes, mainly due to age factors. Oliver-Smith (1990, 1991) suggests that successful relocation of communities is a rarity. There are few examples in the literature showcasing similarly positive results of relocation policies (Petz 2015). Perry and Lindell (1997) found successful outcomes in relation to the relocation of the community of Allenville,

USA. Principles for relocation success, presented by Perry and Lindell (1997) and supported by the findings of this research, include:

- The community be organised and prepared for the relocation – all those affected should be involved in the decision-making process
- Residents should understand the role of the number of organisations involved in the relocation
- Social and personal needs of the affected population should be considered
- Cultural and socio-economic minorities require special attention and extra support.

These principles seemed to have been taken into consideration in the Grantham relocation. The LVRC conducted an extensive amount of community consultation and education in the lead up to, and during, the relocation process. Further research would be beneficial to assess residents' opinions of the impact of the relocation process and, as suggested by King (2014), to document their individual motivations for relocating post-flood. These findings could be used to evaluate the process for future learning for policy development and implementation.

The greatest discussion regarding relocation policy came from SE QLD and UK case studies, which is likely a result of previous experiences the scale of experienced floods and previous experiences with the successful implementation of retreat and relocation policies in these case study areas. The BHKC has involved a form of soft relocation through easements on private land. Two participants suggested to develop greater acceptance and willingness of a community, one method of implementation might be to use relocation as a contingency and transitional policy:

There is an evolution and a window for right here, right now, for councils off the back of this event to say we need to transition that away. Let's put that transition zone in, and then in 5 or 10 years' time when someone is looking at buying up, we're going to go in there and buy it up and take it away to be one parkland, or it's going to become ag., or it's going to become more commercial because the risk to a commercial as opposed to residential is obviously reduced (SEQ9 2011).

You go and talk to the community and say well if that happened, would we rebuild, or would we go somewhere else, and should we plan for that? So not actually *do* work, but say in the circumstances that that happened, "*should we have Plan B*"? They don't have to be enacted right now, but so the councils can say well look, if we needed to move that community, where would we move it to? Let's actually look at that land, and make sure that land isn't built on by somebody else or something. Just in case we have to do that in the future rather than saying to people "*choose now*". Be flooded, or go up to the other thing. They're not going to do that. But if you have a plan that's been talked through by the community and stuff, most of the time they'll say oh it's just contingency, it's just contingency. The day it happens, everybody will go, "*Phew. Thank God we have a plan; we know what to do*" (SEQ6 2011).

Several of the participants in SA and SE QLD also suggest that funding is a significant barrier to the possible implementation of a relocation policy. Most of the vulnerable properties in Brisbane are high value real-estate, and, *'in terms of acquiring hundreds of millions of dollars of real estate to move things out of the way of the water, it's just not going to happen'* (SEQ4 2011). This viewpoint is highlighted below by SEQ4 (2011):

The acquisition is not a problem; it's the money that's the problem. Where does the money come from? The State Government won't give it to us, the money that has been spent so far on flood mitigation has come out of council coffers and the money going forward, unless the Federal government comes to the ground or something will be council money.

But any existing development we won't be going in and acquiring it. a) We just don't have the money and b) we would draw fire from people than for no purpose than to feel good that we bought the land and are now the proud owners of some land that flood. There are other ways to skin that cat.

Some participants acknowledge, however, that retreat may be the only feasible, long-term solution, where the costs of protection will outweigh the benefits, and hence result inevitably in either planned or *ad hoc* relocation.

The general rule will be in some places the protection just won't be worth the cost. It will be way above the value of the asset, which is why in doing an adaptation exercise one of the first things you do is understand what your assets are, their vulnerability, their value, their lifespan, all that sort of stuff (SEQ7 2011).

Another major difficulty in implementing retreat policies was highlighted by SEQ7 (2011), stating that, *'I think in reality people are really hard to shift. They just don't want to move, and in the vast majority of cases, the (flood) risk is small if you're prepared for it'*. SEQ14 (2011) also acknowledged the social difficulties of moving people out of areas at risk, and how it can cause negative impacts that outweigh the risk mitigation; *'It's always, it's a difficult thing to do to a community to do that, so you'd want to be fairly sure that, that was the right thing to do. But they have done that in other areas of Australia, in other areas of the world'*.

Relocation and retreat policies may become more politically appealing and plausible if the key barriers are identified and removed, or at least responded to in policy. The barriers identified in this thesis, consistent with other research (e.g. King *et al.* 2014; Menoni & Pesaro 2008; Okada *et al.* 2014; Oliver-Smith 1990, 1991; Perry & Lindell 1997), include:

- Social impacts
- Attachment to place and community
- Financial limitations
- Lack of government/political support

- Lack of community popular support.

Further research into understanding these barriers is required if long-term, planned movement of communities at risk is to become a meaningful adaptation response.

7.5.2 Insurance

Financial measures are often discounted or rarely considered by flood mitigation practitioners at an operational level, and are often forgotten at the strategic policy level by governments. However, as observed in the UK, insurance can be promoted as an adaptation measure if it is developed as a well-regulated tool. Appropriately-priced insurance can: highlight the level of risk in a location; mitigate the exposure to flood or hazard risk by reducing financial vulnerability; and, increase resilience through improving recovery.

A majority of participants across the three case studies considered the use of insurance as a risk management tool. Interview participants in UK (14 of 15, 93%) and SE QLD (17 of 19, 89%) stated the value of appropriate insurance, and its role in risk management. In contrast, relatively fewer participants on the BHKC catchment case study (6 of 16, 38%) raised the issue, potentially due to the smaller scale and lower frequency of flood events in this region.

Giddens (1991, 1999) states that insurance is becoming increasingly important and will be vital to manage risk in the high modernity. Insurance is one of the fundamental economic factors of the modern society, especially as the calculation of risk can never be made with complete confidence and there will always be unexpected impacts and outcomes (Giddens 1991, 1999). While the future risk environment is unpredictable and uncertain, it becomes open to, '*colonial invasion through counterfactual thought and risk calculation*,' (Giddens 1991, p. 111). Giddens (1999, p. 9) notes that, '*insurance is only conceivable where we believe in a humanly engineered future*'. This emphasises the reliance on technological solutions to manage risk, and that new approaches to risk management will be required in the Anthropocene. Beck (1995) differs in this opinion, and assumes that within a Risk Society measures such as insurance are unable to completely manage risk due its complex, non-calculable nature. Beck (1995) describes that a Risk Society involves new risks of a global scale and difficulty in being defined at a set time or locality, frequently irreparable damage, and the challenge of predictions and calculation of consequences. These new risks therefore are unable to be managed through insurance, which is based around transparency and calculability (Beck 1995; Sørensen 2017).

However, insurance can provide '*a comprehensive buffer against risk*' however the '*underlying vulnerability and exposure to risk [are] not reduced*' (Treby *et al.* 2006, p. 354).

Other literature, such as Arnell (2000), argue that insurance can increase exposure to risk if not implemented correctly, as it encourages property owners to remain in a flood risk area. Refusal by insurance companies to insure properties located in high risk areas may well act as an incentive for individuals to relocate, or for communities to implement a policy of planned relocation.

Two different national insurance options were examined in these case studies of Australia and the UK. Insurance was a key factor in the SE QLD and the UK case studies, and is often underrated until a significant event occurs. This was the case in SE QLD where underinsurance and the misinterpretation of flood and storm inclusions in purchased insurance cover resulted in a significant backlash from the community and government bodies, culminating in a formal review of the insurance industry and changes in operation in Australia.

In comparison, the insurance industry in the UK has a far greater role in risk management and has a significant influence on policy development through direct negotiations with government and the recent introduction of Flood Re, as discussed in Chapter Six. This may be explained by the long history of the insurance industry participating in the governance of floods in the UK where they have been part of the PPRR policy and implementation negotiations. In addition, flood insurance has been available for a significantly longer time in the UK than in Australia, resulting in a higher level of public knowledge and understanding.

From the case studies undertaken, it is clear that while insurance has a role in flood risk management, this role can vary according to the operations of both the national government and insurance industry. The UK's system has a more significant role than Australia's. However, the changes brought about by the *Review* (The Australian Government: The Treasury 2011) have improved the insurance market in Australia through the introduction of standardised definitions, to minimise customer confusion. At this stage, it is worth noting that subsidisation agreement between ABI and the UK government regarding the insurance of high risk properties in the UK has had little long-term impact on property prices and purchases, and lifestyles maintained by owners, which is a commonly listed limitation of using insurance as a flood risk management tool (Lamond 2006).

It is also worth noting that, according to several interview participants, minimal recognition or reward is given by insurance companies to those property owners who install flood mitigation or adaptation apparatus to reduce their flood risk, such as flood gates or raising floor levels of houses. Such critiques highlight that the insurance industry also has areas for improvement in supporting implementation of risk mitigation strategies, in order to improve resilience amongst customers and the broader community.

7.6 Key themes and chapter summary

Flood (and hazard management more generally) encapsulates many interconnected perspectives from different disciplines, with some central areas discussed above. The complexities involved in the politics of flood management show support for Head's (2008) commentary on 'wicked' problems as defined by Rittel and Webber (1973).

Beck recognises the complexities involved in flood management and through the philosophical lens of his Risk Society theory (Beck 1992, 2006, 2009). Results in this thesis reflect the key challenges faced by flood risk governance systems as damages and impacts from extreme events are reaching unprecedented levels, and, *'flooding in cities is usually approached through the crisis management method'* (Joshi 2016, online).

From the study of flood management across local, regional and national scales, the key challenges fall under the following:

- Risk perception – the influence of community and practitioner response and in decision-making processes
- Increasing urbanisation and changes in land use – how governments are balancing requirements for development and aging infrastructure, increasing populations and resultant higher levels of run-off
- Climate change – how to plan for the uncertainty and the change in frequency and magnitude of extreme events
- Governance frameworks – including localism, and policies and planning
- Adaptation options - including landscape management, feasibility of alternative options in urban environments.

The results supported literature that risk perception has significant influence on decision-making processes and community resilience through experience of flood events and community empowerment in the management process, and the consideration of alternative adaptation measures. The role of a comprehensive community engagement, education and awareness program is highlighted as a valuable need to increase resilience.

Adequate governance frameworks were found to be of immense importance for flood management; sub-themes of policy, accountability and responsibility, and political boundaries were noted as having implications for effective and efficient flood management. It was clear from the results of this research that complex and convoluted governance – in particular, lacking clear, articulated organisational responsibilities with associated budgets – generates confusion and inefficiency. Ultimately, this results in various interpretations of policy and ineffective legislative implementation (if in place) for flood and natural hazard management potentially

resulting in poorer outcomes for communities at risk. The results also present a case for stronger ‘hooks’ to encourage compliance to policies and planning, or further action to address the implementation gaps.

The results also demonstrated support for strong, clear and consistent policy tools which communicate strategic directions and priorities. For example, in the UK case study, national and EU policies provided significantly more clarity than policy documents from the Australian case studies; a strong message was sent to decision-makers and communities regarding actions to be taken, the reasoning behind these actions, and the decision-making processes that should be employed.

The BHKC, SE QLD and UK case studies each provided an example for adaptation to future flood risk. These examples have valuable implications for learnings for other risk practitioners wishing to transition systems from a reliance on traditional flood mitigation measures such as dams and levees, to consider implementation of examples such as natural flood management, planned relocation, appropriate insurance, and clever land use planning (or a combination) to deliver holistic outcomes for communities and increase resilience. Barriers for implementation were:

- Lack of evidence
- Lack of funding
- Lack of stakeholder engagement
- Governance framework - including policy and legislation
- An embedded hard structural engineering culture.

These barriers have important implications for future adaptation as they highlight the implicit restrictions for moving towards a sustainable flood risk management paradigm. Communities need to anticipate and adapt to new thresholds of risk, rather than expecting historical experiences will provide accurate guides for the future. There is a need to look beyond the boundaries of current mainstream knowledge, and acknowledge that flood management requires in-depth understanding of ecological, social, cultural and economic systems.

By presenting a synthesis of the results in association with the literature, this thesis posits that governance systems are struggling to manage the current and future predicted levels of environmental risk and uncertainty. This thesis has demonstrated that struggle in the form of continually rising tangible and intangible impacts of floods, and the continual need to manage crisis to flood governance. However, small-scale adaptation was reflected in each case study, indicating a potential shift in management trends to a more sustainable flood risk management paradigm that better reflects local wishes and concerns.

The final chapter will summarise the findings of the three case studies in relation to the aims of this study, and will discuss the broader implications of these key issues for flood management.

Chapter 8: Summation and conclusions

8.1 Introduction

Chapter Eight provides an overview of this research, revisiting the contemporary challenges for flood management across the three case studies for addressing increasing flood risk. Each case study has provided a different example of adaptation approaches to new levels of risk, in the midst of broader pressure on social, economic, and governance systems:

- Case Study One (SA) – development of the BHKC SMP, where a preference for a structural mitigation response was replaced by an integrated approach with a stronger landscape focus, in response to community pressure
- Case Study Two (SE QLD) – relocation of Grantham township in response to catastrophic flooding
- Case Study Three (UK) – the introduction of the *FRM Act 2009*, with a focus on natural and sustainable flood risk management.

The chapter also outlines the research design and methodology employed to address the research aim and objective; summarises the key findings from the case studies; explores the theoretical and policy implications of these findings; and addresses the challenges and limitations of this research. The chapter concludes with a summary of this thesis' contribution to knowledge in relation to governance, planning and adaptation for flood management, and provides recommendations for further research given the unprecedented levels of risk facing flood risk practitioners into the future.

8.2 Research summary

Worldwide, approximately 500 million people per annum are impacted by injuries, fatalities and damage to properties caused by flooding (Swiss Re 2017). Floods impact people across many locations and landscapes, and are the main cause of financial and insurance losses in comparison to all other natural hazards. Governments are being challenged to govern extraordinary flood events and climate uncertainty, with unprecedented impacts on local communities.

Those charged with governing flood risk and their local communities are looking for solutions to address increasing exposure to flood risk, due to changing climates and increasing

populations putting pressure on the natural and urban environment. As a result, existing infrastructure and economic and governance systems are struggling to cope. This thesis has presented an analysis of risk perceptions to flooding and flood governance across three case studies at different scales: local; regional; and national, to understand implications for management. The case studies provide examples of adaptation to new levels of risk and uncertainty, where approaches are aiming to prevent flood risk management reaching a crisis point. These case studies also provide insight into environmental risk as a concept, and the complex framework in which risk is perceived and governance processes occur. The aim of this study, as presented in Chapter One, was to address the following research questions:

- What are the key challenges for flood management in the context of the:
 - Governance framework
 - Local context of the case study site
 - Stakeholders' perceptions and acceptance of risk?
- What are the options for an adaptive management approach to flood risk?

To address this research aim, a qualitative study was undertaken applying components of grounded theory and comparative case study methodology. Semi-structured interviews were conducted with 50 participants across Australia and the UK. These two countries were selected due to their similar political and governance structures, histories of frequent flooding, increasing pressure on outdated infrastructure, problems around legacy land-use planning, and their struggle with cultural issues around the management of flooding.

The interview data was triangulated a document analysis. The multi-case study approach, employing two from Australia and one from the UK was useful for identifying similarities and differences in flood management governance structures, approaches and risk perceptions. The selection process involved screening for case study sites with similar social, political, cultural, and economic characteristics, while offering a range of other variables to aid comparison including across scales. The use of case studies across different scales is reflective of the range governance approaches to manage flood risk. Therefore, the framing of results from multiple perspectives of geographical and political scales has enhanced the understanding of key challenges to allow for increased facilitation of adaptation options to increased flood risk (Radhakrishnan *et al.* 2017).

The first case study examined management in the BHKC catchment in SA. The BHKC catchment was chosen to provide a Local government-led example, where community

backlash against a proposed, hard flood mitigation structure strongly influenced movement to an urban flood risk management paradigm in the development of the SMP. The second case study of SE QLD examined post-disaster perspectives on management, and demonstrated the successful implementation of a planned relocation policy in response to the perceived failure and limitation of hard flood mitigation structures. Third, the UK case study investigated the implementation of national policy and legislation, supporting the use of sustainable flood risk management and natural flood management approaches. These three different case studies demonstrated options which various levels of government can undertake in response to recognising that a reliance on attempting to ‘control’ or mitigate floods is failing in the face of new levels of flood risk. Further to this, the case studies demonstrated that there is a growing recognition of the need to live with floods, and use to landscape cleverly in the process.

Throughout this thesis, a philosophical lens of Beck’s Risk Society theory was applied; this contemporary risk modernity analytical approach enabled the exploration of current practice and future risk adaptation planning. The research findings are a valuable addition to the flood risk adaptation literature, providing evidence that contemporary environmental, technical, and social systems are generating their own risks, and are reaching a tipping point such that new ways of conceptualising flood risk, and managing adaptation, are needed. To better inform policy- and decision-makers, there is a need for greater understanding of local values and socio-cultural factors important for successful adaptation to increasing flood risk, in the context of growing uncertainty. The knowledge gained through this analysis supports the incorporation of local values into future flood risk adaptation policy. Such a tailored approach will result in more beneficial and acceptable socio-ecological outcomes for at-risk communities.

To support these conclusions, the following sections provide a summary of the key findings which emerged from the analysis of data during this research, as they relate to the research aims.

8.3 Key findings

8.3.1 Challenges for flood management

To address the first research question to identify challenges for flood management; Chapters Four, Five and Six demonstrated consistent key challenges for flood management and influencing flood risk in the future. These common, recurring themes included:

- Risk perception – the influence of community and practitioner response and in decision-making processes
- Increasing urbanisation and changes in land use – how governments are balancing requirements for development and aging infrastructure, increasing populations and resultant higher levels of run-off
- Climate change – how to plan for the uncertainty and the change in frequency and magnitude of extreme events
- Governance frameworks – including localism, and policies and planning
- Adaptation options - including landscape management, feasibility of alternative options in urban environments.

Synthesising the literature with the case study results, the consistent high-level challenges for adaptation to increased flood risk were found to be a result of changes in landscape and rainfall and runoff behaviour; issues relating to social influences; and, factors linked to governance scales for flood risk management. Furthermore, issues of great importance to those governing flood risk across the case studies were: the need to balance risk perception of flood risk with actual flood risk and new development; public values and expectations; knowledge of risk and personal responsibility; and, the need to consider alternative methods to manage flood risk.

It was apparent from the case studies that a reactionary approach was the default option where governance frameworks for flood management were diffuse, devolved roles and responsibilities were unclear, and governing bodies lacked capacity. This reactionary governance and risk management approach is a product of these types of challenges faced by those responsible for managing flood and other natural hazards. White's (2001) statement reflects these challenges and a need for change:

Notwithstanding some current frustrations there are signs that the 'hazards community' is ready and eager for change. Increasingly it is understood that the 'natural hazard problem' is deeply embedded in the larger question of sustainable development, and the specific issues of reducing poverty, improving governance, increasing equity, and limiting climate change with its threat of increased extreme events. Thus, the challenge for the hazards community is to build upon the past record, and move on to find ways to effectively link our growing knowledge of hazard vulnerability to the larger issues and needed actions of a sustainability (US National Research Council 1999) (White *et al.* 2001, p. 91).

The capability of hazard management decision-makers to change broader pathways and adapt to the new levels of risk requires an understanding how groups and individuals

understand flood risk (Kunreuther 1996). These perceptions of risk and associated risk-related behaviours can intensify and increase the economic, social, and political impacts of flood events (Burns & Slovic 2012). This thesis has acknowledged the implicit impact of risk perception on the results. For example, a perception of high risk by the local community in the BHKC case study influenced the development of the SMP despite a comparatively low risk to life. In SE QLD, the false perception of protection due to the existence of the Wivenhoe Dam influenced both governance and community responses to the very real flood risk in Brisbane and surrounds.

The three case studies demonstrated that governance was a key issue for flood management and was recognised by interview participants across location and industry representation. Key themes around governance included:

- Issues with the lack of clarity for roles and responsibilities
- Diffuse governance and difficulty with inter-organisation cooperation
- Influence of political boundaries – multiple jurisdictions in one catchment
- Ineffective policy and legislative frameworks and difficulty in implementation – the implementation gap.

The UK case study demonstrated the most comprehensive flood governance framework, with recent restructuring and the introduction of clear legislation which defines responsibilities and provides a ‘hook’ and direction for policy implementation. Such a governance framework was clearly missing across both the Australian case studies, contributing to tension between State and Local governments. Potential reasoning for this was around a lack of capacity for implementation at the Local government level, and a lack of appetite for ownership and implementation due to the lack of a necessary ‘hook’ for compliance and enforcement. The implicit influence of perception of the flood risk also provides an indication of the prioritisation for action across and within governance bodies.

An implementation gap was also present where a discord was prevalent between policy and legislation in place encouraging change, and the actual practice culture. The difference in practice and the governing policy framework was seen in the UK where practitioners were apprehensive of the realities for sustainable flood risk management approaches. The discord recognises that cultural change occurs over the long-term and that the policy and legislative framework is important to have in place to enforce innovation and the cultural change.

These results indicate it is particularly important to explore how those charged with the governance of flood risk are incorporating socio-cultural, environmental, and economic factors, what they perceive as their greatest challenges, and how they are continuing to plan for the future. Further research is required to enhance understanding of the influence that risk perception has on flood management, and the challenge that it presents for management approaches, adaptation options, and governance of systems.

8.3.2 Adaptive management options for flood risk

The second research question was to examine options for an adaptive management approach to flood risk in the context of the three case studies (BHKC, SE QLD and UK). Each site was found to be changing in their ideological approach to managing flood risk despite a broader lingering entrenchment in a structural flood protection paradigm. Key examples of explicit changes in approach included: the adaptation from a focus on structural mitigation to an integrated landscape approach in the BHKC case study; the utilisation of a relocation measure for the township of Grantham in the SE QLD case study; and, the implementation of sustainable flood risk management through changes in legislation in the UK case study. The key driver for change in each of the case studies was different:

- BHKC – community pressure and values
- SE QLD – response to a catastrophic disaster
- UK – policy and legislation from an EU Floods Directive.

This thesis also examined the political landscape for application of various flood risk management approaches – a spectrum from landscape management including planned relocation, land use planning, and natural flood management, and the use of financial measures such as insurance. While there were mixed responses to each strategy among the interview participants, there was a strong acknowledgement and support for a better use of the planning system – supported by the academic literature. Whilst landscape management techniques, such as planned relocation and natural flood management, were considered by stakeholders to be valid hazard management options, they were acknowledged to be difficult to implement on a broad scale. There are risks to governance systems due to the political implications of supporting relocation as such measures are generally unpopular with communities and often perceived to have negative impacts as new communities must be established and existing business and industry are disrupted.

Following discussions with the stakeholders interviewed and a review of academic literature and published reports, a snapshot of alternative approaches for flood management apart from the traditional flood defence and protection structures historically used, was developed for each case study. Throughout Europe and the UK there appears to be a greater culture of managing landscape more effectively to mitigate flood risk, and a willingness to return land use to the traditional floodplain. Reasoning for this change in direction is coming from the *Floods Directive* and a growing realisation by practitioners that to address the growing risk, a combination of approaches must be undertaken.

Despite the move towards the more effective utilisation of landscape for flood mitigation, it was clear that practitioners require a clear evidence-base to support their actions. Many flood managers wanted to integrate ‘natural’ adaptation measures, such as forest plantations and revegetation into their management regimes, but didn’t have the strong scientific evidence-base required to garner resourcing. This is a research gap that needs filling.

In Australia, the greater use of the landscape and natural floodplains hasn’t been undertaken in urban areas to the same extent as in Europe. The key example of planned relocation in the case of Grantham, as an alternative to building mitigation structures in response to the 2011 floods, supports the recognition that governments and communities, given the right circumstances, will support such measures post-disaster. However, from in-depth discussions regarding the implementation of such preventative measures, they are often deemed to be politically difficult and unpopular. Nonetheless, utilising planning responses as an adaptation to risk indicates a shift towards Beck’s Risk Society, rejecting the need for constant employment of protection technologies.

From interview analysis, it was noted that there was still a significant trend of focusing on hard protection and defence mitigation structures for flood risk as the first priority, without a consideration of alternative options. Further progress needs to occur as an industry to achieve a balance of priorities and management of flood risk. Government policy in this area will not be successful without deeper understanding of the interactions within and between psycho-social, environmental, and economic factors (Slovic 2016).

8.3.3 Limitations for future adaptation to increased flood risk

The exploratory nature of applied grounded theory allowed for identification of key limitations that are preventing adaptation to increased flood risk and a changing paradigm of management methods.

In response to the changes in land use and rainfall and runoff behaviour from different factors, there were limitations for adaptation to the new levels of flood risk. Climate change was one of the influences explored as likely to increase flood risk and uncertainty, but was not deemed important by some stakeholders because of the view that there were limited options available to act on and prepare for any changes in risk levels. Other participants felt that adaptation to climate change would most likely be a fluid occurrence, or that it would be a case of exploiting opportunities to return to a greater focus on harnessing natural processes to mitigate flood risk. In other words, adaptation to climate change would become a normalised component of flood risk mitigation.

The other main drivers of increased risk were changes in land use and increasing populations, altering catchments and reducing the ability for water to dissipate in watercourse channels and soak into the ground after intense rainfall due to decreased permeable surfaces. Land managers such as Local government are struggling with the difficulty of balancing new development, aging infrastructure and increasing populations, and keeping urban landscapes compliant with planning requirements for flood hazard. The influence of local politics was found to be a limitation or barrier for implementation of prevention or developing new adaptation measures considering broad-scale risk.

To overcome such complex limitations to adaptation and the introduction of whole-of-landscape approaches there needs to be an underlying cultural change in the way that flood risk is managed. Such a cultural change is likely to require significant investment by those involved in the governance of flood risk around the education, engagement and communication of flood risk amongst decision-makers and the local communities. A focus on adaptation to flood risk will need to filter through all governance and government scales, and have strong public policy backing across all the facets of flood risk management. Any large-scale focus on land use planning to mitigate risk will require a change in the psychology of flood practitioners and the public. Such a change will require education and awareness around the real and perceived level of flood risk as this has significant influence on the decision-making process. Education and awareness are especially important considering that natural hazards are low on the hierarchy of perceived risks despite the possible high level of damage (McDaniels *et al.*

1995). As demonstrated most vividly by the BHKC case study in SA, successful adaptation is unlikely without public support.

8.4 Theoretical and policy implications

The findings of this research have been analysed using a Risk Society philosophical lens to help demonstrate the current gradual transition from ecological modernisation to a Risk Society culture of management (Blowers 1997). However, as mentioned previously, it was evident that a new way of looking at global risk in local contexts is required. As demonstrated by discussion around local risk perception, it is evident that risk is definitively a social construct, incorporating many different economic, cultural, environmental and social influences, all of which need to be considered in any management plan. Beck's discussion paper on emancipatory catastrophism was timely, indicating global risk is indeed changing (Beck 2015). Flood risk is one such example, with the risk impacting across all levels of society, politics, institutions, and individual life. 'Natural' risks are issues of environmental justice and there is a need to, '*bridge the difference between the natural and the social science and humanities*' (Beck 2015, p. 80).

At an implementation level, this requires the inclusion of practitioners and decision-makers from a variety of backgrounds to work together to generate sophisticated outcomes. The need for this was reflected across the three case studies, with management focussing solely on mitigated solutions calling for change. This is most clearly demonstrated in the BHKC case study, where there was a need to incorporate social and cultural factors in the example of the proposed mitigation dam.

The need for integration and inclusion of the natural and social sciences into the engineering-focused culture of flood management was again reflected in the changing approaches observed in the UK. The EU has explicitly acknowledged that best practice flood management considers multi-faceted impacts. Local governments and community areas have implemented sustainable and natural flood management approaches successfully in response to the *Floods Directive*, providing lessons for Australia and elsewhere.

Despite the changes and attempts at transformation of management to reflect a world Risk Society and the best intentions of those working at the flood risk management level, many at the economic and political level remain unwilling to consider approaches away from traditional structural defence and protection engineering. This is despite advancements in research and

technology, and an observed failure of protection against contemporary levels of flood risk - as seen in the SE QLD case study with the Wivenhoe Dam and downstream communities. It is noted there will always be a need for key structural elements of risk mitigation, and there will be many cases where traditional structural flood mitigation is the only realistic response, such as in large cities and areas of significant urban development. However, with increasing changes in the natural landscape due to development coupled with the increasing frequency and intensity of extreme weather events due to climate change, other options will need to be implemented. In many cases, a combination of measures will be appropriate.

This research highlighted that there is a need for broad changes in policy direction and a willingness to consider policies which may not necessarily be popular to prevent the current risks threatening current governance systems. The research has also indicated that a focus on a greater understanding of risk across all levels of governance needs to occur. A greater acknowledgement of the explicit and implicit impacts of risk perception is also required, recognising that perception has an influence from the public through to the highest level of decision-maker. Despite attempts for transition to differing methods, the current dominant paradigm is seemingly continuing to rely on technical solutions. In the face of a management crisis, adaptation will require a transition to Beck's Risk Society and second modernity to address uncertainty and continue to increase community resilience to natural hazards

8.5 Key research challenges

In this study's attempt to achieve an in-depth look at flood management, several key challenges were faced during the research process. Due to the politically contentious nature of some of the content of this thesis, many of the interviewed stakeholders were unable or unwilling to discuss some aspects of their roles as flood risk practitioners. This reluctance was particularly apparent in the SE QLD case study where the *Inquiry* formally limited the topics that could be discussed and the level of information revealed by some stakeholders.

Despite this challenge, a broad scope of risk management issues was covered. However, due to the nature of the research, limitations were apparent from the small-scale study area detailed. This research also focussed on qualitative methods to undertake analyses of the underlying culture and focus of risk management, to expand the knowledge gained from the research the ability to apply quantitative methods could provide a broader context for future directions of adaptation

8.6 Knowledge contribution and future research directions

This thesis contributes to a deeper understanding of flood management and adaptation options for future levels of uncertainty resulting from a series of different factors. The number of complex issues and drivers impacting on policy and management implications have been discussed in detail through the context of three case studies at different scales. Importantly, this research has demonstrated that many of the stakeholders' concerns and the challenges to adaptation in the context of flood risk management are similar, despite the different scales of governance explored and locations of the case studies. This thesis has expanded on previous research by exploring flood management from a social science perspective and focussing on the challenges for adaptation to future risk. The examination of the broad range of factors involved in the management of flood risk, such as insurance, mitigation, adaptation, planning, governance and policy enabled a more holistic view across the spectrum of influencers. Despite the broad examination there are many further aspects of flood risk management which need to be examined in more detail to break down the barriers preventing adaptation to increased risk, such as psychology, community engagement and education, and economic analyses. This thesis has avoided examination of the social, psychological, economic, and cultural and community factors, as well as the emergency response and management field in more detail. This thesis has instead attempted to bridge the noted divide between the social and technical sciences.

In addition to examining the important community and social contributions to flood risk management in more detail, further research is needed to determine enabling factors and contexts where adaptation methods, such as landscape management – including natural flood management – and relocation policies may be implemented, and the policy implications.

One of the barriers highlighted in the results for implementation of adaptation options, such as planned relocation or natural flood management, was a lack of support and research. The UK case study demonstrated that natural flood management techniques are frequently being considered in areas where the economic costs don't support the constant building of mitigation structures. There is plenty of scope within Australia, as well as other OECD countries, to determine locations at high flood risk to look at integrating such approaches and documenting responses during and post-events to determine evidence for future locations.

From a policy perspective, further research is also needed to examine ways to truly engage vulnerable communities in the policy and decision-making process. Communities at risk need

to decide on the acceptable levels of risk, and what losses are suitable in extreme events. Decision-makers need to then look at ways to include such results into their high-level policies, possibly changing the way flood risk is governed and the ultimate objectives for management. Future research could address methods of inclusion through communities identifying public expectations, wants and needs from local planning and flood management governance systems, incorporating involvement with different tiers of government, non-government organisations, industry, and research institutions. Such research could influence possible restructuring and reconceptualising of governance structures.

8.6.1 Final conclusions: a balance of localism in a federalist system

This thesis has determined that Australia and the UK are examples of modern OECD countries that are struggling with the emergence of increasing levels of flood risk. New generations are facing unprecedented flood management challenges, especially as the impacts of climate change generates levels of risk at a scale and level of complexity which have not been seen previously. These challenges are threatening the political and government institutions and the public trust. As a consequence, current flood management systems are seen as increasingly inadequate. The traditional defence and protection paradigm which, was still culturally prominent in the three case studies despite the implementation of adaptation approaches, needs reframing in response to the new complex risk framework. Greater focus on approaches such as land use planning, planned relocation, and use of natural landscapes, as seen in the UK will need to be integrated further. The inclusion of adaptation measures, such as the use of non-structural and soft-structural methods will not only reduce the immediate exposure to the flood risk, but also decrease community vulnerability to the impacts of flood risk, hence increasing resilience (Allen *et al.* 2014; Gunderson *et al.* 2010; Gunderson & Holling 2002; Gunderson & Pritchard 2002). The smarter use of landscape is particularly important as the economic value of infrastructure and development continues to grow, and investments are maintained or increased in high risk areas. Decision-makers will need to consider the multi-sectoral consequences for future generations.

Communities at risk of flood impacts are also required to play greater risk management roles and need to develop a greater level of responsibility and resilience. Governments could support this process by improving engagement with at-risk communities to determine acceptable levels of risk, values and priorities for protection so that large flood events do not

continue to cause devastating psychological, social, environmental and economic impacts on lives. Improved engagement and awareness will also advance knowledge and influence the risk perception resulting in increased buy-in from communities and therefore trust in the technical ‘experts’.

From the broad spectrum of approaches considered throughout this discussion it has become apparent that there are many ways to adapt and increase resilience to flood risk. It is likely that specific, local values and conditions will need to be considered and adaptation and resilience measures adjusted accordingly. It is important for communities to have input into, and understand the actions undertaken in their area for flood risk that will remain even after management interventions. As presented in SE QLD, many of the residents were unaware or misunderstood the function and level of protection that the Wivenhoe and other dams provided, indicating the need for improved risk education and engagement of communities and stakeholders. As the BHKC case study demonstrated, local communities see the value of holistic mitigation measures if educated and aware of risk, and informed of options and consequences. Local communities often have a sophisticated understanding of place and that can be reflected in unique, reflexive management approaches. A cultural shift may need to occur in some factions of the flood management sector to enable a recognition of that sophistication. Indeed, returning to Heazle *et al.* (2013), the dominant rationalist approach seems to discard the value of flexible community adaptation methods, and instead relies on the notion that risk reduction strategies will be improved only with increased resources and knowledge resulting in better defensive infrastructure (Heazle *et al.* 2013).

However, despite a need for locally driven adaptation, there is also a need for strong top-down leadership, supporting Cash *et al.*'s (2006, online) suggestion for, ‘*a middle path that addresses the complexities of multiple scales and multiple levels*’ and returning to Pearce (2003, p. 212), ‘*it is recognised that while a top-down policy is needed, it is really the local-level bottom-up policy that provides the impetus for the implementation of mitigation strategies and a successful disaster management process*’.

To achieve effective responses to an increasingly risky environment, there are broader needs for strong and effective leadership. The critiques presented in the use of Partnership Funding in England and Wales in Chapter Six and the literature, suggest ongoing weaknesses in local approaches that depend on high-level governance leadership that does not engage fully with communities. By developing a balance between private individual and community

interests, and state needs, holistic viewpoints of future risk mitigation approaches can be conceptualised that drive sustainable approaches of flood management.

Appendices

Appendix A: Examples of natural flood risk management projects in the UK

Appendix B: Summary of recurrent themes across case studies

Appendix A – Examples of natural flood risk management projects in the UK

Source: adapted from Adaptation Scotland 2014; AECOM 2012; Cheviot Futures 2013; CRESS 2011a 2011b; Department for Environment Food and Rural Affairs 2013; Forestry Research 2014; Moors for the Future Partnership 2012; Nutt 2012; Richardson 2014; The National Trust 2011; Tweed Forum 2011 2012 2013; Wilkinson 2013; World Wildlife Fund 2005.

Major Organisations Involved	Location	Natural flood management project
Moors for the Future Partnership Environment Agency	The Upper Derwent catchment, the Peak District National Park, Derbyshire, England	Making Space for Water Revegetation Blocking erosion gullies
Forest Research Forestry Commission England The Environment Agency The North York Moors National Park Authority DEFRA	Pickering, North Yorkshire, England	Slowing the flow at Pickering Constructing low-level bunds Revegetation, especially along stream sides and in the floodplain Restoring woody debris dams in small streams Restoring wetlands
The National Trust Environment Agency Penny Anderson Associates and JBA/Maslen University of Exeter Cranfield University Wessex Water Somerset County Council Exmoor National Park Authority Natural England	Aller and Horner Water catchments, in The National Trust's Holnicote Estate on Exmoor, Somerset England	Source to Sea' -Holnicote Project Upland: Grip blocking on degraded peatlands Middle catchment - cloughs, gullies, and combes: Woodland and debris dam creation in upper gullies Middle catchment - meadows: Wet meadow, wet woodland, in-field bunds and debris dam creation Making space for water at the coastal escape in the intertidal zone (widening the shingle infiltration area and creating a bypass channel)

<p>Tweed Forum</p> <p>University of</p> <p>Scottish Borders Council</p> <p>SEPA</p> <p>Scottish Government</p> <p>British Geological Survey</p>	<p>Eddleston Water, Tweed River catchment, including the towns of Peebles and Eddleston, Scottish Borders, Scotland</p>	<p>Eddleston Water</p> <p>Revegetation</p> <p>Fencing erected</p> <p>Over 1km of river re-meandered</p> <p>‘Flow restrictors’ installed</p> <p>Retention ponds created</p>
<p>Forestry Commission Scotland & Forest Research</p> <p>Perth & Kinross Council</p> <p>RSPB</p> <p>Scottish Government</p> <p>SEPA</p> <p>Scotland Natural Heritage</p> <p>Stirling Council</p> <p>CRESS/University of Stirling</p> <p>Halcrow</p>	<p>Allan Water, River Forth catchment, Bridge of Allan, Scotland</p>	<p>Allan Water</p> <p>Restoring meanders</p> <p>Channel restoration</p> <p>Revegetation/habitat restoration</p> <p>Blocking ditches</p>
<p>AECOM</p> <p>South Lanarkshire Council</p> <p>SEPA</p> <p>SNIFFER</p> <p>SNH</p> <p>RSPB</p>	<p>Upper Clyde Valley, Scotland</p>	<p>Upper Clyde</p> <p>Wet woodland planting</p> <p>Introduction of meanders,</p> <p>Riparian planting</p> <p>Creation of washlands</p>
<p>World Wildlife Fund</p> <p>Local landowners</p> <p>Mountain Environment</p> <p>Clackmannanshire Council</p>	<p>River Devon catchment, Scotland</p>	<p>River Devon</p> <p>Revegetation</p> <p>Restoration of wetlands</p> <p>Erosion control</p>

<p>Tweed Forum</p> <p>Environment Agency</p> <p>Forestry Commission</p> <p>RSPB</p> <p>Natural England</p> <p>North Northumberland Council</p> <p>Scottish Borders Council</p> <p>DEFRA</p> <p>Scottish Government</p>	<p>Cheviot Hills, Northumberland and Scottish Borders, Scotland and England</p>	<p>Cheviot Futures</p> <p>Engineered logjams</p> <p>Timber palisade revetment</p> <p>Bank protections works</p> <p>Fencing</p> <p>Retention ponds</p> <p>Revegetation</p>
<p>Local landowners</p> <p>Scottish Rural Development Programme</p> <p>Scottish Borders Council</p> <p>Tweed Forum</p>	<p>Gala Water, Galashiels, Scottish Borders, Scotland</p>	<p>Crookston Farm</p> <p>Water retention ponds</p> <p>Revegetation</p> <p>Fencing</p>
<p>Scottish Borders Council</p> <p>SEPA</p> <p>World Wildlife Fund</p> <p>Scotland Natural Heritage</p> <p>Forestry Commission</p> <p>Scottish Government</p>	<p>Borthwick Water, River Teviot, Scottish Borders, Scotland</p>	<p>Craik Sustainable Flood Management Demonstration Project</p> <p>Water retention ponds</p> <p>Revegetation</p>

Appendix B - Summary of recurrent themes across case studies

Issue	Example Quote
Risk perceptions	<p><i>It's not perceived as a very high risk, it doesn't happen very often. When it does its very, very damaging but it doesn't kill people. It's not as dramatic as something like bushfire. It's not as diffused across the environment as something like storms. I don't think it captures the imagination the same way because floods don't happen in South Australia. So, and there's, we can describe a risk but there's a difference between how a risk is perceived and how it actually is and risk perception is often what drives it (SA7 2013).</i></p> <p><i>There was this sort of myth that Wivenhoe Dam would somehow stop a flood. You don't have to be Einstein to work out that it's not going to stop a flood, especially if that flood is not up there, the floods down here. I think the other thing is, I think people actually had this expectation, and it was a common myth that people actually went with (SEQ6 2011).</i></p>
Urbanisation and increasing population	<p><i>I think the huge factor in all of this is the density of development and the urbanisation, because you can regularly look at new homes being built with impervious surfaces, front and back, with a little token something, which might be one tree, but the whole run off is being directed into gutters that are unable, either in width, or height in particular (to cope). Importantly in our patch, we're the second oldest council in South Australia, so the pipes themselves often are too small to take this volume of water (SA2 2013).</i></p> <p><i>In the UK, the biggest impact is going to be urbanisation, urban creep. So what we're trying to do is to encourage people to basically treat rainwater and deal with rainwater at source, so by building retention storage and porous surfaces and all of that kind of stuff. But again, that's not our responsibility in terms of maintaining those systems so it becomes difficult if you are trying to get people to do the right thing (UK4 2012).</i></p>

<p>Governance / local politics</p>	<p><i>If you look at flooding it's very, very diffuse. So, we have one agency, which is the SES who go out and do their best to deal with the flood. You've got Local councils who own most of the flood mitigating infrastructure, which obviously has a big effect on how good your flood mitigation is in the first place. Depending on where you are, you've got State and Local governments doing land use planning, which can affect who's in the way of the water... It's very easy for different players to point the finger at each other and that's kind of where we are now, so we've got a tiny little catchment of 32 km², but because we're talking about fundamentally an infrastructure issue, the councils are supposed to be the ones who fix it, but they don't have the money. It's a State level risk but the State says well it's the council's problem. The Commonwealth government often funds these things but are basically saying, "We don't have any money and by the way natural disasters are a State problem anyway" (SA7 2013).</i></p> <p><i>There's quite a lot of people that don't recognise the devolved aspect, and then that devolution means that there's no links (UK8 2012).</i></p>
<p>Climate change</p>	<p><i>I think there is a real lack of understanding of realistically what is climate change as it results on a flood (SEQ4 2011).</i></p> <p><i>Our challenge for climate change will be natural flood risk management techniques, because the timescales are going to align with each other. And I think that's what we've got to do, we've got to get the research and data so that as the climate changes practitioners will have the evidence to go and apply techniques which are much more cost effective and beneficial to mitigate the effects of climate change (UK8 2012).</i></p> <p><i>It's something you always have to give a nod to in terms of, "We need to take account of long term development and climate change", but how you do it in practice is proving to be quite difficult (UK3 2012).</i></p>
<p>Insufficient land use planning guidelines</p>	<p><i>You should use Q50, Q100, Q200, Q500, and even PMF, Probable Maximum Flood, so that you can see the shape of your flood risk and people understand that Q100 isn't the end of it. If you only put a single line down they think, "If I'm over the line I'm alright", whereas, "Oh, there's more lines and more lines and there's this funny line that hasn't got a number, it's got letters, that's safety up there and these are all relative levels of risk (SEQ12 2012).</i></p> <p><i>I'm a great sceptic of our planning policies, because they say all of the right things but they don't achieve anything. If you have a look at our planning policies, they all say the right sort of things but there are no hooks, there's no commitment and often there's no funding to it (SA6 2013).</i></p>

Adaptation options	<p><i>The answer to it, in Queensland, the simple answer is adaptation strategies. We must adapt. What does that mean? Well, fundamentally it means we defend or we retreat. Either we put up barriers, or lift everybody's house up on stilts by an enormous degree or we say, "No, this is all too difficult, too expensive, we cannot", and there are some small townships that have no land above Q100 so they flood pretty frequently now, they're going to flood much more frequently in the future, the perhaps we should just say we abandon them and that's a very, very difficult socio-political decision to make (SEQ12 2011).</i></p> <p><i>And should we have it [adaptation options] ready to go rather than running around like headless chooks afterwards? Coming up with crazy idea, or what might seem like crazy ideas, let's have them well thought out. So, then the sort of Grantham thing [relocation] could happen and it could happen all around the place. Because people have seen actually what could happen, and what would be our response rather than just go back and build where we were last time. Because that's what we do. We get knocked over, we get back up again. That's what we do as Australians (SEQ6 2011).</i></p>
Landscape management	<p><i>I think that message is starting to happen that it's not all about an engineering solution. And engineering solutions sometimes actually make things worse rather than better. All the old heads unfortunately, engineering solves everything (SEQ6 2011).</i></p> <p><i>It's a long road because it involves changing the culture, it's a long road. It's not just a question of what's is the best solution, it's a question of thinking differently, it's a question of being willing to take a bit more risk on and so it's going to take a little while to get there (UK4 2012).</i></p>

Reference list

- Abraham, M 2008, 'Dam plan may see creek go Brownhill', *Eastern Courier Messenger*, 9 July 2008, p. 29.
- Adam, B, Beck, U & van Loon, J (eds) 2000, *The Risk Society and Beyond: Critical Issues for Social Theory*, Sage Publication Ltd, London, England, UK.
- Adams, J 1995, *Risk*, UCL Press, London, England, UK.
- Adaptation Scotland 2014a, *Climate Change Adaptation in Scotland*, Scottish Government and SNIFFER, Edinburgh, Scotland, UK, viewed 13 May 2014, <<http://www.adaptationscotland.org.uk/1/1/0/Home.aspx>>.
- 2014b, *Natural Flood Management at Crookston Farm*, SNIFFER, Edinburgh, Scotland, UK, viewed 6 May 2014, <<http://www.adaptationscotland.org.uk/12/136/0/Natural-flood-management-at-Crookston-Farm.aspx>>.
- Adelaide Airport 2009, *Master Plan Adelaide Airport Volume 3: Sustainability Plan [Airport Environment Strategy]*, Adelaide Airport, Adelaide, SA, Australia.
- Adelaide and Mount Lofty Ranges Natural Resources Management Board 2010, *Brownhill and Keswick Creeks Flood Management Master Plan: Stormwater Harvesting Plan*, CEO Group of the Brownhill and Keswick Creeks Stormwater Project, Adelaide, SA, Australia.
- Adger, NW 2002, 'Inequality, environment, and planning', *Environment and Planning A*, vol. 34, no. 10, pp. 1716-1719.
- Adger, NW, Arnell, N & Tompkins, EL 2005, 'Successful adaptation to climate change across scales', *Global Environmental Change*, vol. 15, no. 2, pp. 77-86.
- Adger, NW, Barnett, J, Brown, K, Marshall, N & O'Brien, K 2013a, 'Cultural dimensions of climate change impacts and adaptation', *Nature Climate Change*, vol. 3, no. 2, pp. 112-117.
- Adger, NW, Brown, K & Tompkins, E 2004, *Why do Resource Managers Make Links to Stakeholders at Other Scales*, Working Paper No. 65, Tyndall Centre for Climate Change Research, Manchester, England, UK.
- Adger, NW, Quinn, T, Lorenzoni, I & Murphy, C 2016, 'Sharing the Pain: Perceptions of Fairness Affect Private and Public Response to Hazards', *Annals of the American Association of Geographers*, vol. 106, no. 5, pp. 1079-1096.
- Adger, NW, Quinn, T, Lorenzoni, I, Murphy, C & Sweeney, J 2013b, 'Changing social contracts in climate-change adaptation', *Nature Climate Change*, vol. 3, no. 4, pp. 330-333.
- AECOM 2012, *Pilot Study on Natural Flood Risk Management Techniques to Proceed*, AECOM, Edinburgh, Scotland, UK, viewed May 6 2014, <http://www.aecom.com/News/Where+We+Are/Europe/_news/Pilot+study+on+natural+flood+risk+management+techniques+to+proceed>.

Agriculture and Resource Management Council of Australia and New Zealand Standing Committee on Agriculture and Resource Management 2000, *Floodplain Management in Australia: Best Practice Principles and Guidelines*, SCARM Report 73, CSIRO Publishing, Collingwood, VIC, Australia.

Alexander, M, Priest, SJ, Micou, AP, Tapsell, S, Green, C, Parker, D & Homewood, S 2016, *Analysing and evaluating flood risk governance in England: Enhancing societal resilience through comprehensive and aligned flood risk governance arrangements*, Flood Hazard Research Centre, Middlesex University, London, England, UK.

Allen, CR, Angeler, DG, Garmestani, AS, Gunderson, LH & Holling, C 2014, 'Panarchy: Theory and Application', *Ecosystems*, pp. 1-12.

Allen, J & Cochrane, A 2010, 'Assemblages of state power: topological shifts in the organisation of government and politics', *Antipode*, vol. 42, pp. 1071–1089.

Althaus, C, Bridgman, P & Davis, G 2013, *The Australian Policy Handbook*, Fifth edn, Allen & Unwin, Sydney, NSW, Australia.

Anderson, J 2004, 'Talking Whilst Walking: A Geographical Archaeology of Knowledge', *Area*, vol. 36, no. 3, pp. 254-261.

Arnall, A, Thomas, DSG, Twyman, C & Liverman, D 2013, 'Flooding, resettlement, and change in livelihoods: evidence from rural Mozambique', *Disasters*, vol. 37, no. 3, pp. 468-488.

Arnell, N 2000, 'Flood insurance', in D Parker (ed.), *Floods*, Routledge, London, UK, pp. 412-424.

——— 2002, *Hydrology and Global Environmental Change*, Prentice Hall, Harlow, England, UK.

Arnell, N & Gosling, SN 2016, 'The impacts of climate change on river flood risk at the global scale', *Climatic Change*, vol. 134, no. 3, pp. 387-401.

Association of British Insurers 2013a, *ABI and Government Agree Memorandum of Understanding on Scheme to Safeguard UK Flood Insurance*, Association of British Insurers, London, UK, viewed 8 April 2014.

——— 2013b, *The Future of Flood Insurance: What you need to know about Flood Re*, Association of British Insurers, London, UK, viewed 8 April 2014, <<https://www.abi.org.uk/Insurance-and-savings/Topics-and-issues/Flooding/Government-and-insurance-industry-flood-agreement/The-Future-of-Flood-Insurance>>.

——— 2013c, *Government and Insurance Industry Flood Agreement (Statement of Principles)*, Association of British Insurers, London, UK, viewed 8 April 2014, <<https://www.abi.org.uk/Insurance-and-savings/Topics-and-issues/Flooding/Government-and-insurance-industry-flood-agreement>>.

——— 2017, *Flood Re*, Association of British Insurers, London, England, viewed 23 April 2017, <<https://www.abi.org.uk/products-and-issues/topics-and-issues/flood-re/>>.

Australian Broadcasting Corporation (ABC) News 2017, *Flood Fallout From Cyclone Debbie Stretches Across Two States, Clean-Up Efforts Begin*, Sydney, NSW, Australia, viewed 15 May 2017, <<http://www.abc.net.au/news/2017-04-01/gallery-debbie-devastation-flooding-continues-nsw-qld/8406830>>.

Australian Building Codes Board 2012, *Construction of Buildings in Flood Hazard Areas Standard*, Version 2012.2, Australian Government and States and Territories of Australia, Canberra, ACT, Australia.

—— 2014a, *National Construction Code Series. Volume One: Building Code of Australia Class 2 to 9 Buildings* Australian Government and State and Territory Governments, Canberra, ACT, Australia.

—— 2014b, *National Construction Code Series. Volume Three: Plumbing Code of Australia*, Australian Government and States and Territories of Australia, Canberra, ACT, Australia.

—— 2014c, *National Construction Code Series. Volume Two: Building Code of Australia Class 1 and Class 10 Buildings* Australian Government and States and Territories of Australia, Canberra, ACT, Australia.

Australian Emergency Management Institute 2013, *Managing the floodplain - a guide to best practice in flood risk management in Australia - Handbook 7*, Australian Emergency Management Institute, Barton, ACT, Australia.

—— 2014, *Technical flood risk management guideline: Flood hazard*, Australian Emergency Management Institute, Barton, ACT, Australia.

Attorney General's Department 1992, Event - Adelaide and Region, SA: Floods, viewed 4 August 2011, <<http://www.disasters.ema.gov.au/Browse%20Details/DisasterEventDetails.aspx?DisasterEventID=1099>>.

Australian Water Environments 2008, *Brownhill Creek Flooding Preliminary Assessment of Alternative Options: Final Draft*, City of Mitcham, Adelaide, SA, Australia.

Badri, SA, Asgary, A, Eftekhari, AR & Levy, J 2006, 'Post-disaster resettlement, development and change: a case study of the 1990 Manjil earthquake in Iran', *Disasters*, vol. 30, no. 4, pp. 451-468.

Baldassarre, GD, Brandimarte, L & Beven, K 2016, 'The seventh facet of uncertainty: wrong assumptions, unknowns and surprises in the dynamics of human–water systems', *Hydrological Sciences Journal*, vol. 61, no. 9, pp. 1748-1758.

Bardsley, DK 2006, *There's a change on the way — An initial integrated assessment of projected climate change impacts and adaptation options for Natural Resource Management in the Adelaide and Mt Lofty Ranges Region*, DWLBC Report 2006/06, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Adelaide.

Bardsley, DK & Hugo, GJ 2010, 'Migration and climate change: examining thresholds of change to guide effective adaptation decision-making', *Population & Environment*, pp. 1-25.

- Bardsley, DK & Rogers, GP 2011, 'Prioritizing Engagement for Sustainable Adaptation to Climate Change: An Example from Natural Resource Management in South Australia', *Society and Natural Resources*, vol. 24, no. 1, pp. 1 - 17.
- Baxter, J & Eyles, J 1999, 'The Utility of in-Depth Interviews for Studying the Meaning of Environmental Risk', *The Professional Geographer*, vol. 51, no. 2, pp. 307-320.
- BBC News 2015, *December Storms' Trail of Destruction*, BBC News, London, England, UK, viewed 14 January 2016, <<http://www.bbc.com/news/uk-35193682>>.
- 2016a, *Flooding: Environment Agency told to put homes before nature*, BBC News, London, UK, viewed 14 January 2016, <<http://www.bbc.com/news/uk-politics-35298707>>.
- 2016b, *Homes flooded in Scotland as heavy rain hits*, BBC News, London, England, UK, viewed 14 January 2016, <<http://www.bbc.com/news/uk-scotland-35221823>>.
- BC Tonkin and Associates 1971, *Drainage report for the corporations of the cities of Adelaide, Burnside, Mitcham, Unley, West Torrens*, BC Tonkins and Associates, Adelaide, SA, Australia.
- 1996, *Patawalonga Catchment Water Management Board Comprehensive Catchment Water Management Plan: Draft for Consultation*, Adelaide, SA, Australia.
- Beck, U 1992, *Risk Society: Towards a New Modernity*, trans. M Ritter, Sage Publications, London, England, UK.
- 1995, *Ecological Politics in the Age of Risk*, Polity Press, Cambridge, England, UK.
- 1996, 'World risk society as cosmopolitan society?: Ecological questions in a framework of manufactured uncertainties', *Theory, Culture & Society*, vol. 13, no. 4, p. 1.
- 1999, *World Risk Society*, Polity Press, Cambridge, England, UK.
- 2006, 'Living in the world risk society', *Economy and Society*, vol. 35, no. 3, pp. 329-345.
- 2009, *World at Risk*, Polity, Cambridge, England, UK.
- 2010, 'Climate for Change, or How to Create a Green Modernity?', *Theory, Culture & Society*, vol. 27, no. 2-3, March 1, 2010, pp. 254-266.
- 2015, 'Emancipatory catastrophism: What does it mean to climate change and risk society?', *Current Sociology*, vol. 63, no. 1, January 1, 2015, pp. 75-88.
- Beck, U, Blok, A, Tyfield, D & Zhang, JY 2013, 'Cosmopolitan communities of climate risk: Conceptual and empirical suggestions for a new research agenda', *Global Networks*, vol. 13, no. 1, pp. 1-21.
- Beck, U, Bonss, W & Lau, C 2003, 'The Theory of Reflexive Modernization: Problematic, Hypotheses and Research Programme', *Theory, Culture & Society*, vol. 20, no. 2, pp. 1-33.

- Becker, G, Aerts, JCJH & Huitema, D 2014, 'Influence of flood risk perception and other factors on risk-reducing behaviour: a survey of municipalities along the Rhine', *Journal of Flood Risk Management*, vol. 7, no. 1, pp. 16-30.
- Begg, C, Walker, G & Kuhlicke, C 2015, 'Localism and Flood Risk Management in England: The creation of new inequalities?', *Environment and Planning C: Government and Policy*, vol. 33, no. 4, pp. 685-702.
- Bell-James, J 2014, *Complacency rules as Queensland makes risky edict on sea-level rise*, The Conversation, Brisbane, QLD, Australia, viewed October 24 2017, <<http://theconversation.com/complacency-rules-as-queensland-makes-risky-edict-on-sea-level-rise-35363>>.
- Benton, T & Craib, I 2001, *Philosophy of Social Science: The Philosophical Foundations of Social Thought*, Palgrave, New York, USA.
- Birkholz, S, Muro, M, Jeffrey, P & Smith, H 2014, 'Rethinking the relationship between flood risk perception and flood management', *Science of the Total Environment*, vol. 478, pp. 12-20.
- Biron, P, Buffin-Bélanger, T, Larocque, M, Choné, G, Cloutier, C-A, Ouellet, M-A, Demers, S, Olsen, T, Desjarlais, C & Eyquem, J 2014, 'Freedom space for rivers: A sustainable management approach to enhance river resilience', *Environmental Management*, vol. 54, no. 5, pp. 1056-1073.
- Blackburn, M, Methven, J & Roberts, N 2008, 'Large-scale context for the UK floods in summer 2007', *Weather*, vol. 63, no. 9, pp. 280-288.
- Blaikie, N 1993, *Approaches to Social Enquiry*, Polity Press, Cambridge, England, UK.
- Blowers, A 1997, 'Environmental policy: ecological modernisation or the risk society?', *Urban Studies*, vol. 34, no. 5, pp. 845-871.
- Bogard, WC 1989, *The Bhopal tragedy: Language, logic and politics in the production of hazard*, Westview Press, Boulder.
- Bogardi, J & Warner, K 2009, 'Here comes the flood', *Nature*, vol. 3, pp. 9-11.
- Boland, P 1999, 'Contested multi-level governance: Merseyside and the European Structural Funds', *European Planning Studies*, vol. 7, no. 5, pp. 647-664.
- Bowen, GA 2006, 'Grounded theory and sensitizing concepts', *International Journal of Qualitative Methods*, vol. 5, no. 3, pp. 12-23.
- 2009, 'Document analysis as a qualitative research method', *Qualitative Research Journal*, vol. 9, no. 2, pp. 27-40.
- Boyd, J & Banzhaf, S 2007, 'What are ecosystem services? The need for standardized environmental accounting units', *Ecological Economics*, vol. 63, no. 2–3, pp. 616-626.
- Bracken, LJ 2012, 'Practices of doing interdisciplinary risk-research: Communication, framing and reframing ', in M Kearnes, F Klauser & SN LANE (eds), *Critical Risk Research:*

Practices, Politics and Ethics, John Wiley and Sons, Ltd, West Sussex, England, UK, pp. 23-42.

Brisbane City Council 2005, *Lord Mayor's Taskforce on Suburban Flooding: Strategies to Reduce the Effect of Significant Rain Events on Areas of Brisbane Prone to Flooding*, Brisbane City Council, Brisbane, QLD, Australia.

—— 2007, *Brisbane's Plan for Action on Climate Change and Energy 2007*, Brisbane City Council, Brisbane, QLD, Australia.

—— 2010, *Be Flood Wise: Information for Flood Affected Residents: Voluntary Home Purchase Scheme Fact Sheet*, Brisbane City Council, Brisbane, QLD, Australia, viewed 12 September 2011, <http://www.brisbane.qld.gov.au/2010%20Library/2009%20PDF%20and%20Docs/5.Community%20Support/5.4%20Emergency%20management/March_2010_Voluntary_Home_Purchase_Scheme_FactSheet.pdf>.

—— 2012a, *Brisbane's FloodSmart Future Strategy 2012-2031*, Brisbane City Council, Brisbane, QLD, Australia.

—— 2012b, *Brisbane City Council January 2011 Flood Action Plan: Including Flood Response Review Queensland Floods Commission of Inquiry Interim Report and Final Report*, Brisbane City Council, Brisbane, QLD, Australia.

—— 2012c, *Brisbane Long Term Infrastructure Plan 2012-2031*, Brisbane City Council, Brisbane, QLD, Australia.

—— 2012d, *Temporary Local Planning Instrument 01/12 (TLPI 01/12) - Brisbane Interim Flood Response amendment*, Brisbane City Council, Brisbane, QLD, Australia.

—— 2013a, *Brisbane Vision 2031*, Brisbane City Council, Brisbane, QLD, Australia.

—— 2013b, *DRAFT New City Plan (ePlan)*, Brisbane City Council, Brisbane, QLD, Australia, viewed 10 February 2014, <<http://www.brisbane.qld.gov.au/planning-building/planning-guidelines-and-tools/brisbanes-new-city-plan/planning-scheme-eplan/index.htm>>.

—— 2014a, *Brisbane City Plan 2014*, Brisbane City Council, Brisbane, QLD, Australia.

—— 2014b, *Flooding in Brisbane: An explanation of technical flood terms*, Brisbane City Council, Brisbane, QLD, Australia, viewed 4 February 2014, <http://www.brisbane.qld.gov.au/downloads/community/community_safety/flooding-in-brisbane-an-explanation-of-technical-terms.pdf>.

Brisbane City Council Board of Inquiry 2011, *Brisbane Flood 2011: Independent Review of Brisbane City Council's Response 9-22 January 2011*, Brisbane City Council, Brisbane, QLD, Australia.

Brogan, DW 1963, 'Implications of modern city growth', in O Handlin, & J Burchard (eds), *The Historian and the City*, MIT Press, Cambridge, MA, USA, pp. 146-164.

- Brooks, N 2003, 'Vulnerability, risk and adaptation: A conceptual framework', *Tyndall Centre, University of East Anglia*, Norwich, England, UK.
- Brown Hill Keswick Creek Stormwater Project 2011, *Brownhill Keswick Creek Draft Stormwater Management Plan: Summary Report*, Brown Hill Keswick Creek Stormwater Project, Adelaide, SA, Australia.
- 2014, *Brown Hill Keswick Creek Stormwater Management Plan Part B Report*, Brown Hill Keswick Creek Stormwater Project, Adelaide, SA, Australia.
- 2016, *Brown Hill Keswick Creek Catchment Stormwater Management Plan 2016*, Adelaide, SA, Australia.
- Brown, JD & Damery, SL 2002, 'Managing flood risk in the UK: towards an integration of social and technical perspectives', *Transactions of the Institute of British Geographers*, vol. 27, no. 4, pp. 412-426.
- 2009, 'Uncertainty and risk', in N Castree, D Demeritt, D Liverman & B Rhoads (eds), *A Companion to Environmental Geography*, Wiley - Blackwell, West Sussex, England, UK.
- Bryman, A 2008, *Social Research Methods*, 3rd edn, Oxford University Press, Oxford, England, UK.
- 2016, *Social Research Methods*, 5th edn, Oxford University Press, Oxford, England, UK.
- Bubeck, P, Kreibich, H, Penning-Rowsell, EC, Botzen, WJW, de Moel, H & Klijn, F 2015, 'Explaining differences in flood management approaches in Europe and in the USA – a comparative analysis', *Journal of Flood Risk Management*, online.
- Burby, R, Deyle, R, Godschalk, D & Olshansky, R 2000, 'Creating Hazard Resilient Communities through Land-Use Planning', *Natural Hazards Review*, vol. 1, no. 2, pp. 99-106.
- Burby, RJ 2001, 'Flood insurance and floodplain management: The US experience', *Global Environmental Change Part B: Environmental Hazards*, vol. 3, pp. 111-122.
- Burby, RJ & French, SP 1981, 'Coping with floods: the land use management paradox', *Journal of the American Planning Association*, vol. 47, no. 3, pp. 289-300.
- Bureau of Meteorology 2011a, *Flood Summary for Helidon, Grantham, Gatton, Laidley and Forest Hill* Bureau of Meteorology, Brisbane, QLD, Australia.
- 2011b, *Special Climate Statement 24: Frequent heavy rain events in late 2010/early 2011 lead to widespread flooding across eastern Australia*, Bureau of Meteorology, Melbourne, VIC, Australia.
- 2013, *Known floods in the Brisbane & Bremer River Basin*, Bureau of Meteorology, Canberra, ACT, Australia, viewed 9 December 2013, <http://www.bom.gov.au/qld/flood/fld_history/brisbane_history.shtml>.

- 2014, *Known floods in the Brisbane & Bremer River Basin*, Bureau of Meteorology, Brisbane, QLD, Australia, viewed 19 June 2015, <http://www.bom.gov.au/qld/flood/fld_history/brisbane_history.shtml>.
- Burns, WJ & Slovic, P 2012, 'Risk Perception and Behaviors: Anticipating and Responding to Crises', *Risk Analysis*, vol. 32, no. 4, pp. 579-582.
- Butler, C & Pidgeon, N 2011, 'From 'Flood Defence' to 'Flood Risk Management': Exploring Governance, Responsibility, and Blame', *Environment and Planning C: Government and Policy*, vol. 29, no. 3, pp. 533-547.
- Bye, P & Horner, M 1998, *Easter 1998 Floods: Final assessment by the Independent Review Team*, Environment Agency, Bristol, England, UK.
- Caplan, P (ed.) 2000, *Risk revisited*, Pluto Press, London, England, UK.
- Carter, RA 2012, 'Flood risk, insurance and emergency management in Australia', *The Australian Journal of Emergency Management*, vol. 27, no. 2, pp. 20-25.
- Cartlidge, E 2014, *Updated: Appeals Court Overturns Manslaughter Convictions of Six Earthquake Scientists*, American Association for the Advancement of Science, Washington, DC, USA, viewed 26 June 2017, <<http://www.sciencemag.org/news/2014/11/updated-appeals-court-overturns-manslaughter-convictions-six-earthquake-scientists>>.
- Cash, D, Adger, NW, Berkes, F, Garden, P, Lebel, L, Olsson, P, Pritchard, L & Young, O 2006, 'Scale and cross-scale dynamics: governance and information in a multi-level world', *Ecology and Society*, vol. 11, no. 2.
- Castree, N & Braun, B (eds) 2001, *Social Nature: Theory, Practice, and Politics*, Blackwell Publishers Ltd, Oxford, England, UK.
- Castree, N, Chatterton, P, Heynen, N, Larner, W & Wright, MW (eds) 2010, 'The point is to change it: Geographies of hope and survival in an age of crisis', *Antipode*, vol. 41, Supplement 1, Wiley - Blackwell, West Sussex, England, UK.
- Catastrophic Disasters Emergency Management Capability Working Group 2005, *Review of Australia's Ability to Respond to and Recover From Catastrophic Disasters*, Australian Government Attorney-General's Department Australian Emergency Management Committee, Canberra, ACT, Australia.
- Challies, E, Newig, J, Thaler, T, Kochskämper, E & Levin-Keitel, M 2016, 'Participatory and collaborative governance for sustainable flood risk management: An emerging research agenda', *Environmental Science and Policy*, vol. 55, pp. 275-280.
- Chan, KMA, Shaw, MR, Cameron, DR, Underwood, EC & Daily, GC 2006, 'Conservation Planning for Ecosystem Services', *PLoS Biol*, vol. 4, no. 11, p. e379.
- Charles SP, Fu G 2014, *Statistically Downscaled Projections for South Australia – Task 3 CSIRO Final Report*. Goyder Institute for Water Research Technical Report Series No. 15/1 Adelaide, South Australia.

- Charlton, MB & Arnell, N 2011, 'Adapting to climate change impacts on water resources in England—An assessment of draft Water Resources Management Plans', *Global Environmental Change*, vol. 21, no. 1, pp. 238-248.
- Charmaz, K 2010, 'Studying the experience of chronic illness through grounded theory', in G Scambler & S Scambler (eds), *Assaults on the Lifeworld: New Directions in the Sociology of Chronic and Disabling Conditions*, Palgrave, London, England, UK, pp. 8-36.
- 2014, *Constructing Grounded Theory*, 2nd edn, Sage Publications, London, England, UK.
- Chatterton, J, Viviatene, C, Morris, J, Penning-Rosell, EC & Tapsell, SM 2010, 'The costs of the summer 2007 floods in England' Project Report. Environment Agency, Bristol, England, UK.
- City of Ipswich 2006, *2006 Consolidated Ipswich Planning Scheme*, City of Ipswich, Ipswich, QLD, Australia.
- 2009, *Waterway Health Strategy - 2009: An Integrated Approach to Waterway Health Management for Ipswich City Council*, Ipswich City Council, Ipswich, QLD, Australia.
- 2011, 'A sense of déjà'vu: The 2011 floods', *Planning and Development Update*, no. 7, April 2011.
- 2012, *Ipswich City Council Corporate Plan 2012-2017*, City of Ipswich, Ipswich, QLD, Australia.
- 2013, *Temporary Local Planning Instrument 01/2013 - Flooding Regulation (TLPI 01/2013)*, Ipswich City Council, Ipswich, QLD, Australia.
- 2015a, *Advance Ipswich: For the Future of our City and Community*, City of Ipswich, Ipswich, QLD, Australia.
- 2015b, *Floodplain Management Strategy*, City of Ipswich, Ipswich, QLD, Australia.
- 2015c, *Integrated Water Strategy 2015-2031: A Total Water Cycle Management Framework for Ipswich*, Ipswich, QLD, Australia.
- City of Mitcham 2013, *Brown Hill Creek Stormwater Management*, City of Mitcham, Adelaide, SA, Australia, viewed 7 November 2013, <<http://www.mitchamcouncil.sa.gov.au/page.aspx?u=1593>>.
- COAG 2011, *National Strategy for Disaster Resilience: Building our Nation's Resilience to Disasters*, Council of Australian Governments, Canberra, ACT, Australia.
- Coast Protection Board 1991, *Policy on coast protection and new coastal development*, Coastal Protection Board, Adelaide, SA, Australia, viewed 30 October 2017, <http://www.environment.sa.gov.au/files/fb3b339d-50ac-4e68-aa9c9e3900ec438d/cpb_policy_1991.pdf>.

- Coates, L 2012, 'Moving Grantham? Relocating flood-prone towns is nothing new', viewed 20 July 2012, <<http://theconversation.edu.au/moving-grantham-relocating-flood-prone-towns-is-nothing-new-4878#comments>>.
- Collier, D & Mahoney, J 1996, 'Insights and Pitfalls: Selection Bias in Qualitative Research', *World Politics*, vol. 49, no. 1, pp. 56-91.
- Collins, P & Wilson, J 2009, *Brownhill and Keswick Creeks Flood Mitigation: A Review of the Justification for the Construction of Two Large Detention Dams in the Upper Reaches of Brownhill Creek*, P. Collins and J. Wilson, Adelaide, SA, Australia.
- Commonwealth Treasury 2011, *Reforming Flood Insurance: Clearing the Waters*, Commonwealth of Australia, Canberra, ACT, Australia.
- Comrie, N 2011, *Review of the 2010-11 Flood Warnings and Response*, State of Victoria, Melbourne, VIC, Australia.
- Condamine Alliance 2014, *Condamine Alliance: People, Water, Land, Wildlife*, Condamine Alliance, Toowoomba, QLD, Australia, viewed 10 February 2014, <<http://www.condaminealliance.com.au/>>.
- Constanza, R, d'Arge, R, De Groot, R, Farber, SC, Grasso, M, Hannon, B, Limburg, K, Naeem, S, O'Neill, R, Paruelo, J, Raskin, R, Sutton, PC & Vandenbelt, M 1997, 'The value of the world's ecosystem services and natural capital', *Nature*, vol. 387, pp. 253-260.
- Cook, B, Atkinson, M, Chalmers, H, Comins, L, Cooksley, S, Deans, N, Fazey, I, Fenemor, A, Kesby, M, Litke, S, Marshall, D & Spray, C 2013, 'Interrogating participatory catchment organisations: cases from Canada, New Zealand, Scotland and the Scottish-English Borderlands', *The Geographical Journal*, vol. 179, no. 3, pp. 234-247.
- Cook, B, Forrester, J, Bracken, L, Spray, C & Oughton, E 2016, 'Competing paradigms of flood management in the Scottish/English borderlands', *Disaster Prevention and Management: An International Journal*, vol. 25, no. 3, pp. 314-328.
- Corbin, JM & Strauss, AL 1990, 'Grounded theory research: Procedures, canons, and evaluative criteria', *Qualitative Sociology*, vol. 13, no. 1, pp. 3-21.
- 2015, *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, 4th edn, SAGE Publications, Thousand Oaks, USA.
- Coulthard, T & Frostick, L 2010a, 'The Hull floods of 2007: implications for the governance and management of urban drainage systems', *Journal of Flood Risk Management*, vol. 3, no. 3, pp. 223-231.
- Coulthard, TJ & Frostick, LE 2010b, 'The Hull floods of 2007: implications for the governance and management of urban drainage systems', *Journal of Flood Risk Management*, vol. 3, no. 3, pp. 223-231.
- CRESS 2011, *Allan Water Natural Flood Management Techniques and Scoping Study*, University of Stirling, Stirling, UK.

- Creswell, JW & Miller, DL 2000, 'Determining validity in qualitative inquiry', *Theory into Practice*, vol. 39, no. 3, pp. 124-129.
- Cronin, V & Guthrie, P 2015, 'Community-led resettlement: from a flood affected slum to a new society in Pune, India', *Environmental Hazards*, vol. 10, no. 304, p. 310-326.
- Cutter, SL 1993, *Living with Risk: The Geography of Technological Hazards*, Edward Arnold, London, England, UK.
- 1996, 'Vulnerability to environmental hazards', *Progress in Human Geography*, vol. 20, no. 4, pp. 529-539.
- Daniell, KA, Máñez Costa, MA, Ferrand, N, Kingsborough, AB, Coad, P & Ribarova, IS 2011, 'Aiding multi-level decision-making processes for climate change mitigation and adaptation', *Regional Environmental Change*, vol. 11, no. 2, pp. 243-258.
- Daniels, CB & Tait, CJ (eds) 2005, *Adelaide, Nature of a City: The Ecology of a Dynamic City from 1836-2036*, Biocity: Centre for Urban Habitats, Adelaide, South Australia.
- Davies, SR, Cook, BR & Oven, KJ 2012, 'Risk' in field research', in M Kearnes, F Klauser & SN Lane (eds), *Critical Risk Research: Practices, Politics and Ethics*, John Wiley and Sons Ltd, West Essex, England, UK, pp. 59-75.
- Dawson, RJ, Ball, T, Werritty, J, Werritty, A, Hall, JW & Roche, N 2011, 'Assessing the effectiveness of non-structural flood management measures in the Thames Estuary under conditions of socio-economic and environmental change', *Global Environmental Change*, vol. 21, no. 2, pp. 628-646.
- Deloitte Access Economic 2016, *The economic cost of the social impact of natural disasters*, Australian Business Roundtable for Disaster Resilience and Safer Communities, Sydney, New South Wales.
- Denzin, NK 2001, *Interpretive Interactionism*, 2nd edn, SAGE Publications, Thousand Oaks, CA, USA.
- Department for Environment Food & Rural Affairs 2014a, *Case study. Flood defences: South Derbyshire Residents Help Protect Their Homes*, Department for Environment Food & Rural Affairs, London, England, viewed 18 August 2014, <<https://www.gov.uk/government/case-studies/flood-defences-south-derbyshire-residents-help-protect-their-homes>>.
- 2014b, *FOI release: Flood Defence Partnership Funding*, Department for Environment Food & Rural Affairs, London, England, UK, viewed 18 August 2014, <<https://www.gov.uk/government/publications/flood-defence-partnership-funding>>.
- Department for Environment Food and Rural Affairs 2005, *Making space for water - developing a new Government strategy for flood and coastal erosion risk management in England*, London, England, UK.
- 2010, *Flood and Water Management Act 2010*, UK Parliament, London, England, UK.

— 2013, *Flooding and coastal change: guidance for practitioners*, Department for Environment Food and Rural Affairs, London, England, UK, viewed 5 May 2014, <<https://www.gov.uk/flooding-and-coastal-change-guidance-for-practitioners>>.

Department for Environment Food and Rural Affairs & Environment Agency 2013, *Adapting to climate change*, Department for Environment Food and Rural Affairs, London, England, UK, viewed 13 May 2014, <<https://www.gov.uk/government/policies/adapting-to-climate-change>>.

Department of Energy and Climate Change 2011, *The Carbon Plan: Delivering Our Low Carbon Future*, HM Government, London, England, UK.

Department of Environment and Resource Management, Department of Infrastructure and Planning & Local Government Association of Queensland 2010, *Increasing Queensland's Resilience to Inland Flooding in a Changing Climate: Final Report on the Inland Flooding Study*, Queensland Government, Brisbane, QLD, Australia.

Department of Environment Water and Natural Resources 2017, *Stormwater Project to Avert Flooding Impacts in Brown Hill, Keswick Creek Catchment*, Government of South Australia, Adelaide, SA, Australia, viewed 16 April 2017, <https://www.environment.sa.gov.au/Home/Full_newsevents_listing/170227-stormwater-project-brownhill-keswick-creek>.

Department of Housing and Public Works 2012, *Queensland Development Code*, Queensland Government, Brisbane, QLD, Australia, viewed 12 February 2014, <<http://www.hpw.qld.gov.au/construction/BuildingPlumbing/Building/BuildingLawsCodes/QueenslandDevelopmentCode/Pages/default.aspx>>.

— 2013, *Building laws and codes*, Queensland Government, Brisbane, QLD, Australia, viewed 12 February 2014, <<http://www.hpw.qld.gov.au/construction/BuildingPlumbing/Building/BuildingLawsCodes/Pages/default.aspx>>.

Department of Infrastructure Planning and Natural Resources 2005, *Floodplain Development Manual: The Management of Flood Liable Land*, New South Wales Government, Sydney, NSW, Australia.

Department of Natural Resources and Mines 2014, *Brisbane River catchment flood study*, Queensland Government, Brisbane, QLD, Australia, viewed 19 June 2015, <<https://www.dnrm.qld.gov.au/water/brisbane-river-catchment-flood-study>>.

Department of Planning and Local Government 2010, *The 30-Year Plan for Greater Adelaide: A Volume of the South Australian Planning Strategy*, Government of South Australia, Adelaide, SA, Australia.

— 2011, *South Australian Planning Policy Library*, 6 edn, Government of South Australia, Adelaide, SA, Australia.

Department of Premier and Cabinet 2012, *Queensland Government Response to Queensland Floods Commission of Inquiry Final Report*, Queensland Government, Brisbane, QLD, Australia.

Department of the Environment, Water, Heritage and the Arts, 2009, *Ecosystem Services: Key Concepts and Applications*, Occasional Paper No 1, Department of the Environment, Water, Heritage and the Arts, Canberra, ACT.

Department of Transport Planning and Infrastructure 2014, *Adelaide Hills Council Development Plan. Consolidated 9 January 2014*, Department of Transport, Planning and Infrastructure, Adelaide, SA, Australia.

Department of Transport and Regional Services 2004, *Natural disasters in Australia: Reforming mitigation, relief and recovery arrangements*, Council of Australian Governments, Canberra, ACT, Australia.

Djordjevic, S, Butler, D, Gourbesville, P, Mark, O & Pasche, E 2011, 'New policies to deal with climate change and other drivers impacting on resilience to flooding in urban areas: the CORFU approach', *Environmental Science & Policy*, vol. 14, no. 7, pp. 864-873.

Dominiczak, P 2014, 'UK Floods: David Cameron says Britain 'Cannot let this happen again'', Telegraph, viewed February 13, 2014, <<http://www.telegraph.co.uk/news/weather/10635757/UK-floods-David-Cameron-says-Britain-cannot-let-this-happen-again.html>>

Donaldson, A, Lane, SN, Ward, N & Whatmore, S 2013, 'Overflowing with Issues: Following the Political Trajectories of Flooding', *Environment and Planning C: Government and Policy*, vol. 31, no. 4, pp. 603-618.

Douglas, M 1992, 'Risk and Blame: Essays in cultural theory', Londres, Routledge.

Douglas, M & Wildavsky, A 1982, *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers*, University of California Press, Berkeley and Los Angeles, USA.

Driessen, PP, Dieperink, C, Laerhoven, F, Runhaar, HA & Vermeulen, WJ 2012, 'Towards a conceptual framework for the study of shifts in modes of environmental governance—experiences from the Netherlands', *Environmental Policy and Governance*, vol. 22, no. 3, pp. 143-160.

Driessen, PPJ, Hegger, DLT, Bakker, MHN, van Rijswijk, HFMW & Kundzewicz, ZW 2016, 'Toward more resilient flood risk governance', *Ecology and Society*, vol. 21, no. 4, online.

Dunn, K 2010, 'Interviewing', in I Hay (ed.), *Qualitative Research Methods in Human Geography*, 3rd edn, Oxford University Press, Melbourne, VIC, Australia, pp. 101-137.

Eakin, H, Lerner, AM & Murtinho, F 2010, 'Adaptive capacity in evolving peri-urban spaces: Responses to flood risk in the Upper Lerma River Valley, Mexico', *Global Environmental Change*, vol. 20, no. 1, pp. 14-22.

Eisenhardt, KM 1989, 'Building Theories from Case Study Research', *Academy of Management Review*, vol. 14, no. 4, pp. 532-550.

Emergency Management Australia 1999, *Managing the Floodplain*, Australian Emergency Manuals Series: PART III Emergency Management Practice, vol. 3 - Guidelines, Emergency Management Australia, Canberra, ACT, Australia.

Emery, SB & Hannah, DM 2014, 'Managing and researching floods: sustainability, policy responses and the place of rural communities', *Hydrological Processes*, vol. 28, no. 18, pp. 4984-4988.

Engineers Australia 2015, *Rising sea levels return to Qld planning*, Engineers Australia, Canberra, ACT, Australia, viewed 24 October 2014, <<https://www.engineersaustralia.org.au/portal/news/rising-sea-levels-return-qlld-planning>>.

Environment Agency 2009, *Flooding in England: A National Assessment of Flood Risk*, Environment Agency, Bristol, England, UK.

— 2015, *A Country More Flood Resilient*, HM Government, London, England, UK, viewed 14 January 2016, <<https://www.gov.uk/government/news/a-country-more-flood-resilient>>.

Environment and Natural Resources Committee 2012, *Inquiry into Flood Mitigation Infrastructure in Victoria*, Parliamentary Paper No.169, Session 2010–2012, Parliament of Victoria, Melbourne, VIC, Australia.

Esteves, LS 2013, 'Is managed realignment a sustainable long-term coastal management approach?', *Proceedings 12th International Coastal Symposium, Journal of Coastal Research*, no. 65, pp. 933-938.

European Commission 2009, *White Paper - Adapting to Climate Change: Towards a European Framework for Action*, European Commission, Brussels, Belgium, viewed 1 May 2014, <<http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52009DC0147>>.

— 2014, *Towards better environmental options in flood risk management*, European Commission, Brussels, Belgium, viewed 20 March 2014, <http://ec.europa.eu/environment/water/flood_risk/better_options.htm>.

European Commission Directorate-General Environment 2011, *Note by DG Environment: Towards Better Environmental Options for Flood Risk Management*, no. 1 May, European Commission, Brussels, Belgium.

European Union 2000, *DIRECTIVE 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy*, Brussels, Belgium.

— 2007, *DIRECTIVE 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the Assessment and Management of Flood Risks*, Brussels, Belgium.

Evans, E, Ashley, R, Hall, JW, Penning-Rowsell, EC, Saul, A, Sayers, P, Thorne, C & Watkinson, A 2004, 'Foresight flood and coastal defence project: scientific summary', *Volume I. Future risks and their drivers. Office of Science and Technology*, London, England, UK.

Farber, SC, Costanza, R & Wilson, MA 2002, 'Economic and ecological concepts for valuing ecosystem services', *Ecological Economics*, vol. 41, no. 3, pp. 375-392.

- Farrow-Smith, E & Harper, D 2017, *Insurers move to clear up flood definition*, Australian Broadcasting Corporation (ABC), ABC North Coast, viewed 7 May 2017, <<http://www.abc.net.au/news/2017-04-11/flood-insurance-versus-storm-insurance/8434452>>.
- Few, R, Brown, K & Tompkins, EL 2007, 'Climate Change and Coastal Management Decisions: Insights from Christchurch Bay, UK', *Coastal Management*, vol. 35, no. 2, pp. 255-270.
- Flood and Coastal Defence 2004a, *Future Flooding Scientific Summary: Volume 1 - Future Risks and their Drivers*, Foresight Programme, Office for Science and Technology, London, England, UK.
- 2004b, *Future Flooding Scientific Summary: Volume 2 - Managing Future Risks*, Foresight Programme, Office for Science and Technology, London, England, UK.
- 2004c, *Future Flooding: Action Plan*, Foresight Programme, Office for Science and Technology, London, England, UK.
- 2004d, *Future flooding: Executive Summary*, Foresight Programme, Office for Science and Technology, London, England, UK.
- 2004e, *Future Flooding: Scotland*, Foresight Programme, Office for Science and Technology, London, England, UK.
- Folke, C, Hahn, T, Olsson, P & Norberg, J 2005, 'Adaptive governance of social-ecological systems', *Annual Review of Environment and Resources*, vol. 30, pp. 441-473.
- Foresight Land Use Futures Project 2010, *Land Use Futures: Making the Most of Land in the 21st Century*, The Government Office for Science, London, England, UK.
- Fox, N 1999, 'Postmodern reflections on 'risk', 'hazards' and life choices', in D Lupton (ed.), *Risk and Sociocultural Theory: New Directions and Perspectives*, Cambridge University Press, Cambridge, England, UK, pp. 12-33.
- Funtowicz, SO & Ravetz, JR 1993, 'Science for the post-normal age', *Futures*, vol. 25, pp. 739-755.
- Gale, EL & Saunders, MA 2013, 'The 2011 Thailand flood: climate causes and return periods', *Weather*, vol. 68, no. 9, pp. 233-237.
- Garnaut, R 2008, *The Garnaut Climate Change Review: Final report*, Cambridge University Press.
- Geaves, LH & Penning-Rowsell, EC 2016, 'Flood Risk Management as a public or a private good, and the implications for stakeholder engagement', *Environmental Science & Policy*, vol. 55, Part 2, pp. 281-291.
- Geoscience Australia 2017, *Flood*, Australian Government, Canberra, ACT, Australia, viewed 26 February 2017, <<http://www.ga.gov.au/scientific-topics/hazards/flood/basics/what>>.

- GHD Pty Ltd 2008, *Brownhill Keswick Creek Stormwater Project: Preliminary Assessment Of Flood Detention Basins on Brownhill Creek. Report for Stage 1*, Brownhill and Keswick Creek Stormwater Management Project, Adelaide, SA, Australia.
- Giddens, A 1991, *Modernity and Self-Identity: Self and Society in the Late Modern Age*, Polity Press, Cambridge, England, UK.
- 1999, *Lecture 2: Risk, Reith Lectures 1999: Runaway World (Transcript)*, BBC Radio 4, Recorded 10 April 1999, Hong Kong.
- 2009, *The Politics of Climate Change*, Polity Press, Cambridge, England, UK.
- Glaser, BG 1998, *Doing Grounded Theory: Issues and Discussions*, Sociology Press, Mill Valley, California, USA.
- Glaser, BG & Strauss, AL 1965, *Awareness of Dying*, Aldine, Chicago, USA.
- 1967, *The Discovery of Grounded Theory*, Aldine, Chicago, USA.
- Glavovic, BC, Saunders, WSA, Becker, JS, 2010, 'Land-use planning for natural hazards in New Zealand: The setting, barriers, 'burning issues' and priority actions', *Natural Hazards*, vol. 54, pp. 679-706.
- Goldsmith, D 2008, 'Stormy Standoff', *Weekly Times Messenger*, 10 December 2008, p. 20.
- Goode, N, Spencer, C, Archer, F, McArdle, D, Salmon, P & McClure, R 2011, *Review of Recent Australian Disaster Inquiries*, Monash University Accident Research Centre, Melbourne, VIC, Australia.
- Government of South Australia 2012, *Prospering in a Changing Climate. A Climate Change Adaptation Framework for South Australia*, Department of Environment, Water and Natural Resources, Adelaide, SA, Australia.
- Government of South Australia 2015, *South Australia's Climate Change Strategy 2015-2050 – Towards a low carbon economy*, Department of Environment, Water and Natural Resources, Adelaide, SA, Australia.
- Gralepois, M, Larrue, C, Wiering, M, CrabbÈ, A, Tapsell, S, Mees, H, Ek, K & Szwed, M 2016, 'Is flood defense changing in nature? Shifts in the flood defense strategy in six European countries', *Ecology and Society*, vol. 21, no. 4.
- Grantham Floods Commission of Inquiry 2015, *Grantham Floods Commission of Inquiry Report, October 2015*, Grantham Floods Commission of Inquiry, Brisbane, Queensland.
- Guardian Messenger 2005, 'Flood of Complaints', *Guardian Messenger*, 16 February 2005, p. 9.
- Guba, E & Lincoln, Y 1989, *Fourth Generation Evaluation*, SAGE Publications, Newbury Park, CA, USA.
- Gunderson, LH, Allen, CR & Holling, CS (eds) 2010, *Foundations of Ecological Resilience*, Island Press, Washington, USA.

- Gunderson, LH & Holling, CS (eds) 2002, *Panarchy: Understanding Transformations in Human and Natural Systems*, Island Press, Washington, USA.
- Gunderson, LH & Pritchard, LJ (eds) 2002, *Resilience and the Behaviour of Large-Scale Systems*, SCOPE Report 60, Island Press, Washington, USA.
- Hall, JW, Evans, E, Penning-Rowsell, E, Sayers, PB, Thorne, CR & Saul, AJ 2003, 'Quantified scenarios analysis of drivers and impacts of changing flood risk in England and Wales: 2030–2100', *Global Environmental Change Part B: Environmental Hazards*, vol. 5, no. 3–4, pp. 51-65.
- Hall, JW, Sayers, PB & Dawson, RJ 2005, 'National-scale assessment of current and future flood risk in England and Wales', *Natural Hazards*, vol. 36, no. 1, pp. 147-164.
- Hall, JW, Sayers, PB, Walkden, MJA & Panzeri, M 2006, 'Impacts of climate change on coastal flood risk in England and Wales: 2030–2100', *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, vol. 364, no. 1841, pp. 1027-1049.
- Hall, WA & Callery, P 2001, 'Enhancing the Rigor of Grounded Theory: Incorporating Reflexivity and Relationality', *Qualitative Health Research*, vol. 11, no. 2, pp. 257-272.
- Hand, H 2003, 'The mentor's tale: a reflexive account of semi-structured interviews', *Nurse Researcher*, vol. 10, no. 3, pp. 15-27.
- Handmer, J 1987, 'Flood Problem in Perspective'. *Flood Hazard Management: British and International Perspectives*. Geo Books, Norwich England. pp 9-32.
- Harries, T 2013, 'Responding to flood risk in the UK', *Cities at Risk*, vol. 33, pp. 45-72.
- Harries, T & Penning-Rowsell, EC 2011, 'Victim pressure, institutional inertia and climate change adaptation: The case of flood risk', *Global Environmental Change*, vol. 21, no. 1, pp. 188-197.
- Hartmann, T & Jeupner, R 2014, 'The flood risk management plan: An essential step towards the institutionalization of a paradigm shift', *International Journal of Water Governance*, vol. 2, pp. 107-118.
- Hartmann, T & Spit, T 2016, 'Implementing the European flood risk management plan', *Journal of Environmental Planning and Management*, vol. 59, no. 2, pp. 360-377.
- Hay, I 2010, *Qualitative Research Methods in Human Geography*, 3rd edn, Oxford University Press, Melbourne, VIC, Australia.
- Head, BW 2008, 'Wicked problems in public policy', *Public Policy*, vol. 3, no. 2, pp. 101-118.
- Head, BW & Alford, J 2015, 'Wicked Problems: Implications for Public Policy and Management', *Administration & Society*, vol. 47, no. 6, pp. 711-739.

- Heazle, M, Tangney, P, Burton, P, Howes, M, Grant-Smith, D, Reis, K & Bosomworth, K 2013, 'Mainstreaming climate change adaptation: An incremental approach to disaster risk management in Australia', *Environmental Science & Policy*, vol. 33, pp. 162-170.
- Hegger, DLT, Driessen, PPJ, Wiering, M, van Rijswijk, HF MW, Kundzewicz, ZW, Matczak, P, CrabbÈ, A, Raadgever, GT, Bakker, MHN, Priest, SJ, Larrue, C & Ek, K 2016, 'Toward more flood resilience: Is a diversification of flood risk management strategies the way forward?', *Ecology and Society*, vol. 21, no. 4.
- Higgins, A 2009, 'Mayor's flood of emotion', *Eastern Courier Messenger*, 25 November 2009, p. 17.
- Hillman, M 2009, 'Integrating Knowledge: The Key Challenge for a New Paradigm in River Management', *Geography Compass*, vol. 3, no. 6, pp. 1988-2010.
- HM Government 2008, *Climate Change Act 2008*, HM Government, London, England, UK, viewed 13 May 2014
<http://www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf>.
- 2012, *UK Climate Change Risk Assessment: Government Report*, Department for Environment Food and Rural Affairs, London, England, UK.
- 2013, *The National Adaptation Programme: Making the Country Resilient to a Changing Climate*, Department for Environment Food and Rural Affairs, London, England, UK.
- 2014, *UK Floods 2014: Government Response and Recovery*, HM Government, London, England, UK, viewed 15 May 2014, <<https://www.gov.uk/government/news/uk-floods-2014-government-response>>.
- Hochrainer-Stigler, S, Pflug, G & Luger, N 2013, 'Flood Risk in a Changing Climate: A Multilevel Approach for Risk Management', in A Amendola, T Ermolieva, J Linnerooth-Bayer & R Mechler (eds), *Integrated Catastrophe Risk Modeling*, vol. 32, Springer Netherlands, pp. 263-279.
- Hollis, G 1975, 'The effect of urbanization on floods of different recurrence interval', *Water Resources Research*, vol. 11, no. 3, pp. 431-435.
- Holstead, KL, Kenyon, W, Rouillard, JJ, Hopkins, J & Galán-Díaz, C 2015, 'Natural flood management from the farmer's perspective: criteria that affect uptake', *Journal of Flood Risk Management*, pp 205-218.
- Hooghe, L & Marks, G 2003, 'Unravelling the central state, but how? Types of multi-level governance', *American Political Science Review*, vol. 97, no. 2, pp. 233-243.
- Hooijer, A, Klijn, F, Pedroli, GBM & van Os, AG 2004, 'Towards sustainable flood risk management in the Rhine and Meuse Basins: Synopsis of the findings of IRMA-SPONGE', *River Research and Applications*, vol. 20, pp. 343-357.
- Horner, MW & Walsh, PD 2007, 'Easter 1998 flood', *Water and Environment Journal*, vol. 14, pp. 415-418.

House of Commons Environment Food and Rural Affairs Committee 2014, *Winter Floods 2013-14 (HC 240, First Report of Session 2014-15)*, The Stationary Office, London, England, UK.

House of Commons Select Committee on Agriculture's Special Session on Flood and Coastal Defence 1998, *Agriculture - Sixth Report*, House of Commons, London, England, UK, viewed 14 May 2014,

<<http://www.publications.parliament.uk/pa/cm199798/cmselect/cmagric/707/70702.htm>>.

— 2001, *Agriculture - Third Report*, House of Commons, London, England, UK, viewed 14 May 2014,

<<http://www.publications.parliament.uk/pa/cm200001/cmselect/cmagric/172/17202.htm>>.

House of Representatives Standing Committee on Social Policy and Legal Affairs 2012, *In the Wake of Disasters. Volume One: The Operation of the Insurance Industry During Disaster Events*, Commonwealth of Australia, Canberra, ACT, Australia.

Howe, J & White, I 2004, 'Like a fish out of water: The relationship between planning and flood risk management in the UK', *Planning Practice and Research*, vol. 19, no. 4, pp. 415-425.

Howes, M, Grant-Smith, D, Reis, K, Tangney, P, Bosomworth, K, Heazle, M, McEvoy, D & Burton, P 2012, 'The challenge of integrating climate change adaptation and disaster risk management', *Urban Research Program*, no. 17, pp. 1-9.

Howgate, OR & Kenyon, W 2009, 'Community cooperation with natural flood management: a case study in the Scottish Borders', *Area*, vol. 41, no. 3, pp. 329-340.

Hudson, P, Botzen, WJW, Feyen, L & Aerts, JCJH 2016, 'Incentivising flood risk adaptation through risk based insurance premiums: Trade-offs between affordability and risk reduction', *Ecological Economics*, vol. 125, pp. 1-13.

Hudson, PF, Middelkoop, H & Stouthamer, E 2008, 'Flood management along the Lower Mississippi and Rhine Rivers (The Netherlands) and the continuum of geomorphic adjustment', *Geomorphology*, vol. 101, no. 1-2, pp. 209-236.

Hughes, P 1992, *Woman dies as floods hit Adelaide*, *The Age*, viewed 12 August 2013, <<http://www.adelaidecaravans.com.au/adelaide-caravans-articles/1992/8/30/woman-dies-as-floods-hit-adelaide/>>.

Hugo, G 2011, 'Future demographic change and its interactions with migration and climate change', *Global Environmental Change*, vol. 21, Supplement 1, pp. S21-S33.

Huitema, D, Mostert, E, Egas, W, Moellenkamp, S, Pahl-Wostl, C & Yalcin, R 2009, 'Adaptive water governance: assessing the institutional prescriptions of adaptive (co-) management from a governance perspective and defining a research agenda', *Ecology and Society*, vol. 14, no. 1.

Hulme, M 2010, 'Cosmopolitan climates: Hybridity, foresight and meaning', *Theory Culture Society* vol. 27, no. 2-3, pp. 267-276.

- Huong, H & Pathirana, A 2013, 'Urbanization and climate change impacts on future urban flooding in Can Tho city, Vietnam', *Hydrology and Earth System Sciences*, vol. 17, no. 1, pp. 379-394.
- Hurlimann, A & Dolnicar, S 2011, 'Voluntary relocation – An exploration of Australian attitudes in the context of drought, recycled and desalinated water', *Global Environmental Change*, vol. 21, no. 3, pp. 1084-1094.
- Hussey, K & Pittock, J 2013, *Three Major Floods, Four Reviews, But Still Lessons to Learn*, The Conversation Media Group, Melbourne, Australia, viewed 31 July 2014, <<http://theconversation.com/three-major-floods-four-reviews-but-still-lessons-to-learn-12940>>.
- Hydro Tasmania Consulting 2005, *Flood Mitigation Study for Brownhill and Keswick Creeks: Stage 1 Technical Report - Final Draft*, Patawalonga Catchment Water Management Board, Wayville, SA, Australia.
- 2006, *Brownhill and Keswick Creeks Flood Mitigation Study*, Adelaide and Mount Lofty Ranges Natural Resource Management Board, Adelaide, SA, Australia.
- Insurance Council of Australia 2011a, *Flooding in the Brisbane Catchment, January 2011*, Insurance Council of Australia Hydrology Panel, Sydney, NSW, Australia.
- 2011b, *Response to 2011 Natural Disaster Insurance Review*, Insurance Council of Australia, Sydney, NSW, Australia.
- International Standards Organisation 2009, *ISO 31000:2009, Risk Management - Principles and Guidelines*, International Standards Organisation, Geneva, Switzerland.
- IPCC 2012, 'Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change', in CB Field, V. Baroos, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (ed.), Cambridge University Press, Cambridge, UK and New York, USA.
- 2013, *Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, USA.
- 2014a, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, USA.
- 2014b, *Climate Change 2014: Mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, USA.
- Ivan, MD 2011, 'Ecological Modernisation a Basis for the Tourism Sustainable Development', *Annals of DAAAM & Proceedings*, pp. 1357-1359.

- Johnson, C, Penning-Rowsell, EC & Parker, D 2007a, 'Natural and imposed injustices: the challenges in implementing 'fair' flood risk management policy in England', *The Geographical Journal*, vol. 173, no. 4, pp. 374-390.
- Johnson, C, Penning-Rowsell, EC & Tapsell, S 2007b, 'Aspiration and reality: flood policy, economic damages and the appraisal process', *Area*, vol. 39, no. 2, pp. 214-223.
- Johnson, C & Priest, SJ 2008, 'Flood risk management in England: A changing landscape of risk responsibility?', *International Journal of Water Resources Development*, vol. 24, no. 4, pp. 513-525.
- Johnson, C, Tunstall, S & Penning-Rowsell, EC 2005, 'Floods as catalysts for policy change: Historical lessons from England and Wales', *International Journal of Water Resources Development*, vol. 21, no. 4, pp. 561-575.
- Johnston, L, Wright, C, Watson, A & Nairn, J 2007, *Report on the Meteorology and Hydrology of the Floods in the Adelaide Region: 7 and 8 November 2005*, Bureau of Meteorology, Adelaide, SA, Australia.
- Joint Flood Taskforce 2011, *Joint Flood Taskforce Report March 2011*, Brisbane City Council, Brisbane, QLD, Australia.
- Jones, E 2016, 'Harsh weather puts \$140m Brown Hill and Keswick Creek flood mitigation back in the spotlight', *The Advertiser*, 15 September 2016, viewed 13 April 2017, <<http://www.adelaidenow.com.au/news/south-australia/harsh-weather-puts-140m-brown-hill-creek-and-keswick-creek-flood-mitigation-plan-back-in-the-spotlight/news-story/6f0b81a90447b56207e017d2f6c7b42a>>.
- Jonkman, SN & Dawson, RJ 2012, 'Issues and challenges in flood risk management— Editorial for the special issue on flood risk management', *Water*, vol. 4, no. 4, pp. 785-792.
- Jordan, A, Wurzel, RKW & Zito, A 2005, 'The rise of 'new' policy instruments in comparative perspective: Has governance eclipsed government?', *Political Studies*, vol. 53, no. 3, pp. 477-496.
- Joshi, A 2016, 'Why do our cities flood? Collapse in municipal governance is to blame', *The Wire*, 2 September 2016.
- Kasperson, RE, Renn, O, Slovic, P, Brown, HS, Emel, J, Goble, R, Kasperson, JX & Ratick, S 1988, 'The social amplification of risk: A conceptual framework', *Risk Analysis*, vol. 8, pp. 177-187.
- Kates, RW 2007, 'The Retreat from the Coast', *Environment*, vol. 49, no. 7, pp. C2-C4.
- Kates, RW, Colten, CE, Laska, S & Leatherman, SP 2006, 'Reconstruction of New Orleans after Hurricane Katrina: A research perspective', *Proceedings of the National Academy of Sciences*, vol. 103, no. 40, pp. 14653-14660.
- Kaufmann, M & Wiering, M 2017, 'Discursive junctions in flood risk governance – A comparative understanding in six European countries', *Journal of Environmental Management*, vol. 196, pp. 376-386.

- Kelman, I 2001, 'The autumn 2000 floods in England and flood management', *Weather*, vol. 56, no. 10, pp. 346-360.
- Kemp, D 1998, *Brownhill Creek Hydrology Review*, Transport SA, Adelaide, SA, Australia.
- Kemp, D & Myers, B 2015, 'A verification of the hydrological impact of 20 years of infill development in an urban catchment', *36th Hydrology and Water Resources Symposium: The Art and Science of Water*, pp. 379-386.
- Keskitalo, ECH (ed.) 2010, *Developing Adaptation Policy and Practice in Europe: Multi-Level Governance and Climate Change*, Springer, Berlin, Germany.
- Kettl, D 2009, *The Next Government of the United States: Why our Institutions Fail Us and How to Fix Them*, W.W. Norton, New York, USA.
- Keys, C 1995, 'You can't move the town... so you must make it safe', paper presented to 35th Annual Conference of the NSW Flood Mitigation Authorities, Wellington, NSW, Australia.
- King, D, Bird, D, Haynes, K, Boon, H, Cottrell, A, Millar, J, Okada, T, Box, P, Keogh, D & Thomas, M 2014, 'Voluntary relocation as an adaptation strategy to extreme weather events', *International Journal of Disaster Risk Reduction*, vol. 8, pp. 83-90.
- Kingdon, J 1995, *Agendas, Alternatives, and Public Policies*, HarperCollins, New York, USA.
- Kok, K & Veldkamp, T 2011, 'Scale and governance: conceptual considerations and practical implications', *Ecology and Society*, vol. 16, no. 2.
- Koks, EE, Jongman, B, Husby, TG & Botzen, WJW 2015, 'Combining hazard, exposure and social vulnerability to provide lessons for flood risk management', *Environmental Science & Policy*, vol. 47, pp. 42-52.
- Krol, A 2014, 'Opening policy window for ecological economics: Floods as a catalyst for policy change. Case study from Wales', Planet Europe, Masters Dissertation thesis, Cardiff University.
- Kron, W 2002, 'Flood risk = hazard x exposure x vulnerability', *Flood Defence*, pp. 82-97.
- Kron, W 2005, 'Flood Risk = Hazard • Values • Vulnerability', *Water International*, vol. 30, no. 1, pp. 58-68.
- Kunreuther, H 1996, 'Mitigating disaster losses through insurance', *Journal of Risk and Uncertainty*, vol. 12, no. 2, pp. 171-187.
- Lane, SN 2008a, 'Climate change and the summer 2007 floods in the UK', *Geography*, vol. 93, no. 2, pp. 91-97.
- 2008b, 'Slowing the floods in the UK: Pennine Uplands: a case of waiting for Godot?', *Journal of Practical Ecology and Conservation*.

—— 2012, 'Ethical risk management, but without risk communication?', in M Kearnes, F Klauser & S LANE (eds), *Critical Risk Research: Practices, Politics and Ethics*, John Wiley and Sons Ltd, West Sussex, England, UK.

Lamond, J & Proverbs, D 2006, 'Does the price impact of flooding fade away?', *Structural Survey*, vol. 24, no. 5, pp. 363-377.

Lane, SN, Brookes, CJ, Hardy, RJ, Holden, J, James, TD, Kirkby, MJ, McDonald, AT, Tayefi, V & Yu, D 2003, 'Land management, flooding and environmental risk: new approaches to a very old question', In *Proc. Chart. Inst. Water Env. Man. National Conference. The Environment: Visions, Values And Innovation*. Harrogate, pp. 10-12.

Lane, SN, Landstrom, C & Whatmore, SJ 2011, 'Imagining flood futures: risk assessment and management in practice', *Philosophical Transactions of the Royal Society of London. Series A*: vol. 369, pp. 1784-1806.

Lane, SN, Tayefi, V, Reid, S, Yu, D & Hardy, R 2007, 'Interactions between sediment delivery, channel change, climate change and flood risk in a temperate upland environment', *Earth Surface Processes and Landforms*, vol. 32, no. 3, pp. 429-446.

Lindell, MK & Whitney, DJ 2000, 'Correlates of Household Seismic Hazard Adjustment Adoption', *Risk Analysis: An International Journal*, vol. 20, no. 1, pp. 13-26.

Lo, AY 2013a, 'Household preference and financial commitment to flood insurance in South East Queensland', *Australian Economic Review*, vol. 46, pp. 160-175.

—— 2013b, 'The role of social norms in climate adaptation: Mediating risk perception and flood insurance purchase', *Global Environmental Change*, vol. 23, no. 5, pp. 1249-1257.

Lockyer Valley Regional Council 2011a, *Grantham Relocation Policy*, Lockyer Valley Regional Council, Gratton, QLD.

—— 2011b, *Lockyer Valley Community Recovery Plan*, Lockyer Valley Regional Council, Grantham, QLD, Australia.

—— 2011c, *Lockyer Valley: A Growing Lifestyle | 2012 – 2022 Community Plan*, Gatton, Queensland.

—— 2012a, *Corporate Plan 2012-2017*, Lockyer Valley Regional Council, Gatton, QLD, Australia.

—— 2012b, *Lockyer Valley Planning Scheme (Strategic Framework only)* Lockyer Valley Regional Council, Gatton, QLD, Australia.

—— 2017, *Temporary Local Planning Instrument (TLPI) for Flood Regulation affecting the Gatton Planning Scheme 2007 and the Laidley Shire Planning Scheme 2003*, Lockyer Valley Regional Council, Gatton, QLD, Australia.

Lopez Marrero, TM 2009, 'Adaptive capacity and resilience to floods in the Caribbean: A case study of two flood-prone communities in Puerto Rico', *Geography, Doctor of Philosophy thesis*, The Pennsylvania State University, University Park, Pennsylvania, USA.

- Ludy, J & Kondolf, G 2012, 'Flood risk perception in lands "protected" by 100-year levees', *Natural Hazards*, vol. 61, no. 2, pp. 829-842.
- Lugeri, N, Kundzewicz, Z, Genovese, E, Hochrainer, S & Radziejewski, M 2010, 'River flood risk and adaptation in Europe—assessment of the present status', *Mitigation and Adaptation Strategies for Global Change*, vol. 15, no. 7, pp. 621-639.
- Luisetti, T, Turner, RK, Bateman, IJ, Morse-Jones, S, Adams, C & Fonseca, L 2011, 'Coastal and marine ecosystem services valuation for policy and management: Managed realignment case studies in England', *Ocean & Coastal Management*, vol. 54, no. 3, pp. 212-224.
- Lupton, D 1999a, *Risk*, Routledge, London, England, United Kingdom.
- (ed.) 1999b, *Risk and Sociocultural Theory: New directions and perspectives*, Cambridge University Press, Cambridge, England, UK.
- MacDonald, A 2013, *Hundreds of home owners apply to rebuild higher after their homes flooded in 2011*, The Courier Mail, Brisbane, QLD, Australia, viewed 16 January 2013, <<http://www.adelaidenow.com.au/news/national/hundreds-of-home-owners-apply-to-rebuild-higher-after-their-homes-flooded-in-2011/>>.
- Macnaghten, P & Urry, J 1998, *Contested natures*, Sage Publications Ltd, London, England, UK.
- Madigan, M 2011, *"Queenslander" style of home favoured for flood resistance by statewide planning guide*, The Courier Mail, Brisbane, QLD, Australia, viewed 12 February 2014, <<http://www.couriermail.com.au/news/queensland/queenslanders-built-best-for-floods/story-e6freoof-1226139351508>>.
- 2013, 'Seqwater prepares for courtroom showdown with 2011 flood victims', *The Sunday Mail (QLD)*, 15 December 2013, Brisbane, QLD, Australia, viewed 12 February 2014, <<http://www.couriermail.com.au/news/queensland/seqwater-prepares-for-courtroom-showdown-with-2011-flood-victims/story-fnihsrf2-1226783205477>>.
- Mansell, MG 1997, 'The effect of climate change on rainfall trends and flooding risk in the west of Scotland', *Nordic Hydrology*, vol. 28, no. 1, pp. 37-50.
- Marsh, T 2008, 'A hydrological overview of the summer 2007 floods in England and Wales', *Weather*, vol. 63, no. 9, pp. 274-279.
- Marston, G & Watts, R 2003, 'Tampering with the evidence: a critical appraisal of evidence-based policy-making', *The drawing board: An Australian Review of Public Affairs*, vol. 3, no. 3, pp. 143-163.
- Marzocchi, W & Cocco, M 2013, 'Guilty? Or not?', *Risk Frontiers Newsletter*, vol. 13 (1), Macquarie University, North Ryde, Australia.
- Mason, M 2010, 'Sample Size and Saturation in Phd Studies Using Qualitative Interviews', *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, vol. 11, no. 3, viewed 30 October 2017, <<http://www.qualitative-research.net/index.php/fqs/article/view/1428/3028>>.

- Mathew, S, Trück, S & Henderson-Sellers, A 2012, 'Kochi, India case study of climate adaptation to floods: Ranking local government investment options', *Global Environmental Change*, vol. 22, no. 1, pp. 308-319.
- Mazzege, P, Therond, O, Debril, T, March, H, Sibertin-Blanc, C, Lardy, R & Sant'ana, D 2014, 'Critical multi-level governance issues of integrated modelling: An example of low-water management in the Adour-Garonne basin (France)', *Journal of Hydrology*, vol. 519, pp. 2515-2526.
- McCarthy, D, Rogers, T & Casperson, K 2006, *Floods in South Australia 1836-2005*, The Bureau of Meteorology, Commonwealth of Australia, ACT, Australia.
- McCarthy, J & Prudham, S 2004, 'Neoliberal nature and the nature of neoliberalism', *Geoforum*, vol. 35, pp. 275-283.
- McDaniels, T, Axelrod, LJ & Slovic, P 1995, 'Characterizing perception of ecological risk', *Risk Analysis*, vol. 15, no. 5, pp. 575-588.
- McGuire, B, Mason, I & Kilburn, C 2002, *Natural hazards and environmental change*, Key issues in environmental change, eds JA Matthews, RS Bradley, N Roberts & MAJ Williams, Arnold, London, United Kingdom.
- Menoni, S & Pesaro, G 2008, 'Is relocation a good answer to prevent risk?: Criteria to help decision makers choose candidates for relocation in areas exposed to high hydrogeological hazards', *Disaster Prevention and Management*, vol. 17, no. 1, pp. 33-53.
- Merriam, SB 1988, *Case study research in education: A qualitative approach*, Jossey-Bass, San Francisco, California, USA.
- Merz, B, Aerts, J, Arnbjerg-Nielsen, K, Baldi, M, Becker, A, Bichet, A, Blöschl, G, Bouwer, LM, Brauer, A, Cioffi, F, Delgado, JM, Gocht, M, Guzzetti, F, Harrigan, S, Hirschboeck, K, Kilsby, C, Kron, W, Kwon, HH, Lall, U, Merz, R, Nissen, K, Salvatti, P, Swierczynski, T, Ulbrich, U, Viglione, A, Ward, PJ, Weiler, M, Wilhelm, B & Nied, M 2014, 'Floods and climate: emerging perspectives for flood risk assessment and management', *Nat. Hazards Earth Syst. Sci.*, vol. 14, no. 7, pp. 1921-1942.
- Merz, B, Hall, JW, Disse, M & Schumann, A 2010, 'Fluvial flood risk management in a changing world', *Natural Hazards and Earth System Sciences*, vol. 10, pp. 509-527.
- Messner, F & Meyer, 2006, 'Flood damage, vulnerability and risk perception: challenges for flood damage research', in, J Schanze, E Zeman, & J Marsalek (eds), *Flood risk management – hazards, vulnerability and mitigation measures*, Springer, Switzerland, pp. 149-167.
- Met Office 2012a, *Easter 1998 floods*, Met Office, London, United Kingdom, viewed 17 January 2015, <<http://www.metoffice.gov.uk/climate/uk/interesting/easter1998>>.
- 2012b, *Heavy rainfall/flooding - July 2007*, Met Office, London, United Kingdom, viewed 17 January 2016, <<http://www.metoffice.gov.uk/climate/uk/interesting/july2007>>.
- 2012c, *Heavy rainfall/flooding - June 2007*, Met Office, London, United Kingdom, viewed 17 January 2016, <<http://www.metoffice.gov.uk/climate/uk/interesting/june2007>>.

- 2012d, *The wet autumn of 2000*, Met Office, London, United Kingdom, viewed 17 January 2016, <<http://www.metoffice.gov.uk/climate/uk/interesting/autumn2000.html>>.
- 2014, *Winter storms, December 2013 to January 2014*, Met Office, Exeter, UK, viewed 15 May 2014, <<http://www.metoffice.gov.uk/climate/uk/interesting/2013-decwind>>.
- 2015, *Flooding in Cumbria December 2015*, Met Office, London, United Kingdom, viewed 14 January 2016, <<http://www.metoffice.gov.uk/climate/uk/interesting/december2015>>.
- Miles, MB, Huberman, AM & Saldana, J 2014, *Qualitative Data Analysis: A methods sourcebook*, 3rd edn, SAGE Publications, Thousand Oaks, USA.
- Miller, JD, Kim, H, Kjeldsen, TR, Packman, J, Grebby, S & Dearden, R 2014, 'Assessing the impact of urbanization on storm runoff in a peri-urban catchment using historical change in impervious cover', *Journal of Hydrology*, vol. 515, 7/16/, pp. 59-70.
- Mills, J, Bonner, A & Francis, K 2006, 'Adopting a constructivist approach to grounded theory: Implications for research design', *International Journal of Nursing Practice*, vol. 12, no. 1, pp. 8-13.
- Mol, APJ & Sonnenfeld, DA 2000, 'Ecological modernisation around the world: An introduction', *Environ Politics*, vol. 9, no. 1, 2000/03/01, pp. 1-14.
- Mol, APJ, Sonnenfeld, DA & Spaargaren, G (eds) 2010, *The Ecological Modernisation Reader: Environmental reform in theory and practice*, Routledge, New York, USA.
- Mol, APJ & Spaargaren, G 1993, 'Environment, modernity and the risk-society: the apocalyptic horizon of environmental reform', *Int Sociol*, vol. 8, no. 4, pp. 431-459.
- 2000, 'Ecological modernisation theory in debate: a review', *Environ Politics*, vol. 9, no. 1, pp. 17-49.
- 2009, 'Ecological modernisation and industrial transformation', in N Castree, D Demeritt, D Liverman & B Rhoads (eds), *A companion to environmental geography*, Wiley - Blackwell, West Sussex, UK.
- Montz, BE & Tobin, GA 2008, 'Livin' large with levees: lessons learned and lost', *Natural Hazards Review*, vol. 9, no. 3, pp. 150-157.
- Moore, T 2011, *Is this the Queenslander house of the future?*, Brisbane Times, Brisbane, QLD, Australia, viewed 12 February 2014, <<http://www.brisbanetimes.com.au/business/property/is-this-the-queenslander-house-of-the-future-20110714-1hfst.html>>.
- 2012, *Flood spawns the new Old Queenslander*, Brisbane Times, Brisbane, QLD, Australia, viewed 12 February 2014, <<http://www.brisbanetimes.com.au/queensland/flood-spawns-the-new-old-queenslander-20120608-2019z.html>>.
- Moors for the Future Partnership 2012, *Making space for water*, Moors For The Future Partnership, Hope Valley, UK, viewed 5 May 2014, <<http://www.moorsforthefuture.org.uk/making-space-water>>.

Morse, JM & Field, PA 1995, *Qualitative Research Methods for Health Professionals*, SAGE Publications, Thousand Oaks, California, USA.

Munich Re 2010, *Natural catastrophes 2010: Analyses, assessments, positions.*, Topics Geo, Munich Reinsurance Company, Munich, Germany.

Murray, A 2017, *Natural Flood Management: Adopting ecosystem approaches to managing flood risk*, Friends of the Earth, Dublin, Ireland.

Myers, MF 1997, *Insights Emerging from the 'Assessment of Research and Applications for Natural Hazards' in the United States*, Disaster Preparedness Resources Centre, University of British Columbia, Vancouver, British Columbia, Canada.

Mythen, G 2004, *Ulrich Beck: A Critical Introduction to the Risk Society*, Pluto Press, London.

National Flood Forum 2016a, *Flood Action Groups*, National Flood Forum, Worcestershire, England, United Kingdom, viewed 28 September 2016, <<http://www.nationalfloodforum.org.uk/flood-risk-community-groups/>>.

——— 2016b, 'National Flood Forum Bulletin: November 2016', viewed 17/11/2016, <http://www.nationalfloodforum.org.uk/wp-content/uploads/November-2016_Bulletin.pdf>.

National Weather Service 2017, *Flood Related Hazards*, National Oceanic and Atmospheric Administration, US Department of Commerce, Silver Spring, Maryland, USA, viewed 3 February 2017, <<http://www.floodsafety.noaa.gov/hazards.shtml>>.

NCCARF 2011, *Grantham planned relocation*, NCCARF, viewed 13 September 2011, <<http://www.nccarf.edu.au/node/722>>.

NCCARF 2017, *CoastAdapt*, NCCARF, viewed 30 October 2017, <<https://coastadapt.com.au>>.

Nigussie, TA & Altunkaynak, A 2016, 'Assessing the Hydrological Response of Ayamama Watershed from Urbanization Predicted under Various Landuse Policy Scenarios', *Water Resources Management*, vol. 30, no. 10, pp. 3427-3441.

Nirupama, N & Simonovic, SP 2007, 'Increase of flood risk due to urbanisation: A canadian example', *Natural Hazards*, vol. 40, no. 1, pp. 25-41.

Niven, RJ & Bardsley, DK 2013, 'Planned retreat as a management response to coastal risk: a case study from the Fleurieu Peninsula, South Australia', *Regional Environmental Change*, vol. 13, no. 1, pp. 193-209.

Norman, B, Weir, JK, Sullivan, K & Lavis, J 2014, *Planning and bushfire risk in a changing climate: Final report for the urban and regional planning systems project*, Bushfire CRC, Canberra, Australia.

Nursey-Bray, M 2010, 'Local governance for local governments: A framework for addressing climate change', *Commonwealth Journal of Local Governance*, no. 7.

—— 2017, 'Towards socially just adaptive climate governance: the transformative potential of conflict', *Local Environment*, vol. 22, no. 2, 2017/02/01, pp. 156-171.

Nursey-Bray, M, Pecl, GT, Frusher, S, Gardner, C, Haward, M, Hobday, AJ, Jennings, S, Punt, AE, Revill, H & van Putten, I 2012, 'Communicating climate change: Climate change risk perceptions and rock lobster fishers, Tasmania', *Marine Policy*, vol. 36, no. 3, 5//, pp. 753-759.

Nutt, N 2012, *Natural flood management within the Flood Risk Management (Scotland) Act*, Halcrow, Edinburgh, UK, viewed 5 May 2014, <http://www.scottishhydrologicalgroup.org/Presentations/2012_13/SHGPresentation-NFMwithinFRM-NeilNutt-12Sep12.pdf>.

O'Brien, C 2017, 'Queensland 2011 floods: New study 'should be used to charge fairer insurance premiums'', vol. 2017, no. 7 May 2017, viewed 5 May 2017, <<http://www.abc.net.au/news/2017-05-05/queensland-2011-floods-new-study-should-bring-cheaper-insurance/8499752>>.

Office of the Inspector-General Emergency Management 2015, *Callide Creek Flood Review. Volume 1 : Report*, The State of Queensland, Office of the Inspector-General Emergency Management, Brisbane, Queensland.

Okada, T, Haynes, K, Bird, D, van den Honert, R & King, D 2014, 'Recovery and resettlement following the 2011 flash flooding in the Lockyer Valley', *International Journal of Disaster Risk Reduction*, vol. 8, pp. 20-31.

Oliver-Smith, A 1990, 'Post-Disaster Housing Reconstruction and Social Inequality: A Challenge to Policy and Practice', *Disasters*, vol. 14, no. 1, pp. 7-19.

—— 1991, 'Successes and Failures in Post-Disaster Resettlement', *Disasters*, vol. 15, no. 1, pp. 12-23.

Olsson, P, Folke, C & Berkes, F 2004, 'Adaptive comanagement for building resilience in social-ecological systems', *Environmental management*, vol. 34, no. 1, pp. 75-90.

Oven, KJ, Curtis, SE, Reaney, S, Riva, M, Stewart, MG, Ohlemüller, R, Dunn, CE, Nodwell, S, Dominelli, L & Holden, R 2012, 'Climate change and health and social care: Defining future hazard, vulnerability and risk for infrastructure systems supporting older people's health care in England', *Applied Geography*, vol. 33, no. 0, 4//, pp. 16-24.

Pahl-Wostl, C, Craps, M, Dewulf, A, Mostert, E, Tabara, D & Taillieu, T 2007, 'Social learning and water resources management', *Ecology and Society*, 12 (2), 2007.

Pahl-Wostl, C, Mostert, E & Tabara, D 2008, *The growing importance of social learning in water resources management and sustainability science*, online, *Ecology and Society*, vol. 13, no. 1, <<http://www.ecologyandsociety.org/vol13/iss1/art24/>>.

Paranjothy, S, Gallacher, J, Amlôt, R, Rubin, GJ, Page, L, Baxter, T, Wight, J, Kirrage, D, McNaught, R & Palmer, S 2011, 'Psychosocial impact of the summer 2007 floods in England', *BMC public health*, vol. 11, no. 1, p. 145.

- Parliament of South Australia 2005, 'Flood Zones', House of Assembly, Adelaide, South Australia.
- 2008, 'Flood Mitigation', Legislative Council, Adelaide, South Australia.
- Paton, D & Johnston, D 2001, 'Disasters and communities: vulnerability, resilience and preparedness', *Disaster Prevention and Management: An International Journal*, vol. 10, no. 4, pp. 270-277.
- Pearce, L 2003, 'Disaster Management and Community Planning, and Public Participation: How to Achieve Sustainable Hazard Mitigation', *Natural Hazards*, vol. 28, no. 2, pp. 211-228.
- Pelton, N 2016, 'Challenges for integrated coastal management in the Australian Federation. Understanding Intergovernmental tension: A case study of South Australia', *Geography, Environment and Population*, PhD thesis, University of Adelaide.
- Penning-Rowsell, EC & Handmer, J 1988, 'Flood hazard management in Britain: A changing scene', *Geographical journal*, pp. 209-220.
- Penning-Rowsell, EC, Johnson, C & Tunstall, S 2006, '“Signals” from pre-crisis discourse: Lessons from UK flooding for global environmental policy change?', *Global Environmental Change*, vol. 16, no. 4, pp. 323-339.
- Penning-Rowsell, EC, Priest, SJ & Johnson, C 2014, 'The evolution of UK flood insurance: incremental change over six decades', *International Journal of Water Resources Development*, vol. 30, no. 4, pp. 694-713.
- Perry, RW & Lindell, MK 1997, 'Principles for managing community relocation as a hazard mitigation measure', *Journal of Contingencies and Crisis Management*, vol. 5, no. 1, pp. 49-59.
- Petts, G & Amoros, C (eds) 1996, *Fluvial Hydrosystems*, Chapman and Hall, London, United Kingdom.
- Petz, D 2015, *Planned relocations in the context of natural disasters and climate change: a review of the literature*, The Brookings Institution, Washington, DC, USA.
- Phillips, D 2016, 'Samarco dam collapse: one year on from Brazil's worst environmental disaster', viewed 3 February 2017.
- Pierre, J & Peters, BG 2000, *Governance, Politics and the State*, MacMillian Press, Basingstoke, England.
- Pitt, M 2008, *Learning lessons from the 2007 floods: An independent review by Sir Michael Pitt*, Cabinet Office, London, UK.
- Plattner, T, Plapp, T & Hebel, B 2006, 'Integrating public risk perception into formal natural hazard risk assessment', *Natural Hazards and Earth System Science*, vol. 6, no. 3, pp. 471-483.

- Posthumus, H, Morris, J, Hess, T, Neville, D, Phillips, E & Baylis, A 2009, 'Impacts of the summer 2007 floods on agriculture in England', *Journal of Flood Risk Management*, vol. 2, no. 3, pp. 182-189.
- Potter, K 2008, 'Planning space for water', *Proceedings of the 10th BHS National Hydrology Symposium: Sustainable Hydrology for the 21st Century*, University of Exeter, pp. 15-17.
- PricewaterhouseCoopers 2015, *Review of Queensland flood warning and flood risk management arrangements*, Brisbane, QLD.
- Priest, SJ, Clark, MJ & Treby, EJ 2005, 'Flood insurance: The challenge of the uninsured', *Area*, vol. 37, pp. 295-302.
- QED Pty Ltd 2005, *Reducing the flood risk in the Brownhill and Keswick Creek catchment: information update*, Patawalonga Catchment Water Management Board, Adelaide, South Australia.
- Queensland Floods Commission of Inquiry 2012, *Queensland Floods Commission of Inquiry Final Report*, Queensland Floods Commission of Inquiry, Brisbane, QLD, Australia.
- Queensland Government 2003a, *Disaster Management Act 2003*, Queensland Parliamentary Counsel, Brisbane, QLD, Australia.
- 2003b, *SPP1/03 Mitigating the adverse impacts of flood, bushfire and landslide*, Department of Local Government and Planning and Department of Emergency Services, Brisbane, QLD, Australia.
- 2009, *Sustainable Planning Act 2009*, Brisbane, QLD, Australia.
- Queensland Reconstruction Authority 2011a, *Rebuilding Grantham Together: Development scheme - Grantham Reconstruction Area*, Queensland Reconstruction Authority, Brisbane, QLD, Australia.
- 2011b, *Temporary State Planning Policy 2/11: Planning for stronger, more resilient floodplains*, State of Queensland (Queensland Reconstruction Authority), Brisbane, QLD, Australia.
- 2013, *Queensland Reconstruction Authority*, Queensland Government, Brisbane, QLD, Australia, viewed 9 January 2013, <<http://www.qldreconstruction.org.au/>>.
- Radhakrishnan, M, Pathirana, A, Ashley, R & Zevenbergen, C 2017, 'Structuring Climate Adaptation through Multiple Perspectives: Framework and Case Study on Flood Risk Management', *Water*, vol. 9, no. 2, p. 129.
- Read, K 2006, 'Flood Mitigation', in T Rogers (ed.), *Floods in South Australia 1836-2005*, Bureau of Meteorology, Commonwealth of Australia, ACT, Australia, pp. 35-37.
- Reuben, A 2014, *UK floods: The winners and losers*, BBC News Business, London, UK, viewed 15 May 2014, <<http://www.bbc.com/news/business-26224680>>.

- Ribot, J 2010, 'Vulnerability does not fall from the sky: toward multiscale, pro-poor climate policy', *Social dimensions of climate change: Equity and vulnerability in a warming world*, vol. 2, pp. 47-74.
- Richardson, R 2014, *Natural Flood Management in Scotland*, SEPA, Edinburgh, UK, viewed 5 May 2014, <<http://nwrn.eu/sites/default/files/regional-workshops/West/day%2015-Roy.pdf>>.
- Rietig, K 2014, 'Reinforcement of multilevel governance dynamics: creating momentum for increasing ambitions in international climate negotiations', *International Environmental Agreements: Politics, Law and Economics*, pp. 1-19.
- Rittel, HW & Webber, MM 1973, 'Dilemmas in a general theory of planning', *Policy Sciences*, vol. 4, no. 2, pp. 155-169.
- Rodgers, L & Bryson, M 2014, *10 key moments of the UK winter storms*, BBC News, London, England, UK, viewed 15 May 2014, <<http://www.bbc.com/news/uk-26170904>>.
- Rojas, O, Mardones, M, Rojas, C, Martínez, C & Flores, L 2017, 'Urban Growth and Flood Disasters in the Coastal River Basin of South-Central Chile (1943–2011)', *Sustainability*, vol. 9, no. 2, p. 195.
- Rouillard, JJ, Heal, KV, Ball, T & Reeves, AD 2013, 'Policy integration for adaptive water governance: Learning from Scotland's experience', *Environmental Science & Policy*, vol. 33, pp. 378-387.
- Rowland 2011, *Strengthening Grantham Project: Issues management and recovery communications*, Lockyer Valley Regional Council, Brisbane, QLD, Australia.
- Rubin, C 1991, 'Recovery from disaster', in TE Drabek & GJ Hoetmer (eds), *Emergency Management: Principles and Practice for Local Government*, International City, Washington, DC, pp. 224-261.
- Rufat, S, Tate, E, Burton, CG & Maroof, AS 2015, 'Social vulnerability to floods: Review of case studies and implications for measurement', *International Journal of Disaster Risk Reduction*, vol. 14, pp. 470-486.
- Ruz, C & Kelly, J 2015, 'Storm Frank: What have we done to make the flooding worse?', *BBC News*, viewed 31 December 2015, <<http://www.bbc.com/news/magazine-35199963>>.
- Ryan, P 2011, *Insurer Denies Cowardly Behaviour in QLD floods*, Australian Broadcasting Corporation (ABC), (Online article), viewed 11 April 2011, <<http://au.news.yahoo.com/latest/a/-/latest/9171852/insurer-denies-cowardly-behaviour-in-qld-floods/>>.
- Salinas Rodriguez, CNA, Ashley, R, Gersonius, B, Rijke, J, Pathirana, A & Zevenbergen, C 2014, 'Incorporation and application of resilience in the context of water-sensitive urban design: linking European and Australian perspectives', *Wiley Interdisciplinary Reviews: Water*, vol. 1, no. 2, pp. 173-186.
- Salzman, J, Thompson Jr, BH & Daily, GC 2001, 'Protecting ecosystem services: Science, economics, and law', *Stan. Envtl. LJ*, vol. 20, p. 309.

Samuels, P, Klijn, F & Dijkman, J 2006, 'An analysis of the current practice of policies on river flood risk management in different countries', *Irrigation and Drainage*, vol. 55, no. S1, pp. S141-S150.

Sanderson, I 2002, 'Evaluation, policy learning and evidence-based policy making', *Public Administration*, vol. 80, pp. 1-22.

Schanze, J 2006, 'Flood risk management - A basic framework', in J Schanze, E Zeman & J Marsalek (eds), *Flood risk management: Hazards, Vulnerability and Mitigation Measures*, Springer, New York, USA.

Schultz, B 2006, 'Flood management under rapid urbanisation and industrialisation in flood-prone areas: a need for serious consideration', *Irrigation and Drainage*, vol. 55, no. S1, pp. S3-S8.

Scotland Environment Protection Agency (SEPA) 2014a, *Climate Change Homepage*, SEPA, Edinburgh, Scotland, UK, viewed 13 May 2014, <http://www.sepa.org.uk/climate_change.aspx>.

——— 2014b, *Our Climate Challenge: Helping to Deliver A Resilient, Low Carbon Scotland. SEPA's 2014-2018 Climate Change Plan*, SEPA, Edinburgh, Scotland, UK.

——— 2015, *Flood Risk Management Strategies*, SEPA, Edinburgh, Scotland, UK, viewed 3 December 2015, <<http://apps.sepa.org.uk/FRMStrategies/>>.

Scott, J 1990, *A Matter of Record*, Polity, Cambridge, UK.

Scottish Environment Protection Agency 2016a, *National Flood Risk Assessment*, SEPA, Edinburgh, Scotland, UK, viewed 21 May 2017, <<http://map.sepa.org.uk/nfra/map.htm>>.

——— 2016b, *Responsibilities for flooding*, SEPA, Stirling, Scotland, UK, viewed 4 March 2016, <<http://www.sepa.org.uk/environment/water/flooding/responsibilities-for-flooding#SG>>.

Scottish Government 2009a, *Climate Change (Scotland) Act 2009*, Scottish Government, Edinburgh, Scotland, UK, viewed 13 May 2014 <http://www.legislation.gov.uk/asp/2009/12/pdfs/asp_20090012_en.pdf>.

——— 2009b, *The Flood Risk Management (Scotland) Act 2009*, Scottish Government, Edinburgh, Scotland, UK.

——— 2009c, *Scotland's Climate Change Adaptation Framework*, Scottish Government, Edinburgh, Scotland, UK.

——— 2011, *Getting the Best From Our Land: A land use strategy for Scotland*, Scottish Government, Edinburgh, Scotland, UK.

——— 2014a, *Climate Change*, Scottish Government, Edinburgh, Scotland, UK, viewed 13 May 2014, <<http://www.scotland.gov.uk/Topics/Environment/climatechange>>.

——— 2014b, *Scottish Planning Policy* Edinburgh, Scotland, UK.

Seqwater 2013, *Managing our Dams and Weirs*, SEQWater, Brisbane, QLD, Australia, viewed 19 December 2013, <<http://www.previous.seqwater.com.au/public/source-store-treat-supply/dams>>.

Shukman, D 2015, *Floods Unleash Unprecedented Criticism*, BBC News, London, England, UK, viewed 14 January 2016, <<http://www.bbc.com/news/science-environment-35196046>>.

Silva, W, Dijkman, JPM & Loucks, DP 2004, 'Flood management options for The Netherlands', *International Journal of River Basin Management*, vol. 2, no. 2, pp. 101 - 112.

Simpson, M, James, R, Hall, JW, Borgomeo, E, Ives, MC, Almeida, S, Kingsborough, A, Economou, T, Stephenson, D & Wagener, T 2016, 'Decision Analysis for Management of Natural Hazards', *Annual Review of Environment and Resources*, vol. 41, no. 1, pp. 489-516.

Slovic, P 1994, 'Perceptions of risk: Paradox and challenge', in B Behmer & N-E Sahlin (eds), *Future Risks and Risk Management*, Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 63-78.

—— (ed.) 2000, *The Perception of Risk*, Earthscan Publications Ltd, London, England, UK.

—— (ed.) 2016, *The Perception of Risk*, 2nd edn, Taylor & Francis, London, England, UK.

Slovic, P, Fischhoff, B & Lichtenstein, S 1980, 'Facts and fears: Understanding perceived risk', *Societal Risk Assessment: How Safe is Safe Enough*, vol. 4, pp. 181-214.

Slovic, P & Weber, EU 2002, 'Perception of risk posed by extreme events', paper presented to Risk Management Strategies in an Uncertain World, Palisades, New York, USA, April 12-13, 2002.

Smith, A, Porter, JJ & Upham, P 2016, "'We cannot let this happen again": reversing UK flood policy in response to the Somerset Levels floods, 2014', *Journal of Environmental Planning and Management*, pp. 1-19.

Smith, DI 1998, *Water in Australia: Resources and Management*, Oxford University Press, Melbourne, VIC, Australia.

Smith, DI, Schreider, SY, Jakeman, AJ, Zenger, A, Bates, BC & Charles, SP 2001, *Urban Flooding: Greenhouse-induced impacts, methodology and case studies*, Resource and Environmental Studies, The Australian National University and the Commonwealth Science and Industry Research Organisation (CSIRO), Canberra, ACT, Australia.

Sørensen, MP 2017, 'Ulrich Beck: Exploring and Contesting Risk', *Journal of Risk Research*, pp. 1-11.

Spray, C, Ball, T & Rouillard, JJ 2009, 'Bridging the water law, policy, science interface: flood risk management in Scotland', *Journal of Water Law*, vol. 20, no. 2-3, pp. 165-174.

Stirling, A 2008, "'Opening Up" and "Closing Down" power, participation, and pluralism in the social appraisal of technology', *Science, Technology and Human Values*, vol. 33, no. 2, pp. 262-294.

Stormwater Management Authority (SMA) 2015, *Stormwater Management Authority Resolution Register*, SMA, Adelaide, SA, Australia.

—— 2016, *Priorities for Stormwater Management Planning in South Australia 2016-2020*, Government of South Australia and the Local Government Association of South Australia, Adelaide, SA, Australia.

—— 2017, '2016 Brown Hill and Keswick Creek Catchment Stormwater Management Plan', *The South Australian Government Gazette*, vol. 2017, no. 13, p. 823, viewed 13 April 2017, <http://www.governmentgazette.sa.gov.au/sites/default/files/public/documents/gazette/2017/March/2017_013.pdf>.

Surminski, S & Oramas-Dorta, D 2014, 'Flood insurance schemes and climate adaptation in developing countries', *International Journal of Disaster Risk Reduction*, vol. 7, 2014/03/01/, pp. 154-164.

Swallow, BM, Kallesoe, MF, Iftikhar, UA, van Noordwijk, M, Bracer, C, Scherr, SJ, Raju, K, Poats, SV, Duraiappah, AK & Ochieng, BO 2009, 'Compensation and rewards for environmental services in the developing world: framing pan-tropical analysis and comparison', *Ecology and Society*, vol. 14, no. 2, p. 26.

Swiss Re 2012, *Flood - an Underestimated Risk. Inspect, inform, insure*, Swiss Re, Zurich, Switzerland.

—— 2017, *Floods: an Insurable Peril, Yet Underinsured*, Swiss Re, Zurich, Switzerland, viewed 19 June 2017, <http://www.swissre.com/rethinking/climate_and_natural_disaster_risk/floods_an_insurable_peril_yet_underinsured.html>.

Teague, B, McLeod, R & Pascoe, S 2009, *Victorian Bushfires Royal Commission Final Report*, Parliament of Victoria, Melbourne, VIC, Australia.

Tempels, B & Hartmann, T 2014, 'A co-evolving frontier between land and water: dilemmas of flexibility versus robustness in flood risk management', *Water International*, vol. 39, no. 6, pp. 872-883.

Templeton, A 2011, 'Cover up for floods: Disaster insurance mandatory', *MX Newspaper*, 14 November 2014, p. 1.

Thaler, T 2015, 'Rescaling in flood risk governance - new spatial and institutional arrangements and structures', Flood Hazard Research Centre, School of Science and Technology, *Doctor of Philosophy thesis*, Middlesex University.

Thaler, T & Priest, SJ 2014, 'Partnership funding in flood risk management: new localism debate and policy in England', *Area*, vol. 46, no. 4, pp. 418-425.

The Australian Government: The Treasury 2011, *Natural Disaster Insurance Review: Inquiry into flood insurance and related matters. September 2011*, The Commonwealth of Australia, Canberra, ACT, Australia.

The Metropolitan Glasgow Strategic Drainage Partnership 2011, *The Metropolitan Glasgow Strategic Drainage Partnership*, Glasgow City Council, Glasgow, Scotland, UK, viewed 16 October 2016.

The State of Queensland 2016, *State Planning Policy*, Department of Infrastructure, Local Government and Planning, Brisbane, QLD, Australia.

The Town of Gawler 2014, *GRFMA Scheme: Gawler River Flood Mitigation Scheme*, The Town of Gawler, Gawler, SA, Australia, viewed 16 October 2016, <<http://www.gawler.sa.gov.au/page.aspx?u=697>>.

The World Bank and The United Nations 2010, *Natural Hazards, Unnatural Disasters: The Economics Of Effective Prevention*, The World Bank, Washington DC, USA.

Thomas, G 2009, *How to do Your Research Project: A Guide for Students in Education and Applied Social Sciences*, Sage Publications Ltd, New York.

Thompson, T 2013, *Skyrocketing Insurance Premiums hit Queensland Flood Victims Two Years On*, The Courier Mail, Brisbane, QLD, Australia, viewed 11 December 2013, <<http://www.couriermail.com.au/news/queensland/skyrocketing-insurance-premiums-hit-queensland-flood-victims-and-others/story-e6freoof-1226548519016>>.

Tomich, TP, Thomas, DE & Van Noordwijk, M 2004, 'Environmental services and land use change in Southeast Asia: from recognition to regulation or reward?', *Agriculture, Ecosystems & Environment*, vol. 104, no. 1, pp. 229-244.

Tompkins, EL, Adger, NW, Boyd, E, Nicholson-Cole, S, Weatherhead, K & Arnell, N 2010, 'Observed adaptation to climate change: UK evidence of transition to a well-adapting society', *Global Environmental Change*, vol. 20, no. 4, pp. 627-635.

Toowoomba Regional Council 2009, *Toowoomba Regional Planning Project Flood Study Final Report*, Water Technology Pty Ltd, Toowoomba, QLD, Australia.

— 2012a, *Toowoomba Regional Community Plan*, Toowoomba Regional Council, Toowoomba, QLD, Australia, viewed 10 February 2014, <<http://www.toowoombarc.qld.gov.au/about-council/vision-strategies-a-reports/community-plan/8177-our-toowoomba-region>>.

— 2012b, *Toowoomba Regional Planning Scheme* Toowoomba Regional Council, Brisbane, QLD, Australia, viewed 10 February 2014, <<https://pdonline.toowoombarc.qld.gov.au/masterplan/modules/epln/eplnviewer.aspx#>>.

— 2013, *Assessment of Local and Regional Issues - Corporate plan 2009 - 2014*, Toowoomba Regional Council, Toowoomba, QLD, Australia, viewed 10 February 2014, <<http://www.toowoombarc.qld.gov.au/about-council/vision-strategies-a-reports/corporate-plan-2009-2014/8208-assessment-of-local-and-regional-issues-corporate-plan-2009-2014>>.

— 2014, *Corporate Plan 2014-2019*, Toowoomba Regional Council, Toowoomba, QLD, Australia.

- 2017, *Floodplain Risk Management*, Toowoomba Regional Council, Toowoomba, QLD, Australia, viewed 10 May 2017, <<http://yoursay.tr.qld.gov.au/floodplain-risk-management>>.
- Treby, EJ, Clark, MJ & Priest, SJ 2006, 'Confronting flood risk: Implications for insurance and risk transfer', *Journal of Environmental Management*, vol. 81, no. 4, pp. 351-359.
- Turner, BS (ed.) 2009, *The New Blackwell Companion to Social Theory*, Blackwell Publishing, West Sussex, England, UK.
- Turner, RK, Burgess, D, Hadley, D, Coombes, E & Jackson, N 2007, 'A cost-benefit appraisal of coastal managed realignment policy', *Global Environmental Change*, vol. 17, no. 3-4, pp. 397-407.
- UNISDR 2015, *Making Development Sustainable: The Future of Disaster Risk Management. Global Assessment Report on Disaster Risk Reduction*, United Nations Office for Disaster Risk Reduction (UNISDR), Geneva, Switzerland.
- United Kingdom Climate Impact Program 2014, *Supporting Society in Adapting to Climate Change*, UKCIP & University of Oxford, Oxford, England, UK, viewed 15 May 2014, <<http://www.ukcip.org.uk/>>.
- Urquhart, C 2013, *Grounded Theory for Qualitative Research: A practical guide*, SAGE Publications, London, England, UK.
- Valentine, G 1997, 'Tell Me About...: Using Interviews as a Research Methodology', *Methods in human geography: A guide for students doing a research project*, pp. 110-126.
- van Aalst, MK 2006, 'The impacts of climate change on the risk of natural disasters', *Disasters*, vol. 30, no. 1, pp. 5-18.
- van den Hoek, R, Brugnach, M & Hoekstra, A 2012, 'Shifting to ecological engineering in flood management: Introducing new uncertainties in the development of a building with nature pilot project', *Environmental Science & Policy*, vol. 22, pp. 85-99.
- van den Honert, RC & McAneney, J 2011, 'The 2011 Brisbane Floods: Causes, Impacts and Implications', *Water*, vol. 3, no. 4, pp. 1149-1173.
- van Lieshout, M, Dewulf, A, Aarts, N & Termeer, C 2011, 'Do scale frames matter? Scale frame mismatches in the decision making process about a “mega farm” in a small Dutch village', *Ecology & Society*, vol. 16, no. 1.
- van Stokkom, HTC, Smits, AJM & Leuven, RSEW 2005, 'Flood Defense in The Netherlands - A New Era, a New Approach', *Water International*, vol. 30, no. 1, pp. 76 - 87.
- Vari, A, Linnerooth-Bayer, J & Ferencz, Z 2003, 'Stakeholder Views on Flood Risk Management in Hungary's Upper Tisza Basin', *Risk Analysis*, vol. 23, no. 3, pp. 585-600.
- VDM Consulting 2010, *Audit/review of Hydrology Study for Brownhill Creek: Final Report*, City of Mitcham, Southport, QLD, Australia.

Veerbeek, W, Gersonius, B, Ashley, R, Rijke, J, Radhakrishnan, M & Rodriguez, CS 2016, *Appropriate flood adaptation. Adapting in the right way, in the right place and at the right time.*, Cooperative Research Centre for Water Sensitive Cities, Melbourne, VIC, Australia.

Vidal, J 2015a, 'Storm Desmond rainfall partly due to climate change, scientists conclude', *The Guardian*, Sydney, NSW, Australia 11 December 2015, viewed 7 March 2016, <<http://www.theguardian.com/environment/2015/dec/11/storm-desmond-rainfall-flooding-partly-due-to-climate-change-scientists-conclude>>.

——— 2015b, *UK floods and Extreme Global Weather Linked to El Niño and Climate Change*, 28 December 2015, *The Guardian*, Sydney, NSW, Australia, viewed 7 March 2016, <<http://www.theguardian.com/environment/2015/dec/27/uk-floods-and-extreme-global-weather-linked-to-el-nino-and-climate-change>>.

Viglione, A, Di Baldassarre, G, Brandimarte, L, Kuil, L, Carr, G, Salinas, JL, Scolobig, A & Blöschl, G 2014, 'Insights from socio-hydrology modelling on dealing with flood risk-roles of collective memory, risk-taking attitude and trust', *Journal of Hydrology*, vol. 518, no. 71-82.

von der Dunk, A, Grêt-Regamey, A, Dalang, T & Hersperger, AM 2011, 'Defining a typology of peri-urban land-use conflicts – A case study from Switzerland', *Landscape and Urban Planning*, vol. 101, no. 2, pp. 149-156.

Wachinger, G, Renn, O, Begg, C & Kuhlicke, C 2013, 'The risk perception paradox—implications for governance and communication of natural hazards', *Risk Analysis*, vol. 33, no. 6, pp. 1049-1065.

Wahren, A, Schwärzel, K & Feger, KH 2012, 'Potentials and limitations of natural flood retention by forested land in headwater catchments: evidence from experimental and model studies', *Journal of Flood Risk Management*, vol. 5, no. 4, pp. 321-335.

Walker, G, Whittle, R, Medd, W & Walker, M 2011, 'Assembling the Flood: Producing Spaces of Bad Water in the City of Hull', *Environment and Planning A*, vol. 43, no. 10, pp. 2304-2320.

Waller, V, Farquharson, K & Dempsey, D 2016, *Qualitative Social Research: Contemporary methods for the digital age*, SAGE Publications, London, England, UK.

Ward, PJ, Pauw, W, Van Buuren, M & Marfai, MA 2013, 'Governance of flood risk management in a time of climate change: the cases of Jakarta and Rotterdam', *Environmental Politics*, vol. 22, no. 3, pp. 518-536.

Waylen, K, Holstead, K, Colley, K & Hopkins, J 2017, 'Challenges to enabling and implementing Natural Flood Management in Scotland', *Journal of Flood Risk Management*, online.

Weichselgartner, J 2001, 'Disaster mitigation: the concept of vulnerability revisited', *Disaster Prevention and Management: An International Journal*, vol. 10, no. 2, pp. 85-95.

Weichselgartner, J & Bertens, J 2000, 'Natural disasters: Acts of God, Nature or Society? On the social relation to natural hazards', *WIT Transactions on Ecology and the Environment*, vol. 45.

Wenger, C, Hussey, K & Pittock, J 2013, *Living with floods: Key lessons from Australia and Abroad: Synthesis and Integrative Research Final report*, National Climate Change Adaptation Research Facility, Gold Coast, QLD, Australia.

Werritty, A 2002, 'Living with uncertainty: climate change, river flows and water resource management in Scotland', *Science of the Total Environment*, vol. 294, no. 1, pp. 29-40.

——— 2006, 'Sustainable flood management: oxymoron or new paradigm?', *Area*, vol. 38, no. 1, pp. 16-23.

White, GF 1945, *Human adjustments to floods*, Department of Geography Research, The University of Chicago, Chicago, USA.

——— 1975, *Flood hazard in the United States: A Research Assessment*, Institute of Behavioural Science, University of Colorado, Boulder, USA.

White, GF, Burton, I & Kates, RW 1968, 'The human ecology of extreme geophysical events', *FMHI Publications*, no. 78, pp. 1-33.

White, GF, Kates, RW & Burton, I 2001, 'Knowing better and losing even more: the use of knowledge in hazards management', *Global Environmental Change Part B: Environmental Hazards*, vol. 3, no. 3, pp. 81-92.

White, I & Haughton, G 2017, 'Risky times: Hazard management and the tyranny of the present', *International Journal of Disaster Risk Reduction*, vol. 22, pp. 412-419.

White, I & Howe, J 2005, 'Unpacking the barriers to sustainable urban drainage use', *Journal of Environmental Policy & Planning*, vol. 7, no. 1, pp. 25-41.

White, I & Richards, J 2007a, 'Planning policy and flood risk: The translation of national guidance into local policy', *Planning, Practice and Research*, vol. 22, no. 4, pp. 513-534.

——— 2007b, 'Planning policy and flood risk: The translation of national guidance into local policy', *Planning Practice and Research*, vol. 22, no. 4, pp. 513-534.

Whiting, J 2008, 'Flood plan chaos', *Hills and Valley Messenger*, 30 July 2008, pp. 1-4.

——— 2009, 'Mitcham fights flooding alone', *Hills and Valley Messenger*, 11 February 2009, p. 7.

Wiering, M, Kaufmann, M, Mees, H, Schellenberger, T, Ganzevoort, W, Hegger, DLT, Larrue, C & Matczak, P 2017, 'Varieties of flood risk governance in Europe: How do countries respond to driving forces and what explains institutional change?', *Global Environmental Change*, vol. 44, pp. 15-26.

Wilby, RL, Beven, KJ & Reynard, N 2008, 'Climate change and fluvial flood risk in the UK: more of the same?', *Hydrological Processes*, vol. 22, no. 14, pp. 2511-2523.

Wildavsky, A 1986, 'Defining Risk', *Science*, vol. 232, no. 4749, pp. 439-439.

Wilkins, L 2000, 'Searching for symbolic mitigation: Media coverage of two floods', in D Parker (ed.), *Floods, 2*, Routledge, London, UK, pp. 218-244.

- Wilkinson, I 2001, *Anxiety in a Risk Society*, Routledge, London, England, UK.
- Wilkinson, M 2013, *Using a natural flood management approach for flooding and water quality control* The James Hutton Institute, Aberdeen, UK, viewed 5 May 2014, <[http://www.forestry.gov.uk/pdf/wilkinson_seminar_nrs_jan2013.pdf/\\$FILE/wilkinson_seminar_nrs_jan2013.pdf](http://www.forestry.gov.uk/pdf/wilkinson_seminar_nrs_jan2013.pdf/$FILE/wilkinson_seminar_nrs_jan2013.pdf)>.
- Williams, T 2009, 'Lives at risk in flood disaster', *Eastern Courier Messenger*, 11 March 2009, p. 11.
- Wisner, B, Blaikie, P, Cannon, T & Davis, I 2004, *At Risk: Natural hazards, People's Vulnerability and Disasters*, 2nd edn, Routledge, New York, USA.
- Wood Bromley and Carruthers & Mitchell 1984, *Drainage Study Brownhill, Glen Osmond, Parklands and Keswick Creeks. Vol 1. Main Report*, Wood Bromley and Carruthers & Mitchell, Adelaide, SA, Australia.
- World Wildlife Fund 2005, *Natural Rivers: The River Devon Project. Slowing the flow*, World Wildlife Fund, Aberfeldy, Scotland, UK.
- WorleyParsons Services Pty Ltd 2012, *Brownhill Keswick Creek Stormwater Project Draft Stormwater Management Plan 2012*, The Cities of Adelaide, Burnside, Mitcham, Unley and West Torrens, Adelaide, SA, Australia.
- Wright, C 1999, *Keswick Creek Flood Risk Management Pilot Study Report*, Bureau of Meteorology, Adelaide, SA, Australia.
- 2001a, 'Flash flooding in an urban environment: Causes, effects, potential damages and possible remedies, with particular reference to Keswick Creek in the inner suburbs of Adelaide', Department of Civil and Environmental Engineering, Master of Engineering Science thesis, The University of Adelaide.
- 2001b, *Keswick and Brownhill Creek Flood Risk Management Report*, Patawalonga Catchment Water Management Board, Adelaide, SA, Australia.
- 2006, 'The financial impact of floods', in T Rogers (ed.), *Floods in South Australia 1836-2005*, Bureau of Meteorology, Commonwealth of Australia, ACT, Australia, pp. 39-41.
- Yin, RK (ed.) 2004, *The Case Study Anthology*, SAGE Publications, Thousand Oaks, CA, USA.
- 2009, *Case study research: Design and methods*, 4th edn, SAGE Publications, Thousand Oaks, CA, USA.
- Zander, KK, Petheram, L & Garnett, ST 2013, 'Stay or leave? Potential climate change adaptation strategies among Aboriginal people in coastal communities in northern Australia', *Natural Hazards*, vol. 67, no. 2, pp. 591-609.
- Zevenbergen, C, van Herk, S, Rijke, J, Kabat, P, Bloemen, P, Ashley, R, Speers, A, Gersonius, B & Veerbeek, W 2013, 'Taming global flood disasters. Lessons learned from Dutch experience', *Natural Hazards*, vol. 65, no. 3, pp. 1217-1225.

Zevenbergen, C, Veerbeek, W, Gersonius, B & Van Herk, S 2008, 'Challenges in Urban Flood Management: Travelling across Spatial and Temporal Scales', *Journal of Flood Risk Management*, vol. 1, no. 2, pp. 81-88.

Zhu, T, Lund, JR, Jenkins, MW, Marques, GF & Ritzema, RS 2007, 'Climate change, urbanisation and optimal long-term floodplain protection', *Water Resources Research*, vol. 43, no. 6, p. W06421.

Zografos, C, Goulden, MC & Kallis, G 2014, 'Sources of human insecurity in the face of hydro-climatic change', *Global Environmental Change*, vol. 29, pp. 327-336.